

# RULES

## FOR TECHNICAL SUPERVISION DURING CONSTRUCTION OF SHIPS AND MANUFACTURE OF MATERIALS AND PRODUCTS FOR SHIPS

### PART III

#### TECHNICAL SUPERVISION DURING MANUFACTURE OF MATERIALS

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# **RULES FOR TECHNICAL SUPERVISION DURING CONSTRUCTION OF SHIPS AND MANUFACTURE OF MATERIALS AND PRODUCTS FOR SHIPS**

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Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships have been approved in accordance with the established approval procedure and come into force on 1 January 2023.

The present edition is based the latest version of the Rules, 2022.

The Rules are published in the following parts:

Part I "General Regulations for Technical Supervision";

Part II "Technical Documentation";

Part III "Technical Supervision during Manufacture of Material";

Part IV "Technical Supervision during Manufacture of Products".

The Rules are published in electronic format in Russian and English.

## **REVISION HISTORY**

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

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

## **1 GENERAL**

### **1.1 APPLICATION**

**1.1.1** The provisions of this Part of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships<sup>1</sup> are applied by Russian Maritime Register of Shipping<sup>2</sup> during technical supervision in manufacture and use of materials for ships.

**1.1.2** Technical supervision during manufacture and application of materials intended for fire protection of ships is carried out in accordance with the provisions of Section 4 "Fire Protection Materials, Structures and Products", Part IV "Technical Supervision during Manufacture of Products".

### **1.2 TERMS, DEFINITIONS AND EXPLANATIONS**

**1.2.1** The terms and their definitions and explanations relating to the general terminology are given in Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and in Part I "General Regulations for Technical Supervision" of these Rules.

**1.2.2** The following definitions have been adopted for the purposes of this Part.

**Second party** is an external party involved and interested in the manufacturer's activities, e.g. a customer or an organization/a person acting on its behalf.

**Production model** is the specimen of a material or products batch, made in accordance with the manufacturer's adopted production process for series production, which is subject to testing to verify its conformity with the prototype according to the RS-approved technical documentation.

**Third party** is an external party recognized as independent of the parties involved while determining the conformity of material or product to any existing requirements, e.g. national or international standards, the RS rules, ISO 9001, etc.

### **1.3 TECHNICAL SUPERVISION**

**1.3.1** Technical supervision is carried out on the basis of the RS issued rules and is aimed at determining whether materials and products intended for construction and repair of ships and their equipment meet the rules and additional requirements if specially stated.

The additional requirements include the potential requirements of the Register in the course of technical supervision to obtain some additional data on product quality (change of tests scope and procedures, sampling locations, specimen dimensions, etc.).

**Recognition Certificate for Manufacturer (СПИ)** is the document certifying the manufacturer as the one recognized by the Register to produce materials meeting the RS rules requirements.

The above document confirms the conformity of the supplied product and the conditions of its manufacturing with the requirements of the RS rules, and verifies the fact of listing the manufacturer in the Register issued List of Approved Materials and Recognized Manufacturers.

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<sup>1</sup> Hereinafter referred to as "the Rules".

<sup>2</sup> Hereinafter referred to as "the Register, RS".

The documents confirming the conformity of the material supplied with the rules requirements, and containing the data to identify the supplied product include:

Certificate of Conformity (refer to 1.1.1 and 3.3, Part I "General Regulations for Technical Supervision");

Manufacturer Certificate.

Technical supervision by the Register at the material manufacturers' does not replace the activity of technical control bodies functioning therein branch office.

Firms (manufacturers) can directly address to the Register higher regarding any controversial matters emerging during technical supervision. The RHO decision is considered final.

Interpretation of the provisions in this Part is within the Register competence only.

## **2 METALS**

### **2.1 RECOGNITION CERTIFICATE FOR MANUFACTURER (СПИ)**

#### **2.1.1 General.**

##### **2.1.1.1 Application.**

The Recognition Certificate for Manufacturer (СПИ) is issued to manufacturers producing materials, being the items of the Register technical supervision in accordance with the Nomenclature of Items of the Register Technical Supervision (refer to Appendix 1 to Part I "General Regulations for Technical Supervision").

To get the Recognition Certificate for Manufacturer (СПИ), the manufacturer shall be recognized by the Register in compliance with the requirements of Section 11, Part I "General Regulations for Technical Supervision" and [2.1](#) of this Part.

##### **2.1.1.2 Validity period.**

The validity period of the Recognition Certificate for Manufacturer (СПИ) and the date of its endorsement are established in compliance with the requirements of 3.4, Part I "General Regulations for Technical Supervision".

The Certificate shall be denounced and renewed if the terms of its issue have changed ([refer to 2.1.1.3](#)).

If due to some technological reasons the works needed for renewal of the Recognition Certificate for Manufacturer (СПИ) cannot be performed at set dates, the new dates for those works shall be agreed during the validity period of the Certificate, to keep the Certificate and the manufacturer in the List of Materials (generally, the main reason to postpone an audit is lack of adequate orders, i.e. materials essential for performance of clue tests).

With the satisfactory results of the works, the validity period of the Recognition Certificate for Manufacturer (СПИ) and the date of its next renewal remain unchanged. The Certificate validity is not suspended.

The relevant decision is taken by the RS Branch Office/RHO Location carrying out technical supervision at the manufacturer's on the basis of the manufacturer's application justifying the postponement.

The procedure for proper keeping up the List of Materials is set forth in [2.2.4](#).

##### **2.1.1.3 Conditions for issuing the Recognition Certificate for Manufacturer (СПИ):**

As agreed with RHO, all the works associated with the Certificate issue, endorsement or renewal shall be carried out by the RS Branch Offices having the relevant area of activity.

The Recognition Certificate for Manufacturer (СПИ) is issued to a manufacturer in case certain Register requirements and formalities ([refer to 2.1.2](#)) are fulfilled and on the basis of satisfactory results of the Register initial ([refer to 2.1.3](#)) or renewal surveys.

The survey of a manufacturer is carried out on the basis of a request ([refer to 2.1.2.1](#)) and generally includes fulfillment of the following conditions:

- review of the request and necessary documentation ([refer to 2.1.2](#));

- analysis of the request, identification of financial, labour and time resources, negotiation of plan of works necessary to accomplish the task with the firm (manufacturer) who has applied for the survey;

- familiarization with the production (manufacturing) process and current quality control system ([refer to 2.2](#));

- performance of tests ([refer to 2.2](#));

- review of the results of production (manufacturing) process survey, current quality control system and tests performed and comparing them with the documentation submitted by the manufacturer earlier.

All the information received by the Register for issue, endorsement or renewal of the Recognition Certificate for Manufacturer (СПИ) is considered strictly confidential and cannot be disclosed to any third party without a preliminary agreement with the firm (manufacturer) covered with the information and providing the information.

**2.1.1.4** Survey of the manufacturer.

**2.1.1.4.1** During survey, the information submitted by a firm (manufacturer) in the request and its enclosure regarding manufacturer potentials, product stated and its actual conformity with requirements of the RS rules is confirmed.

If necessary, due to execution of certain orders, product conformity with the additional contract requirements (with standards, specifications and other specified documentation) may concurrently be confirmed.

The survey includes familiarization with actual production (from a stockyard to a stock room and rejected product bay) and practical comparison of the data with the documentation on shops, sections, laboratories and offices of the manufacturer submitted according to [2.2.2.2](#).

**2.1.1.4.2** Initial survey is carried out at a manufacturer's applying to the Register for the first time or at the manufacturer's recognized by the Register and submitting material(s) not specified in the Recognition Certificate for Manufacturer (СПИ) issued.

The survey in the scope equivalent to initial survey may be carried out in the following cases:

- changes of technology associated with any of the material production (manufacturing) processes (heat, casting, rolling and/or heat treatment, forging, pressing etc.) mentioned in the RS rules;

- changes of the maximum thickness (dimensions) of materials supplied;

- changes of chemical composition (composition correction, micro alloying, etc.);

- application of different equipment and means of production used in technological process earlier approved by the Register (mills, thermal and other equipment);

- use of billets (slabs, blooms, etc.) supplied by unknown manufacturers or those not recognized by the Register.

The amount of documentation submitted to the Register for initial approval of the manufacturer shall comply with that specified in [2.1.2](#).

The scope of surveys and tests in initial approval is considered to be basic and shall take into account to the maximum extent particular features of manufacturing products at the specific manufacturers.

**2.1.1.4.3** Survey for endorsement and renewal of the Recognition Certificate for Manufacturer (СПИ) is carried out in accordance with [2.1.4 to 2.1.5](#).

**2.1.1.4.4** If manufacturer's requisites are changed, an appropriate set of documents changed is submitted to the Register, and reissue of the Recognition Certificate for Manufacturer (СПИ) is therewith carried out in accordance with the established procedure but the dates specified in the initial document remain the same. Survey of the manufacturer is not required.

**2.1.1.4.5** In surveying laboratories forming part of metallurgical or other manufacturers, their activity is considered as the integral part of a material production process, and drawing up a Register separate document, i.e. the Recognition Certificate of Testing Laboratory, is not required for them.

The Recognition Certificate of Testing Laboratory may be issued to the laboratory by its individual request, as a rule, when orders of external firms (manufacturers) are executed.

If the manufacturer cannot conduct testing of the stated product, the tests needed shall be carried out in the testing laboratory recognized by the Register.

The basic provisions on a testing laboratory survey are set forth in 1.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.1.1.4.6** In survey of the testing laboratory and in familiarization with the documentation special attention shall be paid to the following:

procedure of receipt and drawing up of requests for work performance by the testing laboratory;

personnel qualification;

sampling procedure, identification in specimens manufacture and tests;

availability of data on testing laboratory accreditation by competent national or international organizations.

**2.1.1.4.7** A testing laboratory passport shall contain all the pertinent information relating to this testing laboratory including requisites, the nomenclature of products and test types and procedures, as well as data on testing laboratory equipment (technical characteristics, data on this condition, date of equipment calibration), the list of regulatory documents, and data on spaces condition and attending personnel.

The form and drawing up of test reports is noteworthy. The report content for separate types of tests may be different, but the general form shall be standardized. Amendments and additions to the report after its issuance may be made only in the form of a separate document. Each report shall be provided with an identification number, and the testing laboratory name, membership (if the testing laboratory belongs to a manufacturer, its name shall be specified), the RS Branch Office and dates of tests performance shall be specified therein.

The reports shall generally be signed by a person in charge of performance of the given test type and by the head of the testing laboratory.

**2.1.1.4.8** Check tests of materials submitted according to the request and carried out at the manufacturer's shall be certified by the RS representative in the course of survey. The test reports shall be witnessed by the RS representative.

During certification of the check tests, the Register shall be governed by technical information presented in Appendix 1 to this Section. When in doubt of the proper condition of equipment and/or correctness of the tests conducted, the Register may engage the experts of other independent laboratories recognized by RS for inspection of the works carried out.

**2.1.1.4.9** In familiarization with documentation and during survey of the quality control system applied at the manufacturer's, the following procedures and formalization thereof shall be in the focus of attention:

receiving inspection;

inspection scope and nature;

identification system for materials or incoming semi-finished products during their storage and the manufacturing process as a whole. It is necessary to ascertain that all the incoming raw or other materials are used and processed later on only provided that the proper inspection is carried out and documented at the manufacturer's. The scope of supplier inspection shall be determined;

technological process effecting quality of the finished product. The stages of the process shall be under control (Instruction specifying inspection and control methods; documented criteria for works performed; corrective actions; marking; a system for gathering, use and storage of manufacturing parameters);

inspection of rejected materials; repair;

processing, re-inspection;

**2.1.1.4.10** Tests shall be carried out in accordance with the agreed program.

Selection of semi-finished products, samples cutting out and specimens manufacturing shall be directly supervised by the RS representative.

Dimensions of semi-finished products submitted for testing shall be consistent with those of semifinished products in supplies expected (at least one of semi-finished products shall have maximum width, thickness and diameter).

Test specimens shall be stamped for their identification with semi-finished product submitted for testing. The cutting and manufacturing procedure, intermediate stamping, as well as diagrams of specimen branch office and samples cutting out shall be preagreed.

All test results shall be noted in the reports signed by the representative of the quality control system applied at the firm's (manufacturer's) and witnessed by the Register representative carrying out technical supervision of testing.

The above results form part of the set of documents (report) submitted to the Register by the firm (manufacturer) as the basis for issuing the Recognition Certificate for Manufacturer (СПИ).

**2.1.1.4.11** The set of documents in the form of a report containing all the information on manufacture and tests of semi-finished products submitted for testing is submitted to the Register for approval.

The report is drawn up in an arbitrary form, but the sections consistent with [2.1.2](#) shall be included.

The report shall include copies of the program and the Register witnessed test reports. The data on conditions of melting, casting, rolling, heat treatment, etc., on microphotography and the results of non-destructive testing shall also be submitted, if needed.

The report content shall meet the requirements of the RS rules and documentation attached to the application. Upon satisfactory results of tests, survey of the manufacturer and review of the report, the RS Branch Office/RHO Location carrying out the survey draws up the Report on Survey of Firm (form 6.3.19) which is the basis for issuing the Recognition Certificate for Manufacturer (СПИ).

The reports and data on test results, surveys and technical documentation review, as well as the documentation as such, shall be kept at the RS Branch Office/RHO Location carrying out technical supervision of the manufacturer during the time period set by this Branch Office. The copies of those reports and data shall be submitted to RHO, unless otherwise specified.

All the information on the key decisions made in the course of approval, the results of the technical documentation review shall be submitted to RHO including the following:

Notice (form 25.П.01/01), in electronic format;

original information document of a firm (form 71.П.01), in electronic format in case the manufacturer's name is changed;

draft Recognition Certificate for Manufacturer (СПИ) (an initial survey) and copies of renewed Recognition Certificate for Manufacturer (СПИ) (in renewal);

copies of agreed documentation for product supply (if any).

Recognition Certificates for Manufacturer issued earlier to the manufacturer become invalid and RHO is informed thereof.

All the decisions made on the results of the RS Branch Office presentations review shall be brought to the notice of the RS Branch Office concerned and firms (manufacturers) by RHO.

## **2.1.2 Issue of request for manufacturer recognition by the Register (obtaining of Recognition Certificate for Manufacturer (СПИ)).**

**2.1.2.1** The firm's (manufacturer's) request generally is an official request on a letter form, which is drawn up by a firm (manufacturer) in an arbitrary form, unless otherwise specified.

Additionally to the objectives of work, the request shall contain information on financial guarantees and the list of documentation necessary for the request review ([refer to 2.1.2.2](#)).

The request forwarded to the RS Branch Office covering the firm (manufacturer) in its area of activity, or it may be forwarded to RHO directly.

In so doing, the following documents shall be submitted to RHO:

data on results of works performed by the RS Branch Office and on the changes that took place (or lack of such) during renewal of the Recognition Certificate for Manufacturer (СПИ);

copy of a request in case of the firm (manufacturer) initial application to the Register or renewal of the RS technical supervision at the firm's (manufacturer's) that had the Recognition Certificate for Manufacturer (СПИ) but it became invalid.

**2.1.2.2** Enclosures to the request.

Concurrent with the request, the brief information on manufacturer and products is submitted to the Register ([refer to 2.2.1.2](#)).

Generally, the information set out in [2.2.1.2](#) is applicable for all the works intended to manufacture or already manufacturing the materials under the RS technical supervision and applying to the Register with relevant requests.

**2.1.3 Issuing the Recognition Certificate for Manufacturer (СПИ).**

**2.1.3.1** The Recognition Certificate for Manufacturer (СПИ) (form 7.1.4.1), if not otherwise stated ([refer to 2.1.1.3](#)), shall be issued by the RS Branch Office that performed the survey of the manufacturer.

**2.1.3.2** The issued Recognition Certificate for Manufacturer (СПИ) shall contain in its annex information on the process and special features of material manufacture, dimensions of semi finished products supplied, procurement documentation and, if needed, special features of product marking ([refer to 1.4.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships](#)).

The code of an item shall be given for each material in the Recognition Certificate for Manufacturer (СПИ) form according to the RS Nomenclature ([refer to Appendix 1 to Part I "General Regulations for Technical Supervision"](#)).

**2.1.4 Endorsement of Recognition Certificate for Manufacturer (СПИ).**

**2.1.4.1** Endorsement of the Recognition Certificate for Manufacturer (СПИ) is carried out within the period stated in the Certificate according to [2.1.1.2](#).

**2.1.4.2** Occasional survey of the manufacturer having the Recognition Certificate for Manufacturer (СПИ) shall be performed during its validity period in the following cases:

inspection for defects in product use or operation, identification of causes effecting the product quality;

rejection to submit product in its manufacture and use;

unsatisfactory operation of the quality control system;

making changes in conditions of approval unless preagreed with the Register;

numerous failures in test performance;

recurring deviations from production or control procedure, and identified degradation of product quality stability (even with the results submitted regarding the review of the deviations detected, and the restoration of the Register confidence in a quality level).

The Recognition Certificate for Manufacturer (СПИ) endorsement may apply to the individual kinds of product or to all the materials listed in the Certificate.

In the above cases the decision on the Recognition Certificate for Manufacturer (СПИ) endorsement is made by the RHO and/or the RS Branch Office carrying out technical supervision at the manufacturer's.

**2.1.4.3** Everything listed in [2.1.4.2](#) may be considered by the Register as calling into question the intact validity of the Recognition Certificate for Manufacturer (СПИ) at a specific manufacturer and therefore may be interpreted by the parties as "occasional renewal" of the Certificate with the relevant drawing up of a manufacturer's request, etc.

**2.1.4.4** Additionally to the listed in [2.1.4.2](#), endorsement may be demanded when the materials supervised by the Register were not supplied during the period exceeding two years after issuance, renewal or previous endorsement of the Certificate.

**2.1.4.5** At endorsement of the Recognition Certificate for Manufacturer (СПИ), the scope of tests and surveys is determined in each particular case and may be equal to that of an initial survey ([refer to 2.1.1.4.2](#)).

**2.1.4.6** If the terms of the Certificate issue and the pertinent statistical data testifying to stability of the product quality level remain unchanged, being formally confirmed by the firm (manufacturer), the Certificate may be endorsed in a brief way.

At the discretion of the RS Branch Office/RHO Location carrying out technical supervision at the manufacturer's the tests may be omitted in the following cases:

with regular supplies of the product specified in the Recognition Certificate for Manufacturer (СПИ) under technical supervision of the Register or another classification society, and with provision of the pertinent information by the manufacturer (a statistically processed form is preferable);

with irregular supplies of the product specified in the Recognition Certificate for Manufacturer (СПИ) under technical supervision of the Register or another classification society, but with provision by the manufacturer of the pertinent information on supply of materials close by their parameters to those supplied and manufactured according to similar procedures. The data on chemical composition shall include all the elements specified for materials being presented by the manufacturer, micro alloying elements inclusive.

Additionally to the above conditions, the RS Branch Office may demand data on product rejecting, internal flaws, surface condition and dimensions.

If data on materials stated in the Recognition Certificate for Manufacturer (СПИ) are lacking, statistics may contain data on similar materials manufactured under the same technology.

**2.1.4.7** Where the product mentioned in the Certificate or like is not produced by the manufacturer, the Certificate can be endorsed when the relevant orders are received. In this case, the scope of surveys and extent of tests may also be equal to that of the initial survey, but it shall be consistent with the order extent and the validity period of the Recognition Certificate.

If the RS Branch Office decides to endorse the Recognition Certificate, the relevant statement is forwarded to the RHO.

#### **2.1.5 Renewal of Recognition Certificate for Manufacturer (СПИ).**

**2.1.5.1** Renewal of the Recognition Certificate for Manufacturer (СПИ) is carried out within the period stated in the Recognition Certificate for Manufacturer (СПИ) form according to [2.1.1.2](#).

**2.1.5.2** Renewal of the Recognition Certificate for Manufacturer (СПИ) at a specific known manufacturer is carried out on the basis of the manufacturer special survey. Decisions on the survey procedure, scope and execution of works, unless otherwise stated, are made by the RS Branch Office carrying out technical supervision at the manufacturer's considering the results of previous surveys ([refer to 2.1.4](#)).

Everything listed in [2.1.4.2](#) and [2.1.4.3](#) is applicable for the conditions of Recognition Certificate for Manufacturer (СПИ) renewal.

**2.1.5.3** At endorsement of the Recognition Certificate for Manufacturer (СПИ), the extent of tests and scope of surveys are determined in each particular case and may be equal to those of the initial survey. Generally, the extent of tests and scope of surveys are determined in accordance with [2.1.4.5](#), [2.1.4.6](#) and [2.1.4.7](#).

Survey within the scope of initial tests, in addition to the above mentioned, may be required in case the previous audit was carried out in a formal way ([refer to 2.1.4.6](#)).

Necessity of work performance and the scope of approval equivalent to the initial one may be agreed with RHO.

#### **2.1.6 Invalidation of Recognition Certificate for Manufacturer (СПИ).**

Generally, the Recognition Certificate for Manufacturer (СПИ) may become invalid in the following cases:

upon the manufacturer's request;

when the product supplied by the manufacturer shows non-conformity with the provisions of Recognition Certificate for Manufacturer (СПИ) issued (with the requirements of the RS rules and documentation entered in the Certificate);

when the terms of the agreement for technical supervision at the manufacturer's are violated;

when the Certificate validity period has expired and the firm (manufacturer) has failed to submit the relevant request at due time;

As a rule, the specific conditions wherein the Certificate becomes invalid are regulated by an agreement on technical supervision concluded between the Register and the firm (manufacturer).

## **2.2 PROCEDURES FOR RECOGNITION OF MANUFACTURERS**

### **2.2.1 Procedure for recognition of manufacturers of semi-finished products for hull structural steels.**

#### **2.2.1.1 General.**

These provisions specify the procedure for recognition (initial survey) by the Register of the manufacturing process of semi-finished products such as ingots, slabs, blooms and billets for hull structural steel.

The procedures for recognition of the manufacturer, issue, endorsement and renewal of the Recognition Certificate for Manufacturer (СПИ) are set forth in [2.1](#).

#### **2.2.1.2 Application. Documentation.**

##### **2.2.1.2.1 Initial documentation.**

The firm (manufacturer) shall submit to the Register the request for recognition, check test program and general information relevant to the following:

**.1** name and site address of the firm (manufacturer), location of the workshops, general indications relevant to the background, dimension of the works, estimated total annual production of finished products for shipbuilding and for other applications, as deemed useful;

**.2** organization and quality:

organizational chart;

staff employed;

staff employed and organization of the quality control department;

qualification of the personnel involved in activities related to the quality of the products;

certification of compliance of the quality system with ISO 9001;

approval certificates already granted by other classification societies, if any;

**.3** manufacturing facilities:

flow chart of manufacturing process;

origin and storage of raw materials;

storage of finished products;

equipment for systematic control during fabrication;

**.4** details of inspections and quality control facilities:

details of system used for identification of materials at different stages of manufacturing;

equipment for chemical analysis and relevant calibration procedures;

list of quality control procedures;

**.5** type of products (ingots, slabs, blooms, billets); grades of steel, range of thickness and aim material properties as follows:

range of chemical composition and aim analyses, including grain refining, micro alloying and residual elements, for the various grades of steel; if the range of chemical composition depends on thickness and supply condition, the different ranges shall be specified, as appropriate;

aim maximum carbon equivalent  $C_{eq}$  according to the formula specified in 3.2.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships;

aim maximum  $P_{cm}$  content for higher strength grades with low carbon content  $C < 0,13 \%$ , unless otherwise specified;

production statistics of the chemical composition and, if available, at rolling mills, mechanical properties ( $R_{eH}$ ,  $R_m$ ,  $A\%$ ,  $KV$ ). The statistics are intended to demonstrate the capability to manufacture the steel products in accordance with the specified requirements;

**.6** steel making:

steel making process and capacity of furnaces and/or converter;

raw material used;

deoxidation and alloying practice;

desulphurization and vacuum degassing installations, if any;

casting methods: ingot or continuous casting. In the case of continuous casting, information relevant to type of casting machine, teeming practice, methods to prevent re-oxidization, inclusions and segregation control, presence of electromagnetic stirring, soft reduction, etc., shall be provided as appropriate;

ingot or slab size and weight;

ingot or slab treatment: scarfing and discarding procedures;

**.7** approval already granted by other classification societies and documentation of approval tests performed.

**2.2.1.2.2** Documentation to be submitted for changing the recognition conditions.

The firm (manufacturer) shall submit to the Register the request ([refer to 2.1.2](#)) for changing the recognition conditions, in the case of the following:

**.1** change of the manufacturing process: steel making, casting (steel making plant, caster);

**.2** change of the thickness range (dimension);

**.3** change of the chemical composition, added element, etc.

The documentation submitted earlier ([refer to 2.2.1.2.1](#)) and subjected to relevant changes shall be enclosed to the request. As for the rest documentation submitted earlier during the previous recognition or endorsement, the request shall contain a record that it remains unchangeable.

The tests program shall be submitted in any case ([refer to 2.2.3.1](#)).

**2.2.1.3** Tests for recognition of manufacturing process and quality of semi-finished products.

**2.2.1.3.1** Extent of tests.

In general, the extent of the test program is specified in [2.2.1.3.6](#).

Types and number of tests may be modified by the Register on the basis of the preliminary information submitted by the firm (manufacturer) in accordance with [2.2.1.2.1](#) and [2.2.1.2.2](#). In particular, a reduction of the indicated number of casts, semi-finished products of certain thicknesses and steel grades to be tested or complete suppression of the tests may be accepted by the Register, taking into account the following:

**.1** approval already granted by other classification societies and documentation of tests performed;

.2 grades of steel to be recognized by the Register and availability of long term statistic results of chemical and mechanical properties (tests performed on rolled products);

.3 change of the recognition conditions by the Register.

An increase of the number of casts and semi-finished products of different thicknesses to be tested may be required in the case of newly developed grades of steel or manufacturing processes.

**2.2.1.3.2 Test program.**

Where the number of tests differs from those specified in [2.2.1.3.6](#), the program shall be submitted to the Register for approval before the tests are carried out, together with the documentation required in [2.2.1.2.1](#) and [2.2.1.2.2](#).

**2.2.1.3.3 Technical supervision.**

The tests carried out at the firm's (manufacturer's) shall be conducted considering the requirements of [2.1.1.4.5 – 2.1.1.4.10](#).

If the manufacturer cannot conduct testing of the stated product, the tests needed shall be carried out at the testing laboratory recognized by the Register.

**2.2.1.3.4 Selection of the test product (metal).**

For each grade of steel, for each type of semi-finished product and for each manufacturing process (e.g. steel making, casting, heat treatment), one test product with the maximum thickness (dimension) and one test product with the minimum thickness (dimension) shall be as a minimum selected for the tests.

The selection of the casts for the test product shall be based on the typical chemical composition, with particular regard to the specified  $C_{eq}$  or  $P_{cm}$  values and grain refining micro-alloying additions.

**2.2.1.3.5 Sampling (Position of the test samples).**

The test samples shall be taken, unless otherwise agreed, from the semi-finished product corresponding to the top of the ingot, or, in case of continuous casting, a random sample.

**2.2.1.3.6 Testing (Tests on base material).**

**2.2.1.3.6.1 Type of tests.**

The tests to be carried out for the recognition of the manufacturing process of semi-finished products are:

chemical analysis. The analysis shall be complete and shall include micro alloying elements; sulphur prints.

In addition, for initial recognition or for any upgrade of the recognition, the Register will require full tests in compliance with the requirements of [2.2.2](#) to be performed at rolling mill on the minimum thickness semi-finished product.

At that it shall be taken into consideration that in case of a multi-caster work, full tests on rolled products (finished products) shall be carried out for one caster only and reduced tests (chemical analysis, sulphur print) for the others.

The selection of the caster shall be based on the technical characteristics of the casters to be performed at rolling mill on products manufactured from the minimum thickness semi-finished product.

**2.2.1.3.6.2 Test specimens and testing procedure.** Generally, the specimens and test procedures shall meet the requirements of 2.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

At that the following tests and procedures apply:

**.1 chemical analyses:**

both the ladle sample and product analyses shall be reported. As the material for rolled material analysis the tensile test specimens are employed. In general, the content of the following elements shall be checked: C, Mn, Si, P, S, Ni, Cr, Mo, Al, N, Nb, V, Cu, As, Sn, Ti.

For steels manufactured from electric and open-hearth furnaces the Sb and B content is additionally checked;

**.2 sulphur prints:**

sulphur prints shall be taken from product edges, which are perpendicular to the axis of the ingot or slab. These sulphur prints shall be approximately 600 mm long taken from the center of the edge selected, i.e. on the ingot centerline, and shall include the full product thickness.

**2.2.1.4 Results.**

All the results and testing conditions shall comply with the requirements of the RS rules and shall be evaluated for recognition by the Register; depending on the results (regulated and not regulated by the RS rules), particular limitations or testing conditions shall be specified in the documents submitted for approval.

Besides, the firm (manufacturer) shall collect a set of documents containing all the information required under [2.2.1.2](#), applicable to the semi-finished products submitted to the tests.

The set of documents shall include all the results of the tests and analyses, operation records relevant to steel making, casting and, when applicable, rolling and heat treatment of test products. The set of documents may be also requested by the Register for review.

**2.2.1.5 Recognition.**

**2.2.1.5.1** Upon satisfactory completion of the survey and tests, the Register will issue the Recognition Certificate for Manufacturer (СПИ) wherein the following information shall be stated:

- type of a semi-finished product;
- steel making and casting processes;
- thickness range of the semi-finished products whereto the RS document applies;
- steel grade.

It shall be also indicated in the Recognition Certificate for Manufacturer (СПИ) that the individual users of the semi-finished products mentioned in the document shall be recognized by the Register for the manufacturing process of the specific grade of rolled steel products they are going to manufacture with those semi-finished products.

**2.2.1.5.2 Renewal of recognition.**

The validity period of the Recognition Certificate for Manufacturer (СПИ) issued by the Register shall be a maximum of five years.

Renewal of the Recognition Certificate for Manufacturer (СПИ) can be carried out by an audit and the assessment of the result of satisfactory survey during the period of validity of the existing Certificate.

Where for operational reasons, the renewal audit (renewal of Recognition Certificate for Manufacturer (СПИ)) falls outside the period of recognition validity, the manufacturer may be considered as recognized by the Register only, if agreement to this audit date is made within the original period of recognition validity.

In this instance, if successful, the extension of recognition will be back dated to the original renewal date.

Manufacturers, who have not produced the grades and products recognized by the Register during the validity period of the Recognition Certificate for Manufacturer (СПИ), shall be required to carry out all necessary tests for renewal of the Certificate. The renewal of the recognition for such grades of steel (their retention in the Recognition Certificate for Manufacturer (СПИ)) may be performed on the basis of results of production of similar brands of steel and types of semi-finished products.

**2.2.1.5.3** Reconsideration of the recognition.

The recognition may be reconsidered during the period of validity of the Recognition Certificate for Manufacturer (СПИ) in the cases specified in [2.1.4.2](#).

**2.2.2 Procedure for recognition of hull structural steel manufacturers.**

**2.2.2.1** General.

These provisions specify the procedure for recognition by the Register of the manufacturing process of rolled steels of normal and higher strength, as required by 1.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The recognition procedure is the basis for the Register verification of the manufacturer's capability to provide satisfactory products stably under effective process and production controls in operation including programmed rolling, and the quality system adopted at the manufacturer's in accordance with the requirements of 3.2.1.3 and 3.2.1.4, XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Generally, the recognition of a certain steel grade produced in accordance with the proposed manufacturing process flow chart, means recognition of a certain type of products supplied by the manufacturer and made of this steel grade meeting the requirements of the RS rules.

**2.2.2.2** Application. Documentation.

**2.2.2.2.1** Initial documentation.

The manufacturer shall submit to the Register the request for recognition, check test program and general information relevant to the following:

**.1** name and site address of the manufacturer, location of the workshops, general indication relevant to the background, dimensions of the works, estimated total annual production and types of products for shipbuilding and for other applications (as deemed useful);

**.2** organization and quality:

organizational chart;

staff employed;

staff employed and organization of the quality control department;

qualification of the personnel involved in activities related to the required quality of products;

certification of compliance of the quality system with ISO 9001 or 9002, if any;

approval certificates already granted by other classification societies, if any;

**.3** manufacturing facilities:

flow chart of manufacturing process;

origin and storage of raw materials;

storage of finished products;

equipment for systematic control during fabrication;

**.4** details of inspections and quality control facilities:

details of system used for identification of materials used at different stages of manufacturing;

equipment for chemical analysis, mechanical tests, metallography and relevant calibration procedures;

equipment for non-destructive testing;

list of quality control procedures;

**.5** types of semi-finished products (sheets/plates, sections, coiled rolled products), grades of steel, thickness range and aim material properties as follows:

range of chemical composition and aim analyses, including grain refining, micro alloying and residual elements, for the various grades of steel (if the range of chemical composition depends on thickness and supply condition, the different ranges shall be specified, as appropriate);

aim maximum carbon equivalent  $C_{eq}$  according to the formula specified in 3.2.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships;

aim maximum  $P_{cm}$  content for higher strength grades with low carbon content  $C < 0,13 \%$ , unless otherwise specified;

production statistics of the chemical composition and mechanical properties ( $R_{eH}$ ,  $R_m$ ,  $A\%$ ,  $KV$ ). The statistics are intended to demonstrate the capability to manufacture the steel products in accordance with the specified requirements;

**.6** steel making:

steel making process and capacity of furnace/s or converter/s;

raw materials used;

deoxidation and alloying practice;

desulphurization and vacuum degassing installations, if any;

casting method: ingot or continuous casting. In the case of continuous casting, information relevant to type of casting machine, teeming practice, methods to prevent re-oxidation, inclusion and segregation control, presence of electromagnetic stirring, soft reduction, etc., shall be provided as appropriate;

ingot or slab size and weight;

ingot or slab treatment: scarfing and discarding procedures;

**.7** reheating and rolling:

type of furnace and treatment parameters;

rolling: reduction ratio of slab/bloom/billet to finished product thickness, rolling and finishing temperatures;

descaling treatment during rolling;

capacity of the rolling stands;

**.8** heat treatment:

type of furnaces, heat treatment parameters and their relevant records;

accuracy and calibration of temperature control devices;

**.9** programmed rolling:

for semi-finished products delivered in the controlled rolling (CR) or thermo-mechanical treatment (TM), the following additional information on the programmed rolling schedules shall be given:

description of rolling process;

normalizing temperature, re-crystallization temperature and  $A_3$  temperature and the methods used to determine them;

control standards for typical rolling parameters used for the different thickness and grades of steel (temperature and thickness at the beginning and at the end of the passes, interval between passes, reduction ratio, temperature range and cooling speed of accelerated cooling, if any) and relevant method of control;

calibration of the control equipment;

**.10** recommendations for bending and welding in particular for steels delivered in the CR or TM condition:

hot and cold bending recommendations if needed in addition to the normal practice used in the shipyards or workshops;

minimum and maximum heat input if different from the ones usually used in the shipyards and workshops (15 — 50 kJ/cm));

**.11** where any part of the manufacturing process is assigned, if possible, to another production facility or to another manufacturer, additional information required by the Register shall be included;

**.12** approval certificates already granted by other classification societies and documentation of tests performed.

**2.2.2.2.2** Documentation to be submitted for changing the recognition conditions.

The firm (manufacturer) shall submit to the Register the request ([refer to 2.1.2](#)) for changing the recognition conditions in the case of the following:

- .1 change of any of the manufacturing process (steel making, casting, rolling and/or heat treatment);
- .2 change of maximum thickness (dimension);
- .3 change of the chemical composition, added element, etc.;
- .4 use of other rolling mills, thermal or other equipment differing from that indicated earlier for recognition of the rolling by the Register;
- .5 use of semi-finished products not included in the Recognition Certificate for Manufacturer (СПИ) and not subjected to the relevant tests, for rolling of the semi-finished products.

However, where the documents are duplicated by the ones at initial recognition by the Register for the same type of semi-finished product, part or all of the documents may be omitted except the test program.

**2.2.2.3** Tests for recognition of manufacturing process and quality of rolled steel.

**2.2.2.3.1** Extent of tests.

In general, the extent of tests is specified in [2.2.1.3.4](#), [2.2.1.3.6](#) and [2.2.1.3.7](#).

The extent and number of tests may be modified by the Register on the basis of the preliminary information submitted by the firm (manufacturer) in accordance with [2.2.1.2.1](#) and [2.2.1.2.2](#). In particular, a reduction of the indicated number of casts, semi-finished products of certain thicknesses and steel grades to be tested or complete suppression of the tests may be accepted.

The decisions are made taking into account the following:

- .1 approval already granted by other classification societies and documentation of tests performed;
- .2 grades of steel to be recognized by the Register and availability of long term statistic results of chemical and mechanical properties;
- .3 recognition for any grade of steel also covers recognition for any lower grade in the same strength level, provided that the aim analyses, method of manufacture and condition of supply are similar;
- .4 for higher tensile steels, recognition of one strength level covers the recognition of the strength level immediately below, provided the steel making process, deoxidation and fine grain practice, casting method and condition of supply are the same;
- .5 change of the recognition conditions by the Register.

In case of multi-source semi-finished products or changing of semi-finished product manufacturer, the rolled steel manufacturer is required to obtain the approval of the manufacturing process of rolled steels using the semi-finished products from each semi-finished product manufacturer.

Tests shall be conducted in accordance with [2.2.2.3.6](#) and [2.2.2.4](#).

A reduction or complete suppression of the tests may be considered taking into account previous recognition as follows:

the rolled steel manufacturer has already been recognized for the manufacturing process using other semi-finished products characterized by the same thickness, steel grade, grain refining and micro-alloying elements, steel making and casting process;

the semi-finished products manufacturer has been recognized by the Register for the complete manufacturing process with the same conditions (steelmaking, casting, rolling and heat treatment) for the same steel types.

**2.2.2.3.2** Test program.

Where the number of tests differs from those specified in [2.2.1.3.6](#) and 2.2.1.3.7, the program shall be submitted to the Register for approval before the tests are carried out, together with the documentation required in [2.2.1.2.1](#) and [2.2.1.2.2](#).

**2.2.2.3.3** Technical supervision.

The tests carried out at the firm's (manufacturer's) shall be conducted in accordance with [2.1.1.4.5 — 2.1.1.4.1.10](#).

If the manufacturer cannot conduct testing of the stated product, the tests needed shall be carried out at the testing laboratory recognized by the Register.

**2.2.2.3.4** Selection of the test product (metal).

For each grade of steel, for each type of semi-finished product and for each manufacturing process (covering the whole cycle: steel making, casting, rolling and condition of supply), one semi-finished product with the maximum thickness (dimension) shall in general be selected for the tests.

In addition, for initial approval, the Register may require selection of one semi-finished product of average thickness.

The selection of the casts for the semi-finished products shall be based on the typical chemical composition, with particular regard to the specified  $C_{eq}$  or  $P_{cm}$  values and content of deoxidizing and grain refining micro-alloying additions.

**2.2.2.3.5** Sampling (Position of the test samples).

The test samples shall be taken, unless otherwise agreed, from the semi-finished product (plate, flat, section, bar) corresponding to the top of the ingot, or, in case of continuous casting, a random sample.

The position of the samples to be taken in the length of the rolled product "top" and/or "bottom" of the piece and the direction of the test specimens with respect to the final direction of rolling of the material are indicated in [Table 2.2.2.3.6.1](#) of this Part. The position of the samples in the width of the product shall be in compliance with 3.2.5 "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.2.2.3.6** Testing (Tests on base material).

**2.2.2.3.6.1** Type of tests.

The tests to be carried out are indicated in [Table 2.2.2.3.6.1](#).

**2.2.2.3.6.2** Test specimens and testing procedures.

The test specimens and testing procedures shall be, as a rule, in accordance with [2.2](#), Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

In particular the following applies:

**.1** tensile tests:

for plates made of hot rolled strip, one additional tensile specimen shall be taken from the middle of the strip constituting the coil;

Table 2.2.2.3.6.1

Type of tests	Position of the samples and direction of the test specimens <sup>1</sup>	Remarks			
Tensile test	Top and bottom transverse <sup>2</sup>	$R_{eH}$ , $R_m$ , $A_5(\%)$ , $RA(\%)$ shall be reported			
Tensile test (stress relieved) only for TM steels	Top and bottom transverse <sup>2</sup>	Stress relieving at 600 °C (2 min/mm with minimum 1 h)			
Impact test <sup>3</sup> on non-aged specimens for steel grades:	Top and bottom, longitudinal	Test temperature, °C			
A, B, A32, A36, A40		+20	0	-20	-
D, D32, D36, D40		0	-20	-40	-
E, E32, E36, E40		0	-20	-40	-60
F32, F36, F40		-20	-40	-60	-80

Type of tests	Position of the samples and direction of the test specimens <sup>1</sup>	Remarks			
		A, B, A32, A36, A40	Top, transverse <sup>4</sup>	+20	0
D, D32, D36, D40	0	-20		-40	-
E, E32, E36, E40	-20	-40		-60	-
F32, F36, F40	-40	-60		-80	-
Impact test <sup>3</sup> on strain aged specimens <sup>5</sup> for steel grades:	Top, longitudinal	Test temperature, °C			
A32, A36, A40		+20	0	-20	-
D, D32, D36, D40		0	-20	-40	-
E, E32, E36, E40		-20	-40	-60	-
F32, F36, F40		-40	-60	-80	-
Chemical analysis <sup>6</sup>	Top	Complete analysis including micro alloying elements			
Sulphur prints	Top	-			
Analysis of microstructure by optical metallgraphy methods	Top	-			
Grain size determination	Top	Only for fine grain steels			
Drop weight tests <sup>4</sup>	Top	Only for steels of grades E, E32, E36, E40, F32, F36, F40			
Through thickness tensile tests	Top and bottom	Only for grades with improved through thickness properties			
<sup>1</sup> For hot-rolled strips — <a href="#">refer to 2.2.2.3.6.2.</a> <sup>2</sup> Longitudinal direction for sections and plates having width less than 600 mm. <sup>3</sup> One set of three V-notch impact specimens is required for each impact test in accordance with 2.2.3.4, Part XIII "Materials" of Rules for the Classification and Construction of Sea-Going Ships. <sup>4</sup> The test is not required for sections and plates having width less than 600 mm. <sup>5</sup> Deformation — 5 % +1 h at 250 °C. <sup>6</sup> Chemical analysis of ladle sample is also required.					

for plates having thickness higher than 40 mm, when the capacity of the available testing machines is insufficient to allow the use of test specimens of full thickness, multiple flat specimens, representing collectively the full thickness, can be used. Alternatively two round specimens with the axes located at one quarter and at mid-thickness can be taken;

for test specimens of full thickness, multiple flat specimens, representing collectively the full thickness, can be used. Alternatively, two round specimens with the axis located at one quarter and at midthickness can be taken;

**.2 impact tests:**

for plates made of hot rolled strip, one additional set of impact specimens shall be taken from the middle of the strip constituting the coil;

for plates having thickness higher than 40 mm, one additional set of impact specimens shall be taken with the axes located at mid-thickness;

when conducting an impact bending test, in addition to the determination of the energy value, required for specimen destruction, also the lateral expansion and the percentage of the tough (brittle) component (crystallinity) shall be reported;

impact test on strain aged specimens, unless otherwise specified, shall be conducted according to 2.2.3.4, Part XIII "Materials" of Rules for the Classification and Construction of Sea-Going Ships. For rolled products having thickness higher than 40 mm, the Register may require to conduct additional tests on specimens taken from the middle of rolled product. Standards of the test results — in accordance with Tables 3.2.2-1 and 3.2.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, depending on the steel grade;

**.3** chemical composition (analyses):

chemical analysis shall be carried out using both the ladle sample and rolled product submitted for testing. The material for rolled product analysis shall be taken from the tensile test specimens. In general, the content of the following elements shall be checked: C, Mn, Si, P, S, Ni, Cr, Mo, Al, N, Nb, V, Cu, As, Sn, Ti and, for steels manufactured from electric and open-hearth furnaces, Sb and;

**.4** sulphur prints:

sulphur prints shall be taken from plate edges, which are perpendicular to the axis of the ingot or slab. These sulphur prints shall be approximately 600 mm long taken from the centre of the edge selected, i.e. on the ingot centreline, and shall include the full plate thickness;

**.5** analysis of microstructure by optical metallographic methods:

the micrographs shall be representative of the full thickness. For thick rolled products in general at least three examinations shall be made at surface, one quarter and mid-thickness of the product;

All photomicrographs shall be taken at  $\times 100$  magnification and where ferrite grain size exceeds the requirements of ASTM 10, additionally at  $\times 500$  magnification. Ferrite grain size shall be determined for each photomicrograph;

The following microstructure parameters shall be determined (the specified criteria are optional):

for normal and higher strength steel with ferritic and pearlitic structure — the ferrite grain size shall not exceed 0,022 mm that being equal to number "8" according to GOST 5639 (refer to Table 1) or an equivalent standard agreed by the Register. Ferritic and pearlitic banded orientation of steel is determined by GOST 5640 or equivalent standard agreed by the Register and shall not exceed two according to scale "3" of the line "A";

higher strength steel with ferritic and bainitic structure - the ferrite grain size shall not exceed 0,015 mm complying with number "9" according to GOST 5639 or an equivalent standard agreed by the Register, thus the anisotropy coefficient of the structure shall not exceed "1"; also the portion and size of bainitic areas of the rake-type morphology shall be determined;

austenite grain size shall not exceed 0,044 mm complying with number "6" according to GOST 5639 or an equivalent standard agreed by the Register.

**.6** drop weight test:

the test shall be performed in accordance with ASTM E208. The nil-ductility test temperature (NDTT) shall be determined and photographs of the tested specimens shall be taken and enclosed with the test report.

The test results shall meet the requirements of 3.2.4, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms;

**.7** through thickness tensile test:

the tests shall be performed in accordance with 2.2.2.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. The test results shall meet the requirements specified for respective steel grades in [3.2](#) of the above-mentioned Part.

**2.2.2.3.6.3** Other tests.

Additional tests, such as CTOD (crack tip opening displacement) test, large scale brittle fracture tests or other tests may be required in the case of newly developed types of steel, outside the scope of 3.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, or when deemed necessary by the Register.

#### **2.2.2.4** Weldability test.

##### **2.2.2.4.1** General.

Tests are required for rolled plates of normal and higher strength steel strength of grades E and F.

The required weldability tests shall be carried out on samples of full thickness plate.

**2.2.2.4.2** Preparation and welding of the test assemblies. In general, welding of two butt weld test assemblies with a heat input approximately 15 kJ/cm and 50 kJ/cm is required.

The butt weld test assemblies shall be prepared with the weld seam transverse to the plate rolling direction, so that impact specimens will result in the longitudinal direction.

The bevel preparation shall be preferably 1/2V or K.

The welding procedure shall be as far as possible in accordance with the normal welding practice used at the shipyards for the type of steel in question.

The welding parameters including grade of welding electrodes and their diameter, pre-heating temperatures, interpass temperatures, heat input, number of passes, etc. shall be reported.

##### **2.2.2.4.3** Type of tests.

From the test assemblies the following test specimens shall be taken:

- .1** one cross weld specimen — for tensile test;
- .2** four sets of specimens, each of three specimens — for impact tests (*KV*).

One set of specimens is with notches located at the fusion line, other two sets — with notches at a distance of 2 mm and 5 mm from the fusion line accordingly, the fourth set — with notches at a minimum distance of 20 mm from the fusion line (refer to Fig. 6.4.5, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships). The fusion boundary shall be identified after etching the specimens with a suitable reagent.

The test temperature shall be the one prescribed for the testing of the steel grade in question;

- .3** specimens for determination of *HV5* hardness across the weldment:

the indentations shall be made along a 1 mm transverse line beneath the plate surface on both the face side and the root side of the weld as follows:

fusion line;

heat affected zone (HAZ): at each 0,7 mm from fusion line into unaffected base metal (6 — 7 minimum measurements for each HAZ).

The maximum hardness value shall not exceed than 350*HV*.

A sketch of the weld joint depicting groove dimensions, number of passes, hardness indentations shall be attached to the test report together with photomicrographs of the weld cross section.

##### **2.2.2.4.4** Other tests.

Additional tests, such as cold cracking tests (controlled thermal severity (CTS) test), CTOD, or other tests may be required in the case of newly developed type of steel outside the scope of 3.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships or in the cases stated in Section 3, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms, or when deemed necessary by the Register.

##### **2.2.2.5** Results.

All the results and testing conditions shall comply with the requirements of the RS rules and shall be evaluated for recognition by the Register: depending on the results (regulated and not regulated by the RS rules), particular limitations or testing conditions shall be specified in the documents submitted for recognition.

Besides, the manufacturer shall collect a set of documents containing all the information required under [2.2.1.2](#), applicable to the semi-finished products subjected to the tests.

The set of documents shall include all the results of tests and analyses, operational records relevant to steel making, casting, rolling, heat treatment or thermo-mechanical treatment of test products. The set of documents may be also requested by the Register for review.

**2.2.2.6 Recognition.**

**2.2.2.6.1 Results of survey.**

Upon satisfactory completion of the survey and tests, the Register will issue the Recognition Certificate for Manufacturer (СПИ).

**2.2.2.6.2 List of recognized manufacturers.**

The manufacturers having the Recognition Certificate for Manufacturer (СПИ) are entered in a list of manufacturers recognized by the Register. The list, besides the names of manufacturers, contains the information on the products manufactured by them and recognized by the Register: grades and/or brands of steel and the main conditions, under which the Register formalized its recognition of the manufacturers.

**2.2.2.6.3 Renewal of recognition.**

Renewal of the Recognition Certificate for Manufacturer (СПИ) can be carried out by an audit and the assessment of the result of satisfactory survey during the period of validity of the existing Certificate.

Where for operational reasons, the renewal audit (renewal of the Recognition Certificate for Manufacturer (СПИ)) falls outside the validity period of recognition, the manufacturer may be considered as recognized by the Register only if agreement to this audit date is made within the original period of recognition validity.

In this instance, if successful, the extension of recognition will be back dated to the original renewal date.

Manufacturers, who have not produced the grades/brands of steel and types of rolled products recognized by the Register during the validity period of the Recognition Certificate for Manufacturer (СПИ), are required to carry out all necessary tests for renewal of the Certificate. The renewal of the recognition for such grades and products (their retention in the Recognition Certificate for Manufacturer (СПИ)) may be performed on the basis of results of production of similar brands of steel and types of rolled products.

**2.2.2.6.4 Reconsideration of recognition.**

Recognition may be reconsidered during the validity period of the Recognition Certificate for Manufacturer (СПИ) in the cases specified in [2.1.4.2](#).

**2.2.3 Procedure for recognition of manufacturers of hull structural steels intended for welding with high heat input.**

**2.2.3.1 General.**

These provisions specify the weldability confirmation scheme of normal and higher strength rolled hull structural steels intended for welding with high heat input over 50 kJ, at the Register recognition of the steel manufacturer in compliance with [2.2.1](#).

The weldability confirmation scheme shall be generally applied by the rolled steel manufacturer's option. On the basis and within the frame of the tests performed, the Register issues the relevant document certifying that the steel has satisfactory weldability for high heat input welding concerned under testing conditions.

The document covers a particular steel mill to manufacture grade of steel to the specific chemical composition range, melting practice, rolling practice, heat treatment and examination for which conformance was established. Scheme stated below does not apply to qualification of welding procedures to be undertaken by the shipyards.

**2.2.3.2 Application. Documentation.**

When applying to the Register, except stated in [2.2.1.2.1](#), the following information shall be submitted:

manufacturing control points to prevent toughness deterioration in heat affected zone when welded with high heat input, relevant to melting, casting, rolling, heat treatment, etc.;  
welding control points to improve joint properties on strength and toughness, if any.

**2.2.3.3 Testing (Confirmation test).**

**2.2.3.3.1 Extent of tests.**

Unless otherwise agreed, extent of testing and respective program for steel grades are specified proceeding from the following provisions:

.1 tests on the lowest and highest toughness levels (proceeding from the impact test parameters and temperatures) cover the intermediate toughness level (e.g. the test results for steel grades PCA36 and PCE36 apply to steel grade PCD36);

.2 tests for normal strength level cover that strength level only;

.3 for high tensile steels, the tests on one strength level cover strength level immediately below;

.4 tests may be carried out separately subject to the same manufacturing process (e.g. differences in melting and/or casting method, and/or rolling, and/or heat treatment);

.5 results of surveys and tests carried out under the technical supervision of another classification society and respective documentation approved by that society may be recognized and approved by the Register without additional testing.

**2.2.3.3.2 Weldability test program.**

The test program shall be drawn up in accordance with 2.2.1.4.3.

However, the test program may be modified proceeding from the local conditions and new tasks. In particular, additional test assemblies or types of tests may be required in the case of newly developed types of steel, welding consumables or welding method, or when deemed necessary by the Register.

The program shall be approved by the Register before the tests are carried out.

**2.2.3.3.3 Requirements for the rolled products to be tested (test plate).**

Test plate (rolled products) shall be manufactured by a process approved by the Register in accordance with the requirements of 2.1.1.4. For each manufacturing process route, two test rolled products shall be selected. The thicker plate ( $t$ ) and thinner plate (less than or equal to  $t/2$ ) shall be proposed by the manufacturer.

Small changes in manufacturing processing (e.g. within the TM process) may be considered for acceptance without testing, at the discretion of the Register.

**2.2.3.3.4 Preparation of test assemblies.**

One butt weld assembly welded with heat input over 50 kJ/cm shall be generally prepared with the weld axis transverse to the plate rolling direction.

Dimensions of the test assembly shall amply sufficient to take all the required test specimens specified in 2.2.1.4.3.

The welding procedures shall be, as far as possible, in accordance with the normal practices applied at shipyards for the test (plate) concerned.

Welding process, welding position, welding consumables (manufacturer, brand, grade, diameter and shield gas) and welding parameters including bevel preparation, heat input, preheating temperatures, interpass temperatures, number of passes, etc. shall be reported.

**2.2.3.3.5 Requirements for tests and examinations.**

Unless otherwise specified, the test assembly shall be examined and tested in accordance with the following:

.1 visual and measurement testing.

Overall welded surface shall be uniform and free from injurious defects such as cracks, undercuts, over-laps, etc.;

.2 macro examination (macroscopic test).

At least one macroscopic photograph shall be representative of transverse section of the welded joint and shall show absence of cracks, lack of penetration, lack of fusion, and other injurious defects;

**.3** micro examination (microscopic test).

Along mid-thickness line across transverse section of the weld, one micrograph shall be taken at each position of the weld metal centreline, fusion line and at a distance 2, 5, 10 and minimum 20 mm from the fusion line. The test results shall be provided for information purpose only;

**.4** hardness test.

Along two lines across transverse weld section 1 mm beneath the plate surface on both face and root side of the weld, indentations by *HV5* shall be made at weld metal centreline, fusion line and each 0,7 mm position from fusion line to unaffected base metal (minimum 6 to 7 measurements for each HAZ).

The maximum hardness value shall not be higher than 350*HV*;

**.5** transverse tensile tests.

At least two transverse (cross weld) tensile specimens shall be taken from the test assembly. Test specimens and testing procedures shall comply with the requirements of [2.2](#) of this Part. The requirements for retesting are set forth in 1.3.2.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The tensile strength shall be not less than the minimum required value for the grade of base metal;

**.6** bend tests.

At least two transverse (cross weld) test specimens shall be taken from the test assembly and bent on a mandrel with diameter of quadruple specimen thickness. Bending angle shall be at least 120°.

For rolled steel (plate) thickness up to 20 mm, one face-bend and one root-bend specimens or two sidebend specimens shall be taken. For rolled steel thickness over 20 mm, two side-bend specimens shall be taken.

After testing, the test specimens shall not reveal any crack nor other open defect in any direction greater than 3 mm;

**.7** impact tests.

Charpy V-notch impact specimens (three specimens for one set) shall be taken within 2 mm below rolled steel (plate) surface on face side of the weld with the notch perpendicular to the plate surface.

One set of specimens transverse to the weld shall be taken with the notch located at the fusion line and at a distance 2, 5 and minimum 20 mm from the fusion line. The fusion boundary shall be identified etching the specimens with a suitable reagent. The test temperature shall be the one prescribed for the testing of the base metal.

For rolled steel (steel plate) with thickness greater than 50 mm or one side welding for plate thickness greater than 20 mm, one additional set of the specimens shall be taken from the root side of the weld with the notch located at each the same position as for the face side.

The average impact energy as a result of the above tests shall comply with Tables 3.2.2-1 and 3.2.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships depending on the steel grade.

At the Register request, additional sets of specimens shall be taken for evaluating the transition temperature curve of absorbed energy and percentage crystallinity. Temperature and the extent of testing are subject to special agreement by the Register.

Tests and test specimen dimensions shall be in compliance with 2.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The requirements for retesting and acceptance criteria are set forth in 1.3.2.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships;

**.8 other tests.**

Additional tests, such as wide-width tensile test, cold cracking tests (CTS, Cruciform, etc.), CTOD or other tests may be required by the Register in the case of newly developed type of steel, when the steel is used in special structures and/or in the event of its intended use in special conditions, etc.

**2.2.3.4 Results.**

The manufacturer shall submit to the Register the complete report including the results and conditions of tests. The report shall contain information on selection of the extent of testing. The Register shall review and evaluate the contents of the test report in accordance with the requirements of this Section and the RS rules in general and decide on the confirmation of weldability.

**2.2.3.5 Recognition.**

**2.2.3.5.1** Where the test results and test report are found to be satisfactory, the Register issues a document (Recognition Certificate for Manufacturer (СПИ)) confirming recognition of the manufacturer of hull structural steel intended for welding with high heat input.

The following information shall be included in the document:

- .1** manufacturer;
- .2** grade designation with notation of heat input (refer to [2.2.3.5.2](#));
- .3** deoxidation practice;
- .4** fine grain practice;
- .5** condition of supply;
- .6** rolled steel (plate) thickness tested;
- .7** welding process;
- .8** welding consumables (manufacturer, brand and grade), if needed;
- .9** actual heat input applied.

**2.2.3.5.2** In the Recognition Certificate for Manufacturer (СПИ), in documentation or on the order, in Quality System Certificates of the manufacturer and at steel branding, the notation indicating the value of heat input applied in the required tests (confirmation test) may be added to the grade designation of the test steel (test plate), e.g. "E36-W300" (in the case of heat input 300 kJ/cm applied). The value of this notation shall be not less than 50 and every 10 added.

**2.2.4 Procedure for recognition of manufacturers of rolled steel for welded chain cable lengths.**

**2.2.4.1 General.**

These provisions specify the procedure for recognition by the Register of the manufacturer of rolled steel (rolled bars) for anchor chain cable lengths.

The recognition procedure forms the basis for the Register verification of the manufacturer's capability to provide satisfactory products stably under effective process and production controls in operation including programmed rolling, and the quality system adopted at the manufacturer's in accordance with the requirements of 3.2.1.3 and 3.2.1.4, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Generally, the recognition of a certain steel grade produced in accordance with the proposed manufacturing process flow chart, means recognition of a certain type of products supplied by the manufacturer and made of this steel grade meeting the requirements of the RS rules.

**2.2.4.2 Application. Documentation.**

Generally, documentation specified in [2.2.1.2.1](#) and [2.2.1.2.2](#) shall be submitted together with the request for recognition.

**2.2.4.3 Testing.**

Extent, approval and performance of tests shall be carried out in accordance with the requirements specified in [2.2.1.3](#).

**2.2.4.3.1 Sampling (Position of the test samples).**

The test samples (refer to 3.6, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going ships) shall be taken, unless otherwise agreed, from the semi-finished product (bar, section) corresponding to the top part of the ingot, or in case of continuous casting, a random sample.

The position of the samples to be taken in the length of the rolled product (top and/or bottom of the piece) are indicated in [Table 2.2.4.3.2](#).

**2.2.4.3.2 Type of tests.**

The tests to be carried out are indicated in [Table 2.2.4.3.2](#).

**2.2.4.3.3** The test results as well as the recognition procedure shall comply with the requirements specified in [2.2.1.5](#) and 2.2.1.6.

**2.2.5 Procedure for recognition of manufacturers of corrosion-resistant (stainless) steels.**

**2.2.5.1 General.**

These provisions specify the procedure for recognition (initial survey) by the Register of the manufacturing process of rolled products, forgings, forged and rolled plates, and stampings of corrosion-resistant (stainless) steel. Procedure for recognition of manufacturer, issue, endorsement and renewal of the Recognition Certificate for Manufacturer (СПИ) is set forth in [2.1](#) of this Part.

Table 2.2.4.3.2<sup>1,2</sup>

Type of tests	Position of the samples and direction of the test specimens	Remarks			
Tensile test	Top and bottom transverse <sup>3</sup>	$R_{eH}$ , $R_m$ , $A_5(\%)$ , $RA(\%)$ shall be reported			
Tensile test (stress relieved) only for TM steels	Top and bottom transverse <sup>3</sup>	Stress relieving at 600 °C (2 min/mm with minimum 1 h)			
Impact test <sup>4</sup> on non-aged specimens for steel grades:		Test temperature, in °C			
1, 2	Top and bottom, longitudinal	+20	0	-20	–
3 and higher		0	-20	-40	–
Impact test <sup>4</sup> on strain aged specimens <sup>5</sup> for steel grades:		Test temperature, °C			
1, 2	Top longitudinal	+20	0	-20	–
3 and higher		0	-20	-40	–
Chemical analysis <sup>6</sup>	Top	Complete analysis including micro alloying elements			
Sulphur prints	Top	–			
Micro examination	Top	–			
Grain size determination	Top	Only for fine-grain steels			
<sup>1</sup> Type, scope and results of testing shall be in compliance with the RS rules requirements and documentation for rolled materials supply.					
<sup>2</sup> In accordance with the RS rules requirements the rolled material mechanical properties shall be identified after the rolled steel heat treatment similar to heat treatment of the chain of relevant grade).					
<sup>3</sup> Longitudinal direction for sections, plates and strip steels having width less than 600 mm.					
<sup>4</sup> One set of three V-notch impact specimens is required for each impact test.					
<sup>5</sup> Deformation — 5 % +1 h at 250 °C.					
<sup>6</sup> Chemical analysis of ladle sample is also required.					

Requirements for corrosion-resistant steels are set forth in 3.16, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.2.5.2** Procedure for recognition of manufacturers of rolled products, forgings, forged and rolled plates, and stampings of corrosion-resistant (stainless) steel.

**2.2.5.2.1** General.

Prior to the commencement of production under the RS technical supervision at the initial survey, the firm (manufacturer) shall prepare and submit documentation containing information on the manufacturing process and stages, at which the relevant process parameters and properties of semi-finished products and finished products are monitored.

**2.2.5.2.2** Application. Documentation.

All the provisions and instructions under [2.2.1](#) and related to the request, the scope and content of the submitted documentation, survey, amount of the metal subjected to the tests, as well as the sampling and test methods are applied to rolled products made of corrosion-resistant steel.

For forgings, forged and rolled plates, as well as stampings of corrosion-resistant (stainless) steel, the provisions and instructions under [2.2.1](#) are also applied.

The manufacturer shall submit together with the request, general information specified in [2.2.1.2.1.1 — 2.2.1.2.1.6](#) and the information relevant to:

- .1** forging and stamping:
  - type of furnace and treatment parameters;
  - capacity of a press/hammer;
  - ratio of ingot/slab/blank to finished product thickness, forging/stamping and finishing temperatures;
  - descaling treatment during forging;
- .2** heat treatment:
  - type of furnaces, heat treatment parameters and their relevant records;
  - accuracy and calibration of temperature control devices;
- .3** programmed forging/stamping:
  - calibration of the control equipment;
- .4** additional information where any part of the manufacturing process is assigned to another production facility or manufacturer (if appropriate).

**2.2.5.2.3** Extent and types of tests.

Unless otherwise specified, test methods and procedures shall comply with the requirements of the agreed national, international standards, RS-agreed documentation, as well as the requirements of 1.3, Section 2 and 3.16, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

As opposed to [2.2.1.3.6.1](#) of this Part, the tests performed at recognition of the manufacturing process and semi-finished product quality shall be comply with [Table 2.2.5.2.3](#).

The test results shall meet the requirements of 3.16, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and/or the standards, specifications agreed by the Register.

At initial survey of the manufacturer, for each mark of steel, each type of semi-finished product, each manufacturing process (steelmaking, casting, rolling: forging and/or stamping, condition of supply), the same semi-finished product from two casts shall in general be selected for the tests. When semi-finished products of different size are produced by one technique, one test product with the maximum thickness (dimension) (the first cast) and one test product with the minimum thickness (dimension) (the second cast) are allowed.

The number of casts and semi-finished products subjected to the tests may be reduced and increased in compliance with the requirements of [2.2.1.3](#).

Table 2.2.5.2.3

Type of tests	Position of the samples and direction of the test specimens	Remarks
Chemical analysis <sup>1</sup>	Top	Bulk analysis, including additions and microalloying elements
Tensile test at room and elevated temperature	Top and bottom, longitudinal <sup>2</sup>	$R_{p0.2}$ , $R_m$ , $A_5(\%)$ , $Z$ shall be reported
Impact test, KV, KCV, for class M-1, MF-2, F-3, AM-4, AF-8, A-9 steels	Top, longitudinal	Test temperature, in °C +20      0
Impact test at negative temperature, KV, KCV, for class:	Top, longitudinal	Test temperature, °C
M-1,		-20
AF-8, A-9		-40
M-1 <sup>3</sup> , AM-4		-60
A-5, A-6 steels		-165
Ultrasonic testing	Over volume	
Macro examination	Top	
Control of non-metallic inclusion content	Top	
Grain size control	Top and bottom	For class F-3, AM-4, A-5, A-6, A-7, AF-8, A-9 steels
Ferritic phase testing	Top	For class A-5, A-6, A-7, A-9 steels
Susceptibility to intergranular corrosion	Top, longitudinal	Except for class M-1 <sup>4</sup> steel
Micro examination	Top and bottom	–
<sup>1</sup> Chemical analysis of ladle sample is also required. <sup>2</sup> Transverse, radial or tangential specimens may be used. <sup>3</sup> For steel mark 07X16H4B only. <sup>4</sup> Steel 07X16H4B is subject to testing.		

The extent of tests shall be, as a rule, agreed at the firm's (manufacturer's) submitting the relevant documentation and shall generally not exceed that specified in 3.16, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, during supervision of manufacturing process.

**2.2.5.2.4 Test program.**

The test program shall be approved by the Register. The test program is developed by the firm (manufacturer) in compliance with 2.2.4.2.3.

When developing the test program, it should be noted that, as opposed to [2.2.1.3.1.3](#) and [2.2.1.3.1.4](#), the recognition for any corrosion-resistant steel mark may also cover recognition for another steel mark of the same alloying system (the same class), provided that the aim analyses, method of manufacture and condition of supply are similar.

Welding procedure and welding consumables used for manufacture of semi-finished products shall be approved by the Register at survey of the manufacturing process.

Weldability tests shall cover all acceptable welding technique, including repair welding. Necessary information on post welding heat treatment shall be submitted. Type and extent of tests, as well as acceptance criteria shall be agreed in each particular case.

**2.2.5.2.5 Sampling (Position of the test samples).**

The test samples shall be taken in compliance with the requirements of 3.16.1.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and/or with the standards agreed by the Register.

When cutting out the specimens from hollow or bored forgings with a wall thickness of up to 100 mm, the specimens shall be cut out at a distance of one half of the forging wall thickness, and with a wall thickness of over 100 mm — at a distance of one third of the forging wall thickness from an outer surface.

When preparing transverse or tangential specimens, their axis shall be at the same distance as for the longitudinal specimens.

Area of cutting out the specimens from non-cylindrical and non-prismatic forgings shall be indicated in the forging drawing.

On agreement between the firm (manufacturer) and the customer cutting out of specimens from the forging surface at the distance not affected by the surface defects or from the forging center is allowed.

Mechanical properties of forgings of "ring" type produced by drawing are defined on tangential specimens.

**2.2.5.2.6 Tests.**

**2.2.5.2.6.1** Mechanical tests shall be performed on semi-finished products after finishing operations, and the test results shall comply with the requirements of the national and international standards and/or the RS-approved documentation and Table 3.16.1.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Mechanical tests are carried out in the presence of the RS representative.

**2.2.5.2.6.2** Chemical analysis.

At initial survey, except ladle analysis, chemical analysis of the manufactured semi-finished product shall be performed. In general, chemical analysis is performed on the tensile tests specimens.

**2.2.5.2.6.3** Tensile test.

At initial survey, the tensile tests shall be performed on the longitudinal and transverse (tangential) specimens taken from both ends of each semi-finished product subjected to tests.

Samples of circular, square and hexagon section steel shall be taken from any end to provide preparation of specimens, which axis is aligned with the rolling direction.

**2.2.5.2.6.4** Impact tests.

At initial recognition, transition temperature curve shall be defined, if possible. The tests shall be performed at five temperatures, generally, with an interval of 20 °C. Test temperatures shall be agreed during development of the test program, depending on the group of steel and application conditions. For impact tests, standard specimens shall be used, if possible.

Samples of circular, square and hexagon section steel shall be taken from any end of the bar to provide preparation of specimens, which axis is aligned with the rolling direction.

**2.2.5.2.6.5** Macro examination.

Macro examination shall be performed on the both ends of the semi-finished product on transverse specimens.

**2.2.5.2.6.6** Grain size control and control of non-metallic inclusion content.

Grain size control for austenitic steels and control of non-metallic inclusion content for all class steels shall be performed on microsections prepared in compliance with the standards.

**2.2.5.2.6.7** Ferritic phase examination.

Ferritic phase examination for austenitic steels shall be performed on at least two specimens prepared from the metal of samples taken during the steel casting.

**2.2.5.2.6.8** Susceptibility to intergranular corrosion.

For intergranular corrosion test of the plate, rolled product and pipe metal, the following specimens shall be prepared:

from austenitic steels — 2 sets of specimens (at least 4 pieces);

from austenitic ferritic steels and steel mark 07X16H4B — 4 sets of specimens (at least 8 pieces), two of which are the check specimens.

For intergranular corrosion tests of the material of forgings of all classes at least 6 specimens shall be prepared, two of which are the check specimens.

Axis of the specimen subjected to intergranular corrosion tests shall be aligned with the rolling direction.

The samples for intergranular corrosion tests shall be taken in compliance with the requirements of the agreed standards.

**2.2.5.2.6.9** Pitting corrosion tests and sulphide stress cracking tests shall be performed on the metal of at least three casts in compliance with the requirements of the standards.

**2.2.5.2.6.10** Additional tests, such as cold cracking tests, etc. may be required by the relevant parts of the RS rules and/or the documentation agreed with the Register.

**2.2.5.3** Procedure for recognition of manufacturers producing pipes of corrosion-resistant (stainless) steel.

**2.2.5.3.1** General.

These provisions cover the pipes manufactured by one of these methods:

pipe is manufactured from a tubular billet by hot forming without welding;

pipe is manufactured from bored, turned hot-formed bare pipes;

pipe is welded with one longitudinal weld without use of adding material like strips.

Prior to the commencement of production under the RS technical supervision, the manufacturer shall prepare and submit documentation containing information on the manufacturing process and stages, at which the relevant process parameters and properties of semi-finished products and finished products are monitored.

**2.2.5.3.2** Application. Documentation.

All the provisions and instructions under [2.2.1](#) and related to the request, the scope and content of submitted documentation, survey, amount of the metal subjected to the tests, as well as the sampling and test methods are applied to pipes made of corrosion-resistant (stainless) steel.

For pipes made of corrosion-resistant (stainless) steel, when applying to the Register, except stated in [2.2.1.2.1](#), the following information shall be submitted together with a request:

procedure for pipe forming;

conditions of alignment and joining for welding (welding procedure and stages, if required by the additional terms of orders);

conditions of final heat treatment;

procedure for cold drawing/calibration/finish rolling carried out during manufacture;

permissible ratios of dimensions;

procedures for dimensions control and tightness tests being carried out during mechanical tests and corrosion resistance tests;

identification and traceability of pipes, method of marking and marking locations;

additional requirements of a customer for pipes depending on operational conditions.

**2.2.5.3.3** Extent and types of tests.

Unless otherwise specified, methods and procedures for testing corrosion-resistant steel pipes shall meet the requirements of the agreed national and international standards, the RS-agreed documentation, as well as the requirements in 1.3, Section 2 and 3.16, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

As opposed to [2.2.1.3.6.1](#) of this Part, the tests performed at recognition of manufacturing process and quality of semi-finished products shall comply with [Table 2.2.5.3.3](#).

The test results shall meet the requirements of 3.16, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and/or standards, specifications agreed by the Register.

Table 2.2.5.3.3

Type of tests	Tests needed <sup>1,2</sup>	Position of the samples and direction of the test specimens	Remarks
Chemical analysis ( <a href="#">refer to 2.2.5.3.5.1</a> )	a/b	From one end	Bulk analysis, including additions and microalloying elements
Tensile test at room temperature and elevated temperature in condition of supply and/or after heat treatment ( <a href="#">refer to 2.2.5.3.5.2</a> )	a/b	From both ends	$R_{p0.2}$ , $R_m$ , $A_5(\%)$ , $Z$ shall be reported
Impact test, KV, KCV, for class M-1, MF-2, F-3, AM-4, AF-8 steels ( <a href="#">refer to 2.2.5.3.5.3</a> )	a/b	From both ends	Test temperature, in °C
			+20                      0
Impact test at negative temperature, KV, KCV, for class:	a/b	From both ends	Recommended minimum test temperature, °C
M-1	a/b		-20
AF-8	a/b		-40
M-1, AM-4	a/b		-60
A-5, A-6 steels ( <a href="#">refer to 2.2.5.3.5.3</a> )	a/b		-165
Weldability test ( <a href="#">refer to 2.2.5.3.5.4</a> )	a		Individual program
Hardness test ( <a href="#">refer to 2.2.5.3.5.5</a> )	a/b	From both ends	
Ultrasonic testing ( <a href="#">refer to 2.2.5.3.5.13</a> )	a/b	Over entire length	
Roughness control ( <a href="#">refer to 2.2.5.3.5.12</a> )	a/b	Over entire length	
Macro examination	a	From one end	
Micro examination ( <a href="#">refer to 2.2.5.3.5.6</a> )	a	From one end	
Control of non-metallic inclusion content ( <a href="#">refer to 2.2.5.3.5.7</a> )	a	From one end	
Grain size control ( <a href="#">refer to 2.2.5.3.5.8</a> )	a/b	From one end	For class F3, AM-4, A-5, A-6, A-7, AF-8 steels
Ferritic phase examination	a/b	From one end	For class A-5, A-6, A-7 steels
Susceptibility to intergranular corrosion ( <a href="#">refer to 2.2.5.3.5.11</a> )	a/b	From one end	Except for class M-1 steel, to be performed for steel 07X16H4B
Flattening and expanding tests ( <a href="#">refer to 2.2.5.3.5.9</a> )	a/b	From one end	
Hydraulic pressure test ( <a href="#">refer to 2.2.5.3.5.10</a> )	a/b	Entire pipe	
<sup>1</sup>	a — at initial approval of the manufacturer.		
<sup>2</sup>	b — during technical supervision of pipe production.		

Tests at initial approval shall be carried out according to the RS-agreed program with due regard to the information given in [2.2.1](#) and [2.2.4.3.3](#) of this Part.

Tests during manufacture of pipes shall be performed in compliance with Table 3.16.4.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and [2.2.4.3.3](#) of this Part.

#### 2.2.5.3.4 Test program.

##### 2.2.5.3.4.1 The test program shall be agreed with the Register.

When developing the test program, it should be noted that, as opposed to [2.2.1.3.1.3](#) and [2.2.1.3.1.4](#), the recognition for any corrosion-resistant steel mark may also cover another steel mark of the same alloying system (the same class), provided that the aim analyses, method of manufacture and condition of supply are similar.

**2.2.5.3.4.2** Tests for recognition of manufacturer shall be performed for each manufacturing process on 10 pipes taken of two batches. If the same manufacturing process is used for pipes of various diameters, the tests may be carried out on pipes of the maximum (first batch) and minimum (second batch) dimensions (diameter, wall thickness).

A batch shall consist of pipes from the same cast, of the same brand, the same temper conditions of heat treatment, of similar diameter and wall thickness.

A batch size shall be, as a rule, agreed at the firm's (manufacturer's) submitting the relevant documentation and shall generally not exceed that specified in 3.16.4, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships during technical supervision of the manufacturing process.

The welding procedure and welding consumables used in pipes manufacture shall be approved by the Register during survey of the manufacturing process, if required.

Weldability tests shall cover all acceptable welding methods, including pipe manufacture, pipeline fitting and repair welding. Pertinent information on post-weld heat treatment shall be provided.

Type, extent of tests and acceptance criteria shall be agreed in each particular case.

**2.2.5.3.4.3** Mechanical tests shall be performed on pipes after heat treatment, drawing and final forming, and shall meet the requirements of the national or international standards and/or the documentation approved by the Register, and/or Table 3.16.4.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Stainless duplex steel pipes shall be tested after solid solution treatment.

**2.2.5.3.4.4** Pipes intended for use in the acid environment shall be additionally tested according to the individual program agreed with the Register.

**2.2.5.3.4.5** At survey and approval of processes of duplex steel pipe manufacture, the Register may require corrosion tests to be performed. The test temperature and acceptance criteria shall be established by agreement, unless otherwise specified.

**2.2.5.3.4.6** Tests with unsatisfactory results.

The provisions below apply both to recognition of pipe production and in the process of pipe manufacture.

In case the tests for recognition of pipe manufacture (initial tests) show unsatisfactory results, the Register may suspend the test performance until submitting the relevant explanations and/or stop the tests unless it is associated with the adverse effect on the test results of such factors as sampling, manufacture and defects of specimens, equipment faults, etc.

If during manufacturing process, the results of even one of the tests are found unsatisfactory, additional tests shall be carried out on the doubled number of pipes from the batch submitted. When the results of one of the additional tests are unsatisfactory, the batch shall be rejected.

In this case, the pipes from the rejected batch may be accepted on the basis of the test results of each pipe among the remained ones in the batch. Where the total number of rejected pipes in a batch exceeds 25 %, the batch shall be also rejected.

In this case, the Register may suspend technical supervision at the pipe manufacturer with regard to the pipes produced according to the same technology as the rejected batch. The firm (manufacturer) shall submit the results of an occurrence review and the Register may require check testing to the extent of the initial tests.

In any case with the unsatisfactory results of any type of tests, their cause shall be identified and corrective actions shall be determined.

Where the adverse effect on the test results of such factors as sampling, manufacture and defects of specimens, equipment faults, etc. is revealed, the equipment and/or specimens may be repaired/replaced by other specimens of the same pipe and the tests shall be repeated.

At the manufacturer's having the Recognition Certificate for Manufacturer (СПИ) during manufacturing process it is allowed upon agreement with the Register to submit, as a new batch, the pipes rejected due to the mechanical characteristics, grain size, intergranular corrosion resistance, provided they are repeatedly heat treated.

#### **2.2.5.3.5 Tests.**

##### **2.2.5.3.5.1 Chemical analysis.**

At initial recognition, in addition to the results of a ladle sample analysis, the chemical analysis for each submitted pipe of a batch shall be carried out.

During technical supervision of the manufacturing process, if specified in the documentation agreed with the Register, steel may be accepted on the basis of the chemical analysis results given in a certificate for tubular billet quality.

The above is referred to the cases when a billet comes to a tube works from the manufacturer recognized by the Register, holding the Recognition Certificate for Manufacturer (СПИ). In other cases, the chemical composition of a metal of one pipe of a batch/cast shall be determined.

##### **2.2.5.3.5.2 Mechanical tests.**

Mechanical tests shall be carried out on the specimens taken from the ends of each pipe subjected to tests. All tests for determination of mechanical properties of pipes under 300 mm in diameter shall be generally carried out on specimens taken parallel to the pipe axis.

Tensile tests shall be carried out on branches, specimens in the form of a segment (rectangular) or round specimens depending on the pipe diameter and wall thickness, the additional terms of an order and the requirements of agreed documentation.

Rectangular specimens shall have a thickness equal to the full thickness of the pipe wall. No flattening of specimens is allowed, but their end parts may be flattened.

At initial approval of the manufacturing process of duplex steel pipes with the design temperature above 20 °C and other steel pipes with the design temperature above 50 °C, their properties at the maximum design temperature shall be determined.

Deviations from the rated value of a yield stress shall be determined.

During technical supervision of the pipe manufacture, the mentioned tests at elevated temperature shall be performed if specified in the documentation recognized by the Register and/or additional terms of an order.

##### **2.2.5.3.5.3 Impact tests.**

At initial recognition, transition temperature curve shall be defined, if possible. The tests shall be performed at five temperatures, generally, with an interval of 20 °C. Test temperatures shall be agreed during development of the test program, depending on the group of steel and application conditions. For impact tests standard specimens shall be used, if possible.

The recommended minimum test temperature for class M1 steel of mark 07X16H4B is — 40 °C.

Where the results of tests previously carried out and acceptable for a given firm (manufacturer) and a given test procedure are submitted, the tests may be carried out at one minimum temperature.

##### **2.2.5.3.5.4 Weldability.**

Weldability tests are carried out at initial recognition in accordance with 2.4, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and [2.2.2.4](#) of this Part.

The weldability tests may be omitted if the relevant results of previous tests are provided.

##### **2.2.5.3.5.5 Hardness test.**

At initial tests, Vickers hardness (*HV10*) shall be generally determined on each pipe submitted. During technical supervision of the manufacturing process, hardness shall be determined in compliance with the requirements of documentation recognized by the Register and/or additional terms of an order.

**2.2.5.3.5.6 Metallographic examination.** Metallographic examination of duplex steels shall be performed after solid solution treatment. Following the latter, the absence of forming carbides, nitrides and non-metallic inclusions at grain boundaries shall be ensured. The ferrite

content shall be determined (35 — 55 %). In any case, examination shall be carried out at ×400 magnification as a minimum.

**2.2.5.3.5.7** Control of non-metallic inclusion content. At initial tests, control of non-metallic inclusion content shall be performed on one pipe from a batch. The latter shall include pipes of one standard size and one cast. During technical supervision of the manufacturing process, control of non-metallic inclusion content shall be carried out in accordance with the requirements of documentation recognized by the Register and/or additional terms of an order.

Control of non-metallic inclusion content, as well as titanium nitrides and carbonitrides content for pipes having a wall thickness under 6 mm may be carried out on rerolling pipes with wall thickness of 6 mm and above.

**2.2.5.3.5.8** Grain size control.

At initial tests, grain size control shall be performed on one pipe from a batch using a metallographic method if the latter is applied in the manufacturing process. Where an ultrasonic method is used, both methods shall be applied at the initial tests.

During technical supervision of the manufacturing process, grain size control shall be performed in compliance with the requirements of documentation recognized by the Register and/or additional terms of an order.

**2.2.5.3.5.9** Flattening and expanding tests. Flattening and expanding tests shall be performed on one pipe from the batch submitted in compliance with the requirements of documentation recognized by the Register and/or additional terms of an order.

**2.2.5.3.5.10** Hydraulic pressure test.

Hydraulic pressure tests shall be performed in compliance with the requirements of documentation recognized by the Register and/or additional terms of an order. Pipes shall be kept under pressure for at least 10 s.

**2.2.5.3.5.11** Intergranular corrosion test, bitergranular corrosion tests shall be performed in compliance with the requirements of documentation recognized by the Register and/or additional terms of an order.

**2.2.5.3.5.12** Roughness control.

Roughness control shall be performed in compliance with the requirements of documentation recognized by the Register and, unless otherwise specified, by a visual comparison with a reference standard.

**2.2.5.3.5.13** Ultrasonic testing.

Unless otherwise specified, ultrasonic testing shall be performed in compliance with the requirements of documentation recognized by the Register.

At initial recognition, ultrasonic testing shall be performed on each pipe subjected to testing.

**2.2.5.3.5.14** Additional tests, such as cold cracking tests, CTOD, etc. may be required by the relevant parts of the RS rules and/or the documentation agreed with the Register.

**2.2.6 Procedure for recognition of manufacturers of wrought aluminium alloys.**

**2.2.6.1** General.

These provisions specify the procedure for recognition (initial survey) by the Register of the manufacturing process of rolled products (plates, strips and sheets) and pressed sections (full sections, hollow sections, panels, angles, bars, etc.) of wrought aluminium alloys. The procedure for recognition of manufacturer, issue, endorsement and renewal of the Recognition Certificate for Manufacturer (СПИ) is specified in [2.1](#) of this Part.

The requirements for wrought aluminium alloys are set forth in 5.1, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.2.6.2** The procedure for recognition of manufacturers of rolled products and pressed semi-finished products of wrought aluminium alloys.

**2.2.6.2.1 General.**

Prior to the commencement of production under the RS technical supervision at the initial survey, the firm (manufacturer) shall prepare and submit documentation containing information on the manufacturing process and stages at which the relevant process parameters and properties of semi-finished products and finished products are monitored.

**2.2.6.2.2 Application. Documentation.**

All the provisions and instructions under [2.2.1](#) and related to the request, the scope and content of the submitted documentation, survey, amount of metal to be subjected to the tests, as well as the sampling and test methods are applied to semi-finished products made of wrought aluminium alloys.

**2.2.6.2.3 Extent and types of tests.**

Unless otherwise specified, test methods and procedures shall comply with the RS-agreed documentation, the requirements of national, international standards, application of which is agreed with the Register, as well as the requirements of 1.3, Section 2 and 5.1, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Test results shall meet the requirements of 5.1, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and/or national, international standards, the application of which is agreed with the Register, the RS-approved specifications.

**2.2.6.2.3.1 Selection of the test product (metal) for initial tests.**

The extent of tests to be conducted at initial survey is determined by the RS-approved test program which shall be developed by the manufacturer of semi-finished products of wrought aluminium alloys. The purpose of these tests is to confirm compliance of the product properties and quality with the documentation submitted by the firm (manufacturer).

For each alloy submitted for testing and for each manufacturing process (e.g. chemical composition making, casting), one semi-finished product with the maximum thickness and one semi-finished product with the minimum thickness shall in general be selected for the tests.

In addition, the Register may require selection of semi-finished products of average thickness for the tests.

The selection of the casts for the semi-finished product shall be based on the typical chemical composition and alloying additions.

The dimensions of the semi-finished products submitted for testing shall be consistent with those of semi-finished products in supplies expected (at least one of semi-finished products shall have maximum width, thickness and diameter).

Tests shall be carried out on a control batch of semi-finished products of wrought aluminium alloys.

The batch shall consist of semi-finished products of the same alloy grade (from the same cast), the same product form and similar dimensions (for plates, the same thickness), the same temper condition and manufactured by the same process.

For each process stated, two semi-finished products of a batch shall be submitted for testing.

Each semi-finished product of the control batch shall be subjected to visual and measurement and ultrasonic testing to determine layer discontinuity zone.

Simultaneously with the test program, recommendations for welding of semi-finished products of wrought aluminium alloys shall be submitted to the Register.

The number of casts and semi-finished products subjected to testing may be reduced or increased in compliance with the requirements of [2.2.1.3](#).

**2.2.6.2.4 Test program.**

The test program shall be agreed with the Register and developed by the firm (manufacturer) in compliance with the requirements of [2.2.6.2.3](#).

Welding procedure and welding consumables used for manufacture of semi-finished products shall be approved by the Register at survey of the manufacturer. Type and extent of tests, as well as acceptance criteria shall be agreed in each particular case.

Necessary information on post-weld heat treatment shall be provided.

**2.2.6.2.5** Sampling (Position of the test samples).

The test samples shall be taken in compliance with the requirements of 5.1.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and/or in accordance with the documentation agreed with the Register, national, international standards the application of which is agreed with the Register.

**2.2.6.2.6** Tests.

**2.2.6.2.6.1** Chemical analysis.

At initial survey, except ladle analysis, chemical analysis of the manufactured semi-finished products shall be performed. In general, chemical analysis is performed on the tensile test specimens. The test results shall comply with the requirements of national or international standards and/or documentation approved by the Register and Table 5.1.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. The tests shall be carried out in the presence of the RS representative

**2.2.6.2.6.2** Mechanical tests shall be performed on semi-finished products upon completion of finishing operations, and the test results shall comply with the requirements of national and international standards and/or documentation approved by the Register and Tables 5.1.3-1 and 5.1.3-2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. The tests shall be carried out in the presence of the RS representative.

**2.2.6.2.6.2.1** Tensile tests.

At initial survey, the tensile tests shall be performed on the specimens taken from both ends of each semi-finished product subjected to tests in accordance with 5.1.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Mechanical properties of wrought aluminium alloys in the annealed condition tested at room temperature shall comply with the RS requirements (refer to Table 5.1.3-1, Part XIII "Materials" of the Rules for the Classification and Construction of Seas-Going Ships) and the appropriate normative documentation.

Parameters to be specified for various categories of wrought aluminium alloys are mechanical properties of material determined at room temperature such as the minimum value for yield stress (proof stress)  $R_{p0,2}$ , minimum value for tensile strength  $R_m$ , reduction in area  $Z$  and relative elongation  $A$ .

**2.2.6.2.6.3** Corrosion testing.

Corrosion testing shall be carried out in compliance with the requirements of 5.1.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, rolled alloys shall be corrosion tested in the marine medium with respect to exfoliation and intergranular corrosion resistance in accordance with ASTM G66 and ASTM G67 or other national standards (GOST 9.021 and GOST 9.904).

During the initial survey of the firm for the purpose of its recognition, the photomicrographs taken at  $\times 500$  magnification shall be presented to exhibit no evidence of exfoliation corrosion and pitting. Assessment criteria for results of corrosion tests shall comply with the requirements of 5.1.8, Part XIII "Materials" of the Rules for the Classification and Construction of Seas-Going Ships.

**2.2.6.2.6.4** Weldability tests.

As a rule, weldability tests shall be carried out for wrought aluminium alloys, the chemical composition, mechanical properties or delivery condition of which do not comply with the requirements of Chapter 5.1, Part XIII "Materials" of the Rules for the Classification and

Construction of Sea-Going Ships; however, for recognition of manufacturer of strain-strength and heat-treated alloys of all categories and grades it shall be proved that mechanical properties of the base metal of welded joint are higher than the similar characteristics of the weld (refer to Table 4.9.3.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships). Preparation of test assemblies of welded joints, selection of filler metal, type of joint, welding position and testing of welded joints of semi-finished products from wrought aluminium alloys shall be carried out in compliance with requirements of 2.2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships and Section 7 of this Part.

**2.2.6.2.6.4.1** Extent and testing procedure.

Type, extent of tests and assessment criteria shall be agreed in each particular case.

Weldability assessment of semi-finished products of wrought aluminium alloys shall consist of testing at room temperature of butt joints of semi-finished products submitted at least for tensile test (minimum two tensile test specimens), bend test (minimum two root bend and face bend test specimens), macro examination (one macrosection).

Tensile and bend tests are conducted on the specimens cut out transverse to the welding joint.

Impact tests of specimens from welded joints of aluminium alloys are not required.

Tensile and bend tests of welded specimens at room temperature shall be conducted to determine the following parameters:

minimum value for tensile strength ( $R_m$ , min);

bending angle of welded specimen on a mandrel with specified diameter.

Mechanical properties of welded joints shall meet the requirements of Table 4.9.3.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

## **2.3 LIST OF RECOGNIZED MANUFACTURERS OF MATERIALS**

**2.3.1** Manufacturers and products they supply which meet the RS rules requirements are entered in the List of Approved (Recognized) Materials and Manufacturers.

The List of Materials is available in an electronic form on the Register official site and on the site for personnel updated daily.

Recognition Certificate for Manufacturer (СПИ) confirms presence in the relevant List of Materials of a specific manufacturer and the product to be supervised by the Register, it supplies ([refer to 2.1](#)).

**2.3.2** The List of Materials is primarily published with the aim to provide information on the suppliers of materials and products meeting the RS rules requirements.

The Register is interested in presenting such information to designers, builders and other firms and manufacturers needing it.

It is supposed that preparing orders for materials to be supervised during their manufacture, a consumer, guided by financial interests at least, is forced to take into account the technical capabilities of material suppliers enjoying the Register confirmation.

**2.3.3** The List of Materials updated by the Register shall contain the following data:

name of a manufacturer;

location of a manufacturer (postal address, telephone, fax, e-mail);

product type and name;

material grade and brand.

Other information related to tests, technology, equipments, etc. is strictly confidential and may be provided only if agreed with the manufacturer.

**2.3.4** Retaining and updating of information in the List of Materials is carried out by the RHO on the basis of data on issue, endorsement, renewal and invalidation of the Recognition Certificates for Manufacturer incoming from the RS Branch Offices issuing these Certificates

Where, due to technological reasons, the Certificate cannot be endorsed/renewed by due date, in order to retain the manufacturer in the List of Materials, the manufacturer shall agree the new date of endorsement/renewal with the RS Branch Office, which issued the Certificate, during the document validity period, i.e. before the renewal date set. The RS Branch Office reports the new date of endorsement/renewal to the RHO IT Research and Development Department (the Notice with the new of endorsement/reissue shall be forwarded).

In the List of Materials a new date of endorsement/renewal is specified. Period of the Certificate validity is not interrupted, and the date of the next endorsement/renewal remains unchanged.

Within 30 days after the endorsement/renewal date set, if RHO is not informed of the decision made by the RS Branch Office, the notice "Not confirmed" is retained alongside the document in the electronic version of the List of Materials, and after 30 days, the manufacturer is excluded from that List.

**2.3.5** Concurrent with the List of Materials, databases for each of the manufacturers at which the Register ever carried out supervision are compiled in RHO.

**2.3.6** If Recognition Certificate for Manufacturer (СПИ) becomes invalid, the manufacturer may be excluded from the List of Materials.

**2.3.7** Manufacturer exclusion from the List of Materials is executed only by the RHO decision based on the relevant statement of the location carrying out supervision at the manufacturer's.

## **2.4 ACCEPTANCE OF MATERIALS**

### **2.4.1 General.**

**2.4.1.1** Materials subject to the RS technical supervision during their manufacture in accordance with 3.2, 3.4 — 3.15, 3.18 — 3.19 and Sections 4, 5, 7, 8 and 11, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships are supplied by manufacturers having the Recognition Certificate for Manufacturer (СПИ) ([refer to 1.3.1](#) and [2.1](#) of this Part of the Rules) together with the RS Certificates of Conformity (C or C3) (forms 6.5.30 or 6.5.31 accordingly) or endorsed Manufacturer's Certificates in accordance with [2.4.1.5](#).

**2.4.1.1.1** Material shall simultaneously comply with the appropriate requirements of the RS rules and regulating documentation: agreed national and international standards, approved specifications or other technical documentation to be complied with in supply performance. In case of discrepancies between the requirements of the rules and regulating documentation, the evaluation shall be made based on the most stringent requirements.

In case the national and international standards, specifications or other technical documentation differing from those agreed earlier are specified in the contract (order), the technical supervision of material may be performed after review of the new requirements comparing them with the previously agreed ones. Where discrepancies in the requirements are detected and they affect the terms of issuing the Recognition Certificate for Manufacturer (СПИ), the scope of application of the valid Recognition Certificate for Manufacturer (СПИ) shall be amended.

**2.4.1.1.2** The Register may perform technical supervision during the manufacture and approve the use of materials specified in [2.4.1.1](#), but supplied by the manufacturer having no valid Recognition Certificate for Manufacturer (СПИ) of these materials, provided that:

the manufacturer submits to the Register a request for issue/extension of the scope of application of the Recognition Certificate for Manufacturer and technical supervision during manufacture of material according to the scope of supply;

together with the request, the documentation specified in the delivery contract (order) is submitted for the agreement. This documentation (standard, specification, special requirements, order, etc.) shall be reviewed as specified in [2.4.1.1.1](#);

scope of requirements for the products and the manufacturer all be equal to that for the initial survey;

tests are performed on metal of supply and their results fully meet the requirements of the RS rules and documentation in compliance with [2.4.1.1.1](#) for the particular conditions of supply;

drawing up the C/C3 and supply are performed after or simultaneously with issuing the Recognition Certificate for Manufacturer (СПИ).

As an alternative, considering the provisions of [2.4.1.1.3](#) and [2.4.1.1.4](#), the RS Branch Office may decide to perform technical supervision of material on the particular contract (order).

**2.4.1.1.3** The Register may perform technical supervision during manufacture of rolled steel product batch without the Recognition Certificate for Manufacturer (СПИ) validity range extension, if the manufacturer has valid СПИ for the respective steel grade of smaller thickness. At that, rolled steel product thickness shall not exceed the recognized one by more than 15 %. A decision on the possibility of carrying out such technical supervision shall be taken considering the following:

**.1** the scope of tests and their criteria shall be agreed upon with the Register before the tests are carried out;

**.2** the authorized RS Branch Office shall be provided with complete information, confirming the firm's ability to execute the respective order. The test results of the previously supplied rolled products of the required thickness of equivalent brands shall be submitted (Manufacturer's Certificates and/or test results forms);

**.3** welding procedure shall comply with the previously approved one, including rolling and heat treatment;

**.4** amount of the supplied material shall be limited to the same steel cast;

**.5** scope of application shall be specified (order, project number, etc.).

**2.4.1.1.4** The Register may perform technical supervision during manufacture and approve the use of materials specified in [2.4.1.1](#) (except of rolled steel product) but supplied by a manufacturer having no valid Recognition Certificate for Manufacturer (СПИ). The decision on the possibility of carrying out such technical supervision shall be taken considering the following:

the RS Branch Office shall be provided with necessary information, confirming the firm's (manufacturer's) ability to execute the respective order;

volume of the order shall be limited;

the scope of tests and their criteria shall be agreed upon with the Register before the tests are carried out.

The information on the firm (manufacturer) ability to execute the respective order may be based on the following:

the manufacturer had a Recognition Certificate for Manufacturer (СПИ) which was not renewed due to absence of orders;

the manufacturer has valid Recognition Certificate for Manufacturer (СПИ) but not for the products under consideration (a variant of extension of the Certificate scope of application);

the manufacturer has an approval of other classification societies for manufacture of the products under consideration or similar ones;

the firm is a manufacturer of the required or similar products having at least 5-year experience of manufacture.

**2.4.1.2** In case of single-item production, materials subject to RS technical supervision during their manufacture and regulated by chapters and sections of the Rules not stated in [2.4.1.1](#), as well as cast iron manufactured in compliance with 3.9 — 3.11, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships may be supplied by the manufacturers both having or not having the Recognition

Certificate for Manufacturer. In the second case, the said materials shall be supplied with the RS Certificates of Conformity (C) (form 6.5.30).

**2.4.1.2.1** The requirements given in [2.4.1.1.1](#) shall be met.

**2.4.1.2.2** The Register may perform technical supervision during the manufacture and approve the use of materials specified in [2.4.1.2](#) provided that:

the manufacturer submits to the Register a request for technical supervision during manufacture of material as per the scope of supply. Together with the request, the documentation (standard, specification, special requirements, order, etc.) for supply of material shall be submitted for approval/agreement. This documentation shall be reviewed considering the requirements stated in [2.4.1.1.1](#) and the following:

scope of supervision shall be limited by one supply order;

scope and criteria of product survey are based on the requirements of the regulating Rules.

**2.4.1.2.3** If the manufacturer of materials has RS СПИ, the supply of materials may be performed together with the Certificates of Conformity (C or C3) (forms 6.5.30 or 6.5.31 accordingly) or with the endorsed Manufacturer's Certificates in accordance with [2.4.1.5](#).

**2.4.1.3** Materials not mentioned in [2.4.1.1](#) and [2.4.1.2](#), but applied in the items of technical supervision of the Register (products, arrangements, equipment, etc.) and subject to supervision according to the approved technical documentation shall be supplied to such items with the RS Certificates of Conformity (C, form 6.5.30).

**2.4.1.3.1** Material shall meet the requirements of the regulating documentation:

standards (national, international), technical specifications or other regulating documents specified in the approved technical documentation (product drawings, specifications, etc.) for the item of application.

**2.4.1.3.2** Materials shall be tested under the RS technical supervision according to the RS-approved program in compliance with the standards (national, international) and other normative documents applicable to the product to be tested. Methods and scope of testing, sampling and sample preparation shall meet the requirements of Section 2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, where applicable.

**2.4.1.3.3** The Register may perform survey of materials provided the following conditions are met:

the applicant submits to RS a request for survey of material. Together with the request, the documentation stated in [2.4.1.3.1](#) and [2.4.1.3.2](#) shall also be submitted;

RS Certificates of Conformity are issued upon receiving the satisfactory test results.

**2.4.1.4** During the technical supervision, the additional requirements may be issued by the Register for verifying the properties of the manufactured products, as applicable. The additional requirements may be issued based on the reasons given in [2.1.4.2](#). Moreover,

change of tests scope and/or types of tests may be demanded when the results of tests correspond to the limit ones (within the area of a tests error).

**2.4.1.5** Materials may be supplied by a recognized manufacturer having the CKK1 Certificate for the respective products with the Manufacturer's Certificates endorsed by the Register. In this case the Manufacturer's Certificate shall be of 3.2 type and shall comply with the requirements of EN 10204:2004; the information issued in the Certificate shall be agreed with the Register in advance.

**2.4.2 Documentation.**

The above RS documents shall be mandatorily supplemented with the manufacturer's certificates. The test results shall be specified in the certificates and/or the attached test reports. The numbers of the attached reports and manufacturer's certificates shall be indicated in the RS Certificate of Conformity.

The content of the manufacturer's certificates shall meet the requirements given in the procurement documents and RS-agreed documentation and shall enable to identify the products supplied. The Certificate of Conformity shall contain at least the following:

- order number;
- manufacturer and customer requisites;
- general information of semi-finished products such as: weight, brand and grade of the material, the numbers of the firm's certificates/reports;
- approved technical documentation, in compliance with which the RS acceptance is performed (in case of [2.4.1.3](#)).

**2.4.3 Marking.**

General provisions on marking of the materials are given in 1.4.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. Peculiarities of marking may also be specified in the appropriate chapters of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships containing the requirements for steel, cast iron, copper and light alloys. Marking shall comply with the effective standards. List of products subject to stamping shall be determined in accordance with the RS Nomenclature.

When semi-finished products are packed in bundles, the manufacturer shall confirm the identification system of every semi-finished product in a bundle, at that putting to put the RS stamp or brand on labels is permitted. When using labels of waterproof film, an imprint of the RS stamp or brand shall be put on the solid surface of these labels.

## **2.5 NON-DESTRUCTIVE TESTING OF STEEL FORGINGS AND CASTINGS OF HULL STRUCTURAL MEMBERS AND MACHINERY COMPONENTS**

### **2.5.1 Non-destructive testing of steel forgings.**

#### **2.5.1.1 General.**

**2.5.1.1.1** These requirements shall be mandatorily fulfilled in cases provided by other parts of the Rules. They may complement the requirements for steel forgings specified in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships as well as other parts of the RS Rules. General guidance for the non-destructive testing (NDT) methods, the extent of testing and the minimum recommended quality levels to be complied with unless otherwise agreed with the Register is introduced herewith. These requirements may be also applied to the testing of austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings.

**2.5.1.1.2** These requirements apply to for surface inspections by visual and measurement testing, magnetic particle testing and penetrant testing and volumetric inspection by ultrasonic testing.

**2.5.1.1.3** Requirements of this Chapter also cover steel forgings (e.g. components for couplings, gears, boilers and pressure vessels) other than those specified herein, considering their materials, kinds, shapes and stress conditions of operation.

**2.5.1.1.4** Forgings shall be subject to non-destructive testing in the final delivery condition. For specific requirements refer to [2.5.1.2.5.2](#) and [2.5.1.3.4.2](#).

**2.5.1.1.5** Where intermediate inspections have been performed, the manufacturer shall provide reports of the results upon the request of the RS representative.

**2.5.1.1.6** Where a forging is supplied in semi-finished condition, the manufacturer shall take into consideration the quality level of final finished machined components.

**2.5.1.1.7** Where advanced ultrasonic testing methods are applied, (e.g. phased array ultrasonic testing (PAUT) or time of flight diffraction (TOFD)), relevant requirements of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. Herewith shall be complied with, the acceptance levels regarding acceptance/rejection criteria shall comply with the stated below.

**2.5.1.1.8** Personnel carrying out NDT shall be certified to a national or international certification scheme, e.g. ISO 9712:2012 and personnel qualification shall be certified by an employer-based qualification scheme such as SNT-TC-1A, 2016 or ANSI/ASNT CP-189, 2016. The procedure in the employer-based schemes applied for personnel qualification may be accepted upon agreement with the Register. Certification procedure shall comply with the requirements of ISO 9712 apart from the impartiality requirements of a certification body.

**2.5.1.1.9** The NDT personnel's certificates and competence shall comprise all industrial sectors and techniques being applied by the manufacturer or its subcontractors.

**2.5.1.1.10** Personnel's certificates shall be made available to the Register for verification, when requested.

**2.5.1.1.11** Procedures shall be approved by Level 3 personnel for the appropriate NDT method.

**2.5.1.1.12** The operators carrying out NDT and interpreting indications, shall as a minimum, be qualified and certified to Level 2 in NDT methods concerned.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at Level 1.

The operator shall have knowledge of materials, weld, structures or components, NDT equipment and limitations that is sufficient to apply relevant NDT method for each application appropriately.

**2.5.1.2** Surface inspection.

**2.5.1.2.1** General.

**2.5.1.2.1.1** Surface inspection of steel forgings shall be carried out by visual and measurement testing, magnetic particle testing or penetrant testing, for the purpose of detecting defects and assessing them against acceptance/rejection criteria stated below. Personnel engaged in visual and measurement testing shall have sufficient knowledge and experience, however, may be exempted from formal qualification requirements specified herein.

**2.5.1.2.1.2** The testing procedures, apparatus and conditions of magnetic particle testing and penetrant testing shall comply with agreed national or international standards.

**2.5.1.2.1.3** Other surface inspection methods e.g. eddy current testing, may be required by the Register as a supplementary method, to confirm the presence of indications, or for detecting the presence of undocumented weld repairs. The criteria of this inspection shall be agreed with the Register in advance.

**2.5.1.2.2** Items of testing.

**2.5.1.2.2.1** The steel forgings specified in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships shall be subjected to a 100 % visual and measurement testing of all accessible surfaces by the manufacturer. The results shall be made available to the RS surveyor upon request. For mass produced forgings the extent of examination shall be agreed with the Register in advance.

**2.5.1.2.2.2** Forgings application of which is not specified herein or in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, but which are used for manufacture of the RS items shall be subjected to non-destructive testing in accordance with the extent, procedures and criteria of agreed national and international standards.

**2.5.1.2.2.3** Austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings acceptance criteria details are specified below. However, other acceptance criteria set by national or international standards may be applied, upon agreement with the Register.

**2.5.1.2.2.4** Where national and international standards in accordance with [2.5.1.2.2.2](#) and [2.5.1.2.2.3](#) are applied, the quality level shall provide reasonable equivalence to the allowable criteria stated in [2.5.1.2.6](#). As a rule, the quality level shall comply with more stringent requirements than specified in [2.5.1.2.6](#).

**2.5.1.2.2.5** Surface inspections by magnetic particle and/or penetrant methods generally apply to the following steel forgings:

- .1 all crankshafts;
- .2 propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 100 mm;
- .3 cylinder heads, connecting rods, piston rods and crossheads, as per the engine type and size requirements in accordance with Appendix 8, Part IV "Technical Supervision during Manufacture of Products";
- .4 bolts with minimum diameter not less than 50 mm, which are subjected to dynamic stresses such as cylinder cover bolts, coupling bolts for crankshafts, tie rods, crankpin bolts, main bearing bolts;
- .5 propeller blade fastening bolts which are subjected to dynamic stresses.

**2.5.1.2.3** Zones for surface inspections.

Magnetic particle, or where permitted penetrant testing, shall be carried out in Zones I, II and III (as applicable), as indicated in [Figs 2.5.1.2.5.1-1 — 2.5.1.2.5.1-4](#).

**2.5.1.2.4** Surface condition.

The surfaces of forgings to be examined shall be free from scale, dirt, grease or paint.

**2.5.1.2.5** Surface inspection.

**2.5.1.2.5.1** Where indicated by [Figs 2.5.1.2.5.1-1 — 2.5.1.2.5.1-4](#), magnetic particle testing shall be carried out with the following exceptions, when penetrant testing shall be permitted:

- austenitic and ferritic-austenitic (duplex) stainless steels;
- interpretation of open visual or magnetic particle indications,
- at the instruction of the RS surveyor.

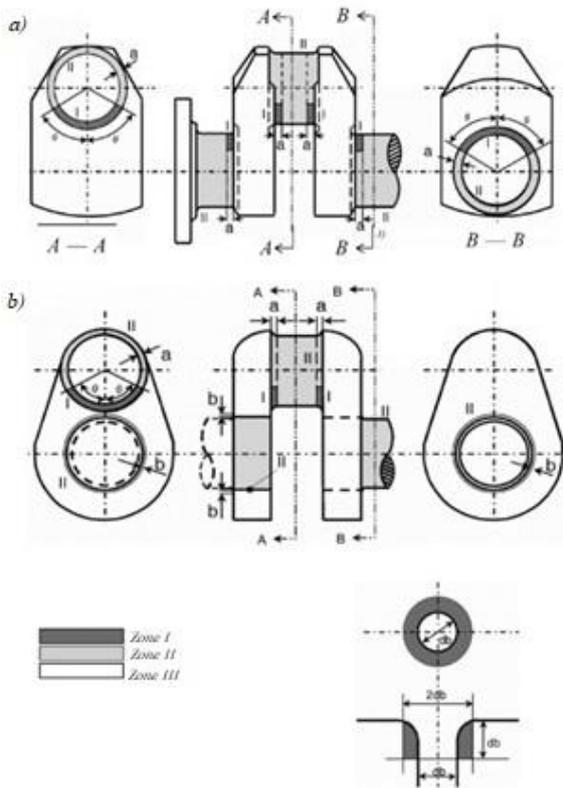


Fig. 2.5.1.2.5.1-1  
Zone for magnetic particle/penetrant testing  
on crankshaft:  
a — solid crankshaft; b — semi built-up crankshaft

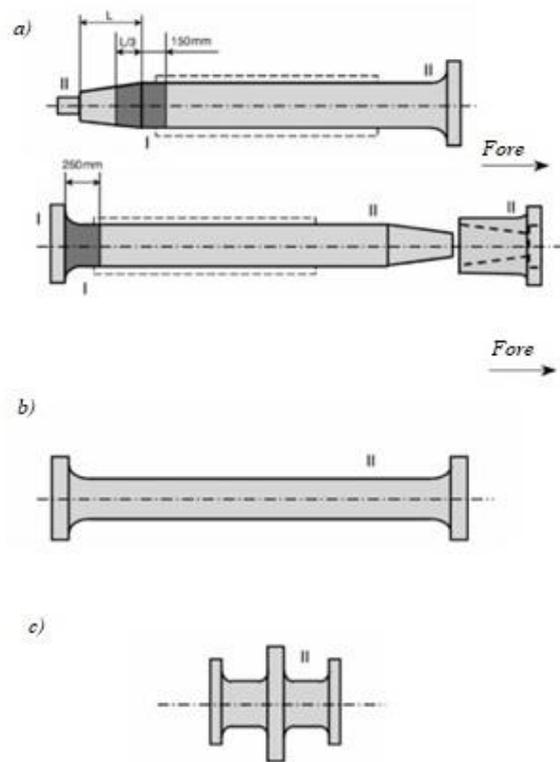


Fig. 2.5.1.2.5.1-2  
Zone for magnetic particle/penetrant testing on shafts:  
a — propeller shaft; b — intermediate shaft;  
c — thrust shaft

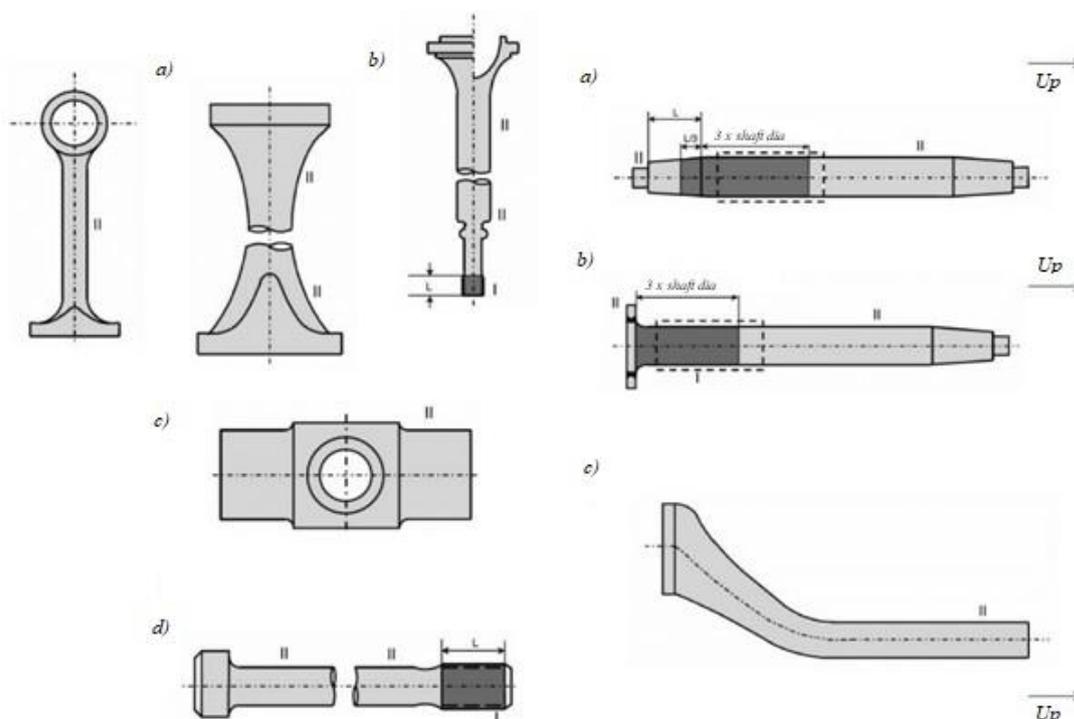


Fig. 2.5.1.2.5.1-3

Zone for magnetic particle/penetrant testing on machinery components:

a — connecting rod; b — piston rod; c — crosshead; d — bolt

Notes: 1. Threads, holes and their circumstances shall be treated as Zone I.

2.  $L$  is the length of thread.

Fig. 2.5.1.2.5.1-4

Zone for magnetic particle/penetrant testing on rudder stocks:

a — Type A, b — Type B, c — Type C

Notes: 1. Welded areas shall be treated as Zone I.

2.  $L$  is the length of tapered portion.

**2.5.1.2.5.2** Unless otherwise detailed in the specification, the magnetic particle test shall be performed on a forging in the final machined surface condition and final thermally treated condition.

**2.5.1.2.5.3** Unless otherwise agreed, the surface crack detection shall be carried out in the presence of the RS surveyor. The surface crack detection shall be carried out before the shrink fitting, where applicable.

**2.5.1.2.5.4** For magnetic particle testing, attention shall be paid to the contact between the forging and the clamping devices of stationary magnetization benches in order to avoid local overheating or burning damage in its surface. Prods shall not be permitted on finished machined items.

**2.5.1.2.5.5** When indications are detected as a result of the surface crack detection, acceptance or rejection shall be decided in accordance with [2.5.1.2.6](#).

**2.5.1.2.6** Acceptance criteria and rectification of defects.

**2.5.1.2.6.1** Acceptance criteria for visual and measurement testing.

**2.5.1.2.6.1.1** All forgings shall be free of cracks, crack-like indications, laps, seams, folds, or other detrimental indications. At the request of the RS surveyor, additional magnetic particle, penetrant and ultrasonic testing may be required for a more detailed evaluation of surface irregularities.

**2.5.1.2.6.1.2** The bores of hollow propeller shafts shall be visually tested and measured from both ends of the shaft.

**2.5.1.2.6.2** Acceptance criteria for magnetic particle testing and penetrant testing.

**2.5.1.2.6.2.1** Indications or defects detected during surface inspection are defined as follows:

**Linear indication** is an indication with a largest dimension three or more times its smallest dimension (i.e.  $l \geq 3w$ ).

**Nonlinear indication** is an indication with a largest dimension less than three times its smallest dimension (i.e.  $l < 3w$ ).

**Aligned indication** is a unique indication. The aligned indication may have the following structure:

three or more non-linear or aligned indications aligned with the distance between indications less than 2 mm. This indication is considered to be a unique indication and its length is equal to the overall length of the alignment;

linear indications aligned with the distance between two indications smaller than the length of the longest indication.

**Open indication** is an indication visible after removal of the magnetic particles or that can be detected by the use of penetrant testing.

**Non-open indication** is an indication that is not visually detectable after removal of the magnetic particles or that cannot be detected by the use of penetrant testing.

**Relevant indication** is an indication that is caused by a condition or type of discontinuity that requires evaluation. Only indications which have any dimension greater than 1,5 mm shall be considered relevant for the categorization of indications.

**2.5.1.2.6.2.2** For the purpose of evaluating indications, the surface shall be divided into reference areas of 225 cm<sup>2</sup>. The area shall be taken in the most unfavourable location relative to the indication being evaluated, i.e. the shape and dimensions of each reference area are chosen so that they cover the maximum number of defects (discontinuities) without their distribution to an adjacent reference area.

**2.5.1.2.6.2.3** For crankshaft forgings, the allowable number and size of indications in the reference area is given in [Table 2.5.1.2.6.2.3-1](#), and for other forgings, in [Table 2.5.1.2.6.2.3-2](#) (including austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings), respectively. Cracks are not acceptable. Irrespective of the results of non-destructive testing, the RS surveyor may reject the forging if the total number of indications is excessive.

Table 2.5.1.2.6.2.3-1

**Crankshaft forgings. Allowable number and size of surface indications in a reference area of 225 cm<sup>2</sup>**

Inspection zone	Total allowable number of indications	Type of indication	Permissible number of indications for each type	Max. Dimension, in mm
I Fillet	0	Linear	0	–
		Nonlinear	0	–
		Aligned	0	–
II Crankpin	3	Linear	0	–
		Nonlinear	3	3
		Aligned	0	–
II Journal	3	Linear	0	–
		Nonlinear	3	5
		Aligned	0	–

Table 2.5.1.2.6.2.3-2

**Forgings excluding crankshaft forgings. Allowable number and size of surface indications in a reference area of 225cm<sup>2</sup>**

Inspection zone	Total allowable number of indications	Type of indication <sup>1</sup>	Permissible number of indications for each type	Max. Dimension, in mm
I	3	Linear	0	–
		Nonlinear	3	3
		Aligned	0	–
II	10	Linear	3 <sup>1</sup>	3
		Nonlinear	7	5
		Aligned	3 <sup>1</sup>	3

<sup>1</sup> Linear and aligned indications shall not be permitted on bolts, which receive direct fluctuating load, e.g. main bearing bolts, connecting rod bolts, crosshead bearing bolts, cylinder cover bolts.

**2.5.1.2.6.3** Rectification of defects.

**2.5.1.2.6.3.1** Indications that exceed values given in [Tables 2.5.1.2.6.2.3-1](#) and [2.5.1.2.6.2.3-2](#) shall be classed as defects, and shall be repaired or rejected as appropriate, in accordance with the approved documentation.

**2.5.1.2.6.3.2** Generally it may be permitted to remove shallow indications by light grinding to a maximum depth of 1,5 mm, however, grinding procedure shall be agreed with the Register.

**2.5.1.2.6.3.3** Complete removal of the defect shall be proved by magnetic particle or penetrant testing, as appropriate.

**2.5.1.2.6.3.4** Repair welding shall not be permitted for crankshafts or rotating items (such as propeller shafts) subjected to torsional fatigue. Repair welding possibility and procedure of other forgings shall be agreed with the Register.

**2.5.1.2.6.3.5** Grinding is not permitted in way of finished machined threads.

**2.5.1.2.7** Reporting.

**2.5.1.2.7.1** Test results of surface inspections shall be recorded at least with the following data:

- .1 date of testing;
- .2 names, signatures and qualification level of inspection personnel involved in non-destructive testing;
- .3 testing method and testing details, including procedure number and the following data:
  - for penetrant testing: the penetrant system used and viewing conditions (as appropriate to the penetrant technique and media used);
  - for magnetic particle testing: method of magnetizing, test media, magnetic field strength, magnetic flux indicators (where appropriate), and viewing conditions (as appropriate to the magnetizing technique and media used);
- .4 type of product (forging application);
- .5 unique forging identification number;
- .6 steel grade;
- .7 heat treatment;
- .8 stage of testing;
- .9 position (zone) of testing;
- .10 surface condition (roughness);
- .11 test standards used, including references to the appropriate acceptance criteria;
- .12 testing condition;

.13 results, including documentation regarding the repair and testing history (as appropriate);

.14 statement of acceptance/non-acceptance;

.15 details of weld repair including sketch/drawings (where applicable).

**2.5.1.3** Volumetric inspection.

**2.5.1.3.1** General.

**2.5.1.3.1.1** Volumetric inspection shall be carried out by ultrasonic testing using the contact method with straight beam and/or angle beam technique. In case of advanced UT methods (e.g. phased array ultrasonic testing (PAUT) or time of flight diffraction (TOFD)), one shall be guided by relevant requirements of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.5.1.3.1.2** The testing procedures, apparatus and conditions of ultrasonic testing shall comply with recognized national or international standards. Generally, the methods of setting test sensitivity and testing evaluation utilize the DAC (distance amplitude correction, is a method for expressing the echo height from a reflector in relation to DAC curve) or DGS (distance-gain size, is a method using the DGS diagram for expressing the echo height from a reflector in terms of the flat bottom hole giving the equivalent echo in terms of the equivalent echo height from disc-shaped reflectors) methods. The applied methodology shall use 2 — 4 MHz straight beam (or normal) probes and/or angle beam probes. For near surface testing (up to a depth of 25 mm) twin crystal 0° probe shall be used, plus a 0° probe (usually single crystal beyond a depth of 25 mm) for the remaining volume. The appropriate acceptance criteria tables shall be used, depending on the sensitivity method selected.

**2.5.1.3.1.3** Fillet radii shall be examined using 45°, 60° or 70° probes, primarily to determine the presence of any cracks within the radiused areas, and as an additional scan to confirm any indications that may have been detected with 0° probe within this area.

**2.5.1.3.1.4** For fabricated forgings and weld repairs, weld testing shall be carried out to the appropriate agreed national and international standard. In these cases, acceptance criteria specified herein shall not be used.

**2.5.1.3.1.5** Construction of DAC curves for normal probes shall be performed using reference blocks containing suitably sized Flat Bottom Holes (FBH) spaced over the inspection thickness.

Reference blocks shall be manufactured from similar material, with similar surface condition to that being inspected.

Where necessary, allowances shall be made for attenuation losses by performing a transfer correction and adjusting the DAC curve as required. The applied transfer correction (measured in decibels (dB)) shall become the new reference sensitivity, to which indications are evaluated against, according to the appropriate table below.

**2.5.1.3.2** Items of testing.

**2.5.1.3.2.1** These requirements cover volumetric inspection of steel forgings:

.1 all crankshafts;

.2 propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 200 mm,

.3 cylinder heads, connecting rods, piston rods, coupling bolts and studs, as well as crossheads as per the engine type and size requirements in accordance with Appendix 8, Part IV "Technical Supervision during Manufacture of Materials".

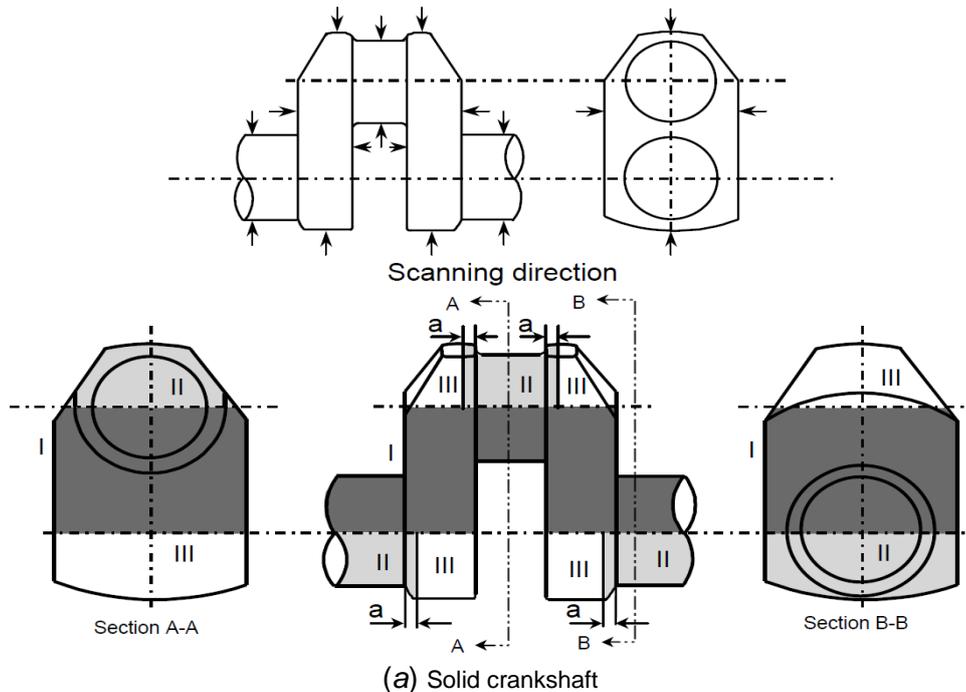
**2.5.1.3.2.2** Forgings application of which is not specified herein or in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, but which are used for manufacture of the RS items shall be subjected to non-destructive testing in accordance with the extent, procedures and criteria of agreed national and international standards.

**2.5.1.3.2.3** Where national and international standards are used or referenced in accordance with [2.5.1.3.2.2](#), the quality level shall provide reasonable equivalence to the allowable criteria specified in [2.5.1.3.5](#). The quality levels shall normally be more stringent as specified in [2.5.1.3.5](#).

**2.5.1.3.2.4** Ultrasonic acceptance criteria detailed in [Tables 2.5.1.3.5.1-1 — 2.5.1.3.5.1-4](#) are intended for C, C-Mn, and alloy steel forgings, and do not apply to austenitic stainless steel or ferritic-austenitic (duplex) stainless steel forgings. To determine acceptance criteria for corrosion-resistant steel forgings, standards ASTM A745/A745/M-20 and EN 10228-4:2016 may be used. Other national or international standards may be used, as agreed with the Register. The required inspection level shall be agreed with the Register in advance.

**2.5.1.3.3** Zones for volumetric inspection.

Ultrasonic testing shall be carried out in the Zones I, II and III as indicated in [Figs. 2.5.1.3.3-1 — 2.5.1.3.3-4](#). Colour identification of zones corresponds to [Fig. 2.5.1.2.5.1-1](#). Areas may be upgraded to a higher zone at the discretion of the RS surveyor.



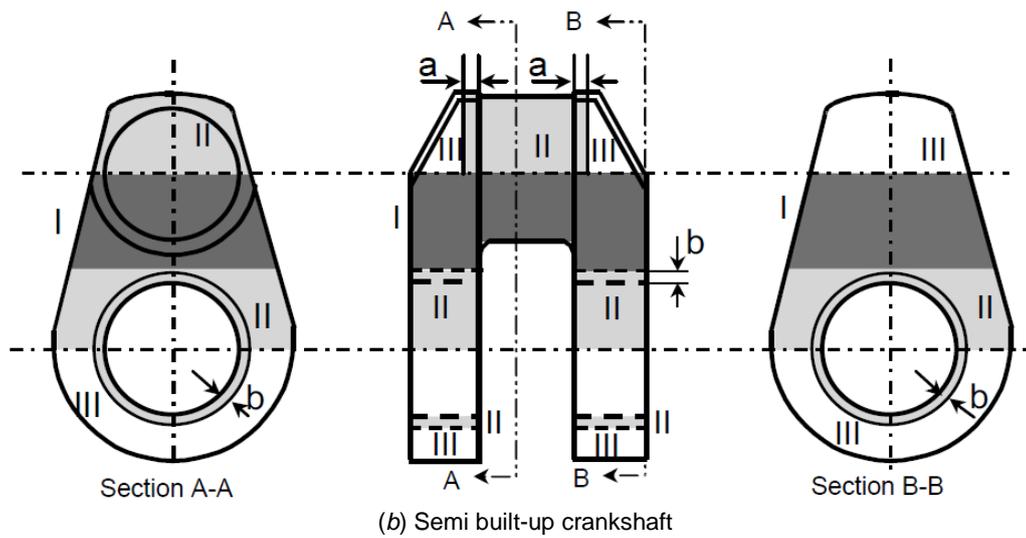


Fig. 2.5.1.3.3-1

Zones for ultrasonic testing on crankshafts

- Notes . 1.  $a = 0,1d$ , but at least 25 mm;  $b = 0,05d$  or 25 mm, whichever is greater (circumstances of shrinkage fit);
2. core areas of crank pins and journals within a radius of  $0,25d$  between the webs may generally be coordinated to Zone II;
3. Colour identification of the Zones refers to [Fig. 2.5.1.2.5.1-1](#).

Zones for radial and axial scanning

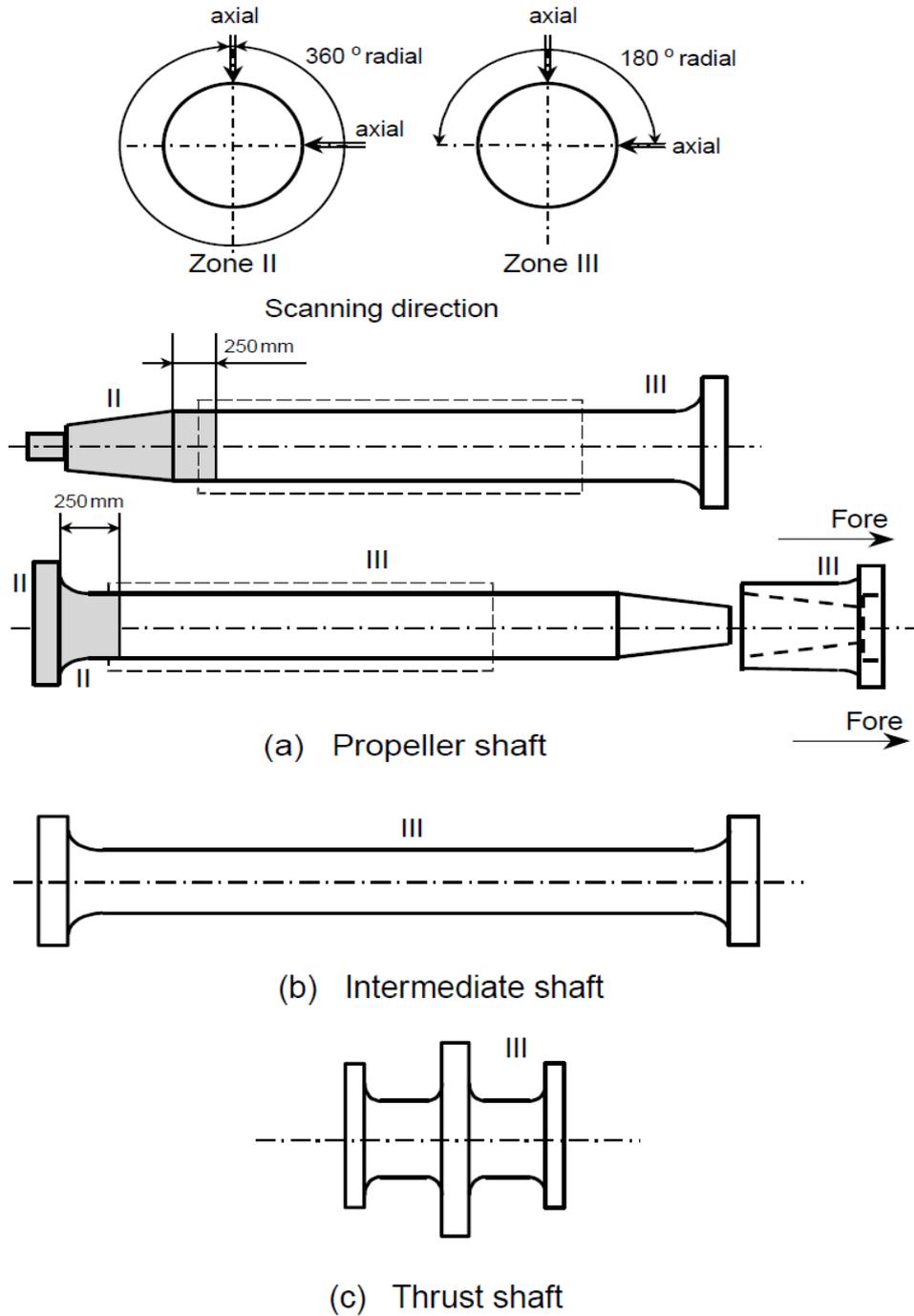
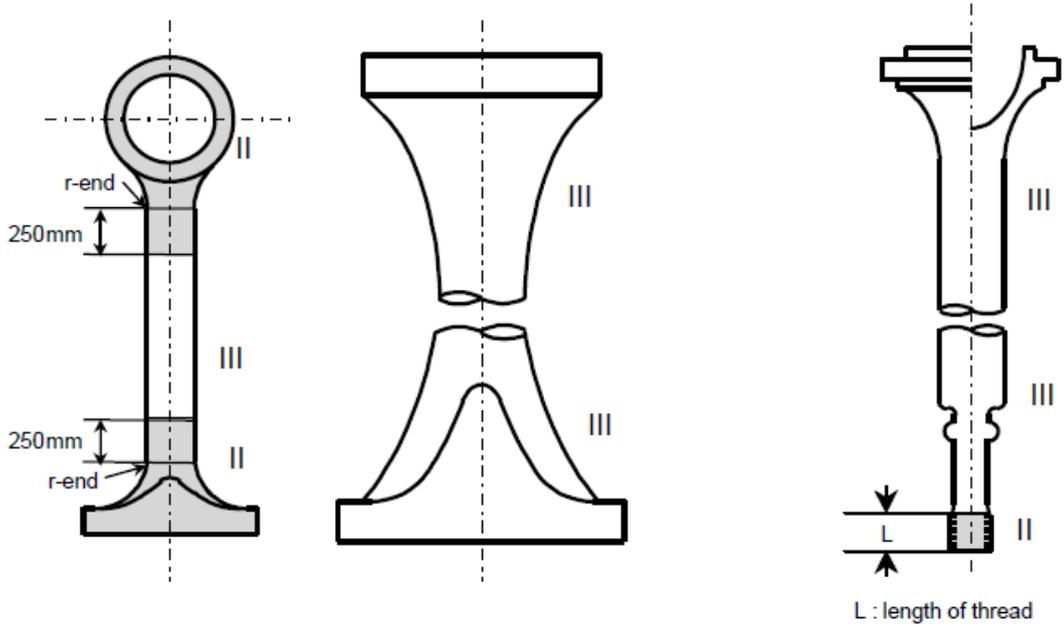
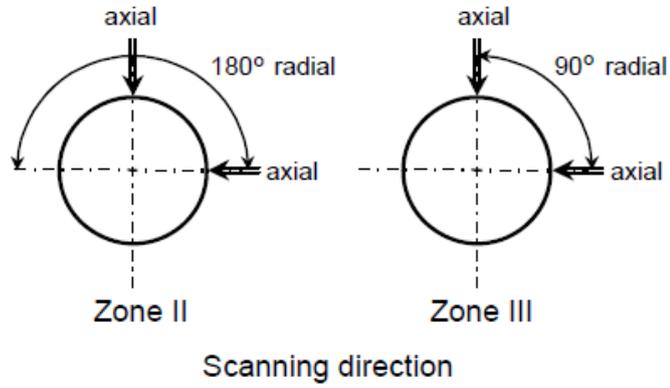


Fig. 2.5.1.3.3-2

Zones for ultrasonic testing on shafts

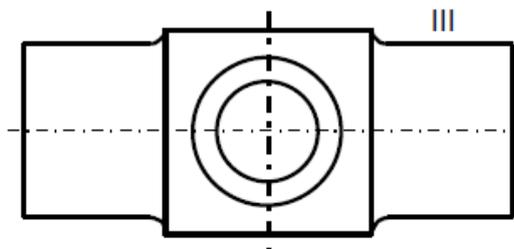
- Notes . 1. For hollow shafts, 360° radial scanning applies to Zone III.  
 2. Circumstances of the bolt holes in the flanges shall be treated as Zone II.

Zones for radial and axial scanning



(a) Connecting rod

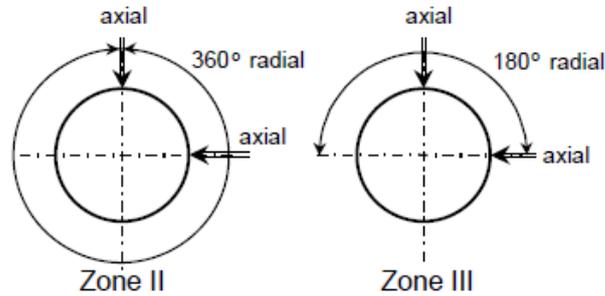
(b) Piston rod



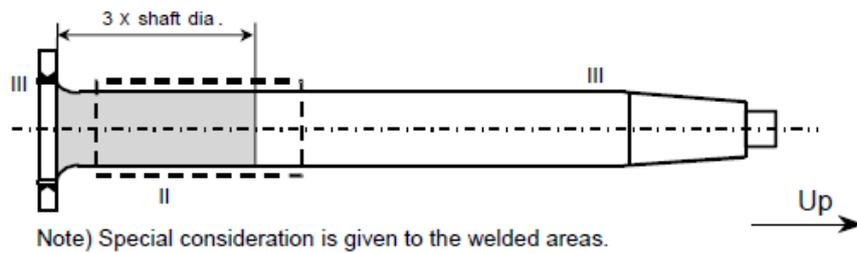
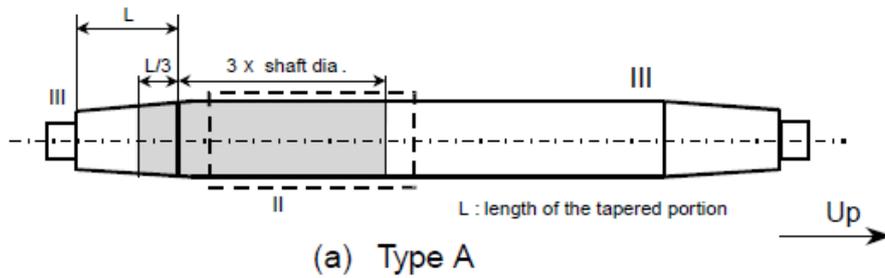
(c) Cross head

Fig. 2.5.1.3.3-3

Zones for ultrasonic testing on machinery components



Scanning direction for Type A and Type B



(b) Type B

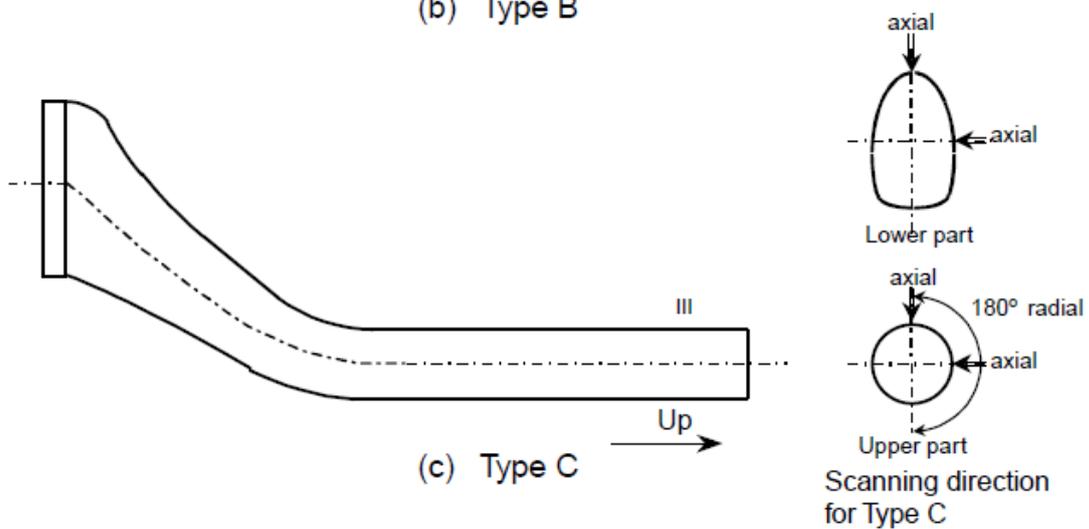


Fig. 2.5.1.3.3-4  
Zones for ultrasonic testing on rudder stock

**2.5.1.3.4 Surface condition.**

**2.5.1.3.4.1** The surfaces of steel forgings to be examined shall be such that adequate coupling can be established between the probe and the forging and that excessive wear of the probe shall be avoided. The surfaces shall be free from scale, dirt, grease or paint.

**2.5.1.3.4.2** The ultrasonic testing shall be carried out after the steel forgings have been machined to a condition suitable for this type of testing and after the final heat treatment, but prior to the drilling of the oil bores, prior to surface hardening and the machining of bolt threads. Black forgings shall be inspected after removal of the oxide scale by either flame descaling or shot blasting methods.

**2.5.1.3.5 Acceptance criteria.**

**2.5.1.3.5.1** Acceptance criteria of volumetric inspection by ultrasonic testing are shown in [Tables 2.5.1.3.5.1-1 — 2.5.1.3.5.1-4](#).

Table 2.5.1.3.5.1-1

**Ultrasonic acceptance criteria for crankshafts: DGS Method — Normal Probes**

Zone	Allowable disc shape according to DGS <sup>1</sup>	Allowable length of indication	Allowable distance between two indications <sup>2</sup>
I	$d \leq 1,0^3$ mm	not applicable <sup>4</sup>	not applicable
II	$d \leq 2,0$ mm	$\leq 10$ mm	$\geq 20$ mm
III	$d \leq 4,0$ mm	$\leq 15$ mm	$\geq 20$ mm

<sup>1</sup> DGS: distance-gain size.

<sup>2</sup> In case of accumulations of two or more isolated indications which are subjected to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication.

This also applies to the distance in axial direction as well as to the distance in depth. Isolated indications with less distances shall be determined as one single indication.

<sup>3</sup> For Zone 1 testing, probe selection shall take into account the limits of probe beam-path length and depth of beam penetration and shall normally be carried out with a minimum probe frequency of 4MHz.

<sup>4</sup> For Zone 1, indications with an echo height greater than a 1,0 mm disc shaped reflector are not acceptable. Indications with an echo height of less than 1,0 mm are acceptable if they are deemed as point reflectors and have no measurable length.

Table 2.5.1.3.5.1-2

**Ultrasonic acceptance criteria for crankshafts: DAC Method – Normal Probes**

Zone	DAC reference level, based on 3,0 mm FBH <sup>1, 2, 3</sup>	Allowable length of indication	Allowable distance between two indications <sup>5</sup>
I	3,0 mm DAC –19 dB	not applicable <sup>4</sup>	not applicable
II	3,0 mm DAC –7 dB	$\leq 10$ mm	$\geq 20$ mm
III	3,0 mm DAC +5 dB	$\leq 15$ mm	$\geq 20$ mm

<sup>1</sup> The requirement of a 3,0 mm FBH shall standardize the DAC reference blocks for clarity and consistency. The dB value for the FBH/DAC setting is equivalent to the disc shaped reflector stated in [Table 2.5.1.3.5.1-1](#), corresponding to the applicable zone.

<sup>2</sup> Other size FBHs may be used for the DAC method (and the dB value adjusted accordingly to provide equivalence with the stated FBH/disc shaped reflector). Where other size FBHs are used, the ultrasonic procedure shall state the equivalence using an appropriate calculation formula.

<sup>3</sup> For Zone 1 testing, probe selection shall take into account the limits of probe beam-path length and depth of beam penetration and shall normally be carried out with a minimum probe frequency of 4MHz.

<sup>4</sup> For Zone 1, indications with an echo height greater than the DAC reference level are not acceptable. Indications with an echo height of less than the DAC reference level are acceptable if they are deemed as point reflectors and have no measurable length.

Zone	DAC reference level, based on 3,0 mm FBH <sup>1, 2, 3</sup>	Allowable length of indication	Allowable distance between two indications <sup>5</sup>
<sup>5</sup> In case of accumulations of two or more isolated indications which are subject to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances shall be determined as one single indication.			

Table 2.5.1.3.5.1-3

**Ultrasonic acceptance criteria for forged machinery components: DGS Method — Normal Probes**

Type of forging	Zone	Allowable disc shape according to DGS <sup>1,2</sup>	Allowable length of indication	Allowable distance between two indications <sup>3</sup>
Propeller shaft	II	outer: $d \leq 2$ mm	$\leq 10$ mm	$\geq 20$ mm
Intermediate shaft		inner: $d \leq 4$ mm	$\leq 15$ mm	$\geq 20$ mm
Thrust shaft	III	outer: $d \leq 3$ mm	$\leq 10$ mm	$\geq 20$ mm
Rudder stock		inner: $d \leq 6$ mm	$\leq 15$ mm	$\geq 20$ mm
Connecting rod Piston rod	II	$d \leq 2$ mm	$\leq 10$ mm	$\geq 20$ mm
Crosshead	III	$d \leq 4$ mm	$\leq 10$ mm	$\geq 20$ mm

<sup>1</sup> DGS: distance-gain size.

<sup>2</sup> Outer part means the part beyond one third of the shaft radius from the centre, the inner part means the remaining core area.

<sup>3</sup> In case of accumulations of two or more isolated indications which are subjected to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances shall be determined as one single indication.

Table 2.5.1.3.5.1-4

**Ultrasonic acceptance criteria for shafts and machinery components: DAC Method — Normal Probes**

Type of forging	Zone	DAC reference level, based on 3,0 mm FBH <sup>1, 2</sup>	Allowable length of indication	Allowable distance between two indications <sup>3</sup>
Propeller shafts, intermediate shafts	II	Outer: DAC -7 dB Inner: DAC +5 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
	III	Outer: DAC Inner: DAC +12 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
Thrust shaft, rudder stocks	II	Outer: DAC -7 dB Inner: DAC + 5 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
	III	Outer: DAC Inner: DAC + 12 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
Connecting rod, piston rod, crosshead	II	DAC minus 7 dB	$\leq 10$ mm	$\geq 20$ mm
	III	DAC + 5 dB	$\leq 10$ mm	$\geq 20$ mm

<sup>1</sup> The requirement of a 3,0 mm FBH shall standardize the DAC reference blocks for clarity and consistency. The dB value for the FBH/DAC setting is equivalent to the disc shaped reflector stated in [Table 2.5.1.3.5.1-1](#), corresponding to the applicable zone.

Type of forging	Zone	DAC reference level, based on 3,0 mm FBH <sup>1,2</sup>	Allowable length of indication	Allowable distance between two indications <sup>3</sup>
<p><sup>2</sup> Other size FBHs may be used for the DAC method (and the dB value adjusted accordingly to provide equivalence with the stated FBH/disc shaped reflector). Where other size FBHs are used, the ultrasonic procedure shall state the equivalence using an appropriate calculation formula.</p> <p><sup>3</sup> In case of accumulations of two or more isolated indications which are subject to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances should be determined as one single indication.</p>				

### 2.5.1.3.6 Reporting.

**2.5.1.2.7.1** Test results of volumetric inspection shall be recorded at least with the following items:

- .1 date of testing;
- .2 names, signatures and qualification level of inspection personnel involved in non-destructive testing;
- .3 testing method including procedure number, and details of the following items:
  - equipment used (instrument, probes [and any adaptations to probes for curved surfaces], calibration and reference blocks);
  - technique(s) used to set test sensitivity (including sensitivity method, specific reference blocks, reflector size, transfer correction);
  - maximum scanning rate (mm/s);
  - details of any testing restrictions;
- .4 type of product (forging application);
- .5 unique forging identification number;
- .6 steel grade;
- .7 heat treatment;
- .8 stage of testing;
- .9 position (zone) of testing;
- .10 surface condition (roughness);
- .11 test standards used, including references to the appropriate acceptance criteria;
- .12 testing condition;
- .13 results, including documentation regarding the repair and testing history (at the Register request);
- .14 statement of acceptance/non-acceptance;
- .15 details of weld repair including sketch/drawing (where applicable).

## 2.5.2 Non-destructive testing of steel castings.

### 2.5.2.1 General.

**2.5.2.1.1** These requirements cover the extent, methods and recommended quality levels applicable to the non-destructive testing (NDT), of steel castings, except in those cases where alternative criteria have been otherwise agreed with the Register. The requirements are obligatory for implementation in cases provided by other parts of the Rules.

**2.5.2.1.2** These requirements may apply to castings different from those specified herein considering their materials, kinds, shapes and stress conditions of operation.

**2.5.2.1.3** Castings intending to be examined by NDT methods are listed on [Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6](#). Criteria for NDT of other castings not listed herein shall be subject to agreement with the Register.

**2.5.2.1.4** In cases where the castings not specified herein and/or in 2.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships but

subjected to survey, relevant national or international standards, or other RS requirements may be applied, to determine the appropriate extent of testing, NDT procedure and defect acceptance criteria.

**2.5.2.1.5** Provisions of [2.5.2](#) may complement the requirements of Section 3, Part III "Equipment, Arrangements and Outfit", 3.8, 7.2 and Section 8, Part XIII "Materials" and Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. General requirements for the non-destructive testing methods, the extent of testing and criteria are also specified herein.

**2.5.2.1.6** Castings shall be NDT examined in the final delivery condition.

**2.5.2.1.7** Where intermediate inspections have been performed the manufacturer shall provide reports of the results upon the request of the RS surveyor.

**2.5.2.1.8** Where a casting is supplied in semi-finished condition, the manufacturer shall take into account the quality level of final finished machined components.

**2.5.2.1.9** Where advanced ultrasonic testing methods are applied (e.g. phased array ultrasonic testing (PAUT) or time of flight diffraction (TOFD)), one shall be guided by relevant requirements of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. Acceptance levels regarding acceptance/rejection criteria are specified below.

**2.5.2.2** Qualification of personnel involved in NDT.

**2.5.2.2.1** Personnel engaged in visual and measurement testing shall have sufficient knowledge and experience and may be qualified in accordance with these requirements.

**2.5.2.2.2** Personnel carrying out visual and measurement testing shall be certified to a recognized national or international certification scheme, e.g. ISO 9712:2012, or personnel qualification shall be certified by an employer-based qualification scheme such as SNT-TC-1A: 2016, or ANSI/ASNT CP-189: 2016. The procedure in the employer-based schemes applied for personnel qualification may be accepted upon agreement with the Register. Certification procedure shall comply with the requirements of ISO 9712 apart from the impartiality requirements of a certification body.

**2.5.2.2.3** Personnel responsible for NDT activity including approval of procedures shall be qualified and certified to Level 3.

**2.5.2.2.4** The NDT personnel's certificates and competence shall comprise all industrial sectors and techniques being applied by the manufacturer or its subcontractors. Certificates issued shall be made available to the Register for verification, when requested.

**2.5.2.2.5** The operator carrying out NDT and interpreting indications, shall, as a minimum, be qualified and certified to Level 2 in the NDT methods concerned.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at Level 1.

The operator shall have adequate knowledge of materials, weld, structures or components, NDT equipment and limitations that are sufficient to apply the relevant NDT method for each application appropriately.

**2.5.2.3** Casting condition.

**2.5.2.3.1** Heat treatment.

Non-destructive testing applied for acceptance purposes to support final casting certification shall be made after the final heat treatment of the casting. Where intermediate inspections have been performed the manufacturer shall provide reports of the results upon request of the RS surveyor.

**2.5.2.3.2** Surface condition.

**2.5.2.3.2.1** The surface of castings to be tested shall be free from scale, dirt, grease, paint, shot and primer, and shall meet the standards of a surface condition for the

corresponding types of testing. The roughness of surface to be tested shall be minimum of  $R_a \leq 6,3 \mu\text{m}$ .

**2.5.2.3.2.2** The surface of the casting being subjected to ultrasonic testing shall be machined or shot blasted to a suitable condition, with a minimum value surface quality of  $R_a \leq 12,5 \mu\text{m}$ . The casting surface shall be such that adequate coupling can be established between the probe and the casting and that excessive wear of the probe is avoided.

**2.5.2.4** Scope of survey.

**2.5.2.4.1** Zones of testing.

**2.5.2.4.1.1** Zones to be examined for detection of surface defects are shown in [Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6](#), the extent of testing and quality level are specified in [2.5.2.4](#) and [2.5.2.6](#).

NDT shall be made in accordance with an inspection plan approved by the Register. The plan shall specify the extent of the testing, the testing procedure, the quality level or, if necessary, level for different locations of the castings.

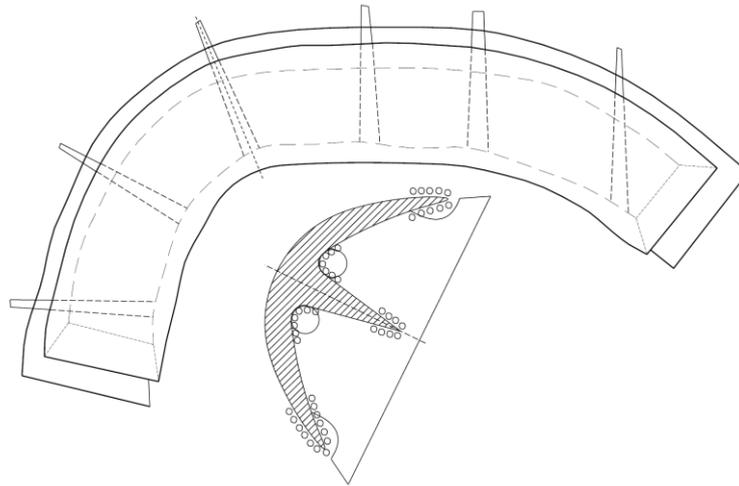


Fig. 2.5.2.4.1-1 Stern Frame

- Notes: 1. All surfaces: visual and measurement testing.  
2. Location indicated with (OOO): magnetic particle and ultrasonic testing.

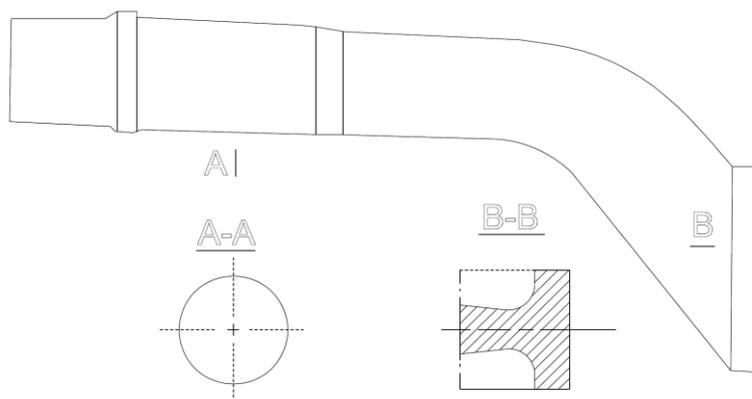


Fig. 2.5.2.4.1-2  
Rudder stock.

Note. All surfaces: visual and measurement testing, magnetic particle and ultrasonic testing.

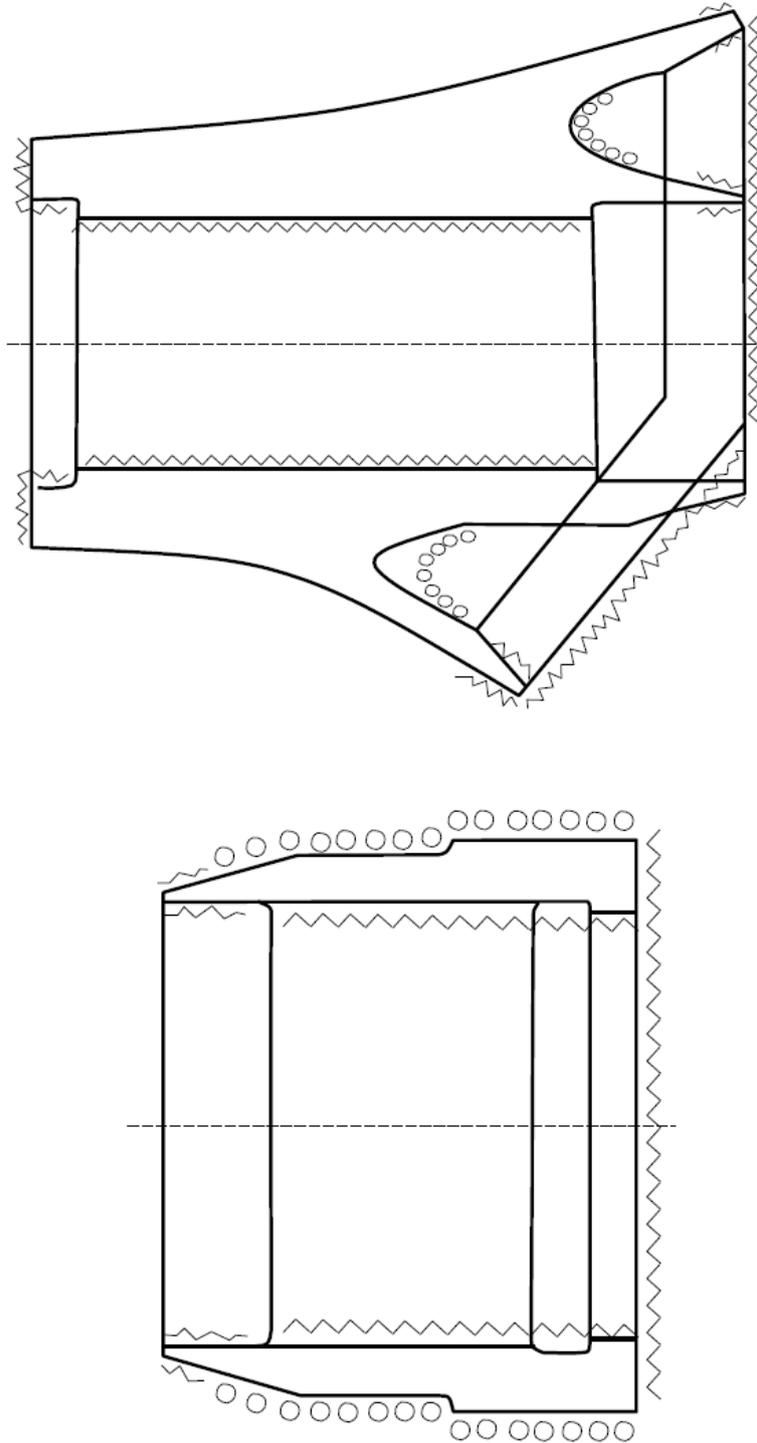


Fig. 2.5.2.4.1-3  
Stern boss

- Notes:
1. All surfaces: visual and measurement testing.
  2. Location indicated with (OO): magnetic particle and ultrasonic testing.
  3. Location indicated with (^^): ultrasonic testing.

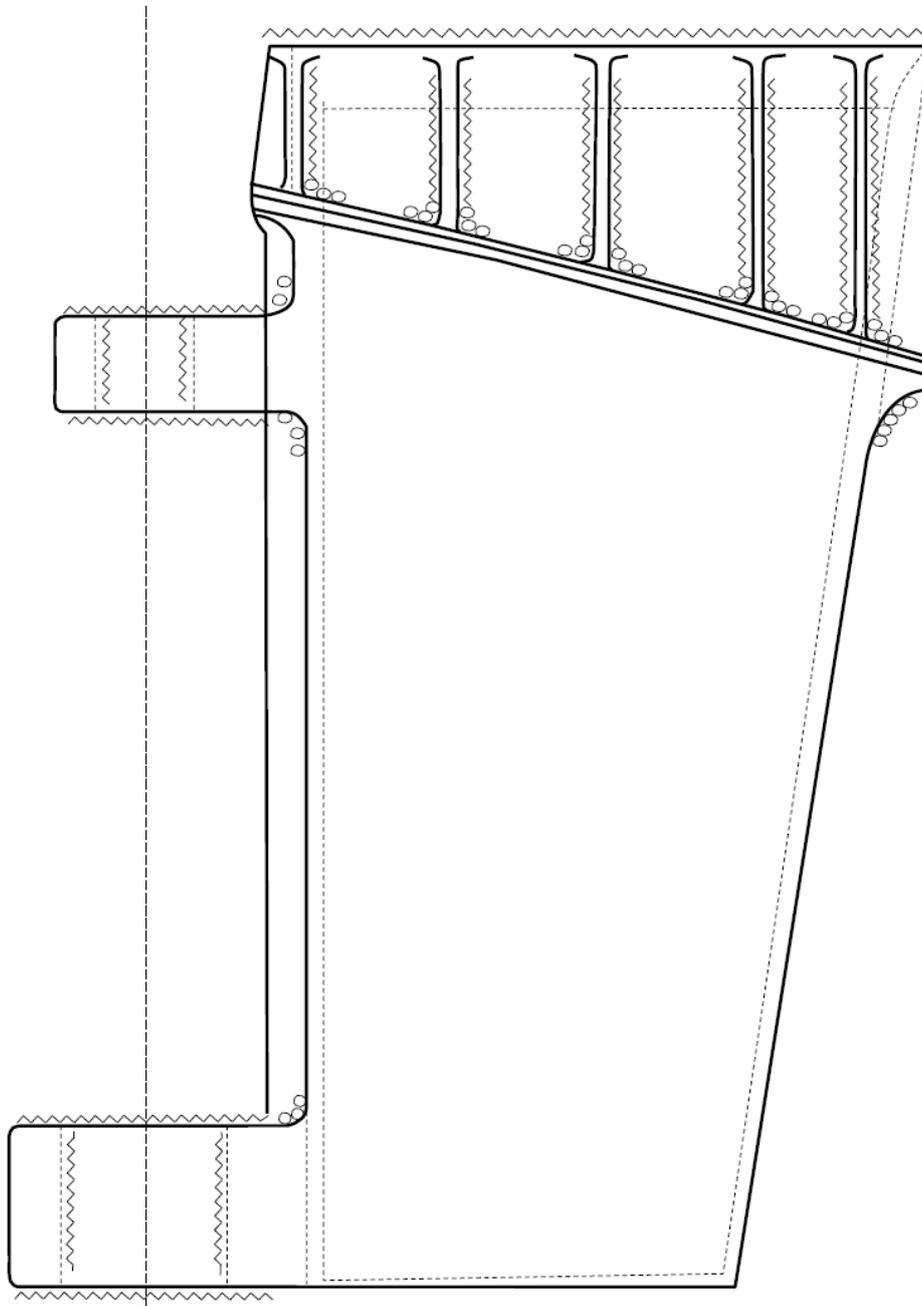


Fig. 2.5.2.4.1-4 Rudder hangings.

- Notes:
1. All surfaces: visual and measurement testing.
  2. Location indicated with (OOO): magnetic particle and ultrasonic testing.
  3. Location indicated with (^^): ultrasonic testing.

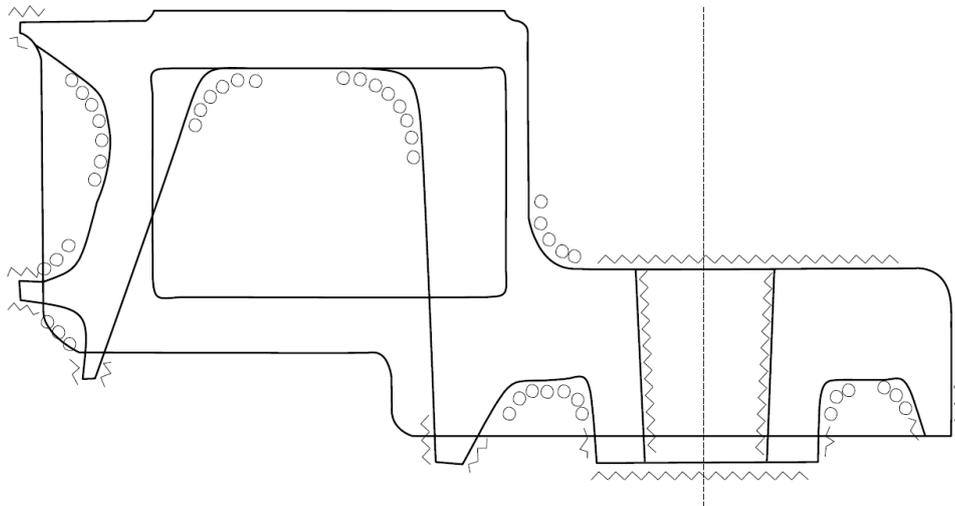


Fig. 2.5.2.4.1-5  
Rudder (upper part).

- Notes:
1. All surfaces: visual and measurement testing.
  2. Location indicated with (OOO): magnetic particle and ultrasonic testing

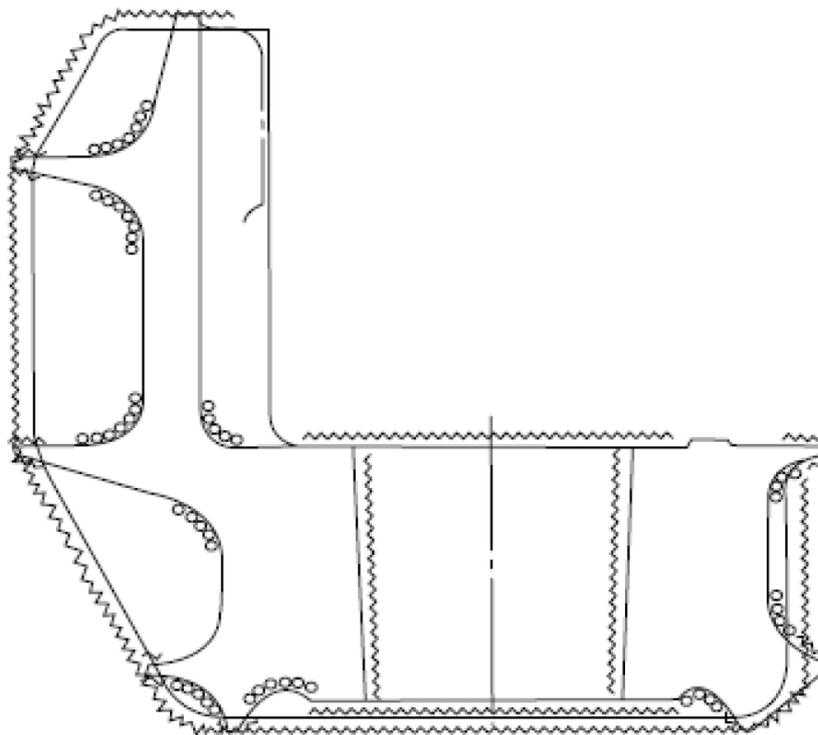


Fig. 2.5.2.4.1-6  
Rudder (lower part).

- Notes:
1. All surfaces: visual and measurement testing.
  2. Location indicated with (OOO): magnetic particle and ultrasonic testing
  3. Location indicated with (^^^): ultrasonic testing.

**2.5.2.4.1.2** In addition to the areas identified on [Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6](#), surface inspections shall be carried out in the following locations:

- at all accessible fillets and changes of section;
- in way of fabrication weld preparation, for a band width of 30 mm;
- in way of chaplets;
- in way of weld repairs;
- at positions where surplus metal has been removed by flame cutting, scarifying or arc-air gouging.

**2.5.2.4.1.3** Ultrasonic testing shall be carried out in the zones indicated on [Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6](#) and also at the following locations:

- in way of all accessible fillets and at pronounced changes of section;
- in way of fabrication weld preparations for a distance of 50 mm from the edge;
- in way of weld repairs where the original defect was detected by ultrasonic testing;
- in way of riser positions;
- in way of machined areas particularly those subject to further machining such as bolt hole positions.

**2.5.2.4.1.4** In cases of survey of castings such as rudder horns, which may have a large surface area still untested after the above inspections have been applied, an additional ultrasonic inspection of the untested areas shall be made along continuous perpendicular grid lines on nominal 225 mm centres, scanning from one surface only.

**2.5.2.5** Testing procedures.

**2.5.2.5.1** Visual and measurement testing.

Steel castings nominated for NDT shall be subjected to a 100 % visual and measurement testing of all accessible surfaces by the manufacturer and made available to the RS surveyor. Viewing conditions at the inspected surfaces shall be in accordance with agreed national or international standards. Unless otherwise agreed, the visual and measurement testing shall be carried out in the presence of the RS surveyor.

**2.5.2.5.2** Surface inspection.

**2.5.2.5.2.1** The testing procedures, apparatus and conditions of magnetic particle testing and penetrant testing shall comply with agreed national or international standards. Magnetic particle testing is preferable to penetrant testing except in the following cases;

- austenitic stainless steels,
- interpretation of open visual and measurement or magnetic particle indications,
- at the instruction of the RS surveyor, where a particular need for penetrant testing has been identified.

**2.5.2.5.2.2** For magnetic particle testing, attention shall be paid to the contact between the casting and the clamping devices of stationary magnetization benches in order to avoid local overheating or burning damage in its surface. Prods shall not be permitted on finished machined items. Damage of finished machined surface by electrical connections shall be avoided. Note that the use of solid copper at the prod tips must be avoided due to the risk of copper contamination into the casting. The pole of the magnets shall have close contact with the component.

**2.5.2.5.2.3** AC magnetization method shall normally be used, as it is more sensitive for detecting surface indications. Where DC magnetization method is used, this shall be substantiated and agreed with the Register.

**2.5.2.5.2.4** When indications have been detected as a result of the surface inspection, acceptance or rejection shall be decided in accordance with [2.5.2.6](#).

**2.5.2.5.3** Volumetric inspection.

**2.5.2.5.3.1** Volumetric inspection shall normally be carried out by ultrasonic testing using the contact method with normal (0°) beam and/or angle beam technique. The testing

procedures, apparatus and conditions of ultrasonic testing shall comply with agreed national or international standards.

**2.5.2.5.3.2** In some cases, due to the shape, nature, complexity of casting, or defect type or orientation, the Register may require radiographic testing. Radiographic testing may be carried out at the initiative of the manufacturer and upon agreement with the Register. Where radiographic testing is applied, procedure, assessment criteria of the results shall comply with the recognized or agreed national or international standards, for example, depending on the thickness of castings: ASTM E446 — 15; ASTM E186 — 15 (2019) e1; ASTM E280 — 15 (2019) e1; ISO 4993:2015. A suitable quality level for marine castings shall normally be severity level 2 or 3 (of the above standards), depending on the location zone and type of casting. Other severity levels may be applied, and shall be agreed with the Register.

**2.5.2.5.3.3** Zone inspection indicated in the approved testing plan is minimum required however if defects are revealed that require amendments in zones to be inspected, the Register may require additional testing of extended zones. Definition of extended zones to be inspected shall be agreed with the Register. The testing plan shall include zones to be inspected in accordance with [2.5.2.4.1.3](#).

**2.5.2.5.3.4** Ultrasonic testing shall be made using a 0° probe of 1 to 4MHz (usually 2MHz) frequency, and angle probes, where required. Whenever possible scanning shall be performed from both surfaces of the casting and from surfaces perpendicular to each other.

**2.5.2.5.3.5** The backwall echo obtained on parallel sections shall be used to monitor variations in probe coupling and material attenuation. Any reduction in the amplitude of the back wall echo due to material properties shall be corrected. Attenuation in excess of 30 dB/m may be indicative of an unsatisfactory annealing heat treatment and may render the effectiveness of the testing as unsuitable. In such cases, the reasons of excessive attenuation shall be investigated and eliminated, as appropriate.

**2.5.2.5.3.6** Machined surfaces, especially those in the vicinity of riser locations and in the bores of stern boss castings, shall also be subject to a near surface (approximately 25 mm) scan using a twin crystal 0° probe.

Additional scans on machined surfaces may be required by the Register in cases where boltholes are drilled or where surplus material such as "padding" has been removed by machining thus moving the scanning surface closer to possible areas of shrinkage.

Additionally, the Register may require to examine the machined bores of castings using circumferential scans with 70° probes in order that axial radial planar flaws such as hot tears can be detected.

Fillet radii shall be examined using 45°, 60°, or 70° probes scanning from the surfaces/direction likely to give the best reflection, primarily to determine the presence of any cracks within the radiused areas, and as an additional scan to confirm any indications that may have been detected with 0° probes within this area.

**2.5.2.5.3.7** In the examinations of those zones nominated for ultrasonic examination the reference sensitivity for the 0° probe shall be established against a 6 mm reflector. Sensitivity can be calibrated either against 6 mm diameter flat bottomed hole(s) in a reference block (or series of blocks) corresponding to the thickness of the casting provided that a transfer correction is made, using the DAC (distance-amplitude-correction) method, or by using the DGS (distance-gain-size) method.

**2.5.2.5.3.8** Where necessary, the reference sensitivity of angle probes shall be established against an appropriate 6 mm reflector (e.g. reference reflectors angled perpendicular to the sound beam) for the DAC method, or equivalent using the DGS method.

**2.5.2.5.3.9** The DGS diagrams issued by a probe manufacturer identify the difference in dB between the amplitude of a backwall echo and that expected from a 6 mm

diameter disk reflector. By adding this difference to the sensitivity level initially set by adjusting a backwall echo to a reference height e.g. 80 %, the amended reference level shall be representative of a 6 mm diameter disk reflector. Similar calculations may be used for evaluation purposes to establish the difference in dB between a backwall reflector and disk reflectors of other diameters such as 12 or 15 mm.

**2.5.2.5.3.10** Having made any necessary corrections for differences in attenuation or surface condition between the reference block and the casting, any indications received from the nominated zones in the casting that exceed the 6 mm reference level shall be marked for evaluation against the criteria given in [2.5.2.6.3](#). Evaluation shall include additional scans with angle probes in order that the full extent of the discontinuity can be plotted.

**2.5.2.6** Acceptance criteria.

**2.5.2.6.1** Visual and measurement testing.

**2.5.2.6.1.1** All castings shall be free of cracks, crack-like indications, hot tears, cold shuts or other detrimental indications. Thickness of the remains of sprues or risers shall be within the casting dimensional tolerance.

**2.5.2.6.1.2** Where non-open indications are suspected, additional magnetic particle, penetrant or ultrasonic testing may be conducted for a more detailed evaluation of surface irregularities at the request of the RS surveyor.

**2.5.2.6.2** Surface inspection.

**2.5.2.6.2.1** The following definitions relevant to indications and defects apply.

**Linear indication** is an indication with a largest dimension three or more times its smallest dimension (i.e.  $l \geq 3w$ ).

**Non-linear indication** is an indication with a largest dimension less than three times its smallest dimension (i.e.  $l < 3w$ ).

**Aligned indication** is a unique indication and its length is equal to the overall length of the alignment. The aligned indication may have the following structure:

three or more non-linear indications aligned with the distance between indications less than 2 mm;

linear indications aligned with the distance between two indications smaller than the length of the longest indication.

**Open indication (defect)** is a defect visible after removal of the magnetic particles or that can be detected by the use of penetrant testing.

**Non-open indication (defect)** is a defect that is not visually detectable after removal of the magnetic particles or that cannot be detected by the use of penetrant testing.

**Relevant indication (defect)** is an indication which have any dimension greater than 1,5 mm and shall be considered relevant for the categorization of indications.

**2.5.2.6.2.2** The surface shall be divided into reference band length of 150 mm for level MT1/PT1 and into reference areas of 22500 mm<sup>2</sup> for level MT2/PT2. The band length and/or area shall be taken in the most unfavourable location relative to the indications being evaluated, i.e. the shape and dimensions of each reference area are chosen so that they cover the maximum number of defects (discontinuities) without their distribution to an adjacent reference area.

**2.5.2.6.2.3** Level MT1/PT1 is applied for fabrication weld preparation and weld repairs; Level MT2/PT2 is used for other locations.

The required quality level shall be shown in the manufacturer's testing program.

The allowable numbers and sizes of indications in the reference band length and/or area are given in [Table 2.5.2.6.2.3](#). Cracks and hot tears shall not be accepted.

Table 2.5.2.6.2.3

Quality level	Total maximum number of all indications	Type of indication	Maximum number of each type of indication	Maximum dimension (e.g. width, length, diameter) of single indication <sup>1</sup> , mm
M1/P1	4 in 150 mm length	Non-linear	4 <sup>2</sup>	5
		Linear	4 <sup>2</sup>	3
		Aligned	4 <sup>2</sup>	3
M2/P2	20 in 22500 mm <sup>2</sup> area	Non-linear	10	7
		Linear	6	5
		Aligned	6	5
<sup>1</sup> In weld repairs, the maximum dimension is 2 mm.				
<sup>2</sup> 30 mm minimum (measured in any direction) between relevant indications.				

**2.5.2.6.3 Volumetric inspection.**

**2.5.2.6.3.1** Acceptance criteria for ultrasonic testing are specified in [Table 2.5.2.6.3.1](#) for UT1 and UT2 quality levels. As stated in [2.5.2.4.1.1](#), the quality levels applicable to the zones to be examined shall be identified in the testing program.

Table 2.5.2.6.3.1

**Ultrasonic acceptance criteria for steel castings using DGS or DAC system**

Quality level	Allowable disc shape according to DGS <sup>1</sup> , mm or diameter of FBH according to DAC <sup>2,3</sup> curve (mm)	Maximum number of indications to be registered <sup>4</sup>	Allowable size of all relevant indications <sup>5,6</sup> , mm
UT1	> 6	0	0
UT2	12 – 15	5	50
	> 15	0	0
<sup>1</sup> DGS: distance-gain size.			
<sup>2</sup> DAC: distance amplitude correction.			
<sup>3</sup> The corresponding DAC level to each of the FBH reflectors is at 100% DAC.			
<sup>4</sup> Grouped in an area measuring 300 x 300 mm.			
<sup>5</sup> Measured on the scanning surface.			
<sup>6</sup> The measured indication is regarded as the longest dimension, as measured in the scanning process.			

For castings specified in [2.5.2.4.1.1](#) the following quality levels are established.

Level UT1 is applicable to:

fabrication weld preparations for a distance of 50 mm;

50 mm depth from the final machined surface including boltholes;

fillet radii to a depth of 50 mm and within distance of 50 mm from the radius end;

castings subject to cyclic bending stresses (shafts and rudder stocks) — the outer one third of thickness in the zones shown in [Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6](#);

discontinuities within the tested zones interpreted to be cracks or hot tears.

Level UT2 is applicable to:

other zones not indicated in [Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6](#) or on the inspection plan;

positions outside locations nominated for level UT1 examination where feeders and gates have been removed;

castings subject to cyclic bending stresses (shafts and rudder stocks) — at the central one third of thickness in the zones nominated for ultrasonic testing in [Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6](#).

**2.5.2.6.3.2** For ultrasonic testing near surface testing (to an approximate depth of 25 mm) twin crystal 0° (normal beam) probe shall be used, plus a 0° probe (usually single crystal beyond a depth of 25 mm) for the remaining volume.

**2.5.2.6.3.3** Ultrasonic acceptance criteria for other casting areas not nominated in [2.5.2.4.1.1](#) shall be subject to special consideration based on the anticipated stress levels and the type, size and position of the discontinuity and shall be agreed with the Register.

**2.5.2.6.3.4** [Table 2.5.2.6.3.1](#) contains acceptance criteria for DGS and DAC.

**2.5.2.6.3.5** DGS and DAC methods may be used for determining sensitivity. The DAC method for normal beam probes may be based on a 6,0 mm diameter reflector or flat bottomed hole (FBH). A DAC curve shall be produced using reference blocks containing 6,0 mm FBH reflectors over a range representative of the inspection thickness, after adjustment for transfer and attenuation losses.

**2.5.2.6.3.6** For quality level UT 1, any discontinuity producing a signal amplitude in excess of the 6,0 mm DAC curve is unacceptable.

**2.5.2.6.3.7** For quality level UT2, the sensitivity may be based on actual size FBH (of 12 mm and 15 mm) or based on equivalent 6 mm FBH, and the sensitivity adjusted to obtain equivalent amplitudes, as described in [2.5.2.6.3.8](#).

**2.5.2.6.3.8** For use of FBH of 6 mm for setting sensitivity, adjustment of signal amplitudes may be determined for 12 mm and 15 mm FBH reflectors: to be DAC +12dB and DAC +16dB (plus any compensation for transfer and attenuation losses). As shown in [Fig. 2.5.2.6.3.8](#), the increase in dB to the indicated levels represents the equivalent FBH sizes (for 12 mm and 15 mm), and their respective corresponding ultrasonic response amplitudes.

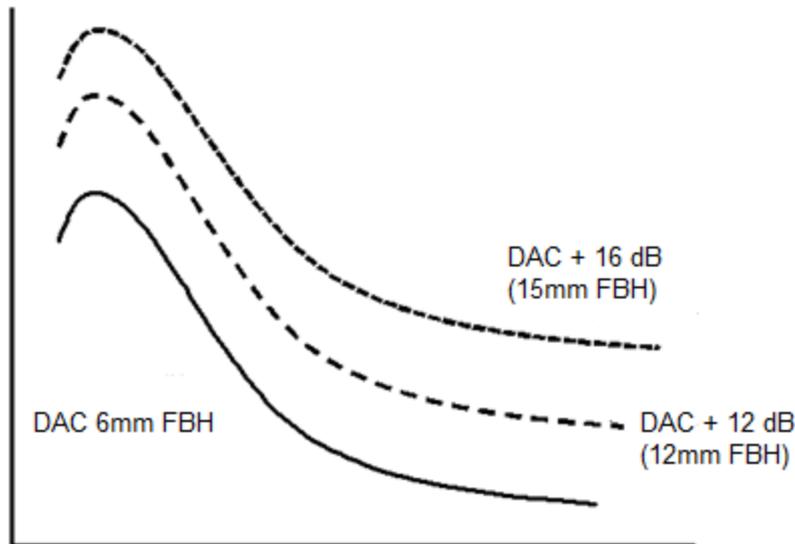


Fig. 2.5.2.6.3.8

DAC curve produced from 6,0 mm FBH reflector and DAC curves adjusted to represent equivalent 12,0 mm and 15,00 mm FBH reflectors

Notes:

1. The bottom curve (DAC) represents a sensitivity based on 6 mm FBH, and the two additional curves above this represent the equivalent sensitivities converted for larger FBH's (12 mm and 15 mm).
2. When scanning using these curves, and applying [Table 2.5.2.6.3.1](#) acceptance criteria, for UT2, any indication below DAC +12 mm shall be disregarded, and any indication above DAC +16 mm shall be rejected.
3. Any indication between these two curves DAC +12 mm and DAC +16 mm shall be evaluated according to its size, as per [Table 2.5.2.6.3.1](#).

**2.5.2.6.3.9** The maximum number of indications to be registered and the maximum length of indications permissible for quality level 2 (as stated in [Table 2.5.2.6.3.1](#)) apply to normal probes.

**2.5.2.6.3.10** For quality level UT 2, any discontinuity producing a signal amplitude in excess of the 15,0 mm DAC curve shall be regarded as unacceptable.

**2.5.2.6.3.11** Any signal between 12 + 15 curve shall be evaluated for length of defect, and referred to [Table 2.5.2.6.3.1](#) for acceptance.

**2.5.2.7** Reporting.

**2.5.2.7.1** All reports of non-destructive examinations shall include the following items:

- .1 date of testing;
- .2 names, signatures and qualification level of inspection personnel involved in non-destructive testing;
- .3 type of casting;
- .4 unique casting identification number;
- .5 steel grade;
- .6 casting condition (heat treatment);
- .7 stage of testing;
- .8 locations of testing;
- .9 surface condition;
- .10 test standards used, including reference to the appropriate acceptance criteria;
- .11 results, including documentation regarding the repair and testing history (as appropriate);
- .12 statement of acceptance/non-acceptance;
- .13 locations of reportable indications and received pulses from defects;
- .14 details of weld repair including sketches/drawings (where applicable).

**2.5.2.7.2** In addition to the items listed in [2.5.2.7.1](#), reports of surface inspections shall include at least the following items:

- .1 for penetrant testing: the penetrant system used;
- .2 for magnetic particle testing: method of magnetising, test media and magnetic field strength and magnetic flux indicators (where appropriate);
- .3 viewing conditions (as appropriate to the penetrant or magnetic technique and media used);
- .4 testing details and procedure number;
- .5 details of any test restrictions.

**2.5.2.7.3** In addition to the items listed in [2.5.2.7.1](#), reports of ultrasonic inspection shall include at least the following information: flaw detector, probe type, size, angle and frequency (and any adaptations to probes for curved surfaces), calibration and reference blocks, sensitivity method (including reflector size, transfer correction), maximum scanning rate (mm/s), and couplant.

**2.5.2.8** Rectification of defects.

**2.5.2.8.1** Indications that exceed the requirements of [Tables 2.5.2.6.2.3](#) and [2.5.2.6.3.1](#), shall be classed as defects, and shall be repaired in accordance with the provisions of 3.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.5.2.8.2** Generally it may be permitted to remove shallow indications by light grinding.

**2.5.2.8.3** Complete removal of the defect shall be proved by magnetic particle testing or penetrant testing, as appropriate.

**2.5.2.8.4** Castings which are repaired shall be examined by the same method as at initial survey, as well as by any additional methods as requested by the RS surveyor.

## **2.6 PROCEDURE FOR APPLICATION OF REGULATION 3-11, PART A-1, CHAPTER II-1 OF SOLAS-74 (CORROSION PROTECTION OF CARGO OIL TANKS OF CRUDE OIL TANKERS), ADOPTED BY IMO RESOLUTION MSC.289(87) "PERFORMANCE STANDARD FOR ALTERNATIVE MEANS OF CORROSION PROTECTION FOR CARGO OIL TANKS OF CRUDE OIL TANKERS"**

**2.6.1** This Chapter supplements the provisions of the Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (hereinafter, PSPC-COT Alt) for Application of Regulation II-1/3-11 (Corrosion Protection of Cargo Oil Tanks of Crude Oil Tankers), adopted by IMO resolution MSC.289(82).

The requirements of this Chapter shall be considered alongside with the requirements of PSPC-COT Alt.

### **2.6.2 Interpretations to 2.1 "General Principles" of PSPC-COT Alt.**

**2.6.2.1** Normal and higher strength corrosion-resistant steels as defined in this Chapter, is steel, which corrosion resistance performance in the bottom or top of the internal cargo oil tank is tested and approved to satisfy the requirements in IMO resolution MSC.289(87) in addition to other relevant requirements for ship material, structure strength and construction. It is not the intention of this document to suggest that corrosion-resistant steels be used for corrosion-resistant applications in other areas of a ship.

**2.6.2.2** Corrosion-resistant steels are similar to conventional ship construction steels in terms of chemical composition and mechanical properties.

**2.6.2.3** The weldability of corrosion-resistant steels is similar to the weldability of conventional ship construction steels and therefore normal shipyard welding requirements in terms of qualification by the approval of welding consumables and welding procedure qualification also apply.

### **2.6.3 Interpretations to 2.2 "Technical File" of PSPC-COT Alt.**

**2.6.3.1** The shipbuilder shall prepare and submit the Technical File to the Register for verification. If the applicable corrosion protection method varies for different locations, the information required for the Technical File shall include each location and corrosion protection method separately. Once verified, one copy of the Technical File shall be placed onboard the ship. The following construction records shall be included in the Technical File:

.1 copy of the Type Approval Certificate;  
.2 other technical data shall include:  
.2.1 detail of the brand of welding consumables and welding process used;  
.2.2 repair method. Only to be included when specially recommended by the manufacturer of corrosion resistant steel;

.3 application records:

.3.1 areas of application/location of corrosion-resistant steel;

.3.2 brand of corrosion-resistant steel and thickness.

[Paras 2.6.3.1.3.1](#) and [2.6.3.1.3.2](#) above may be substituted by the information given in the hull-related approved drawings. However, each brand of corrosion-resistant steel used and its location shall be indicated on the approved drawings, the drawings shall be included in the Technical File;

.4 test certificates and actual measured values of plate thickness of each corrosion-resistant steel, and individual welding conditions need not be included.

**2.6.3.2** After the ship enters service, the shipowner or operator shall maintain repair data in the Technical File for review by the Register. The information required shall include each location and corrosion protection method separately. These records shall include:

.1 where repairs are made in service to the cargo oil tank, in which corrosion-resistant steel is used, the following information shall be added to the Technical File:

- .1.1 areas of repair work;
- .1.2 repair method (replacement by corrosion-resistant steel or coating);
- .1.3 records of the brand of corrosion-resistant steel used, plate thickness and welding consumables (brand name and welding method) if corrosion-resistant steel is used);
- .1.4 records in accordance with Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91)), if coating is used;
- .2 repairs that require records to be maintained as mentioned in [2.6.3.2.1](#) above include the following:
  - .2.1 replacement by corrosion-resistant steel;
  - .2.2 application of coating on members, in which corrosion-resistant steel is used (including cases where corrosion-resistant steel is replaced with conventional steel and coating)<sup>1</sup>;
  - .2.3 repairs of pitted parts<sup>2</sup>;
- .3 plate thickness records during periodical surveys need not be recorded in the Technical File.

**2.6.4 Interpretations to 3.3 "Special Application" of PSPC-COT Alt.**

**2.6.4.1** Where other items of structure, such as appurtenances, are not clearly identified, the application of the PSPC-COT Alt to these items is described here.

**2.6.4.1.1** Means of access, to be used for ship inspections, which are not integral to the ship structure:

- .1 permanent means of access, which are not integral to the ship's structure include:
  - ladders;
  - rails;
  - independent platforms;
  - steps;
- .2 appropriate corrosion protection measures shall be adopted for permanent means of access mentioned in [2.6.4.1.1.1](#);
- .3 when corrosion-resistant steel is used, in principle, a corrosion-resistant steel of the same brand as used in the main structure shall be used for the means of access and the attachments;
- .4 when conventional steel is used, and is welded to corrosion-resistant steel, corrosion protection measures for the attachment and weld are recommended to be in accordance with IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91);
- .5 other corrosion protection measures shall be left to the discretion of the Register;
- .6 where other corrosion protection measures other than those stated above, for example cathodic protection are used, the performance of the corrosion-resistant steel of the surrounding structure shall not be impaired.

**2.6.4.1.2** Access arrangements integral to the ship's structure:

- .1 access arrangements that are integral to the ship structure (refer to 3.2.2 of the Annex to IMO resolution MSC.291(87)) mean access arrangements integral to the ship structure such as the items mentioned below, for access in the cargo oil tanks.

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<sup>1</sup> Details of coating on repairs to corrosion-resistant steel shall be recorded in the Corrosion Resistant Steel Technical File. In such cases, duplicates of these coating records do not need to be included in the Coating Technical File.

<sup>2</sup> The wastage limit of the pitted part or area shall be as deemed appropriate by the classification society and/or Register. However, the standard value of the permissible wastage amount shall be taken as about 40 % of the original thickness. In this case weld repairs are required. Only welding consumables approved for the relevant corrosion-resistant steel shall be used. The full depth of the pitting shall be filled up by the weld metal. If non-approved welding consumables are used, an appropriate area around the repaired part shall be coated suitably after the repairs in accordance with IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91).

Stiffeners and girders with increased depth for walkways;

.2 appropriate corrosion protection measures shall be adopted for access arrangement given in [2.6.4.1.2.1](#). If coating is applied, the provisions of Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91)) shall be followed. If corrosion-resistant steel is used on the above arrangements, in principle, corrosion-resistant steel of the same brand/type as that used in the cargo oil tanks, shall be used.

**2.6.4.1.3** Supporting members, etc.:

.1 is recommended that pipes and supporting members for measuring equipment or outfitting items that are not strength members of the hull be protected either by coating or by use of corrosion-resistant steel in accordance with the provisions of [2.6.4.1.1.4](#).

**2.6.4.1.4** Work attachments:

.1 in the case of attachments (conventional steel) used only during construction work such as hanging pieces, if welding consumables which are not indicated on the Type Approval Certificate of the corrosion-resistant steel are used, it is recommended that the welded part is coated in accordance with [Fig. 2.6.4.1.4.1](#).

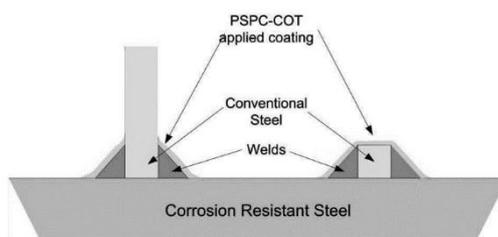


Fig. 2.6.4.1.4.1

Range of coating when work attachments are welded to corrosion-resistant steel

**2.6.5** Interpretations to 3.4 "Area of Application" of PSPC-COT Alt.

**2.6.5.1** Structural members in the crude oil tankers that require protection measures against corrosion are specified in IMO resolution MSC.289(87).

**2.6.5.2** Different methods of corrosion protection (coating and corrosion-resistant steel) may be adopted for (a) and (b) above. Moreover, a combination of different corrosion protection methods may be used for each of the structural members within the areas identified by (a) and (b).

**2.6.5.3** Acceptable combinations of corrosion protection methods are shown in [Table 2.6.5.3](#).

Table 2.6.5.3

**Acceptable combinations of corrosion protection methods**

Member		Lower surface of strength deck (a)	Upper surface of inner bottom plating (b)
Corrosion protection method	Case 1	Corrosion-resistant steel — Brand A <sup>1</sup>	Corrosion-resistant steel — Brand B <sup>1</sup>
	Case 2	Coating	Corrosion-resistant steel — Brand B <sup>1</sup>
	Case 3	Corrosion-resistant steel — Brand A <sup>1</sup>	Coating
	Case 4	Corrosion-resistant steel Brand C <sup>1</sup>	Corrosion-resistant steel Brand C <sup>1</sup>

<sup>1</sup> Corrosion-resistant steel and coating may be used on the same member.

**2.6.5.4** If different corrosion protection methods (coating and corrosion-resistant steel) are selected for either (a) or (b), the selected procedure for each member shall comply with the relevant performance standards.

**2.6.5.5** Where corrosion-resistant steel is used it shall be type approved by the Register (steel shall be supplied by the RS-recognized manufacturers). Welding technology and welding materials shall be approved by the Register.

**2.6.5.6** Where different brands of corrosion-resistant steels are used in the same structural member, refer to [Fig. 2.6.5.6](#), the weld joining the two different steels shall be coated. Coating shall be in accordance with Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91)). However, coating of the weld is not required if the welding consumable used to produce the weld has been subject to the necessary corrosion tests. In such a case, the Type Approval Certificate is required for both steel brands in association with the welding consumable used.

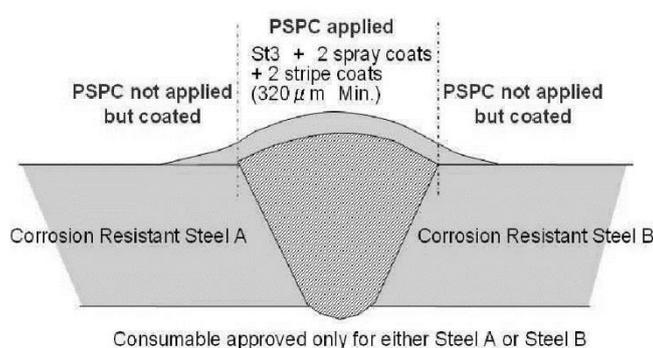


Fig. 2.6.5.6

**2.6.5.7** When corrosion-resistant steel and conventional steel are used together in an area where corrosion protection is necessary, refer to [Fig. 2.6.5.7](#), the conventional steel and the weld shall be coated in accordance with IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91).

**2.6.5.8** Where the welding consumable used is different from that indicated on the Type Approval Certificate of corrosion-resistant steel, in singular cases agreed by the Register the weld shall be coated in accordance with IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91) as amended by IMO resolution MSC.342(91), refer to [Fig. 2.6.5.8](#).

**2.6.6 Interpretations to 4 "Approval" of PSPC-COT Alt.**

**2.6.6.1** Approval procedure.

**2.6.6.1.1** The steel shall be approved and graded accordingly.

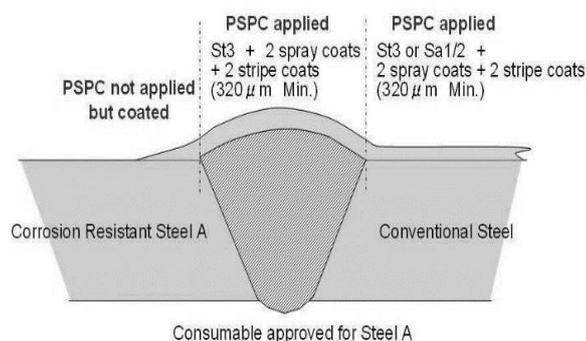


Fig. 2.6.5.7

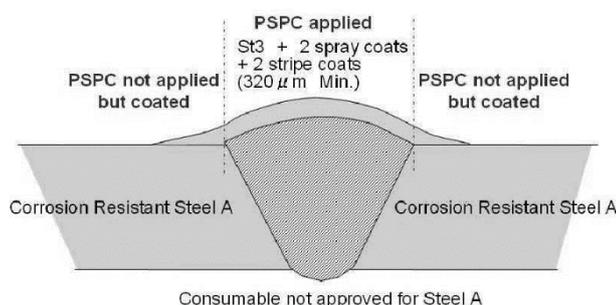


Fig. 2.6.5.8

**2.6.6.1.2** The approval procedure for corrosion testing of corrosion-resistant steel is described in the Annex to IMO resolution MSC.288(87).

**2.6.6.1.3** The RS recognition is not needed for the testing laboratory where the RS surveyor is present at specified stages to witness the approval tests.

**2.6.6.1.4** In case where the RS surveyor is not present at specified stages to witness the approval tests, the testing laboratory shall obtain the Recognition Certificate of Testing Laboratory.

**2.6.6.1.5** Where the scope of approval changes, for example for additions to the applicable welding consumables, the effects of these changes shall be subjected to corrosion resistance tests for the welded joints, specified in the Annex to IMO resolution MSC.288(87).

**2.6.6.2** The Recognition Certificate for Manufacturer (СПИ) for corrosion-resistant steel shall be issued as per [2.1](#).

**2.6.7 Interpretation to 5 "Inspection and Verification Requirements" of PSPC-COT Alt.**

**2.6.7.1** General requirements:

- .1 general requirements are as follows:
  - .1.1 corrosion-resistant steel type approved by the Register shall be used;
  - .1.2 welding consumables used shall be the brand specified on the RS-approved documentation;
  - .1.3 welding work shall be implemented according to the approved welding procedure;
  - .1.4 correct use of corrosion-resistant steel is verified by engineering review and survey;
  - .1.5 shipbuilder shall prepare a Technical File after the construction work has been completed, and submit it to the Register for verification;
  - .1.6 Technical File shall be maintained onboard the ship.

.2 if any of the items in [2.6.7.1.1.1 — 2.6.7.1.1.6](#) above are not complied with, the Register notifies the shipbuilder immediately who confirms the corrective action to be followed and its completion. The Cargo Ship Safety Construction Certificate shall not be issued until all required corrective actions have been closed to the satisfaction of the Register.

**2.6.7.2** Procedure applicable to new ships.

**2.6.7.2.1** Product inspection shall be carried out as part of material certification. The control range of the chemical composition is determined as follows:

.1 manufacturer shall supply data relating to the control of applicable chemical elements that the manufacturer has intentionally added or is controlling to improve corrosion resistance. Upper and lower limits for all such elements and any relationship between these elements shall be disclosed. The manufacturer shall obtain the RS approval for these additions and the relationships;

.2 effect of variation of each element shall be assessed by using sufficient corrosion tests to determine the effects of variation with variations of other elements used to enhance corrosion resistance;

.3 corrosion resistance test shall be conducted in accordance with Appendix of Annex 3 to IMO resolution MSC.289(87).

**2.6.7.2.2** Survey during the construction stage:

.1 the RS surveyor shall verify that corrosion-resistant steel has been used correctly at the appropriate locations;

.2 verification in [2.6.7.2.2.1](#) shall be implemented periodically, and the frequency shall be determined on assessment of quality control feedback of each shipyard. However, if some deficiency is found, the shipyard shall formulate the necessary remedial action with regard to both the deficient location and counter measures to be taken to improve inspection methods.

**2.6.7.3** Procedure applicable to ships in service.

**2.6.7.3.1** If the repair method is described in the Technical File, repairs shall be carried out in accordance with the said method.

**2.6.7.3.2** If corrosion-resistant steel or coated member shall be replaced, the same corrosion protection method to the one used during construction is recommended.

**2.6.7.3.3** If corrosion-resistant steel shall be used during repairs, use of the corrosion-resistant steel of the same brand as that used during construction is recommended.

**2.6.7.3.4** If conventional steel is used in a corrosion-resistant steel member that shall be replaced, coating shall be applied to the conventional steel. In this case, it is required that the coating complies with [3.4.3](#) of the Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91)), refer to [Fig. 2.6.5.7](#).

**2.6.7.3.5** The application of welding consumables to be used shall be confirmed by the RS-approved documentation of the relevant corrosion-resistant steel (brands of the welding consumables).

**2.6.7.3.6** If the welding consumables specified in the RS-approved documentation for the corrosion-resistant steel cannot be used, the weld shall be coated, refer to [Fig. 2.6.5.8](#). In this case, it is required that the coating complies with [3.4.3](#) of the Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91)).

**2.6.7.4** Welding considerations.

**2.6.7.4.1** Welding workmanship standards accepted for conventional steel may be used.

**2.6.7.4.2** An approved welding procedure shall be used for welding work as appropriate to the grades (excluding subscripts related to corrosion resistance), welding consumables, welding position and plate thickness, etc., of the corrosion-resistant steel to be used.

**2.6.8 Interpretation to PSPC-COT Alt Appendix "Test Procedures for Qualification of Corrosion Resistant Steel for Cargo Tanks in Crude Oil Tankers".**

**2.6.8.1 Test on simulated upper deck conditions:**

.1 test condition:

.1.1 chemical composition of the conventional shipbuilding steel used for test purposes (Table 1 in the Annex to IMO resolution MSC.289(87)) shall be based on ladle analysis given in the mill certificate. Steel complying with a national standard that meets the requirements of Table 1 is also acceptable (Appendix to IMO resolution MSC.289(87)). The chemical composition shall meet the requirements of the Recognition Certificate for Manufacturer (СПИ);

.1.2 all the base material specimens shall be located in one tank. Fig. 2 in the Annex to IMO resolution MSC.289(87) only shows locations of 20 specimens. The tank can be designed to hold 25 or more specimens; alternatively specimens can be added and removed as necessary so that the appropriate time periods are achieved within the total timescale of 98 days;

.1.3 since certain factors such as control and measurement of temperature and size of chamber may affect the corrosion rate achieved, it shall be confirmed that the corrosion rate of conventional steel in the conditions and equipment of the test, satisfies the rate criteria, before carrying out corrosion test for evaluation of corrosion-resistant steel;

.1.4 to remove specimens, the chamber shall be purged with 100 % nitrogen gas while the specimens are in the high temperature region until the specimens are dry;

.1.5 the cycling pattern of specimen temperature and temperature of distilled water shall be controlled such that each cycle is as identical as possible throughout the whole corrosion test period. These temperatures shall be recorded. [Refer to Fig. 2.6.8.1.1.5;](#)

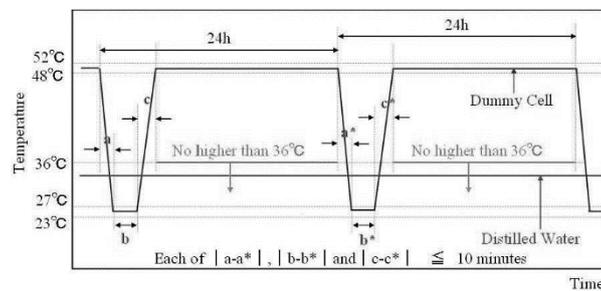


Fig. 2.6.8.1.1.5

Schematic view of temperature controlling accuracy of specimens and distilled water during corrosion test

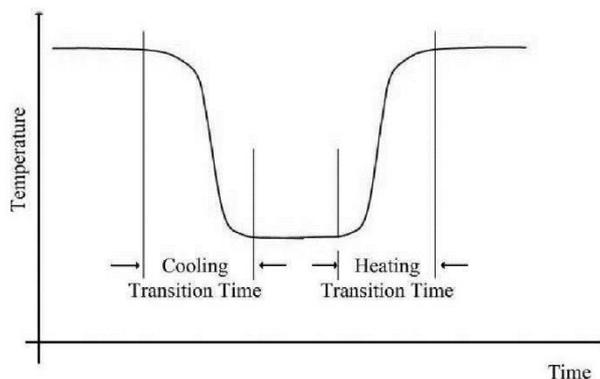


Fig. 2.6.8.1.1.6  
Transition time definition

.1.6 the transition time,  $a$ ,  $a^*$ ,  $c$  and  $c^*$  in [Fig. 2.6.8.1.1.5](#) is the time from when the cooling and heating commences until the lower or upper temperature is reached, refer to [Fig. 2.6.8.1.1.6](#). The transition of each cycle shall be as identical as possible throughout the whole corrosion test period;

.1.7 the temperature of both the specimens and the water shall be continuously recorded throughout the test;

.1.8 welded specimens may be tested with the parent material tests or tested separately against 5 conventional steel specimens;

.1.9 base metal shall be prepared such that the surface to be tested shall be taken from a position within 2 mm of one rolled surface. This surface shall be ground to bare steel and polished to 600 grit finish;

.1.10 for welded samples, a test assembly shall be made from the same steel cast as the base metal test in [2.6.8.1.1.9](#) but may be from a plate of different thickness. The assembly shall be welded using the process and consumable to be approved for use with the base metal. The surface to be tested shall be selected such that the width of weld metal, excluding heat affected zone, shall be between 10 and 20 mm. This surface shall be ground to bare steel and polished to 600 grit finish;

.1.11 specimens shall be weighed to an accuracy of  $\pm 1$  mg;

.1.12 where the calculated corrosion loss of conventional steel is less than 0,05 mm/year, the concentration of H<sub>2</sub>S may be increased in the simulated cargo oil tank gas. All tests will be carried out at this increased level;

.1.13 at least 3 values of individual weight loss of conventional steel shall be in the range of maximum  $X$  and minimum  $Y$  measured in grams:

$$X = (0,11 \times S \times D)/10; \quad (2.6.8.1.1.13-1)$$

$$X = (0,05 \times S \times D)/10 \quad (2.6.8.1.1.13-2)$$

where  $S$  = surface area, in cm<sup>2</sup>;  
 $D$  = density, in g/cm<sup>3</sup>.

#### 2.6.8.1.2 Test on simulated inner bottom conditions:

.1 test condition:

.1.1 the conventional steel used shall also meet the requirements of Table 1 in the Annex to IMO resolution MSC.289(87)) and [2.6.8.1.1.1](#);

.1.2 base metal shall be prepared such that one surface shall be taken from a position within 2 mm of one rolled surface. All surfaces shall be ground to bare steel and polished to 600 grit finish;

.1.3 for welded samples, a test assembly shall be made from the same steel cast as the base metal test in 2.6.8.1.2.5 but may be from a plate of different thickness. The assembly shall be welded using the process and consumable to be approved for use with the base metal. The surface to be tested shall be selected such that the width of weld metal, excluding heat affected zone, shall be between 10 and 20 mm. This surface shall be ground to bare steel and polished to 600 grit finishes;

.1.4 specimens shall be weighed to an accuracy of  $\pm 1$  mg;

.1.5 one specimen that has a corrosion rate deviating from the average corrosion rate by more than + 25 % may be eliminated from the results, provided that the cause of the

accelerated corrosion is demonstrated to be due to localized corrosion around the hanging hole and/or stamp (e.g. crevice corrosion, pitting corrosion, etc.).

**2.6.8.3 Interpretation of weld discontinuity.**

**2.6.8.3.1 Preparation of samples after corrosion test:**

.1 all five samples shall be prepared as follows:

.1.1 two full thickness specimens approximately 20 mm long×5 mm wide shall be sectioned with their principle axis perpendicular to the weld fusion line. Each specimen shall be located such that the weld fusion line is located approximately at its mid length ([refer to Fig. 2.6.8.3.1.1.1](#));

.1.2 the specimens shall be mounted in resin to allow polishing of the cross section. The specimens shall be etched in Nital after polishing to reveal the fusion boundary;

.1.3 a photomicrograph shall be taken at a magnification of approximately×100.

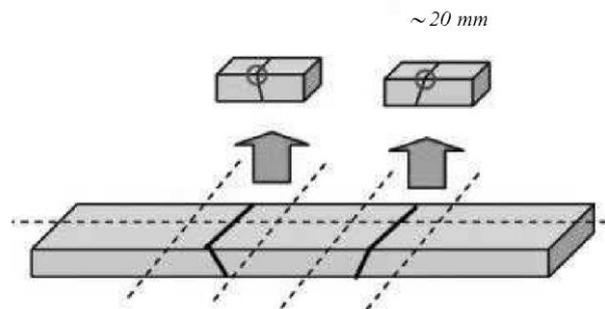


Fig. 2.6.8.3.1.1.1  
Sectioning plan

**2.6.8.3.2 Evaluation of depth step:**

.1 On the photomicrograph, construct a line A—B, perpendicular to the corrosion surface through the point where fusion line and the surface cross ([refer to Fig. 2.6.8.3.2.1](#));

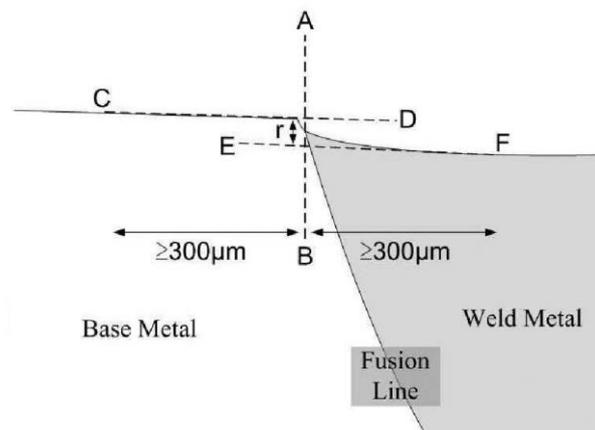


Fig. 2.6.8.3.2.1  
Determination of corrosion depth on photomicrograph

.2 construct two parallel lines C—D and E—F, one representing the higher level, the other the lower level. Each line shall be constructed over a distance of  $\geq 300 \mu\text{m}$  from line A—B on the base metal and weld metal side, respectively;

.3 measure the distance  $r$ , in mm, between the intersection point at line A—B and each average surface line on the photomicrograph;

.4 if the intersection point at line A—B and average surface line of welded metal part is above that of base metal part, then the existence of step shall be neglected for this sample;

.5 calculate the depth of discontinuous step  $R$ , in  $\mu\text{m}$ , from the actual photomicrograph magnification  $M$  as follows:

$$R = \frac{r \times 1000}{M} . \quad (2.6.8.3.2.5)$$

### 2.6.8.3.3 Evaluation of step angle:

.1 evaluation for angle of step is unnecessary if the depth of step calculated on both samples ([refer to 2.6.8.3.2](#)), are not greater than  $30 \mu\text{m}$  or if either step exceeds  $50 \mu\text{m}$  for a single specimen. Otherwise the angle of step shall be calculated as follows:

.1.1 produce a photomicrograph at a magnification of approximately 250X, ([refer to Fig. 2.6.8.3.3.1.1](#));

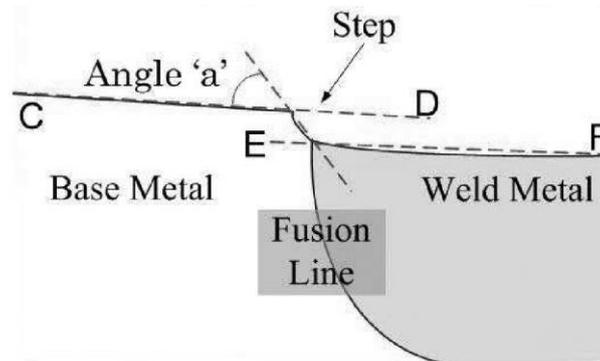


Fig. 2.6.8.3.3.1.1  
Calculation of step angle

.1.2 draw an average surface line C—D for base metal part and E—F for weld metal part;

.1.3 find the closest intersection point with the step of the base metal surface profile and the constructed line C—D and the closest intersection point with the step for weld metal constructed line E—F respectively, and connect those two intersection points;

.1.4 measure the angle 'a', in deg., given by the line C—D and the connected line described in [2.6.8.3.3.1.3](#) ([refer to Fig. 2.6.8.3.3.1.1](#)).

### 2.6.9 Acceptance criteria.

2.6.9.1 If the depth of both steps are less than or equal to  $30 \mu\text{m}$ , then the measurement of angle is unnecessary, and the sample is considered to be acceptable.

2.6.9.2 If the depth of steps on both photomicrographs are less than or equal to  $50 \mu\text{m}$  and in addition if both the measured angles are less than or equal to  $15^\circ$ , then the sample is considered to be acceptable.

2.6.9.3 If either of the conditions described in [2.6.9.1](#) or [2.6.9.2](#) above are not in compliance, the sample is considered to contain a "discontinuous surface" and fails the test.

2.6.9.4 Welds shall be evaluated as "without discontinuous surface" when all 5 corrosion test samples are considered acceptable.

## TECHNICAL SUPERVISION DURING SEPARATE TYPES OF TESTS

### 1. Microstructure and non-metallic inclusion content.

Macrosections shall be polished, free of cracks and surface "blockage" appearing at corners. Microstructure photographs shall be clear, zooming shall comply with the required value or shall be the greater if it is required for consistent assessment of fine-grained structures. Etching of sections shall enable microstructure assessment compliant to the requirement of national standards.

Generation of structure discontinuity in hot-rolled plate causes considerable spreading of mechanical properties, especially impact and even satisfactory delivery performance may lead to poor cold resistance performance. Such discontinuity may be a result of:

unsatisfactory metallurgic quality (large non-metallic inclusions or their accumulations exceeding 100  $\mu\text{m}$ /microns);

ferrite-pearlite striation with extended pearlite areas larger than 30  $\mu\text{m}$ ;

ferrite grains forming at the former large austenite grain boundaries inside of which the rack and lath bainite is formed;

available long areas of lath bainite, portion and length of which are more than the specified values.

The share of lath bainite is a parameter determining the temperature of a ductile-brittle transition ( $T_{kb}$ ), nil ductility test temperature (NDTT) for steels which structure includes the rack and pinion morphology bainite formed within the large non-recrystallized austenite grain.

The structural anisotropy coefficient features the structural peculiarities of steels with ferrite-bainite-aligned structure after thermomechanical treatment and accelerated cooling, being the parameter depending on  $T_{kb}$  as well as the crack tip opening displacement (CTOD)

Liquation streaks grade may affect the temperature of a ductile-brittle transition ( $T_{kb}$ ).

A volume fraction of tempered bainite with specific directed carbide phase line highlighted affects all the steel performance characteristics requiring the statistically correct analysis of the tempered bainite fine structure parameters in such specimens depending on the steel strength category.

### 2. Chemical compound

Specimens shall be free of surface contamination. The same refers to chip scraps selected for carbon content analysis.

Accuracy of values obtained shall be in accordance with the RS requirements. Where special requirements are absent, the devices shall be used with error as a minimum much lower than the required maximum values of impurities.

### 3. Tensile test.

The strength and ductility target parameter framing shall comply with the RS requirements.

Quality of the specimens manufacturing shall be checked with laying onto the plane. Round specimens shall be rolled to detect non-axiality in the functional and gripping parts. For flat test specimens an indentation shall be detected resulting in additional tensile bending. Length of the specimen functional parts between fillets  $L_c$  shall be above the design length  $L_0$ , at least diameter 0,5 d or cross-sectional area  $F$ , to eliminate the influence of the ends on the measured elongation value.

In case of mixed results, the cross-sectional specimen area size shall be used to calculate the strength characteristics measured at a cross-section closest to the sample breakdown point.

The laboratory shall be equipped with manual measuring instrumentation with centre-punching facilities and sample securing during measurements.

During test witnessing it is necessary to check the elastic modulus value at the initial elastic segment load diagram this integrally considering the quality of manufacture and installing the sample into testing machine. A deviation of  $\pm 10\%$  of the reference value for the specified material class is permissible.

During the tensile strength determination it is required to ensure that while processing test results, the reference point is selected corresponding to the global, rather than local, maximum load.

When using some types of grip, the initial compression load occurs with the sample compression. Initial load program reset in such a case is prohibited, otherwise the test result will be overestimated.

The yield stress value is rated in the RS rules as follows:

if the yield platform is available, the upper yield stress  $R_{eH}$  is rated and for this purpose an available extensometer (longitudinal deformation sensor) is not mandatory,

if the yield platform is absent, the yield stress equal to 0,2 % of plastic deformation  $R_{p0,2}$  is rated and for this purpose and available extensometer is not mandatory only in that case — when the straight initial elastic segment load diagram is present, intersection of which with X-axis is taken as the starting point of plastic deformation. Otherwise, (especially, during tests of high-strength steels) the available extensometer is mandatory as well as application of partial or full unloading after passing the yield stress (point) or initial diagram slope ("hysteresis module" technology),

for piping material the yield stress is rated as per the total deformation value, usually 0,5 % —  $R_{t0,5}$ , and for this purpose, use of extensometer is mandatory.

While calculating test results, if the movement is determined by the extensometer signal and to specify the elongation it shall be related to the initial length between the extensometer legs, which is considered to be known, if it was installed before the test with a gauge, or as compared with the initial length corresponding to the zero load on the load diagram. Software reset of the sensor signal at the start of the test load is not allowed (in equivalent to load reset). If the elongation is determined without the extensometer by the signal of cross-beams realignment, the distance between fillets  $L_c$  shall be taken.

Round specimens shall provide higher strength characteristics than flat test specimens in full thickness. The spread of strength characteristics is general within 30 MPa (for construction steel).

#### **4. The stress relieved tensile tests (tensile, impact, bending).**

The tests are carried out for base metal in thermomechanical treatment to check the structural changes after sensitization heating, and also for welded joints to verify possible welding of tackwelding and adjacent seams or rewelding. Standard scheme of thermal treatment includes the oven heat up to 400 — 450 °C, billet fitting, heating up to 580 °C at a rate of approx. 10 °C/min., exposure for 2,5 min per mm thickness, but not less than 2 h and air cooling. The exposure temperature may be agreed upon with another one (up to 650 °C).

The billets shall be thermally treated then the samples are made. Requirements for tests and review of results are similar to those without thermal treatment.

#### **5. Through thickness tensile test.**

To select the sample type the functional part diameter is essential. Pursuant to the Register rules the diameter of 6 mm is required up to rolled products' full-thickness of 40 mm and 10 mm above 40 mm. Length of the specimen functional parts between fillets shall be not less than 2,5 of the diameter. Thus, it is possible to test specimens from approx. 30 mm in length. For lesser thicknesses the specimens with welded-on gripping parts are used.

During tests the relative reduction in is rated at the point of fracture/impact. Through thickness tensile strength reduction shall be minor (up to 20 %) as compared with that obtained during routine tensile strength.

**6. Impact tests.**

The specimens surfaces shall be smooth (if it is not a rough face of the rolled products) and mutually perpendicular. The surface quality in notch shall be not worse than in the sides.

To check the notch location in the centre of the specimen length, two specimens are stacked side by side, then one specimen shall be deployed at 180° and checked whether the notch positions coincide.

The laboratory shall be equipped with the measuring instrumentation allowing to measure the section correctly prior to testing.

The notch depth, angle and radius with its tip shall be checked using an optical technique (projection microscope, sedigraph) with magnifying of no less than 50, provided with templates corresponding to the tolerances on the notch shape. Attention shall also be given to the available notch burrs and notch shape difference on the opposite sides of the sample.

The equipment may have "American" or "European" striker, varying in radius. The RS rules provide for the performance of tests on the "European" striker with a radius of  $2^{+0.5}$  mm. However, the differences in the results are minor and only visible at impact test.

While examining the impact machine, the condition of the anvil shall be examined and it shall be free from splits and burrs. The traces of contact with the anvil shall be identical on both halves of the test sample.

The percentage of fibrous component in the fracture of the specimen may be determined by measuring the crystal spot area with calipers or as compared with the reference collection of fractures for which the specified parameter was previously defined. Collections of fractures allow to perform correct measurement for a particular type of steel, if they are in good (not rusty) condition.

For welded samples it is necessary to check (at random) notch marking location as follows:

checking the notch location mark at the etched billet;

sample etching prior to test and monitoring of the notch position;

sample etching (of all surfaces) after test and monitoring of the notch position; This method is used only in the case of an ambiguous result.

**7. Impact test on non-aged specimens.**

The tests are carried out on the specimens cut out from pre-stretched billets with a section of approximately 12×12 mm, then heat treated. The plastic deformation percentage is rated during billet tensile test (5 or 10 %) and heat (thermal) treatment conditions. At 10 % of the residual plastic deformation required by RS, it ceases to be flat, a neck (crankpin journal) is formed on the billet/workpiece. Thus billets prior to tensile strength test shall be centre-punched with increments of 10 mm to verify the achieved tensile deformation. It is recommended to apply dual legged centre-punch at a distance of 10 mm from each other. Journal area (if any) shall be deleted.

Heat treatment conditions: uniform heating up to 250 °C, exposure for 1 h, air cooling. Both the billets and finished specimens may be heat treated.

Requirements for tests and review of results are similar to normal impact testing.

**8. Weld joint hardness test.**

It shall be carried out on the Vickers hardness tester. The recommended load is 49 N, not 98 N, making it possible to put the prints closer to each other (important for the HAZ examination at the fusion line). During manufacture of sections overburning is not allowed while cutting out the billets. The section surface shall be in condition after polishing and

etching. Polishing provides absence of scratches. Etching shall be weak to identify the seam boundaries but not to bring in the etched out relief.

The hardness test lines "at the surface" shall be located 1 — 2 mm from the rolled surface, regardless of the height of the weld reinforcement.

In case of obtaining the single hardness value (one of three measurements located in one place relative to the seam), two additional measurements are allowed. If the single value has not repeated, it shall be omitted from consideration.

**9. Base metal and welded joints bend.**

The required bending angle of the base metal is 180° (to the alignment of sides), for welded samples located across the weld — 120°. The angle is measured in the unloaded sample condition.

During certification tests of rolled products and their welded joints to receive Recognition Certificate for Manufacturer (СПИ), the bend mandrel diameter shall be equal to:

Minimal guaranteed yield strength of base metal, MPa	Mandrel diameter $D$ on face/root bend ( $T$ — thickness of test specimen)	Side bend mandrel diameter, mm (thickness of test specimen — 10 mm)
not exceeding 390	$2T$	30
420 — 620	$4T$	40
690 and above	$6T$	60

As a rule, the base metal shall be tested in full thickness. If impossible, the specimen test of 25 mm thick is allowed rough side outward. Face bend tests of welded samples located across the weld is allowed to perform on samples in full thickness up to 25 mm or turned to 25 mm at a greater thickness of the weld. Tensile test specimen surface shall have removed reinforcement and weld/seam undercuts.

Reviewing the welded sample testing results, cut out across the weld, the bend is possible with angular distortions (sharp elbow) or "tray", which indicates a discrepancy between the weld and base metal strength. In this case, the prescribed bend radius may not be observed. The certificate specifications of the base metal and welding consumables shall be verified to ensure that the samples comply with the RS rules

**10. Determination of nil ductility test temperature (NDTT).**

The anvil condition shall be checked by measuring the distance of the permissible specimen indentation. For this purpose, the specimen is placed on the anvil sideways and measure the distance from it to the stop, which shall be 7,6 mm for specimens of type P-1, 1,5 mm for P-2 and 1,9 mm for P-3. Allowance  $\pm 0,05$  mm.

The impactor shall be flattened and free of cracks.

The impact machine energy shall be selected according to the actual yield strength of the tested material according to the certificate specifications. If the anvil prints on test samples are absent, the result is non-offsettable and the impact machine energy shall be increased.

The specimen rough face in the notch plane shall not have brands and cuttings. Bead shall have proper brittleness — a crack in it shall be formed at a temperature not lower than NDT +60 °C.

During the tests, the sample temperature control and the time from its termination to the test (within 10 s) shall be checked.

If shrinkages are available on rough face of the test specimen in the notch plane or other doubts as a result of the test, the sample shall be statically opened with a three-point bend to control the crack shape and size. It is recommended to paint it thermally before.

**11. Determining the temperature of a ductile-brittle transition  $TKB$ .**

The notch in specimens shall not have sharp corners. The loading speed of the test specimen shall be 1 mm/s.

Assessment of fibrous component in the fractures is performed by measuring the spot area of the crystal component with manual measuring instrumentation to the nearest 5 — 10 mm<sup>2</sup> and with the fracture photos. Assessment variance shall be within 5 %. Assessment by photo is preferable.

For high strength steels, the fracture crystal component may be slightly different from the fiber (the so-called "dry crystal"). One shall make sure that operators are familiar with such type of fracture, either to perform a low temperature test to get a certain crystal fracture for reference.

## **12. Determining crack resistance parameter CTOD.**

### **12.1 Sampling**

The test samples shall be taken in accordance with a program approved by the RS. Sample cutting is prohibited on scissors.

### **12.2 Sample welding**

K-edges preparation for welding. Edges shall be made during mechanical procedure should be mechanically performed (as a minimum, a straight edge). Welding of certification samples shall be performed with the use of welding consumables, ensuring a relatively high crack arrest toughness at test temperature, so as not to distort the HAZ results (special consideration shall be given to that the certificate specifications of the welding consumables on crack tip opening displacement (CTOD) and with impact test refer to "appropriate" heat input during welding).

For minimum heat input it is recommended to use semiautomatic welding technique in gas-shielded environment (with shielding gas) with flux cored arc welding (welding in a mixture of M21 is preferable to welding in argon), and for the maximum - automatic submerged-arc welding. Automatic submerged-arc welding is usually performed on the lifting for high-quality weld formation.

Certification welding shall be accompanied by the preparation of Welding Procedure Specification — WPS ATP and technological charts indicating the actual welding parameters of each joint.

Welded joints shall provide the minimum weld joint defects in the weld straight edge area.

### **12.3 Test specimen preparation**

It is allowed to test specimens made from welded joints having angular deformations, as well as samples made from pipe with remaining bending, if their installation on the test machine is possible. However, this makes it difficult to obtain a valid form of fatigue crack. Nevertheless, it is preferred to use samples with a thickness close to the billet full thickness after test specimen straightening. Test specimen straightening shall be made after cutting the weld card prior to machining. Metal deformation subjected to straightening is permitted within 5 %.

Samples for three-point bending (SENB type) are used for certification tests.

All samples shall be made from the material in the final heat treatment condition. When testing samples of weld joint metal shall be considered the time is considered between the sample welding and testing, as it can determine the hydrogen content in the metal to reduce its viscosity.

Attention shall be paid to the samples to be cut exactly perpendicular to the weld seam, not the card edge, otherwise getting to the HAZ desired structure is difficult.

The rectangular section sample shape shall be provided (to maintain tolerances on perpendicularity of sides). Cutting alongside the welded sample shall be performed after marking the notch location in the weld. It is allowed not to cut along the length, if it does not exceed the required value within 30 %.

The notch shall be marked on the welded samples so that the crack tip is located along its possible greatest front length in a local structure having presumably the lowest viscosity, while it may not be perpendicular to the specimen lateral faces (within 10°). Two critical

structures are investigated: 3TB 1 — heat affected zone and maximum overheating zone at the fusion line, having the largest grain size, and 3TB 2 - near the border of intercritically and subcritically heat affected zone at a distance from the fusion line. Before marking-out and the notch location the etching and metal structural examination in the heat affected zone shall be performed. The notch location shall be marked after each tested segment of the welded joint the transverse macrosections were cut out, etched and investigated, and the required structure is confirmed to be present at the expected fatigue crack front in sufficient quantities.

Samples cut out from welded joints, as well as from billets/test specimens straightening, have residual stresses, presence of which can lead to uneven growth of fatigue cracks. It is recommended to use for them the method of local edging.

#### **12.4 Growth of fatigue crack**

It shall be carried out using a transducer or servohydraulic machine. The maximum cycle loads shall not be exceeded. Quality crack growth load cycling relates to 30000 — 00000 load cycles.

#### **12.5 Testing and procession results**

The test machine shall have the outfit for specimen alignment in the cryo-chamber or liquid bath, sensors and diagram recorders "load — opening notch mouth" and "load — displacement along the load line".

The sample temperature control shall be considered.

Measurement of the crack length in the fracture after test is carried out at nine equally spaced points with manual measuring instrumentation.

It is easier to check the elastic modulus in the initial loading segment to be calculated in the tests for the three-point bending by the formula

$$E = (1 - \mu^2) \frac{6La}{C_v t b^2} (1,45 - 2,18\gamma + 5,96\gamma^3 - 36,9\gamma^4 + 70,7\gamma^5),$$

where  $\mu$  — Poisson ratio,

$L$  — span between supports,

$a$  — average measured crack length in the fracture,

$t$  — thickness of test specimen

$b$  — depth below notch,

$\gamma = a/b$ ,

$C_n$  — diagram yield "load — opening notch margins", i.e. the incremental ratio of crack opening and load.

Like in tensile tests, the module integrally controls the correctness of measurements and calculations.

When processing the results, evaluation of "jumps" on the loading diagram is most difficult, meaning the simultaneous rapid growth of the opening and drop in load with its further growth. For modern steels in the thermomechanical treatment, jumps may be related to the metal splitting during the test. The standards do not specify whether these events shall be considered. Formally, any jump that causes the load curve slope tangent to drop by 5 % or over is significant and the test may be terminated.

While processing the results, the proper choice of the material yield strength for calculations shall be made, which shall correspond to the metal structure for the notch to pass, and the test temperature.

### **3 NON-METALLIC MATERIALS**

#### **3.1 PROCEDURE FOR APPROVAL OF PROTECTIVE COATINGS FOR HULL STRUCTURES**

##### **3.1.1 General.**

**3.1.1.1** This Section establishes the procedure for approval of the following protective coatings:

anticorrosive protective coatings of hull structures (for ballast tanks, cargo oil tanks of crude oil tankers, cargo spaces, hatch coamings and hatch covers of bulk carriers);

anti-fouling coatings of ship's hulls;

primer coatings not removed before welding in compliance with the requirements of 2.1.9, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships;

ice-resistant coatings;

primary deck coverings and other finishings complying with the requirements of 2.1.1.6 and 2.1.1.7, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships.

**3.1.1.2** The approval procedure comprises the following stages.

**3.1.1.2.1** Review and approval of the documentation defining the coating properties, composition and characteristics (technical conditions, specification, technical data sheet, technological regulations, instructions or descriptions, etc. as appropriate), of the protocols and/or reports on qualification tests, and of the program on coating check tests. The documentation shall take into account the requirements of the RS rules, international conventions, IMO resolutions, etc. The technical documentation is approved for the purpose of determining parameters established in it.

The qualification tests confirm the compliance of coatings with the requirements of the international conventions, IMO resolutions, RS rules, etc.

Such tests shall be carried out in the testing laboratories recognized by the Register or in the accredited laboratories and witnessed by the RS surveyor. The Register may accept results of the tests carried out in the laboratories recognized by other classification societies, Administrations and other authorized organizations or under their technical supervision.

Check tests are carried out to verify the conformity of type material for the coating produced by the manufacturer to the RS-approved documentation. Such tests shall be carried out at the manufacturer in the presence of the RS surveyor. Program of coating check tests shall include verification of main characteristics of the coating. The extent of tests is subject to agreement with the Register.

If the manufacturer cannot conduct testing of any individual coating properties and characteristics included into the program, these tests may be performed in the specialized laboratory upon agreement with the Register. In most cases the extent of check tests shall correspond to the extent of acceptance tests of the coating generally performed for each batch at the manufacturer.

**3.1.1.2.2** The survey of the coating manufacturer for compliance with Section 8, Part I "General Regulations for Technical Supervision".

**3.1.1.2.3** RS surveyor's participation in coating tests according to the approved program.

**3.1.1.2.4** Issuance of the Certificate for the coating with the positive survey results (refer to Section 5, Part I "General Regulations for Technical Supervision").

**3.1.1.2.5** When the products are manufactured under the same name (trade mark) at different subsidiaries of the manufacturer (locations, facilities), each subsidiary of the manufacturer shall be certified ([3.1.1.2.2](#)) and check tests of the announced manufactured

products shall be performed ([3.1.1.2.3](#)). The results of the qualification tests performed for one trade mark of the products at one of the subsidiaries of the manufacturer may apply to the similar products of other subsidiary of the same manufacturer (refer to special requirements of [3.2.7.2.5.17](#) and [3.3.7.2.4.1](#)).

**3.1.2 Anticorrosive protective coatings of hull structures.**

**3.1.2.1** The documentation being submitted for approval, which defines the coating properties, composition and characteristics, shall also contain the following data:

type of a coating system (hard — epoxy, etc., semi-hard);

coating colour;

data on incompatibility with different media and/or cargoes;

application for structures being heated by sun rays or being boundaries of heated cargo spaces;

data on compatibility with the anodic protection against corrosion;

data on satisfactory coating performance. If these are lacking, the coating shall be tested according to the agreed standards for fitness for operational conditions (e.g. immersion test, accelerated hot salt fog test and adhesion test).

**3.1.2.2** The documentation being submitted for approval shall include the following.

**3.1.2.2.1** The Manufacturer's Technical Data Sheet for each coating component.

**3.1.2.2.2** The instruction (standard, recommendations) on surface preparation for coating application which, as a minimum, shall specify:

that the instruction is based on recommendations of IMO resolution A.798(19);

methods of surface preparation;

ambient conditions if abrasive cleaning is used (relative humidity within 85 %, the steel temperature is at least by 3 °C above the dew-point temperature, absence of moisture or condensation signs);

procedures and extent of examinations of surface preparation;

assessment criteria for surface preparation.

**3.1.2.2.3** The instruction (standard, recommendations) on coating application which, as a minimum, shall specify:

environment conditions during application of a coating system;

coating procedures;

thickness of each coating layer (wet and dry);

time interval between surface drying and application of the next coating layer;

use and amount of thinners;

controllable and set parameters during coating;

extent and periodicity of control;

repair of defective or damaged areas.

**3.1.2.2.4** Information on potential risks for health and on precautions needed during coating (Material Safety Data Sheet).

**3.1.2.2.5** The firm's (manufacturer's) procedure on in-service maintenance shall contain, as the minimum, the information on:

recommended frequency of in-service examinations of the coating by the shipowner;

ways to rectify defects identified during in-service examinations;

compatibility of the applied coating with the coatings used for repairs.

It is recommended that the procedure shall take into account:

IMO circular MSC.1/1330 "Guidelines for Maintenance and Repair of Protective Coatings"; and/or

IACS recommendation No. 87 "Guidelines for Coating Maintenance and Repairs for Ballast Tanks and Combined Cargo/Ballast Tanks on Oil Tankers"(June 2004/Rev.1

June 2006/Rev.2 May 2015) (the document is available on the IACS website [www.iacs.org.uk](http://www.iacs.org.uk)); and/or

IMO circular MSC.1/Circ.1399 "Guidelines on Procedures for In-Service Maintenance and Repair of Coating Systems for Cargo Oil Tanks of Crude Oil Tankers".

**3.1.2.2.6** The form of a coating manufacturer's quality certificate issued for each batch (delivery) of the coating which specifies the following;

- the firm (manufacturer) name;
- date of manufacture;
- amount and identification data of the batch delivered;
- coating characteristics (type, brand, colour, etc.).

**3.1.2.3** Semihard coatings shall have the following properties:

- application shall be possible within a wide temperature range;
- the service limit shall be minimum 65 °C;
- good penetration qualities;
- where applicable suitable for bonding to moist surfaces, e.g. water jetted/hydroblasted surfaces according to manufacturer's recommendations;
- flexible properties throughout the service life;
- resistant to foot traffic allowing easy access for inspection purposed;
- resistant to ballast water;
- ability to prevent corrosion for at least three years;
- the wet film thickness shall have an upper limit in order to avoid covering of cracks and slipperiness caused by excessive film thickness;
- light colour coating (distinguishable from rust) is preferable;
- some semihard coatings may also minimize corrosion by passivating the metal surface with a corrosion inhibitor whilst also forming a film to prevent passage of moisture.

**3.1.2.4** Protective coatings for sea water ballast tanks of all the shiptypes and for double side spaces of bulk carriers are approved according to IMO resolution MSC.215(82).

**3.1.2.5** Protective coatings for cargo oil tanks of crude oil tankers (refer to IMO resolution MSC.291(87)) are approved according to IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91).

### **3.1.3 Antifouling coatings of ship's hull.**

**3.1.3.1** The documentation being submitted for approval, which defines the coating properties, composition and characteristics, shall also contain the following data:

- type of the antifouling system<sup>1</sup>;
- name of the antifouling system manufacturer;
- name and colour of the antifouling system;
- active ingredient(s) and its (their) number(s) by the database "Chemical Abstract Service" (CAS number(s));
- detailed marking of packing containers used for coating delivery.

**3.1.3.2** The documentation being submitted for approval shall include:

- technical data for the coating (technical conditions, specifications, Data Sheet);
- material safety data (Material Safety Data Sheet) (such data may be also contained in technical conditions, specification));
- coating manufacturer's certificate (quality certificate for coating) issued for each batch (delivery) of the coating, which shall provide for the above data;

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<sup>1</sup> Examples of appropriate wordings: self-polishing type without tinny organic compounds, ablativ type without tinny organic compounds, common type without tinny organic compounds, silicone type biocide-free paint, etc. Regarding the antifouling system containing no active ingredients, the words "biocide-free" shall be used.

records of qualification tests (analysis) of specimens confirming absence of organotin compounds and cybutryne in the coating (refer to [3.1.3.3](#)).

**3.1.3.3** Sampling and qualification tests (analysis) of specimens, confirming absence of organotin compounds and cybutryne in the coating, shall be carried out in the testing laboratory recognized by the Register. Where the latter is unavailable, the sampling and analysis shall be performed at the attendance of the RS surveyor. The Register may accept results of the tests carried out under ACS technical supervision (refer to [3.1.1.2.1](#)).

**3.1.3.3.1** As an alternative to the qualification tests, statistical data of given coating analyses may be considered (refer also to [3.1.1.2.1](#)).

**3.1.3.3.2** The analysis with regard to the total content of tin and cybutryne per kilo of dry paint is recommended to carry out by applying mass spectrometry with inductively coupled plasma (ICP/MS) and gas chromatography — mass spectrometry (GC-MS). Any other scientifically-recognized procedure for the tin analysis (e.g. AAS, XRF and ICP-OES) is also acceptable.

**3.1.3.3.3** The analysis results shall be consistent with the requirements of 6.5.2.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**3.1.3.4** If the testing laboratory carrying out the regular analysis of coating tin content belongs to the coating manufacturer, that testing laboratory shall be surveyed simultaneously with the manufacturer according to Section 10, Part I "General Regulations for Technical Supervision".

**3.1.3.5** Issuance of RS Certificates.

The Certificate for the anti-fouling coating shall contain the following technical parameters: type of anti-fouling system, colour(s) and active ingredient(s) and its (their) number(s) by the database "Chemical Abstract Service" (CAS number(s)) ([refer to 3.1.3.1](#)). The following entry shall be made in the Certificate: "This approval does not cover other coating properties, such as anti-fouling performance, service life, corrosion protection, health, etc.".

## **3.2 PROCEDURE FOR APPLICATION OF PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR DEDICATED SEAWATER BALLAST TANKS IN ALL TYPES OF SHIPS AND DOUBLE-SIDE SKIN SPACES OF BULK CARRIERS IN COMPLIANCE WITH SOLAS-74 REGULATION II-1/3-2 (IMO RESOLUTION MSC.215(82))**

**3.2.1** This Chapter supplements provisions of the Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in all Types of Ships and Double-Side Skin Spaces of Bulk Carriers in compliance with SOLAS-74 Regulation II-1/3-2 adopted by IMO resolution MSC.215(82) (hereinafter referred to as "PSPC").

This Chapter shall be read in conjunction with PSPC.

**3.2.2** Interpretations to para 2.6, Section 2 "Definitions" of PSPC.

**3.2.2.1** "GOOD" condition is defined as condition with spot rusting on less than 3 % of the area under consideration without visible failure of the coating. Rusting at edges or welds shall be on less than 20 % of edges or welds in the area under consideration.

**3.2.2.2** Coating Technical File (CTF) is a term used for the collection of documents describing issues related to the coating system and its application from the point in time when the first document is provided and for the entire life of the ship, including the inspection agreement and all elements of PSPC 3.4.

**3.2.3** Interpretations to 3.2, Section 3 "General Principles" of PSPC.

**3.2.3.1** Inspection of surface preparation and coating processes agreement shall be signed by shipyard, shipowner and coating manufacturer and shall be presented by the

shipyard to the Register for review prior to commencement of any coating work on any stage of a new building and at least shall comply with PSPC.

**3.2.3.2** To facilitate the review, the following documents from CTF shall be available: coating specification including selection of areas (spaces) to be coated, selection of coating system, surface preparation and coating process; RS Certificate for the coating system.

**3.2.3.3** The agreement shall be included in CTF and shall at least cover: inspection process, including scope of inspection, list of persons carrying out the inspection, qualifications of the coating inspector and appointment of a qualified coating inspector (responsible for verifying that the coating is applied in accordance with PSPC). Where more than one coating inspector is involved, then their areas of responsibility shall be identified (for example, multiple construction sites);

language of the agreement shall be identical to the language used in CTF.

**3.2.3.4** Any deviations in the procedure relative to PSPC noted during the review shall be raised with the shipyard, which is responsible for identifying and implementing the corrective actions.

**3.2.3.5** The Passenger Ship Safety Certificate or Cargo Ship Safety Certificate or Cargo Ship Safety Construction Certificate shall not be issued until all the corrective actions required are implemented and submitted to the Register.

**3.2.4 Interpretations to 3.4 "Coating Technical File", Section 3 "General Principles" of PSPC.**

**3.2.4.1** The shipyard is responsible for compiling CTF either in paper or electronic format, or a combination of the two.

**3.2.4.2** CTF shall contain all the information required by PSPC 3.4 and the inspection of surface preparation and coating processes agreement (refer to PSPC 3.2).

**3.2.4.3** CTF shall be reviewed for content in accordance with PSPC 3.4.2.

**3.2.4.4** Any deviations found under [3.2.4.3](#) shall be raised with the shipyard, which is responsible for identifying and implementing the corrective actions.

**3.2.4.5** Para [3.2.3.5](#) shall apply.

**3.2.5 Interpretations to 3.5 "Health and safety", Section 3 "General Principles" of PSPC.**

**3.2.5.1** In order that the document should meet the provisions of PSPC 3.5, it is recommended to supplement CTF with the manufacturer's relevant documentation relating to health and safety aspects, such as the Material Safety Data Sheet.

**3.2.6 Interpretations to 4.3 "Special application", Section 4 "Coating Standard" of PSPC.**

**3.2.6.1** The guidelines of the IMO MSC.1/Circ.1279 of 23 May 2008 "Guidelines for Corrosion Protection of Permanent Means of Access Arrangements" shall be taken into consideration.

**3.2.7 Interpretations to the Table 1, PSPC.**

**3.2.7.1** Reference standards.

Reference standards in Table 1, PSPC are mandatory.

**3.2.7.2** Paragraph 1.3 "Coating prequalification test".

**3.2.7.2.1** Procedure for coating system approval.

Type Approval Certificate showing compliance with the PSPC Section 5 requirements shall be issued if the results of either method A + D, or B + D, or C + D (see below) are found satisfactory by the Register.

The Type Approval Certificate shall indicate the product and the shop primer tested. The Type Approval Certificate shall also indicate other type approved shop primers with which the

product may be used and which have undergone the cross over test in a laboratory meeting the requirements specified in [3.2.7.2.2.1](#).

The Technical Data Sheet showing all the information required by PSPC 3.4.2.2 shall be attached to the Type Approval Certificate.

For winter type epoxy a separate pre-qualification test is required, including shop primer compatibility test according to Annex 1 to PSPC. Winter and summer type coatings are considered different, unless infrared (IR) identification and specific gravity (SG) data demonstrate that they are the same.

**3.2.7.2.2 Method A: laboratory test.**

**3.2.7.2.2.1** Coating pre-qualification tests shall be carried out, as noted below, by a test laboratory, which is recognized by the Register and meets the requirements of Section 8, Part I "General Regulations for Technical Supervision".

**3.2.7.2.2.2** The results of pre-qualification testing (refer to 1.3, PSPC Table 1) for the coating system shall be documented and submitted to the Register.

**3.2.7.2.2.3** Type approval tests shall be carried out for the epoxy based system with the stated shop primer in accordance with PSPC Annex 1. If the tests are satisfactory, a Type Approval Certificate will be issued to include both the epoxy and the shop primer. The Type Approval Certificate will allow the use of the epoxy either with the named shop primer or on bare prepared steel<sup>1</sup>.

**3.2.7.2.2.4** An epoxy based system may be used with shop primers other than the one with which it was originally tested, provided that the other shop primers are approved as part of a system, 2.3 and 3.2, PSPC Table 1 and have been tested to 1.7, Annex 1 to Appendix 1, which is known as the "Crossover Test". If the test or tests are satisfactory, a Type Approval Certificate shall be issued. In this case the Type Approval Certificate will include the epoxy details and a list of all shop primers with which it has been tested that have passed these requirements. The Type Approval Certificate will allow the use of the epoxy either with the named shop primer or on bare prepared steel<sup>1</sup>.

**3.2.7.2.2.5** Alternatively the epoxy can be tested without shop primer applied on bare prepared steel to the requirements of Annex 1 to PSPC. If the test or tests results are satisfactory, a Type Approval Certificate will be issued. In this case the Type Approval Certificate will just record the epoxy. The Certificate will allow the use of the epoxy on bare prepared steel only. If in addition crossover tests are satisfactorily carried out with the shop primers which are approved as part of the system, the Type Approval Certificate shall include the details of the shop primers, which have satisfactorily passed the crossover test. In the latter case, the Type Approval Certificate will allow the use of the epoxy either with the named shop primer or on bare prepared steel<sup>1</sup>.

**3.2.7.2.2.6** The Type Approval Certificate is invalid if the formulation of either the epoxy or the shop primer is changed. It is the responsibility of the manufacturer to inform the Register immediately of any changes to the formulation.

**3.2.7.2.2.7** For the coating pre-qualification test, the measured average dry film thickness (DFT) on each prepared test panels shall not exceed a nominal DFT (NDFT) of 320 microns plus 20 % unless a paint manufacturer specifies a NDFT greater than 320 microns. In the latter case, the average DFT shall not exceed the specified NDFT plus 20 % and the coating system shall be certified to the specified NDFT, if the system passes the tests according to Annex 1 of IMO resolution MSC.215(82). The measured DFT shall meet the "90/10" rule and the maximum DFT shall be always below the maximum DFT value specified by the manufacturer.

This paragraph shall apply to tests carried out on 1 July 2012 or later.

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<sup>1</sup> It is recommended to indicate in the Type Approval Certificate that the coating is allowed to use on bare prepared steel.

**3.2.7.2.3** Method B: 5 years field exposure.

**3.2.7.2.3.1** Coating manufacturer's records, which shall at least include the information indicated in [3.2.7.2.3.2](#), shall be examined to confirm coating system has 5 years field exposure, and the current product is the same as that being assessed.

**3.2.7.2.3.2** The following manufacturer's records shall be submitted:

original application records;

original coating specification;

original technical data sheets;

current formulation's unique identification (code or number);

if mixing ratio of the base and curing agent has changed, a statement from the manufacturer is needed confirming that the composition of the mixed product is the same as the original composition. It shall be accompanied by an explanation of the modifications made;

current technical data sheets for the current product;

SG and IR identification of the original product;

SG and IR identification of the current product;

statement from the manufacturer confirming that the current product is the same as the original, if SG and IR identification data cannot be provided.

**3.2.7.2.3.3** Either class survey records from the Register or a joint (coating manufacturer/RS surveyor) survey of all ballast tanks of a selected ship shall be carried out for the purpose of verification of compliance with the requirements of [3.2.7.2.3.1](#) and [3.2.7.2.3.7](#). The reporting of the coating condition in both cases shall be in accordance with Section 2 of IACS recommendation No. 87 "Guidelines for coating maintenance and repairs for ballast tanks and combined cargo/ballast tanks on oil tankers" (June 2004/Rev.1 June 2006/Rev.2 May 2015) (the document is available on the IACS website [www.iacs.org.uk](http://www.iacs.org.uk)).

**3.2.7.2.3.4** The ship selected for testing shall have ballast tanks in regular use, of which:

at least one tank is approximately 2000 m<sup>3</sup> or more in capacity;

at least one tank is adjacent to a heated tank;

at least one tank contains an underdeck exposed to the sun.

**3.2.7.2.3.5** In case the selected ship does not meet the requirements specified in [3.2.7.2.5.3](#), the limitations shall be clearly stated in the Type Approval Certificate. For example, "The coating cannot be used in tanks adjacent to heated tanks or underdeck or tanks with volume greater than the size surveyed".

**3.2.7.2.3.6** In all cases of approval by Method B, the shop primer shall be removed prior to application of the approved epoxy based system coating, unless it can be confirmed that the shop primer applied during construction is identical in formulation to that applied in the selected ship used as a basis of the approval.

**3.2.7.2.3.7** All ballast tanks shall be in "GOOD" condition excluding mechanical damages, without touch up or repair in the prior 5 years of operation.

"GOOD" condition is defined as condition with spot rusting on less than 3 % of the area under consideration without visible coating damage. Rusting at edges or welds shall be on less than 20 % of edges or welds in the area under consideration ([refer to 3.2.2.1](#)).

Examples of how to report coating conditions with respect to areas under consideration shall be as those given in IACS recommendation No. 87 (June 2004/Rev.1 June 2006/Rev.2 May 2015) (the document is available on the IACS website [www.iacs.org.uk](http://www.iacs.org.uk)).

**3.2.7.2.3.8** If the applied NDFT is greater than required by PSPC, the applied NDFT shall be the minimum to be applied during construction. This shall be prominently reported in the Type Approval Certificate.

**3.2.7.2.3.9** If results of the survey are satisfactory, a Type Approval Certificate shall be issued to include both the epoxy based system and the shop primer. The Type Approval

Certificate will allow the use of the epoxy either with the named shop primer or on bare prepared steel<sup>1</sup>. The Type Approval Certificate shall reference the survey report, which shall also form part of CTF.

**3.2.7.2.3.10** The Type Approval Certificate is invalid if the formulation of either the epoxy based system or the shop primer is changed. It is the responsibility of the manufacturer to inform the Register immediately of any changes to the formulation.

**3.2.7.2.4** Method C: existing Marintek<sup>2</sup> B1 approvals.

**3.2.7.2.4.1** Epoxy based coating systems with existing satisfactory Marintek test reports minimum level B1, including relevant IR identification and SG, issued before 8 December 2006 can be accepted. If original SG and IR documentation cannot be provided, then a statement shall be provided by the manufacturer confirming that readings for the current product are the same as those of the original.

**3.2.7.2.4.2** The Marintek test report with IR and SG information shall be reviewed and if satisfactory, a Type Approval Certificate shall be issued. The Type Approval Certificate shall allow the use of the epoxy either with the named shop primer, unless there is evidence to indicate that it is unsuitable, or on bare prepared steel<sup>1</sup>.

**3.2.7.2.4.3** The epoxy based systems approved by this method may be used with other shop primers if satisfactory crossover tests are carried out with shop primers, which are approved as part of a system ([refer to 3.2.7.2.2.4](#)). In this case the Type Approval Certificate will include the details of the epoxy based system and a list of all shop primers, which have passed these requirements. Type Approval Certificate will allow the use of the epoxy either with the named shop primer or on bare prepared steel<sup>1</sup>.

**3.2.7.2.4.4** Such coatings shall be applied in accordance with PSPC Table 1 rather than the application conditions used during the approval test, which may differ from PSPC, unless these are more stringent than PSPC Table 1 (for example, if NDFT is higher or high pressure water washing and or sweep blasting of the shop primer is used). In such cases these limiting conditions shall be added to the Type Approval Certificate and followed during coating application at the shipyard.

**3.2.7.2.4.5** The Type Approval Certificate is invalid if the formulation of either the epoxy based system or the shop primer is changed. It is the responsibility of the manufacturer to inform the Register immediately of any changes to the formulation.

**3.2.7.2.5** Method D: coating manufacturer.

**3.2.7.2.5.1** The coating/shop primer manufacturer shall meet the requirements specified in Section 8, Part I "General Regulations for Technical Supervision" and in [3.2.7.2.5.2 — 3.2.7.2.5.16](#), which shall be verified by the Register.

**3.2.7.2.5.2** Extent of engagement — production of coating systems in accordance with IMO resolution MSC.215(82) and PSPC 3.2.

**3.2.7.2.5.3** These requirements apply to both the main coating manufacturer and the shop primer manufacturer where both coatings form part of the total system.

**3.2.7.2.5.4** The coating manufacturer shall provide to the Register the following information:

- a detailed list of production equipment (facilities);
- names and location of raw (basic) material suppliers;
- a detailed list of the test standards and equipment to be used (in scope of approval);
- details of quality control procedures employed;
- details of any sub-contracting agreements;

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<sup>1</sup> It is recommended to indicate in the Type Approval Certificate that the coating is allowed to use on bare prepared steel.

<sup>2</sup> Marintek – Norwegian Marine Technology Research Institute.

list of quality manuals, test procedures and instructions, records, etc;  
copy of any relevant certificates with their issue number and/or date (e.g. quality management system certification).

**3.2.7.2.5.5** Inspection and audit of the manufacturer's facilities shall be based on requirements of IMO resolution MSC.215(82).

**3.2.7.2.5.6** With the exception of early "scale up" from laboratory to full production, adjustment outside the limitations listed in the quality control instruction referred to below is not acceptable, unless justified by trials during the coating system's development program, or subsequent testing. Any such adjustments shall be agreed by the formulating technical centre.

**3.2.7.2.5.7** If formulation adjustment is envisaged for during manufacturing process, the maximum allowable limits shall be approved by the formulating technical centre and clearly stated in the quality control working procedures.

**3.2.7.2.5.8** The manufacturer's quality control system shall ensure that all current production is the same formulation as that supplied for the Type Approval Certificate. Formulation change is not permissible without testing in accordance with the test procedures in IMO resolution MSC.215(82) and issue of the Type Approval Certificate by the Register.

**3.2.7.2.5.9** Batch records, including all quality control test results, such as viscosity, specific gravity and airless spray characteristics shall be accurately recorded. Details of any additions shall be also included.

**3.2.7.2.5.10** Whenever possible, raw material supply and lot details for each coating batch shall be traceable. Exceptions may be where bulk supply such as solvents and pre-dissolved solid epoxies are stored in tanks, in which case it may only be possible to record the supplier's blend.

**3.2.7.2.5.11** Dates, batch numbers and quantities supplied to each coating contract shall be clearly recorded.

**3.2.7.2.5.12** All raw material supplies shall be accompanied with a supplier's Certificate of Conformance. The Certificate shall include all requirements listed in coating manufacturer's quality control system.

**3.2.7.2.5.13** In the absence of a raw material supplier's Certificate of Conformance, the coating manufacturer shall verify conformance to all requirements listed in the coating manufacturer's quality control system.

**3.2.7.2.5.14** Drums shall be clearly marked with the details specified in the Type Approval Certificate.

**3.2.7.2.5.15** Product Technical Data Sheets shall comply with all the PSPC requirements. The quality control system shall ensure that all Product Technical Data Sheets are current.

**3.2.7.2.5.16** Quality control procedures of the originating technical centre shall verify that all production units comply with the above stipulations and that all raw material supply is approved by the technical centre.

**3.2.7.2.5.17** In case that a manufacturer wishes to have products manufactured in different locations under the same name (trademark), then IR identification and SG shall be used to demonstrate that they are the same coating, or individual approval tests will be required for the paint manufactured in each location.

**3.2.7.2.5.18** The Type Approval Certificate is invalid if the formulation of either the epoxy based system or the shop primer is changed. It is the responsibility of the manufacturer to inform the Register immediately of any changes to the formulation. Failure to inform the Register of an alteration to the formulation will lead to cancellation of the Type Approval Certificate for that manufacturer's product.

**3.2.7.3** Paras 1.4 "Job specification" and 1.5 "NDFT (nominal total dry film thickness)".

Wet film thickness (WFT) shall be regularly checked during application for the quality control. PSPC does not state who shall check WFT. DFT shall be checked as the part of the inspection according to PSPC Section 6.

Stripe coats shall be applied as coherent film showing good film formation and no visible defects. The application method employed shall ensure that all areas that require stripe coating are properly coated by brush or roller. A roller may be used for scallops, rat holes, etc. but not for edges and welds.

**3.2.7.4** Para 2 "PSP (Primary surface preparation)".

**3.2.7.4.1** The conductivity of soluble salts shall be measured in accordance with ISO 8502-6 and ISO 8502-9 or using the equivalent method, such as NACE SP0508-2010, and compared with conductivity of 50 mg/m<sup>2</sup> NaCl. If the measured conductivity is less than or equal to 50 mg/m<sup>2</sup> NaCl, the result is acceptable. Minimum readings to be taken shall be one reading per block/section/unit prior to applying coating or one per plate in case of manually applied shop primer. In case where an automatic process for application of shop primer is used, the means shall be provided to demonstrate compliance with PSPC through a quality control system, which shall include a monthly test.

**3.2.7.4.2** Shop primers not containing zinc or not silicate based are considered to be "alternative systems" and therefore equivalency shall be established in accordance with Section 8 "Alternative Systems" of PSPC with test acceptance criteria for "alternative systems" given in 3.1 "Acceptance criteria for alternative systems" (right column), Section 3 "Acceptance criteria" of Appendices 1 and 2 to Annex 1 (PSPC) of IMO resolution MSC.215(82);

**3.2.7.4.3** Procedure for review of quality control of automated shop primer plants.

**3.2.7.4.3.1** It is recognized that the inspection requirements of PSPC 6.2 may be difficult to apply to automated shop primer plants and a quality control approach would be more practical way of enabling compliance with the PSPC requirements.

**3.2.7.4.3.2** As required in PSPC, it is responsibility of the coating inspector to confirm that the quality control procedures ensure compliance with PSPC.

**3.2.7.4.3.3** When reviewing the quality control system for automated shop primer plants the following procedures shall be included:

procedures for blasting grit management, including measurement of salt content and contamination;

procedures for recording steel surface temperature, relative humidity and dew point;

procedures for control or monitoring surface cleanliness, surface profile (roughness), oil, grease, dust and other contamination;

procedures for recording/measuring of salt content on steel surfaces;

procedures for verifying shop primer thickness and curing degree to conform values specified in the Coating Technical Specification.

**3.2.7.5** Paras 3.2 "Sa 2 1/2 on damaged shop primers and welds", 3.3 "Surface treatment after erection", 3.4 "In case of full or partial blasting 30 — 75 urn, otherwise as recommended by the coating manufacturer".

Usually, the fillet welding on tank boundary watertight bulkhead is left without coating on block stage (because not yet be leakage tested), in which case it can be categorized as erection joint ("butt") to be power tooling to St3.

**3.2.7.6** Para 3.6 "Water soluble salts limit equivalent to NaCl after blasting/grinding".

The conductivity of soluble salts shall be measured in accordance with ISO 8502-6 and ISO 8502-9 or using equivalent method, such as NACE SP0508-2010, and compared with conductivity of 50 mg/m<sup>2</sup> NaCl. If the measured conductivity is less then or equal to, then it is acceptable.

All soluble salts have a detrimental effect on coatings to a greater or lesser degree. ISO 8502-9 does not provide the actual concentration of NaCl. Percentage of NaCl in the total

soluble salts content will vary from site to site. Minimum readings to be taken are one reading per block/section/unit prior to applying coating.

**3.2.7.7** Para 4.3 "Testing of coating".

All DFT measurements shall be measured. Only the final DFT measurements need to be measured and reported for compliance with the PSPC by the qualified coating inspector. The Coating Technical File may contain a summary of the DFT measurements which typically will consist of minimum and maximum DFT measurements, number of measurements taken and percentage above and below required DFT. The final DFT compliance with the 90/10 practice shall be calculated and confirmed (refer to PSPC 2.8).

**3.2.8 Interpretations to PSPC Section 5 "Coating system approval".**

[Para 3.2.7.2](#) shall apply.

**3.2.9 Interpretations to PSPC Section 6 "Coating inspection requirements".**

Procedure for assessment of coating inspectors' qualifications.

**3.2.9.1** Coating inspectors required to carry out inspections in accordance with PSPC Section 6 shall be qualified to NACE<sup>1</sup>. Coating Inspector Level II, FROSIO<sup>2</sup>. Inspector Level III, or equivalent qualification.

Equivalent qualifications are described in [3.2.9.3](#) below.

**3.2.9.2** Only coating inspectors with at least 2 years of relevant experience and qualified to NACE. Coating Inspector Level II or FROSIO. Inspector Level III, or with an equivalent qualification, can write and/or authorise procedures, or decide upon corrective actions to eliminate non-compliances.

**3.2.9.3** Equivalent qualification.

**3.2.9.3.1** Equivalent qualification is the successful completion, as determined by course tutor, of an approved course.

**3.2.9.3.1.1** The course tutors shall be qualified with at least 2 years of relevant experience and qualified to NACE. Coating Inspector Level II, FROSIO. Inspector Level III or with an equivalent qualification.

**3.2.9.3.1.2** Approved course is a course that has a syllabus based on the documents associated with PSPC, including the following:

- health, environment and safety;
- corrosion;
- materials and design;
- international standards referenced in PSPC;
- curing mechanisms;
- role of inspector;
- test instruments;
- inspection procedures;
- coating specification;
- application procedures;
- coating failures;
- pre-job conference;
- MSDS and product data sheet review;
- CTF;
- surface preparation;
- dehumidification;
- water jetting;
- coating types and inspection criteria;

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<sup>1</sup> NACE — National Association of Corrosion Engineers.

<sup>2</sup> FROSIO — Norwegian Professional Council for Education and Certification of Inspectors for Surface Treatment.

specialized application equipment;  
use of inspection procedures for destructive testing and non-destructive testing instruments;  
inspection instruments and testing methods;  
coating inspection techniques;  
cathodic protection;  
practical exercises, case studies.

Approved courses may be run by coating manufacturers or shipyards, etc.

**3.2.9.3.1.3** Such a course shall have an acceptable measurement of performance, such as examination with both theoretical and practical elements. The course and examination shall be approved by the Register.

**3.2.9.3.2** Equivalent qualification arising from practical experience.

An individual may be qualified without attending a course where it can be shown that the individual:

has a minimum of 5-years practical work experience as a coating inspector of ballast tanks and/or cargo tanks during new construction within the last 10 years;

has successfully completed the examination given in [3.2.9.3.1.3](#).

**3.2.9.4** Assistant coating inspectors.

**3.2.9.4.1** If the coating inspector requires assistance from other persons to perform part of the inspections, those persons shall perform the inspections under the coating inspector's supervision and shall be trained to the coating inspector's satisfaction.

**3.2.9.4.2** Such training shall be recorded and endorsed either by the coating inspector, the shipyard's training organization or inspection equipment manufacturer to confirm competence in using the measuring equipment and confirm knowledge of the measurements required by PSpC.

**3.2.9.4.3** Training records shall be available for verification.

**3.2.10 Interpretations to PSpC Section 7 "Verification requirements".**

**3.2.10.1** The requirements of PSpC Section 7 shall be verified by the Register.

Monitoring implementation of the coating inspection requirements, as specified in PSpC 7.5, means sample checking that the inspectors are using the correct equipment, techniques and reporting methods, as described in the inspection procedures reviewed by the Register (refer to 2.12.7 of the Guidelines on Technical Supervision of Ships under Construction).

**3.2.10.2** Any deviations from the PSpC provisions shall be raised initially with the coating inspector who is responsible for identifying and implementing the corrective actions.

**3.2.10.3** In the event that corrective actions are not acceptable to the Register or in the event that corrective actions are not carried out, then the shipyard shall be informed.

**3.2.10.4** [Para 3.2.3.5](#) shall apply.

**3.2.11 Interpretations to Annex 1 "Test procedures for coating qualification for dedicated seawater ballast tank of all types of ships and double-side skin spaces of bulk carriers" to PSpC.**

**3.2.11.1** Reference standards in Annex 1 to PSpC are mandatory.

### **3.3 PROCEDURE FOR APPLICATION OF PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR CARGO OIL TANKS OF CRUDE OIL TANKERS IN COMPLIANCE WITH SOLAS-74 REGULATION II-1/3-11 (IMO RESOLUTION MSC.288(87) AS AMENDED BY IMO RESOLUTION MSC.342(91))**

**3.3.1** This Chapter supplements provisions of the Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers and shall be applied to the ships

contracted for construction on or after 1 January 2014 in compliance with SOLAS-74 Regulation II/1/3-11 adopted by IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91) (hereinafter, PSPC-COT).

This Chapter shall be read in conjunction with PSPC-COT.

**3.3.2 Interpretations to 2.6, Section 2 "Definitions" of PSPC-COT.**

**3.3.2.1** "GOOD" condition is defined as condition with spot rusting on less than 3 % of the area under consideration without visible failure of the coating, or not-perforated blistering. Breakdown at edges or welds shall be less than 20 % of edges or weld lines in the area under consideration.

**3.3.2.2** [Para 3.2.2.2](#) shall apply (in this para and hereinafter in the Chapter when the references to interpretations in [3.2](#) apply, the references to PSPC (IMO resolution MSC.215(82)) shall be considered as the references to PSPC-COT (IMO resolution MSC.288(87) as amended by IMO resolution MSC.342(91))).

**3.3.3 Interpretations to 3.2, Section 3 "General Principles" of PSPC-COT.**

**3.3.3.1** [Paras 3.2.3.1 — 3.2.3.4](#) shall apply.

**3.3.3.2** The Cargo Ship Safety Certificate or the Cargo Ship Safety Construction Certificate shall not be issued until all the corrective actions required are implemented and submitted to the Register.

**3.3.4 Interpretations to 3.4 "Coating Technical File", Section 3 "General Principles" of PSPC-COT.**

**3.3.4.1** [Paras 3.2.4.1 — 3.2.4.4, 3.3.3.2](#) shall apply.

**3.3.5 Interpretations to 3.5 "Health and safety", Section 3 "General Principles" of PSPC-COT.**

**3.3.5.1** [Para 3.2.5.1](#) shall apply.

**3.3.6 Interpretations to 4.3 "Special application", Section 4 "Coating Standard" of PSPC-COT.**

**3.3.6.1** [Para 3.2.6.1](#) shall apply.

**3.3.7 Interpretations to Table 1 of PSPC-COT.**

**3.3.7.1** [Para 3.2.7.1](#) shall apply.

**3.3.7.2** Para.1.3 "Coating pre-qualification test".

**3.3.7.2.1** Procedure for coating system approval.

The Type Approval Certificate (CTO) showing compliance with the PSPC-COT Section 5 requirements may be issued if the results of either method A + C, or B + C (see below) are found satisfactory by the Register.

The Type Approval Certificate shall indicate the product and the shop primer tested. The Type Approval Certificate shall also indicate other type approved shop primers with which the product may be used, which have undergone the cross over tests in a laboratory meeting the requirements specified in [3.2.7.2.2.1](#).

The Technical Data Sheet showing all the information required by PSPC-COT 3.4.2.2 shall be attached to the Type Approval Certificate.

For winter type epoxy a separate pre-qualification test is required, including shop primer compatibility test according to Annex 1 to PSPC-COT. Winter and summer type coatings are considered different unless infrared (IR) identification and specific gravity (SG) data demonstrates that they are the same.

**3.3.7.2.2** Method A: laboratory test.

**3.3.7.2.2.1** [Paras 3.2.7.2.2.1 — 3.2.7.2.2.3](#) shall apply.

**3.3.7.2.2.2** An epoxy-based systems may be used with the shop primers other than the one with which it was originally tested provided that, the other shop primers are approved as part of a system, PSPC-COT Table 1: 2.3 and 3.2, and have been tested according to the immersion test of PSPC-COT Annex 1 or in accordance with IMO resolution MSC.215(82),

which is known as the "Crossover tests". If the test or tests are satisfactory, a Type Approval Certificate will be issued. In this instance the Type Approval Certificate will include the details of the epoxy and a list of all shop primers with which it has been tested that have passed these requirements. The Type Approval Certificate will allow the use of the epoxy either with the named shop primer or on bare prepared steel<sup>1</sup>.

**3.3.7.2.2.3** [Paras 3.2.7.2.2.5, 3.2.7.2.2.6](#) shall apply.

**3.3.7.2.2.4** [Para 3.2.7.2.2.7](#) shall apply, except the date of application.

**3.3.7.2.3** Method B: 5 years field exposure.

**3.3.7.2.3.1** [Paras 3.2.7.2.3.1, 3.2.7.2.3.2](#) shall apply.

**3.3.7.2.3.2** Either class survey records from the Register or a joint (coating manufacturer/RS surveyor) survey of cargo tanks of a selected ship shall be carried out for the purpose of verification of compliance with the requirements of [3.3.7.2.3.1](#) and [3.3.7.2.3.6](#). The reporting of the coating in both cases shall be in accordance with the principles given in Section 4 of IMO circular MSC.1/Circ.1399.

**3.3.7.2.3.3** The ship selected for testing shall have cargo tanks in regular use, of which: at least one tank is exposed to minimum temperature of +60 °C or ±3 °C;

for field exposure the ship shall be trading in varied trade routes and carrying substantial varieties of crude oils including highest temperature and lowest pH limits to ensure a realistic sample: for example, three ships on three different trade areas with different varieties of crude cargoes.

**3.3.7.2.3.4** In case the selected ship does not meet the requirements specified in [3.3.7.2.3.3](#), the limitations on lowest pH and the highest temperature of crude oils carried shall be clearly stated in the Type Approval Certificate.

**3.3.7.2.3.5** [Para 3.2.7.2.3.6](#) shall apply.

**3.3.7.2.3.6** All cargo tanks shall be in "GOOD" condition ([refer to 3.3.2.1](#)), excluding mechanical damages, without touch up or repair in the prior 5 years of operation.

Examples of how to report coating conditions with respect to areas under consideration shall be as those given in Section 4 of IMO circular MSC.1/Circ.1399.

**3.3.7.2.3.7** [Paras 3.2.7.2.3.8 — 3.2.7.2.3.10](#) shall apply.

**3.3.7.2.4** Method C: coating manufacturer.

**3.3.7.2.4.1** [Paras 3.2.7.2.5.1 — 3.2.7.2.5.18](#) shall apply.

**3.3.7.3** Paras.1.4 "Job specification" and 1.5 "NDFT (nominal dry film thickness)".

**3.3.7.3.1** [Para 3.2.7.3](#) shall apply.

**3.3.7.4** Para 2 "PSP (primary surface preparation)".

**3.3.7.4.1** [Para 3.2.7.4](#) shall apply.

**3.3.7.4.2** Procedure for review of quality control of automated shop primer plants.

**3.3.7.4.2.1** [Paras 3.2.7.4.3](#) shall apply.

**3.3.7.5** Paras 3.2 "Sa 2 1/2 on damaged shop primers and welds", 3.3 "Surface treatment after erection", 3.4 "In case of full or partial blasting 30 — 75 urn, otherwise as recommended by the coating manufacturer".

**3.3.7.5.1** [Para 3.2.7.5](#) shall apply.

**3.3.7.6** Para 3.6 "Water soluble salts limit equivalent to NaCl after blasting/grinding".

**3.3.7.6.1** [Para 3.2.7.6](#) shall apply.

**3.3.7.7** Para 4.3 "Testing of coating".

**3.3.7.7.1** [Para 3.2.7.7](#) shall apply.

**3.3.8** **Interpretation to PSPC Section 5 "Coating System Approval".**

**3.3.8.1** [Para 3.3.7.2](#) shall apply.

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<sup>1</sup> It is recommended to indicate in the Type Approval Certificate that the coating is allowed to use on bare prepared steel.

**3.3.9 Interpretations to PSPC Section 6 "Coating Inspection Requirements".**

Procedure for assessment of coating inspectors' qualifications.

**3.3.9.1** [Paras 3.2.9.1, 3.2.9.2](#) and [3.2.9.3.1](#) shall apply.

**3.3.9.2** Equivalent qualification arising from practical experience.

An individual may be qualified without attending a course where it can be shown that the individual:

has a minimum of 5-years practical work experience as a coating inspector of ballast tanks and/or cargo tanks during new construction within the last 10 years;

has successfully completed the examination given in [3.2.9.3.1.3](#).

**3.3.9.3** Assistant coating inspectors.

**3.3.9.3.1** [Para 3.2.9.4](#) shall apply.

**3.3.10 Interpretations to PSPC Section 7 "Verification Requirements" (refer to 2.12.7 of the Guidelines on Technical Supervision of Ships under Construction).**

**3.3.10.1** [Paras 3.2.10.1 — 3.2.10.3](#) shall apply.

**3.3.10.2** [Para 3.3.3.2](#) shall apply.

**3.3.11 Interpretations to Annex 1 "Test procedures for coating qualification for cargo oil tanks of crude oil tankers" to PSPC-COT.**

**3.3.11.1** Reference standards in Annex 1 to PSPC-COT are mandatory.

**3.4 PROCEDURE FOR APPLICATION OF PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR VOID SPACES ON BULK CARRIERS AND OIL TANKERS (IMO RESOLUTION MSC.244(83))**

**3.4.1** When IMO resolution MSC.244(83) is applied (refer to 6.5.1.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships), the provisions of [3.2](#), with due regard to provisions of this Chapter, shall be followed, with the exception of [3.2.3.2](#) and interpretation in [3.2.10](#) to 1.4 of Table 1, PSPC.

**3.4.2** Therein, the references in [3.2](#) to the PSPC and IMO resolution MSC.215(82) shall be considered as the references to IMO resolution MSC.244(83).

**3.4.3** Minimum NaCl concentration 100 mg/m<sup>2</sup> required by IMO resolution MSC.244(83) shall be applied in [3.2.10](#).

**3.5 ICE RESISTANT COATINGS**

**3.5.1** Ice resistant coatings are applied on ships in accordance with the requirements of 3.10, Part II "Hull" and 6.5.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**3.5.2** Ice resistant coatings used in case of reduction of average annual diminution of shell plating as a result of corrosion wear and abrasion (by 25 % or 50 %) in accordance with 3.10.4, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships shall be applied in accordance with the additional procedure of the Register technical supervision specified in [3.5.11](#).

If the ship is assigned distinguishing mark **ICE-COAT** at the shipowner's discretion (i.e. without reduction of average annual diminution of shell plating as a result of corrosion wear and abrasion), additional procedure of the technical supervision during application of ice-resistant coating specified in [3.5.11](#) shall not be carried out.

**3.5.3** The documentation being submitted for approval, which defines the coating properties, composition and characteristics, shall also contain the following data:

type of a coating system (epoxy and epoxy with the minimum solvent content);

coating colour;  
data on incompatibility with cathodic protection;  
reports on coating testing according to 6.5.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and [2.5](#) of these Rules conducted in the RS-recognized laboratories or in the laboratories with the attendance of the RS surveyor according to the agreed test program;

description of the application process of ice resistant coatings (refer to [3.5.4](#));  
manufacturer's recommendations on repair of coating in service.

**3.5.4** The application process of ice resistant coatings shall contain:

**.1** technical characteristics of ice resistant coatings specified in the Manufacturer's documents (specification of requirements, specifications, Technical Data Sheet);

**.2** methods of surface preparation prior to application of ice resistant coatings (rust cleaning level, no contamination, profile, roughness, etc.);

**.3** methods of surface preparation examination prior to application of ice resistant coating (visual examination using visual ISO standards and instrumentation check using comparator);

**.4** process conditions required for application of ice resistant coating (air temperature, relative humidity);

**.5** the requirements for equipment for application of ice resistant coatings.

**3.5.5** The requirements for surface preparation prior to application of ice resistant coatings. Process of surface preparation prior to application of ice resistant coatings shall comply with the requirements of ISO 8501-1. When ice resistant coatings are applied, the grade of surface preparation shall be equal to Sa 2½ in compliance with ISO 8501-1.

Roughness of the surface shall be medium (G) as per ISO 8503-1. Abrasive applicable for the surface cleaning shall meet the requirements of ISO 11126, Parts 1 — 8 and have a certificate, as appropriate.

Content of water-soluble chlorides (ISO 11127, Part 7) at the steel surface immediately prior the coating application shall not exceed 50 mg/m<sup>2</sup>.

Prior to application of ice resistant coatings, dust ratio of the surface shall be examined in compliance with ISO 8502-3. Dust quantity rating "1" for dust particles of classes "3", "4" or "5". Dust having the particles of lower classes shall be removed when visually available without image magnification at the surface subject to coating application.

**3.5.6** The requirements to temperature conditions and relative humidity for application of ice resistant coatings.

The coating shall be applied under controlled conditions of humidity and surface depending on the type of the particular coating in compliance with the manufacturer's specifications.

If not otherwise specified by the coating manufacturer, the ambient conditions for application of ice resistant coatings shall be as follows: relative air humidity shall not exceed 80 %; air temperature shall not be less than 10 °C (where not otherwise stated by the coating manufacturer); the coating surface temperature for the coating application shall be not less than 3 °C above the dew-point temperature.

**3.5.7** The number of layers and dry film thickness of ice resistant coating given the approved documentation shall be observed during the application. Subject to customer approval, thickness of ice resistant coating may be increased in particular areas of the underwater hull. It is recommended to increase thickness of ice resistant coating in the anode area. When application of a number of layers of ice resistant coating is permitted by the coating manufacturer, using of different color for each layer is recommended.

**3.5.8** Duration and degree of drying of the ice resistant coating shall be examined at every stage of application. Determination of condition and thorough drying period of paint-and-lacquer coatings. Recommended standards: ISO 1517, ISO 9117.

**3.5.9** For ice resistant coatings, the minimum time prior to ship's launching depending on water temperature and the minimum time prior to commencement of ship operation in ice shall be specified.

**3.5.10** In case of increased thickness of ice resistant coating, the duration of drying and curing at such conditions shall be additionally determined.

**3.5.11** The control procedure of application of ice resistant coatings includes:

Table 3.5.11

Process stage	Documentation to be submitted	Process participants	Requirements	Person in charge
Selection of coating system	Coating Technical File	Coating manufacturer, customer, RS	<a href="#">para 3.5.1</a>	Customer
Coating type			Epoxy-based systems	
Approval of coating by RS	CTO/Type Approval Certificate, Test report	Coating manufacturer, RS	<a href="#">para 3.5.1</a>	Coating manufacturer
Application process	Coating application flowchart	Coating manufacturer, shipyard, RS	<a href="#">para 3.5.4</a>	Coating manufacturer
Coating preparation	Final inspection report on surface preparation for protective coating application (reference recommended form in Appendix 2, Section 2, "Survey of hulls of steel ships" of the Guidelines on Technical Supervision of Ships under Construction).	Coating manufacturer, shipyard, RS	<a href="#">3.5.5 — 3.5.8</a>	Coating Inspection having NACE qualification Coating Inspector Level II, FROSIO. Coating Inspector Level III or equivalent ( <a href="#">3.5.11.2</a> )
Ambient conditions		Coating manufacturer, shipyard, RS, customer		
Coating application		Coating manufacturer, shipyard, customer, RS	<a href="#">3.5.3 — 3.5.8</a>	
Coating repair		Coating manufacturer, shipyard, customer, RS	Customer's document	
Quality control of the coating application		Coating manufacturer, customer, RS		

Prior to work, the process stage given in [Table 3.5.11](#) shall be agreed among the customer, shipyard, coating manufacturer and approved by the RS Branch Office for technical supervision under construction. Documentation shall be presented as a single document — Coating Technical File (CTF).

**3.5.11.1** The RS functions for the supervision of observance of the procedure for application of protective ice resistant coatings are as follows:

**.1** the availability of RS Certificate for ice resistant coating complying with the requirements of [3.5.1](#);

**.2** the availability of certificate to confirm the qualification of coating inspector: "NACE. Coating Inspector Level II", "FROSIO. Coating Inspector Level III" or equivalent to be issued upon the satisfactory results of completion of the RS-recognized training course and complying with [3.5.11.2](#);

**.3** compliance of Final Inspection Report on surface preparation and coating application (reference recommended form in Appendix 2, Section 2, "Survey of hulls of steel ships" of the Guidelines on Technical Supervision of Ships under Construction) with the requirements of the manufacturer's documents (technical requirements, specifications, Technical Data Sheet). The Inspection Report shall be issued by the coating inspector having

qualification in compliance with [3.5.11.1.2](#). The coating inspector shall be responsible for confirmation that quality control procedures for surface preparation and coating application meet the requirements of the RS-approved documentation.

.4 compliance with the requirements for the application process and the quality of the applied ice resistant coating.

**3.5.11.2** Training courses for coating inspectors responsible for ice resistant coatings application shall contain the main sections of the syllabus based on the documents associated with PSPC specified in [3.2.9.3.1.2](#) and the following additional sections:

types of ice resistant coatings;

the procedure and methods of application of ice resistant coatings and the requirements to work performance;

the procedure for the coating curing;

the inspection activity and the inspector responsibility.

Duration of training courses for coating inspectors responsible for inspection of ice resistant coatings application (as applied to lessons in class and group sessions, practical training) shall not be less than 80 academic hours (10 days or more). Therewith, the training course shall be conducted for 10 days or more in the form of a series of sessions.

The trainees shall attend the theoretical classes and participate in practical training, practical use of equipment and tools containing at least 40 % of the total training duration.

Theoretical classes shall intersperse with practical training.

Training aids of CD/DVD type that directly refer to the training course program may be used by the instructors as optional materials.

At the end of theoretical and practical training under the program for training of Coating Inspectors responsible for inspection of ice resistant coatings application, an examination (4 academic hours) shall be conducted for assessment of special theoretical knowledge and practical skills allowing to use the equipment and evaluations required for inspecting work. The training course and examination shall be approved by the Register.

The approved courses may be conducted by the coating manufacturers, shipyards, etc.

**3.5.11.3** The educational organization conducting the training courses for the coating inspectors responsible for inspection of ice resistant coatings application as per [3.5.11.2](#), shall perform its activity based on the RS Certificate of Firm Conformity (CCП) coded 22017020 — Training and examination of coating inspectors. The organization shall meet the requirements specified in Section 8 and special requirements of 12.3, Part I "General Regulations for Technical Supervision".

**3.5.12** All systems other than the epoxy-based systems shall be determined as the alternative systems. Acceptance of the alternative ice resistant protective coatings depends on the evidence that their properties and characteristics comply with 6.5.3.1, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The application procedure of the alternative or new ice resistant protective coatings shall be carried out in compliance with [3.5.4 — 3.5.8](#) and the requirements of manufacturer's documents (technical requirements, specifications, Technical Data Sheet).

## **3.6 POLYMER AND POLYMER COMPOSITE MATERIALS**

### **3.6.1 General.**

This Chapter determines the approval procedure for polymer and polymer composite materials, when other requirements are not specified in the RS rules.

Generally, the following shall be submitted for approval of polymer and polymer composite materials:

documents specifying properties and composition of material (technical specifications/Technical Data Sheets, etc.) taking into consideration the requirements of the RS rules;

operating procedures for manufacture and application of material;

manufacturer Certificates of Quality for raw materials (resins, fillers, etc.);

qualification test reports of material confirming the compliance with the requirements of the RS rules, international conventions, the IMO resolutions and other normative documents related to the RS activities. When the requirements do not reference to testing procedures, standards or they are not clearly specified, it is recommended to submit a program of the estimated qualification tests for approval.

Qualification tests shall be carried out in the RS-recognized laboratory or in the RS-agreed laboratory. In the latter case it is necessary to agree with RS the program of the qualification tests.

The firms shall meet the requirements of Section 8, Part I "General Regulations for Technical Supervision". During the survey of the firm in attendance of the RS surveyor, the check tests of the batch of products shall be carried out in accordance with the standard procedure of the manufacturer given in the firm documents.

**3.6.2 Polymer material applied during assembly of machinery, equipment, ship arrangements and their components.**

**3.6.2.1** Documentation submitted for review shall contain documents specified in [3.6.1](#), as well as material safety data sheets.

**3.6.2.2** Material test reports shall confirm the properties specified in 6.10.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. Tests shall be carried out in RS-recognized laboratories.

## **4 WELDING. REGULATIONS FOR WELDERS' CERTIFICATION**

### **4.1 GENERAL**

**4.1.1** The approval test for welders is the mandatory procedure used by the Register to confirm the skill of welders engaged in manufacturing objects being under the RS technical supervision.

**4.1.2** Welder Approval Test Certificate (forms 7.1.30-1 and 7.1.30-2) is the document verifying that a particular welder meets all the requirements specified in this Section.

**4.1.3** Successful practical test and passing theoretical examination by a welder provides the basis for issuing the Welder Approval Test Certificate.

**4.1.4** The procedure for welder's certification performance and issuance of the Welder Approval Test Certificates shall comply with the requirements given below. The qualification test and scope of approval of the welding operator operating automatic welding equipment shall comply with procedural requirements, similar to those in ISO 14732:2013.

**4.1.5** The welding operators responsible for setting up and/or adjustment of fully mechanized and automatic equipment, such as submerged arc welding, gravity welding, electro gas welding, MAG welding with auto-carriage, friction stir welding (FSW), etc. must be qualified whether they operate the equipment or not. However welding operators, who solely operates the equipment without responsibility for setting up and/or adjustment, do not need qualification provided that they have experience in specific welding work concerned and the production welds made by the operators are of the required quality.

**4.1.6** The training of welders, control of their qualification, professional improvement and maintenance of their skills are the responsibility of shipyards and manufacturers.

### **4.2 REQUIREMENTS FOR WELDERS' CERTIFICATION PROCEDURE AND ARRANGEMENT**

**4.2.1** Welders' approval tests shall be performed in a centralized way by the manufacturer-employer's request in the certification centres whose competence has been verified by the Register.

**4.2.2** The certification centers may be established at manufacturers', educational institutions, specialized organizations and institutions having qualified welding specialists and training and testing base needed for welders' training and testing.

**4.2.3** The structure of the certification centre shall provide the presence of the following key components ensuring its functioning:

- management;

- qualification panel;

- administrative personnel to ensure the performance of all types of tests, and equipment functioning;

- main and auxiliary production equipment for practical tests performance;

- equipment, tools and measurement means for the performance of welded joints testing;

- premises for practical and theoretical tests of welders.

**4.2.4** The standing qualification panel is the working body of the certification centre that directly conducts welders' certification.

The RS surveyor carrying out the technical supervision of test performance is the member of the qualification panel and shall be present during performance of welders' practical tests verifying results thereof. The RS surveyor may participate in welders' theoretical examination and take into account their results confirmed by the qualification panel.

**4.2.5** In survey of the certification centre to confirm its competence, the RS surveyor shall carry out the following:

.1 review the Regulation on the Certification Centre with appendices (with positive results, the stamp "СОГЛАСОВАНО/AGREED" is put on it);

.2 review and approve the program of theoretical training and the list of examination paper questions (to be stamped "ОДОБРЕНО/APPROVED");

.3 review and approve the programme of welders' practical tests performance (to be stamped "ОДОБРЕНО/APPROVED"), as well as the forms of welding procedure specifications completed for practical tests performance (to be signed by the surveyor and witnessed with a personal stamp);

.4 survey the material base including:

process of preparation of test assemblies for welders' practical tests (plates and pipes);

organization of storage and issuance of welding consumables for practical tests (the availability and technical condition of heating furnaces, heat chambers and heating cabinets for storage);

organization of the preliminary check of welding consumables quality prior to their issuance for tests (the availability of a press for T-shape test specimens fracture, the availability and serviceability of an instrument for checking the eccentricity of electrode coverings, equipment for measuring the moisture content of electrode coverings and fluxes, or for checking diffusion hydrogen content in weld metal, etc.);

check the availability and functioning of equipment for back chipping away (by heat gouging — air arc or gas, or by machining);

check the availability and functioning of equipment for the non-destructive testing of welded joints (ultrasonic, radiographic, magnetic particle and dye penetrant testing).

*Note.* When the testing of welded joints is carried out by external organizations, an illuminator for radiographs inspection shall be available in the certification centre;

check the availability of instrumentation for the testing of welded joints by visual and measurement testing (reports of instruments calibration shall be checked);

check the availability and functioning of equipment for mechanical testing of welded joints (reports of test machines calibration shall be checked).

*Note.* When welders are qualified for stainless steel welding, the equipment for performance of intercrystalline corrosion tests and the analysis of a ferritic component content in weld metal shall be available;

check the availability and serviceability of equipment for practical tests performance including the survey of stations for those welding methods which are presented for the welders' approval test;

check the serviceability of the local (welding stations) and general plenum-exhaust ventilation in spaces for practical tests;

check the serviceability of instrumentation for measurements of welding conditions parameters including an interpass temperature (reports of calibration shall be checked);

.5 survey the personnel qualification engaged in test performance including the members of the qualification panel and administrative personnel;

.6 survey the premises for the work of qualification panel members;

.7 check the availability of checking copies of the scientific documentation referred to in the programs of theoretical and practical tests (including the lists of check questions).

**4.2.6** Where the certification centre is established at the manufacturer's that joins structures by welding under the Register technical supervision, and its activity is limited to the qualification of welders of the very enterprise, the procedure for centre recognition by the Register with the drawing-up of proper documents may be ignored.

**4.2.7** All the certification centres engaged in training and/or qualification of welders from external organizations on a profit basis with or without the formation of a legal entity are subject to the Register recognition. Following the results of certification, the Certificate on Firm Conformity (form 7.1.27) is drawn up.

**4.2.8** The welders' qualification is classified as initial, additional, periodical and occasional.

Subject for initial qualification are welders aged 18 years and older who did not previously pass approval tests for the welding of objects and equipment under the Register technical supervision, who are certified as welders and have the work experience of welding performance according to the qualification assigned for at least 12 months, and also have undergone the special theoretical and practical training according to the programs drawn up individually for each type of works and for each welding process in actual welding works for which the welder shall be qualified.

Additional qualification of welders who had undergone the initial qualification is carried out prior to their approval for performance of works other than those specified in the Welder Approval Test Certificate, as well as after a break over six months in performance of the relevant welding works.

All welders undergo periodical qualification to confirm their skills and prolong the validity period of the Welder Approval Test Certificate in compliance with the requirements of 4.6. The welders are subject to the periodical qualification at least once in two years for confirmation of the Welder Approval Test Certificate validity, performed by Option b) and once in 3 years for confirmation of the in the Welder Approval Test Certificate validity, performed by Options a) and c) in accordance with the requirements of 4.6.7.

All welders undergo the occasional qualification prior to their approval for performance of welding after the temporary removal from work due to a poor quality and deviations from the welding procedure. The training period for the occasional qualification (for additional education and training) shall be at least a month since the date of being removed from the work.

In additional, periodical and occasional qualification, the special theoretical and practical training extent is established by the qualification panel and shall be individually agreed with the Register. With the welders' periodical qualification performance theoretical examination is not required, unless otherwise decided by the qualification panel."

**4.2.9** For the welders' approval testing by the Register, manufacturer (employer) administration shall send to the RS Branch Office where the procedure for the attestation is to be performed the request which specifies the following:

- name and address of the certification centre where the welders will be qualified;
- list of the welders to be qualified with their (for every worker) full names, year and place of birth, place of work, specialty and job skill, experience in the work to be qualified for;
- proposed option of the periodical qualification (a, b or c) in accordance with the requirements of 4.6.7;
- copies of documents to confirm the job skill of the workers in the type of the work to be qualified for;
- welding procedure, welding positions and other particulars needed for the qualification and completion of the Welder Approval Test Certificate;
- guarantees of payment for the Register services on Firm Conformity according to the current rates.

### **4.3 DEFINITIONS, TERMS AND SYMBOLS USED IN WELDERS' APPROVAL TESTING**

#### **4.3.1 Terms and definitions.**

Certification is a combination of actions to determine the welder's skill level with a view to ascertain the possibility of his approval for performance of the specific type of welding works.

Certification panel is a team of certification centre specialists that is responsible for the organization of works and the reliability of the results on welders' certification.

Certification centre is a competent body authorized by the Register for performing tests on welders' certification according to the requirements of the RS rules.

Approval test is a special procedure providing the determination of a welder's skill through his certification and the issuance of an official document, i.e. the Welder Approval Test Certificates (CДC, forms 7.1.30-1 and 7.1.30-2), for verifying permission to perform welding in objects under the RS technical supervision within the range of approval specified by the Certificate.

Filling run (runs), in multilayer welding is (are) the run(s) deposited after the root run(s) and before the capping run(s).

Root run (root pass) is first run deposited in the root of a multirun weld.

Range of approval is the extent of welder's skill recognition by the Register basing on the tests carried out in certification.

Capping run in multilayer welding, is (are) the run(s) visible on the weld face(s) after completion of welding.

Test specimen is the part of a test piece used for performance of destructive tests.

Backing is material placed at the reverse side of a joint preparation for the purpose of supporting molten weld metal.

Test piece is a welded assembly used in practical tests for welder's certification.

Welder is a person who holds and manipulates the electrode holder, torch or blowpipe during welding.

Welding operator is person who controls or adjusts any welding parameter for mechanized welding or automatic welding.

Welder Approval Test Certificate (CДC) (forms 7.1.30-1 and 7.1.30-2) is the RS document verifying that a particular welder has succeeded in passing the approval test in the scope of the RS rules requirements and is approved for welding in structures under the RS technical supervision, within the range of approval specified by the Certificate.

Weld metal thickness is thickness of the weld metal, including any reinforcement.

Design (effective) throat thickness is thickness of the weld, excluding any reinforcement. Design value of the height of the largest triangle that can be inscribed in the section of a fillet weld.

Fillet weld (F) is a triangle section weld between two and more components in tee, corner or lap joint.

#### **4.3.2 Symbols relating to welding procedure and welding consumables.**

**4.3.2.1** Welders shall be qualified according to the below requirements separately for each of the following welding type:

M — manual welding in which welding wire is fed and welding torch is moved along and across weld by the welder (manually);

S — semi-automatic, partly mechanized welding in which welding wire is fed mechanically and welding torch is moved along and across weld by the welder;

A — fully mechanized welding or automatic welding in which welding wire is fed and welding torch is moved mechanically without direct involvement of the welder;

T (TIG welding) — tungsten inert gas welding;

FSW — friction stir welding.

**4.3.2.2** Welders shall be qualified separately for each welding process in accordance with [Table 4.3.2.2](#).

Table 4.3.2.2

**Welding Processes for Welders Qualification**

Symbol of welding type	Welding process in actual welding works		Code acc. to ISO 4063:2009
M	Manual welding	Manual metal arc welding with covered electrode (SMAW)	111
		Oxy-acetylene welding (OAW)	311
S	Semi-automatic welding (partly mechanized welding)	Metal inert gas welding (MIG)	131
		Metal active gas welding (MAG)	135
		Flux-cored wire metal arc welding with metal cored wires in active gas (MAG)	138 <sup>1)</sup>
		Flux-cored wire metal arc welding with slag cover in active gas (MAG), FCAW-G	136 <sup>2)</sup>
		Flux cored inert gas arc welding (MIG)	133
		Flux cored self-shielded arc welding (FCAW-S)	114
A	Automatic welding or fully mechanized welding	Submerged arc welding with solid wire electrode (SAW)	121
		Submerged arc welding with flux cored electrode (SAW)	125
		Plasma arc welding	15
		Electroslag welding (ESW)	72
		Electrode gas welding (EGW)	73
T	Tungsten welding in inert gas	Tungsten inert gas (TIG) arc welding with or without solid filler material (wire/rod)	141, 142
FSW	Friction stir welding (FSW), including: double-sided single-run FSW; double-sided multi-run FSW; single-sided FSW with adjustable probe tool	Refer to 1.2.1, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships	43
			43.1
			43.2
			43.3
<sup>1</sup> A change from Metal active gas welding (MAG) (135) to that with flux-cored wire metal arc welding with metal cored wires in active gas (MAG) (138), or vice versa is permitted without additional testing. <sup>2</sup> A change from metal active gas welding (MAG) (135) or flux-cored wire metal arc welding (MAG) (136) to flux-cored wire metal arc welding (MAG), FCAW-G (136) requires a new welder qualification test.			

**4.3.2.3** For assigning the range of approval of the Welder Approval Test Certificates for welding processes 111, 114, 131, 133, 135, 136 the types of electrode covering, wires and flux-cored wire filler shall be indicated in accordance with the instructions given below.

According to ISO 2560:2020, the type of electrode covering, depending on its composition, (welding process 111) is shown by the following letter indices:

- A = acid (oxidizing) covering;
- B = basic covering;
- C = cellulose covering;

R = rutile covering;  
 RA (AR) = mixed rutile-acid covering;  
 RB = mixed rutile-basic covering;  
 RC = mixed rutile-cellulosic covering;  
 RR = rutile thick covering;

The use of solid wire for welding processes 131 and 135 is indicated by S letter index.

According to ISO 17632:2015, depending on the composition, the filler type for flux-cored welding wire (welding processes 114, 133 and 136) is indicated by letter indices according to [Table 4.3.2.3](#).

Table 4.3.2.3

**Symbols for types of electrode core (according to ISO 17632:2015)**

Symbol	Characteristics	Type of weld	Shielding gas
R	Rutile, slow freezing slag	Single and multiple pass (run)	Required
P	Rutile, fast freezing slag	Single and multiple pass (run)	Required
B	Основной	Single and multiple pass (run)	Required
M	Metal powder	Single and multiple pass (run)	Required
V	Rutile or Basic/fluoride	Single pass (run)	Not required
W	Basic/fluoride slow freezing slag	Single and multiple pass (run)	Not required
Y	Basic/fluoride fast freezing slag	Single and multiple pass (run)	Not required
Z	Other types	–	–

Note A description of the characteristics of each of the types of core is given in [Appendix 7](#).

**4.3.2.4** To designate the composition of the shielding gas used for welders' practical tests, the alphanumeric indices unified with ISO 14175:2008 and corresponding to those given in [Table 6.2.2.5](#) are used.

**4.3.2.5** To designate the flux type used for welders' practical tests, the letter indices unified with ISO 14174:2019 which identify a manufacture method are used:

F = fused flux;

A = sintered (ceramic) flux;

M = mixed fluxes (various types of mechanical mixtures and sintered fluxes).

**4.3.2.6** For designation of the flux composition used for welders' practical tests, the letter indices unified with ISO 14174:2019 may be used according to [Table 4.3.2.6](#).

Table 4.3.2.6

**Symbols for types of flux, characteristic of chemical constituents according to ISO 14174:2019<sup>1,2</sup>**

Symbol	Name of compound	Characteristic of flux chemical compound	
		Constituents	Limit of constituent, % of mass
MS	Manganese-silicate	MnO+SiO <sub>2</sub>	≥ 50
		CaO	≤ 15
CS	Calcium-silicate	CaO+MgO+SiO <sub>2</sub>	≥ 55
		CaO+MgO	≥ 15
CG <sup>3</sup>	Calcium-magnesium	CaO+MgO	5 – 50
		CO <sub>2</sub>	≥ 2
		Fe	≤ 10
CB <sup>3</sup>	Calcium-magnesium-basic	CaO+MgO	30 – 80

Symbol	Name of compound	Characteristic of flux chemical compound	
		Constituents	Limit of constituent, % of mass
CG-1 <sup>3</sup>	Calcium-magnesium-iron	CO <sub>2</sub>	≥ 2
		Fe	≤ 10
		CaO+MgO	5 — 45
CB-1 <sup>3</sup>	Calcium-magnesium-iron-basic	CO <sub>2</sub>	≥ 2
		Fe	15 — 60
		CaO+MgO	10 — 70
GS	Magnesium silicate	CaO+CaF <sub>2</sub>	≥ 2
		Fe	15 — 60
		MgO+SiO <sub>2</sub>	≥ 42
ZS	Zirconium-silicate	Al <sub>2</sub> O <sub>3</sub>	≤ 20
		CaO+CaF <sub>2</sub>	≤ 14
		ZrO <sub>2</sub> +SiO <sub>2</sub> +MnO	≥ 45
RS	Rutile-silicat	ZrO <sub>2</sub>	≥ 15
		TiO <sub>2</sub> +SiO <sub>2</sub>	≥ 50
AR	Aluminate-rutil	TiO <sub>2</sub>	≥ 20
BA	Aluminate-basic	Al <sub>2</sub> O <sub>3</sub> +TiO <sub>2</sub>	≥ 40
		Al <sub>2</sub> O <sub>3</sub> +CaF <sub>2</sub> +SiO <sub>2</sub>	≥ 55
		CaO	≥ 8
AAS	Acidic-aluminate-silicat	SiO <sub>2</sub>	≤ 20
		Al <sub>2</sub> O <sub>3</sub> +SiO <sub>2</sub>	≥ 50
		CaF <sub>2</sub> +MnO	≥ 20
AB	Aluminate-basic	Al <sub>2</sub> O <sub>3</sub> + CaO+MgO	≥ 40
		Al <sub>2</sub> O <sub>3</sub>	≥ 30
		CaF <sub>2</sub>	≥ 5
AS	Aluminate-silicat	Al <sub>2</sub> O <sub>3</sub> + SiO <sub>2</sub> + ZrO <sub>2</sub>	≥ 40
		CaF <sub>2</sub> +MgO	≥ 30
		ZrO <sub>2</sub>	≥ 5
AF	Aluminate-fluoride-basic	Al <sub>2</sub> O <sub>3</sub> + CaF <sub>2</sub>	≥ 70
FB	Fluoride-basic	CaO+MgO+ CaF <sub>2</sub> +MnO	≥ 50
		SiO <sub>2</sub>	≤ 20
		CaF <sub>2</sub>	≥ 15
Z	—	Any other composition	—

<sup>1</sup> Carbonates such as CaCO<sub>3</sub> and MgCO<sub>3</sub>, in agglomerated flux are calculated to CaO and MgO and the constituent (as % of molecular weight) shall be the ratio of the remaining amount exclusive of CO<sub>2</sub> content in the flux based on the total content of all constituents in flux equal to 100.

<sup>2</sup> All of metallic Si and Si-compound and/or their alloys are converted to SiO<sub>2</sub>, and all of metallic Mn and Mn-compound and/or their alloys are converted to MnO (as % of their molecular weight) considering their oxidation during welding.

<sup>3</sup> The amount of constituent in the agglomerated flux shall be the ratio of remaining amount exclusive of Fe content in the flux.

**4.3.2.7** To designate the presence of filler involved in weld formation, the following letter indices are used in welders' approval testing:

wm = welding with filler material feed;

nm = welding without filler, i.e. the weld is formed through the melting of base metal only.

**4.3.3 Symbols relating to base metal and joint type.**

**4.3.3.1** The welders' approval testing according to the results of practical tests is carried out with reference to the groups of base metal type composition in accordance with [Tables 4.3.3.1-1](#), [4.3.3.1-2](#) and [4.3.3.1-3](#).

**4.3.3.2** For welders qualification, the following specific features of welding joints are subdivided to be coded using the following indices:

.1 BW — butt welds:

A — single-sided weld with backing;

B — single-sided weld without backing;

C — double-sided weld with back gouging;  
D — double-sided weld without back gouging.

.2 fillet welds — F:

sl — single-layer weld;

ml — multilayer welding;

For fillet welds, welders who passed the qualification tests for multilayer welding can be deemed as qualified for single-layer weld, but not vice versa.

Note. Fillet weld is a triangle section weld between two and more components in tee, corner or lap joint.

Weld is a result of welding. A weld includes weld metal and heat-affected area.

Table 4.3.3.1-1

**Grouping system for steels according to ISO/TR 15608:2017**

Group	Sub-group	Types of steel
1		Steels with a specified minimum yield strength $R_{eH} \leq 460$ MPa <sup>a</sup> and with analysis in %: C $\leq 0,25$ ; Si $\leq 0,60$ ; Mn $\leq 1,80$ ; Mo $\leq 0,70$ <sup>b</sup> ; S $\leq 0,045$ ; P $\leq 0,045$ ; Cu <sup>b</sup> $\leq 0,40$ ; Ni <sup>b</sup> $\leq 0,5$ ; Cr $\leq 0,3$ (0,4 for castings); Nb $\leq 0,06$ ; V $\leq 0,10$ <sup>b</sup> ; Ti $\leq 0,05$
	1.1	Steels with a specified minimum yield strength, $R_{eH} \leq 275$ MPa
	1.2	Steels with a specified minimum yield strength, $275$ MPa $< R_{eH} \leq 360$ MPa
	1.3	Normalized fine grain steels with a specified minimum yield strength $R_{eH} > 360$ MPa
	1.4	Steels with improved atmospheric corrosion resistance whose analysis may exceed the requirements for the single elements as indicated under 1
2		Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength $R_{eH} > 360$ MPa
	2.1	Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength $360$ MPa $< R_{eH} \leq 460$ MPa
	2.2	Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength $R_{eH} > 460$ MPa
3		Quenched and tempered steels and precipitation hardened steels except stainless steels with a specified minimum yield strength $R_{eH} > 360$ MPa
	3.1	Quenched and tempered steels with a specified minimum yield strength $360$ MPa $< R_{eH} \leq 690$ MPa
	3.2	Quenched and tempered steels with a specified minimum yield strength $R_{eH} > 690$ MPa
	3.3	Precipitation hardened steels except stainless steels
4		Low vanadium alloyed steels Cr-Mo-(Ni) with Mo $\leq 0,7$ % and V $\leq 0,1$ %
	4.1	Steels with Cr $\leq 0,3$ % and Ni $\leq 0,7$ %
	4.2	Steels with Cr $\leq 0,7$ % and Ni $\leq 1,5$ %
5		Cr-Mo steels free of vanadium with C $\leq 0,35$ %
	5.1	Steels with $0,75$ % $\leq$ Cr $\leq 1,5$ % and Mo $\leq 0,7$ %
	5.2	Steels with $1,5$ % $<$ Cr $\leq 3,5$ % and $0,7$ % $<$ Mo $\leq 1,2$ %
	5.3	Steels with $3,5$ % $<$ Cr $\leq 7,0$ % and $0,4$ % $<$ Mo $\leq 0,7$ %
	5.4	Steels with $7,0$ % $<$ Cr $\leq 10,0$ % and $0,7$ % $<$ Mo $\leq 1,2$ %
6		High vanadium alloyed Cr-Mo-(Ni) steels
	6.1	Steels with $0,3$ % $\leq$ Cr $\leq 0,75$ %, Mo $\leq 0,7$ % and V $\leq 0,35$ %
	6.2	Steels with $0,75$ % $<$ Cr $\leq 3,5$ %; $0,7$ % $<$ Mo $\leq 1,2$ % и V $\leq 0,35$ %
	6.3	Steels with $3,5$ % $<$ Cr $\leq 7,0$ %; Mo $\leq 0,7$ % и $0,45$ % $\leq$ V $\leq 0,55$ %
	6.4	Steels with $7,0$ % $<$ Cr $\leq 12,5$ %; $0,7$ % $<$ Mo $\leq 1,2$ % and V $\leq 0,35$ %
7		Ferritic, martensitic or precipitation hardened steels with C $\leq 0,35$ % and $10,5$ % $\leq$ Cr $\leq 30$ %
	7.1	Ferritic stainless steels
	7.2	Martensitic stainless steels
	7.3	Precipitation hardened stainless steels
8		Austenitic stainless steels with Cr $\leq 35$ %

Group	Sub-group	Types of steel
	8.1	Austenitic stainless steels with Cr ≤ 19 %
	8.2	Austenitic stainless steels with Cr > 19 %
	8.3	Manganese austenitic stainless steels with 4,0 % < Mn ≤ 12,0 %
	8.4	Austenitic stainless steels with Cr > 18%; 4% < Mn ≤ 12% и 3% < Ni ≤ 8%
9		Nickel alloy steels with Ni ≤ 10,0 %
	9.1	Nickel alloy steels with Ni ≤ 3,0 %
	9.2	Nickel alloy steels with 3,0 % < Ni ≤ 8,0 %
	9.3	Nickel alloy steels with 8,0 % < Ni ≤ 10,0 %
10		Austenitic ferritic stainless steels (duplex)
	10.1	Austenitic ferritic stainless steels with Cr ≤ 24,0 % и Ni ≤ 4,0 %
	10.2	Austenitic ferritic stainless steels with Cr > 24,0 % и Ni > 4,0 %
	10.3	Austenitic ferritic stainless steels with Ni ≤ 4,0
11		Steels with chemical composition identical to group 1 <sup>c</sup> except content of 0,30 % < C ≤ 0,85 %
	11.1	Steels assigned to group 11 with 0,30 % < C ≤ 0,35 %
	11.2	Steels assigned to group 11 with 0,35 % < C ≤ 0,5 %
	11.3	Steels assigned to group 11 with 0,5% < C ≤ 0,85 %
<p>Note. Based on the actual production chemical composition steel of group 2 may be assigned to group 1<sup>c</sup>. If the material has different minimum yield strengths depending on thickness, the maximum yield strength shall be used to define the sub-group.</p> <p>a) In accordance with the steel product standards, <math>R_{eH}</math> may be replaced by <math>R_{p0,2}</math> or <math>R_{t0,5}</math>.</p> <p>b) A higher value is accepted, provided that Cr + Mo + Ni + Cu + V ≤ 0,75 %.</p> <p>c) A higher value is accepted, provided that Cr + Mo + Ni + Cu + V ≤ 1,0 %.</p>		

Table 4.3.3.1-2

**Grouping system for aluminium and aluminium alloys according to ISO/TR 15608:2017**

Group	Sub-group	Type of aluminium and aluminium alloys
21		Pure aluminium impurities content ≤ 1 %
22		Non heat treatable alloys
	22.1	Aluminium-manganese alloys
	22.2	Aluminium-magnesium alloys with Mg ≤ 1,5 %
	22.3	Aluminium-magnesium alloys with 1,5 % < Mg ≤ 3,5 %
23	22.4	Aluminium-magnesium alloys with Mg > 3,5 %
		Heat treatable alloys
	23.1	Aluminium-magnesium-silicon alloys
24	23.2	Aluminium-zinc-magnesium alloys
		Aluminium-silicon alloys with Cu ≤ 1 %
	24.1	Aluminium-silicon alloys with Cu ≤ 1 % и 5 % < Si ≤ 15 %
25	24.2	Aluminium-silicon-magnesium alloys with Cu ≤ 1 %; 5 % < Si ≤ 15 % and 0,1 % < Mg ≤ 0,80 %
		Aluminium-silicon-copper alloys with 5 % < Si ≤ 14,0 %; 1,0 % < Cu ≤ 5,0 % and Mg ≤ 0,8 %
26		Aluminium-copper alloys with 2 % < Cu ≤ 6 %
<p>Note. Groups 21 — 23 are generally for wrought materials and groups 24 — 26 are generally used for cast materials.</p>		

Table 4.3.3.1-3

**Grouping system for copper and copper alloys according to ISO/TR 15608:2017**

Group	Sub-group	Type of copper and copper alloys
31		Copper 6with % Ag and 3 % Fe
32		Copper-zinc alloys
	32.1	Copper-zinc binary alloys
	32.2	Copper-zinc complex alloys
33		Copper-tin alloys

Group	Sub-group	Type of copper and copper alloys
34		Copper-nickel alloys
35		Copper-aluminium alloys
36		Copper-nickel-zinc alloys
37		Copper alloys, low alloyed (with less than 5 % of other elements) not covered by groups 31 — 36
38		Other copper alloys (5 % or more other elements) not covered by groups from 31 — 36

#### 4.3.4 Symbols relating to test piece types and welding positions.

4.3.4.1 For practical tests to approve welders, the unified check welded joints — test pieces complying with the instructions of [Appendix 1](#), shall be used. Geometric parameters and dimensions of the test pieces shall be indicated using the following indices:

$P$  = plate;

$T$  = pipe;

$D$  = outside diameter of a pipe;

$t$  = material thickness of test piece (plate or wall thickness);

$t_1$  = material thickness of test piece for welding process 1;

$t_2$  = material thickness of test piece for welding process 2;

$l_1$  = length of test piece;

$l_2$  = half width of test piece;

$l_f$  = examination length;

$s_1$  = weld metal thickness for welding process 1;

$s_2$  = weld metal thickness for welding process 2;

$a$  = design throat thickness;

$z$  = leg length of fillet weld

4.3.4.2 The welding of welded joint test pieces is carried out in the unified welding positions complying with the instructions of [Appendix 2](#).

### 4.4 PROCEDURE FOR APPROVAL TESTING OF WELDERS

#### 4.4.1 General requirements for welders' certification performance procedure.

The procedure for welders' certification comprises taking theoretical examination and practical by the welder to be certified.

The certification shall be started with the practical testing. If the welder fails to pass the practical testing, he is not admitted to theoretical examination and is considered to have failed to be certified.

During the theoretical examination, the welder shall answer at least 15 questions covering the major sections of general and special (by profession) subjects. The questions are selected for each welding process by the certification panel.

In theoretical examining, the certification panel applies one of the following methods or the combination thereof:

written verification of knowledge;

oral questioning;

computer verification of knowledge;

written description followed by a practical demonstration on the relevant equipment.

The examination results are assessed by the certification panel as "Accepted/Not accepted". The designation "Accepted" corresponds to at least 80 % of the correct answers to the questions asked. The welder is considered to be certified when passing both practical testing and theoretical examination.

If the welder has passed the practical testing, but has failed the theoretical examination, he is allowed to resit the latter by an additional application within half a year since the day of the first examination, but not earlier than two weeks after the initial date of the theoretical examination. In case of reoccurring negative result of the theoretical examination, the welder is considered to have failed the certification.

**4.4.2 Requirements for practical tests procedure.**

**4.4.2.1** Materials for test pieces and welding materials shall meet the requirements of Part XIII "Materials" and Part XIV "Welding", the Rules for the Classification and Construction of Sea-Going Ships.

Welders shall be practically tested by welding test pieces as specified in [Appendix 1](#).

The test pieces shall be welded in presence of at least three members of qualification commission:

- one professional welding engineer;
- one quality control representative skilled sufficiently to make conclusion from visual and measurement testing and;
- one RS representative.

**4.4.2.2** Prior to the welding, an identification number registered in the test report is stamped on test pieces of welded joints.

Additionally, welding positions for all test pieces shall be marked on the test assembly, and for fixed pipe welds, the 12 o'clock welding position shall also be marked.

The assembly of joint parts for welding is carried out by the welder to be certified. The welding of the test piece is allowed by the certification panel member after accepting the quality of assembly for welding.

The certification panel can discontinue the practical examination if the welder has violated the welding conditions and procedure or it is obvious that he is unable to weld the test piece in accordance with the requirements of a specification and the RS rules.

**4.4.2.3** In the performance of practical qualification tests for welders' approval testing, the welding shall be performed on the basis of the Welding procedure specification (of a manufacturer) of an established pattern which is completed in accordance with the actual conditions of welding under production conditions. The following requirements shall be fulfilled:

- test pieces shall be welded using the welding procedures applied in manufacture;
- filler material shall be consistent with the peculiarities of the welding process and position;
- structural elements of edge preparation for the test pieces (groove angle, root face, root gap) shall be representative for those used in manufacture;
- test piece dimensions shall be stated in the Specification and comply with the requirements of [Appendix 1](#);
- welding equipment shall be of the same type as that used in manufacture;
- test piece welding shall be performed in the positions and angles of pipe branch connections normally used in manufacture;
- welding conditions and the welding sequence in the groove shall correspond to those used in manufacture;
- combination of base metal, filler and auxiliary materials shall correspond to the conditions used in manufacture;
- welding time for the test piece shall correspond to the standards applied in manufacture;
- test pieces shall have at least one stop and one re-start in the root run and in the top capping run and shall be identified in the inspection length to be examined;
- this requirement is mandatory for manual and semiautomatic welding;
- where the preheat, controlled heat input are required or the requirement for the minimum/maximum interpass temperature is regulated for particular welded joints

(combinations of base metal and welding consumables) in manufacture practice, these parameters of the technological process shall be met while welding the welded joint test pieces for the welders' approval test;

where the post-weld heat treatment is required for particular welded joints in manufacture practice, this operation becomes mandatory for the welded joint test assemblies only in case when the test program provides for the bend test of test specimens. For other cases, the post-weld heat treatment of welded joint test pieces may be omitted if agreed with the Register;

test pieces shall be unambiguously identified;

it is allowed to remove minor surface imperfections of internal layer beads of the weld by grinding or any other method used in manufacture, only during stops before restart of welding.

**4.4.2.4** The thickness of metal for the test pieces to be welded, their diameter for testing the pipes welding shall be specified with due regard for the actual range of these characteristic values in accordance with the manufacturer's application and for the range of approval by the Register according to the requirements of [4.5.9](#).

The assembly and welding of butt plate joints shall prevent angular deformations of the welded joint completed (its flatness).

In single-side single-run fillet welding of T-joints of plates and pipes, the effective throat thickness of the fillet weld shall be within the following range depending on the base metal thickness  $t$ :

$$0,5t \leq a \leq 0,7t.$$

For pipe connections the minimum check weld length of 150 mm is required. When the pipe circumference is less than 150 mm, welded joint test pieces shall be required for approval tests with the maximum of three test pieces.

#### **4.4.3 Types of test pieces for welders' practical tests.**

**4.4.3.1** The number, dimensions and structural elements of welded joint test pieces for practical tests shall be specified by the certification panel according to the RS rules requirement depending on the range of the works, stated in the application, for which the welder is certified.

Specifying the type of a unified welded joint test piece among those given in [Appendix 1](#), the requirements and explanations set forth below shall be followed.

**4.4.3.2**  $P_1$  test piece is the main test piece used for the approval testing of welders for the welding of plate structures which, depending on the range of approval, may be welded in various welding positions and with various structural elements of the edge preparation.

**4.4.3.3** The T-joint test piece  $P_2$  for plates is additional and is used in the cases specified in [4.5.4.2](#) for the approval testing of welders for the performance of single-run fillet welds without beveling. The welders who have passed the tests on certification on  $P_1$  and/or  $P_2$  test pieces, can be engaged in tack welding within the range of approval specified in his Welder Test Approval Certificate. The tests on certification on test pieces  $P_{1tack}$  and/or  $P_{2tack}$  for assemblers/welders engaged in tack welding only may be required, provided the requirements for the range of approval for essential variables are met.

**4.4.3.4** Butt joint test piece  $P_3$  in pipes is the main test piece used for the approval testing of welders for the welding of pipelines which, depending on the range of approval, may be welded in various welding positions and with various structural elements of the edge preparation.

**4.4.3.5**  $P_4$  test piece may be used for the approval testing of welders for the single-run fillet welding of pipe joints. The main cases of this test piece application are specified in [4.5.5](#).

**4.4.3.6** The unified butt joint test piece  $P_6$  with a restricting ring shall be used for the approval testing of welders for the welding of T-, Y- and K-joints in pipes (pipe-to-pipe or pipe-

to-plate) with full or partial joint penetration. The welding of the welded joint test piece, unless otherwise specified, is performed in the H-LO45 position.

**Note.** The J-LO45 welding position for the test piece  $P_6$  may be used if the welder's range of approval provides (according to the application for qualification) for the downhill welding of pipeline ring butts (from 12 down to 6 hours).

**4.4.3.7** In mounting of ship's pipelines, the welding is generally performed under conditions of the limited access to a welded joint what makes necessary for the welder to have the special training and relevant skill. The presence of entry "Approved for pipe welding at limited access" in column "Range of approval" (line "welding position/type of test piece") of Welder Approval Test Certificate is required when the following conditions (independently of each other or in total) are relevant in actual practice:

**.1** access to the welding zone is bounded in the radial direction by the plane which is parallel to or inclined at some angle to the pipeline axis. The boundary condition: a minimum distance measured perpendicularly to the pipe axis in the plane of the welded joint from the outer pipe surface to the surface (one or more) bounding access to the welding zone does not exceed 400 mm. The welding positions, i.e. pipe axis orientation, shall correspond to the range of approval;

**.2** access to the welding zone is longitudinally bounded by the surface that crosses the pipe in the immediate neighborhood of the welded joint. The boundary condition: a minimum distance measured perpendicularly over the outer pipe surface from the welding line to the pipe-crossing surface does not exceed 100 mm.

The extension of the range of approval in Approval Test Certificate to the pipe welding at limited access requires the mandatory performance of the welder's practical tests on  $P_5$  test pieces. In so doing, in some cases, if agreed with the Register, the welding of  $P_6$  test pieces may be needed only.

**4.4.3.8** The test for branch connection on the  $P_7$  test piece supplements the welders' approval testing for the welding of high-loaded gridwork pipe structures and presumes the availability with the welder of the approval test for the welding of T-, Y- and K- pipe joints of the relevant diameter and wall thickness. This type of tests is mandatory in the welders' approval testing for the welding of pipe joints having the outside diameter of the branch to be joined  $D_2 \geq 200$  mm, its wall thickness  $t_2 \geq 12$  mm and the angle between pipe axes less than  $70^\circ$ .

The  $P_7$  test piece dimensions recommended:

outside diameter of the main pipe  $D_1 \geq 1,5D_2$ ;

outside diameter of the pipe being joined  $D_2 = 200$  to 300 mm and its wall thickness  $t_2 \geq 20$  mm.

The root run and at least four subsequent runs shall be performed within a sector of  $180^\circ$  from 6 to 12 h position. The testing of the  $P_7$  test piece is carried out using the magnetic particle/dye penetrant testing together with the macro examination. Four macrosections corresponding to the 3, 6, 9 and 12 h welding positions shall be taken of the test piece.

**Notes:** 1. The ultrasonic testing of the  $P_7$  test piece may be carried out using the additionally approved diagram and procedure of its performance.

2. For approval testing for the welding of branch connections having parameters not covered by the  $P_7$  test piece, the performance of practical tests on the  $P_6$  test piece is considered as adequate, while for thin-walled pipes ( $t_2 < 3$  mm), the test pieces are various versions of the  $P_3$  and  $P_4$  type.

**4.4.3.9** The  $P_8$  test piece is used for the approval test of welders for repairing casting and forging defects. In so doing, the specific dimensions and material for test piece

manufacture are subject to the additional clarification by the certification panel and individually agreed with the Register.

Note. It is recommended to combine the approval testing for repairing castings and forgings with that for the welding of plate structures or pipes using the same welding process and for the same group of base metal.

#### 4.4.4 Methods for assessment of welders' practical test results.

4.4.4.1 After welding each test piece completed shall be tested according to [Table 4.4.4.1](#) in the as-welded condition. Before cutting out bend and fracture test specimens, visually examine the welds. Specimens shall be tested in the presence of the Register surveyor.

Table 4.4.4.1

Methods of testing of welded joint test pieces in welders' practical tests

Testing methods	Type of welded joint test piece											
	P <sub>1</sub>		P <sub>1back</sub>	P <sub>3</sub>		P <sub>2</sub> and P <sub>4</sub>	P <sub>2back</sub>	P <sub>5</sub> and P <sub>6</sub>		P <sub>7</sub>	P <sub>8</sub>	
	3 ≤ t < 12	t ≥ 12		3 ≤ t < 12	t ≥ 12			3 ≤ t < 12	t ≥ 12		C <sub>1</sub> and C <sub>2</sub>	C <sub>3</sub> and C <sub>4</sub>
Visual and measurement testing	+	+	+	+	+	+	+	+	+	+	+	+
Radiographic test	+ <sup>1,2</sup>	+ <sup>1,2</sup>	–	+ <sup>1,2</sup>	+ <sup>1,2</sup>	–	–	+ <sup>1,2</sup>	+ <sup>1,2</sup>	–	+	–
Ultrasonic test	+ <sup>2</sup>	+ <sup>2</sup>	–	+ <sup>2</sup>	+ <sup>2</sup>	–	–	+ <sup>2</sup>	+ <sup>2</sup>	+	+	–
Bend test	Weld root and top		–	+ <sup>3,4</sup>	–	–	–	+ <sup>1,3,4</sup>	–	–	–	–
	Side bend		–	+ <sup>1,3</sup>	–	–	–	–	+ <sup>1,3,4</sup>	–	–	–
Fracture test	+ <sup>1,3</sup>	+ <sup>1,3</sup>	+ <sup>5</sup>	+ <sup>1,3,4</sup>	+ <sup>1,3,5</sup>	+ <sup>6</sup>	+ <sup>5</sup>	+ <sup>1,3,4</sup>	+ <sup>1,3,4</sup>	–	–	–
Macro examination	–	–	–	–	–	+ <sup>6</sup>	–	+1 pc.	+1 pc.	+3 pc.	+3 pc.	–
Magnetic particle or dye penetrant testing	–	–	–	–	–	+ <sup>6</sup>	–	–	–	+	+	–

<sup>1</sup> Either radiographic testing or bend or fracture tests (but not both at the same time) shall be used for continuity of weld joints metal.  
<sup>2</sup> For thickness of 8 mm and more, the radiographic testing may be replaced by an ultrasonic testing except for austenitic and austenitic ferritic steels (groups 8 and 10, respectively) and for aluminum and copper alloys.  
<sup>3</sup> When radiographic or ultrasonic testing (rather than bend or fracture tests) is used, then additional bend or fracture tests are mandatory for welding processes 131, 135, 138, 141 and 311.  
<sup>4</sup> For outside pipe diameter of butt joints D ≤ 25 mm, the bend or fracture tests may be replaced by a notched tensile test of the complete test piece (refer to [Fig. 4.4.4.4-2](#)).  
<sup>5</sup> Additional tests may be required at the discretion of the Register.  
<sup>6</sup> Instead of the fracture test of a weld, it is allowed to examine the welding quality using magnetic particle/dye penetrant testing in combination with at least two macro examinations.

Where the remaining backings were used during the qualification tests, they shall be removed prior to destructive (mechanical) tests.

The test specimen for macro examination shall be prepared and etched on one side to clearly reveal the weld. Polishing is not required.

In accordance with the indications in [Footnote 3](#) to [Table 4.4.4.1](#) for welding processes 131, 135, 138, 141 and 311, the testing shall be supplemented by either two additional bend tests (one face and one root or two side bends) or two fracture tests (one face and one root).

4.4.4.2 Test pieces P<sub>1</sub> of butt plate joints. The continuity of weld metal of butt plate joint test pieces shall be checked by radiographic testing or, if agreed with the Register, for thickness of 8 mm and more ultrasonic testing is allowed.

As alternative to non-destructive testing, fracture or static bend tests may be used to check the continuity of weld metal.

When fracture test is used, the welded joint test piece examination length shall be cut into the test specimens of equal width within the examination length discarding the plate ends according to [Fig. 4.4.4.2-1](#), a. In so doing, the entire test piece examination length shall be

tested by the bending failure of specimens dimensioned according to [Fig. 4.4.4.2-1](#), c in such a way that the fracture length is not interrupted.

In the case of single-side welding without the remaining backing, half of the examination length of the test piece shall be tested on test specimens loaded on the face side and the other half on the root side according to [Fig. 4.4.4.2-2](#).

If the continuity of weld metal is checked by bend test, the diagram of cutting-out and the number of test specimens depend on the test type (transverse bend test or side bend test).

For initial qualification, the test shall be applied to two weld face bending test specimens and two weld root bending test specimens. For the certificate prolongation, the test shall be applied to one weld face bending test specimen and one weld root bending test specimen. For thicknesses of 12 mm and more, four side bending test specimens (or two specimens for the certificate prolongation) of 10 mm thick may be used.

When only side bend tests are used, a minimum of four test specimens shall be taken equally spaced along the examination length. At least one of these side bend test specimens shall be taken from the start and stop area in the examination length. The size of the specimens and the diagram of bend tests shall comply with requirements of [6.4.4.2](#) and [Fig. 4.4.4.2-3](#).

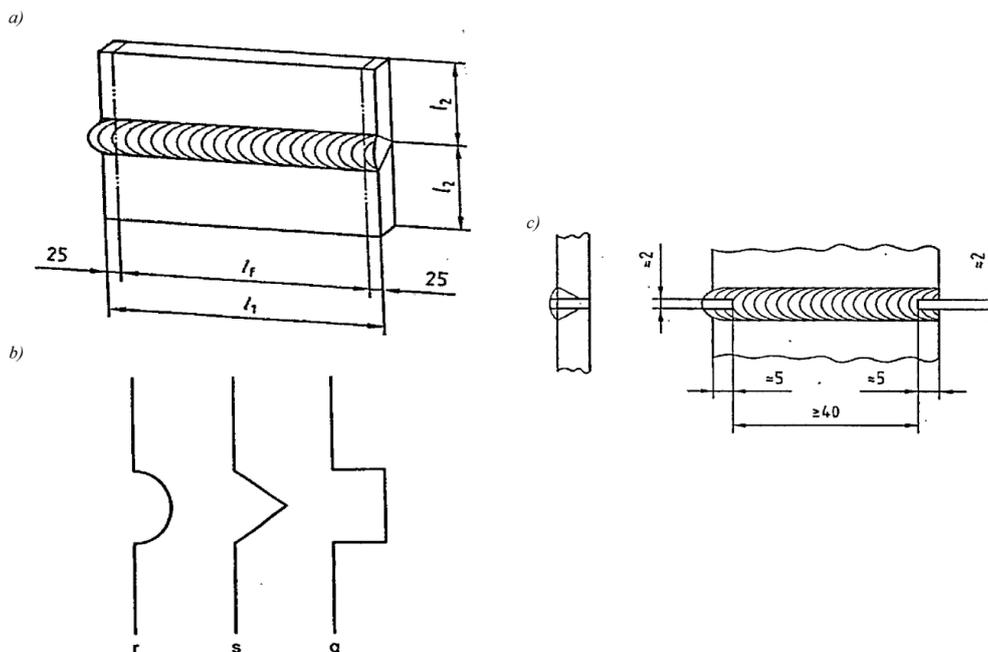


Fig. 4.4.4.2-1

Fracture tests of test pieces P1 of butt plate joints:

- a — diagram of test specimen cutting-out (the examination length  $l_f$  is divided into even number of specimens);
- b — profiles of cuts for preparation of specimens for fracture test according to ISO 9017;
- c — specimen for fracture tests with side cuts of "q" type

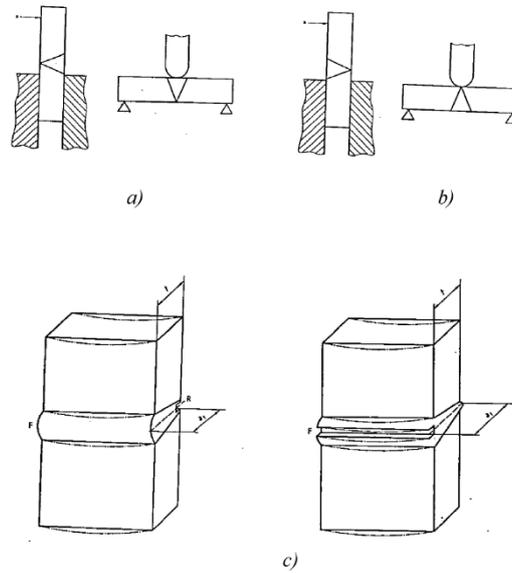


Fig. 4.4.4.2-2

Diagram of fracture test of test pieces  $P_1$  of butt plate joints:  
 a — with tension on weld root; b — with tension on weld reinforcement; c — alternative types of specimens for fracture test with "q" type profile longitudinal notch in the weld centre with tension on weld root and weld reinforcement

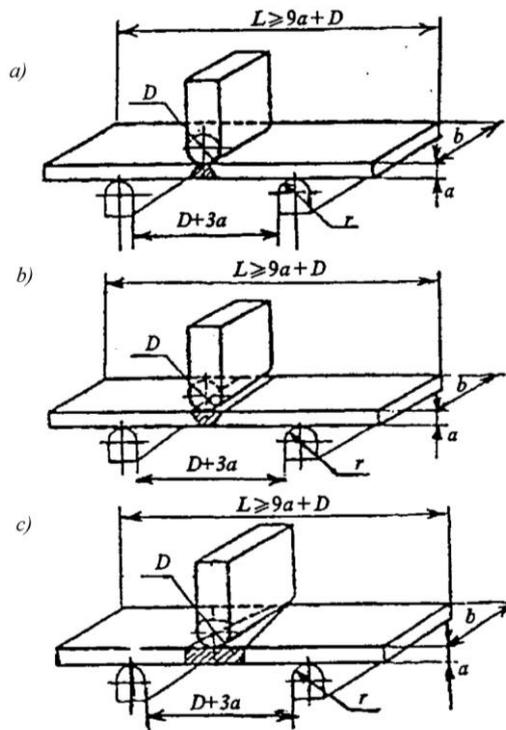


Fig. 4.4.4.2-3

Sizes of specimens and diagram of static bend test with tensioning of the weld face side

(a), weld root (b) and of side bend tests (c) for test pieces  $P_1$  of butt plate joints and  $P_3$ ,  $P_5$  and  $P_6$  of butt pipe joints

**4.4.4.3** Test pieces  $P_2$  of plate T-joints. The continuity of weld metal of plate T-joint test pieces shall be checked by test specimen fracture test according to [Fig. 4.4.4.3](#). For test performance, the test piece shall be cut out into several test specimens within the specified inspection length discarding the plate ends 25 mm wide from each edge according to [Fig. 4.4.4.3](#), a, and each specimen shall be tested in accordance with the diagram shown in [Fig. 4.4.4.3](#), b and examined after destruction. In order to destroy the specimen along the centre of the weld (which is especially important for such viscose materials as aluminum and copper), longitudinal notches of square or sharp angle cross-section may be made along the weld (refer to [Fig. 4.4.4.3](#), c). In such a case, the thickness of the fillet weld on the test piece shall be at least 80 % of the initial value. In some cases preliminary cooling of the specimen is allowed to cause the metal fragile condition.

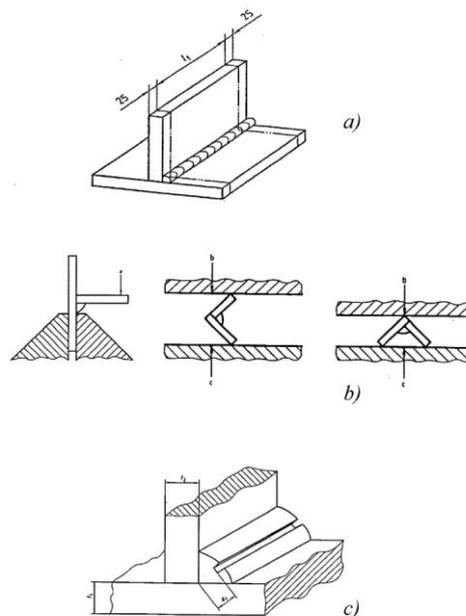


Fig. 4.4.4.3

Bend test of test pieces  $P_2$  of plate T-joints:

a — diagram of test specimen cutting-out;  $l$  — examination length of the weld; b — possible diagrams of testing; c — test specimen with a "q" type profile longitudinal notch in the center of the weld

The weld fracture test may be replaced by the testing of the weld quality using magnetic particle or dye penetrant testing in combination with the macro examination. In this case at least two macrosections shall be made (to be cut out of different sections). One macrosection shall be taken from the start and stop area in the examination length.

**4.4.4.4** Test pieces  $P_3$  of butt pipe joints. The continuity of weld metal of butt pipe joint test pieces shall be checked by radiographic testing or, if agreed with the Register, for thickness of 8 mm and more ultrasonic testing is allowed. Therewith, for welding processes 131, 135, 138, 141 and 311, the number of additional fracture and transverse bend specimens depends on the welding positions used in the test. For welding positions PA and PC testing shall be supplemented by either two additional bend tests, one root and one bend (refer to [Fig. 4.4.4.4-1](#), a). For all other welding positions two additional specimens shall be tested for the root bend and face side bend (refer to [Fig. 4.4.4.4-1](#), b).

As an alternative to non-destructive testing, fracture or static bend tests may be used to check the continuity of weld metal. During the fracture test the whole examination length shall be tested (refer to [Fig. 4.4.4.4-1, a](#)) for which at least four specimens of sizes according to [Fig. 4.4.4.4-1, c](#), shall be tested. If the pipe diameter is too small (examination length of the weld is less than 150 mm) and does not allow making the required number of test specimens, then additional test pieces shall be made and tested in accordance with [4.4.2.4](#).

In order to achieve a fracture in the weld of the test specimen, the latter may be longitudinally notched on both ends of the specimen as shown in [Fig. 4.4.4.4-1, c](#).

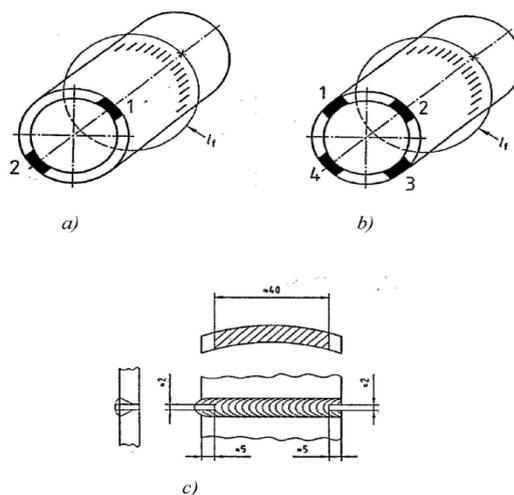


Fig. 4.4.4.4-1

Diagram of cutting-out of test pieces P<sub>3</sub>, P<sub>5</sub> and P<sub>6</sub> of butt pipe joints:

- a — for welding positions PA and PC (1, 2 — places for selection of fracture test or bend test specimens;  $l_f$  — examination length of the weld);
- b — for welding positions PF, PG, H-L045 and J-L045 (1, 2, 3, 4 — places for selection of fracture test or bend test specimens;  $l_f$  — examination length of the weld);
- c — fracture test specimen with "q" type notch profile.

$$t \geq 1,8 \text{ mm: } d = 4,5 \text{ mm}$$

$$t < 1,8 \text{ mm: } d = 3,5 \text{ mm}$$

In the case of single-side welding without the remaining backing, half of the inspection length of the test piece shall be tested on test specimens loaded on the face side and the other half on the root side according to [Fig. 4.4.4.2-2](#).

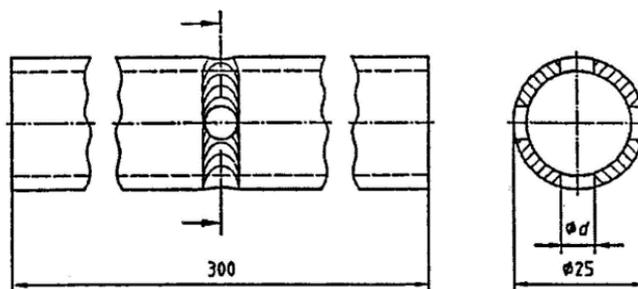


Fig. 4.4.4.4-2

Tension test specimen for testing butt joints of pipes with outside diameter  $D \leq 25$  mm

Where weld metal continuity is checked by bend tests, the diagram of cutting-out and number of test specimens depend on the test types and are similar to the ones specified in 4.4.4.2 for butt plate joint. When only side bend test is carried out, the places of cutting-out of side bend test specimens are according to Fig. 4.4.4.4-1, b.

For test pieces of butt pipe joints with outside pipe diameter  $D \leq 25$  mm, the fracture and bend tests may be replaced by tension test of the welded joint test piece with holes and removed reinforcement of the weld as shown in Fig. 4.4.4.4-2. The holes are not allowed in start and stop areas, and in order to create the destruction plane in the centre of the weld, additional or alternative "q" or "s" type notch profiles are also allowed in circumferential direction according to ISO 9017:2017 (refer to Fig. 4.4.4.2-1, b).

**4.4.4.5** Test pieces  $P_4$  of fillet pipe joints. The continuity of weld metal of fillet pipe joint test pieces shall be checked by fracture test of at least four test specimens according to Fig. 4.4.4.5. The fillet weld fracture test may be replaced by the examination of the weld quality using magnetic particle or dye penetrant testing in combination with the macro examination. For welding positions PA, PB and PD, it is sufficient to prepare and test at least two macrosections (one macrosection shall be taken at the stop/start location), and for welding positions PF and PG, 4 macrosections shall be taken at the weld areas corresponding to positions  $0^\circ$ ,  $90^\circ$ ,  $180^\circ$  and  $270^\circ$ .

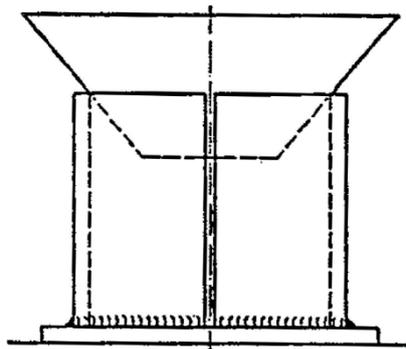


Fig. 4.4.4.5  
Preparation and fracture test of test specimens  $P_4$  of a fillet pipe joints

**4.4.4.6** Test pieces  $P_5$  and  $P_6$  for welding of butt pipe joints at limited access. The test pieces imitating pipe welding at limited access to the weld shall be checked in the same manner as in testing of butt joints  $P_3$  test pieces (refer to 4.4.4.4).

For test piece  $P_5$ , one macrosection shall be taken in the area of cutting-out within the range of  $225^\circ$  —  $270^\circ$ . The cutting-out of specimens from test piece  $P_6$  shall be made in accordance with the instructions of Fig. 6, Appendix 1.

**4.4.4.7** Test piece  $P_7$  of branch connection. Welded joints of the branch connection shall be checked along the full weld inspection length using the following testing:  
magnetic particle or dye penetrant testing (for nonmagnetic materials);  
ultrasonic or radiographic testing (depending on whether it is practicable to use such a testing).

Additionally, three macrosections shall be taken from the welded joint sections corresponding to positions  $135^\circ$ ,  $180^\circ$  and  $225^\circ$ .

**4.4.4.8** Test piece  $P_8$  imitating repair of forgings and castings. The continuity of test piece welds  $C_1$  and  $C_2$  (refer to Fig. 8 of Appendix 1) imitating the elimination of lengthy and point defects shall be checked over their entire length using the following testing:  
radiographic;

ultrasonic;

examination of macrosections taken from the weld C<sub>1</sub> (2 pcs) and weld C<sub>2</sub> (1 pc).

**4.4.4.9** For tack weld the test pieces P<sub>1tack</sub> and P<sub>2tack</sub> shall be examined and tested as follows:

visual and measurement testing;

fracture test performed on at least three test specimen cut from each test piece.

**4.4.5 Criteria for assessment of welders' practical test results.**

**4.4.5.1** Evaluation of welded joint quality in visual and measurement testing.

**4.4.5.1.1** The weld surface as such and the adjacent zone of base metal within at least 20 mm from the fusion line along the entire extent of a welded joint shall be subject to visual and measurement testing.

The visual and measurement testing shall usually be carried out without use of any special optical devices. In doubtful cases, magnifying glasses of no better than ×10 magnification may be used.

If cracks or their indications are detected in the visual and measurement testing of a welded joint, it is recommended to carry out the further flaw detection of a test piece using:

magnetic particle method/dye penetrant testing;

grinding of the surface followed by the chemical cleaning with the reagent used for macrostructure detection.

A depth of undercuts, a height of scaling and unevenness shall be checked by the comparison of welds with standards using special templates or replicating the surface relief. The latter is cut so that the dimension being checked is in the notch plane. In so doing, the dips between beads, and between the weld and base metal shall be measured on the base of 12 mm, the scaling and unevenness, between tops of hillocks and scales.

The measurements of welded joints shall be made in places where deviations from the dimensions specified may be expected at visual and measurement testing. Three measurements, as a minimum, of geometric parameters of a welded joint shall be made within the length of the welded joint test piece.

**4.4.5.1.2** Before testing the welded joints by the visual and measurement testing the following shall be checked:

complete removal of the spatter metal from the tested surface;

no grinding on the face side and the root side of the weld;

identification mark of stop and re-start in the root run and in the top capping run;

availability of mandatory and additional marking on the test piece in accordance with [4.4.2.2](#).

Unless otherwise is agreed with the Register, the assessment of the welded joints quality by the visual and measurement testing results shall be carried out up to quality level B according to the base metal of the international standards:

ISO 5817:2014 for joints in steel, nickel, titanium and their alloys (refer to Table 3.4.2.1, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships);

ISO 10042:2018 for joints in aluminum and copper alloys (refer to Table 3.5.2.1, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships).

Here, criteria may be relaxed down to quality level C for the following types of external defects: weld expulsion, excessive root penetration, excessive weld convexity, and excessive effective throat thickness.

**4.4.5.2** Assessment of welded joints quality in radiographic testing.

**4.4.5.2.1** General requirements for testing.

The radiographic method is preferable for the testing of welded joint test pieces. Unless the otherwise is agreed with the Register, the requirements and parameters of the radiographic testing shall be in compliance with ISO 17636-1:2013, ISO 17636-2:2013 (digital

detectors/with reference numbers) for Test class B (refer to 3.2.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships).

**4.4.5.2.2** Unless otherwise is agreed with the Register, assessment of welded joints quality according to the radiographic testing results shall be carried out up to Quality level 1 according to the relevant base metal of the international standards:

ISO10675-1:2016 for steel welds as well as nickel, titanium and their alloys (refer to Table 3.4.5.3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships);

ISO10675-2:2017 for aluminium and its alloys (refer to Table 3.5.4.3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships).

**4.4.5.3** Assessment of welded joints quality by ultrasonic testing results.

An ultrasonic testing shall be performed according to the agreed national standards.

Weld test scheme on the quantity of scanning directions and scan camera angles applied (PEC inclined input angle) shall comply with the requirements for Control level B in compliance with ISO17640:2017 или EN 1712:1997 + A1:2002.

Unless otherwise is 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 11666:2018 and the following requirements for their application and the interpretation of the testing results as regards instructions of 5.1 of the above-mentioned standard.

All imperfections, echo-signal of which exceeding the reference level of sensitivity, shall be assessed in accordance with the definition of the characteristics of ISO 23279:2017, Stage 3, in order to identify the planar (two-dimensional) imperfections. All detected planar (two-dimensional) imperfections are considered inadmissible. Other imperfections are assessed for Acceptance Level 2 (AL-2) according to ISO 11666:2018 (refer to Table 3.4.6.1, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships).

**4.4.5.4** Assessment of welded joint quality by static bend test results.

In testing of welded joint test specimens made of shipbuilding and high-strength steels for static bend, the requirements of [Table 4.4.5.4-1](#) shall be followed. For cases not specified in [Table 4.4.5.4-1](#), the following instructions shall be applied:

for steels with the rated value of elongation  $A_5 \geq 20$  %, the diameter of the former or inner roller  $d$  shall be  $4t_s$  and the bending angle  $180^\circ$ , and for base metal with elongation  $A_5 < 20$  %, the following equation shall apply:

$$d = (100/A_5 - 1) t_s$$

where  $d$  = the diameter of the former or the inner roller, in mm;

$t_s$  = the thickness of the bend test specimen, in mm;

$A_5$  = the minimum tensile elongation required by the base metal specification, in %;

Table 4.4.5.4-1

**Requirements for static bend test performance for shipbuilding and high-strength steels**

Base metal category	Proportion $d/t_s$	Bend angle, in 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

Base metal category	Proportion $d/t_s$	Bend angle, in deg.
A690 F690	6	180

for copper and copper alloys, the diameter of the former or inner roller shall be  $4t_s$ , and bending angle  $180^\circ$ , unless the low plasticity of the base metal or weld metal imposes other restrictions;

for shipbuilding aluminum alloys, the diameter of the former or inner roller is defined by the requirements of [Table 4.4.5.4-2](#).

Bend test specimens shall not reveal any one single flow equal to or more than 3 mm in any direction. Flaws with length up to 3,0 mm appearing at the edges of the test specimen during testing are ignored and not recorded in the test report.

Table 4.4.5.4-2

**Requirements for static bend test performance for shipbuilding aluminum alloys**

Grade of aluminum alloy	Proportion $d/t_s$ as for delivery condition				Bend angle, in deg
	O/H111	H112; H116; H32; H34; H36	T4	T5; T6	
International alloys					
5754	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; 1565; 1575, 1581	6	6	–	–	180

**4.4.5.5** Assessment of welded joints quality by fracture test results.

**4.4.5.5.1** After the performance of butt welded joint fracture tests, the fracture surface shall be visually tested. The weld defects visible are subject to estimation to quality level B according to ISO 5817:2014.

**4.4.5.5.2** Quality of welded T-joints shall be checked for presence of cracks, porosity and pores, extraneous inclusions, lacks of fusion and incomplete penetration. The weld defects visible are subject to estimation to quality level B according to ISO 5817:2014.

**4.4.5.6** Macro examination.

Macrosections shall be made so that their working surface covers the entire area of the weld and the part of base metal at least 15 mm wide adjacent to the fusion line. The reagent used for etching shall allow the clear identification of weld and separate bead boundaries, the fusion line, heat-affected zone and also the adjacent part of the base metal. In macro examination, the following is subject to control:

- weld shape and geometric dimensions;
- base metal penetration shape and size;
- presence of base metal undercuts and of the shrinkage in the root of a single-side weld;
- presence of intolerable internal defects in the weld and adjacent zone within 10 mm from the heat-affected zone boundary.

Macrosections may have defects if their type and dimensions are not beyond the scope of the requirements in [4.4.5.1](#) and [4.4.5.2](#). In this case, the sum of all defect (external and internal) projections toward a design thickness shall not exceed  $0,15t$  or  $0,15a$ , but not more than 4,0 mm for all the groups of steels and aluminium alloys.

**4.4.6** Procedure for retests performance.

**4.4.6.1** In cases when the certification panel has reliably established that the unsatisfactory result of initial practical tests is due to the causes not associated with the welder's skill (e.g. welding equipment faults, defects of welding electrode covering, etc.), the welder shall be approved for retests on the same number of test pieces. In this case, the quality

of base metal and welding consumables, as well as the serviceability of welding equipment shall be properly checked by the certification panel members. If the specimen does not meet the size requirements due to improper machining, a new specimen shall be prepared, manufactured from a new test piece or an old test piece if there is sufficient amount of waste left and tested in accordance with the established procedure.

**4.4.6.2** If it is established that the unsatisfactory result of initial practical tests is attributed to the welder's lack of skill and is due to the unsatisfactory results of the tests on more than one test specimen, the welder may be approved for the repeat certification after the additional education and training totaled at least a week.

**4.4.6.3** If the results of testing one of the test specimens tested do not meet the requirements specified for the given type of tests, the doubled number of that type test specimens shall be prepared and tested. The test specimens for additional tests may be selected from the store of the available test piece or the new test piece shall be welded under similar conditions.

**4.4.6.4** The tests are assessed as satisfactory when the satisfactory results have been demonstrated on two additional test specimens prepared according to the requirements of [4.4.6.3](#).

If the results of retests for at least one of additional specimens are unsatisfactory, the welder fails the practical tests and shall undergo retesting in accordance with established procedure.

**4.4.6.5** In additional bend tests of test specimens, as well as of sections prepared from fixed butt pipe joints (welding positions PF, PG and H-L045, J-L045 for test pieces P<sub>3</sub> and P<sub>5</sub>, and also test pieces P<sub>6</sub> and P<sub>7</sub>), the place on a test piece, where the test specimens were taken, corresponding to the position of the welding sector for which the unsatisfactory results were obtained in initial tests, shall be retained.

**4.4.6.6** In case when the scope of initial tests provided for welding several test pieces (of one type for various welding positions or different types), but the unsatisfactory results were obtained only for one of those test pieces, the retests according to [4.4.6.2](#) may be performed only with use of the test piece for which the negative result was obtained. In this case, the Register may increase the scope of retests up to the double scope of initial tests.

**4.4.6.7** With the unsatisfactory results of repeat practical tests, the welder is considered to have failed the certification. The welders are approved for the new certification by the certification panel individually with due regard for the professional shortcomings identified. In any case, the time between the certifications for training and acquiring the necessary practical skills shall be at least a month.

**4.4.7 Welding operators of friction stir welding (FSW) equipment for aluminium alloys.**

**4.4.7.1** Welding operators shall be qualified and certified in accordance with ISO 25239-3:2020.

**4.4.7.2** The welding operator shall weld test pieces within the welding parameters set upon results of welding procedure certification. Each test piece shall be taken from the beginning, center and end of the welded joint in such a way that the length of each sample shall be not less than 500 mm. To be certified welding operator shall weld 3 test pieces.

**4.4.7.3** The scope of non-destructive testing of friction stir welded test pieces for certification of welding operators includes:

visual and measurement testing, 100%;

radiographic testing or ultrasonic testing (for thickness of 8 mm and over);

**4.4.7.4** The scope of mechanical tests of welded test pieces for certification of welding operators based on the standard test procedure for the welders, dimensions of welded test pieces shall comply with Section 4.3 of ISO 25239-3:2020.

**4.4.7.5** Certification of FSW operators may be carried out by a standing commission on certification the members of which are approved by the order (instruction) for the firm.

**4.4.7.6** The commission shall include:  
chief welder of the firm (or equivalent position) — chairman of the commission;  
welding engineer — deputy chairman (Secretary);  
head of the Quality Control Department or Inspection Department;  
head (supervisor) of the production site;  
NDT supervisor;  
representative of the Register.

**4.4.7.7** Schedule of work of the commission on certification. Issue of documents.

**4.4.7.7.1** The commission shall check the theoretical knowledge of welding operators, shall be present during welding of samples, and consider the test results in order to make a decision regarding these results.

**4.4.7.7.2** All the members of the commission shall be notified of the date of its meeting:  
employees of the firm — not less than 3 days before the date;  
employees of other organizations — not less than 10 days before the date.

**4.4.7.7.3** The following documents shall be submitted to the commission:  
program of welding operators certification;  
list of welding operators to be certified with indication of education, rate and professional experience;

certificates of welding operators;  
conclusion based on the results of testing of test assemblies;  
reference of the quality of welders' works signed by the Quality Control Department (Inspection Department) in order to exempt the welder from retests.

**4.4.7.7.4** When practical tests are performed, presence of the following members of the commission shall be sufficient:

head of the Quality Control Department/Inspection Department and Welding Engineer to supervise performance of welding and assess the quality of samples visually;  
representative of the Register.

**4.4.7.7.5** Proceeding from the results of the practical and theoretical examinations of welding operators the certifying commission draws up and issues a Welding Operators Approval Test Certificates for Friction Stir Welding (form 7.1.30-FSW).

**4.4.7.7.6** Terms of validity, endorsement and prolongation of the Certificate are established in accordance with 5.2 of ISO 25239-3:2020. Prolongation of the Certificate (form 7.1.30 FSW) shall be carried out according to option c) in compliance with [4.6.7](#).

## **4.5 RANGE OF APPROVAL BASED ON TEST RESULTS**

**4.5.1** The assessment of welders' practical skills in the course of practical tests for defining the range of approval for issuing the Welder Approval Test Certificates is based on the following essential variables of:

- .1 welding process and type;
- .2 product type/structure (plate and pipe);
- .3 type of welded joint (butt and fillet);
- .4 base metal group;
- .5 welding consumable;
- .6 dimensions of welded joint (thickness of materials and outside pipe diameter);
- .7 welding positions;

.8 special features of welding process (backing, back gouging, single-side welding, double-side welding, single-layer weld, multilayer welding, leftward and rightward welding).

Some types of welding may be singled out as requiring individual tests:

pipe welding under conditions of the limited access ([refer to 4.4.3.7](#));

pipe assembly welding ([refer to 4.4.3.6](#) and [4.4.3.8](#));

repair of casting and forging defects ([refer to 4.4.3.9](#)).

All welded joint test pieces shall be generally welded using the essential variables independently, except for combination of two or more welding processes in one test piece ([refer to 4.5.2](#)), as well as dimensions and welding positions ([refer to 4.5.7](#) and [4.5.8](#)).

**4.5.2** Every practical test is generally limited by the range of approval for one welding process/type designated by indices according to the requirements of [4.3.2.1](#) and [4.3.2.2](#).

The change of a welding process in the product manufacture calls for performance of new tests on welders' approval.

If a specific joint is welded in production by one welder using the combination of two or more welding processes, the practical approval tests may be performed as follows:

.1 a test piece is welded in testing using the combination of two or more welding processes in a similar way as in production (e.g. the root — single-side tungsten inert gas welding without backing, groove filling — manual welding with covered electrodes);

.2 in the approval testing, two test pieces are welded for the separate welder's certification for each welding process.

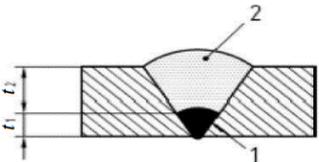
The range of approval of the Welder Approval Test Certificates on the base metal thicknesses for each applicable welding process and for butt welded joints made by multi-process welding is specified in [Table 4.5.2](#) (refer also to [Table 4.5.7.1](#)).

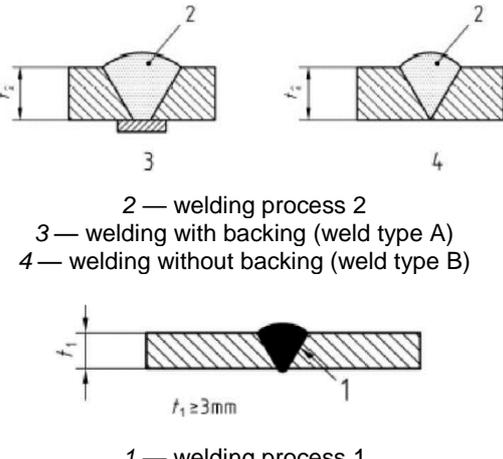
It shall be considered that the use of any variants of testing for combination of two or more welding processes shall not result in reduction of the requirements to the extent of the examination of the welded joint test pieces specified by the requirements of [Table 4.4.4.1](#) for bend tests.

**Note.** It is allowed to carry out the practical test of welders for two or more welding processes by welding one test piece (multi-process welding) or by conducting two or more practical tests.

Table 4.5.2

**Range of approval of the Welder Test Approval Certificate for base metal thicknesses made by single or multi-process welding**

Welding process (combination of welding processes) used for the test piece	Ranges of approval of the Welder Test Approval Certificate for base and weld metal thicknesses for butt welds in accordance with <a href="#">Table 4.5.7-1</a>	
	Single process joint	Multi-process welding
 <p>1 — welding process 1 (weld type B) 2 — welding process 2 (weld type A)</p>	<p>For welding process 1: <math>t = t_1</math> For welding process 2: <math>t = t_2</math></p>	<p><math>t = t_1 + t_2</math></p>

Welding process (combination of welding processes) used for the test piece	Ranges of approval of the Welder Test Approval Certificate for base and weld metal thicknesses for butt welds in accordance with <a href="#">Table 4.5.7-1</a>	
	Single process joint	Multi-process welding
 <p>2 — welding process 2 3 — welding with backing (weld type A) 4 — welding without backing (weld type B)</p> <p>1 — welding process 1</p> <p><math>t_1 \geq 3\text{mm}</math></p>	<p>For welding process 1: <math>t = t_1</math> For welding process 2: <math>t = t_2</math></p>	<p><math>t = t_1 + t_2</math> Welding process 1: only for welding of the root area</p>

**4.5.3** The type of test piece for practical tests, in accordance with the instructions of [4.4.3](#), is assigned depending on the product/structure type (plate or pipe) for welding of which the welder is allowed. [Tables 4.5.8-1 — 4.5.8-3](#) on the range of approval of the Welder Approval Test Certificates shall be complied with taking into account the following:

.1 the range of approval of welding pipes with the outside diameter  $D > 25$  mm may cover welding of plates;

.2 the range of approval of welding plates may cover welding of pipes:  
in fixed position with the outside diameter  $D \geq 150$  mm in welding positions in accordance with [Table 4.5.8-1](#);

in rotating position with the outside pipe diameter  $D \geq 75$  mm in PA, PB, PC and PD positions in accordance with [Table 4.5.8-1](#).

**4.5.4** The range of approval of the Welder Approval Test Certificate for the weld types (butt or fillet weld) shall be determined based on the provisions stated below.

**4.5.4.1** The range of approval of the Welder Approval Test Certificate may cover butt welds in other types of butt joints and welds taking into account [4.5.9](#) except for cases requiring additional types of testing ([refer to 4.5.1](#)).

**4.5.4.2** Butt welds, as a rule, qualify fillet welds. Carrying out separate tests for fillet welds on test pieces  $P_2$  or  $P_4$  is required in the following cases:

.1 the welder, at the request of the manufacturer, shall be qualified only for fillet welds;  
.2 if deemed necessary by the Register, in cases where the majority of work is fillet welding.

Note. This requirement does not apply to the fillet welding with full or incomplete penetration when the edge preparation is provided. As a rule, the approval test for the welding of such welds is conditioned by the extension of the range of approval of the Welder Approval Test Certificate for the welding of butt welds under identical conditions.

**4.5.4.3** The range of approval of the Welder Approval Test Certificate for additional tests is determined in accordance with the general provisions concerning all essential variables. The following specifications shall apply:

butt welds in pipes for test pieces P<sub>6</sub> qualify branch connections with an angle of not less than 60°;

for a branch weld, the range of approval of the Welder Approval Test Certificate for is based on the outside pipe diameter of the branch and wall thickness according to 4.5.7.

**4.5.4.4** In cases when the weld type cannot be qualified by means of type test pieces (e.g. pipe plate welding, etc.), then specific test pieces shall be used.

**4.5.5** In order to reduce the number of practical qualification tests, materials with similar welding characteristics are grouped according to ISO/TR15608:2017 (refer to Tables 4.3.3.1-1, 4.3.3.1-2 and 4.3.3.1-3).

The practical test during which for welding of any metal in a base metal group confers qualification on the welder for the welding of all other metals within the same group with the range of approval of the Welder Approval Test Certificate, as well as other base metal groups according to Tables 4.5.5-1, 4.5.5-2 and 4.5.5-3.

The range of approval of the Welder Approval Test Certificate for metals of different base metal groups is defined in compliance with the following requirements:

**.1** the welder may be allowed for welding of dissimilar metal joints in any combination of base metal groups for welding of which he is qualified in accordance with Tables 4.5.5-1, 4.5.5-2 and 4.5.5-3. In this case the welding consumable shall correspond to the group of one of the welded base metal;

Table 4.5.5-1

**Range of approval of the Welder Approval Test Certificate for base metal (steel)**

Base metal group <sup>1</sup> of the test piece	Range of approval based on 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	x	-	-	-	-	-	-	-	-	-	-	-	-
1.3	x	x	x	x	-	-	-	-	-	x	-	-	x
2	x	x	x	x	-	-	-	-	-	x	-	-	x
3	x	x	x	x	-	-	-	-	-	x	-	-	x
4	x	x	x	x	x	x	x	x	-	x	-	-	x
5	x	x	x	x	x	x	x	x	-	x	-	-	x
6	x	x	x	x	x	x	x	x	-	x	-	-	x
7	x	x	x	x	x	x	x	x	-	x	-	-	x
8	-	-	-	-	-	-	-	-	x	-	x	x	-
9	9.1	x	x	x	-	-	-	-	-	x	-	-	x
	9.2 + 9.3	x	-	-	-	-	-	-	-	-	x	-	-
10	-	-	-	-	-	-	-	-	x	-	x	x	-
11	x	x	-	-	-	-	-	-	-	-	-	-	x

<sup>1</sup> Base metal group according to ISO/TR 15608:2017.  
 Symbols:  
 "x" — indicates those base metal groups for which the welder is qualified.  
 "-" — indicates those base metal groups for which the welder is not qualified.

Table 4.5.5-2

**Range of approval of the Welder Approval Test Certificate for base metal (aluminum alloys)**

Base metal group <sup>1</sup> of the test piece	Range of approval based on test results					
	21	22	23	24	25	26
21	x	x	-	-	-	-
22	x	x	-	-	-	-
23	x	x	x	-	-	-
24	-	-	-	x	x	-
25	-	-	-	x	x	-
26	-	-	-	x	x	x

<sup>1</sup> As in [Table 4.5.5-1](#).  
Symbols: as in [Table 4.5.5-1](#).

Table 4.5.5-3

**Range of approval of the Welder Approval Test Certificate for base metal (copper and copper alloys)**

Base metal group <sup>1</sup> of the test piece	Range of approval based on test results							
	31	32	33	34	35	36	37	38
31	x	–	x	x	x	–	–	–
32	–	x	–	–	–	x	–	–
33	–	–	x	–	–	–	–	–
34	–	–	–	x	x	–	–	–
35	–	–	–	x	x	–	–	–
36	–	x	–	–	–	x	–	–
37	–	–	–	–	–	–	x	–
38	–	–	–	–	–	–	x	x

<sup>1</sup> As in [Table 4.5.5-1](#).  
Symbols: as in [Table 4.5.5-1](#).

**.2** when for dissimilar metal joints welding consumables from base metal group 8 (austenitic stainless steels) or 10 (austenitic ferritic stainless steels) are used, all combinations with base metal group 8 or 10 to other base metal groups are covered.

A practical qualification test made on wrought base metal groups gives qualification for cast material and a mixture of cast and wrought material in the same base metal group.

When welding base metal outside the grouping system according to ISO/TR 15608:2017, a separate qualification test is required.

**4.5.6** Specifying the range of approval of the Welder Approval Test Certificates, a type of electrode covering and flux-cored wire filler which were used for the practical test pieces welding shall be taken into account.

The appropriate ranges of approval of the Welder Approval Test Certificates for the types of electrode covering and flux-cored wire filler are given in [Table 4.5.6](#).

The approval tests performed with the use of filler material, e.g. for welding processes 141, 15 and 311, have the range of approval of the Welder Approval Test Certificates for the same welding process without filler material, but not vice versa.

Table 4.5.6

**Range of approval of the Welder Approval Test Certificates for types of welding consumables<sup>1</sup>**

Welding process	Welding consumables used for tests <sup>2</sup>	Range of approval as per test results			
		A, RA, RB, RC, RR, R	B	C	
111	A, RA, RB, RC, RR, R	x	–	–	
	B	x	x	–	
	C	–	–	x	
–	–	Solid wire (S)	Type of electrode core		
			(M)	(B)	(R, P, V, W, Y, Z)
131	Solid wire (S)	x	x	–	–
135	(M)	x	x	–	–
136					
141					

Welding process	Welding consumables used for tests <sup>2</sup>	Range of approval as per test results				
		A, RA, RB, RC, RR, R	B	C		
136	Type of electrode core	(B)	–	–	x	x
114 136		(R, P, V, W, Y, Z)	–	–	–	x

<sup>1</sup> Symbols of welding consumable types comply with 4.3.2.3.  
<sup>2</sup> Type of welding consumables used in approval tests for root run welding without backing with reverse root formation (B) is a type of welding consumables qualified by the approval for root run welding in production.  
 Symbols:  
 "x" — indicates those welding consumables (electrode covering, electrode core) for which the welder is qualified.  
 "–" — indicates those welding consumables (electrode covering, electrode core) for which the welder is not qualified.

**4.5.7** The range of approval of the Welder Test Approval Certificate shall be specified on the basis on the following welded joint dimensions:

thickness of the base metal and weld;

outside pipe diameter.

Fillet weld thickness shall be:  $0,5t \leq a \leq 0,7t$  for  $t \geq 6$  mm;  $0,5t \leq a \leq t$  for  $t < 6$  mm.

Each practical qualification test shall be conducted within the range of range of approval of the Welder Test Approval Certificate in accordance with the requirements of [Tables 4.5.7-1](#), [4.5.7-2](#) and [4.5.7-3](#).

Table 4.5.7-1  
**Ranges of approval of the Welder Test Approval Certificate for base and weld metal thicknesses for butt welds**

Base metal <sup>1</sup>	Thickness of test piece metal in tests $t$ , in mm	Range of approval of base metal and weld metal thickness, in mm
Steels	$t < 3$	from $t$ to $2t^2$
	$3 \leq t \leq 12$	from 3 to $2t^3$
	$t \geq 12$	from 3
Aluminum and its alloys	$t \leq 6$	from $0,7t$ to $2,5t$
	$6 < t \leq 15$	$6 < t \leq 40^4$
Copper and its alloys	$t$	from $0,5t$ to $1,5t^6$

<sup>1</sup> For multi processes  $t_1$  and  $t_2$  apply according to the instructions in [Table 4.5.2](#).  
<sup>2</sup> For gas (oxy-acetylene) welding — from  $t$  to  $1,5t$ .  
<sup>3</sup> For gas (oxy-acetylene) welding — from 3 mm to  $1,5t$ .  
<sup>4</sup> For base metal having thickness more than 40 mm, separate certification is required which shall be indicated in the Welder Approval Test Certificates and in the test report.  
<sup>5</sup> For gas (oxy-acetylene) welding the welder shall be qualified for the thinnest and thickest base metal thickness, for which he is qualified in practice.

Table 4.5.7-2

**Range of approval for outside pipe diameter**

Base metal	Outside pipe diameter of test piece, in mm	Range of approval by outside pipe diameter, in mm
Steels	$D \leq 25$	from $D$ to $2D$
	$D > 25$	from $0,5D$ and more but not less than 25
Aluminum and its alloys	$D \leq 25$	from $0,5D$ to $2D$
	$D > 25$	from $0,5D$ and more
Copper and its alloys	$D \leq 25$	from $D$ to $2D$
	$D > 25$	from $0,5D$ and more but not less than 25

Note. For structural hollow sections,  $D$  is the dimension of the smaller side.

Table 4.5.7-3

**Range of approval of the Welder Approval Test Certificate for base metal thickness of test piece for fillet welds**

Base metal thickness of test piece $t$ , in mm	Range of approval by base metal thickness, in mm
$t < 3$	From $t$ to 3
$t \geq 3$	From 3 and more

Note . 1. The thickness of the fillet weld shall be within the range:  
 $0,5t \leq a \leq 0,7t$  for  $t \geq 6$  mm;  
 $0,5t \leq a \leq t$  for  $t < 6$  mm.

In case of branch welding, criteria of [Tables 4.5.7-1](#) and [4.5.7-2](#) apply, together with the following rules:

for set-on branch connection, the material thickness and outside pipe diameter are those of the branch;

for set-in or set-through branch connection, the material thickness is that of the main pipe or shell and the outside pipe diameter is that of the branch.

For welded joint test pieces of different outside pipe diameters and base metal thicknesses, the range of approval of the Welder Test Approval Certificate is determined separately for:

the thinnest and thickest material thickness qualified in accordance with [Table 4.5.7-1](#);

the smallest and largest outside pipe diameter qualified in accordance with [Table 4.5.7-2](#).

**4.5.8** The range of approval of the Welder Approval Test Certificates depending on welding position of the test piece welded during practical test is defined according to the requirements of Tables 4.5.8.1 — 4.5.8.3, as well as considering the requirements of [4.5.3](#) and [4.5.4](#).

Table 4.5.8-1

**Range of approval of the Welder Approval Test Certificates for welding positions of butt weld test pieces of plates**

Test welding position	Range of approval as per test results	
	Butt welds	Fillet welds
PA	PA	PA, PB
PC	PA, PC	PA, PB, PC
PE	PA, PC, PE	PA, PB, PC, PD, PE
PF	PA, PF	PA, PB, PF
PG	PG	PG

Table 4.5.8-2

**Range of approval of the Welder Approval Test Certificates for welding positions of fillet weld test pieces of plates**

Test welding position	Range of approval as per test results	
	Fillet welds	
PA	PA	
PB	PA, PB	
PC	PA, PB, PC	
PD	PA, PB, PC, PD, PE	
PE	PA, PB, PC, PD, PE	
PF	PA, PB, PF	
PG	PG	

Table 4.5.8-3

**Range of approval of the Welder Approval Test Certificates for welding positions of weld test pieces of pipes**

Test welding position	Range of approval as per test results	
	Butt welds	Fillet welds
PA	PA	–
PB	–	PA, PB
PC	PA, PC	–
PD	–	PA, PB, PC, PD, PE
PH (fixed pipe joint)	PA, PE, PF	–
PH (fillet pipe with plate)	–	PA, PB, PC, PD, PE, PF, PH (fillet)
PJ (pipe joint)	PA, PE, PG,	–
PJ (fillet pipe with plate)	–	PA, PB, PD, PE, PG
H-L045	PA, PC, PE, PF	–
J-L045	PA, PC, PE, PG	-

Welding of test pieces during practical tests shall be conducted at nominal angles of welding positions to the horizon according to ISO 6947:2019 ([refer to Appendix 2](#)).

The welding positions J-L045 and H-L045 for pipe practical tests cover the range of approval of Welder Approval Test Certificates for all pipe angles.

Welding of two pipes with the same outside pipe diameter, one in welding position PF and one in welding position PC, also covers the range of approval of the Welder Approval Test Certificates for the pipe welded in welding position H-L045.

Welding of two pipes with the same outside pipe diameter, one in welding position PG and one in welding position PC, also covers the range of approval of the Welder Approval Test Certificates for the pipe welded in welding position J-L045.

Welding of pipes with outside diameters  $D \geq 150$  mm may be carried out in two welding positions using only one welded joint test piece (PH or PG — 2/3 of circumference, PC — 1/3 of circumference). This test covers all welding positions applicable to the test ([refer to Fig. 4.5.8](#)).

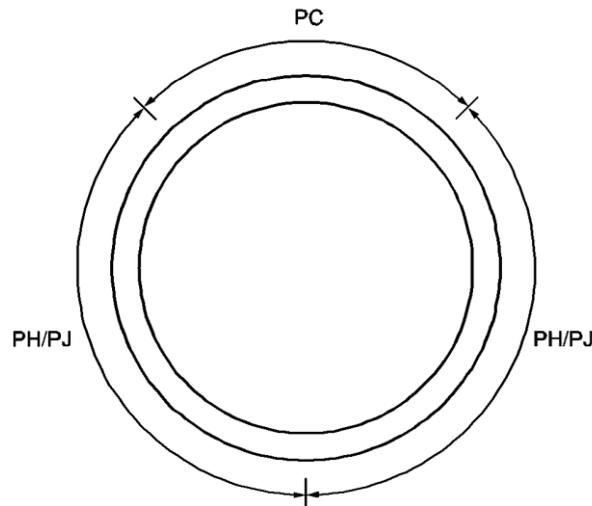


Fig. 4.5.8

**4.5.9** The ranges of approval of the Welder Test Approval Certificate depending on the welding technique are given in [Table 4.5.9](#) with additional reference to [4.3.3.2](#). When welding with gas (oxy-acetylene) a change from rightward welding to leftward welding and vice versa requires a new qualification test.

Table 4.5.9

**Range of approval of the Welder Test Approval Certificate for types of welds**

Qualification weld details				Range of approval
Butt weld	Single-side weld	With backing	A	A, C, F
		Without backing	B	A, B, C, D, F
	Double-side weld	With gouging	C	A, C, F
		Without gouging	D	A, C, D, F
Fillet weld	–	–	F	F

**4.5.10** Range of approval based on certification test results of FSW operators is determined in accordance with the requirements of Section 4.2 of ISO 25239-3:2020.

#### **4.6 DRAWING-UP, VALIDITY AND PROLONGATION OF WELDER APPROVAL TEST CERTIFICATE**

**4.6.1** According to the results of welders' theoretical and practical tests, the certification panel draws up the record on form recommended in [Appendix 3](#).

**4.6.2** The following shall be attached to the record:

- the copy of the certificate of welder's qualification and the reference of a manufacturer's personnel department (in the initial qualification) or the copy of the welder's certificate in other types of certification;

- the copy of an educational establishment document on welder's special training;

- the copies of certificates for base base metal and welding consumables;

- reports, conclusions and other documents on the results of quality control for welded joint test pieces.

Note. One record in the form of a table for a group of welders including all the information and data specified in [Appendix 3](#) may be drawn up.

**4.6.3** The record of welder's certification is executed in two copies. One copy is kept in the certification centre and the other is forwarded to the RS Branch Office carrying out technical supervision of tests performance.

The report documents of welder's certification (records, certificate copies, conclusions on the results of quality control for welded joint test pieces, etc.) shall be kept in the relevant file of the RS Branch Office in a paper or electronic form (as a scanned copy).

**4.6.4** Based on the record of welder's certification and provided all the above requirements are met, the Register draws up and issues the Welder Approval Test Certificate: form 7.1.30-1, when periodical qualification/certification is required once in two years to confirm the Welder Approval Test Certificate validity, performed by Option b) in accordance with [4.6.7](#);

form 7.1.30-2, when periodical qualification/certification is required once in three years to confirm the Welder Approval Test Certificate validity, performed by Options a) and c) in accordance with [4.6.7](#).

**4.6.5** Certificates as per forms 7.1.30-1 and 7.1.30-2 (the Welder Approval Test Certificate) are executed and issued by the RS Branch Office carrying out the technical supervision during the construction of ships or structures. The document is signed by the Head of the RS Branch Office and witnessed with the round anchor stamp. The registration of the Welder Approval Test Certificates is performed in the RS Branch Office according to the place of issuance. Copies of the documents issued can be submitted to RHO on its special demand only.

**4.6.6** The Welder Test Approval Certificate issued is valid prior to periodical certification and prolongation of its validity in the Register provided that it is confirmed every six months by the responsible personnel of the employer. Confirmation of the Welder Test Approval Certificate validity upon each qualification shall be reported to the Register on demand. The confirmation entry introduced in the appropriate columns of the Welder Test Approval Certificate is the acknowledgment by the employer of the fact that the following requirements were complied with in the process of the welder performance of his professional duties within the period of account:

the welder shall be continuously engaged on welding work within the current period of approval. In this case, an interruption in work over six months is not permitted;

the welder's work in production shall correspond in its complexity to the range of approval specified in the Welder Test Approval Certificate;

the welder's skill and knowledge shall not be questioned during working.

If any of these conditions are not fulfilled, the Welder Test Approval Certificate becomes invalid. In this case, the matter of its renewal or issuance of the new one is handled individually in each particular case.

The Welder Test Approval Certificate is valid for 6 years, taking into account terms specified in [4.6.6](#). Upon expiry of the specified period the Register issues a new Welder Test Approval Certificate based on the satisfactory results of the welder's qualification in the scope of the initial one.

*Note.* In accordance with the practice adopted in the national legislation, the welder shall pass regular medical examination and get positive conclusion of a medical commission on professional fitness.

**4.6.7** Prolongation of the Welder Test Approval Certificate validity shall be carried out by the Register based on the confirmation of welders' qualification in the scope of the periodical certification by one of the following options:

Option a). The welder shall be re-tested every 3 years in accordance with [4.6.8.1](#);

Option b). Based on revalidation of the welder's qualifications for the previous 2 years in accordance with the requirements specified in [4.6.8.2](#);

Option c). Based on revalidation of the welder's qualifications for the previous 3 years in accordance with [4.6.8.3](#).

Request for prolongation of the Welder Test Approval Certificate validity shall be submitted to the Register within 30 days before and after the due date for the Certificate renewal. Validity of the Welder Test Approval Certificate may be prolonged within 90 days upon expiry of the 2-year period for Option b) and 3-year period for Options a) and c).

Revalidation of the Welder Test Approval Certificate as per option c) does not cover welders certified in welding of pipes and pressure vessels or oxy-acetylene welding (311).

The documents for the Welder Test Approval Certificate prolongation shall be kept for two years as a minimum.

**4.6.8** Terms of the Welder Test Approval Certificate validity prolongation.

**4.6.8.1** Terms of the Welder Test Approval Certificate validity prolongation as per Option a) in accordance with [4.6.7](#).

The Welder Test Approval Certificate may be prolonged by the Register for up to three years provided the welder has passed new practical testing. At that, passing theoretical examination is not required unless otherwise decided by the certification panel.

*Note.* For prolongation of the Welder Approval Test Certificates the following deviations from the conditions of the initial tests are permitted:

material thickness may vary within the initial range of approval of the Welder Approval Test Certificates;

outside pipe diameter may vary  $\pm 50$  % from the initial test piece.

The prolongation of the Welder Approval Test Certificates for the next three-year period shall be performed by the Register subject to requirements in [4.6.6](#), and the manufacturer (employer) shall submit to RS the test report based on the results of practical testing with the attached conclusion on the specific non-destructive testing of weld test pieces.

**4.6.8.2** Terms of the Welder Approval Test Certificate validity prolongation as per Option b) in accordance with [4.6.7](#).

The Welder Approval Test Certificate may be prolonged by the Register for the next 2-year period without performance of new practical tests and changing of range of approval. Revalidation of the Welder Approval Test Certificate for the next 2-year period is performed by the Register, provided that the conditions listed in [4.6.6](#) are complied with and provided that the manufacturer (employer) has submitted to the Register conclusions on the specific non-destructive testing (RT or UT or their advanced alternatives of at least two weld joint areas for each welder, 400 — 500 mm in length, performed within the last 6 months of the 2-year period).

The submitted results of the non-destructive testing shall demonstrate that the welder has performed all works under conditions identical to those as at the initial approval test except for dimensions of welded joint (material thickness and outside pipe diameter).

**4.6.8.3** Terms of the Welder Approval Test Certificate revalidation as per option c) in accordance with [4.6.7](#).

The Welder Approval Test Certificate may be prolonged by the Register for the next period of three years without performance of new practical tests and changing the range of approval. Prolongation of the Welder Approval Test Certificate for the next 3-year period is performed by the Register, provided that the conditions listed in [4.6.6](#) are complied with as well as the following additional terms and conditions:

The welder is working for the same shipyard/manufacturer (employer) which is responsible for production weld quality as indicated on his or her qualification certificate;

The Register shall verify that the welder quality management system of the shipyard/manufacturer includes as a minimum:

- designated person responsible for the coordination of the welder quality management system;

- list of welders and welding supervisors (QCD) in shipyard/manufacturer;

- if applicable, list of subcontracted welders;

- training requirements for welder qualification program;

- procedure describing the system in place to monitor each welder performance based on results of welds examination records (e.g. repair rate, etc.) including the criteria permitting the maintenance of the welder qualification without retesting.

The shipyards/manufacturers (employers) have to document at least once a year that the welder has produced acceptable welds in accordance with construction quality standards and requirements of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships in accordance with the welding positions, type of welds and backing conditions covered by the Welder Approval Test Certificate. Conclusions on the specific non-destructive testing (RT or UT or their advanced alternatives) of at least four weld joint areas for each welder, 400 — 500 mm in length, performed for each year of the 3-year period shall be submitted to the Register.

**4.6.9** Each shipyard and/or manufacturer is responsible for monitoring validity of certificates and qualification area. The shipyard and/or manufacturer shall assign a person in charge (executive) for this function.

A card index for every certified welder shall include:

- copy of an education document;

- copy of a special training document;

- reference on continuous welding experience;

- records of passing the examinations specifying the members of the certification panel, additional questions, marks received, examination dates, practical examination results;

- conclusion of the panel on examination results;

- copies of the test reports for welded joints made by the welder during an accountable period with the conclusion of a manufacturer-employers responsible official on a possibility to prolong the Certificate for the next six months.

Any of the above documents shall be shown to the RS surveyor, if required.

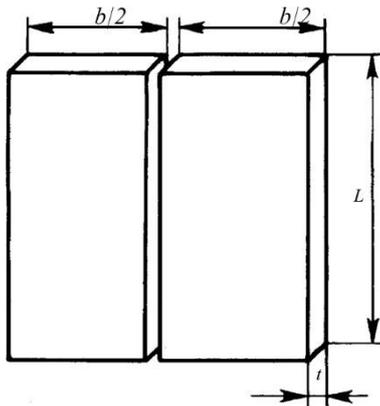
**4.6.10** In the event that the welder shall be approved for the works, which are beyond the scope of the initial range of approval according to the Certificate (forms 7.1.30-1 and 7.1.30-2), the new approval tests shall be performed in accordance with the above requirements.

When the welder's skill or knowledge is questioned ([refer to 4.6.6](#) and [4.6.8](#)), the RS surveyor can make a decision on invalidation of the valid Certificate and/or demand the performance of unscheduled approval tests.

**4.6.11** Practical recommendations for completing the Certificate form are given in [Appendix 4](#).

APPENDIX 1 (Mandatory)

TYPES OF WELDED JOINTS TEST ASSEMBLIES USED IN PRACTICAL TESTS FOR WELDERS' APPROVAL



Welding type	Dimensions of test assembly, in mm	
	L	b
M, S, A, T	≥ 350	≥ 250 (300) <sup>1</sup>
	≥ 800	≥ 300 (400) <sup>1</sup>

<sup>1</sup> Values *b* in brackets are given for aluminium and its alloys

Fig. 1  
Test assembly of P<sub>1</sub> plate butt joint

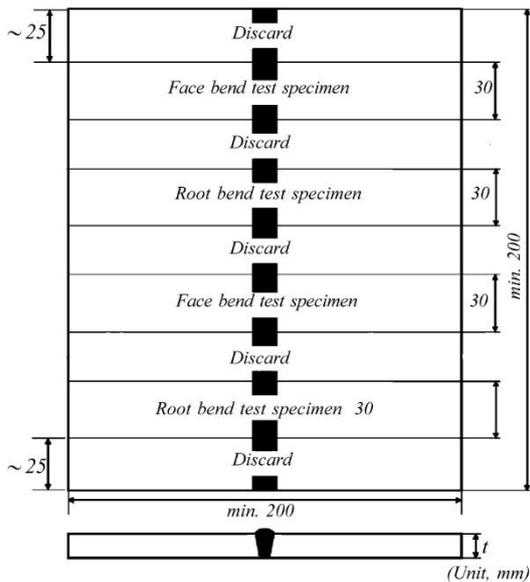


Fig. 1.1  
Dimensions and types of test assembly for butt welds  
( $T < 12$  mm)

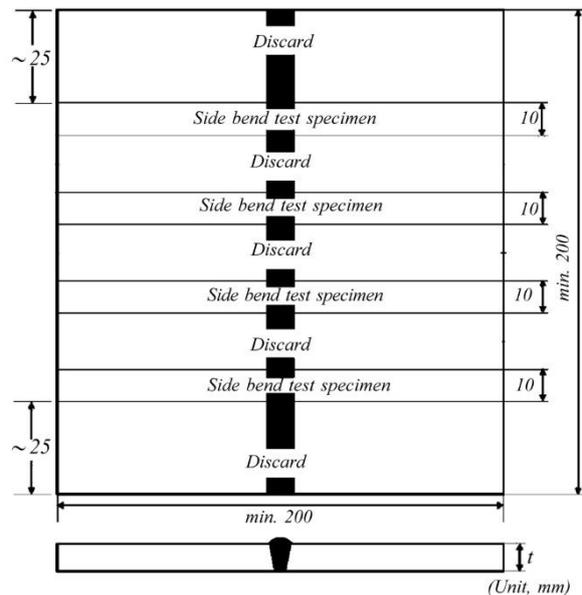
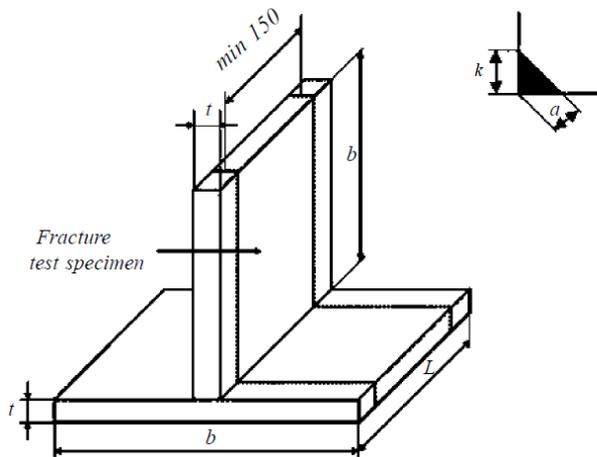


Fig. 1.2  
Dimensions and types of test assembly for butt welds  
( $T \geq 12$  mm)

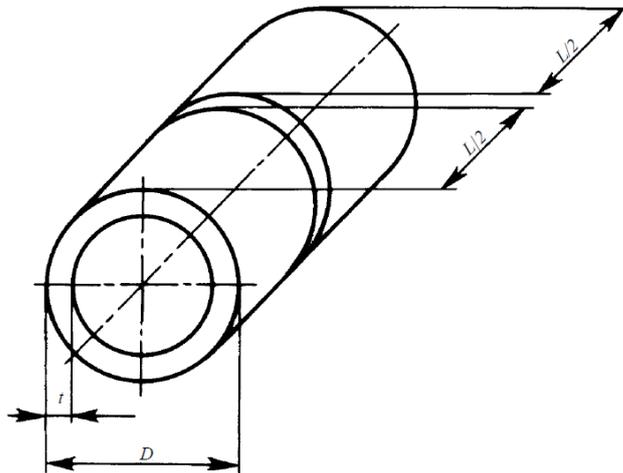


$k = a\sqrt{2}$  For  $t \geq 6 \text{ mm}$ ,  $0,5t \leq a \leq 0,5t + 3 \text{ mm}$   
 For  $t < 6 \text{ mm}$ ,  $0,5t \leq a \leq t$   
 Fracture test specimen

Welding type	Dimensions of test assembly, in mm	
	L	b
M, S, A, T	$\geq 200$	$\geq 100 (150)^1$
	$\geq 800$	$\geq 125 (200)^1$

<sup>1</sup> Values b in brackets are given for aluminium and its alloys.

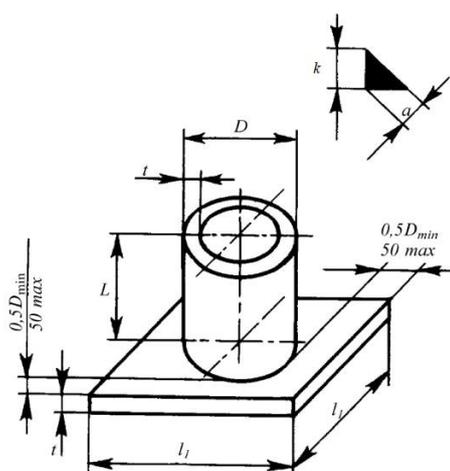
Fig. 2  
Test assembly of P<sub>2</sub> plate T-joint



Welding type	Dimensions of test assembly, in mm	
	D	L
M, S, A <sup>1</sup> , T	$\leq 25$	$\geq 150$
	$25 < D \leq 150$	$\geq 250 (300)^2$
	$> 150$	$\geq 300 (400)^2$

<sup>1</sup> The test assembly size shall be sufficient for reliable equipment operation.  
<sup>2</sup> Values L in brackets are given for aluminium and its alloys.

Fig. 3  
Test assembly of P<sub>3</sub> butt joint in pipes



$k = a\sqrt{2}$   
 $t \geq 6 \text{ mm}$ ,  $a \leq 0,5t$   
 $t < 6 \text{ mm}$ ,  $0,5t \leq a \leq t$   
 $(k \approx 0,7t)$

Welding type	Dimensions of test assembly, in mm	
	D	L
M, S, A <sup>1</sup> , T	$\leq 25$	$\geq 75 (100)^2$
	$25 < D \leq 150$	$\geq 125 (150)^2$
	$> 150$	$\geq 150 (200)^2$

<sup>1</sup> The test assembly size shall be sufficient for reliable equipment operation.  
<sup>2</sup> Values L in brackets are given for aluminium and its alloys.

Fig. 4  
Test assembly of P<sub>4</sub> fillet-welded pipe joint

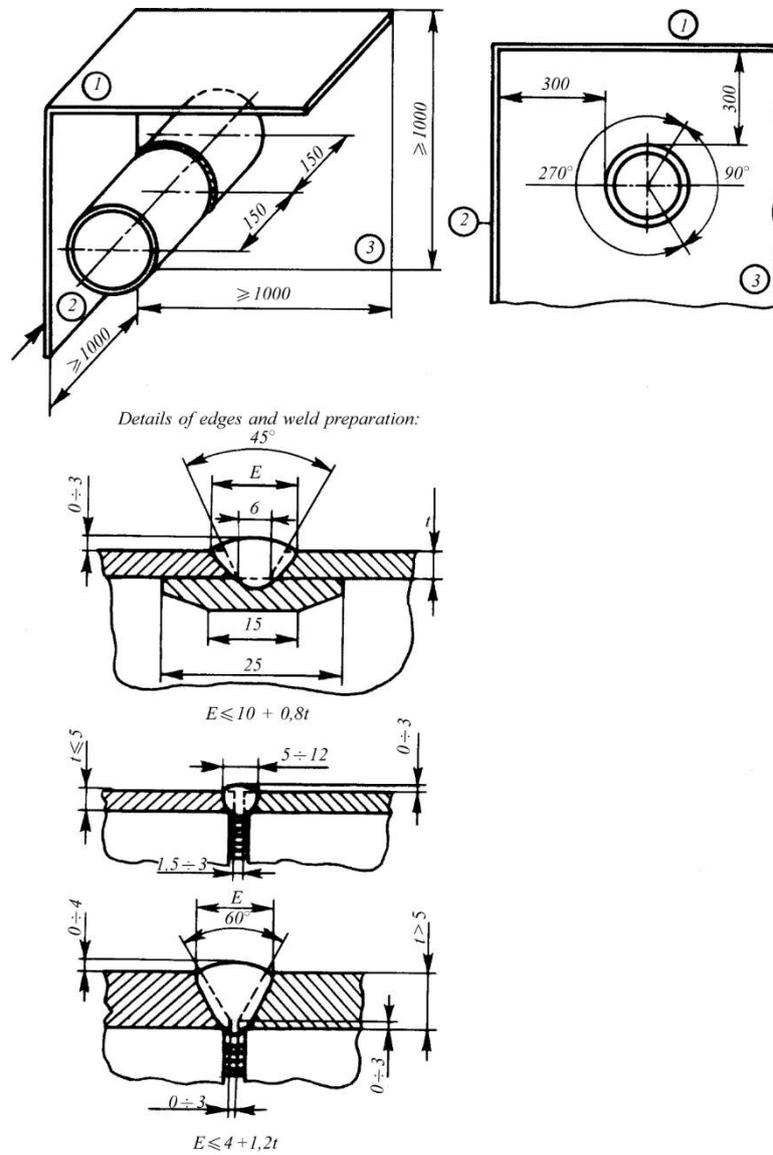


Fig. 5  
Test assembly of pipe joint with a limited access to the welding zone  $P_5$

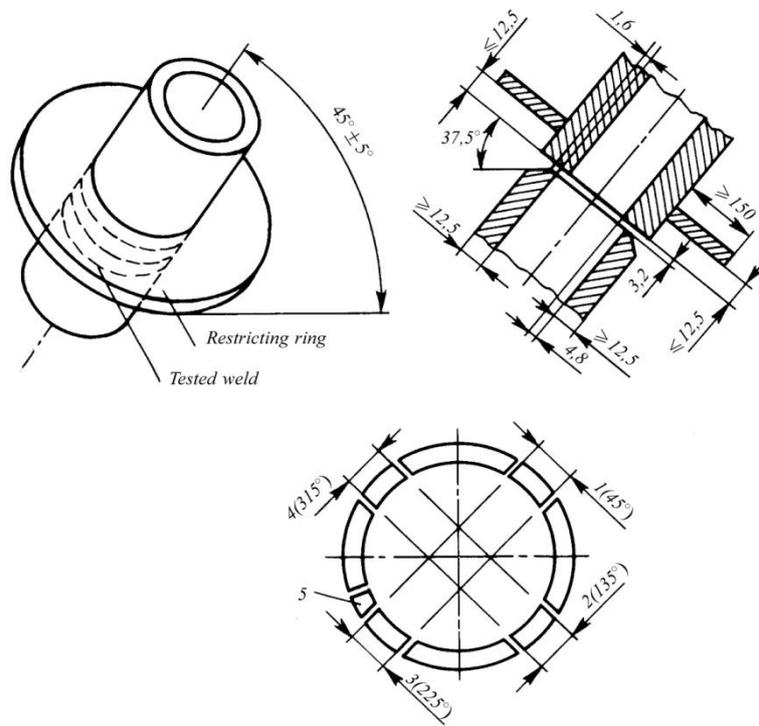


Fig. 6  
Test assembly of P<sub>6</sub> pipe joint with a restricting rings:  
1, 2, 3, 4 — places for taking test specimens for static bend;  
5 — place for taking a macrosection

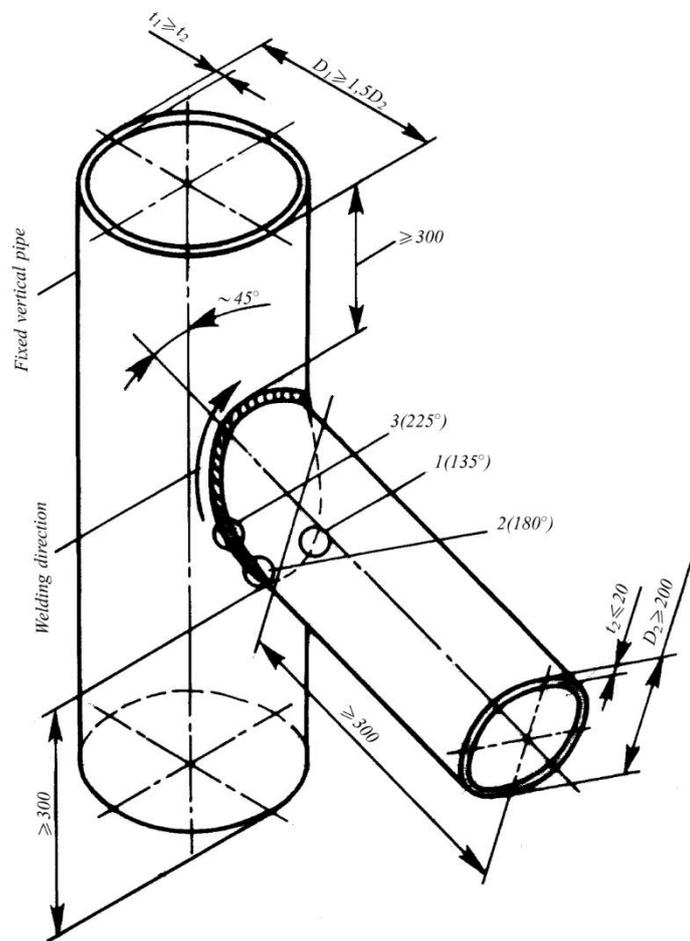


Fig. 7  
Test assembly for P<sub>7</sub> branch connection  
1, 2, 3 — places of taking macrosections

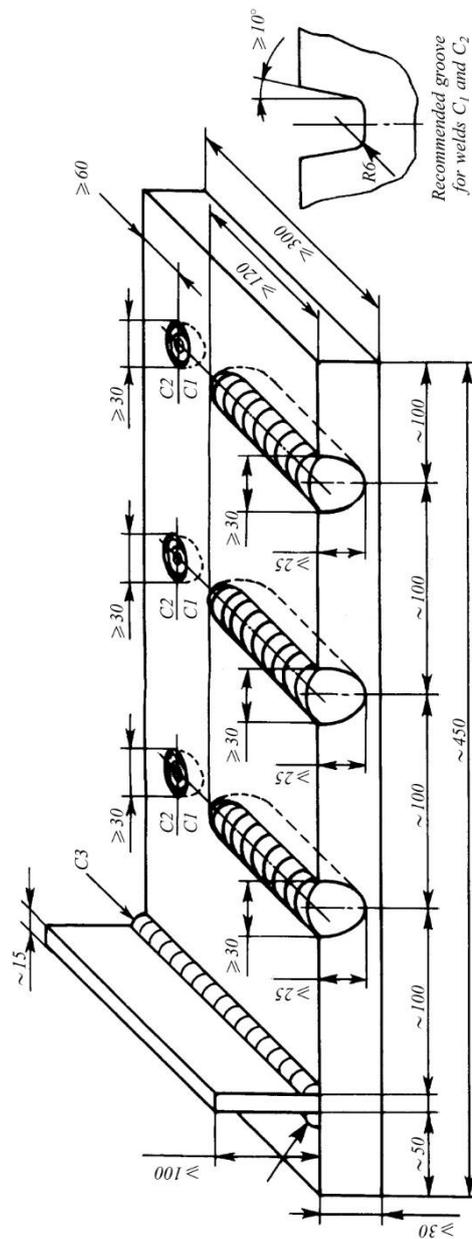


Fig. 8  
Test assembly — simulator P<sub>8</sub> of castings and forgings repair

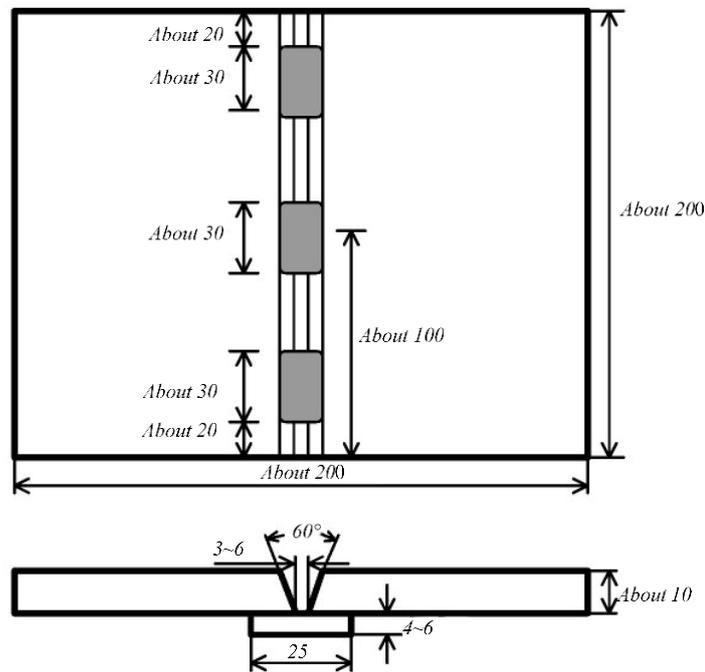


Fig. 9  
Test assembly  $P_{1tack}$  for tack butt welds

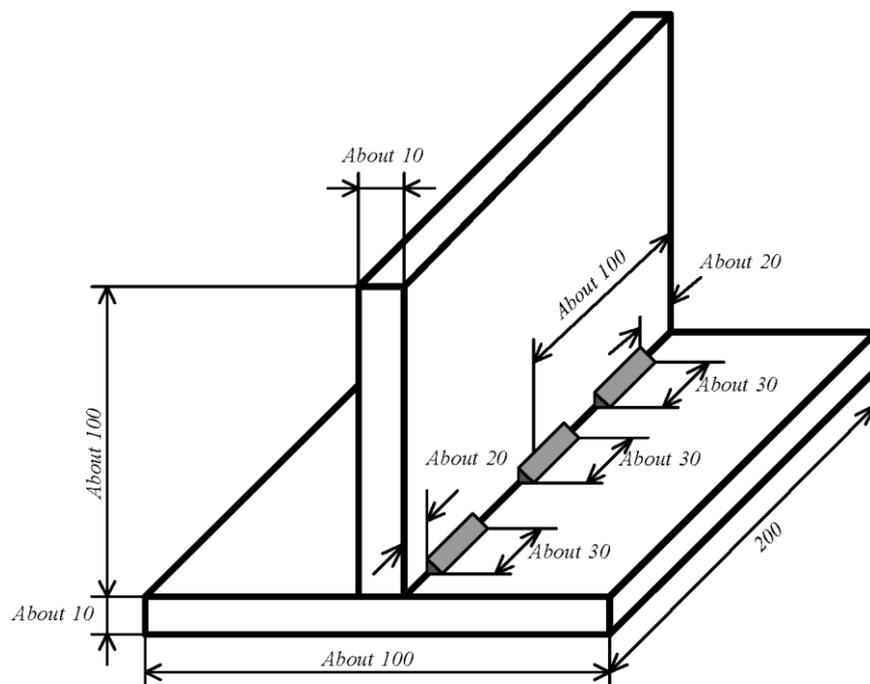
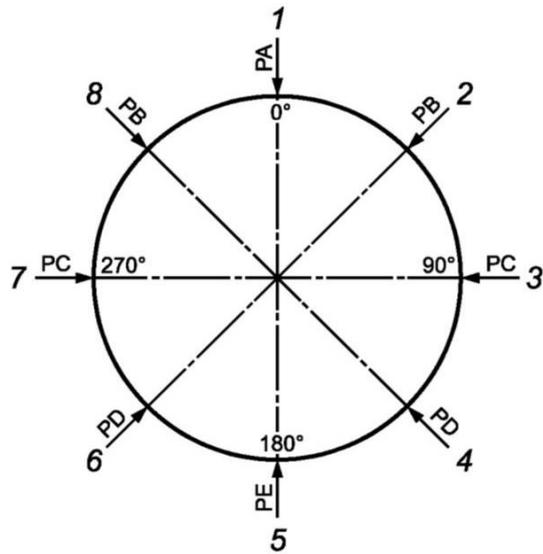
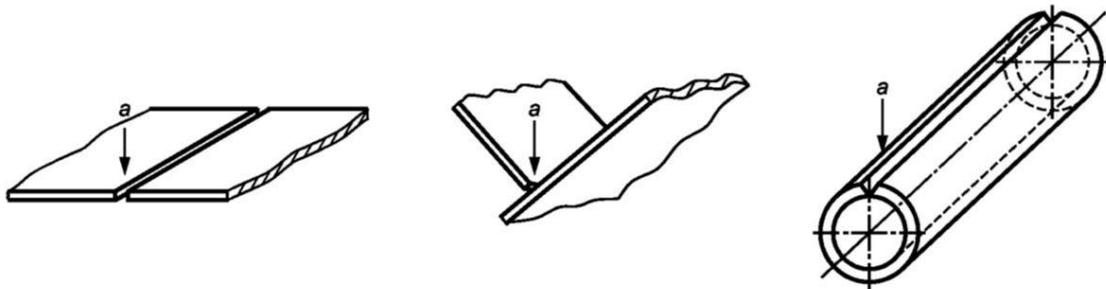


Fig. 10  
T-joint test assembly  $P_{2tack}$  for tack fillet welds

**WELDING POSITIONS**

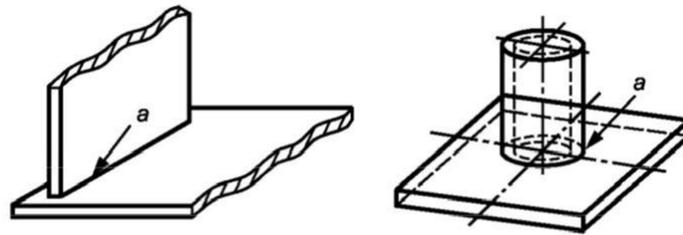


1—flat; 4, 6—overhead T-joint and overhead position at vertical pipe axis position; 2, 8—horizontal T-joint position and horizontal position at vertical pipe axis position; 5—overhead; 3, 7—horizontal



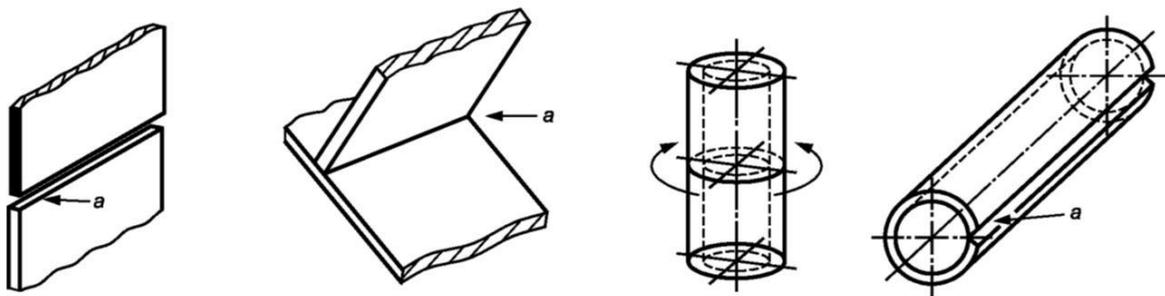
a—arrow shows position during welding

a) PA—flat position



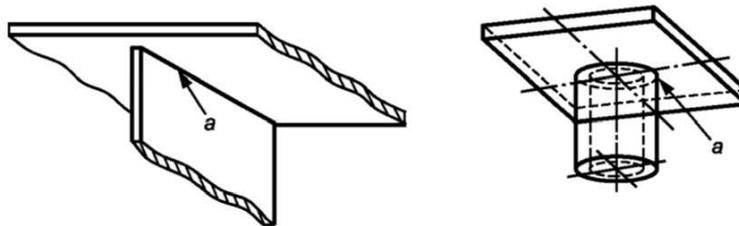
a — arrow shows position during welding

b) PB — horizontal T-joint position and horizontal position at vertical pipe axis position



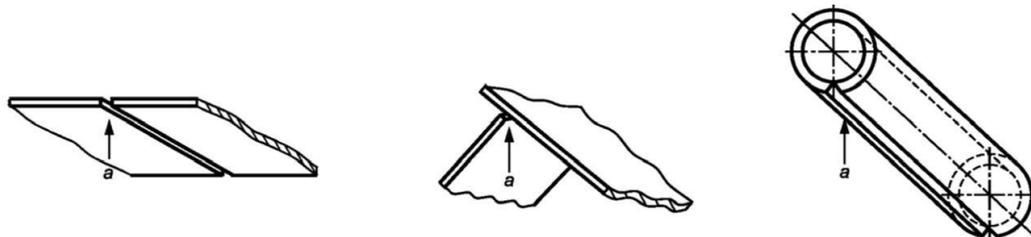
a — arrow shows position during welding

c) PC — horizontal position



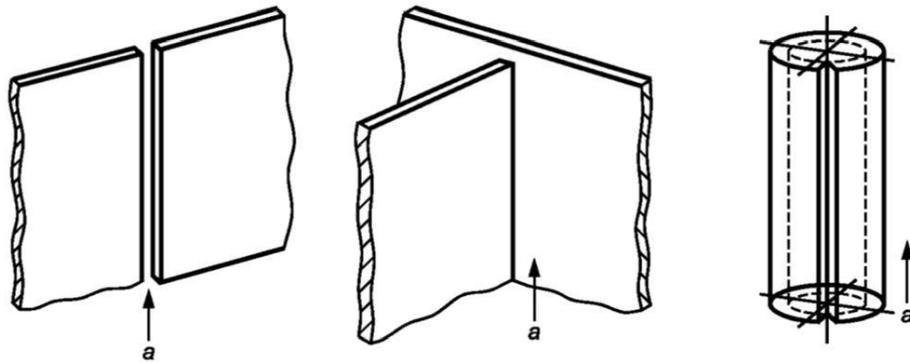
a — arrow shows position during welding

d) PD — overhead T-joint position and overhead position at vertical pipe axis position



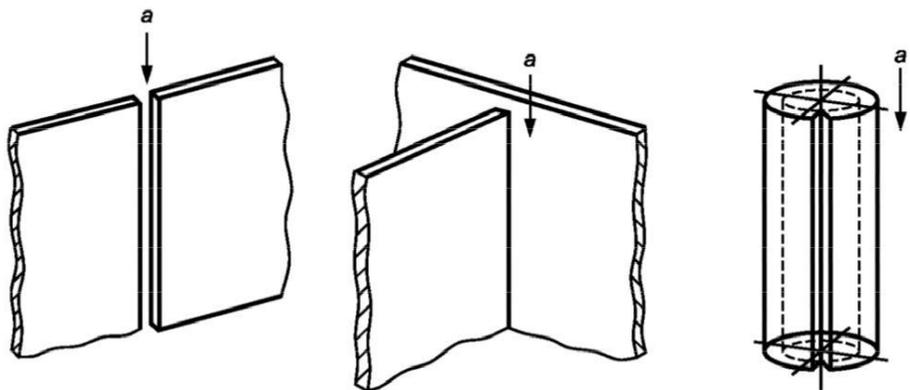
a — arrow shows position during welding

e) PE — overhead position



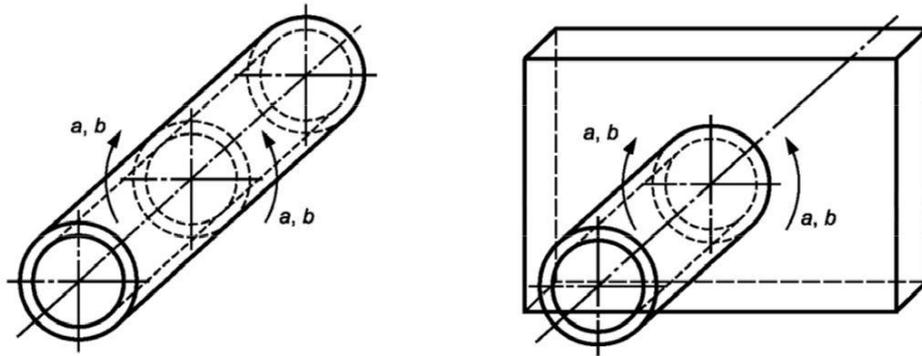
a — arrow shows position during welding

f) PF — vertical position (welding upwards)



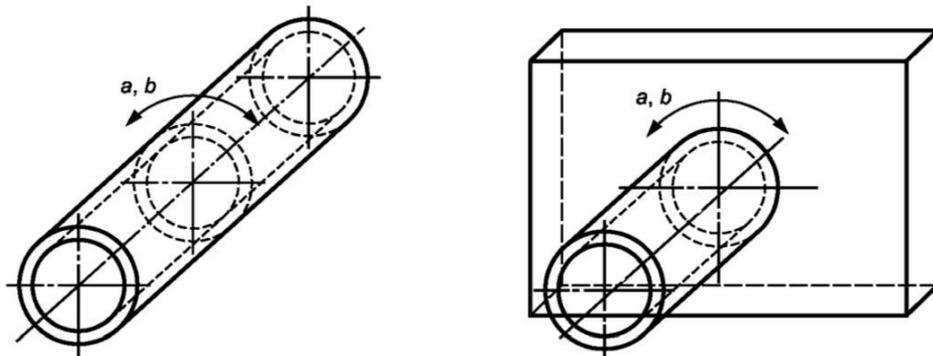
a — arrow shows position during welding

g) PG — vertical position (welding downwards)



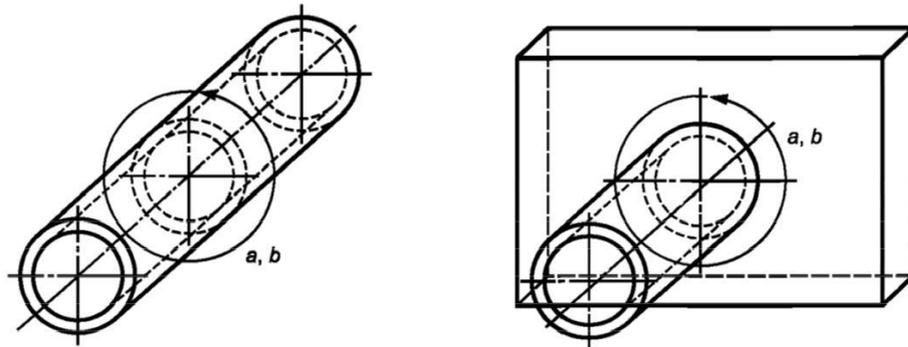
*a* — arrow shows position during welding  
*b* — for special purposes, such as testing of welders, this position is considered as the main

*h*) PH — vertical position for welding upwards (fixed pipe)



*a* — arrow shows position during welding;  
*b* — for special purposes, such as testing of welders, this position is considered as the main

*i*) PJ — pipe position for welding downwards (fixed pipe)



*a* — arrow shows position during welding;  
*b* — for special purposes, such as testing of welders, this position is considered as the main

j) PK — pipe position for orbital welding

Fig. 1  
Welding positions

APPENDIX 3 (Recommended)

(certification body)

**RECORD  
of certification panel meeting**

\_\_\_\_\_ 202\_\_\_\_\_  
(date, month, year)

Panel members:

Chairman \_\_\_\_\_  
(surname, initials)

members \_\_\_\_\_  
(surname, initials)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Issue considered: *certification of welders* \_\_\_\_\_  
(titles of normative documents whereby

\_\_\_\_\_ the certification is carried out)

1 Surname \_\_\_\_\_  
Name \_\_\_\_\_  
Patronymic \_\_\_\_\_

2 Year of birth \_\_\_\_\_

3 Welder's qualification document No. or previous qualification certificate No.  
\_\_\_\_\_

4 Welding experience \_\_\_\_\_

5 Type of certification \_\_\_\_\_

6 Details of check welded joint: \_\_\_\_\_

6.1 Marking (stamp) \_\_\_\_\_

6.2 Welding process \_\_\_\_\_

6.3 Type of parts welded \_\_\_\_\_  
(plate (P) or pipe (T);

6.4 Symbol of welded joint, index (refer to [4.3.3.2](#)) \_\_\_\_\_

6.5 Welding positions \_\_\_\_\_

6.6 Preheating and additional heating \_\_\_\_\_  
(yes, no)

6.7 Heat treatment \_\_\_\_\_  
(yes, no)

7 Material of base metal:

7.1 Brand and group \_\_\_\_\_

7.2 Thickness (mm) \_\_\_\_\_

7.3 Outside pipe diameter (mm) \_\_\_\_\_

8 Welding consumables:

8.1 Electrode or filler wire \_\_\_\_\_  
(brand and type)

8.2 Shielding gas or flux \_\_\_\_\_  
(brand)

9 Results of control:

9.1 Visual and measurement testing \_\_\_\_\_  
(satisfactory, unsatisfactory)

\_\_\_\_\_ (record No. and date)

9.2 Radiographic testing \_\_\_\_\_  
(satisfactory, unsatisfactory)

\_\_\_\_\_ (report No. and date)

9.3 Ultrasonic testing \_\_\_\_\_  
(satisfactory, unsatisfactory)

\_\_\_\_\_ (record No. and date)

9.4 Bend test \_\_\_\_\_  
(satisfactory, unsatisfactory)

\_\_\_\_\_ (record No. and date)

9.5 Macro examination \_\_\_\_\_  
(satisfactory, unsatisfactory)

\_\_\_\_\_ (record No. and date)

9.6 Additional methods of testing \_\_\_\_\_

10 Title of normative document on quality assessment standards \_\_\_\_\_

11 Assessment of theoretical knowledge \_\_\_\_\_  
(credited, not credited)

12 Decision of certification panel \_\_\_\_\_

(certification: designation and range of approval;  
\_\_\_\_\_

\_\_\_\_\_ (details of approval test)

13 Date of periodical certification \_\_\_\_\_

Chairman of panel \_\_\_\_\_  
(signature, surname, initials)

Members of panel \_\_\_\_\_  
(signature, surname, initials)

*APPENDIX 4 (Mandatory)*

**PRACTICAL RECOMMENDATIONS FOR COMPLETING FORMS 7.1.30-1 AND 7.1.30-2  
"WELDER TEST APPROVAL CERTIFICATE"**

1. As a rule, a separate Welder Test Approval Certificate shall be drawn up for each particular version of essential variables. If more than one test assembly was tested during the qualification test, then, the only one variation of the below listed essential variables is permitted for combining in one Certificate:

- type of weld;
- welding position;
- dimensions of welded joint (material thickness and outside pipe diameter).

In this case the Welder Test Approval Certificate is drawn up for combination of the ranges of approval for each test assembly.

2. For welding processes with gas shield, the test performing conditions and range of approval of the Welder Test Approval Certificate are set according to the following requirements:

for welding processes 135 and 136, the qualification tests are performed with one of the shielding gas compositions of C or M groups, which is mostly used in production process and cover all gases compositions of these two groups (C1, C2, M1, M2 and M3);

for welding processes 131, 133, 141 and 15, qualification tests are performed with one of the shielding gas compositions of group I, which are mostly used in production process and cover all gases compositions of this group (I1, I2, I3).

*Note.* Shielding gases of R and F groups are normally not employed for shipbuilding materials, and, therefore, they are not used for testing qualification of welders.

3. For welding processes with the use of fluxes, the range of approval of the Welder Test Approval Certificate is not regulated. The designation (trademark) and manufacture method (indices F, A or M according to [4.3.2.5](#)) of the flux used during the qualification tests are shown in the corresponding column of the Certificate and a dash (–) is inserted in the column for range of approval.

4. In column "Employer", the full name of the manufacturer is entered where the welder works and which applied for his certification.

5. In column "Code/Testing Standard", the rules of Russian Maritime Register of Shipping ("RS Rules") are noted

6. The explanations and indications on completing the main Table "Range of test and approval" are detailed in the Table.

When filling out information about consumables used for weld test details in relevant columns (7, 8, 9) of the Welder Test Approval Certificate (forms 7.1.30-1 and 7.1.30-2), it is recommended to put trade marks (designation) of the consumables used in brackets additionally For instance: wm/S (CB-08Г2C-O), M21 (80%Ar+20%CO<sub>2</sub>), MS (AH-348A), B (УОНИИ-13/55), etc.

In item "Option for the Welder Test Approval Certificate prolongation" one of options shall be specified in accordance with [4.6.7](#).

7. Table "Test results" of the Welder Test Approval Certificate is drawn as follows. Results of practical tests and theoretical examination shall be indicated by terms "Accepted" or "Not tested".

8. Table "Validity and prolongation for approval". The left half of the Table is completed by the employer's official in charge according to the requirements of [4.6.6](#) and [4.6.9](#).

The entry on prolongation of the Welder Test Approval Certificate validity period shall be made in the right half of the Table by the RS surveyor according to [4.6.8](#). and certified by his personal signature and stamp.

9. In the row "Date of first test" the date of issuing the minutes of meeting of the Certification Committee shall be indicated. This date means a commencement of the welder's certificate.

In the row "Valid until" the date of extension from the date of the initial tests shall be indicated in compliance with [4.6.6](#). The row "Location and date of issue" shall contain the name of the RS Branch Office issued the Welder Approval Test Certificate, RS-approved certification center where the tests for issuing of the Welder Approval Test Certificate have been carried out (where applicable) and the actual date of the Certificate issuing.

Table

Forms 7.1.30-1 and 7.1.30-2, columns	Weld test details (to be entered)	Range of approval (to be entered)
1 Welding procedure specification	No. of appropriate WPS if drawn up for practical tests	Insert a dash (–)
2 Welding type	Coded welding type designation ( <a href="#">refer to 4.3.2.1</a> )	Coded welding type designation and its full name
3 Welding process	Coded welding process ( <a href="#">refer to 4.3.2.2</a> )	Coded welding process designation and its abbreviated alphabetical designation is indicated according to <a href="#">Table 6.2.2.1</a>
4 Plate or pipe	Coded designation P or T ( <a href="#">refer to 4.3.4.1</a> )	Code designation of test assembly type according to <a href="#">4.5.3</a> and reference "refer to welding positions"
5 Joint type	Full code designation of weld type of test assembly, including details of welding process. Possible designation variants:	Coded designation of the welded joint type and of welding details according to <a href="#">4.5.4</a> and <a href="#">4.5.9</a> . Possible designation variants:
	A;	A, C, F
	B;	A, B, C, D, F
	C;	A, C, F
	D;	A, C, D, F
F	F	
6 Base metal group/designation	Designation of base metal subgroup (group) ( <a href="#">refer to Tables 4.3.3.1-1, 4.3.3.1-2 and 4.3.3.1-3</a> ), and for shipbuilding materials, after "/" symbol, the category designation in compliance with Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. For other materials, brands may be additionally designated in accordance with the national standards.	Designations of base metal subgroups according to <a href="#">4.5.5</a> ( <a href="#">refer to Tables 4.5.5-1, 4.5.5-2 and 4.5.5-3</a> ).
7 Filler material type / designation	In numerator: coded designation for filler material: wm — welding with filler material; nm — welding without filler material. In denominator: filler material type: E — covered electrodes; S — solid wire; FCW — flux-cored wire; SR — solid rod; FR — flux-cored rods. For welding without filler material a dash (–) is inserted.	Range of approval of the Welder Test Approval Certificate for the presence and type of filler material taking into account the expanded range of approval in accordance with <a href="#">4.5.6</a> for specific welding processes.

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and Products for Ships (Part III)*

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Forms 7.1.30-1 and 7.1.30-2, columns	Weld test details (to be entered)	Range of approval (to be entered)
8 Shielding gas composition/flux	Group of shielding gas composition in use during tests for the range of qualification ( <a href="#">refer to 4.3.2.4</a> ). For welding processes 121 and 125 flux designation (brand) and method of its manufacture are indicated ( <a href="#">refer to 4.3.2.5</a> ).	According to the requirements 2 and 3 of the present Appendix
9 Type of flux or electrode covering	Coded designation of electrode covering or filler of the flux-cored wire used during the tests ( <a href="#">refer to 4.3.2.3</a> )	Range of approval of Welder Test Approval Certificate according to requirements of <a href="#">Table 4.5.6</a>
10 Auxiliary materials	Data on auxiliary materials, namely: backing type and material, various pastes and fluxes for oxy-acetylene welding, composition of shielding gas for backing on the back of weld, etc.	Range of approval of the Welder Test Approval Certificate by auxiliary materials of the same type as that used in testing, or in case of no auxiliary materials, a dash (–) is inserted.
11 Base metal thickness	Actual thickness of base metal of test assemblies welded (refer also to <a href="#">Table 4.5.2</a> for combination of welding processes on one test assembly)	Range of thicknesses of base metal the welder is approved for according to <a href="#">4.5.7</a> . For a combination of welding processes the range of thickness is indicated separately for each welding process and their combination. E.g.: 141: $3 \text{ mm} \leq t \leq 10 \text{ mm}$ 135 : $t \geq 5 \text{ mm}$ or 141/135: $t \geq 5 \text{ mm}$
12 Pipe outside diameter	Actual values of outside pipe diameters of test assemblies welded.	Range of pipe diameters the welder is approved for according to <a href="#">4.5.7</a> .
13 Welding position (s) / type of test assembly	In numerator: designations of test assembly welding positions according to <a href="#">Appendix 2</a> separated by "/" symbol. In denominator: designation of test assembly in accordance with <a href="#">Appendix 1</a> .	Welding positions the welder is approved for according to <a href="#">4.5.8</a> (for plates and pipes separately). For shortening the record, the entry: "All except... " is permitted.

## **REGULATIONS ON WELDERS' CERTIFICATION CENTRES**

### **1 APPLICATION**

**1.1** These Regulations establish the organizational and legal form, rights and responsibilities of certification centers, the procedure for their recognition by the Register and the main requirements for their operation, as well as for their training and testing base.

The Regulations are intended for use by:

the RS Branch offices carrying out technical supervision of welders' approval testing;  
the organizations or enterprises interested in their recognition as certification centers;  
certification centers in their practical activities.

### **2 GENERAL**

**2.1** The status of a certification centre may be given to an independent organization/enterprise being a legal entity of any organizational and legal form, and of property forms provided that it meets all the requirements of these Regulations and the Rules for the Classification and Construction of Sea-Going Ships.

**2.2** The recognition of certification centers authority is effected by the Register as follows:

submission to the Register of an application containing the data and enclosures specified in [2.3](#);

Register review of the application and documents regulating certification centre activities;

Register survey of the training and testing base of the certification centre;

elimination by an applicant of nonconformities identified in documentation and at the training and testing base;

issuance by the Register of documents on the recognition of certification centre authority, and direct participation in the centre activity.

**2.3** The application for certification centre accreditation shall include: certification centre name and full postal and financial details;

full names of the head and the official in charge of contacting the Register;

list of welding processes the welders will be certified for, and the list of groups of a base metal type composition;

guarantee of payment for the Register services.

The following documents shall be attached to the application:

copy of the Charter of the certification centre;

draft Regulations on Certification Centre;

sets of programs of preparation for certification, and of collections of examination questions, and also of practical exercises for all the types of examinations to be performed.

**2.4** The Regulations on Certification Centre shall include:

information on the availability of spaces for theoretical examinations and practical tests;

information on the organizational structure of the centre;

information on the material base including the welding equipment, stock of machine tools and outfit available and used in certification, on the equipment and means of welded joints quality control, computer equipment;

information on the centre personnel including examiners and certified specialists on non-destructive testing methods;

information on certification activities organization;  
information on the procedure for sending and testing appeals;  
procedure of keeping the register of certified welders, and of archiving.

### **3 CERTIFICATION CENTRE STRUCTURE AND FUNCTIONS**

**3.1** The certification centre is managed by a head appointed on the contract basis or by order of founder(s) in accordance with the procedure established by the RF legislation.

**3.2** Certification panels conducting theoretical examinations and practical tests are part of the certification centre.

The main objectives of the certification panel include:

organization and control over the welders' preparation for approval testing;  
development of programs of welders' special theoretical and practical training for certification;

setting target times for certification performance;

preparation of the relevant training and testing base;

preparation of the collection of examination questions on welding processes and the base metal type;

establishment of the procedure for theoretical examination performance;

performance of the theoretical examination and assessment of its results;

development of the welding procedure specifications for the performance of test welding joints;

inspection of materials to be used for welders' practical test;

monitoring of welders' performance in welding and of welded joints marking;

organization of welded joints quality control performance and assessment of their quality in accordance with the RS rules requirements;

execution of a test report and taking decision on the results of the welder's approval test;

preparation of proposals for updating normative documents on welder's certification issues.

The certification panel is authorized to:

remove welders from an approval test if they do not fulfill the requirements of a welding procedure or violate the procedure for test performance;

give a conclusion on the possibility to prolong the validity period of the Welder Approval Test Certificate;

set up working groups to review the activities of the locations ensuring control over welders' performance at manufacturers;

submit proposals on updating the welders' certification procedure.

**3.3** The certification panel members are approved by the head of the certification centre and agreed with the RS Branch offices.

The certification panel includes:

chairman and his deputy being certified specialists in welding;

authorized RS representative;

certified specialist on non-destructive testing authorized to sign the conclusions on the results of visual and measurement testing, and also on radiographic testing or ultrasonic testing.

The following persons may also be drawn into activities of the certification panel on the permanent or temporary basis (depending on the certification centre status):

the person in charge of welding at an employer's (a senior welder, the head of a welding shop, etc.);

the person in charge of monitoring welders' performance at the employer's;  
the authorized representative of an employer's technical control service;  
highly qualified specialists in the area of individual welding processes or in the groups of a base metal type composition (e.g. specialists in the welding of non-ferrous metals and their alloys, etc.).

**3.4** The certification centers include a training and testing base which provides and opportunity to perform theoretical examinations and practical tests for welders' approval.

Generally, the training and testing base needs the following spaces for its normal functioning:

- welding shop with working stations for practical tests performance;
- space for preparing parts for welding;
- space for power supply (gas and electrical supply, ventilation and heating) equipment;
- space for studies (lectures);
- domestic spaces;
- spaces for mechanical testing and welded joints quality control.

**3.5** The main functions of the certification centre are the welders' certification, and also office work performance and keeping a record of the welders certified.

In certification performance, the centre ensures

- drawing up of welders' certification programs;
- forming certification programs;
- approval testing for specific welding processes and groups of a base metal type composition;
- keeping up of the operational status of the training and testing base;
- control over the observance of requirements unity and over the objectivity of the examination results assessment.

The office work performance provides for keeping a card index for every certified welder, which includes the following:

- application for certification;
- copy of a document on education;
- copy of a document on special training;
- reference on work experience in welding (an extract form of the work-record card);
- reference on the state of health;
- examination sheets;
- copies of reports of welded joints quality control;
- report on passing the examinations by the welder being certified with the conclusion of the examination panel;
- 3 x 4 cm photograph and the signature pattern of a certified welder;
- copy of the Welder Approval Test Certificate.

**Note.** The extent of the card index may be reduced for the certification centers established at manufacturers and providing services to their employees.

The information on certified welders shall be retained within two validity periods of the Welder Approval Test Certificate following the last certification.

If the welder fails examinations, the information about this is kept in the certification centre a year after the decision has been taken by the certification panel.

*APPENDIX 6 (Recommended)*

**SECTIONS AND QUESTIONS FOR CONDUCTING A TEST OF A WELDER JOB KNOWLEDGE**

The sections and questions contained in this Appendix can serve the standard minimum for testing a welder professional knowledge. The actual questions may differ from the ones offered in this section and are drawn up at the discretion of the examining board, but, in any case, they shall include questions on the areas covered by the sections given above, and the questions shall be limited to the matters related to the welding process used in practice.

**Section 1. Welding equipment**

**1.1 Oxy-acetylene welding:**

- .1 identification of gas cylinders, cylinder valves, reduction gears;
- .2 identification and assembly of essential components;
- .3 selection of correct nozzles and welding torches.

**1.2 Arc welding:**

- .1 identification and assembly of essential components and equipment;
- .2 type of welding current;
- .3 power sources for arc welding and their external characteristics for certain welding processes;
- .4 correct connection of the welding return cable and ways of eliminating magnetic blowout.

**Section 2. Welding process (specific features and general information)**

**2.1 Oxy-acetylene welding:**

- .1 gas pressure and flow rate;
- .2 selection of nozzle type;
- .3 type of gas flame;
- .4 leftward and rightward welding;
- .5 effect of overheating.

**2.2 Metal arc welding with covered electrode:**

- .1 handling and calcination (drying) of electrodes;
- .2 differences of types of electrodes.

**2.3 Self-shielded tubular-cored arc welding:**

- .1 types and size of electrodes;
- .2 type, size and maintenance of nozzles/contact tip;
- .3 selection and limitations of mode of metal transfer;
- .4 protection of the welding arc from draught.

**2.4 Gas-shielded metal arc welding, tungsten inert gas welding, plasma arc welding:**

- .1 type and size of electrodes;
- .2 identification of shielding gas and flow rate;
- .3 type, size and maintenance of nozzles/contact tip;
- .4 selection and limitations of mode of metal transfer;
- .5 protection of the welding arc from draughts.

**2.5 Submerged arc welding:**

- .1 types and size of electrodes;
- .2 calcination (drying), feeding and correct recovery of flux;
- .3 correct alignment and travel of welding head.

**Section 3. Base metals**

- 3.1 Classification of parent metals and alloys.
- 3.2 Methods and control of pre-heating.
- 3.3 Control of interpass temperature.

**Section 4. Welding consumables**

- 4.1 Identification of welding consumables.
- 4.2 Storage, handling and conditions of welding consumables.
- 4.3 Selection of correct size.
- 4.4 Cleanliness of electrodes and filler wire.
- 4.5 Control and monitoring of gas flow rates and quality.

**Section 5. Safety precautions**

- 5.1 General:
  - .1 safety assembly, setting up and turn off procedures;
  - .2 safe control of welding fumes and gases;
  - .3 personal protection;
  - .4 fire hazards;
  - .5 welding in confined spaces;
  - .6 awareness of welding environment.
- 5.2 Oxy-acetylene welding:
  - .1 safe storage, handling and use of compressed gases;
  - .2 leak detection on gas hoses and fittings;
  - .3 procedure to be taken in the event of a flashback.
- 5.3 All arc welding processes:
  - .1 environment of increased hazard of electric shock;
  - .2 radiation from the arc;
  - .3 effects of stray arcing:
- 5.4 Shielded gas arc welding.
  - .1 safe storage, handling and use of compressed gases;
  - .2 leak detection on gas hoses and fittings.

**Section 6. Welding procedure specification (WPS)**

Appreciation of the WPS requirements and the influence of welding parameters.

**Section 7. Joint preparation and weld representation**

- 7.1 Conformance of joint preparation to the WPS.
- 7.2 Cleanliness of fusion faces.

**Section 8. Weld imperfections**

- 8.1 Identification of imperfections.
- 8.2 Causes.
- 8.3 Prevention and remedial action.

**Section 9. Welder qualification**

The welder shall be aware of the range of approval for the qualification for all essential variables of the welding procedure.

## DESCRIPTION OF TYPES OF ELECTRODE CORE

### 1. R type

Tubular cored electrodes of the R type are characterized by a spray metal transfer, low spatter loss, and rutile-basic slag that fully covers the weld bead. These tubular cored electrodes are designed for single and multiple pass welding in the flat and horizontal-vertical position. Tubular cored electrodes of the R type are generally designed for use with carbon dioxide as shielding gas. However, argon/carbon dioxide mixtures can be used to improve arc transfer and reduce spatter, when recommended by the manufacturer.

### 2. P type

Tubular cored electrodes of the P type are similar to the R type, but the rutile-based slag is designed for fast-freezing characteristics that enable welding in all positions. These tubular cored electrodes are generally produced in smaller diameters and exhibit spray metal transfer when using carbon dioxide shielding gas. The running characteristics can be improved with the use of argon/carbon dioxide mixtures when recommended by the manufacturer.

### 3. B type

Tubular cored electrodes of the B type are characterized by a globular metal transfer, slightly convex bead shape, and a slag that can or cannot cover the weld bead surface.

Weld deposits produced with these tubular cored electrodes have superior impact properties and crack resistance.

### 4. M type

Tubular cored electrodes of the M type are characterized by a very fine droplet spray metal transfer and minimal slag cover. The core composition of these tubular cored electrodes consists of metal alloys and iron powder along with other arc enhancers which enable these tubular cored electrodes to produce high deposition rates with an insensitivity to lack of fusion. These tubular cored electrodes are primarily used with argon/carbon dioxide shielding gas mixtures in the flat and horizontal-vertical positions. However, welds in other positions are also possible using the short-circuiting or pulsed arc modes of transfer.

### 5. V type

Tubular cored electrodes of the V type are used without a gas shield and exhibit a slightly globular to spray metal transfer. The rutile or basic/fluoride slag system of these tubular cored electrodes includes a range from slow to fast freezing slag. Tubular cored electrodes with a slow slag freezing system are used for single pass welding of galvanized steels in all welding positions. Tubular cored electrodes with a fast freezing slag are designed for automatic welding at high speeds. These tubular cored electrodes are used for single pass welds in the flat, horizontal-vertical, and limited inclined positions. Some of the electrodes in the V type are recommended for metal not thicker than 5 mm. Some tubular cored electrodes are primarily designed for root runs in circumferential pipe girth welds in all pipe thickness.

### 6. W type

Tubular cored electrodes of the W type are used without a gas shield and exhibit a globular to quasispray metal transfer. This basic/fluoride slag system is designed to make very high deposition rates possible. Some tubular cored electrodes have a metal powder addition in the core and provide good operability. The weld deposits are very low in sulphur and very resistant to cracking. Tubular cored electrodes of this type are used for single and multiple pass welding in the flat and horizontal-vertical welding positions. With some tubular cored electrodes, vertical down welding is possible.

**7. Y type**

Tubular cored electrodes of the Y type are used without a gas shield and exhibit a quasi-spray transfer. These basic/fluoride slag tubular cored electrodes are designed for single and multiple pass, in all welding positions. They exhibit good crack resistance and low temperature impact properties.

**8. Z type**

Other types of tubular cored electrodes are not covered by this classification.

## **5 WELDING CONSUMABLES. QUALITY REQUIREMENTS FOR MANUFACTURE, TESTING AND APPROVAL PROCEDURE**

### **5.1 REQUIREMENTS FOR THE QUALITY SYSTEM OF WELDING CONSUMABLES' MANUFACTURERS**

#### **5.1.1 Terms and definitions.**

**5.1.1.1** Firms and companies involved in manufacture and distribution of welding consumables are classified as manufacturers, suppliers, distributors and subcontractors as defined below.

**Distributor** is the company, which receives the welding consumables from a manufacturer or supplier and distributes them under the manufacturer's or supplier's brand name.

**Manufacturer** is the company, which manufactures welding consumables totally or performs the final part of production, which determines the quality of the consumables.

The firms purchasing the above-mentioned products as semi-finished or finished products, but undertaking the full guarantee with regard to the chemical composition, quality and properties of these products, are also regarded as manufacturers.

**Supplier** is the company, which purchases the welding consumables from a manufacturer and supplies them under its own brand name.

**Subcontractor** is the company, which on the order of a manufacturer can produce part or the whole of the consumable or on the order of a manufacturer or supplier can provide service.

**5.1.1.2** The requirements of this Section may be applied to both the manufacturers of welding consumables and the companies being suppliers, distributors and subcontractors.

#### **5.1.2 General.**

**5.1.2.1** The manufacturer or supplier shall establish and maintain a documented quality system as the means of ensuring that welding consumables conform to the specified requirements. The quality system shall include the preparation and implementation of documented procedures and/or instructions and the use of periodic internal audits to determine the effectiveness of the system.

**5.1.2.2** The quality system shall provide the following:

compliance of the consumables produced with the requirements of the RS rules, as well as other contract documents including the national standards;

uniform quality of the products ensuring the identity of properties and characteristics of all the consumables produced with the figures achieved during certification under the RS technical supervision;

elimination of possibility of storage and supply to customers of the finished products, which do not comply with the requirements specified in the contract documents.

**5.1.2.3** The manufacturer and supplier shall establish and maintain procedures for audit and inspection review. Each procedural requirement shall be reviewed to ensure that:

the requirements are adequately defined;

the established contractual requirements for products can be completely met.

**5.1.2.4** The manufacturer shall establish and maintain methods for traceability by identification during all stages of production and delivery.

The procedures for consumables' delivery shall be established and identification maintained at all stages.

**5.1.2.5** All production facilities and processes used by the manufacturer shall be such as to permit uniform production with uniform quality of welding consumables.

**5.1.3 Organizational structure.**

**5.1.3.1** The manufacturer or supplier shall appoint a management representative who, irrespective of other responsibilities, shall have defined authority and responsibility for quality matters and for ensuring that the requirements for the quality system are implemented and maintained.

In particular, he shall be responsible for the following:

the coordination and monitoring of the quality system;

the resolution of any non-conformity in the system;

the implementation of timely and effective action by the appropriate department to ensure compliance with the specified requirements for welding consumables.

**5.1.3.2** The manufacturer or supplier shall identify in-house verification requirements, provide adequate resources and assign trained personnel for appropriate verification and control activities.

**5.1.3.3** The quality system shall be reviewed at appropriate intervals by the manufacturer's or supplier's management to ensure its continuing suitability and effectiveness. Records of such reviews shall be maintained according to instructions in [5.1.10](#).

**5.1.4 Document control.**

**5.1.4.1** The manufacturer and supplier shall establish and maintain clear, complete and current written production, inspection and test procedures for each operation.

This control shall ensure that:

appropriate documents are available at all locations where operations essential to quality are performed;

obsolete documents are promptly removed from all points of use.

**5.1.4.2** Changes of documents shall be reviewed and approved by the authorized personnel. They shall have access to pertinent appropriate background information and specifically to any specification or a standard, to which conformity is claimed for consumables.

**5.1.5 Purchasing.**

**5.1.5.1** The manufacturer and supplier shall ensure that the intended purchased products, raw materials and services conform to the specified requirements.

**5.1.5.2** The manufacturer and supplier may subcontract elements of manufacture or service, which have a bearing on the quality of the finished welding consumables. Such subcontractors shall be assessed on their ability to meet subcontract requirements, by the manufacturer or supplier or by approval by the third body.

Records of subcontractors shall be established and maintained and shall indicate the basis for acceptance.

**5.1.5.3** Purchasing specifications shall be established by the manufacturer and approved by the authorized personnel and clearly define the consumable, raw material or service. They shall include, where applicable:

the type, class, grade or other precise identification using standards;

the title or other positive identification and applicable issue of specifications, process requirements, inspection instructions and other relevant technical data.

Such specifications shall include, in case of rods, wire, strips, powders and solutions, whatever limits need to be placed on chemical composition or physical conditions to ensure that the finished product meets the specified requirements.

**5.1.6 Production process control.**

**5.1.6.1** The manufacturer and its subcontractors shall identify and plan the production processes, which directly affect the quality and shall ensure that these processes are carried out under controlled conditions.

Controlled conditions shall include the following:  
documented work instructions for all operations and processes where the absence of such instructions would adversely affect quality;  
the production facilities, which shall be adequately equipped with measuring and control devices;  
specifications, work instructions or procedures for production processes.

**5.1.6.2** Production process control by means of monitoring shall, as a minimum, include the following key operations:

- formulations;
- weighing;
- mixing;
- wire-drawing, cleaning, annealing and surface treatment, if applicable;
- extrusion, flux melting or granulation;
- drying and calcination;
- marking and packaging.

**5.1.7 Inspection and testing.**

**5.1.7.1** The manufacturer and supplier shall control, calibrate and maintain suitable inspection, measuring and test equipment used at all the stages of the production process to demonstrate the conformity of product to the specified requirements. Such equipment shall, as a minimum, include that used for the following key operations:

- weighing;
- dimensional checks;
- chemical analysis;
- welding;
- temperature measuring;
- mechanical tests.

**5.1.7.2** The manufacturer and supplier shall not use, process and supply incoming raw materials and consumables until they have been inspected or otherwise verified as conforming to the specified requirements.

Confirmation of quality at all stages of the production process shall be in accordance with the documented procedures.

**5.1.7.3** The manufacturer shall perform inspection during manufacture on all specified characteristics that cannot be inspected at a later stage.

The manufacturer shall ensure that process controls are implemented and are effective.

The identification of inspection and test status shall be maintained as necessary throughout production to ensure that only product that has passed the required inspection and tests is dispatched or used.

**5.1.7.4** The documented procedures for release from production shall require that all specified inspection and tests, including those specified either on receipt of product or in process, have been carried out and that the data meet the specified requirements.

**5.1.7.5** The supplier shall establish and maintain the records, which give evidence that the product has passed inspection and/or tests with defined acceptance criteria.

No consumables shall be dispatched until the release documentation is authorized.

**5.1.8 Non-conforming materials and corrective actions.**

**5.1.8.1** The manufacturer and supplier shall establish and maintain the procedures to ensure that raw materials, consumables or welding consumables that do not conform to the specified requirements before, during or after manufacture, transportation and storage are prevented from inadvertent use.

**5.1.8.2** Non-conforming materials, semi-finished products or welding consumables may be rejected or scrapped, or subject to rework, if appropriate, to meet the specified

requirements. Reworked material shall be reinspected in accordance with a documented procedure.

**5.1.8.3** The manufacturer and supplier shall establish and maintain procedures to: investigate the cause of non-conformities and customer complaints and analyze adverse quality trends;

initiate effective corrective actions to prevent recurrence, wherever practicable;

assess the effectiveness of corrective actions and changes in procedure.

**5.1.9 Handling, packaging and storage.**

**5.1.9.1** The manufacturer and supplier shall establish, document and maintain procedures for handling, packaging and storage of welding consumables at all stages and in all manufacturing areas.

**5.1.9.2** The manufacturer and supplier shall establish methods of handling that prevent damage to welding consumables.

**5.1.9.3** The manufacturer and supplier shall control packaging, including materials used, to avoid damage to welding consumables and to ensure their conformity to the specified requirements.

The marking of the packaging shall be in accordance with the requirements of the appropriate national standards and the Rules.

**5.1.9.4** The manufacturer and supplier shall provide adequate storage areas to maintain the consumables in the specified condition.

Because temperature and humidity can essentially affect the condition of consumables, these factors shall be considered in the appropriate documented procedures. The condition of product in stock shall be assessed at appropriate intervals but not less than once every twenty four hours.

**5.1.10 Quality records.**

**5.1.10.1** The manufacturer and supplier shall, as appropriate, maintain sufficient records of the production and of all inspections and tests performed to substantiate conformity of the consumables and conditions of their manufacture to the specified requirements.

**5.1.10.2** The quality records shall include, but not be restricted to: identification of all kinds of raw materials, semi-finished products and accessories used during manufacturing process;

lot or batch identification and, if appropriate, heat identification;

evidence of test results compliance with the specified requirements;

identification of non-conformities;

confirmation of any corrective actions taken.

Retention times of quality records shall be 5 years, unless otherwise specified.

## **5.2 SURVEY OF WELDING CONSUMABLES' MANUFACTURERS**

**5.2.1 General provisions.**

**5.2.1.1** The procedure for approval of the welding consumables by the Register shall include the survey of a manufacturer.

The survey preceding the initial approval shall provide the verification of the following: availability and technical condition of production equipment, which shall be able to ensure steady production process and uniform quality of the finished product;

availability of manufacturer's instructions and control of their observance at the main stages of the welding consumable manufacture;

observance of all documented requirements to incoming inspection of materials and semi-finished products, as well as of the conditions of their storage and launching;

completeness of an acceptance inspection of finished products, as well as the conditions of their storage and order of their delivery;

measurement assurance of all kinds of tests and inspections including survey of welding, manufacture and specimen testing areas;

survey of the manufacturer's quality system in whole shall be performed according to special requirements of [5.1](#) and general requirements of [Sections 5](#) and [6](#), Regulations for Confirmation of Conformity of RS Suppliers' Quality Systems.

**5.2.1.2** At annual surveys within the period of validity of the Certificate of Approval for Welding Consumables, the extent of inspections may be reduced at the discretion of the RS surveyor to 50 % of the initial survey in accordance with the provisions of [5.2.2.2](#), [5.2.3.3](#), [5.2.4.3](#) and [5.2.5.3](#) but renewal inspections at intervals at least every 5 years (renewal of Certificate of Approval for Welding Consumables) shall be carried out to the full extent according to [5.2.2.1](#), [5.2.3.2](#), [5.2.4.2](#), [5.2.5.1](#) and [5.2.5.2](#).

**5.2.1.3** A specific scheme of survey and its scope shall be established with regard to the type of welding consumables, the manufacturer's production procedure in use and the share of subcontracted deliveries in the finished products, the details of product manufacturing methods and production equipment, quality system and availability of its approval (recognition) by the Register. The extent of inspections shall be determined in each particular case on the basis of the recommendations given below as applied to the manufacture of the following types of welding consumables:

coated welding electrodes;

welding wire and solid rods with the independent groups separated for manufacture of wire of small and large diameters;

flux-cored welding wire and rods;

welding fluxes with the independent groups separated for manufacture of fused and ceramic fluxes.

**5.2.1.4** The following processes, if available at the manufacturer's, form a separate subgroup:

breaking, cracking and preparation of bulk raw materials for electrode and flux manufacture;

manufacture of wire rod for welding wire production;

melting and preparation of liquid glass for electrode and ceramic flux manufacture.

Scope of surveys for these processes may be reduced to the level of incoming inspection of contractor's supplies.

**5.2.1.5** Issue of the Certificates.

**5.2.1.5.1** The Certificate of Approval for Welding Consumables with Annex (forms 6.5.33 and 6.5.33.1, respectively) or C (form 6.5.30) unless stipulated otherwise, is issued by the RS Branch Office which performed the survey of the firm (manufacturer) and technical supervision during testing of the welding consumables.

**5.2.1.5.2** The Certificate of Approval for Welding Consumables is issued on the basis of the Report on Survey (form 6.3.18) recording the results of the inspections of the production process in compliance with the requirements of [5.2.2 — 5.2.5](#), as well as of testing of welding consumables within the scope of requirements of [4.2 — 4.8](#), Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships taking into consideration the instructions of [5.4](#). Where necessary, the list of protocols and documents agreed with the Register shall be included in the Annex to the Report.

**5.2.1.5.3** C is issued on the basis of testing of welding consumables within the scope of requirements of [4.2 — 4.8](#), Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships taking into consideration the instructions of [5.4](#) and

manufacturer's certificate (M). Where necessary, the list of protocols and documents agreed with the Register shall be included in the manufacturer's certificate.

**5.2.2 Survey of production of coated welding electrodes.**

**5.2.2.1** The survey of production of coated welding electrodes at the initial approval of the manufacturer shall include the following production areas and key operations:

- stockyard of bulk raw materials with verification of an incoming inspection log;
- stockyard of welding wire or wire rod with verification of an incoming inspection log;
- raw material conditioning area with verification of an operating control log;
- rod drawing/straightening and cutting area with a sampling control of specimens taken from a hopper (length, cut fineness, diameter, bending and corrugation);
- dry blend measuring area;
- liquid glass melting/preparation area with verification of an in-process control log;
- dry and wet mixing of components;
- electrode extrusion area, including a control check of cover eccentricity and quality as the electrode leaves a press;
- electrode calcination and drying area;
- product sorting and packaging area;
- specimen welding area;
- specimen preparation and test area;
- stockyard of finished products.

**5.2.2.2** At annual survey of production for confirmation of the Certificate of Approval for Welding Consumables, extent of inspections, at the discretion of the RS surveyor, may be reduced to 50 % of that specified in [5.2.2.1](#). At that the inspection shall, as a minimum, include the following production areas:

- stockyard of raw materials;
- stockyard of welding wire or wire rod;
- electrode extrusion area;
- sorting area with check sample for product testing;
- specimen welding area with testing of the electrodes;
- specimen preparation and test area with check tests of the products being certified.

**5.2.2.3** In the electrode sorting and packaging area, the RS surveyor and a representative of the manufacturer's quality control department shall sample the finished product according to [5.4.1.3](#). The technical requirements for electrode quality shall be verified according to [5.3](#).

Preparation of test samples and procedures of testing shall meet the appropriate instructions in [5.4](#).

**5.2.3 Survey of solid welding wire production.**

**5.2.3.1** At survey of solid welding wire production, the specific conditions of wire manufacture shall be considered. These are generally defined by the following factors:

- sensitivity of incoming billet metal to work hardening, which is defined by a permissible degree of shrinkage in wire-drawing without stress relief (annealing);
- special requirements for conditions of heat treatment, which is particularly relevant for high-alloyed steels and non-ferrous alloys;
- necessity of additional wire etching/cleaning after interannealing, which is defined by a chemical activity of metal and the medium wherein the annealing is performed (air, inert gas, vacuum, fused salt, etc.);
- sequence in application of the copper plating of wire during wire-drawing (intermediate and finishing copper plating);
- requirements for the surface condition and the tolerance for the finished product diameter;

type of delivery (coils, rim, spool) and special requirements for evenness of welding wire winding;

availability of a cutting/straightening operation as applied to supply of welding rods;

availability of final chemical treatment with supply of aluminium alloy wire or rods.

**5.2.3.2** As applied to manufacture of welding wire made of carbon steel and low-alloyed steel, the initial survey of production shall provide the inspection of the following areas and operations:

stockyard of uncleaned wire rod with verification of an incoming inspection log and the measures provided for traceability of an incoming billet in the further production;

rod etching area with the sampling control of the cleaned rod surface;

area of first drawing and finishing treatment of large diameter welding wire;

area of welding wire interannealing (for small diameter welding wire only);

area of wire cleaning after annealing and preliminary copper plating if the latter is used (for small diameter welding wire only);

area of finishing drawing and copper plating of small diameter welding wire;

welding wire winding and packing;

audit of checking operations performed during the product acceptance and manufacture;

inspections of product storage conditions, handling operations and issue of documents during the product release.

**5.2.3.3** The minimum extent of inspections at annual survey of the manufacture of welding wire made of non-alloyed and low-alloyed steel, in the absence of claims for the previous period of technical supervision, may consist of the following inspections of areas, operations and product quality characteristics:

area of the first drawing and finishing treatment of large diameter welding wire;

area of finishing drawing and copper plating of small diameter welding wire;

audit of checking operations performed during the product acceptance and manufacture;

inspections of product storage conditions, handling operations and issue of documents during the product release.

**5.2.3.4** During production survey, the RS surveyor and a representative of the manufacturer's quality control department shall sample the finished product according to [5.4.1.5](#). The technical requirements for welding wire quality shall be verified according to [5.3](#), other characteristics, according to [5.4](#).

#### **5.2.4 Survey of flux-cored welding wire production.**

**5.2.4.1** At survey of the flux-cored welding wire production, the specific conditions of wire manufacture, which are generally defined by the factors below, shall be considered:

diameter ratio of an incoming billet and finished wire;

permissible degree of shrinkage without annealing the tubular material as part of the wire;

kind of an incoming billet (strip or tube) and respectively the way of its filling with a charge;

kind and type of a core material (slagless and slag-forming components of a various type);

opportunity of charge separating during the filling and respectively the measures to be taken to prevent this;

availability of any operation for the finishing treatment of the wire surface;

availability of a cutting/straightening operation as applied to supply of welding rods.

**5.2.4.2** As applied to manufacture of flux-cored welding wire by forming from carbon steel and low-alloyed steel strip, the initial survey of production shall provide the inspection of the following areas and operations:

stockyard of free-flowing raw materials with checking an incoming inspection log;

stockyard of incoming billets for the strip with checking an incoming inspection log;

area of preparing raw materials with checking the operating control logs;

strip cutting with a sampling control of cut quality and billet dimensions;

- area of measuring and mixing wire core components;
- area of wire forming and drawing;
- area/operation of wire interannealing (if used) and finishing drawing;
- flux-cored welding wire winding and packing;
- audit of checking operations performed during the product acceptance and manufacture;
- area of specimen welding with testing of the wire;
- specimen preparation and test area with check tests of the products.
- stockyard of finished products.

**5.2.4.3** The minimum extent of inspections at annual survey of the manufacture of flux-cored welding, in the absence of claims for the previous period of technical supervision, may consist of the following inspections of areas, operations and product quality characteristics:

- area of measuring and mixing wire core components;
- wire forming and first drawing;
- wire interannealing and finishing drawing;
- welding wire winding and packing;
- audit of checking operations performed during the product acceptance and manufacture;
- inspections of product storage conditions, handling operations and issue of documents during the product release.

**5.2.4.4** During production survey, the RS surveyor and a representative of the manufacturer's quality control department shall sample the finished product according to [5.4.1.5](#).

The technical requirements for welding wire quality shall be verified according to [5.3](#), other characteristics, according to [5.4](#).

**5.2.5 Survey of welding flux production.**

**5.2.5.1** The survey of the welding fused flux production shall be carried out at initial approval and shall include the following inspections:

- inspection of raw materials and their preparation for melting, including blend measuring;
- sampling control over the observance of the manufacturer's procedure requirements at stages of melting, granulation, drying and packing;
- survey of the test base for test performance and check analyses during the product manufacture and acceptance; sampling control of the finished product quality according to [5.3.3.4](#) and [5.4.3](#).

**5.2.5.2** As applied to manufacture of agglomerated (ceramic) welding fluxes, the production survey at initial approval shall be carried out at initial approval and shall include inspections of the following production areas and operations:

- inspection of the stockyard of raw materials with checking an incoming inspection log;
- area of preparing and measuring charge (raw) materials with checking an operating control log;
- area of melting (preparation of binding agent/liquid glass);
- granulation and flux drying-calcinating;
- flux packing and procedure for the finished product inspection;
- conditions of the product storage at the stockyard and procedure for the product delivery;
- survey of the test base for test performance and check analyses during the product manufacture and acceptance;
- sampling control of the finished product quality according to [5.3.3.4](#) and [5.4.4](#).

**5.2.5.3** The minimum extent of inspections at annual survey of welding flux manufacture of welding flux, in the absence of claims for the previous period of technical supervision, may consist of the following inspections of areas, operations and product quality characteristics:

- stockyard of raw materials with checking an incoming inspection log and their launching;

sampling control over the observance of the manufacturer's procedure requirements at stages of flux manufacture;

sampling control of the finished product quality according to [5.3.3.4](#) and [5.4.3.3](#), the welding and technological properties check as minimum included.

### **5.3 TECHNICAL REQUIREMENTS FOR QUALITY AND SUPPLY OF WELDING CONSUMABLES SUBJECT TO THEIR APPROVAL BY THE REGISTER**

#### **5.3.1 General provisions.**

**5.3.1.1** The technical requirements for welding consumables quality and supply conditions shall be documented as the technical conditions or specifications signed by the authorized personnel. In general, the technical conditions or specifications for supply of welding consumables shall meet the requirements of the appropriate standards, contract documentation and the RS rules.

**5.3.1.2** This Chapter contains the minimum requirements, which shall be met during manufacture and supply of the products under the Register technical supervision, supplementing, but not replacing, the requirements specified by other regulatory or contract documents.

**5.3.1.3** The manufacturer or supplier of welding consumables is fully responsible to the customer and the Register for observance of the technical requirements specified in this Chapter.

#### **5.3.2 Product marking.**

##### **5.3.2.1 Marking of welding consumables.**

**5.3.2.1.1** Coated electrodes shall have a mark on the covering near their grip end applied with a resistant paint. The mark shall, at least, include the designation of its own distinctive name (coded notation) of the material brand of the manufacturer or supplier. It is also recommended to include in the marking the mandatory part of the consumable classification indices in compliance with the standard for electrodes in use.

The paints of only such composition that has no adverse effect on the welding results shall be used for marking.

*Note.* In addition to the marking on the covering, the marking directly on the grip end applied with a heat-resistant paint is also recommended. In this case, the marking colour shall be specified on a package.

**5.3.2.1.2** Welding wire, flux-cored wire and welding strip delivered wound on spools or in coils shall have on each spool or coil the marking applied in a manner resistant to exposure and having the designation of its own distinctive name (coded notation) of the material brand of the manufacturer or supplier.

**5.3.2.1.3** Every rod for tungsten arc welding and plasma arc welding shall have the stamped mark, which unambiguously identifies the product for one manufacturer or supplier. The materials, which cannot be marked by stamping, may be marked with stickers (tags).

*Note.* If required in the standard used, tubular cored rods and rods for oxyfuel gas welding shall be marked as above.

##### **5.3.2.2 Marking on package.**

Every pack unit of the product shall have the following data clearly shown on its outer side:

name of manufacturer or supplier;

trade name;  
designation of its own distinctive name (coded notation) of the material brand of the manufacturer or supplier;  
designation in the stamp (for welding rods only);  
designation in compliance with the appropriate standards;  
dimensions in compliance with the requirements of the appropriate national standards;  
number of a batch and, if appropriate, number of a heat;  
type of a welding current, where required;  
welding conditions (current range) recommended for coated electrodes;  
number of product units in a pack or net weight;  
instructions on redrying or recalcination, where applicable (coated electrodes, welding fluxes);  
approvals of classification societies and technical supervisory bodies, where available;  
requirements on health protection and safe handling, where appropriate.

**5.3.3 Technical requirements for terms of supply of welding consumables.**

**5.3.3.1 General provisions.**

**5.3.3.1.1** This Chapter contains the minimum requirements, which may be applied by the Register during:

review of the manufacturer technical conditions or specifications for welding consumable supply;

assessment of the results of a product sampling control during production survey.

Where more rigorous criteria for product acceptance are set by the national standards, contract requirements or manufacturer specifications, the Register shall apply them during the sampling control of products.

**5.3.3.1.2** Every batch of welding consumables may be provided with the manufacturer certificate which, based on the inspections and tests performed, confirms the product compliance with the technical requirements for terms of supply. The content of the manufacturer certificate shall at least comply with the requirements of 5.4, Part I "General Regulations for Technical Supervision".

**5.3.3.2 Technical requirements for supply of welding electrodes.**

**5.3.3.2.1** The electrode covering shall be free of any irregularities, dents, hairlines, rough edges, pores, cracks and other surface defects, which may exert an adverse effect on welding. The surface defects complying with the provisions in [5.3.3.2.2](#) are acceptable.

**5.3.3.2.2** The following single defects may be allowed on the surface of an electrode covering:

longitudinal surface cracks and local netted crackings numbered not more than one per electrode with the extent of each crack or cracking part within 10 mm;

local dents of a depth not more than 50 % of the covering thickness numbered not more than two with the total extent of up to 20 mm per electrode. In this case, two local dents located on two sides of the electrode in one cross-section may be taken as one dent, if their total depth does not exceed 50 % of the covering thickness;

local scores not more than 15 mm in length and not more than 25 % of a nominal covering thickness in depth numbered not more than two per electrode;

defects of one kind among the above mentioned may be allowed on a single electrode, if their size is close to the permissible maximum. In other cases, the combination of defects of various kinds is acceptable, provided their number does not exceed two and the total extent is within 20 mm.

The total number of electrodes with the above acceptable covering defects shall be within 10 % of the number of the electrodes inspected in a check sample.

**5.3.3.2.3** Electrode dimensions and the length of a grip end shall be in compliance with the recommendations of [Table 5.3.3.2.3](#) and [Fig. 5.3.3.2.3](#).

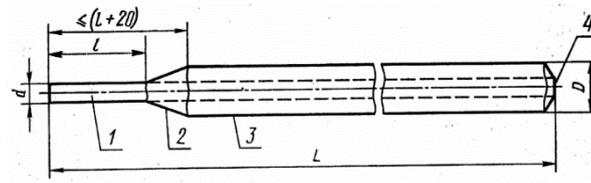


Fig. 5.3.3.2.3

Diagram for determination of the electrode nominal dimensions  
 1 — rod; 2 — transitional section; 3 — covering;  
 4 — contact end without covering

Table 5.3.3.2.3

**Dimensions and tolerances for coated electrodes with a rod of low-carbon or alloyed steel wire**

Nominal diameter of electrode $d$ , in mm, defined by rod diameter	Nominal length of electrode $L$ , in mm (limit deviation $\pm 3$ mm)	Length of grip end $l$ , in mm (limit deviation $\pm 5$ mm)
1,6	200 250	20
2,0	250 300	
2,5	250 300 350	
3,0 and 3,2 <sup>1</sup>	300 350 450	25
4,0	350 450 <sup>2</sup>	
5,0 and 6,0 <sup>1</sup>	450 <sup>2</sup>	

<sup>1</sup> Electrodes with a rod of 3,15 mm and 6,3 mm in nominal diameter are acceptable.  
<sup>2</sup> In special cases (e.g. for gravity welding), the electrode length may be increased up to 900 mm, inclusive.

**5.3.3.2.4** The electrode covering shall be concentric and consistent lengthwise to prevent its asymmetric melting-off during welding. The difference of a covering thickness (eccentricity) at any cross-section along the working length of the electrode shall not exceed the values given in [Table 5.3.3.2.4](#).

Table 5.3.3.2.4

Nominal diameter of the electrode $d$ , in mm	Covering eccentricity $e$ , in mm	
	Medium and thick coated electrodes (covering of types R, RR, RC, RA, A and B)	Thin coated electrodes (type C covering)
1,6	0,04	—
2,0	0,06	—
2,5	0,08	0,04
3,0; 3,15 and 3,20	0,10	0,06
4,0	0,14	0,08
5,0	0,18	0,10
6,0 and 6,3	0,20	—

**5.3.3.2.5** The electrode covering shall not be destroyed after the free fall of the electrode on a smooth steel plate from a height of:

- 1 m — for the electrodes of 3,25 mm and less in diameter;
- 0,75 m — for the electrodes of 4,0 mm and 5,0 mm in diameter;
- 0,5 m — for the electrodes of 6,0 mm and 6,3 mm in diameter.

In this case, the partial chippings-off of the covering having the total extent of up to 5 % of the covering length are acceptable. These defects shall be measured with an accuracy of up to 1 mm.

**5.3.3.2.6** The residual moisture of the electrode covering after the standard (recommended by the manufacturer) calcination shall not exceed:

0,1 % — for the electrodes having type B and RB coverings;

0,3 % — for the electrodes having type R, RR, RA and A coverings;

the residual moisture of a covering for the electrodes with type C and RC coverings is specified by the manufacturer technical documentation.

The residual moisture of a covering shall be measured by bringing the covering removed from a controllable electrode to a level mass at a temperature of:

400±10 °C — for type B and RB coverings;

180±10 °C — for type R, RR, RA and A coverings;

110±5 °C — for type C and RC coverings.

The content of residual moisture  $B_w$ , in %, is determined by the formula

$$B_w = \frac{m_1 - m_2}{m_1} \times 100\%, \quad (5.3.3.2.6)$$

where  $m_1$  = initial mass of the covering, in g;

$m_2$  = level mass of the covering, in g.

**5.3.3.2.7** For one brand of electrodes, analytical tolerances for the content of base alloying elements and impurities in the deposited metal in compliance with the manufacturer or supplier technical conditions or specifications shall be, generally, within the limits specified by the requirements in [Table 5.3.3.2.7](#).

Table 5.3.3.2.7

Alloying elements and impurities	Electrodes for welding of normal strength steel and higher strength steel with covering type			Electrodes for welding of high strength steel with covering type
	B, RB	R, RR, RA, A	C	B
C	≤ 0,10	≤ 0,12	≤ 0,18	≤ 0,10
Si	±0,20			±0,15
Mn	±0,25			±0,25
P	≤0,030			≤ 0,025
S	≤0,030			≤ 0,020
Cr	–			± 0,20
Ni	–			±0,25
Mo	–			± 0,10
V	–			± 0,10

**5.3.3.2.8** The indicators of mechanical and special properties of the weld metal, deposited metal or a welding joint for electrodes of each batch shall meet the requirements of:

the national standards as applied to the electrode classification specified by the technical conditions or specification;

the RS rules for welding consumables grade specified in the Certificate of Approval for Welding Consumables;

the contract conditions and also the documentation for supply and relating to the special properties or characteristics, which exceed the values specified by the standards.

**5.3.3.2.9** The electrodes package shall, as a minimum, prevent their potential damage during transportation and storage in dry spaces.

Electrodes shall generally be packed up by one of the ways:

in sealed plastic boxes;

in boxes of cardboard of at least 0,7 mm thick sealed with polyethylene film each;

in boxes of cardboard of at least 0,8 mm thick, which have a waterproof covering.

The height of above boxes stacking on shipping pallets or in large-sized boxes shall not, generally, exceed 600 mm.

**5.3.3.3** Technical requirements for supply of welding wire and rods.

**5.3.3.3.1** The requirements given below cover welding wire and rods, flux-cored wire and rods, strip electrodes and cored strip electrodes.

**5.3.3.3.2** The surface of welding consumables shall be free from contamination and surface defects, which adversely affect welding. Any surface finish is acceptable, provided it ensures welding performance and does not exert an adverse effect on weld metal properties. All cored welding consumables shall have the distribution of cavity-filling ingredients lengthwise with such a uniformity, which has no harmful effect on the use of consumables, on the chemical composition and properties of the deposited metal.

**5.3.3.3.3** Wire and strip electrodes, as well as flux-cored welding wire shall be supplied in coils or wound on spools as per [Fig. 5.3.3.3.3](#) and [Table 5.3.3.3.3](#). They shall be free from kinks, waves, sharp bends and other irregularities, which may affect the continuity of wire feeding.

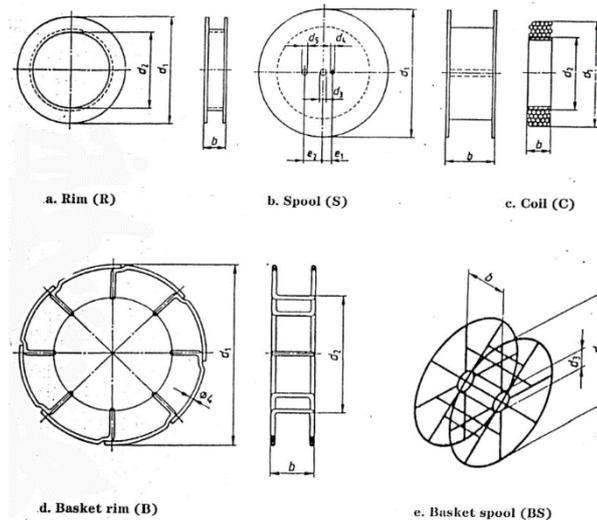


Fig. 5.3.3.3.3

Types of welding wire winding for supply:

- a — rim (R); b — spool (S); c — square-sectioned coil (C);  
d — basket rim (B); e — basket spool (BS)

Table 5.3.3.3.3

Type (refer to Fig. 5.3.3.3.3)	Standard dimensions	Outer diameter $d_1$	Inner diameter $d_2$	Outer width $b$	Axial diameter on spool $d_3$	Pin hole			
						Diameter		Distance from axis	
						$d_4$	$d_5$	$l_1$	$l_2$
S	S100	100±2	—	45 <sup>0</sup> <sub>-2</sub>	16,5 <sup>+1</sup> <sub>0</sub>	—	—	—	—
S	S200	200±3	—	55 <sup>0</sup> <sub>-3</sub>	50,5 <sup>+2,5</sup> <sub>0</sub>	10 <sup>+1</sup> <sub>0</sub>	—	44,5	—
S	S300	300±5	—	103 <sup>0</sup> <sub>-3</sub>	50,5 <sup>+2,5</sup> <sub>0</sub>	10 <sup>+1</sup> <sub>0</sub>	—	±0,5	—
S	S350	350±5	—	103 <sup>0</sup> <sub>-3</sub>	50,5 <sup>+2,5</sup> <sub>0</sub>	10 <sup>+1</sup> <sub>0</sub>	—	44,5	—
S	S760	760 <sup>0</sup> <sub>-10</sub>	—	200 <sup>+10</sup> <sub>-1</sub>	40,5 <sup>+1</sup> <sub>0</sub>	25 <sup>+1</sup> <sub>0</sub>	35 <sup>+1</sup> <sub>0</sub>	±0,5	110±1
R	R435	435±5	300 <sup>+15</sup> <sub>0</sub>	90 <sup>0</sup> <sub>-15</sub>	—	—	—	44,5	—
B	B300	300 <sup>0</sup> <sub>-5</sub>	180±2	100 <sup>+3</sup> <sub>-3</sub>	—	—	—	±0,5	—

Type (refer to Fig. 5.3.3.3.3)	Standard dimensions	Outer diameter $d_1$	Inner diameter $d_2$	Outer width $b$	Axial diameter on spool $d_3$	Pin hole			
						Diameter		Distance from axis	
						$d_4$	$d_5$	$l_1$	$l_2$
B	B450	450 max	300±5	100 <sup>+3</sup> <sub>-3</sub>	–	–	–	65±1	–
BS	BS300	300±5	–	103 <sup>0</sup> <sub>-3</sub>	50,5 <sup>+2,5</sup> <sub>0</sub>	–	–	–	–
C	C435	435 max	300 <sup>+15</sup> <sub>0</sub>	90 <sup>0</sup> <sub>-15</sub>	–	–	–	–	–
C	C450	450 max	300 <sup>+15</sup> <sub>0</sub>	100 <sup>+10</sup> <sub>-5</sub>	–	–	–	–	–
C	C800	800 max	600 <sup>+20</sup> <sub>0</sub>	120 <sup>+10</sup> <sub>-5</sub>	–	–	–	–	–

**5.3.3.3.4** Welding wire of every coil or spool shall be continuously wound with the wire beginning and end brought out, fastened and secured.

Welding consumables on coils without formers shall be tied at four places at least.

**5.3.3.3.5** Standardized dimensions and tolerances for welding wire and rods shall comply with the recommendations of [Table 5.3.3.3.5](#). In this case, if agreed between the parties in contact, other values of diameters (intermediate) may be used, to which the requirements for manufacture accuracy tolerances specified in [Table 5.3.3.3.5](#) shall be applied.

**5.3.3.3.6** Strip electrodes shall meet the requirements of [Table 5.3.3.3.6](#) for standard sizes and manufacture accuracy tolerances. The tolerances for cored strip electrodes are subject to approval by the parties in contact.

**5.3.3.3.7** Welding wire for steel welding shall not have a helix above the values below. The wire helix is defined as the vertical separation between any part of one loop of wire placed on a flat surface without restraint and the flat surface. It shall not exceed 25 mm for spools of up to 200 mm (S200) in outer diameter and 50 mm for spools of over 200 mm in outer diameter ([refer to Table 5.3.3.3.3](#)).

**5.3.3.3.8** The cast (diameter of some loops of wire placed on a flat surface without restraint), helix and condition of all the wires shall be such as to be suitable for uniform uninterrupted feeding on the equipment for semi-automatic welding.

Table 5.3.3.3.5

Welding wire diameters and their deviations, in mm							
Welding process	Wire			Flux-cored wire	Welding rods		
	131, 135, 141, 51, 52	121, 72, 73	111 (for electrodes)	132, 133, 136, 138 114, 125, 143, 73	141, 31, 15		
Nominal diameter	Extreme deviations of nominal diameter				Extreme deviations of diameter	Length	Extreme deviations of length
0,5	+0,01	–	–	–	–	–	–
0,6	–0,03			–			
0,8	+0,01 –0,04	±0,04	–0,06 – –0,06 – –0,06 –	+0,02	±0,1	from 500 up to 1000	±5
1,0				–0,05			
1,2				–			
1,4				–			
1,6				–			
1,8				–			
2,0	–0,06	–	–	+0,02	–	–	–
2,4				–0,06			
2,5	+0,01 –0,04	±0,06	–0,08	–	–	–	–
2,8				–			
3,0				–			
3,2				–			
4,0	–	–	–0,10	+0,02	–	–	–
5,0				–0,07			
6,0				–0,08			
8,0	–	–	–	–	–	–	–

Welding process	Wire			Flux-cored wire	Welding rods		
	131, 135, 141, 51, 52	121, 72, 73	111 (for electrodes)	132, 133, 136, 138 114, 125, 143, 73	141, 31, 15		
Nominal diameter	Extreme deviations of nominal diameter				Extreme deviations of diameter	Length	Extreme deviations of length

Note. Reference numbers for welding processes to ISO 4063 (refer to [Table 6.2.2.1](#))

Table 5.3.3.3.6

Dimensions and tolerances for strip electrodes, in mm

Electrodes	Dimensions	Tolerances
Nominal thickness	≤1,0	±0,05
Nominal width	≤100	+0,50
	>100	+0,80

**5.3.3.3.9** A chemical composition of welding wire and rods by the content of alloying elements and impurities shall meet the requirements of the appropriate standards for a specific class wire, as well as the additional restrictions of the manufacturer on technical conditions or specifications for welding consumable supply.

**5.3.3.3.10** The measures of mechanical and special properties of the weld metal, deposited metal or welded joint of each batch of welding wire or rods shall meet the requirements of:

the national standards as applied to the classification of welding consumables established by the technical conditions or a specification;

the RS rules for the welding consumables grade specified in the Certificate of Approval for Welding Consumables;

the contract terms and supply documents as well.

**5.3.3.3.11** The package of welding wire shall prevent its potential damage and loss of welding characteristics during transportation and storage. Special measures therewith, including a vacuum package with a controlling sorbent, shall be taken regarding the kinds of welding wire, which may completely or partially lose their welding properties in storage at the natural humidity. Among such welding consumables is flux-cored wire.

**5.3.3.4** Technical requirements for supply of welding fluxes.

**5.3.3.4.1** The requirements below apply to fused, ceramic and also sintered fluxes or mixtures.

**5.3.3.4.2** Technical documents for supply and manufacture of fluxes shall include the requirements for the following characteristics:

structure and grain colour;

homogeneity;

chemical composition;

grain-size composition;

humidity and content of diffusive hydrogen in deposited metal;

volume weight;

welding and technological properties;

measures of mechanical and special properties of the weld metal, deposited metal or welded joint.

**5.3.3.4.3** Homogeneity is generally an acceptance characteristic for fused fluxes. Homogeneity is determined by examining a flux sample of 10 g at not less than ×10 magnification. The sample shall contain not more than 3 % of grains and foreign particles having visible distinctions by colour and structure from those required by the regulated documents.

**5.3.3.4.4** A grain-size composition of flux is determined by screening a flux sample of at least 100 g through a proper sieve and by comparing the obtained results with the check values in the technical conditions for supply. The flux manufacturer or supplier shall inform a customer about the grain-size composition of flux with the symbols corresponding to the recommendations of [Table 5.3.3.4.4](#), which shall be given on every pack unit. The symbols for designation of the greatest and least dimension of flux particles shall be given as a minimum.

Table 5.3.3.4.4

**Symbols for designation of flux grain dimension on product package**

Dimension of flux particles, in mm	2,5	2,0	1,6	1,25	0,8	0,5	0,31 5	0,2	0,1	<0,1
Symbol	25	20	16	12	8	5	3	2	1	<i>D</i>

**5.3.3.4.5** The flux humidity is determined by calcination and bringing the flux sample of about 100 g to a level mass. In determining the humidity, three samples, of which the mass shall not differ from one another by more than 5 g, shall be used for the measurements. The calcination temperature for fused fluxes is  $300 \pm 10$  °C, and for ceramic and sintered fluxes and mixtures,  $350 \pm 10$  °C. The time of sample calcination shall be at least 2 h. The humidity of fluxes used in shipbuilding shall not generally exceed 0,05 %.

**5.3.3.4.6** Indices of chemical composition, volume weight, welding and technological properties of flux shall meet the requirements of the manufacturer (supplier) technical conditions or specifications approved by the Register.

**5.3.3.4.7** Indices of mechanical and special properties of the weld metal, deposited metal or welded joint of each batch of flux shall meet the requirements of:

the national standards as applied to the classification of welding consumables established by the technical conditions or specification;

the RS rules for the welding consumables grade specified in the Certificate of Approval for Welding Consumables;

the contract terms and supply documents as well.

**5.3.3.4.8** The package for welding fluxes shall prevent its potential damage and loss of quality characteristics during transportation and storage. Special measures therewith, including a completely tight (rigid inclusive) package, shall be taken regarding the kinds of welding fluxes, which may lose their welding properties during storage and transportation. Among such fluxes are the ceramic ones, particularly, those of a homogeneous granulation, which may lose their initial grain-size composition during transportation in the paper bags.

**5.3.3.5** Technical requirements for shielding gases and their mixtures.

**5.3.3.5.1** Shielding gases for welding are classified under the groups of a standard composition depending on their chemical activity relative to molten metal in accordance with the requirements of [Table 6.2.2.5](#).

Deviations by the content of single components in the mixture from the values given in the manufacturer specification for supply shall be within the below limits:

$\pm 10$  % of a nominal value at the component content in the mixture above 5 vol. %;

$\pm 0,5$  % of the mixture volume at the component content in the mixture from 1 vol. % incl. to 5 vol. % incl.;

at the component content in the mixture under 1 vol. % the limits are subject to agreement.

**5.3.3.5.2** The value of the maximum dew-point temperature, as well as the minimum purity of shielding gases (limitation on their total content of impurities) for the standard composition groups shall comply with [Table 5.3.3.5.2](#).

For special gas mixtures, the requirements for the dew point, purity and humidity shall correspond to the base gas or gas mixture in use similarly to the recommendations of [Table 5.3.3.5.2](#).

For some active metals (e.g. titanium and tantalum), shielding gases and mixtures of the purity higher than specified in [Table 5.3.3.5.2](#) may be needed. In this case, the requirements for gas supply shall be subject to the additional approval by the supplier and the customer.

Table 5.3.3.5.2

Main groups/gas		Purity, min, in vol. %	Dew point at 0,101 in MPa, max, in °C	Moisture, max, in vol. ppm
I	inert	99,99	-50	40
M1 <sup>1</sup>	gas mix	99,9	-50	80
M2 <sup>1</sup>	gas mix	99,9	-44	120
M3 <sup>1</sup>	gas mix	99,9	-40	120
C <sup>1</sup>	carbon dioxide	99,8	-40	40
R	reducing	99,95	-50	40
N	nitrogen	99,9	-50	40
O	oxygen	99,5	-50	40

<sup>1</sup> Nitrogen: 1000 ppm max.

**5.3.3.5.3** Shielding gases may be delivered in a gaseous state in cylinders under pressure or liquefied. The cylinders and dewars shall have a distinctive painting and marking in compliance with the requirements of the national standards.

## 5.4 PROCEDURE FOR INSPECTION AND TESTING OF WELDING CONSUMABLES DURING THEIR APPROVAL

### 5.4.1 Sampling of the finished products.

**5.4.1.1** Within the scope of survey of the manufacturer, witnessed by the RS surveyor, the specimens of welding consumables being subject to inspection and testing shall be sampled. The sampling may be performed in:

- the grading area after product acceptance by the manufacturer's quality control department, but prior to the final packaging of products;
- the stockyard of the finished products prepared for delivery.

The sampling of welding consumables shall be confirmed with a report signed by the manufacturer's responsible person and the RS surveyor.

**5.4.1.2** At the initial approval of manufacturers, the sampling and follow-up inspections shall be carried out for each brand of material to the following extent:

- for electrodes — in one batch for each diameter, but a total of, at least, two batches checked;
- for fluxes — at least, two batches checked;
- for welding and flux-cored wire/strip — in one batch for each standard size, but a total of, at least, two batches checked.

**5.4.1.3** To check each batch of coated welding electrodes, 10 samples of 20 electrodes each shall be taken. Each sampling shall be carried out from the different packages or, alternatively, during manufacture and acceptance at equal time intervals.

200 electrodes sampled shall be subjected to checking: dimensions and appearance of all the electrodes;

- covering thickness difference for 50 electrodes;
- covering strength for 30 electrodes;
- bending for 50 electrodes.

The check for the covering moisture content shall be carried out according to the results of three measurements (one electrode for each measurement).

The electrodes, which have undergone the above checks tests, are thereafter used for:  
verification of welding and technological properties among the electrodes, which had the maximum values of covering eccentricity;  
determination of a chemical composition of the deposited metal;  
welding of deposited metal test assemblies for determining deposited metal properties, and butt joints according to a test programme.

**5.4.1.4** To check each batch of flux, at least six samples of 2,5 kg each shall be taken from the different packages. Following mixing, the flux sampled is brought by quartering to a mass of 2,5 kg. In this case, the weight of 0,5 kg is further used for determining a chemical composition and humidity of flux, and the weight of 2,0 kg, for determining a grain-size composition, uniformity and volume weight of flux.

The flux checked as above is further used for:  
verification of welding and technological properties;  
welding of the deposited metal test assemblies for determining the deposited metal properties, and butt joints, if required, according to a test programme.

**5.4.1.5** To check each batch of welding wire and tubular welding wire, the following samples shall be taken and the following tests shall be conducted:

diameter and ellipticity measurements in two mutually perpendicular directions for at least 10 packages with 2 measurements for each package. The points of diameter measurements shall be spaced at least 5 m apart;

the condition of a wire surface is determined similarly to the diameter measurements and may be also checked in winding the wire on cassettes and spools or coils;

10 packages, as a minimum, shall be checked for measures of the helix, cast, as well as for the measures defining the winding quality (the requirement applies to the welding wire intended for semiautomatic welding and robotized complexes with the requirements for observance of a winding difference);

flux-cored wire shall be checked for a fill factor on the samples taken from, at least, five packages;

copper-clad wire shall be checked for the measure of the thickness/relative mass of a copper coating on the samples taken from, at least, five packages;

a chemical check analysis of wire shall be carried out for, at least, two packages. For this purpose two samples of wire spaced, at least, 10 m apart shall be taken from each package;

for welding high-alloy wire of an austenitic and austenitic-ferritic grade, on demand of the RS surveyor, the content of  $\alpha$ -phase may be checked in addition to the chemical composition (applicable to A-5, A-6, AF-8, A-9sp steel grades).

For further checks and tests, a welding wire sample having a mass of at least 5 kg shall be taken, which shall be checked to the extent of the requirements of the RS rules according to the approved test programme for the purpose of determining:

welding and technological properties during welding in various welding positions (the test applies to the wire intended for metal-arc gas welding);

chemical composition of the deposited metal;

content of diffused hydrogen in the deposited metal (for flux-cored wire, and on a special demand — for wire with a non-copper-plated surface for metal-arc gas welding);

properties of the deposited metal;

properties of a butt welded joint.

**5.4.2 Preparation of the deposited metal test assemblies and butt welds.**

**5.4.2.1** During preparation of deposited metal test pieces and butt welds, the requirements of Section 4, Part XIV "Welding" of the Rules for the Classification and

Construction of Sea-Going Ships for the relevant kinds of welding consumables shall be met. It is recommended therewith to follow the additional instructions given below, which are harmonized with the appropriate international standards used for classification of the welding consumables. Those instructions cover the welding consumables, intended for welding of normal strength and higher strength steels, which provide the minimum values of the deposited metal tensile strength of 440 — 560 N/mm<sup>2</sup> during welding under the standard conditions.

Note. The above tensile strength range also covers the welding consumables for welding high strength steels, which, in compliance with the requirements of 4.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships, may be identified by a strength level as (3Y/5Y)42 and (3Y/5Y)46 steel grades.

**5.4.2.2** While welding the deposited metal test pieces in order to perform classification of coated electrodes in accordance with the international standards the following standard conditions shall be complied with.

Welding shall be carried out without preheating of ambient air at a room temperature.

During welding, an interpass temperature shall be controlled by means of crayons, surface thermometers or thermocouples and it shall be within limits of 100 — 150 °C. If the test piece temperature after the next run exceeds the set limit, the test piece shall be air cooled up to the specified temperature.

Welding shall be carried out at the welding current values corresponding to 70 – 90 % of the maximum value specified by the manufacturer for welding in a flat position.

The procedure for runs in the test piece groove shall be in compliance with the recommendations of [Table 5.4.2.2](#).

Table 5.4.2.2

Electrode diameter <sup>1</sup> , in mm	Technology of weld bead application		
	Number of layer	Number of runs in layer	Number of layers
4,0	From root to surface	2 <sup>2</sup>	7–9
5,0	From root to surface	2 <sup>2</sup>	6–8
6,0	From root to surface	2	5–7

<sup>1</sup> For electrodes which diameter is less than 4,0 mm as well as 5,0 and 6,0 mm the technology of weld bead application is not regulated by the international standards and it may be additionally agreed with the Register.  
<sup>2</sup> Two upper layers may consist of three weld beads.

The welding direction of each run within one layer shall not change, but shall be changed to the opposite one in transition to the next layer. Thickness of each weld bead shall be not less than 2 mm and not more than 4 mm. If electrodes are intended for welding at alternating and direct current, the welding of test piece is usually made at alternating current. In DC welding, the polarity requirements in accordance with the recommendations of the welding consumables manufacturer shall be met.

**5.4.2.3** While welding the deposited metal test pieces for classifying the combinations "wire — flux" as well as their component (welding wire and flux) in accordance with the international standards the following standards shall be complied with.

The welding shall be performed without preheating at ambient room temperature by several layers consisting of one or several runs in accordance with the usual application practice. Meanwhile, each subsequent layer shall be welded in the direction opposite to the previous one from the end of each plate. After completion of welding of each run the residual flux and solidified slag shall be removed. Thickness of each layer shall not be less than the diameter of welding wire but not less than 4 mm. In welding, an interbead (interpass)

temperature shall be under control with use of crayons, surface thermometers or thermocouples and shall not exceed the values given in [Table 5.4.2.3](#). If the test piece temperature after the next run exceeds the set limit, the test piece shall be naturally cooled in the air down to the specified temperature. After completion of welding the test pieces shall not be exposed to any thermal treatment. If the combination "wire-flux" is intended for welding using alternating and direct current, the welding of test piece is usually made at alternating current. In DC welding, the polarity requirements in accordance with the recommendations of the welding consumables manufacturer shall be met.

Welding wire of 4,0 mm or 3,2 (3,0) mm in diameter depending on the larger diameter supplied shall be used for welding.

The conditions for (one-electrode) welding shall comply with the recommendations of [Table 5.4.2.3](#).

Table 5.4.2.3

Welding conditions <sup>1</sup>	Wire diameter <sup>2</sup>	
	3,2	4,0
Test piece length, mm	Min 200	Min 200
Current type	DC	DC
Welding current, A	440 ± 20	580 ± 20
Arc voltage, V	27 ± 1	29 ± 1
Travel speed, mm/min	400 ± 50	550 ± 50
Interpass temperature, °C	150 ± 50	150 ± 50
Electrode extension, mm	30 ± 5	30 ± 5
<sup>1</sup> Where DC and AC welding is required, the AC welding only shall be used for welding the test piece. <sup>2</sup> For electrodes which diameter is less than 3,2 mm or more than 4,0 the technology of weld bead application shall not be regulated by the international standards and it may be additionally agreed with the Register.		

**5.4.2.4** While welding the deposited metal test pieces for classifying the combinations "wire-gas" as well as welding wire for the combination "wire-gas" in accordance with the international standards the following standards shall be complied with.

The welding of the test pieces shall be performed without preliminary heating at ambient room temperature. In welding, an interbead (interpass) temperature shall be under control with use of crayons, surface thermometers or thermocouples. After each run the test piece shall be cooled in a natural way on air down to the temperature below 250 °C, but not less than 100 °C. The temperature shall be measured in the centre of weld bead surface. If after the next run the temperature of test piece exceeds preset limit value the test piece shall be cooled in a natural way on air down to the required temperature. After completion of welding the test pieces shall not be exposed to any thermal treatment.

Tests shall be carried out using the welding wire of diameter 1,2 mm. The welding shall be carried out at the values of welding current intensity of 280±20 A and of welding wire extension of 20±3 mm. The procedure for passes in the test piece groove shall be in compliance with the recommendations of [Table 5.4.2.4](#). The welding direction of each run within one layer shall not change, but shall be changed to the opposite one in transition to the next layer. The thickness of each weld bead shall remain within 2 — 6 mm.

Table 5.4.2.4

Electrode diameter <sup>1</sup> , in mm	Procedure for passes		
	Layer number	Number of runs per layer	Number of layers
1,2	From root to surface	2 <sup>2</sup>	6 — 10
<sup>1</sup> For electrodes of other diameters the weld bead application is not regulated by the international standards and it may be additionally agreed with the Register.			

Electrode diameter <sup>1</sup> , in mm	Procedure for passes		
	Layer number	Number of runs per layer	Number of layers
<sup>2</sup> Two top layers may comprise three beads.			

**5.4.2.5** Welding of test pieces of welded metal for classifying flux cored wire for welding with the additional gas shield or without it in accordance with the international standards the following conditions shall be complied with.

Requirements for the interbead (interpass) temperature and its control shall be identical to the requirements in 5.4.2.4. The total number of runs, the number of runs in the layer and number of layers shall comply with recommendations of Table 5.4.2.5. Direction of welding of each run within one layer shall remain unchanged and in the next layer it shall change to the opposite direction.

Table 5.4.2.5

Electrode diameter, mm	Average heat input, in kJ/mm	Number of runs per layer		Total number of layers
		First layer	Other layers <sup>1</sup>	
0,8 and 0,9	0,8 to 1,6	1 or 2	2 or 3	6 to 9
1,0 and 1,2	1,2 to 2,0	1 or 2	2 or 3	6 to 9
1,4 and 1,6	1,4 to 2,2	1 or 2	2 or 3	5 to 8
2,0	1,8 to 2,4	1 or 2	2 or 3	5 to 8
2,4	2,0 to 2,6	1 or 2	2 or 3	4 to 8
2,8	2,0 to 2,8	1 or 2	2 or 3	4 to 7
3,2	2,2 to 3,0	1 or 2	2	4 to 7
4,0	2,6 to 3,3	1	2	4 to 7

<sup>1</sup> The final (capping) layer may have four runs.

If the flux cored wire is intended for welding using alternating and direct current, the welding of test piece is usually made at alternating current. During welding at direct current the requirements for polarity in accordance with the recommendations of manufacturer of welding materials shall be observed.

**5.4.3 Requirements for approval of welding fluxes used for welding as part of "wire — flux" combinations.**

**5.4.3.1** The welding fluxes to be approved for use as part of the "wire-flux" combinations may be approved by the Register according to the following schemes:

in a similar way to the wire used for welding as part of "wire — flux" combinations, i.e. to the extent of the requirements in 4.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships for this combination;

for compliance with the requirements of the national and international standards. This form of approval is generally used as additional pursuant to the manufacturer's request.

**5.4.3.2** The scope of welding flux tests to the extent of the requirements given in 4.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships shall include:

at initial approval: the determination of the deposited metal and weld metal properties for all the brands of welding wire which, pursuant to the manufacturer's request, shall be included in the Certificate of Approval for Welding Consumables;

at annual tests to confirm the Certificate of Approval for Welding Consumables: one of the welding wire brands among those included in the Certificate in combination with a specific flux brand shall be verified to the extent of the requirements given in 4.4.4.1, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**5.4.3.3** The scope of tests for welding fluxes at their approval for compliance with the requirements of the national and international standards shall be in compliance with the

requirements of these standards. At initial approval, to be verified is the whole array of flux properties and characteristics specified by the relevant standards for their acceptance and classification.

In order to confirm the approval, if nothing evidences the unstable quality of products or the change in its manufacture procedure, check tests may be reduced to the extent of the verification of mandatory characteristics to be controlled in each batch according to the specification and/or pertinent standards. However, in any case, welding and technological properties of the flux in welding shall be verified.

**5.4.4 Extent of approval tests for shielding gas for welding.**

**5.4.4.1** The Register approves shielding gases and their mixtures by verifying their compliance with the requirements of the national and international standards. Unless otherwise agreed with the Register, the below requirements shall be met, unified with ISO 14175, which cover shielding gases and their mixtures used for:

- tungsten inert gas arc welding (TIG);
- metal arc inert gas and active gas welding;
- plasma-arc welding;
- additional protection of the root surface of the weld.

The scope of the necessary tests and checks for the shielding gases used for welding active metals like titanium and tantalum may be extended on the Register's demand.

**5.4.4.2** At the initial approval of each group of the shielding gas standard composition, the scope of verification includes taking check test specimens from transport units (cylinders and dewars). Each shielding gas sample taken shall be verified for:

- compliance of gas purity with the specified requirements;
- meeting the requirements for a dew point and the absolute humidity of gas;
- accuracy of measuring single components of the gas mixture.

In this case, where the approval applies to the mixtures of shielding gases having a standard composition, on the Register demand, the initial components being part of the composition may be checked.

**5.4.4.3** When confirming the Type Approval Certificate it is allowed to limit the scope of manufacturer verification by reviewing the documents on product quality verification, which is carried out within the framework of the quality system in use. In case of systematic product quality non-conformities, changes in the suppliers' circle and in other justified cases, the Register may demand to extend the scope of verification up to the level of the initial approval.

**5.4.5 Evaluation of a possibility of welding in various positions at approval of coated welding electrodes and flux-cored wire.**

**5.4.5.1** The requirements of this Chapter apply to the performance of tests aimed at the determination of a possibility of welding in various positions at the Register initial approval of coated welding electrodes and flux-cored wire for welding with or without additional gas shield. The requirements below are harmonized with ISO 15792-3 and may be used both at the approval of welding consumables for the compliance with the RS rules and with the aim to classify them in compliance with the appropriate international standards.

**5.4.5.2** The T-joint test pieces corresponding to the recommendations of [Fig. 5.4.5.2-1](#) shall be used in tests for determining a possibility of welding in various positions. As a minimum, both ends of the welded on plate shall be tack-welded. The length of the test piece shall comply with the recommendations of [Fig. 5.4.5.2-2](#) and be sufficient to allow at least the deposition of the entire length of one coated electrode. The welding shall be carried out with a single-run fillet weld without edge preparation using the electrode/flux-cored wire diameter and in welding positions according to the recommendations of [Table 5.4.5.2](#).

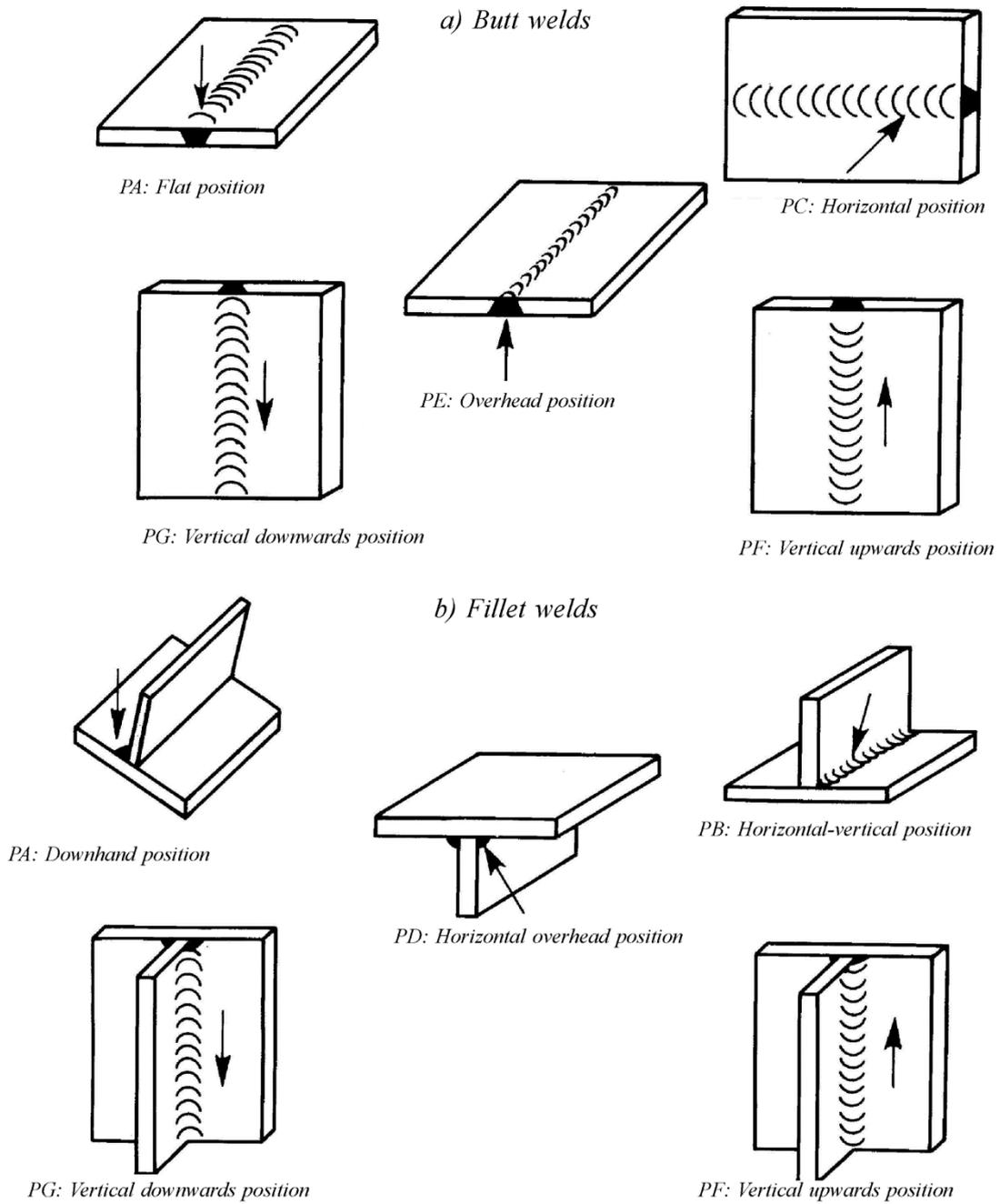


Fig. 5.4.5.2-1  
Welding positions specified for T-joint test piece welding (ISO 6947)

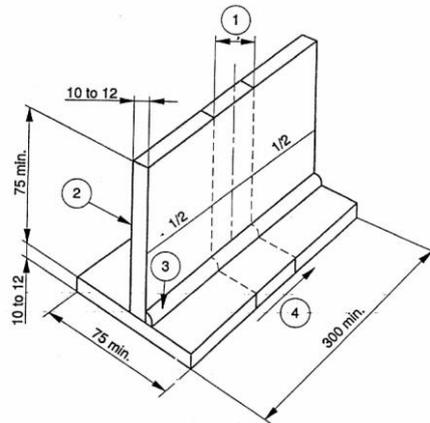


Fig. 5.4.5.2-2

T-joint test piece for tests of welding in various welding positions:  
 1 — location for removal of a macrosection of approximately 25 mm wide;  
 2 — loading applied in a fracture test; 3 — start of welding; 4 — direction of welding

Table 5.4.5.2

Symbols of positions for welding consumables classification <sup>1</sup>	Type of electrode covering pursuant to ISO 2560	Welding positions <sup>2</sup> for test pieces	Electrode diameter <sup>3</sup> , in mm	Fillet size <sup>4</sup> , in mm	Leg length difference, in mm	Convexity, in mm
1, 2	C	PB	6,0	4,5 min	1,5 max	2,5 max
	RX <sup>5</sup>		6,0	5,0 min	2,0 max	3,0 max
	B		6,0	5,0 min	2,0 max	3,0 max
3	For all T <sup>6</sup>	PB	2,4	5,5 min	2,0 max	3,0 max
	A		6,0	5,0 min	2,0 max	3,0 max
	RR		6,0	5,0 min	2,0 max	3,0 max
5	For all T <sup>6</sup>	PB	2,4	5,5 min	2,0 max	3,0 max
	R		6,0	4,5 min	1,5 max	2,5 max
	B		5,0	4,5 min	1,5 max	2,5 max
1, 2	For all T <sup>6</sup>	PF	2,4 <sup>7</sup>	5,5 min	2,0 max	3,0 max
	C		4,0	4,5 max	—	2,0 max
	RX <sup>5</sup>		4,0	4,5 max	—	2,0 max
	B		4,0	5,5 max	—	2,0 max
1, 2, 5	For all T <sup>6</sup>	PD	8	7,0 max	—	2,0 max
	C		4,0	4,5 max	1,5 max	2,5 max
	RX <sup>5</sup>		4,0	4,5 max	1,5 max	2,5 max
	B		4,0	5,5 max	2,0 max	3,0 max
5	For all T <sup>6</sup>	PG	1,2 <sup>9</sup>	4,5 max	1,5 max	2,5 max
	B		5,0	5,0 min	—	1,5 max <sup>10</sup>
	For all T <sup>6</sup>		1,2 <sup>9</sup>	4,5 min	—	1,5 max <sup>10</sup>

<sup>1</sup> Indices of materials classification are in compliance with ISO 2560:

1 — all welding positions;

2 — all welding positions, but vertical downwards;

3 — flat position for butt and fillet welds, as well as the PB position for fillet welds;

4 — flat position only;

5 — vertical downwards position, as well as the welding position according to index 3.

<sup>2</sup> Test piece welding positions are in compliance with the designations of Standard ISO 6947 and shown in Fig. 5.4.5.2-1.

<sup>3</sup> Where the largest diameter specified by the manufacturer for a welding position is smaller than that given in this Table, this largest standard size and recalculated assessment criteria shall be used.

<sup>4</sup> Fillet size is design throat thickness.

Symbols of positions for welding consumables classification <sup>1</sup>	Type of electrode covering pursuant to ISO 2560	Welding positions <sup>2</sup> for test pieces	Electrode diameter <sup>3</sup> , in mm	Fillet size <sup>4</sup> , in mm	Leg length difference, in mm	Convexity, in mm
<sup>5</sup>	RX includes types R, RC, RA and RB.					
<sup>6</sup>	T means tubular cored wire.					
<sup>7</sup>	Or largest diameter made up to 2,4 mm.					
<sup>8</sup>	Maximum diameter, for which positional classification is given by the manufacturer.					
<sup>9</sup>	Or as recommended by the manufacturer.					
<sup>10</sup>	Maximum concavity (fillet weld concavity).					

The steel plate of the grade (brand), for which welding the welding consumables are approved, shall be used as the material for the test piece preparation.

**5.4.5.3** Following welding performance each test piece shall be visually tested and measured to detect unacceptable defects and to gauge weld sizes for determining their compliance with the requirements of [Table 5.4.5.2](#). The weld shall be free of the unacceptable defects specified in Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

The throat thickness and leg length of a fillet weld shall meet the requirements of [Table 5.4.5.2](#) with the measurements to be made at three sections as a minimum.

One macrosection, approximately 25 mm wide, shall be removed from a point in the centre of the weld. One surface of the macrosection shall be polished and etched for detecting weld edges. The weld dimensions, including the actual throat thickness, convexity or concavity, the design throat thickness, shall meet the requirements of [Table 5.4.5.2](#) with the measurements to be made with an accuracy of up to 0,5 mm.

Dimensions of fillet welds are shown in [Fig. 5.4.5.3-1](#).

To assess internal imperfections the remaining two joint sections shall be subjected to testing for fillet weld section fracture. The failure plane shall be about the fillet weld centre.

To localize the failure plane at the given weld section, the following measures may be taken: building-up of additional reinforcing welds, as shown in [Fig. 5.4.5.3-2](#), along each leg of the weld;

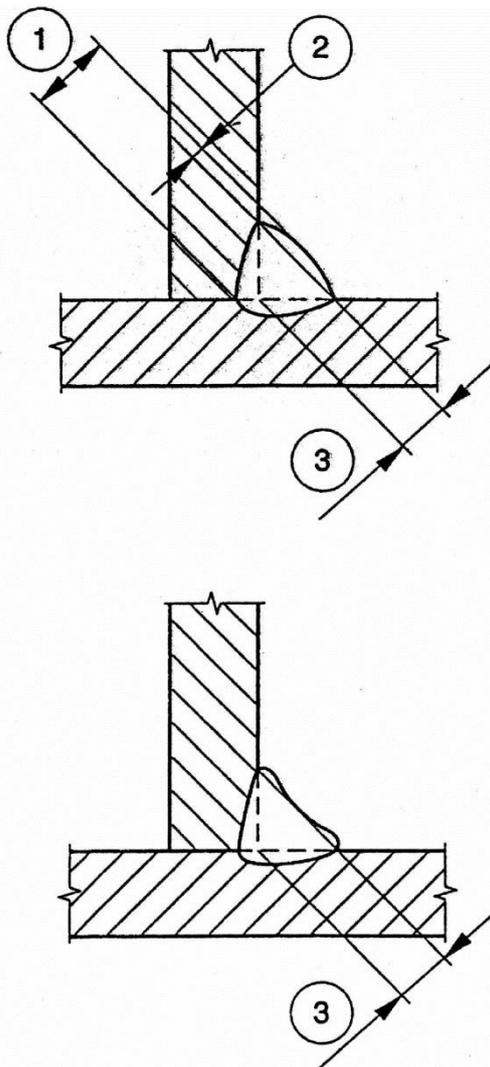


Fig. 5.4.5.3-1

Dimensions of fillet welds:

- 1 — total throat thickness; 2 — convexity;
- 3 — design throat thickness

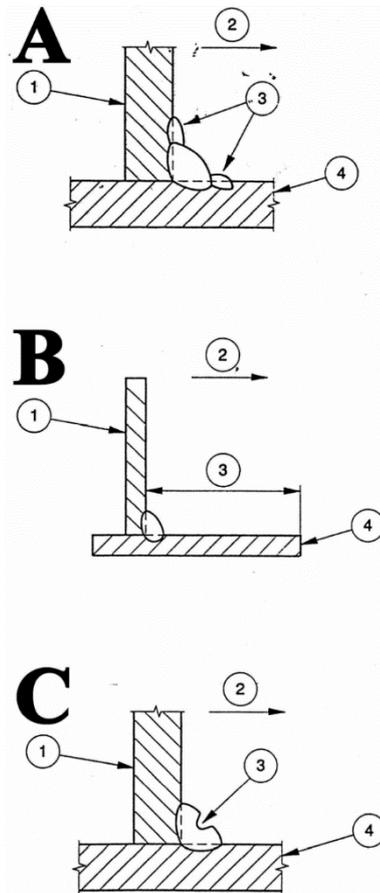


Fig. 5.4.5.3-2

Alternative methods for facilitating fillet weld fracture.

A. Building-up of additional reinforcing welds:

1 — web; 2 — fracturing force;

3 — reinforcing weld; 4 — flange.

B. Asymmetric position of the web on the flange:

1 — web; 2 — fracturing force;

3 — 3/4 width of flange; 4 — flange.

C. Longitudinal notch:

1 — web; 2 — fracturing force;

3 — maximum depth of notch = 1/2 actual throat;

4 — flange

the position of the web may be moved from the centre to the edge ([refer to Fig. 5.4.5.3-2](#));  
 the weld face may be notched;  
 the weld metal may be deliberately changed to a brittle state by cooling down the test piece below 0 °C.

After the fracture the weld face shall be visually tested and measured to detect unacceptable internal defects. Minor defects like small pores and slags may be accepted,

provided their relative area does not exceed 1 % of controlled theoretical section of the fracture. In this case the pores and slags are considered as minor if their linear size in the failure plane does not exceed 0,2Z, but not more than 20 mm (Z — fillet leg).

**5.4.6 Determination of diffusible hydrogen content during approval of welding consumables.**

**5.4.6.1 General.**

**5.4.6.1.1** The content of diffusible hydrogen shall be determined during initial tests of welding consumables for the purpose of obtaining the RS approval on their use for:

welding of higher strength steels as applied to electrodes having covering and to flux-cored wire (for other types of welding consumables — by the manufacturer request);

welding of high strength steels as applied to all types of welding consumables (except for the combination "wire-gas" provided the coppered welding wire is used with the wire surface free from technological wire-drawing grease).

**5.4.6.1.2** The content of diffusible hydrogen in annual tests of welding consumables for confirmation of the Certificate of Approval for Welding Consumables may be determined:

on the Register demand after an expiry date of validity of the Certificate of Approval for Welding Consumables, i.e. once every 5 years;

on the Register demand with the changes made by the manufacturer in the procedure, formula, specifications for raw materials delivery, etc. which can affect the classification of welding consumables by diffusible hydrogen content;

upon request of the welding consumables manufacturer for the purpose of changing the previously RS-assigned classification of welding consumables by diffusible hydrogen.

**5.4.6.1.3** Methods for determination of the diffusible hydrogen content in weld metal shall be classified according to the following criteria:

medium for hydrogen extraction and collection (vacuum, inert gas, liquid);

temperature for degassing of test pieces (room temperature, temperature increased from 45 °C to 150 °C and high temperature — from 180 °C to 400 °C);

apparatus for measuring the amount of hydrogen released (liquid pressure gauges, membrane type pressure gauges and other types of gauges for vacuum methods, gas thermal conductivity detector (TCD)).

The following methods for determination of the diffusible hydrogen content may be used, provided the requirements of this Chapter are met:

**.1** mercury method standardized by ISO 3690:2018 and considered as a reference method, which provides degassing of the test pieces in mercury at atmospheric pressure and room temperature. The word "mercury" is associated with the kind of a locking and manometric liquid. Vacuum system is used in mercury method for preparation of the facility for measuring as well as for pre-drying (degassing) the test piece surface;

**.2** methods standardized by ISO 3690:2018 and based on the test specimens degassing in inert gas using TCD as measuring apparatus. These methods by the name of the apparatus used to measure the amount of hydrogen released are also commonly called as gas chromatographic ones;

**.3** vacuum method based on degassing of the test pieces in a vacuum at a room temperature and producing the results comparable with the method per ISO 3690:2018. The amount of gas released may be determined by the liquid pressure gauges and by other types pressure gauges that provide acceptable accuracy within the working measuring range;

**.4** methods based on degassing of test pieces and collecting of hydrogen released in glycerin at a normal pressure and temperature of 45 °C. Test temperature has been chosen due to temperature and viscosity properties of glycerin, since temperature of 45 °C corresponds to the minimal one, at which gas bubbles can freely emerge and form the meniscus of a correct shape in the pressure tube used for measuring the gas volume.

**5.4.6.1.4** For determination of the diffusible hydrogen content, the requirements given below for apparatus, preparations for testing, test performance and analysis of test results shall be met. Any potential deviations shall be agreed with the Register.

**5.4.6.2** Test piece assemblies.

**5.4.6.2.1** Base metal.

Normal strength hull structural steel of any grade, which chemical composition and the condition of supply meet the requirements below, shall be used as a base metal for manufacture of blanks for test specimens:

C ≤ 0,18 %;

Si ≤ 0,35 %;

Mn ≤ 0,80 %;

S ≤ 0,020 %;

P ≤ 0,035 %;

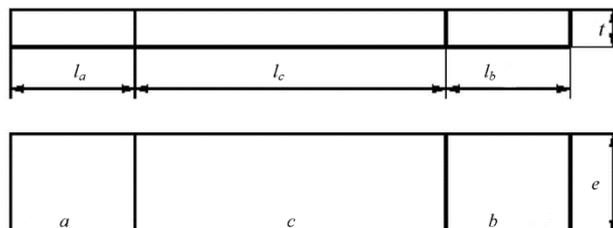
condition of supply — normalized (N).

*Note.* Rolled plates, which are supplied according to the national standards and meet the above requirements, may be used as an alternative.

**5.4.6.2.2** Requirements for preparation and dimensions.

Plate test specimens shall conform to the dimensions shown in [Fig. 5.4.6.2.2](#), with a tolerance of ±0,25 mm on all dimensions except the length. Their total length and embodiment depend on the method of determining the diffusible hydrogen content, welding process and shall comply with the recommendations of [Fig. 5.4.6.2.2](#) where the lengths represent minimum values.

The test piece assemblies shall be polished on all sides along with run-on and run-off pieces (if applied). Sharp edges and corners of the test piece assemblies shall be rounded off with a radius of approximately 1 mm.



Test assembly	$l_a$ and $l_b$ , in mm	$l_c$ , in mm	$e$ , in mm	$t$ , in mm
A <sup>1</sup>	≥ 25 (50) <sup>2</sup>	80 (100) <sup>3</sup>	25	12
B	≥ 25 (50) <sup>2</sup>	30	15	10
C	≥ 50	15	30	10

<sup>1</sup> Comparable to the specimen geometry according to AWS A4.3-93.

<sup>2</sup>  $l_a \geq 25$  mm and  $l_b \geq 25$  mm: manual and partly mechanized (semiautomatic) welding;  $l_a \geq 50$  mm and  $l_b \geq 50$  mm: fully mechanized (automatic) welding.

<sup>3</sup> 100 mm according to GOST 23338, method 2 (vacuum method).

Fig. 5.4.6.2.2

Dimensions of the weld test assembly:

$a$  — run-on piece of length  $l_a$ ;  $b$  — run-off piece of length  $l_b$ ;  $c$  — centre test piece of length  $l_c$ ;  
 $e$  — test piece width;  $t$  — test piece thickness

**5.4.6.2.3** Requirements for preparation of test piece assemblies.

The centre test piece shall be numbered by engraving or stamping on the opposite side of that used for welding. When methods involving the test piece assemblies heating

from 180 °C to 400 °C are used for determination of the diffusible hydrogen content, then prior to testing the entire test piece assembly shall be degassed at  $650 \pm 10$  °C for 1 h and cooled in either a dry inert gas atmosphere or a vacuum. Alternatively, the test piece assembly may be degassed and cooled in air if the surface oxide layer is removed prior to testing. Degassed test piece assemblies shall be stored in a desiccator or under other suitable conditions to prevent oxidation of the test pieces. After numbering and removal of oxide, the mass,  $m_1$ , of each centre test piece shall be determined to the nearest 0,1 g for assembly A or to the nearest 0,01 g for assembly B or assembly C.

In other cases after the test piece assembly numbering those that have not been degassed shall be washed in solvents. Washing shall be carried out as follows:

in chemically pure toluene with the following wiping with filter paper;

in chemically pure acetone;

in ethyl hydroxide (a grade as for medical purposes) with subsequent drying in a hot air flow.

Degassed test piece assemblies prepared as specified above shall be stored in a desiccator in the presence of desiccant (silica gel).

**5.4.6.3** General requirements for welding of test piece assemblies.

**5.4.6.3.1** Welding consumables (including covered electrodes, combinations "wire-flux" and flux-cored wire) used for tests shall be calcinated in compliance with the manufacturer's recommendations or other normative documents, which regulate this operation.

Welding consumables delivered tightly packaged (vacuum package or metal containers) are considered suitable for use and shall be tested within the time period of 4 h after package opening.

Shielding gases used for welding shall be controlled with regard to dew point or moisture content to verify that these parameters comply with the requirements of relevant standards (e.g. ISO 14175).

**5.4.6.3.2** A single weld bead shall be made on the test piece assembly side of e width (refer to [Fig. 5.4.6.2.2](#)) along its axis. In welding the test piece assembly shall be clamped in a copper water-cooled welding fixture such as that shown in [Fig. 5.4.6.3.2](#).

Four parallel experiments shall be performed for testing each brand of the welding consumable. All four test piece assemblies shall be welded in series within the total time not exceeding 30 min, so as to extremely reduce the environment impact on the result obtained.

The weld shall start and end within approximately 5 mm from the test piece assembly ends or run-on and run-off pieces in case of manual and partly mechanized welding or within approximately 15 mm in case of fully mechanized submerged arc welding.

**Note.** To form a proper weld in case of fully mechanized submerged arc welding, it is allowed to start and complete welding on additional attached plates placed clear of the copper water-cooled welding fixture.

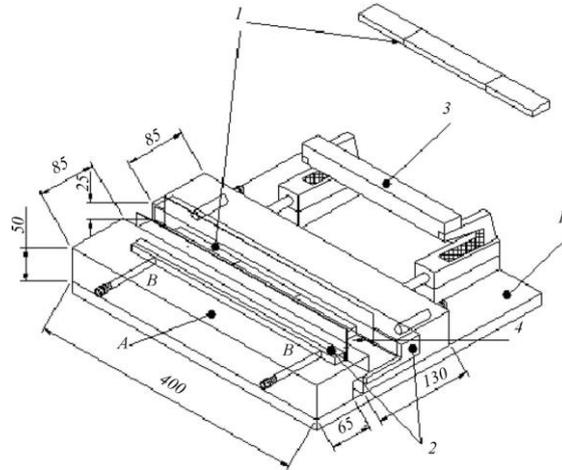


Fig. 5.4.6.3.2

Example of a suitable welding fixture and test piece assembly for weld deposits (ISO 3690:2018): 1 — test piece assembly (refer to Fig. 5.4.6.2.2); 2 — water cooling jacket; 3 — lever clamp; 4 — copper foil inserts (1 mm × 15 mm min. × 300 mm); A — copper; B — carbon steel

During welding of the test piece assemblies the following requirements shall be met:

the temperature of the copper water-cooled welding fixture before each weld is made shall be controlled to prevent condensation of water on the test piece assembly or copper water-cooled fixture (be controlled to ambient temperature or as much as 25 °C higher);

the ambient absolute humidity during welding of the test piece assembly shall be at least 3 g of water vapour per 1000 g of dry air, this corresponds to 20 °C and 20 % relative humidity. The actual data on relative humidity and temperature shall be included in the test report.

Special requirements for welding procedures for the production of weld specimens using different welding processes are given in 5.4.6.4.

#### 5.4.6.4 Special requirements for welding procedures.

##### 5.4.6.4.1 Manual metal arc welding (metal arc welding with covered electrode).

5.4.6.4.1.1 For testing the covered electrodes, the test piece assemblies may be used having dimensions corresponding to those shown in Fig. 5.4.6.2.2 for assembly A or assembly B.

After calcination, the test electrodes storage time prior to test specimen welding shall not generally exceed 4 h. All electrodes not used within specified period of time shall be re-calcinated and subsequently used for the test.

5.4.6.4.1.2 The testing of covered electrodes, unless otherwise agreed with the Register, is carried out using 4,0 mm diameter electrodes. In this case, the welding current shall be 15 A less than the maximum or 90 % of the maximum stated by the manufacturer, being maintained within a tolerance of ±10 A.

5.4.6.4.1.3 For an electrode with a diameter of 4,0 mm, the speed of welding shall be adjusted to produce an 8 g minimum weld deposit on the centre test piece assembly A or a 3 g minimum weld deposit on the centre test piece assembly B, which is usually accomplished with an electrode consumption of between 120 and 130 mm per 100 mm of weld. The deposit shall be made without weaving along the centre line of the test piece assembly using a new electrode for each weld. The lengths of the run-on and of the run-off pieces shall be 25 mm minimum.

**5.4.6.4.2** Submerged arc welding (combination "wire-flux").

**5.4.6.4.2.1** For testing the "wire-flux" combination, the test piece assemblies may be used having dimensions corresponding to those shown in [Fig. 5.4.6.2.2](#) for assembly A or assembly C. The lengths of the run-on and of the run-off pieces shall be 50 mm minimum.

Unless otherwise agreed with the Register, for determination of the diffusible hydrogen content as applied to submerged arc welding (combination "wire-flux") a welding wire of 4,0 mm in diameter shall be used. The bead shall be built up on the plate with due regard to the following requirements for welding conditions:

Table 5.4.6.4.2.1

Welding conditions	Electrode diameter, in mm	
	3,0 and 3,2	4,0
Welding current, in A	440 ± 20	580 ± 20
Welding voltage, in V	27 ± 1	29 ± 1
Welding/travel speed, in mm/min	400 ± 50	550 ± 50
Electrode extension, in mm	30 ± 5	30 ± 5

**5.4.6.4.2.2** Flux calcinated in compliance with the manufacturer's recommendations shall be used within 4 h. Alternatively, the flux shall be cooled and placed in a sealed container and stored until required for use. Used flux shall not be recycled.

The flux depth, unless otherwise is recommended by the manufacturer, shall be about 25 mm. For controlling flux depth, the levelling off along the top of the copper foil inserts as shown in [Fig. 5.4.6.4.2](#) is recommended.

**5.4.6.4.3** Flux-cored arc welding.

**5.4.6.4.3.1** For testing the flux-cored wire, the test piece assemblies may be used having dimensions corresponding to those shown in [Fig. 5.4.6.2.2](#) for assembly A or assembly B. The lengths of the run-on and of the run-off pieces shall be 25 mm minimum.

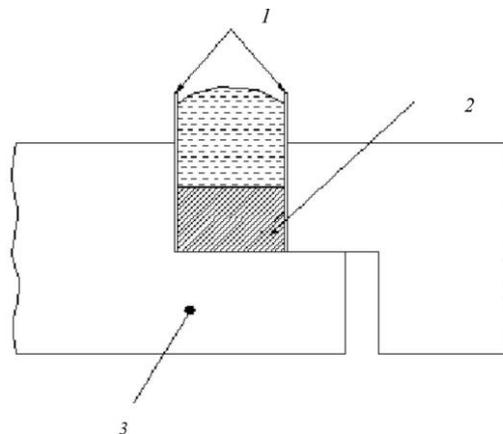


Fig. 5.4.6.4.2

Example of the use of copper foil to maintain constant flux depth:  
 1 — 1 mm copper foil, of dimensions 35 × 300 mm or 37 × 300 mm  
 (for flux depth of 25 mm);  
 2 — test piece assembly; 3 — welding fixture

**5.4.6.4.3.2** The testing of flux-cored wire, unless otherwise agreed with the Register, is carried out using the following wire diameters:

for gas-shielded arc welding, the wire of 1,2 mm in diameter or of the next larger diameter shall be used if 1,2 mm diameter wire is not manufactured;

for self-shielded tubular-cored arc welding, the wire of 2,4 mm in diameter or of the maximum manufactured diameter if it is less than 2,4 mm shall be used.

**5.4.6.4.3.3** The welding conditions and shielding gas flow shall be in accordance with the appropriate recommendations of the flux-cored wire manufacturer and shall be sufficient to obtain a weld deposit mass on the centre test piece of 8 g minimum (assembly A) or 3 g minimum the centre test piece (assembly B). The welding shall be made without transverse weaving of electrode. Details of the shielding gas composition and flow shall be recorded on the test.

**5.4.6.5** Treatment of test assemblies after welding.

**5.4.6.5.1** Mercury and TCD methods (ISO 3690:2018).

Sequence of operations performance and the time needed for this during test assembly treatment shall comply with the following requirements:

Table 5.4.6.5.1

Nos.	Operation	Time	Working media, temperature
1	Test assembly removal from the welding fixture	4 s ± 1 s	Atmosphere, room temperature
2	Colling in ice-cold water	20 s ± 2 s	Water, about 0 °C
3	Low-temperature bath	min 2 min	Methanol and solid carbon dioxide – 78 °C
4	Breaking off of the run-on and run-off pieces from the centre test piece and test assembly cleaning <sup>1</sup>	max 2 min	Atmosphere, room temperature
5	Centre test pieces storage before analysis	max 72 h	Methanol and solid carbon dioxide, – 78 °C
		max 21 days	Liquid nitrogen, 196 °C

<sup>1</sup> If this entire operation is not completed within 60 s, the centre test piece shall be returned to the low temperature bath for a minimum of 2 min before completing these steps.

**5.4.6.5.2** Vacuum method (GOST 23338, method 2).

Sequence of operations performance and the time needed for this during test assembly treatment shall comply with the following requirements:

Table 5.4.6.5.2

Nos.	Operation	Time	Working media, temperature
1	Test assembly removal from the welding fixture	max 10 s	Atmosphere, room temperature
2	Colling in ice-cold water	max 10 s	Water, about 0 °C
3	Breaking off of the run-on and run-off pieces from the centre test piece and test assembly cleaning <sup>1</sup>	max 60 s	Atmosphere, room temperature
4	Test piece washing	max 30 s	Sequentially washed during 10 s in each bath: ethyl hydroxide, acetone, ethylic ether; room temperature
5	Test piece drying <sup>1</sup>	30 s ± 5 s	Atmosphere
6	Centre test pieces storage before analysis	–	Operation is not required
7	Total time for test piece preparation	max 2 min 15 s	–

<sup>1</sup> Drying in a hot air flow: weld fractures shall be dried up on each test piece side during 10 s each while the weld faces and the back side of the test piece, 5 s each.

**5.4.6.5.3** Glycerine method.

Sequence of operations performance and the time needed for this during test assembly treatment shall comply with the following requirements:

**5.4.6.6** Requirements for use of mercury method for determination of the diffusible hydrogen content according to ISO 3690:2018.

Table 5.4.6.5.3

Nos.	Operation	Time	Working media, temperature
1	Test assembly removal from the welding fixture	4 s ± 1 s	Atmosphere, room temperature
2	Colling in ice-cold water and removal of slag and deposited metal spatter <sup>1</sup>	max 30 s	Water, about 0 °C
3	Breaking off of the run-on and run-off pieces from the centre test piece (if any) <sup>1</sup>	max 10 s	Atmosphere, room temperature
4	Low-temperature bath <sup>2</sup>	max 15 min	Methanol and solid carbon dioxide – 78 °C
5	Drying up with filter paper	max 10 s	Atmosphere, room temperature
6	Test piece washing in ethyl hydroxide	max 10 s	–
7	Drying up with filter paper	max 10 s	Atmosphere, room temperature
8	Total time for test piece preparation <sup>3</sup>	max 60(70) s	–

<sup>1</sup> Glycerine method permits the use of test piece assemblies without run-on and run-off pieces with the length of a centre test piece equal to 125 mm as applied to the manual and partly mechanized welding.

<sup>2</sup> Low-temperature bath is used if the location of test piece welding is noticeably remote from the diffusible hydrogen collecting apparatus. The test piece shall be carried at this temperature, provided the time for its storage does not exceed 15 min.

<sup>3</sup> Total time of operations for the test piece carriage from a cooling jig (with consideration of footnote 2) till the commencement of measurements shall not exceed 70 s for a test assembly with run-on and run-off pieces.

**5.4.6.6.1** Determination of the diffusible hydrogen content by mercury method may be carried out in compliance with the requirements of ISO 3690:2018. The basic requirements for its use in accordance with the latest (third) edition are given below.

For determination of the diffusible hydrogen content by mercury method, the gas collection apparatus illustrated in [Fig. 5.4.6.6.1](#), known as a Y-tube, and mercury shall be used as the collecting fluid. Other designs of collecting may be used, provided the same principles as for the Y-tube are used. The gas collection apparatus specified is for use with test centre piece assembly B or assembly C ([refer to Fig. 5.4.6.2.2](#)). The preparation of test piece assemblies shall comply with the requirements of [5.4.6.2](#) and the process of bead welding the shall meet the requirements of [5.4.6.3](#).

**5.4.6.6.2** Preparation of gas burette.

The volume of mercury required to fill the size of a gas burette illustrated in [Fig. 5.4.6.6.1](#) is about 110 ml. The mercury shall be free of contaminants. The mercury shall be poured into the wide limb of the gas burette (bent arm 3 in [Fig. 5.4.6.6.1](#), c). After connecting cone 2 of Y-tube to the socket 1 of two-way glass vacuum stopcock, the vacuum stopcock shall be fitted and vacuum applied. Air shall be removed by laying the gas burette on a flat surface so as to allow an unrestricted application of the vacuum to the top of the capillary tube 5. After degassing, the gas burette shall be slowly raised to the vertical position and air admitted to the wide limb by rotating the stopcock ([refer to Fig. 5.4.6.6.1](#), c — left part). It is important that there is no air bubble at the top of the capillary tube. If air is present, then all above operations (the evacuation process) shall be repeated until a final check confirms the absence of air. The vacuum stopcock shall be removed from the wide limb of the gas burette.

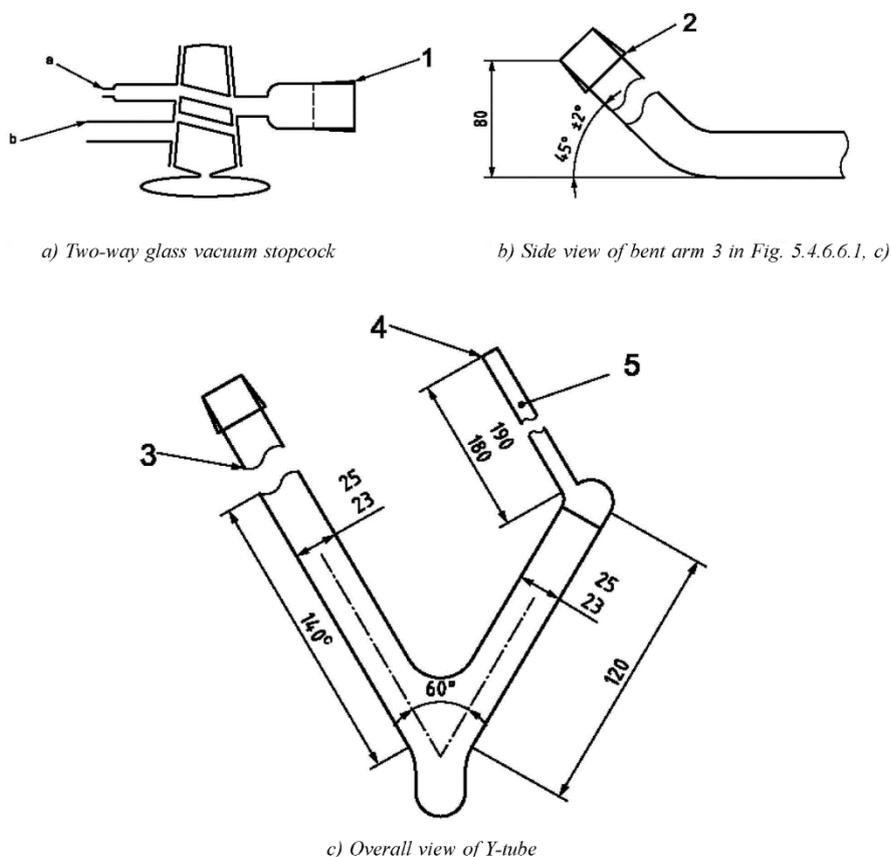


Fig. 5.4.6.6.1

Diffusible hydrogen collecting apparatus (Y tube) according to ISO 3690:

1 — 29/32 socket; 2 — 29/32 cone; 3 — arm bent up 45° (refer to Fig. 5.4.6.6.1, b); 4 — seal (flat inside) of precision bore tube 5; 5 — precision bore tube; a — to air; b — to vacuum; c — straight portion before bend.

### 5.4.6.6.3 Test piece loading.

The test piece loading shall be carried out as quickly as possible, taking not more than approximately 2 min.

The test piece shall be removed from the storage coolant and raised to slightly above 0 °C. This can be conveniently achieved by immersing the test piece in water until the ice which forms initially has detached or melted.

Following a rinse with acetone and drying in a jet of air, the test piece shall be transferred to the wide limb of the burette through bent arm 3 (refer to Fig. 5.4.6.6.1, c). The Y-tube with the test piece loaded shall be connected to the socket of the two-way vacuum stopcock and vacuum applied. Acetone and traces of condensed water evaporate from the surface of the test piece and are removed with the evacuated air. Using a magnet, the test piece shall be manoeuvred into position under the capillary tube by carefully lowering the burette towards the horizontal position until it just floats along the mercury surface. It is essential that care be taken to prevent air from entering the capillary tube when the burette is raised to the vertical position and air is admitted to the wide limb. The two-way stopcock shall be removed and the wide limb closed by means of a stopper or a glass cap, for example, to prevent the release of traces of mercury vapour.

Diffusible hydrogen is evolved from the test piece and collects in the capillary tube.

**5.4.6.6.4** Analytical procedure (measurements and calculations).

The test piece shall be maintained at  $25 \pm 5$  °C, until there is no increase in calculated hydrogen volume, corrected to standard temperature and pressure (STP), i.e. 0 °C and 760 mm Hg, on successive days. "No increase" can be understood as allowing for a change, over 24 h, of no more than 1 % of the total volume collected. Room temperature and atmospheric pressure shall be measured and recorded. The volume of hydrogen collected, corrected to STP,  $V$ , in ml, is given by the following formula:

$$V = \frac{273 \times (p-h) \pi r^2 C}{760 \times (273+T) \times 1000} \quad (5.4.6.6.4-1)$$

where  $p$  = the atmospheric pressure, in mm of mercury;  
 $h$  = the differential head, in mm, of mercury between the two limbs of the Y-tube;  
 $r$  = the inside radius, in mm, of the capillary tube;  
 $C$  = the length, in mm, of the gas column above the mercury in mm;  
 $T$  = the room temperature, in °C, at the time of hydrogen measurement.

When evolution has ceased, the test piece shall be removed from the apparatus and its final mass  $m_2$ , in g, shall be determined, to the nearest 0,01 g. All the relevant data shall be recorded.

The volume at STP of diffusible hydrogen in deposited metal,  $H_D$ , in ml per 100 g, shall be calculated from the following formula:

$$H_D = V_{STP} \times 100 / (m_2 - m_1), \quad (5.4.6.6.4-2)$$

where  $V_{STP}$  = the volume  $V$ , in ml, of hydrogen gas at STP;  
 $m_2$  = the final mass, in g, of the test piece with deposited metal;  
 $m_1$  = the initial mass, in g, of the test piece ([refer to 5.4.6.3.2](#)).

**5.4.6.7** Requirements for use of TCD method for determination of the diffusible hydrogen content according to ISO 3690.

**5.4.6.7.1** In general, systems utilizing a thermal conductivity detector fall into one of two types:

the first is hot carrier gas extraction where the specimen is heated at a relatively high temperature (up to 400 °C) and the diffusible hydrogen is evolved from the specimen and measured continuously;

the second type is where the specimen is loaded into a suitable collection chamber that is heated at a relatively lower temperature (typically between 45 °C and 150 °C). Quantification of the hydrogen collected is performed as a separate step, typically utilizing a gas chromatography device.

As it is not the objective of ISO 3690 to specify parameters of any system incorporating the facility for measuring the diffusible hydrogen in weld metal, the calibration procedures and gas extraction and thermal conductivity detection equipment typically utilizing gas chromatography and a TCD have to provide a proper correlation, in terms of accuracy and reproducibility with regard to mercury method. This method is valid for the centre test piece assembly A, B or C ([refer to Fig. 5.4.6.2.2](#)).

**5.4.6.7.2** Test piece loading.

The test piece loading shall be carried out as quickly as possible, taking not more than approximately 2 min.

The centre test piece shall be removed from the methanol and solid carbon dioxide bath, denatured alcohol and solid carbon dioxide bath or liquid nitrogen bath and raised to slightly

above 0 °C. This can be conveniently achieved by immersing the test piece in water until the ice which forms initially has detached or melted. The test piece shall be rinsed in acetone, dried in an air jet, and loaded into a suitable container for collection of hydrogen. The container shall be purged and filled with an inert gas such as argon and isolated from the atmosphere.

**5.4.6.7.3 Measurement method by hot carrier gas extraction.**

Hydrogen extraction is accomplished in this procedure within a short period of time (rapid method). The manufacturer's instructions shall be followed to operate the equipment. After warming the specimen in accordance with [5.4.6.7.2](#), it shall be loaded into a suitable container for the collection of hydrogen. The test piece and container may be heated up to a maximum of 400 °C for measurement of the diffusible hydrogen content. Collection and measurement of the hydrogen occurs continuously until all of the diffusible hydrogen is quantified. Exceeding the degassing temperature of 400 °C can lead to an activation of further release of so-called residual hydrogen associated with dislocations and typically measured as a fraction.

*Note.* Residual or fixed hydrogen as opposed to the diffusible one, is a fraction of hydrogen which can not freely diffuse into the metal and be extracted at room temperature for any exposure time.

**5.4.6.7.4 Measurement method for collection and subsequent measurement of hydrogen.**

After warming the specimen in accordance with [5.4.6.7.2](#), it shall be loaded into a suitable container for the collection of hydrogen. The container shall be purged (typically by pre-evacuation) and filled with an inert gas such as argon and sealed to the atmosphere. The container shall be transferred to an oven or other suitable heating device for collection of hydrogen per the operating conditions specified in [Table 5.4.6.7.4](#).

Table 5.4.6.7.4

**Minimum holding time at a given temperature for complete hydrogen evolution**

Minimum extraction time, in h	Temperature, in °C
0,35	400±3
0,4	390±3
0,5	360±3
1	285±3
2	225±3
3	195±3
4	175±3
5	160±3
6	150±3
8	140±3
10	125±3
12	120±3
14	115±3
15	110±3
18	100±3
36	70±3
64	50±3
72	45±3

Upon completion of the heating and collection period, the container shall be cooled to room temperature and analyzed for hydrogen. This can be accomplished by analyzing either the entire quantity of hydrogen evolved from the test piece or an aliquot that can be apportioned to the entire quantity. A TCD shall be used to quantify the amount of hydrogen present in the outgas mixture.

Conversion of the measured value of hydrogen collected  $V$  to give the hydrogen volume at STP,  $V_H$ , in ml, shall be made as follows:

$$V_H = \frac{273}{273+T} \times \frac{pV}{760}, \quad (5.4.6.7.4-1)$$

where  $V_H$  = the volume of hydrogen collected  $V$  corrected to STP, in ml;  
 $p$  = the pressure of the measured hydrogen volume, in mm of mercury;  
 $V$  = the measured volume of hydrogen, in ml;  
 $T$  = the temperature at the time of hydrogen measurement, ° C.

The test piece shall be removed from the container, weighed, and the mass,  $m_2$ , recorded to the nearest 0,1 g for assembly A centre pieces or to the nearest 0,01 g for assembly B or C centre test pieces.

The volume at STP of diffusible hydrogen in deposited metal,  $H_D$ , in ml per 100 g, shall be calculated from the following formula:

$$H_D = V_H \times 100 / (m_2 - m_1), \quad (5.4.6.7.4-2)$$

where  $V_H$  = the volume of hydrogen collected  $V$  corrected to STP, in ml;  
 $m_2$  = the final mass, in g, of the test piece with deposited metal;  
 $m_1$  = the initial mass, in g, of the test piece (refer to 5.4.6.3.2).

#### 5.4.6.8 Requirements for use of vacuum method (GOST 23338-91, method 2).

5.4.6.8.1 For determination of the diffusible hydrogen content by vacuum method, the measuring device illustrated in Fig. 5.4.6.8.1 or other designs of measuring may be used, provided the same principles of operation and accuracy as for the device for determination of diffusible hydrogen content are used. The test piece assembly A is used for testing (refer to Fig. 5.4.6.2.2). The preparation of test piece assembly shall comply with the requirements of 5.4.6.2 and the process of bead welding the shall meet the requirements of 5.4.6.3.

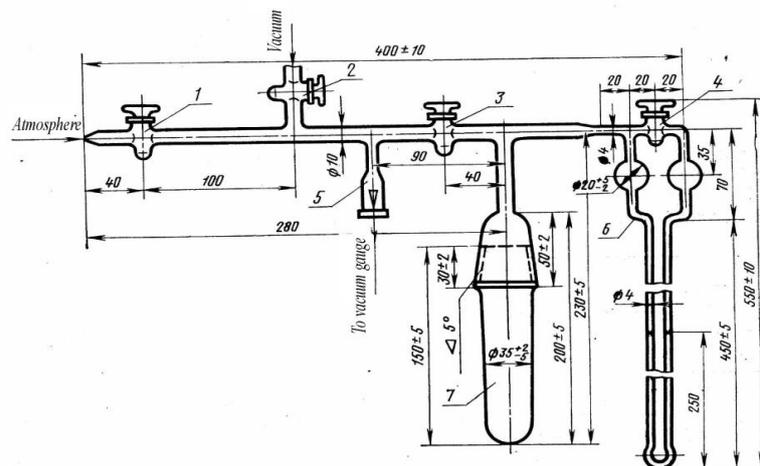


Fig. 5.4.6.8.1

Measuring device for determination of diffusible hydrogen content (GOST 23338-91, method 2):  
 1, 2, 3, 4 — vacuum cocks; 5 — vacuum-gauge lamp; 6 — oil pressure gauge; 7 — gas burette

5.4.6.8.2 Design of measuring device for determination of the diffusible hydrogen content.

**5.4.6.8.2.1** A measuring device shall be made of molybdenum glass (refer to Fig. 5.4.6.8.1). The thickness recommended for the device sides is approximately 2 mm.

**5.4.6.8.2.2** The volume of the volumetric flask  $V_f$ , in  $\text{cm}^3$ , and tubes from cock 2 (refer to Fig. 5.4.6.8.1) to the oil pressure gauge capillaries shall be calibrated with distilled water with an accuracy of up to  $0,10 \text{ cm}^3$  and shall be  $150 - 160 \text{ cm}^3$ .

**5.4.6.8.2.3** In the device only vacuum cocks may be used.

**5.4.6.8.2.4** Vacuum seals shall be effected using vacuum lubrication only. If necessary, lubrication shall be removed with benzol.

**5.4.6.8.2.5** The vacuum level shall be measured with the use of a vacuum-gauge thermocouple lamp on the device "Vacuum ionization thermocouple gauge".

**5.4.6.8.2.6** The device oil pressure gauge shall be filled with  $2 - 3 \text{ cm}^3$  of degasified dibutyl phthalate oil. The pressure gauge scale shall read 1 mm with its length of  $400 - 450 \text{ mm}$ .

**5.4.6.8.2.7** The vacuum in the device shall be effected with a roughing-down pump having a capacity of 50 l/min.

**5.4.6.8.3** The test piece loading and testing shall be carried out as follows:

.1 test piece with a deposited bead shall be placed for analysis in a separate device not later than in 5 s after drying;

.2 draw air into the device with cocks 1, 3 and 4 opened and cock 2 closed (refer to Fig. 5.4.6.8.1);

.3 detach the bottom part of the flask, incline it horizontally, insert the test piece into it and then return the former to its place with thorough reseating;

.4 evacuate the device with the test piece while cocks 2, 3 and 4 are opened and cock 1 (refer to Fig. 5.4.6.8.1) is closed. When the test piece is placed in the device, the evacuation shall be carried out at a pressure of  $2,7 \text{ Pa}$  ( $2 \times 10^{-2} \text{ mm Hg}$ ) and shall not exceed 60 s;

.5 when the vacuum is settled at a value of  $2,7 \text{ Pa}$  ( $2 \times 10^{-2} \text{ mmHg}$ ), the cocks 3 and 4 (refer to Fig. 5.4.6.8.1) shall be simultaneously closed, then cock 2 follows and the vacuum pump shall be switched off. The cock position shall be the same during the entire time of the test piece analysis;

.6 the test pieces shall be kept in the device at a room temperature during 5 days.

Alternatively, during thermostating of the device flasks with the test pieces in an oil thermostat with an oil temperature of  $45 \pm 2 \text{ }^\circ\text{C}$ , the exposure time may be reduced to 48 h;

.7 after the expiry of the test piece exposure time, specified in 5.4.6.8.3.6, in the device, the difference of pressure gauge liquid levels ( $\Delta h$ ) with an accuracy of 0,5 mm oil head shall be recorded;

.8 after determination of the difference of pressure gauge liquid levels ( $\Delta h$ ) (the test test piece shall be removed from the device in the following manner: open cock 4, thereafter cocks 3 and 1 (refer to Fig. 5.4.6.8.1) (cock 4 remains closed), detach the bottom part of the flask with the test piece, incline it horizontally and remove the test piece from the flask by slight rocking.

**5.4.6.8.4** Analytical procedure.

At the time of taking the pressure gauge readings, specified in 5.4.6.8.3.7, the air temperature in the space  $t$  while taking the pressure gauge readings shall be recorded. The temperature shall be measured using a thermometer with an accuracy of  $\pm 0,5 \text{ }^\circ\text{C}$ . The removed test piece shall be weighed and its mass  $m_2$ , in g, shall be determined, to the nearest 0,01 g. All the relevant data shall be recorded.

The test piece volume after welding  $V_{\text{test piece}}$ , in  $\text{cm}^3$ , shall be determined by the following formula:

$$V_{test\ piece} = m_2/7,85 \quad (5.4.6.8.4-1)$$

where  $m_2$  = final mass of the test piece with deposited metal, in g;  
7,85 = density of low-carbon steel, in g/cm<sup>3</sup>.

The total quantity of the hydrogen released  $V_H$ , in cm<sup>3</sup>, corrected to STP shall be determined by the following formula:

$$V_H = \frac{273 \times 10^{-3}}{273+t} (V_f - V_{test\ piece})(\Delta h + \Delta h_{cf}), \quad (5.4.6.8.4-2)$$

where  $t$  = air temperature in the space while taking the pressure gauge readings, in °C;  
 $V_f$  = volume of a flask, in cm<sup>3</sup>;  
 $V_{test\ piece}$  = volume of test piece after welding, in cm<sup>3</sup>;  
 $\Delta h$  = difference of pressure gauge liquid levels, in cm;  
 $\Delta h_{cf}$  = correcting factor of the device determined for each particular device and remained unchanged for all the determinations, in cm.

The volume at STP of diffusible hydrogen in deposited metal,  $H_D$ , in cm<sup>3</sup> per 100 g, shall be calculated from the following formula:

$$H_D = V_H \times 100 / (m_2 - m_1) \quad (5.4.6.8.4-3)$$

where  $V_H$  = the volume of hydrogen released corrected to STP, in cm<sup>3</sup>;  
 $m_2$  = the final mass, in g, of the test piece with deposited metal;  
 $m_1$  = the initial mass, in g, of the test piece ([refer to 5.4.6.3.2](#)).

#### 5.4.6.9 Requirements for use of glycerin method.

**5.4.6.9.1** For determination of the diffusible hydrogen content by glycerin method, the apparatus illustrated in Figs. [5.4.6.9.1-1](#), [5.4.6.9.1-2](#) or other designs of measuring may be used, provided the same principles of operation and accuracy as for the device for determination of diffusible hydrogen content are used. The test piece assembly A is used for testing ([refer to Fig. 5.4.6.2.2](#)). The test pieces without run-on and run-off pieces with the length of a centre test piece equal to 125 mm may be used for the manual and partly mechanized welding. The preparation of test piece assembly shall comply with the requirements of [5.4.6.2](#) and the process of bead welding shall meet the requirements of [5.4.6.3](#).

**5.4.6.9.2** Design of the device for determination of the diffusible hydrogen content using the glycerin method is shown in [Fig. 5.4.6.9.1-1](#) and the drawing of the main functional part of the device, i.e. the gas burette with a measuring capillary tube and a stopcock, is shown in [Fig. 5.4.6.9.1-2](#).

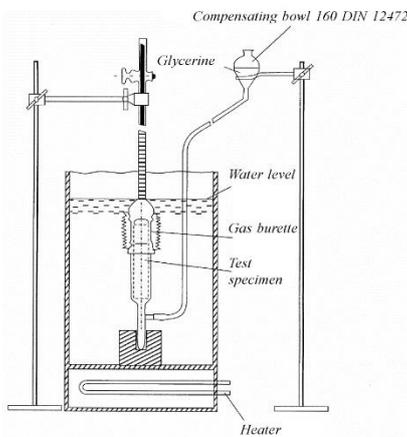


Fig. 5.4.6.9.1-1

Device for determination of the diffusible hydrogen content by glycerin method

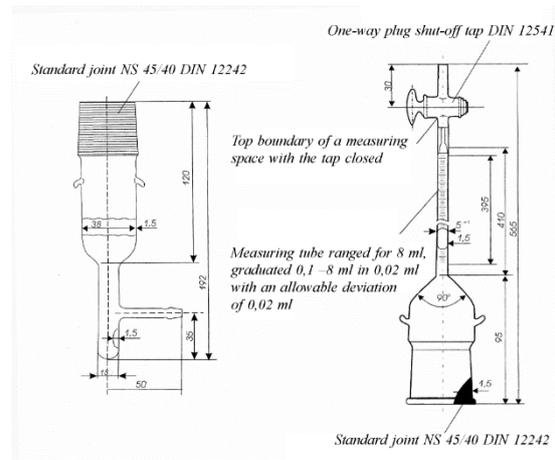


Fig. 5.4.6.9.1-2

Gas burette for determination of the diffusible hydrogen content

The chemically pure glycerin (wax oil) shall be used as a medium for collecting the diffusible hydrogen released.

**5.4.6.9.3** Upon completion of preparations according to [5.4.6.5.3](#) the test piece shall be loaded into the gas burette as shown in [Fig. 5.4.6.9.1-2](#). The latter is made serviceable by joining the top and bottom parts and then is filled with the glycerin from the compensating bowl to the zero scale mark of the measuring capillary tube.

After filling the burette with the glycerin the measuring capillary tube shall be isolated from the atmosphere by closing the stopcock and the very burette shall be placed in a water bath having a temperature of  $45 \pm 20$  °C. This temperature shall be kept constant within the above limits using a thermostat. The water level in the water bath shall be approximately at the level of the measuring capillary tube outlet.

**5.4.6.9.4** Four test pieces being welded and prepared according to [5.4.6.3](#), [5.4.6.4](#) and [5.4.6.5.3](#), shall be degassed simultaneously each in a separate measuring device. The degassing time for each test piece is 48 h.

**5.4.6.9.5** Upon completion of 48-hour degassing of each test piece, the diffused hydrogen volume  $V$ , in ml, shall be read from the measuring capillary (pressure gauge) of the gas burette. All readings shall be taken carefully to ensure that the level of liquid in the burette is the same as that in the compensating bowl. It is achieved by changing the height of the compensating bowl followed by its securing.

**5.4.6.9.6** At the time of taking the pressure gauge readings according to [5.4.6.9.5](#), the air temperature in the space  $t_c$  while taking the pressure gauge readings and atmospheric pressure  $p$ , in mm of mercury, shall be measured and recorded. The temperature shall be measured using a thermometer with an accuracy of  $\pm 0,5$  °C. The removed test piece shall be weighed and its mass  $m_2$ , in g, shall be determined, to the nearest 0,01 g.

**5.4.6.9.7** The readings of the diffused hydrogen volume  $V$ , in ml, obtained according to [5.4.6.9.5](#) shall be corrected to STP by the following formula:

$$V_{STP} = V \times B \times 273,15/760 \times T_k, \quad (5.4.6.9.7-1)$$

where  $V_{STP}$  = the hydrogen volume, in ml, corrected to STP;  
 $V$  = the hydrogen volume determined according to the measuring capillary readings in experiment performance, in ml;

$B = p$  = correcting readings of a barometer corresponding to the atmospheric pressure at the time of readings taking, in mm of mercury;  
 $T_k = 273,15 + t_c$  where  $t_c$  corresponds to the temperature in the space at the time of taking readings of the diffused hydrogen volume, in °C.

The volume of diffusible hydrogen in deposited metal  $H_D$ , in ml per 100 g, shall be calculated from the following formula:

$$H_D = V_{STP} \times 100 / (m_2 - m_1), \quad (5.4.6.9.7-2)$$

where  $V_{STP}$  = the hydrogen volume, in ml, corrected to STP;  
 $m_2$  = the final mass, in g, of the test piece with deposited metal;  
 $m_1$  = the initial mass, in g, of the test piece ([refer to 5.4.6.3.2](#)).

**5.4.6.10** Classification of welding consumables by the diffusible hydrogen content in the deposited metal.

Welding consumables may be classed by the Register with the assignment of classification indices H5, H10 or H15 depending on the specific content of diffusible hydrogen in the deposited metal.

Individual and common mean values of the diffusible hydrogen content shall be included in the test report wherein the method of its determination shall be also specified.

The common mean values for four test pieces shall not exceed the values given in [Table 5.4.6.10](#). In this case the individual values for the diffusible hydrogen content, which exceed the required in [Table 5.4.6.10](#) by not more than 10 %, may be allowed for two specimens.

Table 5.4.6.10

**Diffusible hydrogen content in the deposited metal**

Index of classification by hydrogen content <sup>1</sup>	Diffusible hydrogen content in the deposited metal (not more than 1 cm <sup>3</sup> per 100 g of deposited metal) determined by:	
	ISO 3690:2018 <sup>2</sup>	glycerin method <sup>3</sup>
H15	15	15
H10	10	10
H5	5	Not applicable

<sup>1</sup> Additional index H3 corresponding to the mean value of the diffusible hydrogen content (not more than 3,0 cm<sup>3</sup> per 100 g of the deposited metal) is allowed for ultra-low hydrogen welding consumables.  
<sup>2</sup> In parallel with the mercury and chromatographic (TCD) method per ISO 3690:2018, the vacuum method (GOST 23338-91, method 2) is acceptable provided all the requirements of this Section are complied with.  
<sup>3</sup> Provided all the requirements of this Section for this test method are met.

## **6 APPROVAL OF WELDING PROCEDURES FOR STEEL STRUCTURES AND ITEMS**

### **6.1 GENERAL**

**6.1.1** For welding of structures subject to the Register technical supervision the welding procedures defined by the relevant welding procedure specifications (WPS) which have passed qualification tests and are approved by the Register shall be used.

**6.1.2** Unless otherwise agreed, the approval by welding procedure qualification tests shall be carried out for preliminary WPS (pWPS) and followed by filling in the established forms of welding procedure qualification records (WPQR).

On agreement with the Register, the welding procedure approval scheme may be used based on carrying out pre-production welding tests meeting the requirements of ISO 15613, as well as based on adoption of a standard WPS in compliance with the requirements of ISO 15612.

**6.1.3** Approval of welding procedures shall meet the requirements set forth below. One may be guided by the RS-recognized requirements of international and national standards ISO 15614-1, ASME Section IX, ANSI/AWS D1.1 taking into account the requirements for the extent of tests and range of approval given below.

**6.1.4** The decision on recognition of the welding procedure qualification test results (WPQR) surveyed by another classification society or an authorized 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 the present Section.

**6.1.5** 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 edge preparation, e.g. electron beam and laser welding.

### **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.

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.

Essential variables for welding procedure mean welding procedure parameters which define scope of welding procedure approval by the Register based on the welding procedure qualification tests and stated in the 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.

Heat input  $E_1$  means electric energy consumed per unit weld length and calculated by the formula  $E_1 = IU/v$ , kJ/cm, where  $I$  means welding current, A;  $U$  means welding voltage, B;  $v$  means welding speed, cm/s.

Pre-production welding tests mean the tests for approval of welding procedure based on the use of non-standard specimens and test pieces and simulating welding in actual production conditions.

Preliminary welding procedure specification (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 pWPS.

Welding procedure qualification tests mean the tests conducted under technical supervision and within the scope of the RS requirements to confirm the capability of the manufacturer to carry out welding of particular structures; the tests closely simulate actual working conditions and are performed in accordance with the WPS requirements.

Welding Procedure Approval Test Certificate means the RS 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, edge preparation data and all process parameters.

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" there with 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 Designations.**

**6.2.2.1** The designations for welding processes according to ISO 4063:2009 shall correspond to those given in [Table 6.2.2.1](#).

Table 6.2.2.1

Corresponding ISO 4063:2009 reference numbers for the welding processes

Reference numbers for the welding processes	Another commonly used designations (acronyms and abbreviations) for the welding processes	Name of welding process
111	MMAW (SMAW:USA)	Manual metal arc welding (metal arc welding with covered electrode)
112	GAW	Gravity (arc) welding with covered electrode
114	(FCAW-S:USA)	Self-shielded tubular cored arc welding
12	SAW	Submerged arc welding:
121	SAW	Submerged arc welding with solid wire electrode
122	SAW	Submerged arc welding with strip electrode
124	SAW	Submerged arc welding with metallic powder addition
125	SAW	Submerged arc welding with tubular cored electrode
126	SAW	Submerged arc welding with cored strip electrode
13	GMAW	Gas-shielded metal arc welding in particular:
131	MIG	Metal inert gas (MIG) welding with solid wire electrode
132	MIG	MIG welding with flux cored electrode
133	MIG	MIG welding with metal cored electrode
135	MAG	Metal Active Gas (MAG) welding with solid wire electrode
136	MAG FCAW-G (USA)	MAG welding with flux cored electrode
138	MAG	MAG welding with metal cored electrode; gas metal arc welding using active gas and metal cored electrode
14	TIG (GTAW:USA)	Gas-shielded arc welding with non-consumable tungsten electrode:
141	TIG	Tungsten inert gas (TIG) welding with solid filler material (wire/rod)
142	TIG	Autogenous TIG welding
143	TIG	TIG welding with tubular cored filler material (wire/rod)
15	PAW	Plasma arc welding:
151	–	Plasma MIG welding
152	–	Powder plasma arc welding
31	OFW (USA)	Oxyfuel gas welding:
311	OAW (USA)	Oxyacetylene welding
43	FSW	FSW (Friction Stir Welding)
51	EBW (USA)	Electron beam welding
52	LBW (USA)	Laser welding
72	ESW	Electroslag welding
73	EGW	Electrogas welding

**6.2.2.2** Approval of welding processes 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 international standard ISO/TR 15608:2017 as given in [Table 4.3.3.1-1](#).

**6.2.2.3** When executing the documentation related to the approval of welding processes, it is recommended to use coding of welded joint types as follows:

- A — single-sided weld with backing;
- B — single-sided weld without backing;
- C — double sided weld with back gouging;
- D — double sided weld without back gouging;
- F — fillet weld;
- ss — single-side welding;
- bs — welding from both sides;
- sl — single-layer weld;

- ml — multilayer welding;
- nb — welding without backing;
- mb — welding with backing;
- gb — welding with gas backing;
- gg — welding with back gouging or back grinding of welds;
- ng — welding without back gouging.

**6.2.2.4** Welding conditions applied to the welding of test pieces and range of approval for welding processes shall be specified with reference to unified welding positions, the designations for which according to ISO 6947:2019 are given in [Appendix 2 to Section 4](#).

**6.2.2.5** Symbols of components of gas and gas mixtures used in welding (welding processes 131, 133, 135, 136, 141 and 15) shall meet the requirements of ISO 14175:2008 and are given in [Table 6.2.2.5](#).

Table 6.2.2.5

**Classification of process gases for fusion welding and allied processes according to ISO 14175:2008**

Symbol		Components in nominal percentage of volume						
Main group	Subgroup	Oxidizing		Inert		Reducing	Low reactivity	
		CO <sub>2</sub>	O <sub>2</sub>	Ar	He	H <sub>2</sub>	N <sub>2</sub>	
I	1			100				
	2				100			
	3			backing <sup>1</sup>	0,5 ≤ He ≤ 95			
M1	1	0,5 ≤ CO <sub>2</sub> ≤ 5		backing <sup>1</sup>		0,5 ≤ H <sub>2</sub> ≤ 5		
	2	0,5 ≤ CO <sub>2</sub> ≤ 5		backing <sup>1</sup>				
	3		0,5 ≤ O <sub>2</sub> ≤ 3	backing <sup>1</sup>				
	4	0,5 ≤ CO <sub>2</sub> ≤ 5	15 < CO <sub>2</sub> ≤ 25	backing <sup>1</sup>				
M2	0	5 < CO <sub>2</sub> ≤ 15		backing <sup>1</sup>				
	1	15 < CO <sub>2</sub> ≤ 25		backing <sup>1</sup>				
	2		3 < O <sub>2</sub> ≤ 10	backing <sup>1</sup>				
	3	0,5 ≤ CO <sub>2</sub> ≤ 5	3 < O <sub>2</sub> ≤ 10	backing <sup>1</sup>				
	4	5 < CO <sub>2</sub> ≤ 15	0,5 ≤ O <sub>2</sub> ≤ 3	backing <sup>1</sup>				
	5	5 < CO <sub>2</sub> ≤ 15	3 < O <sub>2</sub> ≤ 10	backing <sup>1</sup>				
	6	15 < CO <sub>2</sub> ≤ 25	0,5 ≤ O <sub>2</sub> ≤ 3	backing <sup>1</sup>				
M3	7	15 < CO <sub>2</sub> ≤ 25	3 < O <sub>2</sub> ≤ 10	backing <sup>1</sup>				
	1	25 < CO <sub>2</sub> ≤ 50		backing <sup>1</sup>				
	2		10 < O <sub>2</sub> ≤ 15	backing <sup>1</sup>				
	3	25 < CO ≤ 50	2 < O <sub>2</sub> ≤ 10	backing <sup>1</sup>				
	4	5 < CO <sub>2</sub> ≤ 25	10 < O <sub>2</sub> ≤ 15	backing <sup>1</sup>				
C	5	25 < CO <sub>2</sub> ≤ 50	10 < O <sub>2</sub> ≤ 15	backing <sup>1</sup>				
	1	100						
	2	backing	0,5 ≤ O <sub>2</sub> ≤ 30					
	R	1			backing <sup>1</sup>		0,5 ≤ H <sub>2</sub> ≤ 15	
		2			backing <sup>1</sup>		15 ≤ H <sub>2</sub> ≤ 50	
N	1			backing <sup>1</sup>			100	
	2			backing <sup>1</sup>			0,5 ≤ N <sub>2</sub> ≤ 5	
	3			backing <sup>1</sup>			5 < N <sub>2</sub> ≤ 50	
	4			backing <sup>1</sup>		0,5 ≤ H <sub>2</sub> ≤ 10	0,5 ≤ N <sub>2</sub> ≤ 5	
	5					0,5 ≤ H <sub>2</sub> ≤ 50	backing	
O	1		100					
Z	Gas mixtures containing components not listed, or mixtures outside the composition ranges listed <sup>2</sup>							

<sup>1</sup> For the purpose of this classification, argon may be substituted partially or completely by helium.

<sup>2</sup> Two gas mixtures with the same Z-classification may not be interchangeable.

### **6.3 TYPES OF WELDED JOINT TEST PIECES AND REQUIREMENTS FOR THEIR PREPARATION**

#### **6.3.1 Classification of test pieces, their purpose and dimensions.**

##### **6.3.1.1 General.**

**6.3.1.1.1** Welding procedure qualification tests shall be carried out with use of welded joint test pieces that meet the requirements of the present Section. Welding of test pieces shall be performed by welders who undertook the welding procedure test satisfactorily and were qualified for the appropriate range of qualification for welding of structures subject to the RS technical supervision in compliance with the requirements of [Section 4](#).

Note. On agreement with the Register it is permitted that both approval tests for welders and welding procedure qualification tests may be done together. In this case, the results of testing for approval of welding procedure performed by the welder to be certified may be considered as valid for practical tests of welders.

**6.3.1.1.2** Length or number of test pieces shall be sufficient to allow all required qualification tests to be carried out in compliance with the requirements stated below. Additional test pieces, or longer test pieces than the minimum size, may be prepared in order to allow for extra and/or for re-testing specimens in compliance with the requirements of the present Section.

The number of the Tekken test pieces for cold cracking tests shall be as follows:

at least one test piece for gas-shielded automatic welding and self-shielded tubular-cored arc welding (without additional gas shielding);

at least two test pieces for manual metal arc welding with covered electrode, partly mechanized gas-shielded welding and self-shielded tubular-cored arc welding (without additional gas shielding).

**6.3.1.1.3** For all test pieces except branch connections and fillet welds ([refer to Fig. 6.3.1.4](#)) the material thickness shall be the same for both plates/pipes to be welded.

If required by the test extent, the direction of plate rolling shall be marked on the test piece when impact tests are required to be taken in the heat-affected zone (HAZ).

The thickness and/or pipe outside diameter of the test pieces shall be selected in compliance with the requirements of [6.4](#) for the range of approval for the pWPS to be qualified.

**6.3.1.1.4** Edge preparation and welding of test pieces shall be carried out in accordance with the pWPS to be qualified. In so doing, the general conditions of welding in production for process procedure subject to the Register approval shall be met.

Edge preparation for the Tekken test pieces shall be carried out by machining means (a saw, a milling cutter or a cutting wheel) followed by milling or grinding of the edges to be welded with a roughness of max. Rz 80. Surfaces to be welded shall be smooth, free from scale, rust, oil, grease and other contaminants. Non-welded edges of the test specimens may be in condition after gas cutting.

**6.3.1.1.5** Welding of welded joint test pieces and testing of test specimens shall be witnessed by the RS surveyor.

**6.3.1.1.6** Where tack welds and crater rewelding ("stop-restart" operation) are used in the welding procedure subject to approval by the Register, they shall be included in the test length.

**6.3.1.1.7** Where the pWPS subject to qualification does not provide for edge dressing to remove shop primer, the latter shall be applied to the test piece elements to be butted, and its thickness shall be adequately measured and stated in the test report.

**6.3.1.2** The test piece for a butt-welded joint in plates shall be prepared in accordance with [Fig. 6.3.1.2](#).

Notes: 1. When testing automatic single-side welding procedures at specialized assembling and welding stands provided with clamping devices, the test piece length shall not be less than 3000 mm.

2. When testing automatic vertical welding procedures, including forced weld formation, the test piece length shall correspond to technical capabilities of the equipment applied in production.

Strips for butt-welded test pieces from rolled plates shall be prepared taking into account the last rolling direction and axial orientation of specimens for impact test, the test results for which are given in accompanying documents for the base metal (refer also to [Table 6.4.4.7.4](#)). For impact tests of rolled products with the use of longitudinal specimens,  $KV_L$  (as a rule, for all hull structural steels of normal and higher strength) the test pieces are welded in such a way, that the weld is perpendicular to the direction of last rolling. In impact tests of rolled products using transverse specimens,  $KV_T$  the weld shall be parallel to the direction of last rolling (as a rule, for high-strength steels and steels of improved weldability).

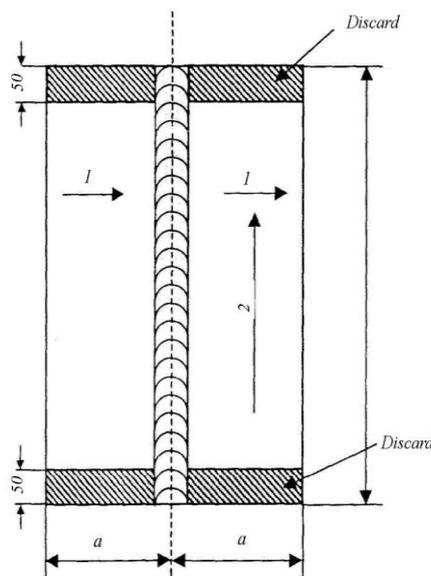


Fig. 6.3.1.2

Test piece for a butt-welded joint in plates:

1 — rolling direction for plates impact tested in the longitudinal direction  $KV_L$  (longitudinal specimens);

2 — rolling direction for plates impact tested in the transverse direction  $KV_T$  (transverse specimens);

$a$  and  $b$  — test piece dimensions adopted depending on a welding process:

$a \geq 150$  mm, but not less than  $3t$  and  $b \geq 350$  mm, but not less than  $6t$  for manual and semi-automatic welding;

$a \geq 200$  mm and  $b \geq 1000$  mm for automatic welding;  $t$  — thickness of the test piece

**6.3.1.3** Welding procedures for butt joint in pipe are approved on the basis of tests using the test piece which is prepared in accordance with [Fig. 6.3.1.3](#).

For pipes with outside diameter exceeding 500 mm the approval of manual and semi-automatic welding procedures may be obtained by the results of testing the butt joints in plates carried out in identical conditions (refer to the requirements for welding positions listed in [Table 6.6.3.2](#) and to other parameters of the range of approval in accordance with [6.6.1](#), [6.6.2](#), [6.6.3](#) and [6.6.4](#)).

Note. The manufacturer on agreement with the RS surveyor is entitled to change the location of the test piece to suit the particular features of actual welded joints. For instance, a box-shaped test piece may be used instead of the pipe, etc.

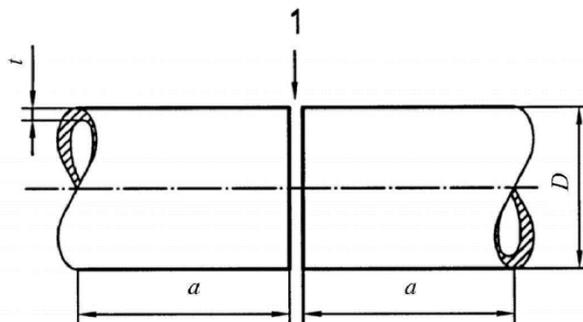


Fig. 6.3.1.3

Test piece for a butt-welded joint in pipe:  
 $a \geq 150$  mm — half of the test piece length;  
 $D$  — outside pipe diameter;  
 $t$  — wall thickness of the pipe;

1 — edge preparation and fit-up as detailed in the pWPS

**6.3.1.4** Welding procedures for corner, tee (T-) and cruciform joints fillet-welded in plate are approved on the basis of testing the T-joint test piece, which is prepared in accordance with [Fig. 6.3.1.4](#).

Note. In case of approval of automatic welding procedures for framing at specialized assembling and welding stands provided with clamping devices and ensuring fillet welding from both sides simultaneously, the test length shall be not less than 3000 mm.

Use of T-joint test piece in plate without edge preparation is limited by the following conditions and requirements:

- applied welding consumables are of special purpose type and not used for welding butt joints in production;
- the given procedure prevails in production and its approval within the range of approval for butt joints is inexpedient to perform;
- approval cannot be performed within limitations for the range of approval;
- for approval of welding procedures for fillet welds with deep penetration (rated thickness of the fillet weld exceeds the nominal one);
- upon the Register requirement for the approval of welding procedures for single-run fillet welds without removal of the shop primer.

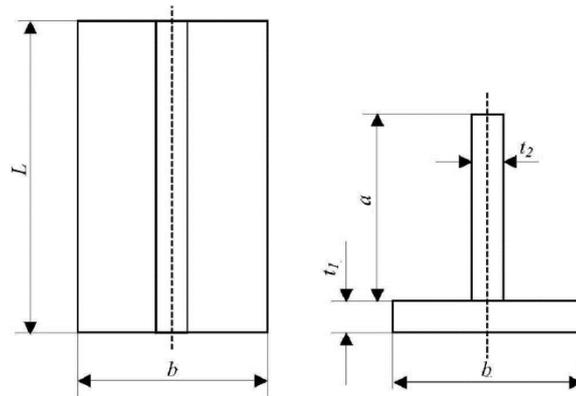


Fig. 6.3.1.4

Test piece for a fillet-welded T-joint without edge preparation:  
 web depth  $a \geq 3t_2$ , minimum value 150 mm; flange width  $b \geq 3t_1$ , minimum value 150 mm;  
 $t_1$  — flange thickness;  $t_2$  — web thickness;  
 test piece length  $L \geq 350$  mm, but no less than  $6 \max\{t_1 \text{ and } t_2\}$  for manual and semi-automatic welding and  
 $L \geq 1000$  mm for automatic welding

**6.3.1.5** Welding procedures for corner, T- and cruciform joints in plate with full penetration are approved on the basis of testing the T-joint test piece, which is prepared in accordance with [Fig. 6.3.1.5](#).

**6.3.1.6** Welding procedures for pipe and branch connections are approved on the basis of testing the test piece for a branch connection which is prepared in accordance with [Fig. 6.3.1.6](#).

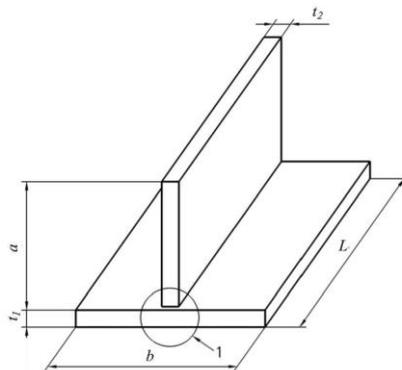


Fig. 6.3.1.5

The test piece of a T-joint in plate with full penetration:  
 web depth  $a \geq 3t_2$ , minimum value 150 mm; flange width  $b \geq 3t_1$ , minimum value 150 mm;  
 $t_1$  — flange thickness;  $t_2$  — web thickness;  
 test piece length  $L \geq 350$  mm, but no less than  $6 \max\{t_1 \text{ and } t_2\}$  for manual and semi-automatic welding  
 and  $L \geq 1000$  mm for automatic welding; 1 — edge preparation and fit-up as detailed in the pWPS

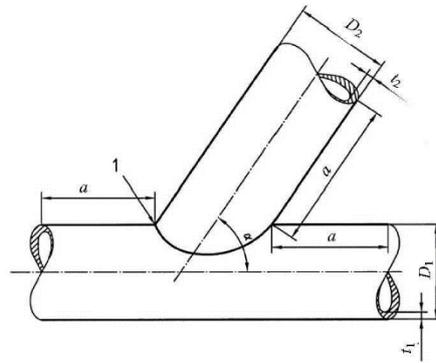


Fig. 6.3.1.6

Test piece for a branch connection:

$a \geq 150$  mm;  $D_1$  — outside diameter of the main pipe;  $t_1$  — wall thickness of the main pipe;  
 $D_2$  — outside diameter of the branch pipe;  $t_2$  — wall thickness of the branch pipe;  $\alpha$  — branch angle;  
 1 — edge preparation and fit-up as detailed in the pWPS

**6.3.1.7** Welding procedures for high strength steels are approved considering testing results of the Tekken test pieces prepared in accordance with [Fig. 6.3.1.7](#) from base and welding materials for cold cracking according to GOST R ISO 17642-2-2012.

**6.3.2 Requirements for preparation of welded joint test pieces.**

**6.3.2.1 General.**

**6.3.2.1.1** Test pieces shall be welded meeting the following requirements:

- edge preparation and the fit-up shall be as detailed in the pWPS;
- the test piece is joined and held by tack welds to provide the correct gap and groove angle;
- the tack welds shall be included in the weld length if this corresponds to normal conditions in production;

unless otherwise stated, the rolling direction on the test piece of butt joint in plates shall be in compliance with the requirements of [Table 6.4.4.7.4](#) as regards the orientation of rolled products for the impact test specimens;

after welding 50 mm of each end of the test pieces of butt joints in plates and T-joints are discarded.

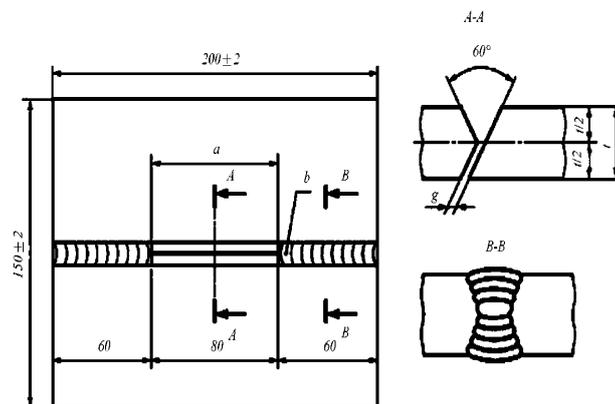


Fig. 6.3.1.7

The Tekken test piece after anchor welding:

$a$  — tested weld deposition zone;  $b$  — anchor weld;  $g$  — root gap of  $(2,0 \pm 0,2)$  mm;  
 $t$  — plate thickness taken as the largest of the declared thicknesses for a given steel grade, but not less than 12 mm.

**6.3.2.1.2** Welding of T-joint test piece in plates without edge preparation shall meet the following requirements:

T-joint test piece in plates shall be assembled and positioned edgewise so as to constitute a tee-assembly with no clearance;

as far as possible the plates shall be of a sufficient size to ensure a reasonable heat distribution;

the requirements of qualified welding procedure for welding without removal of the shop primer shall be fully met. Shop primer thickness shall be measured, and the availability of shop primer on the edges of the test piece to be welded shall be marked in the test report;

the test piece shall be fillet welded from one side only. For manual and semi-automatic welding, the stop and restart position shall be included in the test length and shall be clearly marked for subsequent examination.

**6.3.2.1.3** For butt joint test pieces in plates it is allowed to overlap positions of PA (flat) and PE (overhead) welding of a single test piece as of actual structure.

**6.3.2.1.4** For the Tekken test piece. Anchor welds shall be made with welding materials used for the tested weld. Anchor welds shall be welded in the modes recommended by the manufacturer of welding materials. To weld anchor welds, it is allowed to use other welding materials with the yield strength equal to or lower than the yield strength of the base metal by no more than 25 %. To prevent hydrogen cracking, if necessary, pre-heating, heating between welding runs and post-heating shall be used in the welding process. To ensure the lowest hydrogen content, all welding materials used to make anchor welds shall be dried up according to the manufacturer's recommendations. After completing anchor welds, they should be cooled down to ambient temperature and visually tested and measured for surface cracks in accordance with ISO 17637 (inspection class is not regulated).

**6.3.2.2** Requirements for welding procedure and preparation of test pieces.

**6.3.2.2.1** Preheating is only used if it is specified in pWPS for the given material. But even if the preheating is not used, the RS surveyor has the right to require welding of joint test pieces 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 pWPS.

**6.3.2.2.2** One shall meet the pWPS requirements, if any, with respect to interbead (interpass) temperature. If pWPS does not specify measures in control of this parameter, the temperature in welding of test pieces 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 piece 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 pWPS requirements. Besides, the welding of test pieces 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) or when the pWPS heat input is reduced by 25 % for welding of high strength steels on the Tekken test piece (for cold crack testing). 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 pWPS down to values actually observed in the tests and corresponding to the range of approval.

**6.3.2.2.4** Heat treatment of welded joints shall be performed only, if it is specified by pWPS. In this case the actual conditions of the welded joint test piece 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).

**6.3.2.2.5** Welding of test pieces shall be performed, as far as possible, with the use of production equipment and in workshop conditions.

**6.3.2.2.6** The welding scheme for the Tekken test piece test joint shall correspond to [Fig. 6.3.2.2.6](#). The weld shall be made in one run. After welding, the sample shall be kept at ambient temperature for at least 48 hours before the start of crack testing. The ambient temperature during welding shall be taken as the temperature of the ambient air during the welding. This temperature shall be entered to the WPS.

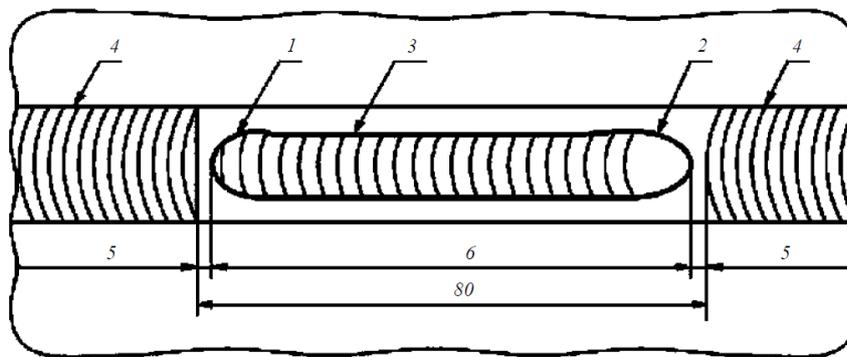


Fig. 6.3.2.2.6

The welding scheme for the Tekken test piece test joint:

1 — beginning of weld; 2 — end of weld; 3 — test weld; 4 — anchor weld; 5 — size equal to approximately 2 mm; 6 — size equal to approximately 76 mm

## 6.4 REQUIREMENTS FOR TEST PIECES 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 piece 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 testing, test specimens preparation and test results evaluation shall meet the requirements given below.

Table 6.4.1.1

Requirements for extent of testing for approval of welding procedures

Nos.	Type of welded test piece	Type of test	Extent of testing
1	Butt joint in plate and pipe — refer to <a href="#">Figs. 6.3.1.2</a> and <a href="#">6.3.1.3</a>	Visual and measurement testing	100 % of weld length
		Radiographic or ultrasonic testing <sup>1</sup>	100 % of weld length
		Surface crack detection <sup>2</sup>	100 % of weld length
		Transverse tensile test	2 specimens
		Transverse bend test <sup>3</sup>	4 specimens
		Impact test	From 3 to 8 series of 3 specimens each <sup>4</sup>
		Hardness test <sup>5</sup>	Required
		Macro examination	1 transverse macrosection

Nos.	Type of welded test piece	Type of test	Extent of testing
2	T-joints in plate with edge preparation (with full penetration), refer to Fig. 6.3.1.5. Pipe branching node with edge preparation on branch to be welded on (double tee-butt joint), refer to Fig. 6.3.1.6	Visual and measurement testing	100 % of weld length
		Surface crack detection <sup>2</sup>	100 % of weld length
		Ultrasonic testing <sup>1,6</sup>	100 % of weld length
		Hardness test <sup>5</sup>	1 or 2 specimens required <sup>7</sup>
		Macro examination	2 or 3 transverse specimens required <sup>7</sup>
		Additional tests <sup>8</sup>	
3	T-joints in plate without edge preparation (fillet/joint), refer to Fig. 6.3.1.4. Pipe branching node without edge preparation on branch to be welded (without penetration), refer to Fig. 6.3.1.6	Visual and measurement testing	100 % of weld length
		Surface crack detection <sup>2</sup>	100 % of weld length
		Hardness test <sup>5</sup>	1 or 2 specimens required <sup>7</sup>
		Macro examination	2 or 3 transverse specimens required <sup>7</sup>
		Fracture test	Required for the test piece of a joint in plate
		Additional tests <sup>8</sup>	
4	Tekken test piece	Visual and measurement testing for surface cracks	100 % of weld length
		Macro examination of the test weld for cracks	4 transverse specimens in the absence of any visible surface cracks in the weld
<sup>1</sup> Ultrasonic testing shall not be used at base metal thicknesses $t < 10$ mm, as well as for austenitic and austenitic stainless steels (groups 8 and 10 according to ISO/TR 15608). <sup>2</sup> Penetrant testing or magnetic particle testing. For non-magnetic materials, penetrant testing. <sup>3</sup> In compliance with the requirements of 6.4.4.2. <sup>4</sup> In compliance with the requirements of 6.4.4.4. <sup>5</sup> Hardness test is required if prescribed by requirements in 6.4.4.5. <sup>6</sup> For outside diameter $D \leq 50$ mm no ultrasonic test is required. For outside diameter $D > 50$ 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. <sup>7</sup> In compliance with the location of test specimens for tests according to Figs. 6.4.2-2 to 6.4.2-5. <sup>8</sup> In cases when the welding procedure according to pWPS 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 edge preparation.			

**6.4.1.2** Requirements for welding procedure qualification test of welding procedures of steels with indices "BCA1" and "BCA2" shall comply with the requirements for each steel grade without indices "BCA1" or "BCA2", excluding those of 6.4.4.5.

**6.4.2 Requirements for location and taking of test specimens for mechanical tests.**

Test specimens for mechanical tests shall be taken after all non-destructive testing (NDT) has been carried out and which has passed the relevant inspection criteria for the NDT method(s) used within the scope of requirements specified in Table 6.4.1.1. It is acceptable to take the test specimens from locations avoiding areas which have imperfections within the acceptance limits for the NDT method(s) used.

Test specimens for mechanical tests shall be taken in accordance with Figs. 6.4.2-1 — 6.4.2-5. Test specimens from Tekken test piece shall be taken in accordance with Fig. 6.4.2-6.

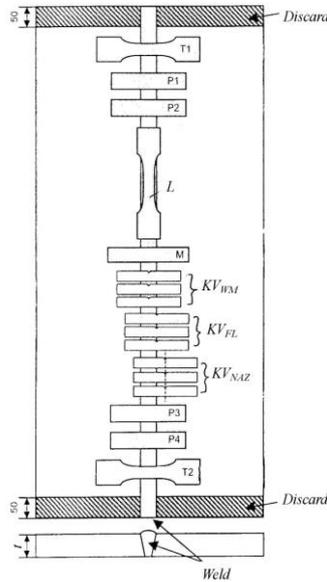


Fig. 6.4.2-1

Location of test specimens in the test piece of a butt-welded joint for mechanical tests:

- $T_1$  and  $T_2$  — transverse tensile test specimens;
- $P_1$  and  $P_3$  — transverse face bend test specimens or two side bend test specimens;
- $P_2$  and  $P_4$  — transverse root bend test specimens or two side bend test specimens;
- $L$  — longitudinal tensile test specimen, if required;
- $KV_{WM}$  — Charpy V-notch impact test specimens (notch in weld metal);
- $KV_{FL}$  — Charpy V-notch impact test specimens (notch on fusion line);
- $KV_{HAZ}$  — Charpy V-notch impact test specimens (notch in HAZ);
- $M$  — macro examination and hardness test specimens;
- $t$  — thickness of the test piece

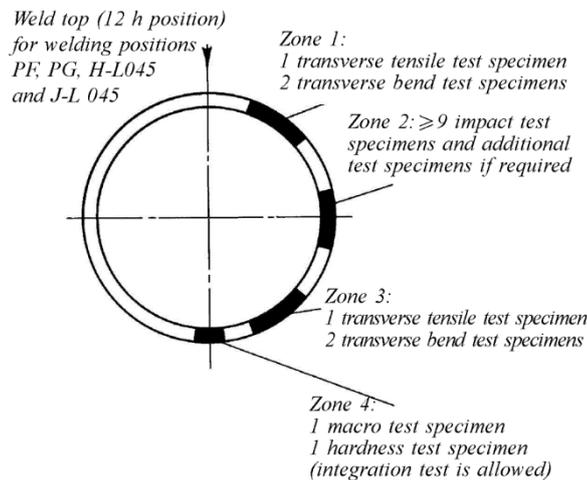


Fig. 6.4.2-2

Location of test specimens in the test piece of a butt-welded joint in pipes for mechanical tests

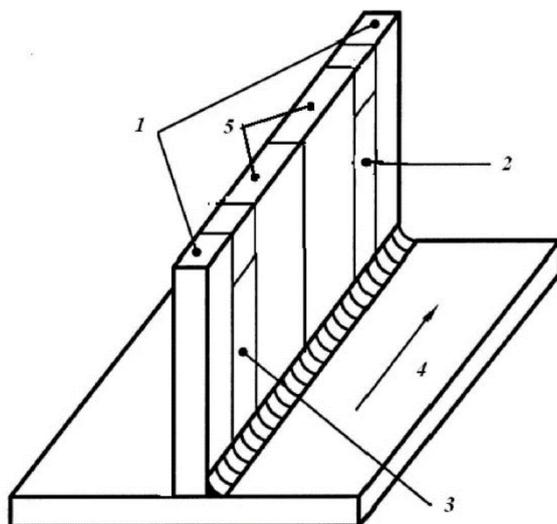


Fig. 6.4.2-3

Location of test specimens in the test piece of a fillet-welded T-joint in plates for mechanical tests:

- 1 — discard 50 mm;
- 2 — macro test specimen;
- 3 — macro and hardness test specimen (combined in one specimen);
- 4 — welding direction; 5 — fracture test specimens

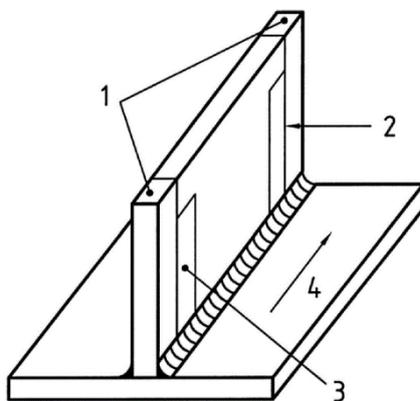


Fig. 6.4.2-4

Location of test specimens in the test piece of a T-joint in plates with full penetration for mechanical tests:

- 1 — discard 50 mm;
- 2 — macro test specimen;
- 3 — macro and hardness test specimen (combined in one specimen);
- 4 — welding direction

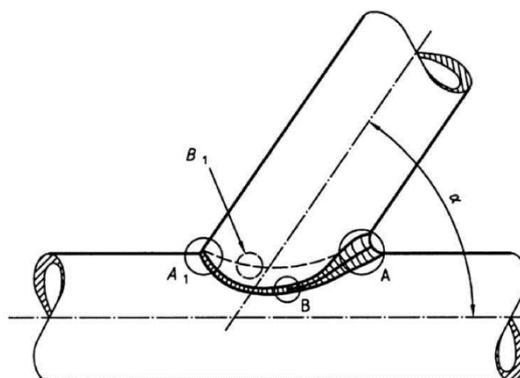


Fig. 6.4.2-5

Location of test specimens in the test piece of a branch connection for mechanical tests:

A<sub>1</sub> (12 h) macro and hardness test specimen (combined in one specimen);

A (6 h) macro and hardness test specimen (combined in one specimen);

B (9 h) or B<sub>1</sub> (3 h) — macro test specimen

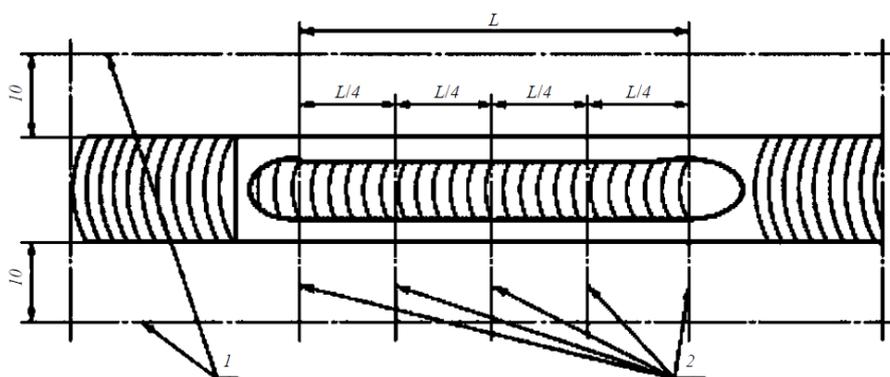


Fig. 6.4.2-6

Location of test specimens:

1 — cutting towards the specimen width; 2 — position of the test section.

### 6.4.3 Non-destructive testing.

**6.4.3.1** Test pieces shall be examined by visual and measurement testing and by non-destructive testing prior to the cutting of test specimen in accordance with [Table 6.4.4.1](#). In case that any post-weld heat treatment is required or specified, non-destructive testing shall be performed after heat treatment. For high-strength steels meeting the requirements of 3.13, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and having specified minimum yield strength of 420 MPa and above, the NDT shall be delayed for a minimum of 48 h after welding, unless heat treatment has been carried out. General requirements for carrying out and basic parameters of non-destructive testing of the welded joint test pieces shall be in compliance with 3.2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships taking into account of the admissible imperfections for Acceptance Quality Level ([refer to 6.4.3.2](#)).

**6.4.3.2** In case it complies with the contractual requirements and specifications for manufacturing specific products, the assessment of the test piece of welded joint under NDT results shall be carried out up to Acceptance Quality Level B according to ISO 5817. The reduction criteria down to Acceptance Quality Level C is therewith admissible for external imperfections associated with oversized welds (excessive height and breadth of a butt weld

reinforcement, excess throat thickness of a fillet weld, excessive reinforcement of a single — side butt weld root). Allowed is the assessment criteria downgrading to Acceptance Quality Level C for external imperfections as per weld dimensions in excess (excess in height and breadth reinforcement).

During examination by specific NDT methods the requirements of ISO 17635 to Test Class and Quality Level shall be comply:

to perform Quality Level B examination by visual and measurement testing as per ISO 5817 NDT methods in accordance with ISO 17637 (Test Class is not regulated);

to perform magnetic particle testing of Quality Level 2X in compliance with ISO 23278, test methods shall be carried out in accordance with ISO 17638 (Test Class is not regulated);

to perform radiographic testing of Acceptance Quality Level 1 in compliance with 10675-1, test methods shall be carried out in accordance with ISO 17636 (Test Class B);

to perform ultrasonic testing of Quality Level 2 as per ISO 11666 (refer to 3.4.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships ), the test procedure in accordance with ISO 17640 (testing level B).

#### 6.4.4 Mechanical tests.

##### 6.4.4.1 Tensile test.

Two transverse tensile specimens taken from the test pieces for butt joints in plate and pipe having dimensions as shown in [Fig. 6.4.4.1-1](#) or [6.4.4.1-2](#) shall be tested.

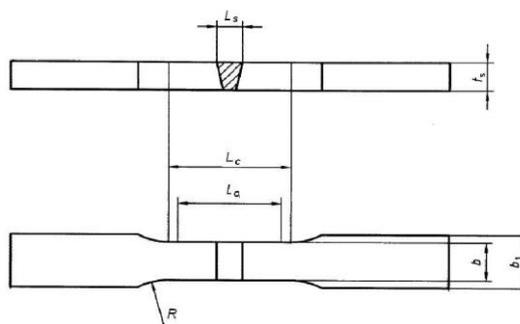


Fig. 6.4.4.1-1

Transverse specimen for tensile test of plates:

$L_s$  — greatest weld width (weld top);  $L_c = L_s + 60$  mm — parallel test length;  $L_0$  — gauge length;  
 $b$  — width of the parallel test length is defined as follows:  $b = 12$  mm for  $t_s \leq 2$  mm and  $b = 25$  mm for  $t_s > 2$  mm;  
 $b_1 \geq (b + 12)$  mm — width of the specimen gripping part;  $t_s$  — thickness of specimen;  $R \geq 25$  mm — transition radius

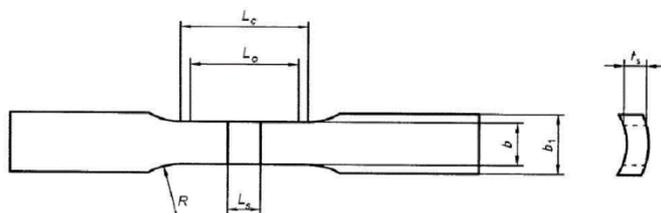


Fig. 6.4.4.1-2

Transverse specimen from a butt joint in pipes for tensile test:

$L_s$  — greatest weld width (weld top);  
 $L_c \geq L_s + 60$  mm — parallel test length;  
 $L_0$  — gauge length;  $b$  — width of the parallel test length is defined as follows:  
 $b = 6$  mm for  $D \leq 50$  mm,  $b = 12$  mm for  $50 < D \leq 168,3$  mm and  $b = 25$  mm for  $D > 168,3$  mm;  
 $b_1 \geq (b + 12)$  mm — width of the specimen gripping part;  
 $t_s$  — thickness of specimen;  $R \geq 25$  mm — transition radius

Thickness of a test specimen  $t_s$  shall be, as a rule, equal to the thickness of a base metal (refer to Fig. 6.4.4.1-3, a). In case the testing of the weld full section is required with metal thickness above 30 mm, several specimens shall be cut out to cover the overall weld thickness (refer to Fig. 6.4.4.1-3, b). In this case location of each specimen shall be indicated in the test report.

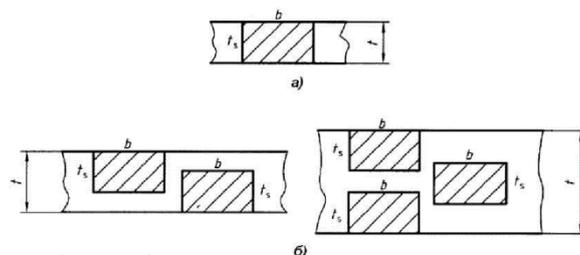


Fig. 6.4.4.1-3

Example showing the position of test specimens in welded joint section:

- a — testing of base metal full section  $t_s = t$ ;
- b — testing of several specimens in section for  $t > 30$  mm

For pipes  $D > 50$  mm outside diameter, the weld reinforcement shall be removed on both faces to give the test specimen a thickness equal to the wall thickness of the pipe.

For pipes  $D \leq 50$  mm outside diameter, and when full section small diameter pipes are used, the weld reinforcement may be left undressed on the inside surface of the pipe.

If for welding of test pieces the welding consumables were used, which have no Certificate of Approval for Welding Consumables, one or two (depending on the welding process) longitudinal round tensile test specimens with 10 mm diameter of effective part shall be additionally prepared and tested in accordance with Fig. 6.4.4.1-4. The following version of specimens preparation for testing is acceptable: cutting from the butt-joint test piece, if the dimensions of the specimen effective part are fit for weld cross-section in accordance with Fig. 6.4.4.1-5;

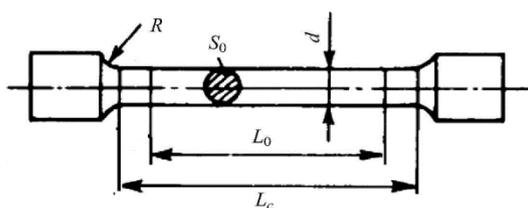


Fig. 6.4.4.1-4

Longitudinal round specimen for weld metal tensile tests:

- $d = 10$  mm — diameter of the parallel test length;
- $L_0 = 5d$  — gauge length;  $L_c = L_0 + d$  — parallel test length;
- $R = 10$  mm — transition radius

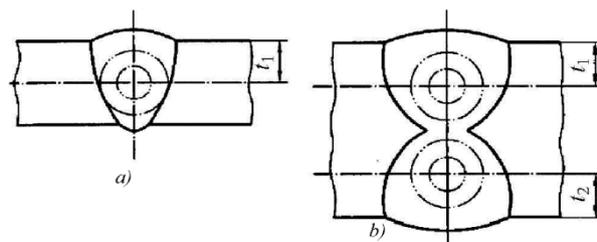


Fig. 6.4.4.1-5

Location of longitudinal round test specimens for tensile tests:

- a — test specimen from a joint welded from one side only;
- b — test specimen from a joint welded from both sides

cutting from additionally prepared deposited metal test piece meeting the requirements of 5.4.2 for relevant welding consumables and welding processes.

Note. When the specimens are taken from the butt-welded joint test piece, 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.

#### 6.4.4.2 Bend test.

Four transverse bend test specimens taken from the test pieces of butt joints in plate and pipe having dimensions as shown in [Fig 6.4.4.2-1](#) shall be tested for static bend:

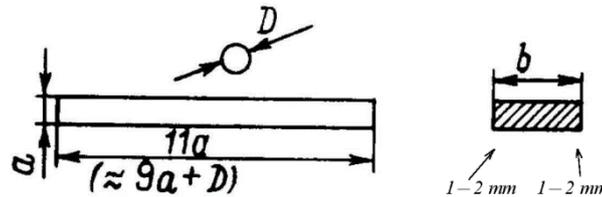


Fig. 6.4.4.2-1

Test specimens for bend test:

- a) at  $t < 12$  mm  
(specimens with extension of a weld root and weld face),  
 $a = t$ ,  $b = 30$  mm;
  - b) at  $t \geq 20$  mm (specimens for side bend),  $a = 10$  mm,  $b = t$ ;
  - c) at  $12 \leq t < 20$  mm, type a) or b) specimens may be used;
- $t$  — thickness of the test piece

for thicknesses of a base metal  $t < 12$  mm two root and two face bend test specimens shall be tested;

for thicknesses of a base metal  $12 \leq t < 20$  mm four side bend specimens are recommended instead of root and face bend tests;

for thicknesses of a base metal  $t \geq 20$  mm four side bend specimens shall be tested.

The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate and the sharp corners of the specimens rounded to a radius not exceeding 2 mm.

The bend test methods are shown in [Fig. 6.4.4.2-2](#). If the test procedure allows for the bending (wrapping) of test specimen around the mandrel, the test specimen length may exceed  $11a$ .

When testing specimens for side bending and if the base metal thickness  $t \geq 40$  mm, the specimen may be divided into two parts of width  $b \geq 20$  mm.

When testing dissimilar welded joints, the tests of transverse bend specimens are replaced, if agreed with the Register, by testing the same number of longitudinal specimens ([refer to Fig. 6.4.4.2-3](#)) having the same orientation of a tension zone (weld root and weld face).

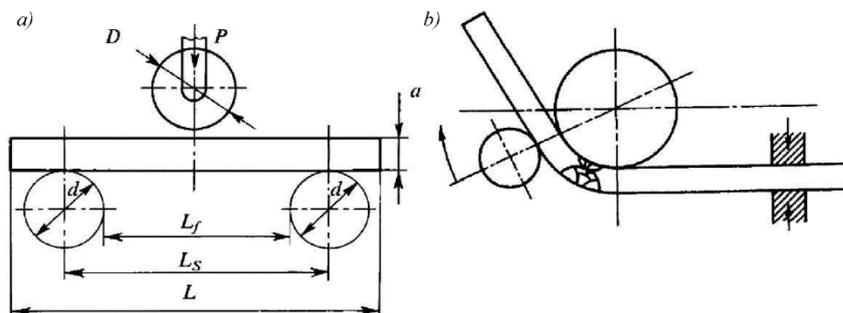


Fig. 6.4.4.2-2

Bend test methods:

*a* — three-point free bend test; *b* — wrap around bend test

Symbols: *D* — mandrel diameter;  $L_f = D + 3a$  — free interval between rollers;

$L \approx 9a + D$  for version *a*) or  $L \approx 11a$  for version *b*) — specimen length;

$L_s = L_f + d$  — free interval between supporting rollers; *d* — diameter of supporting rollers

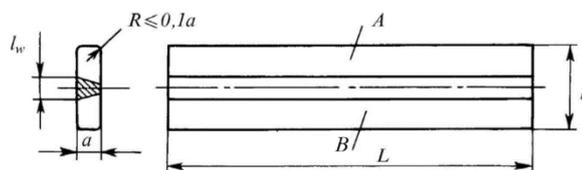


Fig. 6.4.4.2-3

Longitudinal bend test specimen for dissimilar welded joints:

*A* and *B* — parts of the dissimilar welded joint of steels different grades or classes;

$L \approx 9a + D$  for version *a*) or  $L \approx 11a$  for version *b*);

*L* — specimen length;

$a = t$ ;  $b = (l_w + 20)$  mm at  $t \leq 20$  mm and

$b = (l_w + 30)$  mm at  $t > 20$  mm

### 6.4.4.3 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 — 120 mm in length shall be used for testing. Each specimen shall be tested in compliance with the requirements of ISO 9017 or similar agreed national standards.

If necessary to facilitate fracture in the critical cross-section, a longitudinal notch may be done on the centre of the weld surface ([refer to Fig. 6.4.4.3](#)), or/and additional notches about 5 mm depth on both edges of the fillet weld (side notching) may be done.

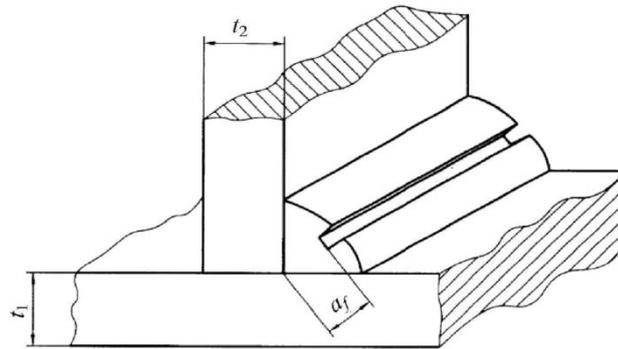
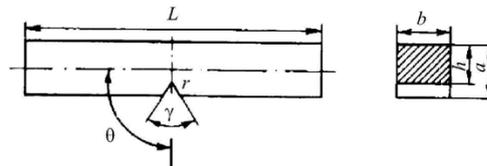


Fig. 6.4.4.3  
Specimen for fracture of fillet welds in plate with longitudinal square ("q" type) notch according to ISO 9017

**6.4.4.4 Impact test.**

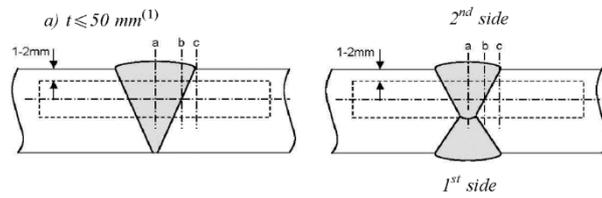
Charpy V-notch impact specimens shall comply with the dimensions shown in [Fig. 6.4.4.4-1](#). All impact tests shall be carried out on Charpy machines complying with the requirements of ISO 148 or appropriate agreed international and national standards, and having a striking energy of not less than 300 J in testing steel specimens and not less than 150 J in testing non-ferrous metal specimens. Where the test temperature is other than ambient temperature of the test specimen at the moment of breaking the specified temperature shall be within  $\pm 2$  °C.

The number of series consisting of three Charpy V-notch impact specimens each, as well as location of notches on specimens of each series shall comply with [Figs. 6.4.4.4-2](#), [6.4.4.4-3](#) or [6.4.4.4-4](#) depending on the thickness of the test piece metal, the heat input of welding or the base metal grade.



Dimensions	Nominal	Tolerances
Length $L$ , in mm	55	$\pm 0,60$
Thickness $a$ , in mm	10	$\pm 0,06$
Width $b$ , in mm		
standard specimen	10	$\pm 0,11$
subsize specimen	7,5	$\pm 0,11$
subsize specimen	5,0	$\pm 0,06$
V-notch angle $\gamma$ , in deg	45	$\pm 2$
Depth below notch $h$ , mm	8	$\pm 0,06$
Root radius $r$ , mm	0,25	$\pm 0,025$
Distance of notch from end of test specimen $L/2$ , in mm	27,5	$\pm 0,040$
Angle between plane of notch symmetry and the longitudinal axis of test specimen $\theta$ , in deg	90	$\pm 2$

Fig. 6.4.4.4-1  
Charpy V-notch specimen for impact tests



Note (1). For one side single run welding over 20 mm notch location "a" shall be added on root side.

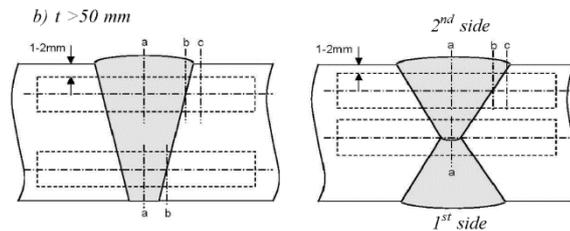
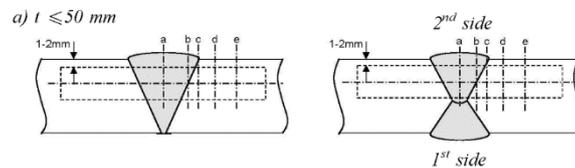


Fig. 6.4.4.4-2

Location of V-notch for butt weld of normal heat input (heat input  $\leq 50$  kJ/cm):

- a — notch in centre of weld (WM);
- b — notch on fusion line (FL);
- c — notch in HAZ, 2 mm from fusion line (FL + 2)



Note (1). For one side welding with thickness over 20 mm notch locations "a", "b" and "c" shall be added on root side.

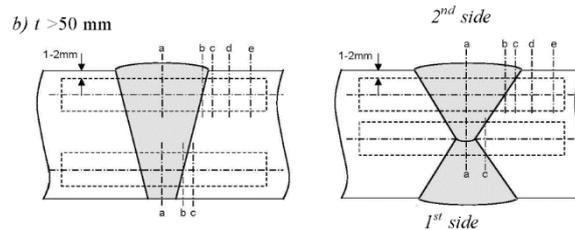
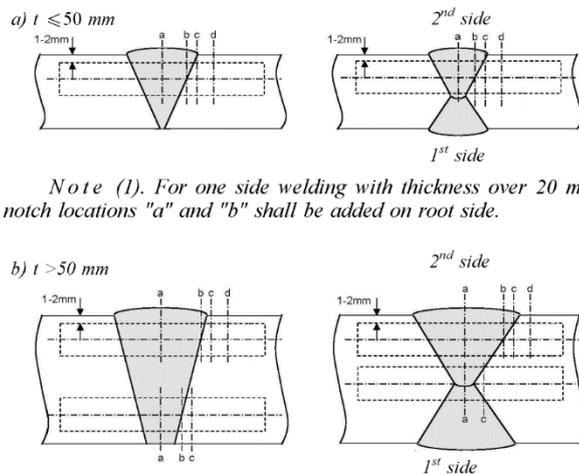


Fig. 6.4.4.4-3

Location of V-notch for butt weld of high heat input (heat input  $> 50$  kJ/cm):

- a — notch in centre of weld (WM);
- b — notch on fusion line (FL);
- c — notch in HAZ, 2 mm from fusion line (FL + 2);
- d — notch in HAZ, 5 mm from fusion line (FL + 5);
- e — notch in HAZ, 10 mm from fusion line (FL + 10)



Note (1). For one side welding with thickness over 20 mm notch locations "a" and "b" shall be added on root side.

Fig. 6.4.4.4-4

Location of V-notch for butt weld of high strength steels:

- a — notch in centre of weld (WM);
- b — notch on fusion line (FL);
- c — notch in HAZ, 2 mm from fusion line (FL + 2);
- d — notch in HAZ, 5 mm from fusion line (FL + 5)

#### 6.4.4.5 Hardness test.

Hardness test is required in approval of welding procedures for hull structural steels with a specified minimum yield strength  $R_{eH} \geq 355$  MPa, and also for high-strength steels of all grades.

The results from the hardness test shall not exceed the following:

for welded joints in pipes made of steels with  $C_{eq} > 0,41$  %;

for welded joints in forgings and castings made of steels of sub-group 1.1 (refer to Table 4.3.3.1-1) with the carbon content  $C > 0,18$  % and thickness of welded elements  $t > 40$  mm;

for welded joints in steels of sub-groups 1.2 ( $R_{eH} = 360$  MPa), 1.3, 1.4 steels, and also in groups 2 — 7 and 9 — 11 (refer to Table 4.3.3.1-1).

The Vickers hardness of the welded joint metal (HV10) shall be determined with the use of macro test specimens in accordance with Figs. 6.4.4.5-1 — 6.4.4.5-6. In so doing, the hardness of each welded joint zone (weld, heat-affected zone, base metal) shall be determined on the basis of at least three indentations (measurements) on both sides of the weld axis. The first indentation in the heat-affected zone shall be made as close to the fusion line as possible. The distance between the centre points of the indentations shall be at least 1,0 mm for scale HV10.

For EH47 steel and steel with indices "BCA1" and "BCA2", measurement points shall include mid-thickness position in addition to the points specified in Figs. 6.4.4.5-1 — 6.4.4.5-6.

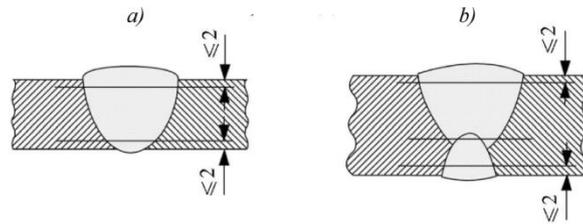


Fig. 6.4.4.5-1  
Examples of hardness test with rows of indentations in butt welds:  
a — butt weld from one side only, both single and multirun;  
b — butt weld from both sides, both single and multirun

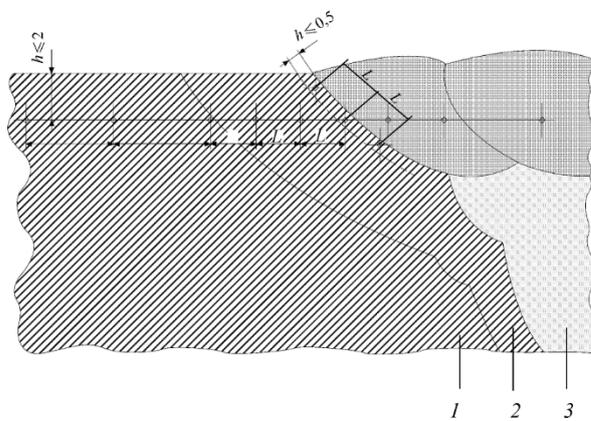


Fig. 6.4.4.5-2  
Example showing the position of the indentations for hardness test in butt welds:  
1 — base metal outside HAZ;  
2 — HAZ; 3 — weld metal;  
 $L$  — distance between the centre points of the indentations:  
in HAZ  $L \geq 1,0$  mm for HV10 and  $L \geq 0,7$  mm for HV5

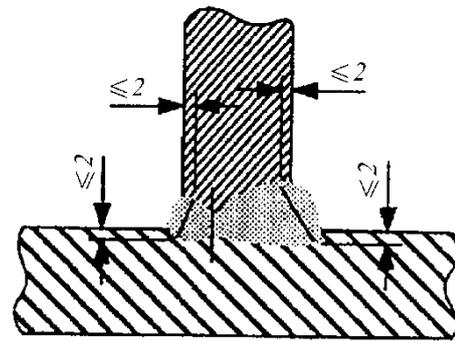


Fig. 6.4.4.5-3  
Examples of hardness test with row indentation in T-joint welds with full penetration

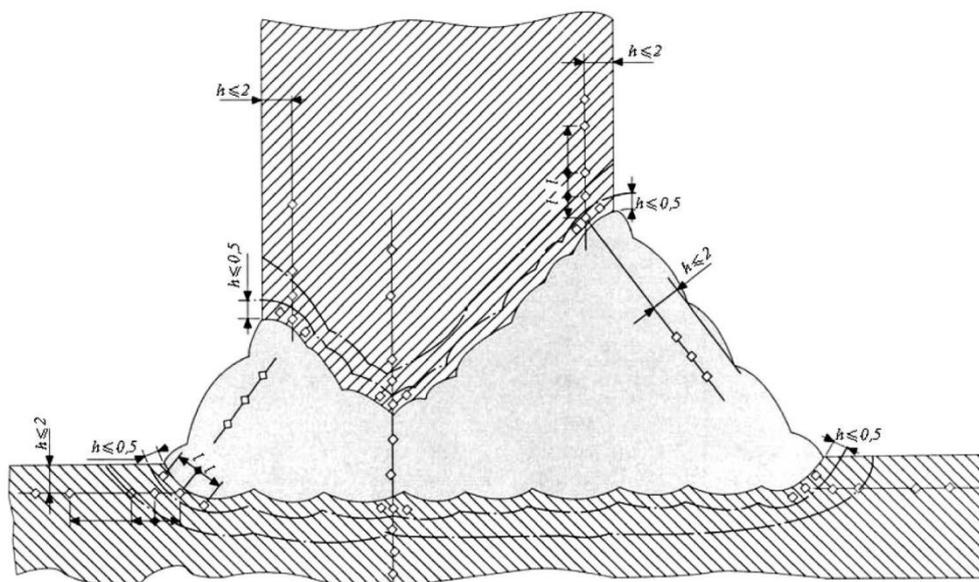


Fig. 6.4.4.5-4

Example showing the position of the indentations for hardness test in T-joint welds with full penetration

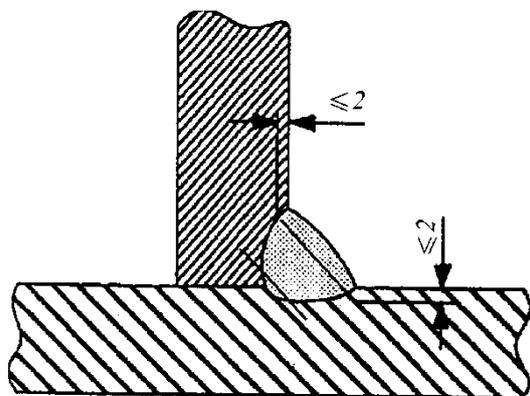


Fig. 6.4.4.5-5

Examples of hardness test with row indentation in fillet welds and in T-joint welds without edge preparation

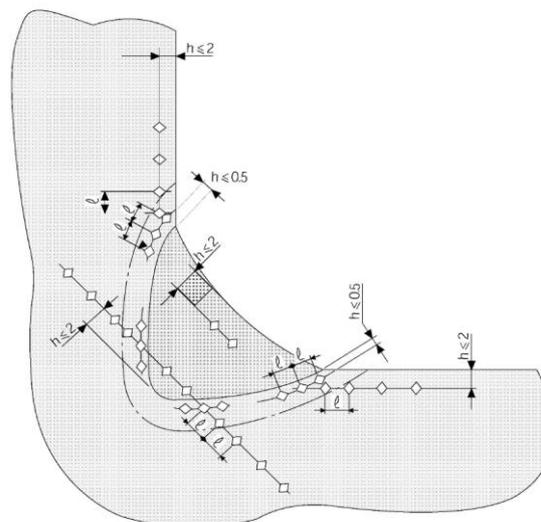


Fig. 6.4.4.5-6

Example showing the position of the indentations for hardness test in fillet welds and in T-joint welds without edge preparation

#### 6.4.4.6 Macro examination.

The test specimens shall be ground and etched on one side to clearly reveal the weld metal, the fusion line and the heat-affected zone.

Macro examination shall include weld, HAZ and about 10 mm unaffected base metal.

The microstructure of welded joints shall be examined only if deemed necessary by the Register, and the requirements for test procedure and results evaluation are subject to agreement in each particular case.

**6.4.4.7** Requirements for estimation of mechanical test results.

**6.4.4.7.1** The tensile strength value when testing transverse tensile specimens of butt-welded joints made of normal, higher and high strength hull structural steels shall not be less than the values given in [Table 6.4.4.7.1](#). In other cases the tensile strength value determined during testing shall not be less than the values stated in Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships or in the Register recognized national/international standards for the relevant base metal considering its thickness.

Table 6.4.4.7.1

**Test result requirements for specimens of welded joints of normal, higher and high strength steel**

Grade of welded steel	Tensile test, min				Bend test <sup>1</sup>		Hardness test HV10, max
	Transverse specimens, $R_m$ , in MPa	Longitudinal round specimens			Mandrel diameter $D$	Bending angle, $\alpha$ , in deg.	
$R_m$ , in MPa		$R_{eH}$ , in MPa	$A_5$ , in %				
A — E	400	400 — 560	305	22	$4t$	180	Not standardized
A32 — F32	440	490 — 660	375	22	$4t$	180	Not standardized
A36 — F36	490	490 — 660	375	22	$4t$	180	350
A40 — F40	510	510 — 690	400	22	$4t$	180	350
A420 — F420(W)	530	530 — 680	420	20	$5t$	180	350
A460 — F460(W)	570	570 — 720	460	20	$5t$	180	420
EH47	570	570 — 720	460	19	$5t$	180	350
A500 — F500(W)	610	610 — 770	500	18	$5t$	180	420
A550 — F550	670	670 — 830	550	18	$6t$	180	420
A620 — F620	720	720 — 890	620	18	$6t$	180	420
A690 — F690	770	770 940	690	17	$6t$	180	420

<sup>1</sup>  $t$  is the thickness of a bend test specimen.

For dissimilar welded joints the tensile strength shall not be less than the minimum value specified for the material having the lowest tensile strength.

When proportional longitudinal round specimens are tested, the values of mechanical properties of the weld metal shall meet the requirements of Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships for the relevant grades of welding consumables, and also shall correspond to the values given in [Table 6.4.4.7.1](#).

**6.4.4.7.2** During bend testing the ratio of mandrel diameter to specimen thickness ( $D/t$ ) shall be increased by 1,0 relative to the values stated in Section 4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships for the approval of the relevant grades of welding consumables ([refer to Table 6.4.4.7.1](#)). In cases not specified in [Table 6.4.4.7.1](#) the following requirements shall be met:

the diameter of the former or the inner roller  $D$  shall be equal to  $4t$  for steels with nominal elongation  $A_5 \geq 20$  %;

for the base metal with elongation  $A_5 < 20$  % the following formula shall be applied:

$$D = \frac{(100 \times t)}{A_5} - t,$$

where  $D$  = diameter of the former or the inner roller, in mm;

$t$  = thickness of the bend test specimen, in mm;

$A_5$  = minimum tensile elongation required by material specification (nominal value), in %.

The tests shall be carried out until the bending angle of 180° is reached. After testing, the test specimens shall not reveal any open defects in any direction greater than 3 mm. Defects

appearing at the corners of a test specimen during testing shall be investigated and evaluated case by case.

The longitudinal bend test results are subject to agreement with the Register in each particular case. In so doing, the above ratios relative to the material with the lower value of nominal elongation  $A_5$  are recommended to be assumed as the basis.

**6.4.4.7.3** During testing of T-joint welds for static fracture, the specimen's fracture surface shall be inspected for the presence of inadmissible internal defects (pores and porosity, slag inclusions, lack of fusion and cracks), the value of fusion in the root weld shall also be checked. Imperfections that are detected shall be evaluated in accordance with ISO 5817 (EN 25817), quality level B.

**6.4.4.7.4** For welded joints of the normal, higher and high strength steels the requirements for impact test results shall comply with the requirements of [Table 6.4.4.7.4](#).

Table 6.4.4.7.4

**Impact test requirements for butt joints of normal, higher and high strength steels ( $t \leq 50$  mm)<sup>1</sup>**

Grade of steel	Value of minimum average absorbed energy on weld, KV, in J				Value of minimum average absorbed energy on fusion line and in heat affected zone, KV, in J					
	Testing temperature, in C°	Electrodes and combinations for semi-automatic welding		Combinations for automatically welded joints	Testing temperature, in C°	KV <sub>T</sub>	KV <sub>L</sub>			
		Downhand, horizontal and overhead positions	Vertical position							
A	+20	47	34	34	+20	-	27 <sup>1,2</sup>			
B	0				0					
D	0				0		47 <sup>1,2</sup>			
E	-20				-20					
A32, A36	+20				+20		47 <sup>1,2</sup>			
D32, D36	0				0					
E32, E36, E36BCA1, E36BCA2	-20				-20					
F32, F36	-40				-40					
A40	+20				39		39	+20	-	47 <sup>1,2</sup>
D40	0							0		
E40, E40BCA1, E40BCA2	-20	-20								
F40	-40	-40								
A420, A420W	-20	42	42	0		28		42 <sup>3</sup>		
D420, D420W	-20			-20						
E420, E420W	-40			-40						
F420, F420W	-60			-60						
A460, A460W	-20			47	46		0		31	46 <sup>3</sup>
D460, D469W	-20	-20								
E460, E460W	-40	-40								
F460, F460W	-60	-60								
EH47	-20	64	64			64	-	64		
A500, A500W	-20	50	50	50	0	33	50 <sup>3</sup>			
D500, D500W	-20				-20					
E500, E500W	-40				-40					
F500, F500W	-60				-60					
A550	-20				55			55	55	0
D550	-20	-20								
E550	-40	-40								
F550	-60	-60								

Grade of steel	Value of minimum average absorbed energy on weld, KV, in J				Value of minimum average absorbed energy on fusion line and in heat affected zone, KV, in J		
	Testing temperature, in C°	Electrodes and combinations for semi-automatic welding		Combinations for automatically welded joints	Testing temperature, in C°	KV <sub>T</sub>	KV <sub>L</sub>
		Downhand, horizontal and overhead positions	Vertical position				
A620	-20	62	62	62	0	41	62 <sup>3</sup>
D620	-20						
E620	-40						
F620	-60						
A690	-20	69	69	69	0	46	69 <sup>3</sup>
D690	-20						
E690	-40						
F690	-60						

<sup>1</sup> For rolled product thickness above 50 mm impact test requirements shall be specified with due regard for Table 3.2.2.-1, Table 3.2.3, Table 3.5.2.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and be subject to additional agreement with the Register.

<sup>2</sup> In accordance with 3.2.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, in general, the impact tests of delivered steel shall be performed on longitudinal (KV<sub>L</sub>) specimens only (test results on transverse specimens shall be guaranteed by the manufacturer), unless otherwise stated by the customer and agreed by the Register.

<sup>3</sup> In accordance with 3.13.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, unless otherwise specified by the Register, the impact tests of high strength steel plates and wide flats of more than 600 mm in width shall be performed on transverse (KV<sub>T</sub>) specimens. Where rolled products of another cross-sectional shape are concerned, the impact tests shall be performed on longitudinal (KV<sub>L</sub>) specimens.

For the joints between different steel grades/types, the test specimens shall be taken from the side of the joint with the lower toughness of steel. Temperature and absorbed energy results shall comply with the requirements for the lower toughness steel.

Where more than one welding process or consumable has been used to make the test weld, impact test specimens shall be taken from the respective areas where each was employed. This shall not apply to the process or consumables used solely to make the first weld run or root deposit.

The testing of sub-size specimens shall be carried out in compliance with the requirements of 2.2.3.1, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. In special cases, when designation of the consumables quality grade does not comply with the requirements of Table 2.2.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships (e.g., for MODU and FOP structures), the absorbed energy and test temperature shall comply with the requirements of Section 4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships for respective consumable quality grade, relative to the weld metal and fusion line, while for the metal of heat-affected zone it shall comply with the requirements of 3.2 and 3.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships for steel of respective grade considering the direction of rolled product at specimen welding. At that, for steel welded joints of grade F, the Register may require testing of the additional specimen series, having notch located on the heat-affected zone at a distance of 5 mm from the fusion line, regardless of the heat input of welding ([refer to Fig. 6.4.4.4-4](#)).

For steel castings and forgings the impact tests for the fusion line and the heat-affected zone shall be carried out in compliance with the requirements for the base metal of 3.7 and 3.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Tests for the weld metal are conducted relative to the consumable quality grade, prescribed in the documentation approved by the Register for a particular item or structure.

For corrosion resistant steels, impact tests at approval of welding procedures shall be conducted on agreement with Register, in case this type of testing is provided for the base metal by the rules or the documentation approved by the Register for a particular product (for example, for propeller castings of corrosion resistant steels in compliance with the requirements of 3.12, Part XIII "Materials"). Unless otherwise agreed with the Register, the temperature and estimation criteria for the impact test results shall comply with the values specified for the base metal.

**6.4.4.7.5** The results from the hardness test shall meet the following requirements:

for higher and high strength hull structural steels the maximum values of hardness shall not exceed the values given in [Table 6.4.4.7.1](#);

in other cases, unless otherwise specified in a contract documentation, the requirements of ISO 15614-1 given in [Table 6.4.4.7.5](#) shall be met.

Table 6.4.4.7.5

**Permitted maximum hardness values (HV 10)**

Steel groups according to ISO/TR 15608	Non-heat treated	Heat treated
1 <sup>1,2</sup>	380	320
3 <sup>2</sup>	450	380
4, 5	380	320
6	–	350
9.1	350	300
9.2	450	350
9.3	450	350

<sup>1</sup> If hardness tests are required ([refer to 6.4.4.5](#)).

<sup>2</sup> For steels with min  $R_{eH} > 890$  MPa special values shall be specified.

**6.4.4.7.6** Macro examination shall include regular weld profile and reveal the following:  
 cracks;  
 incomplete penetration;  
 lack of fusion;  
 inadmissible undercuts;  
 inadmissible internal defects (pores and slag inclusions).

The imperfections revealed shall be evaluated in compliance with the requirements of [6.4.3](#).

**6.4.4.8 Cold cracking test.**

**6.4.4.8.1** The test weld shall be visually tested and measured for surface cracks in accordance with ISO 17637 (inspection class is not regulated). If there are any visible surface cracks, the test is considered failed. If no cracks are found, then the weld test specimens shall be examined on macrosections.

*Note.* If it is not possible to identify the visible defect as a crack, then the weld test specimens shall be further examined on macrosections.

**6.4.4.8.2** Surfaces of macrosections shall be prepared in accordance with [6.4.4.6](#) and inspected for any possible cracks. The inspection shall be carried out using optical instruments of at least  $\times 50$  magnification. The conclusion that the specimens have no cracks shall be confirmed with the use of magnification of at least  $\times 200$ . 3 options for inspection results are possible as follows:

- .1 no cracks are found on macro-sections, the test is considered to have satisfactory results;
- .2 cracks with a length of under 0,5 mm inclusive are found on macrosections, the test is considered to have satisfactory results;
- .3 cracks with a length over 0,5 mm are found on macrosections, the test is considered to have unsatisfactory results;

**Note.** If the first and the last test specimens have cracks in the sections which are closest to the anchor welds, it is necessary to perform visual evaluation of the deposited weld metal area of the specified test specimen, which shall not be significantly smaller than the area of the deposited weld metal cross-section at the opposite side. Otherwise, the test specimen at the side of the cross-section with a smaller deposited metal area shall be re-grinded up to the area close to the opposite side weld area and shall be re-checked for cracks.

**6.4.4.8.3** If tests are failed, the welding technology in the pWPS shall be amended. When making amendments to the welding technology, the cold cracking tests shall be repeated.

**Note.** The increased resistance to cold cracking can be achieved through preheating, increasing the welding heat input, using "softer" formable welding materials, etc.

When choosing a preheat temperature, it is allowed to follow:

- .1 [Table 6.4.4.8.3](#);
- .2 metal welding recommendations of the British Standard EN 1011-2, which includes impact on the preheating temperature ( $T_p$ ), carbon equivalent (CET), plate thickness ( $d$ ), diffusion hydrogen content in the weld metal (HD), and the welding heat input ( $Q$ ) by the following formula:

$$T_p = 697 \times CET + 160 \times tg(d/35) + 62 \times HD_{0,35} + (53 \times CET - 32) \times Q - 328 \text{ (}^\circ\text{C)}.$$

This ratio is valid for structural steels with the following parameters:

YS up to 1000 MPa;

CET = from 0,2 to 0,5 %;

$d$  = from 10 to 90 mm;

HD = from 1 to 20 ml/100 g;

$Q$  = from 0,5 to 4,0 kJ/mm.

When setting the preheating temperature according to the recommendations given, the lowest temperature shall be selected from the two ones. If unsatisfactory results are obtained from tests (specimen cracks), it is necessary to increase the preheating temperature up to the inter-roll temperature in accordance with the pWPS.

Table 6.4.4.8.3

**Preheating temperature requirements for high strength steel welding**

Welded steel grade	Metal thickness, mm	Ambient air temperature, °C	Diffusion hydrogen content in the deposited metal, cm <sup>3</sup> /100g	Minimal preheating temperature, °C
(A/F)690	Up to 130	From 0 and above	Up to 3,0 (H3)	80
			Above 3,0 up to 5,0 (H5)	100
		From 0 to -10	Up to 3,0 (H3)	120
			Above 3,0 up to 5,0 (H5)	130
From -11 to -15	Up to 3,0 (H3)	Following the manufacturer's recommendations agreed by RS		

Welded steel grade	Metal thickness, mm	Ambient air temperature, °C	Diffusion hydrogen content in the deposited metal, cm <sup>3</sup> /100g	Minimal preheating temperature, °C
(A/F)690 and (A/F)550	Up to 40	From 0 and above	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5)	40 60
		From 0 to -15	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5)	80 100
		From -16 to -20	Up to 3,0 (H3)	Following the manufacturer's recommendations agreed by RS
	41-100	From 0 and above	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5)	60 100
		From 0 to -15	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5)	120 120
		From -16 to -20	Up to 3,0 (H3)	Following the manufacturer's recommendations agreed by RS
(A/F)500	Up to 40 inclusive	From 0 and above	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5) Above 5,0 up to 10,0 (H10)	Without heating 40 60
		Below 0 down to -15	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5)	60 80
		Below -15 down to -20	Up to 3,0 (H3)	100
	Above 40 up to 100 inclusive	From 0 and above	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5)	60 80
		Below 0 down to -15	Up to 3,0 (H3) Above 3,0 up to 5,0 (H5)	80 100
		Below -15 down to -20	Up to 3,0 (H3)	Following the manufacturer's recommendations agreed by RS

**Notes:** 1. The Table establishes the minimum level of requirements for preheating temperature and interpass temperature for hardened and tempered steel in terms of cold crack susceptibility.  
 2. For steels of categories (A/F)500, manufactured using thermomechanical processing with accelerated cooling and having  $C_{eqv} \leq 0,41$  %, lower heating temperatures and interpass temperatures are allowed.  
 3. Actual values of preheating temperatures and interpass temperature shall be approved by the Register on the basis of tests for approving of welding procedures, including control of all the limiting parameters of a specific project (maximum hardness of the heat-affected zone, weld, etc.).  
 4. Preheating is regulated for welding methods with a heat input value not exceeding 3,5 kJ/mm.  
 5. Welding of steels with a yield strength of above 690 MPa is carried out at positive temperatures (above 0°C), if welding is carried out at negative temperatures (from 0 °C to -10 °C) with low-alloyed welding materials, the values of the minimum preheating temperature increase by 50 °C. At temperatures from -10 °C to -25 °C, welding is carried out only with austenitic welding materials with edge preheating for at least 40 °C.

## 6.5 REQUIREMENTS FOR RE-TESTING

**6.5.1** If the test piece fails to comply with any of the requirements for non-destructive testing one further test piece shall be prepared and subjected to the same examination. If the additional test piece 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 any test specimen fails to comply with the relevant requirements for mechanical tests due to weld imperfections only, two further test specimens for each one that failed shall be prepared and subjected to the same test. The specimens for re-testing can be taken from the same test piece if there is sufficient material available or from a new test piece. If either of these additional test specimens does not comply with the relevant requirements, the pWPS and the welding procedure are considered unsuitable for use in production without modifications ensuring the required quality of welded joints.

**6.5.3** If a tensile 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 piece if there is sufficient material available or from a new test piece. When both additional specimens have demonstrated satisfactory test results, the common result of the tensile tests is considered positive. If one or both additional specimens have failed at retesting, the pWPS and the welding procedure are considered unsuitable for use in production without modifications ensuring the required quality of welded joints.

**6.5.4** If there is a single hardness value for a welded joint metal above the maximum values specified by the requirements of [6.4.4.7.5](#), additional hardness tests shall be carried out (on the reverse of the macrosection or after sufficient grinding of the tested surface). The results of the additional tests are considered positive, if none of the hardness values for the welded joint metal does not exceed the specified maximum ones. Otherwise the pWPS and the welding procedure are considered unsuitable for use in production without modifications ensuring the required quality of welded joints.

**6.5.5** If a test piece is rejected due to the hardness test results (there is more than a single hardness value for a welded joint metal above the maximum values specified by the requirements of [6.4.4.7.5](#)), the re-testing shall be carried out on a doubled number of specimens. The specimens for re-testing are taken in compliance with the requirements of [6.5.2](#).

**6.5.6** 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 further set of three specimens shall be carried out with the results estimation according to 1.3.2.3.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. 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 — 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.**

**6.6.1.1** 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.

**6.6.1.2** All the conditions of validity stated below shall be met independently of each other.

**6.6.1.3** 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. In this case the manufacturer who performed the welding procedure qualification test retains complete responsibility for all welding carried out to it.

**6.6.1.4** Shop primers may have an influence on the quality of fillet welds and shall be considered in specifying the range of approval. Range of approval for the qualification tests on test pieces with shop primer on the edges to be welded will qualify the welding procedure with the dressing of the edges to be welded, but not vice versa.

**6.6.1.5** Permanent backing material shall be considered as a base metal within the range of approval in compliance with the requirements of [6.6.2.1](#).

**6.6.1.6** Approved welding procedures for steel without indices "BCA1" and "BCA2" are applicable to the same welding procedures applied to the same grade with index "BCA1" or "BCA2", except high heat input processes over 50 kJ/cm.

### **6.6.2 Requirements for the range of approval related to base metal.**

**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 applicable 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 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 thermo-mechanically rolled steels (TM steels) and vice versa;

**.4** for austenitic stainless steels, when specifying the range of the procedure approval, the welding shall be performed at high heat input not exceeding 35 kJ/cm.

**6.6.2.1.3 Steel forgings.**

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 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, 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 approval of quenched and tempered hull steel forgings does not quality other delivery conditions and vice versa.

**6.6.2.1.4 Steel castings.**

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 3.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, the following requirements shall be met:

- .1 the range of approval is considered applicable to the castings with the same and lower strength level as that tested;
- .2 the approval of quenched and tempered hull steel castings does not quality 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 ISO 15614-1 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 ISO/TR 15608 is subdivided into groups given in [Table 4.3.3.1-1](#).

The tests conducted with the use of particular steel belonging to one of those groups given in [Table 4.3.3.1-1](#) obtain the range of approval as specified in [Table 6.6.2.1.5](#).

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).

Table 6.6.2.1.5

<b>Range of approval for steel groups and sub-groups</b>	
Steel group according to ISO/TR 15608	Range of approval
1 — 1	$1^1 — 1$
2 — 2	$2^1 — 2, 1 — 1, 2^1 — 1$
3 — 3	$3^1 — 3, 1 — 1, 2 — 1, 2 — 2, 3^1 — 1, 3^1 — 2$
4 — 4	$4^2 — 4, 4^2 — 1, 4^2 — 2$
5 — 5	$5^2 — 5, 5^2 — 1, 5^2 — 2$
6 — 6	$6^2 — 6, 6^2 — 1, 6^2 — 2$
7 — 7	$7^3 — 7$
7 — 3	$7^3 — 3, 7^3 — 1, 7^3 — 2$
7 — 2	$7^3 — 2^3, 7^3 — 1$
8 — 8	$8^2 — 8$
8 — 6	$8^3 — 6^2, 8^3 — 1, 8^3 — 2, 8^3 — 4$
8 — 5	$8^3 — 5^2, 8^3 — 1, 8^3 — 2, 8^3 — 4, 8^3 — 6.1, 8^3 — 6.2$
8 — 3	$8^3 — 3^1, 8^3 — 1, 8^3 — 2$
8 — 2	$8^3 — 2^1, 8^3 — 1$
9 — 9	$9^2 — 9$
10 — 10	$10^2 — 10$
10 — 8	$10^2 — 8^3$
10 — 6	$10^2 — 6^2, 10^2 — 1, 10^2 — 2, 10^2 — 4$
10 — 5	$10^2 — 5^2, 10^2 — 1, 10^2 — 2, 10^2 — 4, 10^2 — 6.1, 10^2 — 6.2$
10 — 3	$10^2 — 3^1, 10^2 — 1, 10^2 — 2$

Steel group according to ISO/TR 15608	Range of approval
10 — 2	$10^2 — 2^1, 10^2 — 1$
11 — 11	$11^2 — 11, 11^2 — 1$

<sup>1</sup> Range of approval covers the equal or lower specified yield strength steels of the same group.  
<sup>2</sup> Range of approval covers steels in the same sub-group and/or any lower (for alloying level) sub-group within the same group.  
<sup>3</sup> Range of approval covers steels in the same sub-group.

Notes: 1. A separate approval procedure is required for each steel or their combinations not covered by the grouping system according to [Table 4.3.3.1-1](#).  
2. If a particular steel used in testing belongs to two groups or sub-groups, then specifying the range of approval it shall be classified in the lower group/sub-group (for a yield strength level or alloying elements content).  
3. If the dissimilar joint is not covered by the grouping system according to [Table 6.6.2.1.5](#), the range of approval and test program shall be agreed with the Register.

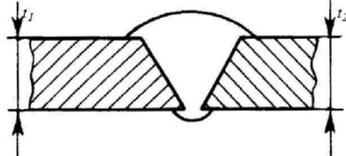
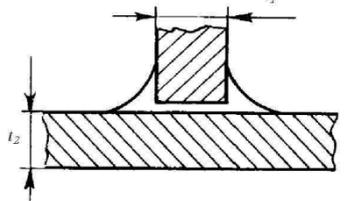
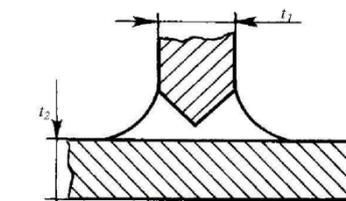
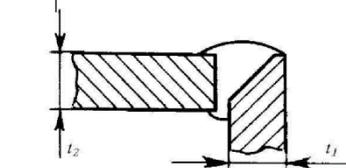
**6.6.2.2 Base metal thickness and pipe diameter.**

**6.6.2.2.1** For single welding procedure 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 piece metal in qualification tests shall be specified in compliance with the requirements of [Table 6.6.2.2.2](#).

Table 6.6.2.2.1

**Determination of base metal nominal thickness**

Item	Type of joint Sketch <sup>1</sup>	Nominal thickness of base metal $t$
1. Butt joint in plates and pipes		$t$ corresponds to the size of the thinner part for joints of unequal thickness: $t = \min\{t_1 \text{ and } t_2\}$ for $t_1 \neq t_2$ , $t = t_1 = t_2$ for $t_1 = t_2$
2. Fillet weld in plates		$t$ corresponds to the size of the thicker part for joints of unequal thickness: $t = \max\{t_1 \text{ and } t_2\}$ for $t_1 \neq t_2$ , $t = t_1 = t_2$ for $t_1 = t_2$
3. T-joint and corner joint in plates	<p>a) </p> <p>b) </p>	<p>a) For T-joints <math>t</math> is assumed equal to the thickness of the part with full penetration (with edge preparation): <math>t = t_1</math>  b) For corner joints <math>t</math> is assumed equal to the thickness of the thinner part:  <math>t = \min\{t_1 \text{ and } t_2\}</math> for <math>t_1 \neq t_2</math>,  <math>t = t_1 = t_2</math> for <math>t_1 = t_2</math></p>

Type of joint		Nominal thickness of base metal $t$
Item	Sketch <sup>1</sup>	
4. T-joint in pipes for a seton branch connection (with or without edge preparation)		$t$ is assumed equal to the wall thickness of pipe to be welded: $t = t_2$
5. Corner and T-joints in pipes for a set-in or set-through branch connection (with or without edge preparation)		$t$ is assumed equal to the wall thickness of pipe to be welded: $t = t_2$

Table 6.6.2.2.2

**Approval range of base metal thickness  $t$  for butt and T-joint welds and fillet welds**

Thickness of test pieces in qualification tests $t$ , in mm <sup>1</sup>	Range of approval <sup>2</sup>	
	Butt and T-joint welds with single run or single run from both sides	Butt and T-joint welds with multirun and fillet welds <sup>3</sup>
$t \leq 3$	from $t$ to $1,1t$ inclusive	from $t$ to $1,5t$ inclusive
$3 < t \leq 12$	from $0,7t$ to $1,1t$ inclusive	from 3 to $2t$ inclusive
$12 < t \leq 100$	from $0,7t$ to $1,1t$ inclusive <sup>4</sup>	from $0,5t$ to $2t$ inclusive (max. 150 mm)
$t > 100$	—	from $0,5t$ to $2t$ inclusive

<sup>1</sup> For multi process procedures, the recorded thickness contribution of each process shall be used as a basis for the range of approval for the individual welding process (similar to the requirements stated in [Table 4.5.2](#)).  
<sup>2</sup> During certification tests on the Tekken test piece, the range of approval is limited to 3 to  $1,0t$  inclusive.  
<sup>3</sup> For fillet welds without edge preparation, the range of approval shall be applied to both base metals.  
<sup>4</sup> For high heat input processes over 50 kJ/cm, the upper limit of range of approval shall be up to  $1,0t$  inclusive.

**6.6.2.2.3** In addition to the requirements of [Table 6.6.2.2.2](#), the limitations stated below apply to the range of approval for fillet weld throat thickness depending on its value  $a$  in qualification tests:

for single run welds:  $0,75a$  —  $1,5a$ , inclusive;

for multirun welds: as for butt welds with multirun (i.e.  $a = t$ );

for vertical-down welding: the upper limit of the range of approval is equal to  $1a$ , inclusive.

**6.6.2.2.4** For vertical-down welding the range of approval in all cases (for multirun welds, and also for single run or single run from both sides) is restricted by the upper limit for base metal thickness up to  $1,0t$ , inclusive.

**6.6.2.2.5** Range of approval for vertical-down welding procedures is restricted in all cases (for single and multirun welds) by the upper limit for throat thickness of a fillet weld up to 1,0a, inclusive.

**6.6.2.2.6** Notwithstanding the above, the approval of maximum thickness of base metal for any technique shall be restricted to the thickness  $t$  of test piece if three of the hardness values in the heat-affected zone are found to be within 25HV of the maximum permitted, as stated in [6.4.4.7.5](#).

**6.6.2.2.7** In parallel with standardization of the range of approval for throat thickness of fillet welds, there are also limitations on the range of approval for the availability of shop primer ([refer to 6.6.1.4](#)).

**6.6.2.2.8** Where a fillet weld without edge preparation is qualified by means of a butt weld test, the range of approval for fillet weld throat thickness shall be based on the thickness of the deposited metal within the range of approval specified in [Table 6.6.2.2.2](#) for the relevant welding procedure (single and multirun welds).

**6.6.2.2.9** 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 [Table 6.6.2.2.9](#).

Table 6.6.2.2.9

<b>Range of approval for outside diameter of welded pipes</b>	
Diameter of test pieces in qualification tests $D$ , in mm <sup>1,2</sup>	Range of approval for diameters of welded pipes, in mm
$D \leq 25$	from 0,5D to 2D
$D > 25$	from 0,5D and plates but not less than 25
<sup>1</sup> $D$ is the outside diameter of the pipe or outside diameter of the branch pipe. <sup>2</sup> Qualification given for plates also covers pipes when the outside diameter is > 500 mm ( <a href="#">refer to Table 6.6.3.2</a> ).	

**6.6.2.2.10** A welding procedure test carried out on a branch connection with angle  $\alpha$  shall qualify all branch angles  $\alpha_1$  in the range of  $\alpha \leq \alpha_1 \leq 90^\circ$ .

**6.6.3 General requirements for the range of approval related to welding procedure.**

**6.6.3.1** Welding process and welding type.

The approval is only valid for the welding process and welding type used in the welding procedure qualification test.

Each degree of the welding mechanization shall be qualified independently (manual, partly mechanized, fully mechanized and automatic). In the same way, it is not allowed to change the means of the welding mechanization implementation (manual, partly mechanized, fully mechanized or automated) unless newly qualified.

For multi-process procedures the welding procedure approval may be carried out with separate welding procedure tests for each welding process and with a multi-process procedure test similarly to approval tests for welders. In this case, the relevant range of approval according to weld metal thickness for each welding process used shall be specified. The approval of such a test is only valid for the process sequence carried out during the multi-process procedure test.

Note. It is not allowed to use a multi-process procedure test to qualify any single process.

**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 pieces 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 piece within the scope of the requirements specified in [6.4.1.1](#).

Table 6.6.3.2

Range of approval for welding procedures according to welding positions

Type of welding the test piece <sup>1</sup>	Weld position of the test piece <sup>2</sup>	Range of approval according to welding positions <sup>2</sup>			
		Butt welds		Fillet welds	
		Plates	Pipes	Plates	Pipes
Butt welds in plate	PA	PA	PA3	PA	PA3
	PC	PC	PC3	PB	PA3, PB3, PD3
	PG	PG	–	PG	–
	PF	PF	–	PF	–
	PE	PE	–	PD	PA3, PD3
	PC+PF	All except for PG	All except for PG3	All except for PG	All except for PG3
Butt welds in pipe	PA	PA	PA	PA	PA
	PC	PC	PA, PC	PB	PA, PB, PD
	PG	PG	PG	PG	–
	PF	PA, PC, PE	PA, PF	PA, PB, PD	PA, PB, PD
	PC+PF or H-LO45	All except for PG	All except for PG	All except for PG	All except for PG
Fillet welds in plate (no beveling)	PA	–	–	PA	PA3
	PB			PB	PA3, PB3, PD3
	PF			PF	–
	PG			PG	–
	PD			PD	PA3, PB3, PD3
	PB+PD			All except for PG	All except for PG3
Fillet welds in pipe (no beveling)	PA	–	–	PA	PA
	PB			PB	PA, PB, PD
	PG			PG	PG
	PD			PD	PA, PB, PD
	PF			All except for PG	All except for PG

<sup>1</sup> Branch connections are subject to separate qualification tests.  
<sup>2</sup> Designations of welding positions comply with ISO 6947.  
<sup>3</sup> Pipes with outside diameter  $D > 500$  mm are considered equivalent to plates according to the range of approval (not applicable to branch connections).

**6.6.3.3 Type (of welded joint).**

Range of approval for the types of welded joints shall be, as used in the welding procedure qualification tests, subject to the requirements of [Table 6.6.3.3](#) and the limitations stated below:

- .1 range of approval for full penetration butt welds qualifies full and partial penetration butt welds, as well as fillet welds. Qualification tests for fillet welding shall be required in cases specified by the requirements of [6.3.1.4](#);
- .2 range of approval for butt joints in pipes may also qualify branch connections with an angle  $\alpha_1 \geq 60^\circ$ ;
- .3 range of approval for T-joints butt welded with edge preparation only qualifies this type of joints and fillet welds;
- .4 range of approval for butt welds made from one side without backing qualifies welds with backing and welds made from both sides;
- .5 range of approval for butt welds made with backing qualifies welds made from both sides;
- .6 range of approval for welds made from both sides without gouging qualifies welds made from both sides with gouging;
- .7 range of approval for fillet welding qualifies this type of joint only;
- .8 it is not permitted to change a multirun deposit into a single run (or single run on each side) or vice versa for a given process.

Table 6.6.3.3

Range of approval of welding procedures by types of welded joints

Type of welded test assembly in tests for approval			Range of approval												
			Plates (P)										Pipes (T) <sup>1</sup>		
			Butt welds (BW)				T-joints (TW)				Fillet bead welds without beveling (F)	Butt welds		Fillet joints (F)	
			Single side welding		Both side welding		Single side welding		Both side welding			Single-side welding	Fillet joints (F)		
with backings (A)	without backings (B)	with gouging (C)	without gouging (D)	with backings (A)	without backings (B)	with gouging (C)	without gouging (D)	with backings (A)	without backings (B)						
Butt weld of plates	Single side welding	with backings (A)	*	–	x	–	–	–	–	–	–	x	–	–	x
		without backings (B)	x	*	x	x	–	–	–	–	–	–	x	–	–
	Both side welding	with gouging (C)	–	–	*	–	–	–	–	–	–	x	–	–	x
		without gouging (D)	–	–	x	*	–	–	–	–	–	x	–	–	x
Butt weld of pipes	Single side welding	with backings (A)	x	–	x	–	–	–	–	–	–	x	*	–	x
		without backings (B)	x	x	x	x	–	–	–	–	–	x	x	*	x
T-joint with edge preparation (TW)	Single side welding	with backings (A)	–	–	–	–	*	–	x	–	x	x	–	–	x
		without backings (B)	–	–	–	–	x	*	x	x	x	x	–	–	x
	Both side welding	with gouging (C)	–	–	–	–	–	–	*	–	x	x	–	–	x
		without gouging (D)	–	–	–	–	–	–	x	*	x	x	–	–	x
Fillet (gauge) weld (F)	Plates (P)		–	–	–	–	–	–	–	–	–	*	–	–	x
	Pipes (T)		–	–	–	–	–	–	–	–	–	x	–	–	*

<sup>1</sup> Pipes with outside diameter  $D > 500$  mm shall be considered similar to the plates by ranges of approval (unacceptable to branch connections).

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.

**6.6.3.4** Welding consumables.

**6.6.3.4.1** Grades of welding consumables.

Range of approval for high heat input processes up to 50 kJ/cm, inclusive, based on qualification testing the particular brand of the welding consumable approved by the Register, complying with the requirements of 4.3 — 4.7, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships, 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 4.1.2.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. 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, if agreed with the Register, for grade 4 (–40 °C).

In this case, if the WPS requirements in welding the test piece 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.

*Note.* The approval may cover consumables with the grade corresponding to the lower diffusible hydrogen content in the deposited metal, but not vice versa. For example, the approval of the welding procedure for welding consumables of grade 2YH10 also covers the ones of grade 2YH5.

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 4.8, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships, shall also cover the other brands of the welding consumables with similar grade approved by Register, including the identification suffixes of typical chemical composition of deposited metal according to the requirements of 4.8.1.3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**6.6.3.4.2** Filler material designation and manufacturer.

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 RS approval for the grades specified by the requirements of 4.2, 4.5, 4.6 and 4.8, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

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 mechanical properties;

equivalent values of the impact energy of deposited metal;

the same type of electrode covering, core of flux cored wire, or the same classification of welding flux composition;

the same nominal chemical composition of wire or deposited metal, as appropriate;

the same or lower hydrogen content.

When impact testing is required, for processes 111, 114, 12, 133 and 136 ([refer to Table 6.2.2.1](#)) the range of approval is restricted to the particular manufacturer of the

welding consumables used in the welding procedure test. It is permissible to change the trade mark of the welding consumables produced by one manufacturer to those of the others with the same compulsory part of the designation according to national standards when an additional test piece is welded. In this case, if the WPS requirements in welding the test piece during the additional tests are fully met, the extent of testing at substitution of one welding consumable trade mark for another with the same compulsory part of the designation according to national standards may be restricted to determination of impact energy for the weld metal and fusion line.

Note. The above does not apply to solid wire and rods for welding processes 131, 135, 141 and 151 ([refer to Table 6.2.2.1](#)) with the same designation according to national standards and the same nominal chemical composition.

**6.6.3.4.3** Size of filler materials.

It is permitted to change the standard size of filler materials within their manufacturer's recommendations on their use provided that the requirements for heat input according to [6.6.3.6](#) are met.

**6.6.3.5** Type and polarity of current.

Welding procedure approval is only valid for the type of current and polarity used in the welding procedure qualification test. For manual metal arc welding with covered electrode, alternating current also qualifies direct current (both polarities) when impact testing is not required.

**6.6.3.6** Heat input.

**6.6.3.6.1** The upper limit of heat input approved is restricted to the following values:

25 % greater than that used in welding the test piece during qualification tests, but not exceeding 55 kJ/cm for heat input processes not more than 50 kJ/cm;

the upper limit of heat input approved may be 10 % greater than that for high heat input processes over 50 kJ/cm.

**6.6.3.6.2** The lower limit of heat input approved may be 25 % lower than that used in welding the test piece during qualification tests.

**6.6.3.6.3** The range of approval of the welding procedure by heat input value shall not be less than the nominal value that occurred during welding of the Tekken test piece in course of certification testing.

**6.6.3.7** 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 piece in qualification test. If there is no preheating temperature, the range of approval of the welding procedure shall not be lower than the ambient temperature that occurred during welding of the test piece in cold cracking certification tests.

The specified temperatures shall be recorded in the test reports and shall be entered to the WPS.

**6.6.3.8** 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.

**6.6.3.9** Post-heating for diffusible hydrogen release.

The temperature and duration of post-heating for diffusible hydrogen release shall not be reduced. Post-heating shall not be omitted from welding process, but may be added without additional tests.

**6.6.3.10 Post-weld heat treatment.**

Addition or deletion of post-weld heat treatment is not permitted and shall be subject to new welding procedure qualification tests.

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  $\pm 20$  °C.

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 function of thickness.

**6.6.3.11 Initial heat treatment.**

A change in the initial heat treatment condition prior to the welding of precipitation hardenable materials is not permitted.

**6.6.4 Special requirements for the range of approval related to welding processes.**

**6.6.4.1 Submerged arc welding (welding process 12).**

Range of approval is limited only to that welding process (121 to 125) that used in the welding procedure qualification test.

The range of approval for the flux is restricted to the particular manufacturer and designation that used in the welding procedure qualification tests.

**6.6.4.2 Gas metal arc welding (welding processes 131, 133, 135 and 136 ).**

Range of approval given to the shielding gas is restricted to the symbol for the gas according to ISO 14175 classification (main-group and sub-group) and identical to the one used in the welding procedure qualification test. However, the content of CO<sub>2</sub> in a mixture shall not exceed 10 % of that used in the welding procedure qualification test.

For shielding gases not covered by ISO 14175 classification the range of approval is restricted to the nominal composition used in the welding procedure qualification test.

Range of approval given is restricted to the wire system used in the welding procedure qualification test (e.g. single-wire or multiple-wire system).

For solid and metal cored wires (designated with symbol (letter) "M" according to ISO 17632 [refer to Table 4.3.2.3](#)), the qualification using short circuiting transfer (dip) qualifies only short circuiting transfer (dip). The qualification using spray or globular transfer qualifies both spray and globular transfer.

*Note.* In compliance with the requirements of ISO 4063, the metal transfer mode is indicated by the following letters placed after the reference numbers of welding processes:

*D* — short-circuit transfer (dip transfer);

*G* — globular transfer;

*S* — spray transfer;

*P* — pulsed transfer.

For example, MIG welding with solid wire electrode using short-circuiting transfer is designated as: ISO 4063-131-D.

**6.6.4.3 Tungsten inert gas (TIG) welding with solid filler material (wire/rod) (welding process 141).**

Range of approval given to the shielding gas is restricted to the symbol of the gas according to ISO 14175 classification (main group and sub-group) and identical to the one used in the welding procedure qualification test.

For shielding gases not covered by ISO 14175 classification the range of approval is restricted to the nominal composition used in the welding procedure qualification test.

A welding procedure test made without a backing gas qualifies a welding procedure with backing gas. Welding with filler material does not qualify for welding without filler material and vice versa.

**6.6.4.4 Plasma-arc welding (welding process 15).**

Range of approval for the welding procedure shall be restricted to the plasma gas composition used in the welding procedure qualification test.

Range of approval given to the shielding gas and backing gas is restricted to the symbol of the gas according to ISO 14175 classification (main group and sub-group) and identical to the one used in the welding procedure qualification test. For shielding gases not covered by ISO 14175 classification the range of approval is restricted to the nominal composition used in the welding procedure qualification test.

Welding with filler material (welding processes 151 and 152) does not qualify for welding without filler material and vice versa.

**6.7 ADDITIONAL REQUIREMENTS FOR APPROVAL OF WELDING PROCEDURE FOR STRUCTURES AND ITEMS FROM SPECIAL PURPOSE STEEL**

**6.7.1 Additional requirements for approval of welding procedure for structures and nickel steel products designed for low temperature impact.**

**6.7.1.1** The following requirements cover approval of welding procedure for ferritic nickel steel structures, group 9 in compliance with ISO/TR 15608 (cargo tanks, technological pressure vessels and secondary barriers) for the ships carrying liquefied gases in bulk.

**6.7.1.2** In the test piece for a butt joint in plate shall meet the requirements of [6.3.1.2](#). In this case, the weld shall be placed in parallel with the main direction of the last rolling ([refer to Fig. 6.3.1.2](#)) in compliance with impact tests of rolled products using transverse specimens,  $KV_T$ . Location of test specimens for mechanical tests shall be in compliance with the recommendations of [6.4.2](#).

**6.7.1.3** Test piece for a butt joint in pipe shall be as stated in [6.3.1.3](#). Location of test specimens for mechanical tests shall be in compliance with the recommendations of [6.4.2](#).

**6.7.1.4** Location of test specimens for a T-joint in plates in compliance with [6.3.1.4](#) and [6.3.1.5](#), shall be used provided a welding procedure may not be approved within the range of approval in compliance with the recommendations of [6.7.1.8](#). In addition, in any case the applied welding consumables shall provide the required impact energy value during impact test in accordance with [Table 6.7.1.6-2](#). To comply with this requirement, additional butt weld test assembly may be required ([refer to reference 6 to Table 6.4.1.1](#)).

**6.7.1.5** All applicable tests shall be made after welding on each test piece within the scope of the requirements in the scope of [6.4](#) as regards additional instructions given below.

According to [Fig. 6.7.1.5](#) from each test piece for butt joints in plates and pipes five sets of three V-notch impact tests specimens each with the notch located:

- notch in the centre of the weld;
- notch on the fusion line;
- notch in HAZ, 1 mm from the fusion line;
- notch in HAZ, 3 mm from the fusion line;
- notch in HAZ, 5 mm from the fusion line.

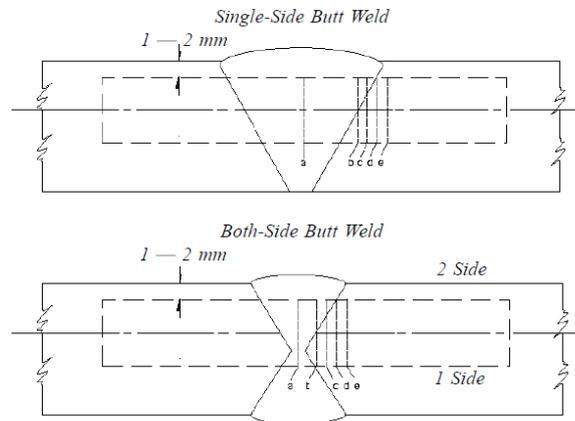


Fig. 6.7.1.5

Location of V-notch impact test for butt weld:

- a — notch in the centre of the weld;
- b — notch on fusion line fusion line;
- c — notch in HAZ, 1 mm from the fusion line;
- d — notch in HAZ, 3 mm from the fusion line;
- e — notch HAZ, 5 mm from the fusion line.

**6.7.1.6** Results of mechanical testing of welded joints shall meet the requirements of [Tables 6.7.1.6-1](#) and [6.7.1.6-2](#).

The use of welding consumables with lower tensile strength values during testing of longitudinal cylindrical specimens as regards minimum values regulated by [Table 6.7.1.6-1](#) may be approved. In this case, where testing of transverse tensile samples is carried out, tensile strength values specified in [Table 6.7.1.6-1](#) shall be provided, and sample breakdown point shall be documented in the test report.

Table 6.7.1.6-1

Welded steel		Tensile test, min.				Bend test <sup>1</sup>		Determination of hardness HV10, max
Subgroup ISO/TR 15608	Type	Transverse specimens $R_m$ , in MPa Not less than	Longitudinal round specimens			Mandrel diameter $D$	Bending angle $\alpha$ , in deg.	
			$R_m$ , in MPa	$R_{eH}$ , in MPa Not less than	$A_5$ , in % Not less than			
9.1	1,5 Ni	470	470 — 640	275	22	4t	180	350
	2,25 Ni	510	510 — 660	305	22	4t	180	350
9.2	3,5 Ni	540	540 — 690	345	22	4t	180	350
	5 Ni	570	570 — 710	390	21	4t	180	350
9.3	9 Ni	640	640 — 840	490	19	5t	180	350

<sup>1</sup> t is the thickness of a bend test specimen.

Table 6.7.1.6-2

Welded steel			Impact test			
Subgroup ISO/TR 15608 15608	Type	Thickness <i>t</i> , in mm	Impact test temperature, in °C	Impact test, in J Not less than <sup>1</sup>		
				Weld	Weld fusion line and heat-affected zone (HAZ)	
					<i>KV<sub>T</sub></i> <sup>2</sup>	<i>KV<sub>L</sub></i> <sup>3,4</sup>
9.1	1,5 Ni	<i>t</i> ≤ 25	-65	27	27	41 (34)
		25 ≤ <i>t</i> ≤ 30	-70			
		30 ≤ <i>t</i> ≤ 35	-75			
		35 ≤ <i>t</i> ≤ 40	-80			
	2,25 Ni	<i>t</i> ≤ 25	-70	27	27	41 (34)
		25 ≤ <i>t</i> ≤ 30	-75			
		30 ≤ <i>t</i> ≤ 35	-80			
		35 ≤ <i>t</i> ≤ 40	-85			
9.2	3,5 Ni	<i>t</i> ≤ 25	-95	27	27	41 (34)
		25 ≤ <i>t</i> ≤ 30	-100			
		30 ≤ <i>t</i> ≤ 35	-105			
		35 ≤ <i>t</i> ≤ 40	-110			
	5,0 Ni	<i>t</i> ≤ 25	-110	27	27	41 (34)
		25 ≤ <i>t</i> ≤ 30	-115			
		30 ≤ <i>t</i> ≤ 35	-120			
		35 ≤ <i>t</i> ≤ 40	-125			
9.3	9,0 Ni	<i>t</i> ≤ 40	-196	27	27	41 (41)

<sup>1</sup> The average values while testing one set of three specimens are given in the Table. The relevant single tolerable values shall be equal to:  
19 J for the average value of 27 J;  
29 J for the average value of 41 J;  
24 J for the average value of 34 J.

<sup>2</sup> Unless otherwise agreed, sheet products and wide flats shall be tested using the transverse tensile samples *KV<sub>T</sub>*.

<sup>3</sup> Pipes, sections and also forgings shall be tested with the use of longitudinal specimens *KV<sub>L</sub>*.

<sup>4</sup> Impact test values for pipes forgings and castings for the cargo and process piping are given in brackets.

**6.7.1.7** The requirements for re-testing are similar to [6.5](#). Whereby impact re-testing may be performed on one additional set of three test specimens taken from the same sample if sufficient quantity of metal is available. Results of additional tests are recognized satisfactory if a new average adsorbed impact energy value (three performed plus three additional ones) and above the required average value and not more than two results from six below the above required average value and not more than on one specimen the result is obtained 30 % less than required.

**6.7.1.8** Approval of Welding Procedure on the basis of butt weld test piece testing remains valid:

- for corresponding base metal;
- for corresponding welding consumable;
- for corresponding welding procedure;
- for corresponding welding position.

Other welding procedure essential variables shall be approved the Register in compliance with the requirements of [6.6](#), frequency and scope of welding procedure tests used during production (fabrication testing). Whereby the approved thickness range shall comply with the requirements of [Table 6.7.1.6-2](#) as per the temperature in testing the impact test specimens.

**6.7.2 Additional requirements for approval of welding procedure for welding of structures and ferritic-austenitic stainless steel (duplex).**

**6.7.2.1** The requirements given below cover approval of welding procedure for structures and items from ferritic-austenitic stainless steel (duplex), group 10 in compliance with ISO/TR 15608.

**6.7.2.2** Test piece for a butt joint in plate shall meet the requirements of 6.3.1.2. In this case, the weld shall be placed in parallel with the direction of the last rolling (refer to Fig. 6.3.1.2), in compliance with impact tests of rolled products using transverse specimens,  $KV_T$ . Location of test specimens for mechanical tests shall be in compliance with the recommendations of 6.4.2.

**6.7.2.3** Test piece for a butt joint in pipe shall be as stated in 6.3.1.3. Location of test specimens for mechanical tests shall be in compliance with the recommendations of 6.4.2.

**6.7.2.4** Location of test specimens for T-joints in plates in compliance with 6.3.1.4 and 6.3.1.5, shall be used provided a procedure for welding may not be approved within the range of approval in compliance with the recommendations of 6.7.2.9. Whereby in any case the applied welding consumables shall provide the required impact energy value during impact test in accordance with Table 6.7.2.6-2. To comply with this requirement, additional butt weld test assembly may be required (refer to reference 6 to Table 6.4.1.1).

**6.7.2.5** All applicable tests shall be made after welding on each test piece within the scope of 6.4 as regards additional instructions given below.

.1 according to Fig. 6.4.4.4-4 from each test piece for a butt joint in plates and pipes four sets of three V-notch impact tests specimens each with the notch located:

- in the centre of the weld;
- on the fusion line;
- in HAZ, 2 mm from the fusion line;
- in HAZ, 5 mm from the fusion line.

.2 duplex stainless steel test welds shall be tested for pitting resistance in compliance with 6.7.2.7;

.3 scope of tests shall include micro-structural examination and the ferrite content determination in the weld metal as per 6.7.2.8;

.4 as appropriate (if stipulated by technical documentation for a specific product or structure) the scope of tests may include specific determination of butt weld susceptibility to intergranular corrosion compliant to 6.7.3.6.

**6.7.2.6** Results of mechanical tests of welded joints shall comply with the requirements of Tables 6.7.2.6-1 and 6.7.2.6-2.

**6.7.2.7** Duplex stainless steel test welds with chrome content of 25 % and over (sub-group 10.2 ISO/ TR 15608) shall be tested for pitting and crevice corrosion resistance in compliance with Method A of ASTM G48, or other similar standards (for example, GOST 9.912-89 chemical method) as regards the requirements given below.

Table 6.7.2.6-1

Welded steel			Tensile test, not less than				Bend test <sup>1</sup>		Hardness test HV10, max
Subgroup ISO/TR 15608	Typical chemical composition	UNS Type	Transverse specimens $R_m$ , in MPa	Longitudinal round specimens			Mandrel diameter $D$	Bending angle $\alpha$ , in deg.	
				$R_m$ , in MPa	$R_{p0.2}$ , in MPa	$A_5$ , in %			
10.1	x3CrNiMoN 22 5 3	S31803	620	620	450	25	4t	180	
10.2	x3CrNiMoWCuN 25 7 3	S31260	690	690	485	20	5t	180	
	x4CrNiMoCuN 26 6 4 2	S32550	760	780	550	20	6t	180	
	x3CrNiMoN 26 8 5	S32750	800						
	x3CrNiMoWCuN 26 8 4 1 1	S32760	750						

<sup>1</sup> t is thickness of a bend test specimen.

Table 6.7.2.6-2

Welded steel			Impact test			
Subgroup ISO/TR 15608	Typical chemical composition	UNS Type	Impact test temperature, in °C	Impact test, in J, not less than		
				Weld	Weld fusion line and heat-affected zone (HAZ)	
					$KV_1^{1,2}$	$KV_2^{2,3}$
10.1	x3CrNiMoN 22 5 3	S31803	-20	27	27	41
10.2	x3CrNiMoWCuN 25 7 3	S31260	-20	27	27	41
	x4CrNiMoCuN 26 6 4 2	S32550	-20	27	27	41
	x3CrNiMoN 26 8 5	S32750	-20	27	27	41
	x3CrNiMoWCuN 26 8 4 1 1	S32760	-20	27	27	41

<sup>1</sup> Unless otherwise agreed, plates and wide flats shall be tested using the transverse tensile specimens  $KV_T$ .  
<sup>2</sup> The average values while testing one set of three specimens are given in the Table. The relevant single admissible values shall be equal to: 19 J for the average value of 27 J; 29 J for the average value of 41 J.  
<sup>3</sup> Pipes, sections and also forgings shall be tested with the use of longitudinal specimens  $KV_L$ .

Test pieces shall be tested in accordance with [Fig. 6.7.2.7](#).

According to width of a weld reinforcement the weld test length is assumed to be as follows:  $L = 50$  mm when  $BW \leq 30$  mm and  $L = BW + 20$  mm when  $BW > 30$  mm. Cut edges and weld test angles of the specimen shall be prepared according to ASTM G48.

Treatment and test of the specimens shall include operations as follows:

test plates are cut out to carry out tests (with mechanical procedure or abrasive disk and water cooling);

weld test marking with welding position identification and "stop and re-start" operation;

surface precheck with stereomicroscope zooming  $\times 20$ .

Test Report shall include availability and position of the significant defects — for example, pores or slag inclusions as well as coating on both surfaces;

surface preparation (plate butts/panels) after being cut and their degreasing. Surface preparation includes wet grinding with emery paper 120 (ANSI, USA) or P120 (FEPA, Europe);

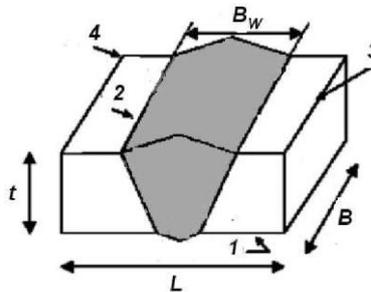


Fig. 6.7.2.7

Welded joint test piece for pitting corrosion:

$L$  — welded joint test piece length;

$B = 25$  mm — welded joint test width;

$BW$  — width of a weld reinforcement;

$t$  — welded joint test thickness;

1 — welded joint test surface from the root side of the weld;

2 — welded joint test surface from the face of the weld;

3 — welded joint test edge;

4 — welded joint test edge angle.

weighing to the nearest: 0,0001 g at the plate mass  $W_t \leq 120$  g,

0,001 g at the plate mass  $W_t > 120$  g,

sample etching prior to testing in the solution 5 % HF + 20 % HNO<sub>3</sub>, 60 °C, 5 min.;

carrying out tests; sample store in 10 % water solution  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$  (6 % equivalent to anhydrous salt  $\text{FeCl}_3$ ) with density  $1,049 \pm 0,002 \text{ g/cm}^3$  shall be performed for 24 h at  $40 \text{ }^\circ\text{C}$ . The solution volume shall comply with ratio  $20 \text{ ml/cm}^2$  of the test plates area;

sample cleaning after tests (ultrasonic in ethanol);

weighing to the nearest: 0,0001 g at the plate mass  $W_t \leq 120 \text{ g}$ ,

0,001 g at the plate mass  $W_t > 120 \text{ g}$ ;

probing the surface for pitting corrosion (local recesses) using stereomicroscope at  $\times 20$  magnification (a needle may be used for fixing recesses).

The test results are considered satisfactory unless pitting corrosion indications are detected and total corrosion wear (sample mass loss) shall be less than  $4 \text{ g/m}^2$  of the test plates area.

**6.7.2.8** From welded joints test pieces of duplex steels sections shall be selected and manufactured to inspect microstructure. Duplex stainless steel types shall be microstructurally examined and the test samples shall comprise the weld metal, heat affected zone and base metal. The working section area shall be suitably etched for microstructure and examined at  $400\times$  magnification. The weld shall be free from grain boundary carbides and precipitates in HAZ. The ferrite content in the weld metal root and unreheated weld cap shall be determined in accordance with ASTM E 562 and be in the range of 30 — 70 %.

**6.7.2.9** Based on the test results welding procedure range of approval shall comply with [6.6](#) except for additional limitations in terms of heat input within  $\pm 15 \%$  from the nominal value during tests.

**6.7.3 Additional requirements for approval of welding procedure for structures and items from austenitic stainless steel.**

**6.7.3.1** The requirements given below cover the approval of welding procedure for structures and items from austenitic stainless steel, group 8 in compliance with ISO/TR 15608.

**6.7.3.2** Test piece for a butt welded-joint in plate shall be in compliance with [6.3.1.2](#). In this case, the weld shall be placed parallel to the direction of the last rolling ([refer to Fig. 6.3.1.2](#)), in compliance with impact tests of rolled products using transverse specimens  $KV_T$ . Location of test specimens for mechanical tests shall be in compliance with the recommendations of [6.4.2](#).

**6.7.3.3** Test piece for a butt joint in pipe shall be as stated in [6.3.1.3](#). Location of test specimens for mechanical tests shall be in compliance with the recommendations of [6.4.2](#).

**6.7.3.4** Location of test specimens for T- joints in plates in compliance with [6.3.1.4](#) and [6.3.1.5](#), shall be used provided a procedure for welding may not be approved within the range of approval in compliance with the recommendations of [6.7.3.8](#).

**6.7.3.5** All applicable tests shall be made after welding on each test piece within the scope of [6.4](#) as regards additional instructions given below.

**.1** testing impact test specimens is not required if the design operational temperature is above  $-105 \text{ }^\circ\text{C}$ .

**.2** where impact testing is required, test temperature is  $-196 \text{ }^\circ\text{C}$ , and impact test average value shall not be less than 27 J for transverse specimens (one single test may give value from three tests below the required average but not lower than 19 J);

**.3** if impact tests are required, according to [Fig. 6.7.1.5](#) from each test piece for a butt joint in plates and pipes five sets of three V-notch impact tests specimens each with the notch located:

in the centre of the weld;

on the fusion line;

in HAZ, 1 mm from the fusion line;

in HAZ, 3 mm from the fusion line;

in HAZ, 5 mm from the fusion line.

- .4 in a capping run/runs the ferrite content shall be determined;
- .5 as appropriate (if stipulated by technical documentation for a specific product or structure) the scope of tests may include specific determination of the welded joint susceptibility to intergranular corrosion according to [6.7.3.7](#).

**6.7.3.6** Results of mechanical tests of welded joints shall comply with the requirements of [Table 6.7.3.6](#). In a capping run/runs the ferrite content shall be in the range of 2 — 10 % except for S31245 and N 08904 super austenitic stainless steels, where its content shall be nominal at zero point.

Table 6.7.3.6

Welded steel			Tensile test, min.				Bend test <sup>1</sup>		Determination of hardness HV10, max	Impact test <sup>2,5</sup>		
Subgroup ISO/TR 15608	Typical chemical composition designation	Type AISI/ UNS	Transverse specimens $R_m$ , in MPa Not less than	Longitudinal round specimens			Mandrel diameter D	Bending angle $\alpha$ , in deg.		Weld	Weld fusion line and heat-affected zone (HAZ)	
				$R_m$ , in MPa Not less than	$R_{p0.2}$ , in MPa Not less than	$A_5$ , in % Not less than					$KV_{WM}$ , in J	$KV_{T^3}$ , in J
8.1	x3CrNiMo 19 11 3	316L	500	500	270	25	4t	180	Not required	27	27	41
	x3CrNiMo 19 11 3	316LN	530	540	305	25	4t	180	Not required	27	27	41
	x8CrNi Ti 18 11	321	500	550	290	22	4t	180	Not required	27	27	41
	x8CrNi Nb18 11	347	515	550	290	22	4t	180	Not required	27	27	41
8.2	x3CrNi 20 11	304L	500	500	270	25	4t	180	Not required	27	27	41
	x3CrNiMo 20 13 4	317L	530	530	305	22	4t	180	Not required	27	27	41
	x3CrNiMo 20 13 4	317LN	570	570	340	22	4t	180	Not required	27	27	41
	x2CrNiMoCu 20 18 6 1	S31254	650	650	370	22	4t	180	Not required	27	27	41
	x2CrNiMoCu 21 23 4 2	N08904	500	500	270	22	4t	180	Not required	27	27	41

<sup>1</sup> t is the thickness of a bend test specimen.  
<sup>2</sup> Testing impact test specimens is not required if the design operational temperature is not exceeding – 105 ° C. Where testing impact test specimens is required, test temperature is –196 ° C.  
<sup>3</sup> Unless otherwise agreed, sheet products and wide flats shall be tested using longitudinal specimens  $KV_T$ .  
<sup>4</sup> Pipes, sections and also forgings shall be tested with the use of longitudinal specimens  $KV_L$ .  
<sup>5</sup> The average values while testing one set of three specimens are given in the Table. The relevant single tolerable values shall be equal to: 19 J for the average value of 27 J; 29 J for the average value of 41 J.

**6.7.3.7** If according to the contract terms or product operation the determination of welded joint susceptibility to intergranular corrosion is required, they shall be carried out in the boiling copper sulfate water solution ( $CuSO_4 \cdot 5H_2O$ ) and sulfuric acid ( $H_2SO_4$ ) with present metallic copper chip scraps compliant to the RS recognized international and national standards (ASTM A262, Practice E; ISO 3651-2; GOST 6032, AMU method). If applicable, the preference shall be given to use of the test specimen with transverse weld.

**6.7.3.8** For the cargo tanks, echnological pressure vessels and secondary barriers for the ships carrying liquefied gases in bulk the welding procedure range of approval is similar to [6.7.1.8](#). In all other cases based on the test results welding procedure range of approval shall comply with [6.6](#) except for additional limitations in terms of heat input within  $\pm 15$  % of the nominal value during tests.

**6.7.4 Additional requirements for approval of welding procedures of steels with "Arc" index.**

**6.7.4.1** Requirements specified below apply to approval of welding procedures of ship and MODU/FOP structures, as well as "Arc"-indexed steel products.

**6.7.4.2** Qualification of welding procedures of steels with "Arc" index shall be supplemented by tests of weld metal for crack resistance parameter  $CTOD$ . The tests shall be carried out in accordance with the requirements of 2.2.10.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**6.7.4.3** Types of test specimens shall comply with the requirements of 2.2.10.5.3.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**6.7.4.4** When imposing requirements for the crack resistance parameter CTOD of the weld metal, the minimum quantity of tested specimens with correct test results shall be at least three. Test temperature for welding procedures of steels with "Arc" index shall correspond to the minimum operating temperature  $T_d$  of the structural member.

Values of CTOD shall not be less than those indicated in [Table 6.7.4.4](#):

Table 6.7.4.4

Thickness not more than, mm	Strength group								
	norm.	Y32 и Y36	Y40	Y42	Y46	Y50	Y55	Y62	Y69
40	0,10	0,10	0,15	0,15	0,15	0,15	0,15	0,20 <sup>1</sup>	0,20 <sup>1</sup>
50	0,10	0,10	0,15	0,15	0,15	0,15	0,20 <sup>1</sup>	0,20 <sup>1</sup>	0,25 <sup>1</sup>
70	0,10	0,15	0,15	0,20	0,20	0,20	0,25 <sup>1</sup>	0,25 <sup>1</sup>	0,30 <sup>1</sup>
100	0,15	0,20	0,20	0,20	0,25	0,25	0,30 <sup>1</sup>	0,30 <sup>1</sup>	0,35 <sup>1</sup>

<sup>1</sup> Test result is considered satisfactory if maximum load has been reached before unstable brittle fracture of all tested specimens independently of the reached value of  $\delta_m$ , refer to 2.2.10.5.1.1, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

.1 when testing three correct specimens neither of the results obtained shall be lower than 50 % of the average value;

.2 when testing five or more correct specimens one minimum result obtained may be taken out of consideration. The rest shall be not lower than 50 % of the average value.

For materials of welded joints exceeding 70 mm in thickness the possibility of their use for special and primary structures is defined upon agreement with the Register by the procedures for calculation of brittle fracture resistance and, using as the basis of specially determined fracture toughness characteristics  $K_{Ic}$  or  $J_{Ic}$ .

**6.7.4.5** When defining the crack resistance of welded joint metal the notch shall be arranged so that the tip of the crack over the largest possible length of its front was located within the welded joint zone specified by the Register (centre of the weld, metal adjoining the fusion line, etc.). The technological parameters of welding procedure and type of edge preparation shall comply with the type of welded joint to be tested. Before marking out and cutting of the notch it is necessary to carry out etching and study of the metal inner structure. The accuracy of obtained results shall be ensured by larger quantity of test specimens (up to 8 — 10 per one test temperature) and by rejection after testing of those specimens where the crack propagated beyond the limits of the zone under study.

**6.7.5 Additional requirements for approval of welding procedures of EH47 steel.**

**6.7.5.1** If CTOD testing is carried out, it shall comply with the requirements of 2.2.10.5 and 6.7.4.3 – 6.7.4.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

## 6.8 ISSUE AND TERMS OF VALIDITY OF WELDING PROCEDURE APPROVAL TEST CERTIFICATE

**6.8.1 Issue of the Certificate.**

**6.8.1.1** When all the requirements of this Section are met, the Register draws up and issues the Welding Procedure Approval Test Certificate (form 7.1.33, pp. 1 and 2).

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.

**6.8.1.2** The Welding Procedure Approval Test Certificate is drawn up and issued by the RS 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.

**6.8.2 Drawing up attachments to Certificate.**

**6.8.2.1 Details of Weld Test (DWT).**

The Details of Weld Test form (form 7.1.33, pp. 3 and 4) 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.

Notes: 1. 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.

2. It is allowed to fill in the Welding Procedure Qualification Record (WPQR) directly by the responsible official of the manufacturer of welded structures using the forms identical to Annex A (Record of weld test) of ISO 15614-1.

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 pieces;
- copy of the certificate for the filler material used for welding test pieces (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 specialized firms are used);
- copy of the certificate for the backing material (e.g. ceramic backing).

**6.8.2.2 Test Results form.**

The Test Results form (form 7.1.33, pp. 5 and 6) 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.

Notes: 1. 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 pieces who is authorized to sign the documents.

2. It is allowed to fill in the Test results directly by the responsible official of the manufacturer of welded structures using the forms identical to Annex A (Test results) of ISO 15614-1.

The Test Results form shall be supplemented with attachments confirming documentarily the test results which can be lacking in the document, including:

- records (copies) of hardness tests and macrosections examination (refer to Attachment to form 7.1.33);
- records of non-destructive testing of welded test pieces with detailed description of type and size of the defects revealed.

It is recommended to supplement the Test Results form with the basic documents (copies/originals or extracts from the minutes) which confirm the data provided.

**6.8.2.3 Welding Procedure Specification.**

This document is compiled by the manufacturer of welded structures in compliance with the requirements of ISO 15609-1 (arc welding) or ISO 15609-2 (gas welding). The relevant requirements and explanations are given in [Table 6.8.2.3](#).

**6.8.3 Terms of validity of the Welding Procedure Approval Test Certificate.**

**6.8.3.1** The period of validity of the Welding Procedure Approval Test Certificate and its endorsement are determined in compliance with the requirements of Section 6, Part I "General Regulations for Technical Supervision". In so doing, the Welding Procedure Qualification Record (WPQR), generally, has no restriction on the period of validity and may be taken into consideration by the Register in review of welding procedure specifications drawn up on the basis of the above WPQR.

Table 6.8.2.3

**Requirements for filling-in the WPS form**

Nos.	Name of form positions	Requirements for form filling-in
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	Designation of Details of Weld Test and Test Result forms on the basis of which the particular welding
	Result forms (WPQR)	procedure is approved by the Register
4	Base metal:	Grade of base metal in accordance with the RS rules and/or its designation according to national
	grade and trade mark;	standards, designation of the standard.
	thickness range;	Minimum and maximum thickness of weld metal.
	pipe's outside diameter range	Minimum and maximum outside diameter of pipes to be welded
5	Welding process	Designation of welding process in accordance with ISO 4063:2009
6	Type of welding	Designations: M — manual welding; S — semi-automatic welding; A — automatic welding; T (TIG welding) — tungsten inert gas arc welding; FSW — friction stir 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; 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

Nos.	Name of form positions	Requirements for form filling-in
<b>DETAILS OF WELDING CONSUMABLES</b>		
<b>13</b>	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 RS rules, if it is stipulated by the RS 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
<b>14</b>	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, 133, 135, 136, 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 specialized 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
<b>DETAILS ON WELDING PROCEDURE</b>		
<b>15</b>	Welding position and direction	Designations according to ISO 6947:2019 (refer to Figs. 6.2.2.4-1 — 6.2.2.4-3)
<b>16</b>	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
<b>17</b>	Back gouging and back grinding	If this operation is employed, method and requirements for its performance shall be indicated: gg — welding with back gouging or back grinding of welds; ng — welding without (no) back gouging or without (no) back grinding of welds
<b>18</b>	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
<b>19</b>	Single run and multirun	Designations: sr — single run; mr — multirun welding
<b>20</b>	Orifice/gas cup size (torch nozzle)	For welding processes 131, 133, 135, 136, 141 and 15 the torch nozzle diameter shall be indicated
<b>21</b>	Distance contact tube/workpiece	For welding processes 12, 131, 133, 135, 136 and 15 the distance from the conductive welding torch nozzle to the welded piece surface shall be indicated
<b>22</b>	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.)
<b>23</b>	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
<b>24</b>	Post-weld heat treatment (PWHT)	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
<b>ELECTRICAL CHARACTERISTICS</b>		
<b>25</b>	Type of current and polarity	Designations: DC+ — direct-current of reverse polarity; DC- — direct-current forward polarity; DC± — direct-current of reverse and forward polarity; AC — alternating current

Nos.	Name of form positions	Requirements for form filling-in
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)
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
29	Travel speed	Range of rated travel speed for type A shall be indicated
30	Welding wire feed rate	For welding types S — semi-automatic welding and A — fully mechanized or automatic welding — 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.)

**6.8.3.2** 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.

**6.8.3.3** During the period of validity of the Welding Procedure Approval Test Certificate no problems shall arise in connection with the quality of welded joints manufactured with the use of the procedure approved by the Register. The manufacturer of welded structures shall maintain systematical control and analysis of the quality of welded joints, also with subdivision by particular welding procedures. The results of such analysis shall be made available to the RS surveyor, dealing with the procedure for endorsement of the Welding Procedure Approval Test Certificate in accordance with [6.8.3.4](#).

Where the imperfection of welds is permanently too high, the Register may cease the period of validity of the Welding Procedure Approval Test Certificate, and the welding procedure shall be revised and subjected to new qualification tests.

**6.8.3.4** Endorsement of the Welding Procedure Approval Test Certificate is performed by the RS surveyor based on the request of the manufacturer of welded structures within the period stated in Section 6, Part I "General Regulations for Technical Supervision". In this case the Certificate endorsement and its reissuance for a new period do not usually require new or additional qualification tests provided all the above terms of the Certificate validity are met.

Request for endorsement of the Welding Procedure Approval Test Certificate for the next 2,5-year period shall be submitted to the Register within 30 days before and after the set date of the Certificate endorsement. Validity of the Welding Procedure Approval Test Certificate may be prolonged within 90 days after the expiry of 2,5-year period.

## 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 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 (form 7.1.33).

**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. It is allowed to use other schemes of approval for the welding procedures of aluminium alloys. 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 can not 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** In the event of the application of welding processes not provided for in this Section or of welding procedures associated with the increased degree of defects formation risk (e.g., procedure of a single-sided welding with free back forming of a weld root), the appropriate tests in manufacture shall be carried out. These tests shall ensure the monitoring of welding procedures stability.

### 7.2 DEFINITIONS, TERMS AND SYMBOLS

**7.2.1** Definitions and explanations.

Definitions, explanations and terms used in the present Section 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 welding processes (the symbols comply with ISO 4063:2009):

131 — metal-arc inert gas welding;

141 — tungsten inert gas arc welding with solid filler material (wire or rod);

15 — plasma arc welding;

43 — friction stir welding;

43.1 — double-sided single-run SFW;

43.2 — double-sided multi-run SFW;

43.3 — single-sided SFW with adjustable probe tool.

Depending on the degree of welder's labour mechanization, the welding types/processes are divided into groups as specified in [4.3.2.2](#).

The welding fillers used for the welding of shipbuilding aluminium alloys are classified by categories according to Tables 4.9.1.3-1 and 4.9.1.3-2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

Shielding gases used for welding depending on their composition are divided into groups designated with indices in accordance with Table 4.9.1.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

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 and 5.1.3-2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. In this case, in the approval of welding procedures, aluminium alloys are additionally grouped according to [Table 7.2.2](#).

Table 7.2.2

**Classification of international shipbuilding aluminium alloys by type composition groups according to ISO/TR 15608:2017**

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-heat-treatable alloys	
	22.1	Aluminium-magnesium alloys	3103 [AlMn 1]
	22.2	Aluminium-magnesium alloys with Mg content $Mg \leq 1,5 \%$	5005 [AlMg 1(B)] 5050 [AlMg 1,5(C)]
	22.3	Aluminium-magnesium alloys with Mg content $1,5 \% < Mg \leq 3,5 \%$	5251 [AlMg2] 5052 [AlMg2,5] 5754, 1530 [AlMg3]* 5154 [AlMg3,5]
	22.4	Aluminium-magnesium alloys with Mg content $Mg > 3,5 \%$	5086 [AlMg4]* 5083 [AlMg4,5Mn0,7]* 5383 [AlMg4,5Mn0,9]* 5456, 1550 [AlMg5]* 5059[-]* 1561, 1565ч [AlMg6Mn1]* 1575[AlMg6Mn0,5Sc]* 1581 [AlMg5Sc0,03]*
23		Heat-treatable alloys	
	23.1	Al-Mg-Si alloys	6060[AlMgSi] 6063[AlMg0,7Si] 6005A[AlSiMg(A)]* 6082[AlSi1MgMn]* 6061[AlMg1SiCu]*
	23.2	Al-Zn-Mg alloys	7075[AlZn6MgCu1,5]
24		Al-Si alloys with Cu content $Cu \leq 1 \%$	
	24.2	Al-Si alloys with Cu content $Cu \leq 1 \%$ , $5 \% < Si \leq 15 \%$ и $0,1 \% < Mg \leq 0,80 \%$	42100[AlSi7Mg0,3] 42200[AlSi7Mg0,6] 43100[AlSi10Mg(b)] 44100[AlSi12(b)]

\* Marks shipbuilding aluminium alloys covered by the classification of Section 5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

In the approval of welding procedures, the symbols of welding positions comply with ISO 6947:2019 and are given in [Appendix 2](#) to Section 4.

The symbols relating to the type of a welded joint and to the technological peculiarities of its making comply with the requirements in [6.2.2.3](#).

### **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 edge preparation, 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 edge preparation 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, interrun 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](#).

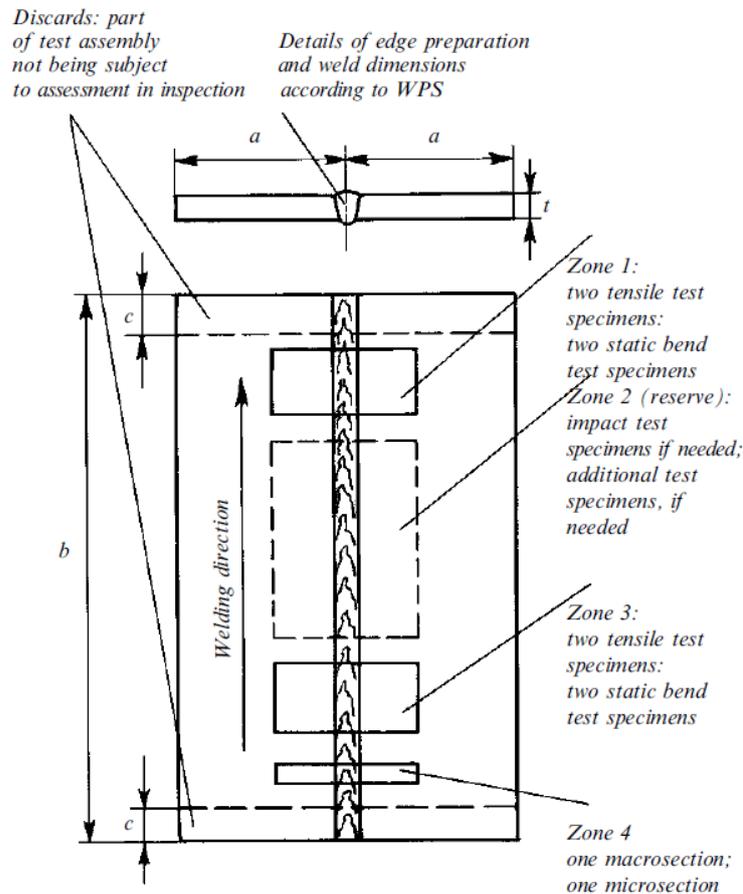


Fig. 7.3.2.1

Test assembly of welded butt joint and the diagram of test specimens' cutting-out:

for manual and semiautomatic 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;  $b \geq 1000$  mm and  $c \approx 50$  mm

Table 7.3.2.1

Examination and testing type	Examination and testing extent	Notes
Visual and measurement testing	100 % weld length 100 % weld length	—
Radiographic or ultrasonic testing		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 test specimens	4 test specimens	Tests are conducted on two tensile test specimens with weld reinforcement removed and on two test specimens with the reinforcement complying with the national standard requirements
Transverse static bend test of test specimens	4 test specimens	For welded joints having thickness $t < 12$ mm, two 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 four test specimens

Examination and testing type	Examination and testing extent	Notes
Macrosection examination	1 transverse macrosection	—
Microsection examination	1 transverse microsection	—

**7.3.2.2** For the approval of welding procedures for the butt joints of pipes 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.

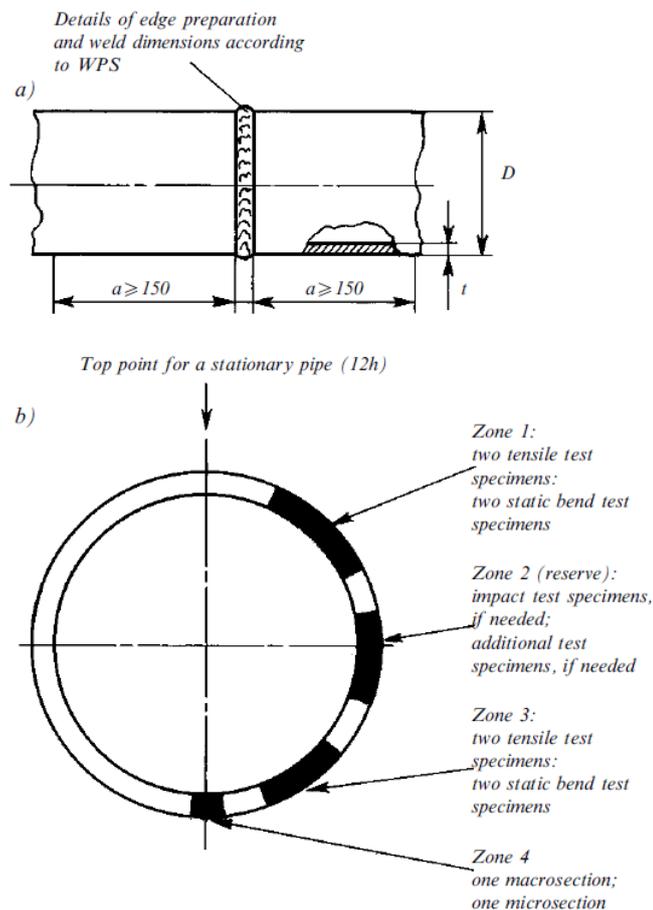


Fig. 7.3.2.2  
Test assembly of butt pipe joint:  
a — test assembly dimensions;  
b — diagram of test specimens cutting-out

**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.

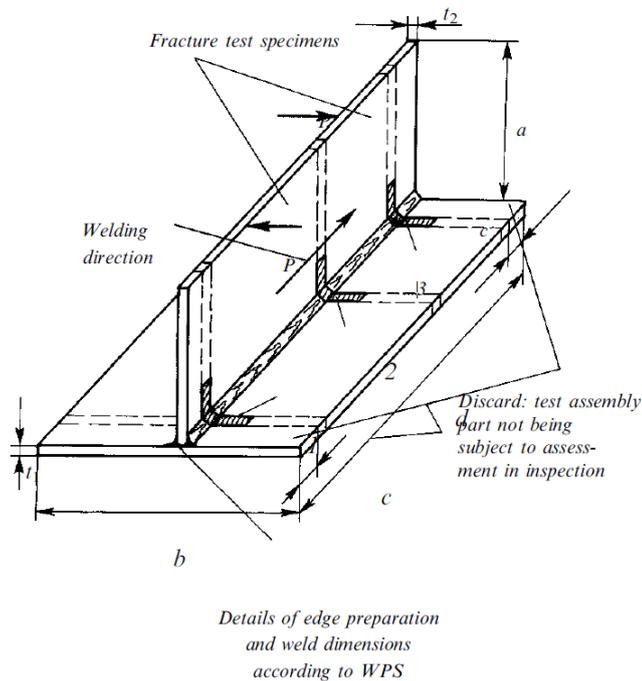


Fig. 7.3.2.3

Test assembly of tee-welded joint and the diagram of test specimens' cutting-out:

for manual and semiautomatic welding with dimensions:

$b \geq 150$  mm, but not less than  $6t$ , for joints without beveling;

$b \geq 350$  mm, but not less than  $6t$ , for joints with beveling;

$c \approx 25$  mm;  $a \geq 150$  mm, but not less than  $3t_2$ ;

$d \geq 350$  mm, but not less than  $6t_1$

(macrosection 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  $6t_1$ ;  $d \geq 1000$  mm;

$c \approx 50$  mm (macrosection sampling is made in Zones 1, 2 and 3, microsection sampling — in Zone 3)

In accordance with pWPS, the tee-joint test assembly may be fabricated:  
without beveling (fillet welding),

or with beveling (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 beveled tee-joints;

for the approval of a welding procedure with a single-run fillet weld without beveling.

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 semiautomatic 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 macrosection.

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	–
Macrosection examination	2 (3) test specimens	One macrosection for a manual and semiautomatic 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 test specimens (≥120 mm)	Fracture test is used only for joints without beveling made with a singlerun fillet weld

**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  $\alpha$  between pipes axes shall comply with the minimum value accepted in manufacturing practice.

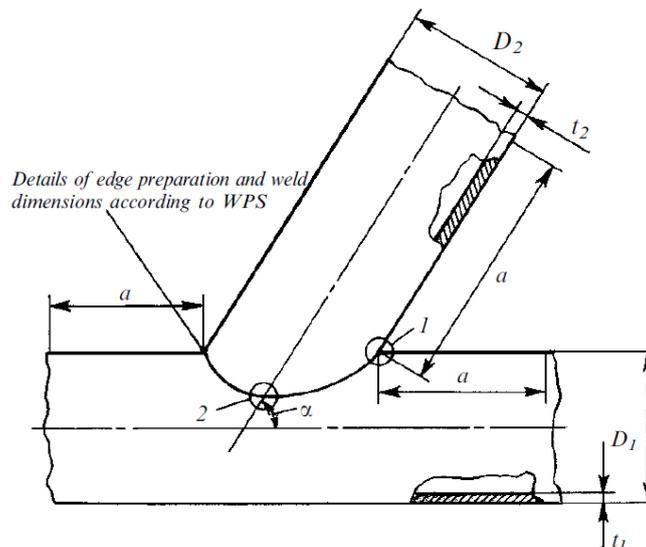


Fig. 7.3.2.4.1

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 edge preparation 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 beveling in the qualification of welding procedures for fillet welding, or with beveling 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 beveling is mandatory while conducting tests for the approval of:

welding procedures for a manual and semiautomatic 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 robotized systems.

In this case, the following instructions shall be followed:

for a manual and semiautomatic 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 robotized 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  $\pm 30^\circ$  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 beveling of joined components may be approved.

**7.3.2.4.3** The use of a pipes joint test assembly without beveling is mandatory while conducting tests for the approval of:

welding procedures for an automatic welding including robotized 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 beveling 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 and testing 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	–
Macrosection examination	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 specified in [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** Unless otherwise specified by the contract or specification for a particular product manufacture, as a result of examination by the NDT methods the quality evaluation of the welded joints test pieces of aluminium alloys shall be carried out in compliance with ISO 10042:2018 for the Acceptance Quality Level B. The reduction criteria down to Quality Level C is therewith acceptable for imperfections associated with oversized welds (excessive height and width of a butt weld reinforcement, excess throat thickness of a fillet weld, excessive reinforcement of a single-side butt weld root).

During examination by specific NDT methods the requirements of ISO 17635:2016 to examination class and Quality Level shall comply:

to perform Level B by visual and measurement testing according to ISO 10042:2018 test methods shall be carried out in compliance with ISO 17637:2016 (Testing Class is not regulated);

for magnetic particle testing the Quality Level 2X in compliance with ISO 23277:2015, test methods shall be carried out in accordance with ISO 3452-1:2021 (Testing Class is not regulated);

for radiographic testing Acceptance Level 1 in compliance with 10675-2:2017, test methods shall be carried out in accordance with ISO 17636:2013 (Testing Class B);

General procedure for performance and basic parameters of NDT test pieces shall comply with 3.2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**7.4.1.4** The examination and tests of welded joints test assemblies shall be performed in the following sequence:

- .1 visual and measurement 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 machining 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 — 7.4.1.10](#).

**7.4.1.5** Where the results of the welded test assembly non-destructive testing according to [Tables 7.3.2.1](#), [7.3.2.3](#) and [7.3.2.4.4](#) 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 fail 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 — 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 [6.4.4.1](#) 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 [6.4.4.2](#);

specimens for the static bend test of the weld side surface according to [6.4.4.2](#);

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](#).

Table 7.4.2.2

Base metal		Grade of welding consumable	Properties of welded joints (at least)		
Grade	Condition of supply		Tensile strength	Static bend <sup>1</sup>	
			$R_m$ , MPa	Ratio $d/t_s^2$	Bend angle, in 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,	R1/W1			
	$t_s \leq 12,5$ MM		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

Base metal		Grade of welding consumable	Properties of welded joints (at least)		
Grade	Condition of supply		Tensile strength	Static bend <sup>1</sup>	
			$R_m$ , MPa	Ratio $d/t_s^2$	Bend angle, in deg.
1565ч	O, H112, H116, H321	R3/W3	305	6	180
		R4/W4	335	6	180
1561H	H32, H321	R3/W3	305	6	180
1575	O, H111, H112	R4/W4	360	6	180
1581	O, H112	R3/W3	320	6	180
		R4/W4	355	6	180
[AlSi1MgMn]	T5, T6	R5/W5	165	7	180

<sup>1</sup> 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.

<sup>2</sup> Symbols:  $d$  — diameter of punch or inner roller, in mm;  
 $t_s$  — bend test specimen thickness, in mm.

The transverse macrosections shall be free from prohibitive 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.

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.).

**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 [6.4.4.3](#). 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 welding procedure approval the requirements given below shall be followed. The changes inserted in pWPS by a manufacturer, which are beyond the scope of the range of approval, need new tests.

The approval of a welding procedure by the Register obtained by a shipyard or welded structures manufacturer is valid for welding in all workshops of the given shipyard/manufacturer subject to the WPS requirements for this welding procedure.

### 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 4.9.1.3-1 and 4.9.1.3-2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

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 beveling,  $t$  is the thickness of the thicker material;
- for tee-joints of beveled plates,  $t$  is the thickness of a beveled component (welded-on element);
- for fillet joints with bevelling,  $t$  is the thickness of the thinner material;
- for joint assemblies of pipes like the "blind" welded-on adaptors,  $t$  is the welded-on element wall thickness;

Table 7.5.2.2

Thickness of test piece in qualification tests $t$ , in mm	Range of approval by base metal thickness
$t \leq 3$	From $0,5t$ to $2t$ inclusive
$3 < t \leq 20$	Above 3 mm to $2t$ inclusive
$t > 20$	From $0,8t$ and above

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, the welding procedure approval covers welded joints with design throat thickness of fillet welds from  $0,75a$  to  $1,5a$  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 7,5 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  $0,75a$  to  $1,1a$  inclusive.

For fillet welds, in parallel with the standardization 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](#).

Table 7.5.2.4

Diameter of test piece $D$ , in mm <sup>1</sup>	Range of approval
$D \leq 25$	From $0,5D$ to $2,0D$
$D > 25$	$\geq 0,5D$ but not less than 25 mm

<sup>1</sup>  $D$  is the outside diameter of the pipe or outside diameter of the branch pipe.

**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  $\alpha_1$  between the axes of pipes



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Type of welded test assembly in approval tests		Range of approval								Fillet welds on pipe and plate without beveling (FW)
		Butt joint on plate (P:BW)				Butt joint on pipe (T:BW)		Branch connections (T:TW)		
		Welded from one side (ss)		Welded from both sides (bs)		Welded from one side (ss)		Welded from one side (ss)	Welded from both sides (bs)	
		with backing (mb)	no backing (nb)	with gouging (gg)	no gouging (ng)	with backing (mb)	no backing (nb)	–	–	
Fillet joints without beveling (FW)	Pipes (T)	–	–	–	–	–	–	–	–	×
<sup>1</sup> Plate qualifies pipe with external diameter $D > 500$ mm. <sup>2</sup> Butt joints on plate qualify T-joints. Symbols: × indicates those welding types of joints covered by WPS (without additional tests). – indicates those welding types of joints not covered by WPS (new approval tests are required).										



Type of welded test assembly in approval tests	Range of approval												Fillet welds on pipe and plate without beveling (F)
	Butt joint on plates				T-joints on plates (TW)				Butt joint on pipe (T)		Branch connections (T:TW)		
	Welded from one side		Welded from both sides		Welded from one side		Welded from both sides		Welded from one side		Welded from one side	Welded from both sides	
	with backings (A)	without backings (B)	with gouging (C)	without gouging (D)	with backings (A)	without backings (B)	with gouging (C)	without gouging (D)	with backings (A)	without backings (B)			
<sup>1</sup>	Plate qualifies pipe with external diameter $D > 500$ mm.												
<sup>2</sup>	Butt joints on plate qualify T-joints.												
Symbols:													
*	indicates those welding types of joints for which WPS is approved directly by the test results;												
x	indicates those welding types of joints covered by WPS (without additional tests);												
–	indicates those welding types of joints not covered by WPS (new approval tests are required).												

**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 interrun temperature shall comply with an actual interrun 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 interrun temperature shall comply with an actual interrun 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.

**7.5.3.10** The range of approval for the welding procedure of metal-arc inert gas welding (131) shall be limited by:

the group of the standard composition of inert gas (refer to [Table 6.2.2.5](#)), 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 6.2.2.5](#)), 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 6.2.2.5](#)), 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).

## **7.6 APPROVAL OF FRICTION STIR WELDING PROCEDURES FOR ALUMINIUM ALLOYS**

**7.6.1** Prior to certification of FSW procedure using experience from previous production jobs, the manufacturer shall prepare preliminary welding procedure specification (pWPS) in order to achieve the required quality levels specified in ISO 25239-5:2020. pWPS shall comply with the requirements of ISO 25239-4:2020.

**7.6.2** Certification of welding procedure shall be obtained by qualification tests in accordance with ISO 25239-4:2020.

Qualification test reports shall comply with ISO 25239-4:2020.

**7.6.3** Welding procedure specification (WPS) shall be prepared after the qualification test report on the Register approved procedure has been drawn up.

**7.6.4** Range of approval shall be limited by the following:

**.1** manufacturer. Welding procedure approved for the specified firm is only valid for this firm;

**.2** types of materials. Certification of FSW procedure is limited by the applicable brand of aluminium alloy and its condition of supply;

**.3** pipe thickness and diameter. The scope of approval of FSW procedure is limited by the thickness of test pieces welded within the certification process. Where certification of thickness range is required, it is necessary to perform welding of test pieces with integral values of thicknesses within the specified range upon 1 mm increment and to carry out further tests. In case of approval of FSW procedure, for each thickness of rolled products at least one test piece with the length not less than 500 mm shall be welded.

If in its process activity the firm performs rolled product welding with thickness other than integral values (with indication of decimal values of millimeters of thickness), prior to welding the additional control tests with test pieces welding of these rolled products thicknesses on corrected FSW parameters regarding conditions specified in Welding Procedure Approval Test Certificate (COTΠC) shall be performed.

Scope of approval per pipe diameters welded by FSW shall be determined if FSW parameters remain unchanged (refer to [7.6.4.7](#));

**.4** types of joints. Certification of FSW procedure is carried out on butt welds and is limited only by those butt welds that have been produced during welding procedure testing;

**.5** welding equipment. Certification of FSW procedure is limited by the specified welding equipment used during qualification tests;

**.6** welding tool. Certification of FSW procedure is limited by the specified type of welding tool used during qualification tests:

tool with adjustable probe;

tool with fixed probe;

bobbin tool with shoulders separated by a fixed length probe;

bobbin tool with shoulders separated by an adjustable length probe;

**.7** range of welding parameters. Certification of FSW procedure covers only those values of welding parameters that have been fixed during tests. Standard for deviations from these parameters ( $\Delta$ ) shall be indicated in the RS-approved documentation of the firm.

Mandatory limited welding parameters during certification of FSW procedure are:

welding speed ( $V$ );

speed of welding tool ( $\omega$ ).

longitudinal tilt angle ( $\alpha xz$ ) and transverse tilt angle ( $\alpha yz$ );

force on the probe ( $p$ );

force on the welding tool ( $P$ );

heel plunge depth ( $h$ );

For tools specially developed to form the specified sense of rotation, the limitation shall be the sense of rotation that has been applied during certification. In tools for which the priority of rotation is not applicable and there are no particulars in geometry affecting the sense of rotation, rotation parameters of the tool shall cover both senses;

**.8** requirements for assembly. Certification covers only those conditions that have been fixed during tests. The mandatory limited welding parameters during certification of FSW procedure are:

gaps between butt details for welding ( $a$ );

permissible transverse misalignment of butt edges ( $Y$ );

permissible vertical misalignment of butt edges (Z);  
heat-removing method.

**.9** method for edge preparation and cleaning. Certification covers the method of edge preparation and cleaning of welded details (mechanical, abrasive or chemical) that is applied during tests. When amending the method of edge cleaning the repeated tests shall be required. Welding shall be performed not later than in one day after their cleaning;

**.10** welding position. In general, certification of FSW procedure covers only welding position in which the welding has been carried out during the tests. The scope of approval may include other welding positions if during tests the invariability of welding parameters (refer to [7.6.4.7](#)) is determined.

Standard for deviations from these parameters shall be indicated in the RS-approved documentation of the manufacturer.

## 8 APPROVAL OF WELDING PROCEDURES FOR TITANIUM ALLOYS

### 8.1 GENERAL

**8.1.1** The requirements of the present Section supplement the requirements of Section 6 of the present Part and specify the conditions for approval of welding procedures for titanium alloys. In case there are no special requirements, the above mentioned conditions for approval shall be applied.

**8.1.2** The requirements of the present Section apply to the wrought titanium alloys supplied in plates (BT1-00, BT1-0, ПТ-3B) and pipes (BT1-00, BT1-0, ПТ-1М, ПТ-7М, ПТ-3B) complying with the requirements of Section 9, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. In other cases during approval of welding procedures for titanium alloys the requirements of international standard ISO 15614-5 or similar national standards (e.g., GOST R ISO 15614-5) shall be applied.

**8.1.3** Definitions, clarifications and terms applied for the approval of welding procedures for titanium alloys are similar to those indicated in [6.2.1](#).

The symbols used for the approval of welding procedures for titanium alloys are similar to those indicated in [7.2.2](#).

**8.1.4** Welding procedure approval for titanium 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.

In so doing, depending on the use of labour-saving devices by welders, welding types are divided into the following groups:

M/MW<sup>1</sup> = 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);

A = fully mechanized (automatic) welding wherein the processes of wire feed and welding gun manipulation are mechanized and carried out without welder's direct participation.

**8.1.5** The welding fillers used for the welding of shipbuilding titanium alloys are classified by categories according to [Table 8.1.5](#).

Table 8.1.5

Grade of welding consumable		Letter designation of grade of welding consumable	Base metal for tests	Range of approval
Wire	Rod			
TiWA	TiRA	BT1-00св	BT1-0	BT1-00, BT1-0
TiWB	TiRB	2B	ПТ-3B	BT1-00, BT1-00, ПТ-1М, ПТ-7М, ПТ-3B
		ПТ-7Мсв <sup>1</sup>	ПТ-7 <sup>1</sup>	BT1-00, BT1-0, ПТ-1М, ПТ-7М

<sup>1</sup> The approval of welding consumables intended exclusively for welding alloys used only for pipe manufacture is performed in scope of the requirements for the approval of welding procedures for the butt joints of pipes with diameter  $D \leq 25$  mm and  $D \geq 80$  mm with wall thickness  $t \leq 3$  mm and  $t \geq 10$  mm, appropriately, in one welding position.

**8.1.6** Shielding gases used for welding depending on their composition are divided into groups designated with indices in accordance with Table 4.9.1.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

<sup>1</sup> The symbol "MW", is used before 1 October 2019, the symbol "M" is used on and after 1 October 2019.

## 8.2 WELDED TEST ASSEMBLIES TYPES AND TEST METHODS

### 8.2.1 General requirements for test assemblies' preparation.

**8.2.1.1** The structural elements of edge preparation, 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 edge preparation and fit-up to ensure the quality of welded joints shall be checked.

*Note.* In order to fulfill 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.).

**8.2.1.2** The welding of test assemblies during tests shall be made with the use of equipment similar to that used in production conditions.

**8.2.1.3** 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.

**8.2.1.4** Where assembly tack welds are the part of structure welds, they shall be included into the test assembly part to be tested.

**8.2.1.5** The procedure parameters and welding conditions shall meet the pWPS requirements. In this case, the requirements for the heating temperature, interrun temperature and for the parameters of welded joints heat treatment/ageing, if any, shall be followed.

**8.2.1.6** 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.

**8.2.1.7** The thickness of the base metal 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.

**8.2.1.8** For the welding of test assemblies, the welding wire (rods) of the maximum diameter specified in pWPS or, by an agreement with the Register, by one standard size less, shall be used.

**8.2.1.9** Tests of assemblies, besides those stipulated by [8.2.2](#), on the Register demand or under the contract terms applied may additionally include the following:

tensile tests of longitudinal specimens from weld metal;

bend testing of welded joint longitudinal specimens;

impact testing of weld metal and welded joint;

hardness test;

testing for resistance to corrosion;

chemical analysis.

### 8.2.2 Classification of test pieces, their purpose and dimensions.

**8.2.2.1** Length or number of test pieces shall be sufficient to allow all required qualification tests to be carried out in compliance with the requirements stated below.

Additional test pieces, or longer test pieces than the minimum size, may be prepared in order to allow for extra and/or for re-testing specimens in compliance with the requirements of this Section.

**8.2.2.2** For all test pieces, except branch connections and fillet and tee joints, the material thickness shall be the same for both plates/pipes to be welded.

**8.2.2.3** Welding of welded joint test pieces and testing of test specimens shall be witnessed by the RS surveyor.

**8.2.2.4** The test piece for a butt-welded joint in plates shall be prepared in accordance with [Fig. 8.2.2.4](#).

**8.2.2.5** Welding procedures for butt joint in pipe are approved on the basis of tests using the test piece, which is prepared in accordance with [Fig. 8.2.2.5](#).

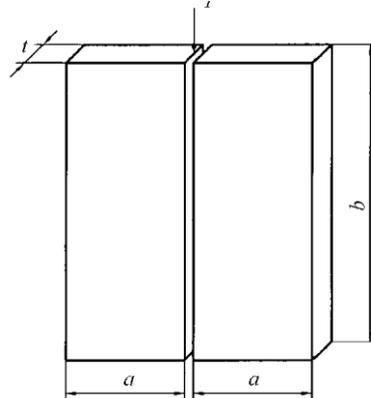


Fig. 8.2.2.4

Test piece for a butt joint in plate:

- 1 — edge preparation and fit-up as detailed in pWPS;  $t$  — base metal thickness;
- $a \geq 150$  mm (transverse bend test specimens may require a larger  $a$ );
- $b \geq 350$  mm

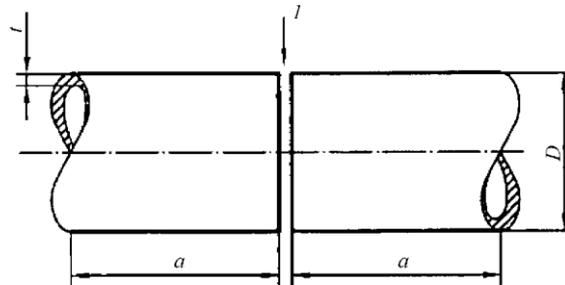


Fig. 8.2.2.5

Test piece for a butt joint in pipe:

- 1 — edge preparation and fit-up as detailed in pWPS;
- $t$  — base metal thickness;  $a \geq 150$  mm;
- $D$  — outside pipe diameter

**8.2.2.6** For the approval of welding procedures for fillet and tee-joints of plates and semi-finished products, the tee-test assembly dimensioned according to [Fig. 8.2.2.6](#) with regard to the requirements of [8.2.1.7](#) may be used.

In accordance with pWPS, the tee-joint test assembly may be fabricated:  
without beveling (fillet welding);  
or with beveling (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 beveled tee-joints;  
for the approval of a welding procedure with a single-run fillet weld without beveling.

In other cases, the welding procedure approval for fillet and tee-joints of plates and semi-finished products may be carried out within the range of approval according to [8.5.3.3](#).

**8.2.2.7** Welding procedures for pipe and branch connections (T-, Y- and K-shaped pipe connections) are approved on the basis of testing the test piece for a branch connection which is prepared in accordance with [Fig. 8.2.2.7](#).

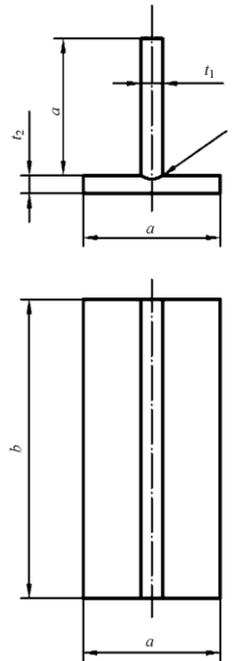


Fig. 8.2.2.6

Test piece for a tee-joint in plate and semi-finished product:

1 — edge preparation and fit-up as detailed in pWPS;

$t$  — base metal thickness;  $a \geq$  mm;  $b \geq 350$  mm

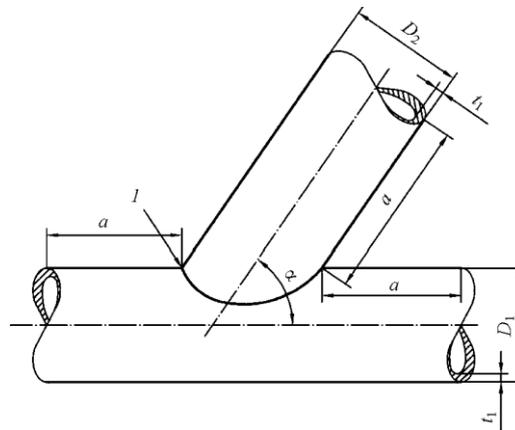


Fig. 8.2.2.7

Test piece for a branch connection:

1 — edge preparation and fit-up as detailed in pWPS;

$t$  — base metal thickness;  $a \geq 150$  mm;

$D_1$  — outside diameter of the main pipe;

$D_2$  — outside diameter of the branch pipe;

$t_1$  — main pipe material thickness;

$t_2$  — branch pipe material thickness;

$\alpha$  — branch angle

### 8.3 REQUIREMENTS FOR TEST ASSEMBLIES EXAMINATION, TEST SPECIMENS PREPARATION AND TEST RESULTS EVALUATION

#### 8.3.1 Extent of the test assemblies examination and testing.

8.3.1.1 Each test assembly after welding shall be subjected to testing within the scope of the requirements specified in [Table 8.3.1.1](#). At the same time the welded joints examination, test specimens preparation and test results evaluation shall meet the requirements given below.

Table 8.3.1.1

**Requirements for extent of testing for approval of welding procedures**

Nos.	Type of welded test piece	Type of test	Extent of testing
1	Butt joint in plate — refer to <a href="#">Fig. 8.2.2.4</a>	Visual and measurement testing	100 % of weld length
		Radiographic or ultrasonic testing <sup>1</sup>	100 % of weld length
		Dye penetrant testing	100 % of weld length
		Transverse tensile test	2(4) specimens <sup>2</sup>
		Transverse bend test	4 specimens <sup>3</sup>
		Hardness test	Required
		Macro examination <sup>4</sup>	Required: 1 transverse macrosection
		Micro examination <sup>4</sup>	Required: 1 transverse microsection
2	Butt joint in pipe — refer to <a href="#">Fig. 8.2.2.5</a>	Visual and measurement testing	100 % of weld length
		Radiographic or ultrasonic testing <sup>1</sup>	100 % of weld length
		Dye penetrant testing	100 % of weld length
		Transverse tensile test	2(4) specimens <sup>2</sup>
		Transverse bend test <sup>5</sup>	4 specimens <sup>3</sup>
		Flattening test <sup>5</sup>	2 specimens
		Hardness test	Required
		Macro examination <sup>4</sup>	Required: 1 transverse macrosection
3	T-joints in plate with edge preparation (with full penetration), refer to <a href="#">Fig. 8.2.2.6</a>	Visual and measurement testing	100 % of weld length
		Radiographic or ultrasonic testing <sup>1</sup>	100 % of weld length
		Dye penetrant testing	100 % of weld length
		Hardness test	Required
		Macro examination <sup>6</sup>	Required: 2 transverse macrosections
		Micro examination	Required: 1 transverse microsection
4	T-joints in plate without edge preparation (fillet/joint) — refer to <a href="#">Fig. 8.2.2.6</a>	Visual and measurement testing	100 % of weld length
		Dye penetrant testing	100 % of weld length
		Macro examination	Required: 2 transverse macrosections <sup>7</sup>
		Micro examination	Required: 1 transverse microsection
		Fracture test	Required: 1 specimen
5	Branch connection with edge preparation on branch to be welded (with penetration) — refer to <a href="#">Fig. 8.2.2.7</a>	Visual and measurement testing	100 % of weld length
		Dye penetrant testing	100 % of weld length
		Ultrasonic testing <sup>8</sup>	100 % of weld length
		Hardness test	Required
		Macro examination	Required: 4 transverse macrosections <sup>9</sup>
		Micro examination	Required: 1 transverse microsection
6	Branch connection without edge preparation on branch to be welded (without penetration) — refer to <a href="#">Fig. 8.2.2.7</a>	Visual and measurement testing	100 % of weld length
		Dye penetrant testing	100 % of weld length
		Hardness test	Required
		Macro examination	Required: 2 transverse macrosections <sup>10</sup>
		Micro examination	Required: 1 transverse microsection

Nos.	Type of welded test piece	Type of test	Extent of testing
1			Ultrasonic testing shall not be used at base metal thicknesses $t < 8$ mm.
2			2 specimens with removed weld reinforcement and 2 specimens with weld reinforcement in compliance with the national standards. 2 specimens with weld reinforcement shall be tested only in case the structure reinforcement is stipulated by the national standards (weld metal does not provide full strength with the base metal).
3			For thicknesses $t < 12$ mm, 2 root and face bend test specimens are required. For thicknesses $t \geq 12$ mm, 4 side bend test specimens are required. <sup>4</sup> Combined test in one specimen is allowed.
5			For pipe outside diameter $D \leq 50$ mm, 4 bend test specimens may be substituted by 2 flattening test specimens.
6			In cases when the welding procedure according to pWPS 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 edge preparation.
7			For manual welding 1 macrosection at start/stop location.
8			For pipe outside diameter $D \leq 50$ mm, no ultrasonic test is required. For pipe outside diameter $D > 50$ 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.
9			According to Fig. 8.3.2.4 specimens are sampled in areas A, A <sub>1</sub> , B and B <sub>1</sub> .
10			According to Fig. 8.3.2.4 specimens are sampled in areas A, B or B <sub>1</sub> .

**8.3.1.2** The examination and tests of welded joints test assemblies shall be performed in the following sequence:

- visual and measurement testing;
- dye penetrant testing;
- radiographic or ultrasonic testing if specified for the joint type concerned;
- marking-out of test assemblies and sampling for mechanical tests;
- test specimens machining and mechanical test performance;
- assessment of the test results.

**8.3.2 Requirements for location and taking of test specimens for mechanical tests.**

Test specimens for mechanical tests shall be taken after all non-destructive testing (NDT) has been carried out and which has passed the relevant inspection criteria for the NDT methods used within the scope of requirements specified in [Table 8.3.1.1](#). It is acceptable to take the test specimens from locations avoiding areas which have imperfections within the acceptance limits for the NDT method used. Test specimens for mechanical tests shall be taken in accordance with [Figs. 8.3.2.1-1 — 8.3.2.1-5](#).

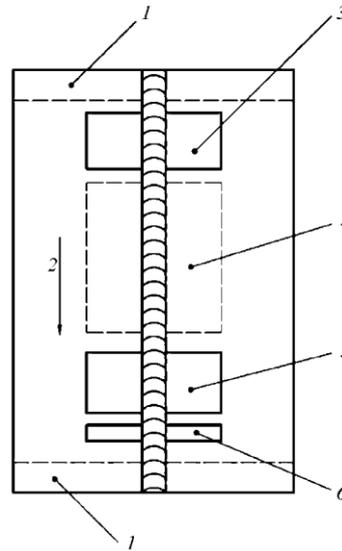


Fig. 8.3.2.1-1

Location of test specimens for a butt joint in plate:

- 1 — discard; 2 — welding direction;
- 3 — area for 1 tensile test specimen and 2 bend test specimens;
- 4 — area for additional test specimens, if required;
- 5 — area for 1 tensile test specimen and 2 bend test specimens;
- 6 — area for 1 macrosection and 1 microsection

### 8.3.3 Requirements for non-destructive testing and test results evaluation.

**8.3.3.1** Test pieces of welded joints shall be examined by visual and measurement testing and non-destructive testing prior to the cutting of test specimen in accordance with [Table 8.3.1.1](#).

**8.3.3.2** Unless otherwise specified by the contract or specification for a particular product manufacture, as a result of examination by the NDT methods evaluation of the welded joints test pieces quality shall be carried out in compliance with ISO 5817 for the Acceptance Quality Level B. The reduction criteria down to Quality Level C is therewith acceptable for imperfections associated with oversized welds (excessive height and width of a butt weld reinforcement, excess throat thickness of a fillet weld, excessive reinforcement of a single-side butt weld root).

During examination by specific NDT methods the requirements of ISO 17635 to examination class and Quality Level shall be complied with:

to perform Level B by visual and measurement testing as per ISO 5817 test methods shall be carried out in accordance with ISO 17637 (Testing Class is not regulated);

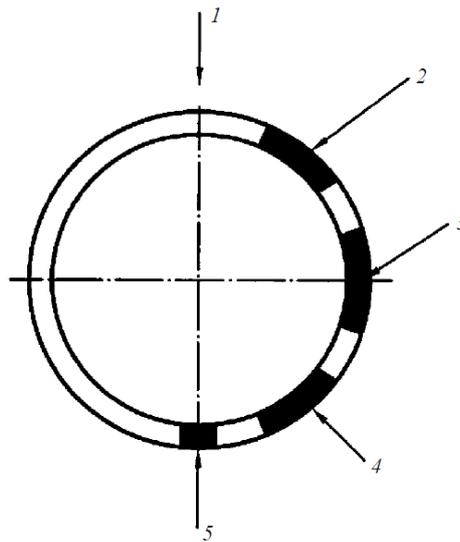


Fig. 8.3.2.1-2

Location of test specimens for a butt joint in pipe: 1 — top of fixed pipe; 2 — area for 1 tensile test specimen and 2 bend test specimens; 3 — area for additional test specimens, if required; 4 — area for 1 tensile test specimen and 2 bend test specimens; 5 — area for 1 macrosection and 1 microsection

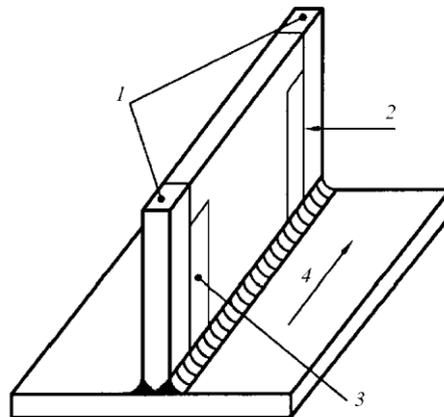


Fig. 8.3.2.1-3

Location of test specimens for a T-joint in plates with full penetration: 1 — discard; 2 — area for 1 macrosection and 1 microsection; 3 — area for 1 macrosection; 4 — welding direction

for magnetic particle testing the Quality Level 2X in compliance with ISO 23278, test methods shall be carried out in accordance with ISO 17638 (Testing Class is not regulated);

for radiographic testing the Quality Level 1 in compliance with 10675-1, test methods shall be carried out in accordance with ISO 17636 (Testing Class B);

for ultrasonic testing Quality Level 2 as per ISO 11666 (in compliance with 3.4.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships), the test procedure in accordance with ISO 17640 (Testing Level B).

General procedure for performance and basic parameters of non-destructive testing (NDT) test pieces shall comply with 3.2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**8.3.3.3** Accepted colours on the weld metal surface: silver and straw. A narrow band of intensive colours close to the limits of the gas shielding is acceptable. Darker brown, purple and blue colours and grey or flaky white are not acceptable.

**8.3.4 Requirements for mechanical tests.**

**8.3.4.1** Scope of mechanical tests regarding types and quantity of test specimens shall comply with [Table 8.3.1.1](#).

**8.3.4.2** Tensile tests.

Two tensile specimens taken from the test pieces for butt joints in plate and pipe having dimensions in compliance with ISO 4136 ([refer to Fig. 6.4.4.1-1](#) or [6.4.4.1-2](#)) shall be tested. 2 specimens with weld reinforcement are additionally tested in case when the structural reinforcement is required by the national standards (weld metal does not provide full strength with the base metal).

For pipes  $D > 50$  mm outside diameter, the weld reinforcement shall be removed on both faces to give the test specimen a thickness equal to the wall thickness of the pipe.

For pipes  $D \leq 50$  mm outside diameter, and when full section small diameter pipes are used, the weld reinforcement may be left undressed on the inside surface of the pipe.

**8.3.4.3** Bend test.

Four bend test specimens taken from the test pieces of butt joints in plate and pipe having dimensions as given in ISO 5173:2009 ([refer to Fig. 6.4.4.2-1](#)) shall be tested for static bend: for thicknesses of a base metal  $t < 12$  mm, two root and two face bend test specimens shall be tested;

for thicknesses of a base metal  $12 \leq t < 20$  mm, four side bend specimens are allowed instead of root and face bend tests;

for thicknesses of a base metal  $t \geq 20$  mm, four side bend specimens shall be tested.

**8.3.4.4** Flattening tests of butt joints in pipe.

For butt joints in pipe with the outside diameter  $D \leq 50$  mm, 4 bend test specimens may be substituted by 2 flattening test specimens in pipe in compliance with the international or national standards (e.g., ISO 8492, ASTM A513, GOST 8695). Test specimens with the removed weld reinforcement shall be tested.

For pipes with the ratio of the outside diameter to the wall thickness  $D/t \leq 10$ , test shall be performed in two stages:

for distance between the formers (before release of the load) equal to  $0,67D + 2t$ , examination of the internal and external surfaces of the specimen shall be performed;

for distance between the formers equal to  $0,55D + 2t$ , examination of the external surface of the specimen only shall be performed.

For pipes with the ratio of the outside diameter to the wall thickness  $10 < D/t \leq 20$ , test shall be performed for distance between the formers (before release of the load) equal to  $0,6D$ , examination of the internal and external surfaces of the specimen shall be performed.

**8.3.4.5** 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 of one specimen in compliance with ISO 9017 or similar national standards. If necessary to facilitate fracture in the critical cross-section, a longitudinal notch may be done on the centre of the weld surface or additional notches about 5 mm depth on both edges of the fillet weld (side notching) may be done.

**8.3.4.6** Hardness test.

The Vickers hardness of the welded joint metal (HV10) for butt joints in plate and pipe shall be determined with the use of transverse and longitudinal macrosections.

Examples of hardness test for butt joints in pipe are given in [Fig. 8.3.4.6](#). Hardness of T-joints in plate and pipe shall be determined only with the use of transverse sections.

The Vickers hardness (HV10) shall be determined with the distance between the centre points of the indentations 1 mm for transverse sections and 2 mm for longitudinal sections.

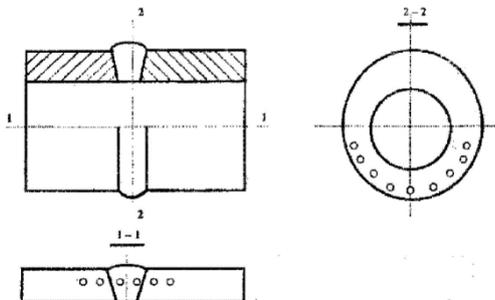


Fig. 8.3.4.6  
Examples of hardness test for butt joints in pipe

### 8.3.4.7 Macro and micro examination.

The test transverse macro and micro sections shall be ground and etched on one side to clearly reveal the weld metal, the fusion line and the heat-affected zone in compliance with EN 1321 (or similar international or national standard).

Macro examination shall include all areas of welded joint and unaffected base metal.

A photo for each macro examination shall be taken to record the examination results.

Examination of welded joints microstructure shall be conducted according to the program agreed with the Register. The program shall include the requirements for test procedures and results assessment criteria.

Transverse macro sections shall be examined to reveal the following:

- regular weld profile;
- absence of incomplete penetration;
- absence of inadmissible undercuts;
- inadmissible internal defects in the weld and the adjacent zone;
- compliance of welding sequence in the groove with pWPS.

### 8.3.5 Requirements for evaluation of mechanical test and macro and micro examination results.

8.3.5.1 The tensile strength value when testing transverse tensile specimens of butt-welded joints shall not be less than the minimum value for base metal given in [Table 8.3.5.1](#).

Table 8.3.5.1

Base metal		Properties of welded joints		
Type of product	Category	Tensile strength	Static bend	
		$R_m$ , MPa <sup>1</sup>	Mandrel diameter $D_{mandrel}/t_s^2$	Bending angle, in deg.
Plates	BT1-00	295	6	180
	BT1-0	370	6	180
	ПТ-3В	640	8	180
Pipes	BT1-00	295	6	180
	BT1-0	343	6	180
	ПТ-1М	343	6	180
	ПТ-7М	480	8	180
	ПТ-3В	686	8	180

<sup>1</sup> But not more than tensile strength of base metal in compliance with supply documentation.

<sup>2</sup>  $t_s$  — thickness of the bend test specimen.

For dissimilar welded joints the tensile strength shall not be less than the minimum value specified for the material having the lowest tensile strength.

**8.3.5.2** During bend testing the ratio of mandrel diameter to specimen thickness ( $D_{mandrel}/t$ ) shall comply with [Table 8.3.5.1](#). In cases not specified in [Table 8.3.5.1](#) the following requirements shall be met:

the diameter of the former or the inner roller  $D_{mandrel}$  shall be equal to  $6t_s$  for alloys with nominal elongation  $A_5 \geq 20\%$ , except materials of group 51 ISO/TR 15608 with the mandrel diameter equal to  $4t_s$ ;

for the base metal with elongation  $A_5 < 20\%$ , the following formula shall apply:

$$D_{mandrel} = (100/A_5 - 1) \times t_s$$

where  $D_{mandrel}$  = diameter of the former or the inner roller, in mm;

$t_s$  = thickness of the bend test specimen, in mm;

$A_5$  = minimum tensile elongation required by material specification (nominal value), in %.

The tests shall be carried out until the bending angle of  $180^\circ$  is reached. The specimens shall be subjected to one-type bending and the weld section, heat affected zone (HAZ) and base metal shall exactly correspond to the mandrel radius. It confirms that the gas shielded welding does not deteriorate the joint plasticity and molding properties of the base metal.

After the specimen testing, no defects more than 3 mm in length shall appear on its surface.

Cracks appearing at the corners of a test specimen during testing shall be neglected.

**8.3.5.3** In the flattening tests of the butt joints in pipes, the quality of welded joint shall be considered unsatisfactory when obtaining the distance specified in [8.3.4.4](#) the cracks visible by unaided eye are observed on the specimen surface.

**8.3.5.4** During testing of T-joint welds for static fracture, the specimen's fracture surface shall be inspected for the presence of inadmissible internal defects (pores and porosity, slag inclusions, lack of fusion and cracks), the value of fusion in the root weld shall also be checked. Imperfections that are detected shall be evaluated in accordance with ISO 5817, quality level B.

**8.3.5.5** Hardness value  $HV_{10} \leq 230$  for welding wire TiWA/TiRA(BT1-00CB),  $HV_{10} \leq 300$  for welding wire TiWB/TiRB(ПТ-7Mcb and 2B). Hardness in HAZ shall not exceed the hardness of base metal.

Single values up to 400 are allowed in case when hardness value at this point (3 – 4 points at distance of 1 mm)  $\leq 230$  for welding wire TiWA/TiRA (BT1-00CB),  $\leq 300$  for welding wire TiWB/TiRB(ПТ-7Mcb and 2B). Not more than three adjoining measuring points on butt joints are allowed.

**8.3.5.6** Transverse macrosections shall be examined in scope of the requirements given in [8.3.4.7](#) for monitoring and revealing the deficiencies specified in [8.3.3](#). In the test report all the revealed external and internal defects or deficiencies, including allowable ones, shall be recorded.

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.

## 8.4 REQUIREMENTS FOR RE-TESTING

**8.4.1** If the test piece fails to comply with any of the requirements for visual and measurement testing and non-destructive testing, one further test piece shall be prepared and

subjected to the same examination. If the additional test piece does not comply with the relevant requirements, the pWPS shall be regarded as not capable of complying with the requirements without modification.

**8.4.2** If any test specimen fails to comply with the relevant requirements for mechanical tests due to weld imperfections only, two further test specimens for each one that failed shall be prepared and subjected to the same test. The specimens for re-testing can be taken from the same test piece if there is sufficient material available or from a new test piece. If either of these additional test specimens does not comply with the relevant requirements, the pWPS and the welding procedure are considered unsuitable for use in production without modifications ensuring the required quality of welded joints.

**8.4.3** If a tensile 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 piece if there is sufficient material available or from a new test piece. When both additional specimens have demonstrated satisfactory test results, the common result of the tensile tests is considered positive. If one or both additional specimens have failed at retesting, the pWPS and the welding procedure are considered unsuitable for use in production without modifications ensuring the required quality of welded joints.

**8.4.4** If a test piece is rejected due to the hardness test results, the re-testing shall be carried out on a doubled number of specimens. The specimens for re-testing are taken in compliance with the requirements of [8.4.2](#).

**8.4.5** 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. Sampling for re-testing is carried out similarly to the requirements of [8.4.2](#).

**8.4.6** If any test specimen has not satisfied a test due to the presence of permissible slag or gas inclusions, one additional test specimen shall be machined for re-testing. Sampling is carried out similarly to the requirements of [8.4.2](#).

**8.4.7** 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 [8.4.2 — 8.4.6](#), the welding procedure is considered unsuitable for use without modifications ensuring the required quality of the welded joint metal.

## **8.5 RANGE OF APPROVAL FOR WELDING PROCEDURE BASED ON QUALIFICATION TEST RESULTS**

### **8.5.1 General.**

**8.5.1.1** 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.

**8.5.1.2** All the conditions of validity stated below shall be met independently of each other.

**8.5.1.3** 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. In this case the manufacturer who performed the welding procedure qualification test retains complete responsibility for all welding carried out to it.

### 8.5.2 Requirements for the range of approval related to base metal.

**8.5.2.1** Tests carried out on the titanium alloy of one of the groups in [Table 8.5.2.1](#) 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 8.3.5.1](#).

Table 8.5.2.1

#### Classification of titanium and titanium alloys by type composition groups

Group designation as per ISO 15608	Type and characteristic of alloys	Category of titanium alloys
52	$\alpha$ alloys	BT1-00, BT1-0, ПТ-1М
53	$\alpha - \beta$ alloys	ПТ-3В, ПТ-7М

### 8.5.2.2 Base metal thickness and pipe diameter.

**8.5.2.2.1** Tests for welding procedure approval conducted on test assemblies having the nominal thickness  $t$  are valid for the thickness range according to [Table 8.5.2.2.1](#). 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;

Table 8.5.2.2.1

#### Approval range of base metal thickness $t$ for butt and T-joint welds and fillet welds

Thickness $t$ of test piece in qualification tests, in mm <sup>1</sup>	Range of approval	
	Single run or single run welding from both sides	Multirun welding <sup>2</sup>
$t \leq 3$	$0,7t - 1,5t$	$0,7t - 2t$
$3 < t \leq 12$	$0,7t - 1,3t$	$3 \text{ mm} - 2t$
$t > 12$	$0,7t - 1,1t$	$0,5t - 2t$

<sup>1</sup> For fillet and branch connections made by fillet welds without edge preparation, the range of approval shall be applied to both base metals.  
<sup>2</sup> For multi process procedures, the recorded thickness contribution of each process shall be used as a basis for the range of approval for the individual welding process.

for fillet joints without beveling,  $t$  is the thickness of the thicker material;

for tee-joints of beveled plates,  $t$  is the thickness of a beveled component (welded-on element);

for fillet joints with bevelling,  $t$  is the thickness of the thinner material;

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.

**8.5.2.2.1.2** In addition to the requirements of [Table 8.5.2.2.1](#), the limitations stated below apply to the range of approval for fillet weld throat thickness from  $0,75a$  to  $1,5a$ , inclusive; where  $a$  is the test throat thickness.

Where a fillet weld without edge preparation is qualified by means of a butt weld test, the range of approval for fillet weld throat thickness  $a$  shall be based on the thickness of the deposited metal within the range of approval specified in [Table 8.5.2.2.1](#) for the relevant welding procedure (single and multirun welds).

**8.5.2.2.1.3** 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 8.5.2.2.1.3](#).

Table 8.5.2.2.1.3

**Range of approval for pipe outside diameters**

Diameter of the test piece $D$ , in mm <sup>1</sup>	Range of approval for pipe outside diameters, in mm <sup>2</sup>
$D \leq 25$	$0,5D - 2D$
$D > 25$	$0,5D, 5D$ but not less than 25 mm

<sup>1</sup>  $D$  — outside diameter of the pipe or outside diameter of the branch pipe.  
<sup>2</sup> Approval given for plates also covers pipes when the outside diameter is  $> 500$  mm (refer also to [Table 6.6.3.2](#)).

Approval given for plates also covers pipes when the outside diameter  $> 500$  mm or when the diameter  $> 150$  mm welded in the welding position PA or PC.

**8.5.2.2.1.4** In tests for welding procedures approval which are associated with the welding of pipe joint assemblies, the range of approval as to the angle  $\alpha_1$  between the axes of pipes to be joined shall be specified in relation to the angle  $\alpha$  during the tests proceeding from the condition  $\alpha \leq \alpha_1 \leq 90^\circ$ .

**8.5.3 General requirements for the range of approval related to welding procedure.**

**8.5.3.1** Welding process and type.

The approval is only valid for the welding process and welding type used in the welding procedure qualification test.

Each degree of the welding mechanization shall be qualified independently (manual, partly mechanized, fully mechanized and automatic). In the same way, it is not allowed to change the means of the welding mechanization implementation (manual, partly mechanized, fully mechanized or automated) unless newly qualified.

For multi-process procedures the welding procedure approval may be carried out with separate welding procedure tests for each welding process and with a multi-process procedure test similarly to approval tests for welders. In this case, the relevant range of approval according to weld metal thickness for each welding process used shall be specified. The approval of such a test is only valid for the process sequence carried out during the multi-process procedure test.

*Note.* It is not allowed to use a multi-process procedure test to qualify any single process.

**8.5.3.2** Welding positions.

Welding of a test in any one position (pipes or plates) qualifies for welding in all positions (pipes or plates) except for PG and J-L045 where a separate welding procedure test is required.

**8.5.3.3** Type (design features) of welded joint.

Range of approval for the types of welded joints shall be, as used in the welding procedure qualification tests, comply with the limitations stated below:

range of approval for full penetration butt welds qualifies full and partial penetration butt welds, as well as fillet welds. Qualification tests for fillet welding shall be required where this is the predominant form of production welding;

range of approval for butt joints in pipe may also qualify branch connections with an angle  $\alpha_1 \geq 60^\circ$ ; range of approval for T-joints butt welded with edge preparation qualifies this type of joints and fillet welds;

range of approval for butt welds made from one side without backing qualifies welds with backing and welds made from both sides;

range of approval for butt welds made with backing qualifies welds made from both sides;

range of approval for fillet welding qualifies fillet welding only;

it is not permitted to change a multirun deposit into a single run (or single run on each side) or vice versa for a given process.

**8.5.3.4** Welding consumables.

Range of approval for filler materials cover other filler materials as long as they have equivalent mechanical properties, same nominal composition according to the designation in the appropriate standard for the filler material concerned.

**8.5.3.5** Type and polarity of current.

The qualification is given for the type of current (alternating, direct, pulsed current) and polarity used in the welding procedure test.

**8.5.3.6** Interpass temperature.

The upper limit of the qualification is the highest interpass temperature reached in the welding procedure test.

**8.5.3.7** Post-weld heat-treatment.

Addition or deletion of post-weld heat treatment is not permitted and shall be subject to new welding procedure qualification tests.

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 +20 °C.

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.

**8.5.3.8** Welding of the joint back side with gas shield.

Range of approval for welding of the joint back side without gas shield covers welding of the joint back side with gas shield but not vice versa.

**8.5.3.9** Welding in the controlled-atmosphere chamber.

Range of approval for welding outside the chamber covers welding in the controlled-atmosphere chamber but not vice versa.

**8.5.4** **Special requirements for the range of approval related to welding processes.**

**8.5.4.1** Gas metal arc welding (welding process 131).

**8.5.4.1.1** Range of approval given to the shielding gas is restricted to the symbol for the gas according to ISO 14175 classification and identical to the one used in the welding procedure qualification test.

For shielding gases not covered by ISO 14175 classification, the range of approval is restricted to the nominal composition used in the welding procedure qualification test.

**8.5.4.1.2** Range of approval given is restricted to the wire system used in the welding procedure qualification test (e.g. single-wire or multiple-wire system).

**8.5.4.1.3** For solid and metal cored wires, the qualification using short circuiting transfer (dip) qualifies only short circuiting transfer (dip). The qualification using spray or globular transfer qualifies both spray and globular transfer.

**Note.** In compliance with the requirements of ISO 4063, the metal transfer mode is indicated by the following letters placed after the reference numbers of welding processes:

*D* — short-circuit transfer (dip transfer);

*G* — globular transfer;

*S* — spray transfer;

*P* — pulsed transfer.

For example, ISO 4063-131-D.

**8.5.4.2** Tungsten inert gas (TIG) welding (welding process 141).

**8.5.4.2.1** Range of approval given to the shielding gas is restricted to the symbol of the gas according to ISO 14175 classification ([refer to Table 6.2.2.5](#)) and identical to the one used in the welding procedure qualification test. For shielding gases not covered by ISO 14175 classification, the range of approval is restricted to the nominal composition used in the welding procedure qualification test.

**8.5.4.2.2** Welding with filler material does not qualify for welding without filler material or vice versa.

**8.5.4.3** Plasma-arc welding (welding process 15).

**8.5.4.3.1** Range of approval for the welding procedure shall be restricted to the plasma gas composition used in the welding procedure qualification test.

**8.5.4.3.2** Range of approval given to the shielding gas and backing gas is restricted to the symbol of the gas according to ISO 14175 classification ([refer to Table 6.2.2.5](#)) and identical to the one used in the welding procedure qualification test. For shielding gases not covered by ISO 14175 classification, the range of approval is restricted to the nominal composition used in the welding procedure qualification test.

**8.5.4.3.3** Welding with filler material (welding processes 151 and 152) does not qualify for welding without filler material and vice versa.

## **9 APPROVAL OF WELDING PROCEDURES FOR COPPER AND COPPER ALLOYS**

**9.1** For the approval of welding procedures for copper and copper alloys, ISO 15614-6 standard or another agreed standard shall be referred to.

Russian Maritime Register of Shipping

**Rules for Technical Supervision during Construction of Ships  
and Manufacture of Materials and Products for Ships  
Part III**

**Technical Supervision during Manufacture of Materials**

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