CHAPTER 1

General Requirements, Proof of Qualification, Approvals
# Table of Contents

## Section 1  General Rules
1. General ................................................................. 1
2. Other Rules, Standards and Specifications ....................... 2
3. Information in Working Documents .................................. 2
4. Materials, Weldability .................................................. 3
5. Welding Consumables and Auxiliary Materials .................... 4
6. Quality Assurance by the welding Shop ............................ 4
7. Inspection Tests, Liability .............................................. 5

## Section 2  Requirements for Welding shops, Approval
1. Approval of Welding Shops ........................................... 7
2. Requirements for Welding Shops ...................................... 9
3. Inspection of Welding Shops ........................................... 11
4. Welding Procedure Tests .............................................. 11
5. Certification of Approvals, Certificates according to EN 729/ISO 3834...... 12

## Section 3  Welder’s Qualification Tests
1. General ........................................................................ 13
2. Testing Bodies, Certificates ............................................ 14
3. Scope of Testing and Range of Approval ............................ 15
4. Performance of Welder’s Qualification Tests ....................... 15
5. Period of Validity, Repeat Tests ....................................... 16
6. Other Welder’s Tests .................................................... 17

## Section 4  Welding Procedure Tests, Production Tests
1. General ........................................................................ 19
2. Performance of welding Procedure and Production Tests .......... 20
3. Evaluation of test Results, Requirements, Repeat Test Specimens, Test Reports .. 24
4. Limits of Application, Period of Validity ................................ 25

## Section 5  Welding Consumables and Auxiliary Materials
1. General ........................................................................ 29
2. Covered Electrodes for Manual Metal-Arc Welding of Hull Structural Steel .... 39
3. (Flux-cored) Wire-Gas Combinations and Flux-cored Wire electrodes for Semi-Mechanized Welding of Hull Structural Steels ........................................ 48
4. Wire-Flux Combinations for Submerged-Arc Welding of Hull Structural Steels .. 51
5. Welding Consumables and auxiliary Materials for Electrogas and Electroslag welding of Hull Structural Steels .................................................. 58
6. Welding Consumables and Auxiliary Materials for High-Strength (Quenched and Tempered) Structural Steels .......................... 61
7. Welding Consumables and Auxiliary Materials for Steels Tough at Subzero Temperatures .................................................. 64
8. Welding Consumables and Auxiliary Materials for High-Temperature Steels .... 66
<table>
<thead>
<tr>
<th>Section</th>
<th>Overweldable Shop Primers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>General</td>
</tr>
<tr>
<td>2.</td>
<td>Testing and Approval of Shop Primers</td>
</tr>
<tr>
<td>3.</td>
<td>Supervising the Use of Shop Primers, Production Tests</td>
</tr>
</tbody>
</table>

Appendix 1 Application for Approval 89
Appendix 2 Description of Welding Shop 91
Appendix 3 Assessment Form for Welder Qualification Test Certification 95
Appendix 4 Welding Procedure 97
Appendix 5 Welding Consumables and Auxiliary Materials 101
Section 1

GENERAL RULES

1. GENERAL

1.1 Scope

1.1.1 These Rules apply to all welding work performed in the course of new construction, conversion or repairs carried out on ships and their machinery installations, including steam boilers, pressure vessels and pipelines, for which an application for classification has been submitted to Bulgarian Register of Shipping (BRS) or which have been classified by BRS.

Note: The terms "welding", "welding work", “welding process” etc. used in these rules also cover all other thermal and/or mechanized joining processes such as brazing which, because they are deemed as “special processes” under the terms of the quality assurance standards, require pre-qualification which has to be carried out by qualified personnel and constantly monitored. These rules shall be applied in an analogous manner to these processes. Where no special provisions are made in the following paragraphs, the nature and scope of the quality assurance measures required will be specified by the Society on a case-by case basis.

1.1.2 They also apply to all welding work on components, installations or implements for which the Society has issued rules, guidelines or other technical directions in which reference is made to these Welding Rules.

1.1.3 These Welding Rules shall be applied in analogous manner where other rules, guidelines or directions issued by the Society contain no special instructions with regard to welding work.

1.2 Application in other fields

These Welding Rules may be applied in analogous manner to welding work carried out on structures and components other than those mentioned under 1.1, the supervision and inspection of which is the concern of the Society. Where necessary, appropriate arrangements shall be made with the Society.

1.3 Exceptions to these Rules

Exceptions to these Welding Rules require the consent of the Society's head office in each individual case.

1.4 Alterations and additions

The Society reserves the right to alter or add to these Rules from time to time, should this prove necessary on the basis of more recent knowledge or operating experience.
2. OTHER RULES, STANDARDS AND SPECIFICATIONS

2.1 Other relevant standards

2.1.1 The standards or other technical directions mentioned in the following sections form an integral part of these Welding Rules and shall also be complied with. The same applies to the working documents, e.g. drawings, welding specifications, etc. approved by the Society.

2.1.2 Where the following sections refer to standards in which a date is specified, the current version shall apply. Where no dates are specified, the version of the standards which shall be applicable shall be the one valid at the time that these rules were issued. The use of later versions of these standards is subject to the consent of the Society.

2.1.3 Where the following sections and chapters refer to both EN and ISO standards, and if, where they are both specified, the standards are not identical, the EN standards shall take precedence. Where the two standards are identical, either the EN or the ISO standard may be used.

2.1.4 The application of other rules, standards, regulations or other technical directions is subject to the consent of the Society's head office in each individual case. The Society may make any such approval conditional upon construction and dimensioning also being subject to these directions.

2.2 Differences in requirements

If there are differences in requirements between these Rules and the other relevant standards or specifications, the requirements of these Welding Rules shall take precedence, unless otherwise stipulated.

3. INFORMATION IN WORKING DOCUMENTS

3.1 Drawings, other working documents

3.1.1 The drawings and other working documents to be submitted before commencing the fabrication work must contain all the necessary details for the preparation, execution and, where applicable, the inspection of the welds.

This information shall in particular include details of:

- Base materials, shapes and dimensions of products
- Welding processes, welding consumables and auxiliary materials
- Shapes and dimensions of welds
- Preheating and heat input during welding
- Heat treatment after welding
- Subsequent treatment of the welds
- Nature and scope of inspections
- Requirements applicable to the welded joints (e.g. quality, weld performance, evaluation
category or the like).

3.1.2 Provided that in the fabrication of ship's structures, the materials, welding processes, welding consumables, auxiliary materials and the shapes and dimensions of welds conform to normal shipbuilding practice, these Rules and the approvals, these details need not be specified.

3.2 Additional information and documentation

For particular structures (e.g. liquefied gas tanks), materials (e.g. quenched and tempered structural steels and clad plates) or welding processes, the following additional information and documentation shall be provided as necessary:

– Weld preparation, assembly, auxiliary (tack) welds
– Welding positions, welding sequence (drawings)
– Weld build-up, number of passes
– Heat input during welding (heat input per unit length of weld)

This information shall be combined in a welding specification. (see Appendix I). For test schedules and specifications for non-destructive testing, please refer to Chapter 2, Section 4.

4. MATERIALS, WELDABILITY

4.1 Choice of materials

All materials shall be of proven weldability. They shall be chosen in accordance with the intended application and the conditions of service and shall comply with the requirements stated in Part 1, Metallic Materials. Their properties shall be documented to the specified extent by test certificates, e.g. in conformity with EN 10 204.

Note:

The hull structural steels and rolled products described in Part 1, Metallic Materials, for the manufacture of steam boiler, vessel, pipeline and machinery are deemed to be of proven weldability.

4.2 Proof of weldability

If, notwithstanding para. 4.1, materials are to be welded whose properties are not described in the Society's Rules for Materials, the welding shop concerned shall furnish proof of their weldability (e.g. by reference to existing standards) or submit specific material specifications for approval. If there is doubt as to the weldability of a material, the welding shop shall specially demonstrate this in the course of the welding procedure tests.

4.3 Supervision during fabrication

The welding shop shall ensure that only materials which meet the requirements of 4.1 and 4.2 are used for both original and replacement, and shall furnish proof thereof to the Surveyor on request.
5. WELDING CONSUMABLES AND AUXILIARY MATERIALS

5.1 Test of product suitability, approval

5.1.1 The welding consumables and auxiliary materials shall enable a welded joint to be made which is suited to the base material and the operating conditions. They shall have been tested for product suitability in accordance with Section 5 and approved for the application in question. This provision applies in an analogous manner to brazing metals.

5.1.2 Approval shall as a rule have been given by the Society. If, in special cases, e.g. repairs, no welding consumables which have been tested by the Society are available, welding consumables approved by other recognized testing bodies may be used with the Society's consent. Relevant proof of this must be submitted to the Society’s surveyor.

5.2 Supervision during fabrication

The welding shop's supervisors shall ensure that only tested welding consumables and auxiliary materials which have been approved by the Society are used and shall furnish proof thereof to the Surveyor on request.

6. QUALITY ASSURANCE BY THE WELDING SHOP

6.1 Compliance with Rules, Quality Inspections

6.1.1 Shipyards or welding shops are responsible for ensuring that the welding work conforms to these and any supplementary rules as applicable, the approved working documents, any conditions as may be stated in the approvals, good shipbuilding practice, and also the state of the art technology relating to welding.

6.1.2 Shipyards or welding shops must ensure, by means of regular in-house quality inspections during the production process and at the end of the welding work, that such work has been properly and expertly executed. The responsibilities of the welding supervisors are also covered in EN 719/ISO 14731. The tests to be performed by BRS surveyors shall not relieve the welding shop of this responsibility.

6.1.3 The range and extent of the quality inspections required is determined by the structure in question. In each case, however, it is necessary to ensure that the specified materials, welding consumables and auxiliary materials are used and that weld preparation, assembly, performance of tack and welding work, together with the accuracy to size and completeness of the components and welded joints meet the requirements.

6.1.4 Following inspection by the welding shop and any repairs which may be necessary, the components must be presented to the Society’s Surveyor for inspection at appropriate stages of construction, easily accessible and as a rule unpainted. The Surveyor may reject those components which have been inadequately inspected by the welding shop and specify that a component be presented again after a successful inspection by the welding shop and, where necessary repairs.

6.2 Placing subcontracts

6.2.1 When placing orders with subcontractors, independent branch companies or suppliers as
well as outside companies working in the welding shop who are themselves approved (so-called "contract companies", cf. note to paragraph 1.1.1 in Section 2) the "prime contractor" must ensure that the provisions stated in 6.1 are also complied with by the "subcontractors".

6.2.2 Where the outside companies working in the welding shop are not themselves approved or where contract labour is used, the welding shop placing the contract shall be responsible for ensuring that the conditions stated in 6.1 are complied with and that the quality inspections are performed. The Society shall be notified of the placing of subcontracts or the use of contract labour.

6.3 Deviation from approved working documents, repairs

6.3.1 If alterations to the design compared with the approved drawings or deviations from approved fabrication procedures become necessary, the welding shop shall promptly obtain the Surveyor's consent thereto. He shall be notified of any repairs which become necessary during fabrication.

6.3.2 If, due to inadequate or incorrect information in the production documents (e.g. workshop drawings), the quality or functional capability of a component cannot be guaranteed or is doubtful, the Society may require appropriate repairs to be carried out.

6.3.3 This shall apply in an analogous manner to supplementary or additional components (e.g. reinforcements) even if these are not specified during the examination of the drawing or could not be specified owing to a lack of detail shown in the "class plans".

6.4 Marking and identification of materials

6.4.1 The materials shall be marked in such a way that they can be identified and matched up with the test certificates even during and after fabrication.

6.4.2 If the marking is likely to be erased during manufacture, the welding shop shall promptly see to it that it is transferred to another part of the product. This can be dispensed with in the case of small parts of minor importance such as ribs or bracings, provided that any confusion of materials can be prevented by operational means.

6.5 Marking of welds

6.5.1 In the fabrication of steam boilers and vessels under internal pressure, each weld section shall be marked with the symbol of the welder who executed it. This may be dispensed with if the welding shop supervisory staff keep a record of the names of the welders who execute the individual weld sections.

6.5.2 In special cases, the Society may also require marking or record-keeping as described in 6.5.1 for other components or their welded joints.

7. INSPECTIONS, TESTS, LIABILITY

7.1 Presentation of components

The welding shop shall be obliged to present the components to the Surveyor for the required intermediate and final inspections. Steps shall be taken to ensure unimpeded access to the welds. The welds shall not be treated with coatings or preservatives which make it difficult or impossible to assess the condition of the welds.
7.2 Supplying of test documentation

For the inspections, all the manufacturer's records and documents concerning the quality assurance measures undertaken by him shall be submitted. These include in particular:

– Drawings (approved if required) and other working documents
– Material test certificates
– Welder's and welding procedure test certificates
– Test reports and films of the non-destructive tests
– Certificates of hot-forming and heat treatment, where applicable
– Results of production tests, intermediate results if necessary.

7.3 Subsequent defects

The Society gives no guarantee that the welded structures or components tested by its Surveyor at the spots laid down (normally random tests) conform to the requirements in every respect and that their manufacture has been performed correctly and in accordance with the tested procedure. Products which prove defective in use or in the operation or processes which exhibit deficiencies in use may be rejected even if an earlier inspection was satisfactory, if it is not possible to remedy the defect or deficiency.
Section 2

REQUIREMENTS FOR WELDING SHOPS, APPROVAL

1. APPROVAL OF WELDING SHOPS

1.1 General

1.1.1 Shipyards and welding shops, including branches and subcontractors, which perform welding work covered by these Rules must have been approved for this work by the Society. The preconditions for this approval are that the shops satisfy the requirements under 2., have been inspected by the Society in accordance with 3. and, where necessary, have carried out welding procedure tests in accordance with 4.

Note:

The term “welding shop” used in the following paragraphs is understood to mean the welding production plant which, due to its space and organisational facilities, can be regarded as an independent unit. Branches and subcontractors shall generally be regarded as “independent” facilities which have to meet the requirements stated below. In particular, each welding shop must have available its own permanent in-house welding supervisory staff (cf 2.2.) Outside companies working in welding shops may be approved as independent companies. For details of this and contract labour, cf. Section 1, 6.2.

1.1.2 Any approval in accordance with 1.1.1 covers the most essential welding quality requirements in accordance with the standards EN 729/ISO 3834. For certification under the terms of these standards, the requirements set out in 1.2.2 and 1.3.2 must also be met. These additional requirements shall be regarded as having been met when the welding shop has in place a certified quality assurance system in accordance with the series of standards EN 29000/ISO 9000.

1.1.3 In individual valid exceptions, e.g. in the case of repairs, the Society may grant approval for welding work to be executed even without approval being granted to the welding shop, subject to a time limit and restricted to a specific structure, if the welding shop pre-conditions have been specified for such work and the quality of the welds performed is demonstrated by relevant tests, e.g. non-destructive and/or production tests.

1.2 Application for approval

Introductory remark:

Where no special provisions are given in the following paragraphs or, in an individual case, no other arrangements are made, the provisions for "Approval" set out in accordance with these rules shall also apply in an analogous manner to "Certification" in accordance with EN 729/ISO 3834.

1.2.1 Approval shall be applied for in writing to the Society's head office. The application shall contain the following details, which shall be related to each other as far as possible, of the scope of the desired approval:

– Nature of the structure and/or components
Materials and dimensional ranges
- Welding procedures and positions
- Heat treatments (if necessary)
- Weld factor (for steam boilers and pressure vessels).

1.2.2 If a certificate of compliance with the welding quality requirements stipulated in EN 729/ISO 3834-2, -3 or -4 is required over and above approval in accordance with these Rules for Welding, this must be expressly noted in the application for approval.

1.3 Approval documents

1.3.1 Welding shops applying for approval to carry out welding work must submit the following documents to the Society’s head office with their application for approval:

- A description of the welding shop; cf. the form in Appendix 2.
- Copies of the qualification documents of the welding supervisor(s)
- Copies of the valid welder’s certificates or a list of the qualified welders (testing standard, testing body, date of testing, test category, date of last retest) signed by the Surveyor.
- Copies of documentation as proof of the qualification of supervisory and test personnel, as appropriate.
- Copies of reports of welding procedure tests performed elsewhere, including the approvals granted, as appropriate.

1.3.2 For certification in accordance with 1.2.2, information and documents relating to the elements specified in Appendix 2 to EN 729-1/ISO 3834-1 for the respective grade of requirement (EN 729-2/ISO 3834-2 = full, -3 = standard, or -4 = basic quality requirements) must also be enclosed with the application for approval (e.g. in the form of relevant procedure instructions):

- contract review
- design review
- treatment of subcontractors
- equipment maintenance
- quality inspections
- nonconformances
- calibration
- identification
- traceability
If the welding shop operates a certified quality assurance system conforming to the series of standards EN29000/ISO 9000, the QA manual and - if specified in Appendix 2 to EN 729-1/ISO 3834-1 - documentation relating to the quality assurance measures performed (quality reports) must be submitted to the Society for inspection in place of the above information and documents.

1.4   Period of validity of approval, renewal

1.4.1   An approval granted according to these Rules or certification in accordance with EN 729/ISO 3834 shall be valid for three years. Provided that welding work is constantly performed under the Society's supervision during the validity of the approval and that the preconditions on which approval was granted have not changed, approval may be extended on application by the welding shop for further three years subject to an appropriate inspection.

1.4.2   If no welding work has been carried out under the Society's supervision for more than a year, the approval may only be renewed on application at the end of the period of validity if the necessary preconditions continue to apply, which shall be verified by a reinspection of the welding shop. The approval may then be renewed for a further period of three years.

1.5   Changes, revocation

1.5.1   If the preconditions under which approval was granted change, e.g. through the use of untested welding procedures, materials and/or welding consumables, or if changes are made to the welding shop supervisory staff, the Society shall be notified voluntarily. As a rule, this necessitates a revision of the approval.

1.5.2   An approval shall cease to be valid if the preconditions under which it was granted cease to apply. If serious defects are detected in the components or the welds, the Society is entitled to carry out interim reinspections of the production facilities and may, if necessary, revoke the approval.

2.   REQUIREMENTS FOR WELDING SHOPS

2.1   Technical equipment

2.1.1   Welding shops must have at their disposal suitable workshops, equipment, machinery and jigs on a scale necessary for proper performance of the welding work. This includes, for example, the provision of storage facilities and baking equipment for the welding consumables and auxiliary materials, preheating and heat treatment equipment, testing appliances and agents, and means of weather protection for carrying out welding work in the open air.

2.1.2   Equipment and facilities not belonging to the welding shop itself, e.g. testing appliances, may be taken into account when evaluating the capabilities of a welding shop, provided that the preconditions necessary to proper fabrication and testing are satisfied and that such equipment is available without restriction.

2.2   Welding shop supervisory staff

2.2.1   Welding shops shall have at least one fully qualified welding supervisor, who is responsible for ensuring that the welding work is competently performed. Welding supervisors shall have training and experience corresponding to the scope of the fabrication work and shall provide the Society with the necessary documentary proof thereof. They shall also have been approved by the Society for their sphere of responsibility.
2.2.2 The names of the welding supervisor in charge and his deputy must be notified to the Society, cf. Appendix 2 "Description of the Welding Shop", 3. If the supervision role is carried out by more than one person, the responsibilities and tasks of each person must be established and specified. The welding supervisor in charge and his deputy shall be recognised by the Society as part of the approval for the welding shop.

2.2.3 The following persons shall be appointed as welding supervisors depending on the nature and scope of the work:

– Welding engineers for fabrication of important components of the hull structure and of offshore installations, also of handling equipment, steam boilers, pressure vessels, pressure lines and engine and gearbox components

– Welding specialists for fabrication of simpler or less heavily stressed components

For information relating to the qualification of the welding supervisory staff, their tasks and responsibilities, cf. EN 719/ISO 14731.

2.2.4 The welding supervisor(s) shall be permanently employed by the welding shop. Supervision of the welding work by outside staff is not acceptable. A suitable deputy for the welding supervisor in charge shall be nominated to the Society.

2.3 Welders and operators

2.3.1 Welding shops shall be staffed with qualified welders and, for fully mechanized and automatic welding equipment, adequately trained operators. The required number of qualified welders is determined by the size of the welding shop and the scope of the welding work to be performed under the Society's supervision. However, a minimum of two qualified welders are required.

2.3.2 Welders for manual and semi-mechanized welding must have passed a test in accordance with Section 3 and in conformity with a recognized standard (EN 287/ISO 9606, ASME Section IX). The test shall cover the conditions likely to occur in the fabrication work with regard to the process(es), base material, welding consumable and welding position(s). The production of test pieces in a successfully completed welding procedure or production test may be taken as proof of manual skill for testing of welders.

2.3.3 Operators of fully mechanised or automatic welding equipment and of welding robots must have been trained in the use of the equipment. They must also be capable of setting or programming and operating the equipment in such a way that the required weld quality is achieved. The qualification of such personnel must be demonstrated in accordance with EN 1418/ISO 14732 on welded test pieces, e.g. in welding procedure or fabrication tests or by means of random tests and operational tests as applicable.

2.4 Test supervisory staff and test personnel

Where the welding shop has its own test supervisory staff and test personnel (cf. Chapter 2, Section 4.3) documentary proof of their qualification (e.g. certificates conforming to EN 473/ISO 9712) shall be submitted to the Society.
3. INSPECTION OF WELDING SHOPS

3.1 Shop inspection

Before starting the fabrication work, it shall be proved to the Society's Surveyor in the course of an inspection of the welding shop that the requirements applicable to the technical equipment as stated in 2.1 are satisfied. For this purpose the Surveyor shall be given access to all departments and laboratories relevant to fabrication and testing. The fabrication and quality control procedures shall also be described and explained to him if he so requests. For certification according to EN 729/ISO 3834, compliance with the additional quality requirements stated in the standards shall be demonstrated to the Surveyor (cf. 1.3.2).

3.2 Submission of documentation

As part of the welding shop inspection procedure, originals of all documents necessary in order to evaluate the fabrication and quality assurance procedures shall be submitted to the Surveyor. These especially include the welding supervisor's qualification documents, welder's certificates, reports on previous welding procedure tests, and results of quality tests and welder's retests. For certification according to EN 729/ISO 3834, compliance with the additional quality requirements stated in the standards shall be demonstrated to the Surveyor (cf. 1.3.2).

4. WELDING PROCEDURE TESTS

4.1 General provisions

4.1.1 If welding procedure tests are required, their successful performance shall be a further precondition for the approval of a welding shop or for extending its approval. Requirements for the performance of this tests and requirements applicable to test results are given in Section 4 and in Chapter 3, Sections 1 to 5.

4.1.2 Welding procedure tests shall be performed in such a way that the conditions of fabrication can be covered with regard to materials, welding processes, welding consumables and auxiliary materials, wall thicknesses, shapes of welds and heat treatments. The properties of the base materials for the test pieces shall be documented by test certificates.

Note:

Please refer to the detailed information given in Section 4.4.

4.2 Scope of the welding procedure test

4.2.1 In general, a welding procedure test is valid only within the limits specified in the approval and is not transferable from the welding shop where it is performed to a different welding shop. The Society may permit exceptions in the case of a branch welding shop which is under the constant supervision of the main welding shop, where the same fabrication conditions prevail and where the same welding processes are used.

4.2.2 Welding procedure tests performed in a workshop are in general not simultaneously valid for welding in the field. In such cases, the welding procedure test must be repeated in whole or in part under field conditions as determined by the Society. The Society may waive the repeat testing by prior agreement if the properties of the field welds are documented by production tests.
4.3 Recognition of other tests

Welding procedure tests performed under the supervision of other testing bodies which are independent of the works may be recognized in full or in part by the Society at the welding shop's request if this is acceptable on the basis of the test results. In such a case, the complete test reports and the approval certificate of the other testing body shall be submitted to the Society for evaluation.

5. CERTIFICATION OF APPROVALS, CERTIFICATES ACCORDING TO EN 729/ISO 3834

5.1 The Society issues certificates for the approval of welding shops to carry out welding work and for welding procedure tests if the relevant requirements are satisfied in the tests. These welding shop and welding procedure approvals are valid within the limits stated in the certificates.

5.2 Where proof has been furnished that the additional requirements listed in 1.3.2 according to EN 729/ISO 3834 have been met, the Society issues a certificate based on this in accordance with this standard.

5.3 If previously issued approval certificates are replaced or supplemented by more recent ones (cf. 1.5.1) and the details in the more recent approval certificates contradict those of previous approvals, the details in the more recent certificate shall be valid. This applies especially to the range of application, e.g. for a specific welding process.
Section 3
WELDER'S QUALIFICATION TESTS

Preliminary remarks:

The following rules for the testing of welders conform to or make use of the standards EN 287 resp. ISO 9606, Parts 1 (Steel) and 2 (Aluminium). For other non-ferrous metals, DIN 8561 shall continue to apply until the corresponding parts of EN 287 and ISO 9606 come into force.

Where no details of the tests are specified in the following Rules, the tests shall be performed in accordance with these standards. References in the text also refer to these standards unless otherwise specified.

Some deviations from the standards have been made with regard to the testing of steel welders (EN 287-1 resp. ISO 9606-1), especially in relation to the ranges of approval for base materials and weld types which have been somewhat narrowed down compared with the standards. As far as the testing of non-ferrous metal welders is concerned, it is chiefly the weld forms which differ from those of the standard.

1. GENERAL

1.1 Compulsory testing (welding processes)

1.1.1 Welder's qualification tests are required for all welders who are to perform welding work using manually guided welding appliances (as in manual metal arc welding or semi-mechanized gas-shielded metal arc welding) and where the quality of the welded joints depends mainly on the manual skill of the welder.

1.1.2 For welders who perform welding work on steam boiler installations, Appendix 2, Guidelines for testing and supervising boiler welders, shall also be complied with.

1.1.3 For operators of fully mechanized and automatic welding equipment and of welding robots, shall be demonstrated in accordance with EN 1418/ISO 14732 on welded test pieces e.g. as part of the welding procedure or fabrication tests or by means of random tests and operational tests (cf. The standards).

1.2 Training, manual skill, knowledge

1.2.1 Welder's qualification tests may only be taken by welders who have received appropriate previous training and who have had sufficient opportunity to practise the craft.

1.2.2 Besides the necessary manual skill, the welder shall also possess the professional knowledge enabling him to perform the welding work competently. Cf. the relevant information in the standards.
1.3 Lists of welders, symbols

1.3.1 Welding shops are required to maintain lists or card index files which furnish information about the number, names and test categories of the welders and the dates of their initial and repeat tests. These lists shall be submitted to the Society for examination on demand together with the relevant original documentation or, where appropriate, together with the description of the welding shop (cf. Section 2, 1.3).

1.3.2 Each welder shall be assigned an unmistakeable symbol, which shall be recorded in the testing documentation (certificates, lists, etc.). The Society may in addition - depending on the application - require the components and welds to be marked with the symbol of the welder who performed the work; cf. also Section 1, 6.5.

2. TESTING BODIES, CERTIFICATES

2.1 Initial tests in the welding shop

The initial testing of welders in the welding shop is to be conducted by the welding supervisory staff in the presence of the Society's representative. Following submission of the assessment forms completed by the welding shop and initialled by the Surveyor (cf. Appendix 3), these tests will be confirmed by the Society’s head office in the form of test certificates.

2.2 Repeat tests in the welding shop

2.2.1 Repeat tests taken by welders who have been certified by the Society or by those certified by other recognized testing bodies and recognized by the Society may be conducted independently by the welding engineer recognized by the Society in conjunction with the approval granted to the welding shop. Tests conducted by other welding supervisors shall be carried out in the presence of the Society's representative.

2.2.2 The extension of the validity of a test certified by the Society by a further two years may, however, only be authorised by the Society. For this purpose, a full set of test documentation (welding procedure specification, assessment form and test certificate) must be submitted to the Surveyor. Cf. 5.4.

2.3 Tests conducted by other testing bodies

Welder's qualification tests conducted by other testing bodies (e.g. welding training and testing establishments or welding training establishments, cf the foreword to EN 287) which are independent of the welding shop and which are recognized by the Society will be recognized by the Society subject to the test categories specified below. Such recognition is subject to the submission to the Society of a full set of test documentation, as described in 2.2.2 above.

2.4 Tests conducted as part of the welding procedure tests

The testing of welders may be included in the welding procedure tests (cf. Section 4, 2.5.3) and their names will then be included in the welding procedure approval. A welder’s qualification test certificate conforming to the standards may, however, only be issued provided that all the provisions of the standards, e.g. scope of test and job knowledge testing, have been met and that this is recorded in an assessment form which has been completed accordingly (cf. Appendix 3).
3. SCOPE OF TESTING AND RANGE OF APPROVAL

3.1 Base materials

3.1.1 In the case of base materials - and in contrast to the provisions of the standards EN 287-1 resp. ISO 9606-1 - higher-strength (hull structural) steels with a minimum yield strength ReH of up to 355 [N/mm²] (up to 360 [N/mm²] in the case of pipe-grade steels) shall only be considered, following testing, as being included in the material category W 01 if the test (using the appropriate welding consumables) was also performed on a higher-strength steel.

3.1.2 Unless otherwise stipulated by the Society in a particular case, the test categories conforming to the standards shall also apply to the base materials. The Society may, however, require a more precise subdivision of the categories in accordance with the note to Chapter 3, Section 1, 6.2.

3.2 Joint types

3.2.1 In the case of joint types - and in contrast to the provisions of the standards - the test performed on butt welds does not also include fillet welds. Where welders are required to lay down butt welds as well as fillet welds, both weld forms must be included in the test.

3.2.2 Unless otherwise stipulated by the Society in a particular case, the test categories conforming to the standards shall also apply to the weld forms.

3.3 Sub-categories, inclusions and exclusions

Unless otherwise specified by the society in a particular case, the inclusions and exclusions stipulated in the standards shall otherwise apply.

3.4 Deviations, special features, particular applications

3.4.1 If deviations from the rules for testing (e.g. with regard to the welding positions) or special features (e.g. grooving of the root and welding of cap passes) are to be included in the welder's qualification test, this shall be denoted by the letter 'X' appended to the designation of the test category. The nature of the deviation or special feature is to be stated on the assessment sheet under "Remarks" and will be noted in the test certificate.

3.4.2 Welder's qualification tests for particular applications (particular materials or shapes of weld) which are not covered by the tests and work assignments described above and in the standards (e.g. for clad plates or tubular nodes) shall be carried out according to a test schedule to be agreed with the Society on a case-by-case basis.

4. PERFORMANCE OF WELDER'S QUALIFICATION TESTS

4.1 Welding of test pieces, Welding Procedure Specification (WPS)

For welding test pieces, a "Manufacturer’s" Welding Procedure Specification (WPS) shall be produced by the welding shop - a separate one for each welding task - in accordance with the Annex C of the standards EN 287 resp. ISO 9606. The welding conditions for testing shall match those during fabrication.
4.2 Test pieces, specimen types and tests

The test pieces, the specimen types and the performance of the tests shall conform to the standards.

4.3 Evaluation of test pieces and specimens, recording of results

4.3.1 Depending upon the kind and scope of the tests, test pieces and specimens shall be evaluated, conforming to the specifications of the standards, according to the following criteria:

– Thickness, reinforcement and appearance of weld (external results)
– Radiograph (internal results)
– Appearance of fracture (internal results)
– Mechanical properties, where applicable
– Metallographic specimen, if required.

4.3.2 A welder shall be regarded as having passed the test provided that the imperfections fall within the limits of assessment category B conforming to EN 25817 resp. ISO 5817. Exceptions to this rule include the following imperfections: weld reinforcement too large (butt and fillet welds), excessive fillet weld thickness and excessive root reinforcement, to which assessment category C applies.

4.3.3 A test shall only be passed as successful if all the requirements stated in the standards relating to the test piece in question and the specimens taken from it can be evaluated as having been met. Repeat test pieces and specimens are subject to the specifications of the standards EN 287 resp. ISO 9606.

4.3.4 The assessment form provided at Appendix 3 is to be used to record the details and results of the tests (p = passed, np = not passed). Additional sheets shall be used as necessary.

5. PERIOD OF VALIDITY, REPEAT TESTS

5.1 Standard period of validity

A welder's qualification test remains valid for two years, provided that during this period welding work is constantly performed under the Society's supervision and the work of the welder is monitored by the welding supervisors at all times.

5.2 Reduced period of validity

5.2.1 The Society may demand repeat tests at annual intervals if the supervision of the welder's work mainly takes the form of visual inspections.

5.2.2 A repeat test relating to an individual welding process is required where a welder who has been tested in more than one welding process has not used the process in question for longer than six months.
5.2.3 A repeat test is necessary where a welder has not performed any welding work as defined in para. 5.1 for longer than three months.

5.2.4 The Society may demand a repeat test at any time should reasonable doubts arise as to a welder's skill.

5.3 Continuous supervision

5.3.1 A repeat test may be dispensed with where the quality of the work performed by the welder in a work assignment range corresponding to his test category is systematically and verifiably monitored during fabrication by the welding shop's welding engineer recognized by the Society and this is confirmed, as described above in paragraph 5.1 above, at intervals of no more than six months.

5.3.2 For this purpose the following measures shall be implemented at times of which the welder has no prior knowledge and which shall occur at intervals of not more than three months:

– Destructive tests on test welds or sections of weld produced by the welder (wherever possible, in the most difficult positions), and/or

– Non-destructive tests for internal defects on production welds, e.g. by means of radiographs, provided that these tests can be documented.

5.3.3 The results of these tests are to be noted in the lists of welding personnel (cf. 1.3.1) and are to be submitted to the Society for examination and confirmation at intervals of not more than one year.

5.4 Nature and scope of repeat tests

5.4.1 With respect to their nature and scope, repeat tests shall be performed in accordance with the standards, taking into account the provisions of 3.

5.4.2 A repeat test may only be performed and certified in the test category in which the initial test took place. Where the initial test included special features (e.g. root welding on ceramic backing or root protection with nitrogen-hydrogen mixture, welder's qualification tests incorporating the symbol "X"), these features shall be included in the repeat test.

5.4.3 If a repeat test is carried out with a restricted scope of testing compared with the standards, the initial test (without X) shall be restricted to the same extent, even if originally complete. It may only be extended in conjunction with a complete test (initial test).

6. OTHER WELDER'S TESTS

6.1 Other rules and standards

6.1.1 The Society may consent to the performance of welder's qualification tests in accordance with other recognised rules, standards or codes. The work assignments of welders tested in accordance with these tests will be specified in analogous manner to the above Rules, depending on the scope of testing. The period of validity is as specified in 5.
6.1.2 Welder's tests conforming to other rules, standards or codes which have been conducted by an independent testing body in analogous manner to 2.3. may be recognized by the Society subject to the foregoing provisions. The relevant test reports, test certificates and, upon request, the rules, standards or codes shall be submitted to the Society for this purpose.

6.2 Exceptions

In technically justified exceptional circumstances (e.g. repairs), the Surveyor may, subject to a specified time limit and to limitation to a particular structure, authorise the employment of well-trained welders without the documentary qualifications stipulated above, provided that he has reason to believe that the welders concerned are competent to perform the work envisaged and that the quality of the welds produced by them can be verified by suitable, e.g. non-destructive, tests.
Section 4

WELDING PROCEDURE TESTS, PRODUCTION TESTS

1. GENERAL

1.1 Welding procedure tests in the user's works

1.1.1 Welding procedure tests shall be carried out under the Society's supervision in the user's works before starting the fabrication work according to the scope described in the relevant sections of Chapter 3 under workshop conditions (available space, weather protection, welding equipment, operating jigs, welders, etc.). Any intended extreme cold-forming operations as well as heat treatments of the materials and/or the welds shall form an integral part of the welding procedure tests.

1.1.2 The Society may dispense with a welding procedure test for certain "standard" processes for welding of unalloyed steels where the quality of the welded joints essentially depends on the choice of the welding consumables and the manual skill of the welder (e.g. manual metal arc welding (E) or semi-mechanized gas- shielded metal arc welding (MAG) of normal-strength hull structural steels, except for vertical-down welding).

1.1.3 Welding procedure tests which have already been carried out by other independent testing bodies are subject to the provisions of Section 2, 4.3. In such cases the Society reserves the right to demand that supplementary production tests be carried out before the start of fabrication or during production.

1.1.4 In individual, technically justified exceptional circumstances (e.g. repairs), the Surveyor may, subject to a specified time limit and to limitation to a particular structure, authorise the use of particular welding processes without carrying out a welding procedure test beforehand, provided that proof is furnished by means of other suitable tests (e.g. non-destructive weld tests and/or production tests) that the welding process in question is being applied correctly and safely.

1.2 Preliminary welding procedure test

1.2.1 A preliminary welding procedure test shall be carried out on the premises of manufacturers of welding equipment or welding consumables or at research institutions if, for special reasons, an immediate welding procedure test in the user's works appears inappropriate.

In this test, the welding parameters and, where applicable, the post-weld heat treatments shall conform to the conditions prevailing in the user's works. In all other respects, the provisions governing welding procedure tests in the user's works apply.

1.2.2 The preliminary welding procedure test does not relieve the user's works of the obligation to carry out a definitive welding procedure test. On the basis of the preliminary test, a simplified test schedule for the definitive welding procedure test may be accepted.

1.3 Production tests

1.3.1 Production tests shall be performed to the extent described in the relevant sections of Chapter 3 in the course of fabrication to monitor the quality of the welded joints. Test pieces welded at
the same time as the production welds (e.g. in the course of a longitudinal weld of a plate, pipe or vessel shell ring) or sections of production welds may be used for this purpose. Where applicable, the test pieces shall as far as possible be heat-treated together with the component. As a rule, the production tests shall comprise both non-destructive tests and mechanical and technological tests.

1.3.2 Production tests are also required if a particular welding process has not been used under the Society's supervision for a long time or if processes and/or materials to be welded require constant verification of the weld quality. The nature and scope of such production tests shall be established on a case-by-case basis.

1.3.3 In addition, the Society may require production tests to be carried out if the way in which the welding work is performed gives rise to doubts as to the quality of the welded joints or if individual welding parameters, welding consumables or auxiliary materials have been changed or changes have been made in the welding shop personnel. The scope of such production tests will be established on a case-by-case basis.

1.3.4 For production tests in conjunction with overweldable shop primers, please refer to Section 6, 3.

2. PERFORMANCE OF WELDING PROCEDURE AND PRODUCTION TESTS

2.1 Application for approval

2.1.1 Application for approval of a welding process and for the performance of a welding procedure test shall be made to the Society's head office, with simultaneous notification of the competent Surveyor, giving the following details (to be specified in Appendix 2):

- Range of application (components, materials, plate/wall thicknesses, pipe diameters, weld factor where applicable)
- Welding process
- Welding positions
- Welding equipment and parameters
- Weld shapes, weld build-up
- Welding consumables and auxiliary materials
- Joint preparation
- Cold- or hot-forming operations prior to welding
- Overweldable shop primers
- Welding jigs and weather protection
- Preheating and heat input during welding
- Post-weld heat treatment, other after-treatment
2.1.2 Where possible, the application should enclose a proposal for a test schedule in accordance with the rules set out in Chapter 3 with sketches and dimensions of the test pieces, describing the intended specimens and tests. If the information and parameters stipulated in 2.1.1 are based on in-house standards or other (welding) specifications, these are also to be enclosed with the application.

2.2 Scope of testing, requirements, test schedule

2.2.1 The scope of testing (test pieces, specimens, etc.), tests and requirements for the individual fields of application (shipbuilding, steam boiler and pressure vessel fabrication, pipeline fabrication, etc.) are described in the relevant sections of Chapter 3 of these Rules, while details of the non-destructive tests are given in Section 4 and details of the mechanical and technological tests in Section 5 of Chapter 2.

2.2.2 If a test schedule appropriate to the intended field and range of application has already been drawn up by the applicant in accordance with 2.1.2 and 2.2.1 as applicable, this must be agreed with the Society before starting the tests. Otherwise such a test schedule must be drawn up by the applicant - with the agreement of the Society - and submitted to the Society’s Head Office for final authorisation.

2.3 Materials, welding consumables and auxiliary materials

2.3.1 The materials used in the welding procedure tests must be unambiguously identifiable on the basis of their marking and certificates. The direction of rolling of the test pieces must be ascertainable. If not, check specimens shall be prepared and tested.

2.3.2 The welding consumables and auxiliary materials should if possible have already been tested and approved by the Society; however, they may be tested and approved at the same time as the welding process. Cf. Section 5, 1.1.3. Approvals of this type are generally restricted to the user's works and are valid for a maximum of one year, unless repeat tests are performed in accordance with Section 5, 1.3.

2.3.3 Welding consumables and auxiliary materials used in the welding procedure tests may only be replaced in the subsequent fabrication work by others of the same kind which bear the Society's approval if this is expressly stated in welding procedure approval certificate; cf. also 1.3.3.

2.4 Test pieces, dimensions, direction of rolling, welding positions

2.4.1 The shape and size of the test pieces shall be compatible with the welding procedure concerned and the number of specimens. The most commonly used test pieces are described in the relevant sections of Chapter 3. The dimensions of the test pieces may be changed if this does not adversely affect the test and is necessary for evaluating the process. Unless otherwise stipulated in an individual case both butt welded and fillet weld test pieces shall be welded in the specified positions for the fabrication process.

2.4.2 For vertical welding (e.g. electrogas or electroslag welding) the length of the test piece (length of the weld) shall conform to the production welding jig, while with appliances using a fusible wire-guide electrode, the length of the test piece shall be geared to the length of the wire-guide electrode or the height of the components to be welded, as applicable. Any special features affecting the application of these processes (e.g. welding operations performed through the deck) shall be allowed for in determining the shape of the test piece.
2.4.3 The plate thicknesses shall be chosen in accordance with the information on the limits of application in the relevant sections of Chapter 3 in line with the intended range of application. Where possible, two different plate thicknesses should be welded and tested for each range of application. The weld shapes shall be those to be used in subsequent practice in line with the welding process.

2.4.4 Where the characteristics of the welding process or the dimensions, and hence the number of passes which these entail, are likely to have a considerable effect on the results of the test, the thickness of the test pieces and the number of passes shall be made to conform to the limit thicknesses for the range of application concerned. In the case of vertical downward welding, the thickness of the test piece shall be the upper limit thickness of the range of application, whereas with a variable number of passes depending on the plate thickness (e.g. with single- and multi-pass welding) the scope of the test shall include the various techniques and the thickness of the test pieces shall be chosen accordingly. The same applies in analogous manner to the weld thicknesses.

2.4.5 Normally, test pieces shall be welded in the positions occurring in subsequent practice. Depending on the welding processes and materials concerned, it may be agreed to restrict the test to certain specified welding positions, e.g. in the case of manual arc welding or semi-mechanized gas-shielded metal arc welding the test may be limited to the positions applicable to the corresponding welder's qualification tests as stated in Section 3. The horizontal-vertical position PC (h-v) is, however, always to be included in the welding procedure test for single-side welding. Where overhead welding PE (o) is included, this may be combined with the downhand position PA (d).

2.4.6 The direction of rolling of the plates shall be parallel to the direction of welding. The orientation of the rolling direction shall be stated in the test report.

2.5 Welding of test pieces

2.5.1 All welding procedure tests shall investigate, in accordance with workshop practice, the effects of prior cold-forming operations, weld preparation as practised in the welding shop and air gap exactness, together with the use, where applicable, of production coatings (shop primers). Difficult fabrication conditions (e.g. limited accessibility) shall be simulated in the welding procedure test.

2.5.2 Welding shop facilities, welding equipment, aids to assembly and tack welds used in the test shall conform to those used in actual production. In the downhand and vertical positions, account is to be taken of the maximum anticipated angular deviations from the theoretical welding position (e.g. slope of slipway).

2.5.3 Where possible, several (at least two) welders or teams of operators shall participate in a welding procedure test. Each welder or team of operators, as applicable, shall carry out anew the preparation (tack welding) of the test pieces, the alignment of the welding appliances, and the setting of the current supply and feed rate.

2.5.4 Preheating, heat input per unit length of weld, interpass temperature, electrode changing and the starting and stopping of welding appliances (starting points/end craters) shall conform to subsequent practice. Rod electrodes are to be used down to the clamping butt.

2.5.5 In welding procedure tests, cap passes, with or without grooving of the root depending on the process, are generally permitted. In single-side welding, the same types of backing shall be used as in the subsequent fabrication work.

2.5.6 In the case of mechanized welding processes in shipbuilding, an interruption of the welding operation followed by complete cooling of the test piece and restarting of the equipment shall be demonstrated. The machining of the end crater and the preparation of the new starting point shall be carried out in accordance with normal practice. The test results from these weld areas will be evaluated separately.
2.5.7 Minor welding defects occurring in the course of a welding procedure test may, with the consent of the Surveyor, be repaired or ignored when preparing specimens. In the case of serious defects, the causes shall be established and remedied, after which new test pieces shall be welded.

2.5.8 The following data shall be recorded when welding the test pieces:
- Shape of weld and method of preparation
- Weld build-up and number of passes
- Welding consumables and auxiliary materials (type, trade name, dimensions, quantities)
- Method of root grooving and interpass cleaning/treatment
- Preheating, interpass temperatures
- Welding equipment and parameters (amperage, voltage, welding speed, heat input per unit length of weld)
- Interruptions/disturbances in the welding sequence
- Names of welders/operators
- Special features applying to the tests (e.g. climatic influences, limited accessibility).

2.6 Post-weld heat treatment, other kinds of after-treatment

2.6.1 If post-weld heat treatment of the components (e.g. annealing to relieve stresses) is intended in the subsequent fabrication work, the test pieces are to be subjected to the same post-weld heat treatment. This applies in analogous manner to other types of after-treatment, e.g., TIG after-treatment of the weld interfaces. If approval of the welding process is desired for both the untreated and after-treated conditions, the test shall be carried out for both conditions.

2.6.2 Where possible, post-weld heat treatment of the test pieces should be carried out in the annealing furnaces which are to be used for the fabricated components. The equipping of the annealing furnace with a temperature recorder is mandatory. The time-temperature curve shall be recorded. Other types of after-treatment shall be described in the test report. Further information on post-weld heat treatment is given in Chapter 2, Section 3.

2.7 Non-destructive testing

2.7.1 Prior to sectioning, each butt-welded test piece shall undergo visual and non-destructive testing over the entire length of the weld to detect any external or internal welding defects. Unless otherwise agreed, the test pieces shall be radiographed and those with a thickness of 30 mm or over (10 mm or over in the case of single-side submerged-arc welded test pieces) shall additionally undergo ultrasonic testing.

2.7.2 Where the base materials or weld metals are liable to crack, surface testing for cracks shall be carried out in addition to the above. If the material is magnetizable, this shall take the form of magnetic particle inspection; otherwise the dye penetrant method shall be used. The Society may require specific testing intervals (e.g. 72 hours) to be adhered to between completion of the welding work and performance of the crack tests.

2.7.3 Each K-shape or fillet-weld test piece (T-joint or cruciform test piece) shall undergo a
visual inspection for external welding defects. Test pieces made from a material other than normal-strength hull structural steel or comparable simple structural steels shall in addition be subjected to testing for surface cracks.

2.7.4 In contrast to the recording limits stated for the production tests, all welding defects and indications detected during non-destructive ultrasonic testing shall be recorded.

2.8 Sectioning of test pieces, preparation of specimens

2.8.1 Sectioning of the test pieces shall be carried out as described in the relevant sections of Chapter 3. The test pieces shall be sectioned mechanically. If thermal cutting methods are employed, a sufficient machining allowance shall be provided and the heat-affected zone must thereafter be machined off.

2.8.2 The individual specimens shall be marked before sectioning and during machining in a way which enables them to be identified at all times and their orientation in the test piece to be reconstructed.

2.8.3 From all butt-welded and fillet-welded (cruciform) test pieces for manual and semi-mechanized welding processes, one set of specimens each shall normally be taken and tested. From the test pieces for fully mechanized welding processes, one set of specimens each from the beginning and end of the weld shall be taken and tested. In the case of these latter test pieces, a third set of specimens from the middle of the weld may be additionally demanded in special circumstances, e.g. where long seams are concerned or the welding process has been recently developed. Where single-side submerged-arc welding is performed with flux backing, a third set of specimens shall be subjected to test in every case.

2.9 Shapes and dimensions of test specimens, mechanical and technological tests

2.9.1 The shapes and dimensions of the specimens, the preparation and performance of the tests and the determination of the results are subject to the provisions of Chapter 2, Section 5. Furthermore, the corresponding provisions in the Rules for Materials (Part 1, "Metallic Materials", Chapter 1, Sections 1 and 2) shall also be complied with.

2.9.2 All tests shall be carried out by trained staff using calibrated testing equipment. The testing equipment shall be maintained by its owners in fully functional condition and shall be calibrated at regular intervals by an independent testing body.

2.9.3 Unless otherwise stipulated or agreed, all mechanical and technological tests shall be performed in the presence of the competent Surveyor. The metallographic specimen shall be submitted to him for evaluation.

3. EVALUATION OF TEST RESULTS, REQUIREMENTS, REPEAT TEST SPECIMENS, TEST REPORTS

3.1 Designation of test results

3.1.1 To ensure that the description and evaluation of welding processes and positions, test results, etc. are as clear and uniform as possible, use shall be made of the terminology and symbols in the relevant standards (e.g. ISO 857, EN ISO 6947, EN 26520/ISO 6520, EN 25817/ISO 5817, EN 30042/ISO 10042) and, for internal defects, Table 4.1 in Chapter 2, Section 4. The position of a defect or fracture must be indicated and may be designated as follows:
3.2 Requirements, repeat test specimens

3.2.1 The requirements are specified in the relevant sections of Chapter 3.

3.2.2 If, in the tests, individual specimens fail to meet the requirements or the failure of these specimens is due to localized defects in the specimen or deficiencies in the testing equipment, it is sufficient to test two repeat test specimens or sets of repeat specimens in each case, which must then meet the requirements.

3.2.3 In the testing of notched bar impact test specimens, unless otherwise specified in a particular case, the average value of three specimens shall apply; none of the individual values may be less than 70 % of the required value. If these conditions are not met and the average value is not less than 85 % of the required value, three repeat test specimens may be tested and the results added to the values originally obtained. The new average value from these six specimens must then meet the requirements. If the average value of the first three specimens is less than 85 % of the required value, six repeat test specimens shall be tested, the average value of which must meet the requirements.

3.2.4 If the requirements are not met by a sizeable number of specimens and/or in several areas of testing, the causes of the failures shall be investigated. When the faults have been cured, new test pieces shall be welded and fully tested.

3.3 Reports, storage times

3.3.1 Reports (cf. Appendix 2) shall be prepared of all trial welds and tests and submitted to the Society in duplicate, signed by the tester and the testing supervisor.

3.3.2 The debris of test pieces, specimens and the test documentation are to be kept until all the tests and inspections are concluded by the confirmation of approval issued by the Society. For the storage time of documents relating to the non-destructive testing of welds (e.g. radiographs), see Chapter 2, Section 4.

4. LIMITS OF APPLICATION, PERIOD OF VALIDITY

4.1 Works and sub-works

4.1.1 Welding procedure approvals are generally non-transferable. The Society may allow exceptions in the case of a branch works where the welding work is carried out under the constant supervision of the main works, provided that the fabrication work is performed under the same conditions and the same specified welding processes are used. The Society may, however, require proof as to whether the welding processes are being applied correctly and the mechanical properties are adequate by means of non-destructive tests and/or simplified production tests.
4.1.2  Welding procedure tests performed in a workshop are in general not simultaneously valid for welding in the field. In such cases, the welding procedure test must be repeated in full or in part under field conditions as determined by the Society. The Society may dispense with repeat testing by prior agreement if the qualitative properties of the field welds are demonstrated by production tests.

4.2  Range of application

4.2.1  The other materials included in a welding procedure approval on the basis of the testing of a particular material are indicated in the relevant sections of Chapter 3.

4.2.2  With regard to plate thicknesses, unless otherwise stated in the relevant sections of Chapter 3 or in a particular case a plate thickness range of approx. 0.7 – 1.7 t (t = tested plate thickness) shall apply to hull structures according to Chapter 3, Section 1 and a range of 0.75 – 1.5 t shall apply in the other fields of application according to Chapter 3. The Society may limit this range of application, in accordance with the standards (EN 288/ISO9956), to 0,8 – 1,1 t or extend it to 0,5 – 2 t; cf. the Sections in Chapter 3. In the case of vertical downward welding, the thickness of the plate tested shall in each case be regarded as the upper limit of application.

4.2.3  The welding procedure approval is generally valid for the welding positions tested. Depending on the welding process, particular welding positions may be included; these are stated in the approval document where applicable.

4.2.4  The welding procedure approval is valid for the welding process and weld build-up tested.

4.2.5  The welding procedure approval is valid for the heat treatment condition for which the test was performed, e.g. untreated, annealed to relieve stresses, normalized.

4.2.6  Any minimum or maximum design or operating temperatures taken into account during testing are stated in the procedure approval document.

4.3  Period of validity

4.3.1  A welding procedure approval is generally valid without limit of time or with a time limit - depending upon the range of application; cf. Table 4.1 and the relevant sections of Chapter 3. This is, however, always provided that the conditions under which it was granted do not change significantly.

4.3.2  The welding procedure approval is tied to the approval of the welding shop to perform welding work and expires when the approval of the welding shop expires. For renewal of the welding shop approval document (cf. Section 2, 1.4.), it must be demonstrated to the Society that the approved welding processes have not been changed in the current production run and have been used without any significant defects.

4.3.3  For the production tests necessary in individual fields (e.g. steamboiler, pressure vessel) of application to maintain the validity of a welding procedure approval, please refer to 1.3. The Society will check the aforementioned conditions in the course of the three-yearly renewal of the welding shop approval; cf. Section 2.

4.3.4  The Society may revoke part or all of a welding procedure approval and require a fresh welding procedure test or fresh production tests if doubts arise as to whether a welding process is being applied correctly or safely or if defects in or damage to the welds made by this process lead to the conclusion that the quality of the welded joints is inadequate.
<table>
<thead>
<tr>
<th>Range of application</th>
<th>Welding of hull structures</th>
<th>Welding of steam boilers</th>
<th>Welding of pressure vessels</th>
<th>Welding of pipelines</th>
<th>Welding of machinery components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components:</td>
<td>Hull structures and equipment parts used in shipbuilding</td>
<td>Pressure bearing parts &amp; parts welded to them</td>
<td>Pressure bearing parts &amp; parts welded to them</td>
<td>Pipe class III</td>
<td>Pipe classes I + II</td>
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<td>Bedplates, pedestals, gearboxes, casings, wheel bodies, auxiliary deck machinery etc.</td>
<td></td>
</tr>
<tr>
<td>Form and principles for acceptance</td>
<td>Acceptance of “standard procedures” or based on experience</td>
<td>Acceptance based on welding procedure tests</td>
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<td>Acceptance based on welding procedure tests</td>
</tr>
<tr>
<td>The Society’s Welding Rules/Part/Chapter/Section</td>
<td>II/3/1/4, 1.1.2 and II/3/3/1, 2.3</td>
<td>II/3/1/4 and II/3/3/1, 6.</td>
<td>II/3/1/4 and II/3/3/1, 6.</td>
<td>II/3/1/4 and II/3/3/4, 7.</td>
<td>II/3/1/4, 1.1.2 and analogously II/3/3/1, 2.3</td>
</tr>
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<td>Relevant ISO/EN/standard; Rule:</td>
<td>ISO 9956 and EN 288, Parts 6 and 7</td>
<td>ISO 9956 and EN 288, Parts 3 and 4</td>
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<td>ISO 9956 and EN 288, Parts 6 and 7</td>
<td>ISO 9956 and EN 288, Parts 3 and 4</td>
</tr>
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<td>General preconditions</td>
<td>Approved welding shops, recognized welding supervisors, welders certified to ISO 9606 / EN 287; certified materials from approved manufacturers approved welding consumables and auxiliary materials; authorized welding procedure specifications (pWPS or WPS) conforming to ISO 9956 / EN 288 Part 2</td>
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<td>Materials</td>
<td>Normal-strength hull structural steels</td>
<td>All others (see II/3/3/1, 6.1.3, footnote 1)</td>
<td>All</td>
<td>All</td>
<td>Normal-strength hull structural steels and comparable unalloyed structural steels, e.g. S235</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>All others (see II/3/3/1, 6.1.3, footnote 1)</td>
</tr>
<tr>
<td>Plate/wall thickness; pipe diameters:</td>
<td>Depending on the scope of the applicable welder’s qualification tests, SAW-T: 4-25, -M: -40 mm</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Depending on the scope of the applicable welder’s qualification tests</td>
</tr>
<tr>
<td>Welding process:</td>
<td>E-manual, MAG-M and -C (solid and flux-cored wire electrodes), together with single wire submerged arc, except for single-side welding</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Manual (incl. TIG) and semi-mechanized welding processes; others as for pipe cl. I + II</td>
</tr>
<tr>
<td>Welding positions:</td>
<td>All except for PG (v-d) PA 6d only for submerged arc</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>All except for PG (v-d) PA 6d only for submerged arc</td>
</tr>
<tr>
<td>Validity</td>
<td>generally not subject to time limit</td>
<td>generally not subject to time limit</td>
<td>1 year</td>
<td>1 year</td>
<td>generally not subject to time limit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>generally not subject to time limit</td>
</tr>
<tr>
<td>Extension based on:</td>
<td>Proof according to 4.3.2</td>
<td>Proof according to 4.3.2</td>
<td>Production tests or repeat welding procedure test</td>
<td>Production tests or repeat welding procedure test</td>
<td>Proof of quality e.g. NDT, or repeat welding procedure test</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Proof according to 4.3.2</td>
</tr>
</tbody>
</table>

Table 4.1: Recognition (qualification) of welding processes—summary
Section 5

WELDING CONSUMABLES AND AUXILIARY MATERIALS

1. GENERAL

1.1 Approval procedure, marking

1.1.1 All welding consumables and auxiliary materials (rod electrodes, wire-gas or wire-flux combinations, etc.) which are to be used within the area governed by the Welding Rules or other Rules, guidelines, etc. issued by Bulgarian Register of Shipping must be tested and approved by the Society for that purpose in accordance with the following provisions. The same also applies in an analogous manner to brazing materials, the tests and requirements for which will be specified on a case-by-case basis.

1.1.2 Approval is normally granted on the basis of specimen welds and tests carried out on the weld metal and the weld joints on the manufacturer’s premises under the Society’s supervision with each individual product (individual manufacturer’s brand) in accordance with 1.1.1, for which approval was applied for. For details of transfers of approvals, cf. 1.2.

1.1.3 An inspection of the manufacturer’s production facilities (production workshops, stores etc.) and especially the internal quality assurance measures applied shall be carried out in the course of normal production in conjunction with the approval tests.

Note: The quality requirements relating to the manufacture, supply and marketing of welding consumables and the processes applied are described in EN 12074/ISO 14344. Unless other or contrary provisions relating to this are stipulated in the following paragraphs, the quality requirements stated in this standard may be used as a basis for the inspection of the manufacturer’s facilities.

1.1.4 For the approval of welding consumables and auxiliary materials in conjunction with a (preliminary) welding procedure test, see also Section 4, 2.3.2. The user must have consented to the approval (on behalf of the manufacturer). In such cases the testing of the pure weld metal shall also be included in the scope of the welding procedure tests. Testing of specimens taken from the welded joint is not regarded as testing of the pure weld metal.

1.1.5 Where approval is applied exclusively for auxiliary materials such as ceramic backing strips (i.e. not in conjunction with welding consumables), their properties shall be tested, and where appropriate their effect on the quality of the welded joints established on the basis of the relevant product standards or the manufacturer’s specifications in accordance with a test schedule to be specified in each individual case.

1.1.6 If welding consumables and auxiliary materials are to be approved in exceptional cases on the basis of approval tests conducted elsewhere by other bodies recognized by the Society (e.g. other classification societies or Technical Supervisory Authorities) the complete test reports shall be submitted and tests at least corresponding to the compulsory (annual) repeat tests shall be performed.
1.1.7 In isolated, urgent cases, consent may exceptionally be given for the use of welding consumables and auxiliary materials which have been approved by other recognized classification societies or neutral testing authorities (e.g. Technical Supervisory Authorities), though such consent shall be subject to a time limit and shall be restricted to a particular structure. In the case of larger projects, the manufacturer shall simultaneously apply for approval.

1.1.8 Applications for approval shall be submitted in one copy to the Society's head office, with simultaneous notification of the competent Surveyor, giving the following information and accompanied by the most recent catalogues:

- Manufacturer's name and manufacturing works (name of licensor, where appropriate)
- Nature of the welding consumables and auxiliary materials
- Manufacturer's brand (licensor's designation, where applicable)
- Dimensions for which approval is applied for (diameters, lengths)
- Grades for which application is made, including additional symbols
- Proposed range of application, including for example base materials, welding processes, welding positions for which approval is sought, heat treatment condition and any special operating conditions (e.g. low temperatures)
- Instructions for use (welding current, polarity, baking, heat treatment, etc.)
- Classification to EN, ISO or other standards
- Marking, packaging
- Any previous approvals (e.g. from other classification societies or a Technical Supervisory Authority)
- Proposed testing laboratory and date of test.

Note:

The classification to EN, ISO or other standards is included in the approval certificate and in the list of welding consumables and auxiliary materials approved by the Society, but is not normally covered by the tests and therefore is not part of the approval granted by the Society; cf. 1.4. If the Society is so required to check the classification in accordance with the standards, a separate application should be made to this effect.

1.1.9 The applicant is generally the manufacturer of the welding consumables and auxiliary materials. The manufacturer is the firm which carries out the final quality-influencing stage of the manufacturing process (e.g. coiling in the case of wire electrodes). If the applicant is not the manufacturer of the welding consumables and auxiliary materials, he shall give the Society the names of his suppliers. Any change of supplier shall be promptly notified to the Society and generally necessitates a fresh approval test.

1.1.10 In the case of applicants with several production facilities which have separate organisations and are in separate locations, approval of the welding consumables and auxiliary materials will generally be granted for the plant that manufactured them. If production is relocated, already existing approvals may be transferred to the new plant. The conditions relating to the transfer
of approvals specified in 1.2 shall apply in an analogous manner hereto.

1.1.11 If the applicant is not the manufacturer of the welding consumables and auxiliary materials, he shall give the Society the names of his suppliers. Any change of supplier shall be promptly notified to the Society and generally necessitates a fresh approval test.

1.1.12 If welding consumables of the same composition are manufactured by several suppliers and marketed by the applicant under a brand name, the inhouse records and the printing on the packaging (e.g. fabrication number) must clearly identify the manufacturer in question beyond all doubt. The relevant code system used must be notified to the Society.

1.1.13 On the successful conclusion of the specimen welds and tests, the Society's head office will issue an approval certificate. The Society also maintains and publishes a "List of Approved Welding Consumables and Auxiliary Materials".

1.1.14 With the approval, the manufacturer assumes responsibility for ensuring that during fabrication, the composition and properties of the products conform at all times to those of the tested welding consumables and auxiliary materials; see also Section 1, 6.1, and under 1.3.2.

1.1.15 Manufacturers are obliged to state in their catalogues at least those items of information from the approval certificate which appear in the "List of Approved Welding Consumables and Auxiliary Materials".

1.1.16 Besides the brand name, identifying marks and the manufacturer's details concerning the nature and use of the welding consumable or auxiliary material, the printing on the packaging or the adhesive label or the tag attached to reels, coils of wire, etc. must indicate at least the full BRS quality grade plus any additional symbols. The details given in the current approval list published by the Society in accordance with 1.1.13 shall, however, take precedence in each case.

1.1.17 Wherever possible, each rod electrode, welding wire, etc. shall be permanently identified by colour-coding, stamping or impressed marking. The marking must match that on the packaging.

1.2 Transfers of approval

1.2.1 On application, an approval, once granted, may be transferred to welding consumables and auxiliary materials manufactured in the same works but bearing a different brand designation or to welding consumables and auxiliary materials with the same or a different brand designation and produced by other manufacturers (including subsidiary companies) under licence. An approval has already been based on a transfer of approval cannot be transferred.

1.2.2 For this purpose, manufacturing and marketing companies as well as licensors and licensees must confirm that the welding consumables are identical in composition, manufacture and the welding properties on which approval was based, and they must constantly ensure that this identity is preserved in accordance with para. 1.1.14. Marketing companies are also required to confirm that other welding consumables and auxiliary materials (from other manufacturers) are not marketed under the same brand name; cf. also para. 1.1.9 and note to 1.3.3.

1.2.3 Transfer of approval is normally conditional upon a previous test corresponding in scope to the prescribed (annual) repeat test. However, a test differing from this in scope and timing may be agreed. A test may be waived where the transfer relates to welding consumables and auxiliary materials manufactured in the same works provided that the prescribed (annual) repeat tests were performed on the manufacturer's premises in the period stipulated.

1.2.4 The company (marketing company, licensee) in whose name the approval certificate has
been issued is responsible for the prescribed (annual) repeat tests. Where welding consumables and auxiliary materials are produced in the same works, repeat tests need not be duplicated.

1.2.5 Changes to welding consumables and auxiliary materials or their brand designations or in the relationship existing between companies shall be brought to the Society's attention by each of the companies concerned. The provisions of 1.1 are to be applied in analogous manner.

1.3 Period of validity and repeat tests

1.3.1 Subject to the proper performance and sufficient results of the prescribed (annual) repeat tests, approvals of welding consumables and auxiliary materials remain valid indefinitely until revoked. If welding consumables and auxiliary materials do not undergo the prescribed annual repeat tests, the approval shall lapse and they shall be removed from the list of approved products. Equivalent alternative documentary proof may be recognized by the Society by prior special agreement.

Note:

The Society may accept regular in-house tests performed as part of a recognized quality assurance system as equivalent alternative proof provided that this system meets the recommendations “Guidelines for the Acceptance of Manufacturer’s Quality Assurance Systems for Welding Consumables” which have been jointly drawn up by the IACS classification societies and that satisfactory quality assurance test records are submitted to the Society for inspection at not more than yearly intervals. The Society may also perform interim tests on a random basis in order to satisfy itself that the specified procedure is being followed and that the prescribed requirements are being met.

1.3.2 The continued validity of the approval is conditional upon the composition and properties of the starting and end products remaining unchanged, not only on the date of testing but in the intervening period, as well as upon the constant monitoring of these products by the manufacturer in accordance with 1.1.9 and upon the maintenance of verifiable records of this monitoring. The Society may demand sight of these records at any time, may inspect the current production and may also, in case of doubt, call for interim sampling or testing, as appropriate.

1.3.3 Transfers of approval are generally valid for a year at a time from the date of issue of the certificate, but at the most up to the (annual) repeat test at the premises of the manufacturer (licensor) which follows the issuing of the transfer certificate. Transfers of approval may be extended for a further year at a time on application by the marketing company (licensee) if both the manufacturer (licensor) and the marketing company (licensee) submit appropriate confirmations of identity (affidavits) in accordance with Section 1.2.2.

Note:

The Society may waive the requirement for the submission of annual confirmations of identity (Affidavits) if, in conjunction with the first transfer of approval, the manufacturer (licensor) and marketing company (licensee) both expressly declare that they agree to the Society continuing to certify the annual repeat test(s), (until revoked), i.e. extending the approval(s).

1.3.4 A transfer of approval to brand designations used for marketing in accordance with 1.2.1 shall cease to be valid when the approval of the corresponding manufacturer's product expires. A transfer of approval for a product made under licence by another manufacturer may, on application, continue to be valid, provided that the prescribed (annual) repeat tests continue to be conducted by the licensed manufacturer.

1.3.5 Repeat tests shall be performed under the Society's supervision and shall be of the scope
described for the various welding consumables and auxiliary materials. Unless otherwise agreed, the tests shall be performed at yearly intervals. They relate to a period of one year calculated from the date of the approval and are to be concluded by the end of this period at the latest. If no welding consumable or auxiliary material is manufactured within this period, i.e. is sold “ex stock” from a production run that the Society has already inspected, the Society may, on application, defer the repeat test. The Society issues collective certificates covering these repeat tests.

**Note:**

If the scheduled repeat test is missed, the subsequent repeat test shall apply retrospectively to the period in which it should have been performed and may be subject to a time limit. The manufacturer is then required to perform subsequent repeat tests at shorter intervals to ensure that on average the prescribed annual test period is once again achieved. Approval is revoked if repeat testing is not performed in two consecutive years.

1.3.6 Repeat tests for welding consumables and auxiliary materials which have been approved for use in both untreated condition and for one or more heat-treated conditions (cf. para. 1.7.4) shall be carried out according to the prescribed scope for use in untreated condition and for use in each of the heat-treated conditions in question.

1.3.7 Welding consumables and auxiliary materials which have been tested and approved in conjunction with welding procedure tests conducted on the user's premises (cf. Section 4, 2.3.2) or in conjunction with a preliminary welding procedure test (cf. Section 4, 1.2) shall be subjected to annual repeat tests in line with these provisions, which shall be carried out on the premises of either the manufacturer or the user. In the case of welding consumables and auxiliary materials for special welding processes or materials, the scope of the tests applicable will be determined on a case-by-case basis.

1.4 Classification and designation (quality grades, added symbols)

1.4.1 Welding consumables and auxiliary materials for the welding of hull structural steels (including the corresponding grades of steel forgings and castings) and of comparable structural steels are subject to classification, designation and approval as follows:

− According to their nature (e.g. rod electrode, flux-cored wire electrode, wire-gas combination or wire-flux combination),

− According to quality grades 1, 2, 3 and 4 or higher, depending on their notch impact energy and test temperature (cf. 2. to 5.),

− With the added symbol Y or Y 40 (= yield controlled) for welding of higher-strength hull structural steels,

− With the added symbol H15(H), H10 (HH) or H5 (HHH) for controlled hydrogen content of the weld metal (applies only to quality grades 2, 3 and 4 or higher),

− With the added symbol S (= semi-automatic) for semi-mechanized welding,

− With the added symbol T (= two run technique) for welding in one pass on each side, M designating a multirun technique, or TM which covers both (and is applicable only to welding consumables and auxiliary materials for fully mechanized welding),

− With the added symbol V (= vertical welding process) for electrogas or electroslag welding.
Each higher quality grade includes the one (or those) below. Approval for higher-strength hull structural steels (added symbol Y or Y40) generally encompasses approval for normal-strength hull structural steels; cf. Table 1.1 in Chapter 3, Section 1, 5. For welding processes where a high base material content may influence the properties of the weld metal (e.g. in submerged-arc welding using the two-run technique or in electrogas or electroslag welding), the Society may require testing of both categories of material. Approval for semi-mechanized welding (added symbol S) subsumes approval for fully mechanized multi-run welding (added symbol M) in flat positions.

1.4.2 Welding consumables and auxiliary materials for the welding of high-strength (quenched and tempered) structural steels with minimum yield strengths in excess of 390 N/mm² are subject to classification, designation and approval in analogous manner to para. 1.4.1, with the following differences:

- With the quality rating 3 or higher, depending on their notch impact energy and test temperature (see 6.),

- With the added symbol Y and an appended code number designating the minimum yield strength of the weld metal (e.g. Y46 for a minimum yield strength of 460 N/mm²).

Each higher quality grade includes the one (or those) below. Approval for steels having the minimum yield strength designated by the code number subsumes approval for steels of similar type having the next two lower yield strengths (e.g. approval for a steel with the symbol Y50 subsumes approval for steels with the symbols Y46 and Y42). In the case of steels with minimum yield strengths of 550 N/mm² and above (symbols Y55, Y62 and Y69), the approval only subsumes the steel with the next lower yield strength. In special cases, welding consumables and auxiliary materials are approved only for specific materials.

1.4.3 Depending on their nature and condition (type of alloy), welding consumables and auxiliary materials for welding of steels tough at subzero temperatures are classed as equivalent to those for high-strength (quenched and tempered) structural steels (see 6.), for austenitic stainless steels (see 9.), or for nickel and nickel alloys (see 12.) and are subject to classification, designation and approval as follows:

- For approvals in accordance with 6., according to a quality grade which depends on their notch impact energy and test temperature and, where applicable, with the added symbol Y and the code number for the minimum yield strength (cf. 1.4.2)

or

- For approvals in accordance with 9., according to a quality grade consisting of the abbreviated material number of the material or material category for which approval was granted (cf. 1.4.5), also stating the test temperature used for the approval test

or

- For approvals in accordance with 12., according to a quality grade corresponding to the code designation shown in the standard applicable to the welding consumable (cf. 1.4.8), also stating the test temperature used for the approval test.

The inclusions and exclusions of the category of welding consumables and auxiliary materials according to which approval was granted apply, unless otherwise stated in the approval certificates.

1.4.4 Welding consumables and auxiliary materials for welding of high-temperature steels are subject to classification, designation and approval as follows:
According to a quality grade corresponding to the code designation for the material or material category for which the approval was granted (see 8.).

The materials included in the respective approvals are shown in Table 5.18.

**1.4.5** Austenitic welding consumables and auxiliary materials for welding of stainless and non-magnetic steels and nickel alloy steels tough at subzero temperatures are subject to classification, designation and approval as follows:

1. For welded joints in (austenitic) stainless steels, according to a quality grade consisting of the abbreviated material number of the base material to be welded with the product (e.g. quality grade 4571 for the welding of steel with the material number 1.4571 X6CrNiMoTi 17 12 2)

2. For welded joints in (austenitic) non-magnetic stainless steels, according to a quality grade consisting of the abbreviated material number of the welding consumable itself (e.g. quality grade 3954 for the welding of steel with the material number 1.3964 X2CrNiMnMoNNb 21 16 5 3)

3. For welded joints between these steels and unalloyed or low-alloy (hull) structural steels, for intermediate weld runs in clad plates and build-up welding, according to a quality grade consisting of the abbreviated material number of the welding consumable itself (e.g. quality grade 4370 for the welding consumable with the material number 1.4370 X15CrNiMn 18 8)

4. For welding of nickel alloy steels tough at subzero temperatures, according to a quality grade consisting of the abbreviated material number of the base material to be welded with the product in question (e.g. quality grade 5662 for welding of steel with the material number 1.5662 X8Ni9).

The steels also covered by the approval and information on the types of application are shown in 9. (Tables 5.21 to 5.24). In special cases, e.g. where the inclusions and exclusions differ, the relevant information is given in the approval certificates.

**1.4.6** Welding consumables and auxiliary materials for welding of aluminium alloys are subject to classification, designation and approval according to a quality grade corresponding to the code designation according to the standard, e.g. quality grade S-AlMg 4.5 Mn. For other aluminium alloys covered by the respective approval, see 10, Table 5.26.

**1.4.7** Welding consumables and auxiliary materials for welding of copper and copper alloys are subject to classification, designation and approval according to a quality grade corresponding to the code designation according to the standard, e.g. quality grade CuNi30Fe. For other base materials covered by the respective approval, see 11, Table 5.29.

**1.4.8** Welding consumables and auxiliary materials for welding of nickel and nickel alloys are subject to classification, designation and approval according to a quality grade corresponding to the code designation according to the standard, e.g. quality grade NiCu30MnTi. For other base materials covered by the respective approvals, see 12, Table 5.31.

**1.4.9** The code numbers and letters indicated in Table 5.1 are used to identify the approved welding positions. In special cases, the approved welding positions are specified individually; for example, an approval applicable only to the vertical-down (v-d) position. For the limitations relating to the use of vertical-down welding, see Chapter 3, Section 1, 8.6.
Table 5.1  Welding positions

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Welding positions, code letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All welding positions</td>
</tr>
<tr>
<td>2</td>
<td>All except the vertical-down position</td>
</tr>
<tr>
<td>3</td>
<td>Butt welds in the down-hand position, fillet welds in the down-hand and horizontal positions</td>
</tr>
<tr>
<td>4</td>
<td>Butt welds in the down-hand position and fillet welds in the down-hand position</td>
</tr>
<tr>
<td>5</td>
<td>Vertical down-positions and those as for code no. 3</td>
</tr>
</tbody>
</table>

Table 5.2  Type of current and polarity

<table>
<thead>
<tr>
<th>Code letter and symbol</th>
<th>Type of current and polarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC +</td>
<td>Direct current, + polarity</td>
</tr>
<tr>
<td>DC -</td>
<td>Direct current, – polarity</td>
</tr>
<tr>
<td>DC ±</td>
<td>Direct current, + and – polarity</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating current</td>
</tr>
</tbody>
</table>

1.4.10  The code letters indicated in Table 5.2 are to be used to designate the type of current approved for use with the relevant welding consumables and auxiliary materials.

1.5  Upgrading and downgrading

1.5.1  The upgrading of approved welding consumables and auxiliary materials into a higher quality grade shall be applied for by the manufacturer and may suitably be effected on the occasion of the prescribed (annual) repeat tests. Upgrading requires that in addition to the repeat tests, notched bar impact test specimens shall be taken from all the butt-welded test pieces (welded joints) prescribed for the (original) approval test in the various positions and shall be subjected to test. Radiographic examination of the butt-welded test pieces is recommended.

1.5.2  Downgrading into an appropriately lower quality grade results when the outcome of the prescribed (annual) repeat tests fails to fulfil the requirements, even if the retest specimens are included.

Where the earlier test results and the evaluation of all the new test findings point to the likelihood that the failure of the specimens was due to defects in the material or the welding, the repeat test may be repeated at short notice. If the requirements are still not met, the quality grade will be reduced. In such a case, a renewed upgrading may take place after three months at the earliest, i.e. after thorough revision and improvement of the product, and only after testing as described in 1.5.1.

1.5.3  The extension of an existing approval covering the welding of normal-strength hull
structural steels to the welding of higher-strength hull structural steels (e.g. from grade 2 to grade 2Y or from grade 3Y to grade 3Y40) requires the performance of a complete new approval test using higher-strength hull structural steel in question as the base material. This requirement applies in analogous manner to other materials as well.

1.5.4 Extension of an existing approval to include the added symbol H15(H) or the modification of the symbol H15(H) to H10(HH) or H5(HHH) is permissible provided that the weld metal can be proved to contain the stipulated lower quantity of hydrogen by a test in accordance with 2.4. Corresponding tests performed elsewhere may be recognized as furnishing the necessary proof, provided that they were carried out not more than three years previously.

1.6 Physical characteristics, welding performance and packaging

1.6.1 All welding consumables and auxiliary materials must have physical characteristics compatible with the proposed application and conforming to the relevant standards and must display a satisfactory general welding performance. The packaging must be such as to prevent excessive moisture absorption and damage to the contents provided that the materials are properly handled and stored. Verification of these characteristics and testing of the packaging form an integral part of the approval tests and repeat tests.

1.6.2 In the case of rod electrodes, the coating must encase the core rod concentrically and with uniform thickness. When the electrodes are correctly used, no projecting crater rim may be formed at one side of the coating during welding. The coating shall not display any marked irregularities or surface defects. It must adhere firmly to the core rod and be capable of storage within the specified limit conditions. Subject to proper handling and use, the coating shall not rupture or break away from the core rod. The clamping butt and the arcing end must be free from coating material.

1.6.3 Welding wires (wire electrodes and welding rods) must have a smooth surface and must be free from surface defects, rust or other contamination which might impair the satisfactory execution of the welding operation (e.g. by impeding the current flow). Although welding wires may be provided with metal coatings, these shall not adversely affect their welding performance or the properties of the weld. Coiled welding wires must be free from buckling and must unwind smoothly.

1.6.4 Welding fluxes and shielding gases must possess a degree of purity conforming to the relevant standards together with the lowest possible moisture content. Welding fluxes should be granular in consistency and free-flowing to facilitate their smooth passage through the flux supply system. The granulometry of the flux should be uniform and constant from one package to another. Regarding the identity testing of gases and the inspection of shielding gas mixing devices on the user's premises, see 3.1.5.

1.6.5 Other auxiliary materials such as nitrogen-hydrogen mixtures and powder or ceramic weld pool supports (backings) should as far as possible be metallurgically neutral and have no effect on the characteristics of the weld. Where such an effect cannot be ruled out (e.g. with powder supports which deplete or add to the alloying constituents), the materials shall be included in the scope of the relevant approval or repeat tests, or shall be tested as part of the (preliminary) welding procedure tests; cf. Section 4, 1.2 and 2.3.2.

1.6.6 Welding consumables - where appropriate in conjunction with the corresponding auxiliary materials - must in all positions and even at the limit values of the welding current display a satisfactory and constant welding performance without excessive spatter.

The coating of rod electrodes shall not flake off during welding, nor may coated wire electrodes burst open. Should the arc be accidentally interrupted during welding, the slag shall not impede the speedy restoration of the arc. Cooled slag shall be capable of being removed from the weld.
without undue difficulty. The external characteristics of the weld and its internal features (as revealed by radiography) must meet the subsequent requirements of fabrication (cf. Chapter 2, Section 4, 7.).

1.7  Performance of approval tests

1.7.1  Unless otherwise stated below, approval tests shall be conducted in accordance with Section 4. The conditions under which the specimen welds are made (welding parameters, number of runs, weld build-up, etc.) must conform to the manufacturer's recommendations and to normal welding practice and be placed on record. Covered electrodes shall be consumed down to a residual length of approx. 50 mm. The heat input (energy input per unit length of weld E) applied during welding shall be determined by the following formula and shall also be placed on record:

\[ E = \frac{U \text{[volts]} \cdot I \text{[amps]} \cdot \text{welding time[min]} \cdot 6 \text{[kJ]} \text{[mm]} }{\text{length of seam[mm]}} \]

1.7.2  The base materials used for approval tests shall be of the chemical composition and strength category for which the welding consumables and auxiliary materials are to be approved. For an approval covering only normal-strength hull structural steels (quality grades 1, 2 or 3), a normal-strength hull structural steel or, failing this, a comparable structural steel possessing the same minimum tensile strength (400 N/mm²) shall be used. For approvals covering higher-strength hull structural steels (quality grades 1Y, 2Y, 3Y or 4Y), a higher-strength hull structural steel or a comparable structural steel (e.g. St 52-3) having a tensile strength of at least 490 N/mm² shall be used.

For approvals covering the quality grades 2Y40, 3Y40 or 4Y40, a hull structural steel or a comparable structural steel with a tensile strength of at least 510 N/mm² shall be used. For testing the pure weld metal, normal-strength hull structural steels or comparable structural steels may generally be used. For welding consumables with a very divergent chemical composition, the side walls of the test piece may, if necessary, be provided with a buffer (e.g. in the case of stainless steels) and a backing strip of the same composition as the plate may be used. For the special features applicable to submerged-arc welding, see 4.3.2 and 4.3.5.

1.7.3  Where welding consumables and auxiliary materials are to be approved for welding with both direct and alternating current, the test shall be conducted with alternating current. In special cases, verification of the welding characteristics using direct current may be demanded as an alternative or in addition (e.g. for rod electrodes used for gravity welding with direct and alternating current, and for certain welding processes).

1.7.4  Post-weld heat treatment of the test pieces or specimens is not allowed where products are to be approved for the untreated condition alone; see also the preliminary remarks relating to 2. Excepted from this rule is the heat treatment of tensile specimens to reduce their hydrogen content as described below in relation to the various welding consumables and auxiliary materials. Where welding consumables and auxiliary materials are also to be approved for the heat-treated condition, the prescribed additional test pieces must be prepared (cf. 8.1.3) and heat-treated accordingly. Follow-up heat treatment of the specimens once they have been removed from the test pieces is not allowed.

1.7.5  In special cases, further tests (e.g. hardness measurements, examination of macro- or micrographic specimens to check weld penetration and structural characteristics, etc.) or the testing of notched bar impact test specimens at temperatures lower than those specified may be stipulated in addition to the test pieces and specimens called for in the following paragraphs. In the case of welding consumables and auxiliary materials for austenitic stainless steels, proof is required of resistance to intergranular corrosion and for solid austenitic steels resistance to hot cracks must also be demonstrated.
1.7.6 Should individual test results fail to meet the requirements, a double quantity of test pieces and specimens of the same kind shall be freshly prepared and subjected to testing. Base materials, welding consumables and auxiliary materials originating from the same delivery as those used for the first test shall be used for this purpose. Should the specimens again fail, approval will not be granted until the reasons have been deducted (cf. also 1.5.2). For the repetition of notched bar impact tests, see the following provisions relating to the various welding consumables and auxiliary materials.

2. COVERED ELECTRODES FOR MANUAL METAL-ARC WELDING OF HULL STRUCTURAL STEELS

Preliminary remarks:

In normal shipbuilding practice, components are in general not subjected to post-weld heat treatment (e.g. annealing to relieve stresses). Consequently, the welding consumables and auxiliary materials to be used in shipbuilding are generally tested and approved for the untreated, i.e. as-welded, condition.

Should post-weld heat treatment nevertheless be intended or required in special cases, only welding consumables and auxiliary materials with properties and quality grades which have been proved to be adequate in the respective heat-treated condition shall be used. The nature and scope of the necessary verifications shall be determined on a case-by-case basis.

In the case of welding consumables for hull structural steels, the test temperature for the base material in question (see Chapter 3, Section 1, Table 1.1 as well as the Rules for the Construction of Ocean-going Vessels, Chapter 1, Section 2) may be assumed to be the minimum load temperature (design temperature). A temperature of 300 °C is generally considered to be the maximum load temperature.

2.1 General

2.1.1 The following provisions apply to rod electrodes for manual metal-arc welding of hull structural steels, including the corresponding grades of steel forgings and castings, and of comparable structural steels. Rod electrodes for semi-mechanized gravity welding and spring-loaded welding processes are treated in the same way as those for manual metal-arc welding.

2.1.2 Rod electrodes for normal-strength hull structural steels are approved according to quality grades 1, 2 and 3 depending on the notch impact energy values achieved during the approval tests. Rod electrodes for higher-strength hull structural steels are approved according to quality grades 2Y, 3Y and 4Y or, where applicable, 2Y40, 3Y40 and 4Y40. In special cases, e.g. when the electrodes are also used for steels tough at subzero temperatures, approval may be granted with a higher quality grade, as with welding consumables and auxiliary materials for high-strength (quenched and tempered) structural steels (cf. 6. and Table 5.14). Regarding added symbols, inclusions and exclusions, see 1.4.1.

2.2 Testing the weld metal

2.2.1 For testing the deposited weld metal, two test pieces of the type shown in Fig. 5.1 are to be prepared in the downhand (d) welding position.

One of the test pieces is to be welded with 4 mm diameter rod electrodes, the other with rod electrodes of the maximum diameter produced, up to a limit of 8 mm. Where the electrodes produced are of one diameter only or do not exceed 4 mm in diameter, one test piece is sufficient.
In accordance with the rod electrodes used and normal welding practice, the weld metal shall be laid down in layers comprising single or multiple runs. The layers shall be welded in alternate directions, and the individual runs shall be 2 - 4 mm thick. Prior to the welding of each new layer, the test piece shall be cooled in still air to 250 °C or below, but on no account to below 100 °C. The temperature shall be measured at the surface of the centre of the weld.

2.2.2 The chemical composition of the deposited weld metal shall be determined by the manufacturer using recognized methods of analysis and shall be certified by him. The analysis shall encompass all the important alloying constituents and impurities (e.g. phosphorus and sulphur). The results of the analysis shall not exceed the limits specified in the standards. In special cases, narrower tolerances for the constituents may be stipulated.

2.2.3 Following the recommended radiographic examination, one round tensile test specimen as shown in Fig. 5.2 and three ISO V-notch impact test specimens conforming to Fig. 5.3 shall be machined from each weld metal test piece. The longitudinal axis of the round tensile specimen shall be located in the centre of the weld at the mid-point of the plate thickness. The upper lateral surface of the impact test specimens shall lie 5 mm below the surface of the plate with the notch also located in the centre of the weld.

To remove the hydrogen from the weld metal, the round tensile specimens may be subjected to a temperature not exceeding 250 °C for not longer than 16 hours prior to the tensile test.

In the notched bar impact test, the temperature of the specimens for quality grades 2, 2Y, 2Y40, 3, 3Y, 3Y40, 4Y and 4Y40 shall not deviate from the prescribed test temperature by more than 2 °C.

---

**Fig. 5.1** Weld metal test piece

K = Notched bar impact test specimen  
R = Round tensile test specimen
2.2.4 The mechanical properties of the weld metal must meet the requirements stated in Table 5.3. If the tensile strength exceeds the upper limit, approval of the electrode will be granted only after careful consideration of its other technological properties and the chemical analysis of the weld metal. The mean value for the notch impact energy must meet the requirements of the following sections; an individual value may be below the required mean value but not less than 70% of this value.

2.2.5 If the tensile strength exceeds the upper limit, approval of the electrode will be granted only after careful consideration of its other technological properties and the chemical composition of the weld metal. For the carrying out of retests, see 1.7.6; the requirements for the notch impact energy test are as follows:

If the required notch impact energy values are not attained, but not more than two of the individual values are below the required mean value and not more than one of them is less than 70% of the required value, three more impact test specimens may be taken from the same or an identical weld metal test piece and tested. The results obtained are to be added to the first results and the resulting new mean value must then meet the requirements. In addition, no more than two of the six individual values in all may be below the required mean value and of these, not more than one may be less than 70% of the required value.

2.2.6 Further repeat tests require the consent of the Society in each individual case; see also 1.7.6. Such tests, however, shall without exception comprise the welding of a new test piece and the testing of all the specimens originally required, even if some of them gave satisfactory results in the first test.

2.3 Testing on welded joints

2.3.1 Tests on welded joints are generally performed on butt-welded test pieces in accordance with Fig. 5.4 and Table 5.4. Where rod electrodes are to be approved only for fillet welding (e.g. for gravity welding), fillet-welded test pieces as shown in Fig. 5.7 instead of butt-welded test pieces shall be welded and subjected to test. In special cases, the Society may call for fillet-welded as well as butt-welded test pieces, e.g. for vertical-down welding.

2.3.2 Butt-welded test pieces in accordance with Fig. 5.4 shall be welded in the positions and with the electrode diameters shown in Table 5.4 according to the welding positions covered by the
approval application (cf. 1.4.9 and Table 5.1). For the base mate-rials to be used, see 1.7.2; their chemical composition is to be recorded.

The two parts of the test piece are to be juxtaposed with sufficient allowance for angular shrinkage. Prior to the welding of each new pass, the test piece shall be cooled in still air to 250 °C or below, but on no account below 100 °C. The temperature is to be measured at the surface of the centre of the weld. Before the backing pass is laid down, the root is to be grooved – wherever possible by machining - from the rear.

2.3.3Following the recommended radiographic examination, one flat tensile test specimen in accordance with Fig. 5.5, two 30 mm wide transverse bend test specimens (one with the cover pass and one with the backing pass in tension) and three ISO V-notch specimens conforming to Fig. 5.3 are to be machined from each butt-welded test piece as shown in Fig. 5.4.

The parallel length of the flat tensile test specimens shall be equal three times the plate thickness or the weld width plus twice the plate thickness, whichever is the greater. On the tension side, the edges of the transverse bend test specimens may be rounded to a radius of not more than 2 mm. The position of the impact test specimens shall conform to Fig. 5.6. The weld reinforcement shall be machined flush with the surface of the plate on both sides of all specimens.

### Table 5.3 Required properties of the weld metal (rod electrodes)

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Minimum yield strength [N/mm²]</th>
<th>Tensile strength [N/mm²]</th>
<th>Minimum elongation (L₀ = 5 d₀) [%]</th>
<th>Minimum notch impact energy [J]</th>
<th>Test temperature [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>305</td>
<td>400 - 500</td>
<td>22</td>
<td>47 (33)</td>
<td>+ 20</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 20</td>
</tr>
<tr>
<td>2 Y</td>
<td>375</td>
<td>490 - 660</td>
<td>22</td>
<td>47 (33)</td>
<td>0</td>
</tr>
<tr>
<td>3 Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 20</td>
</tr>
<tr>
<td>4 Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 40</td>
</tr>
<tr>
<td>2Y40</td>
<td>400</td>
<td>510³ - 690</td>
<td>22</td>
<td>47 (33)</td>
<td>0</td>
</tr>
<tr>
<td>3Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 20</td>
</tr>
<tr>
<td>4Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- 40</td>
</tr>
</tbody>
</table>

¹ For possible higher quality grades, see 2.1.2
² Mean value of three specimens; ( ) for minimum individual values; for this and retests, see 2.2.4 and 2.2.5
³ A tensile strength 500 [N/mm²] is acceptable if adequate values are achieved in the welded joint.

---

**Fig. 5.4 Butt-weld test piece**
**Fig. 5.5** Flat tensile test specimen

**Fig. 5.6** Position of impact test specimens

### Table 5.4 Butt-weld test pieces, welding positions and electrode diameters

<table>
<thead>
<tr>
<th>Position(s) applied for approval</th>
<th>Butt-weld test pieces required . . .</th>
<th>. . . in position(s)</th>
<th>. . . with electrode diameter(s) $^1$</th>
<th>Back pass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Position</td>
<td>Root pass</td>
<td>Fill and cover passes</td>
</tr>
<tr>
<td>All positions incl. vertical-down</td>
<td>1</td>
<td>PA (d)</td>
<td>4</td>
<td>5 to 8 $^2$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PF (v-u)</td>
<td>3,25</td>
<td>4 or 5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PE (o)</td>
<td>3,25</td>
<td>4 or 5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PG (v-d)</td>
<td></td>
<td>acc. to manufacturer’s instructions</td>
</tr>
<tr>
<td>All positions except vertical-down</td>
<td>1</td>
<td>PA (d)</td>
<td>4</td>
<td>5 to 8 $^2$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PF (v-u)</td>
<td>3,25</td>
<td>4 or 5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PE (o)</td>
<td>3,25</td>
<td>4 or 5</td>
</tr>
<tr>
<td>Download positions and vertical-up</td>
<td>1</td>
<td>PA (d)</td>
<td>4</td>
<td>5 to 8 $^2$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PF (v-u)</td>
<td>3,25</td>
<td>4 or 5</td>
</tr>
<tr>
<td>Download positions only</td>
<td>1</td>
<td>PA (d)</td>
<td>4</td>
<td>5 to 8 $^2$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PC (h-v)</td>
<td>4 or 5</td>
<td>5</td>
</tr>
<tr>
<td>Horizontal-vertical PS (h-v) position only</td>
<td>1</td>
<td>PC (h-v)</td>
<td>4 or 5</td>
<td>5</td>
</tr>
<tr>
<td>Other individual Positions</td>
<td>1</td>
<td>(x)</td>
<td></td>
<td>all specified above</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Electrode diameters in [mm].
2. Filler passes with 5 or 6 mm size; last two runs including the cover pass with the largest diameter electrodes produced, up to a maximum of 8 mm.
3. Includes the horizontal-vertical PC (h-v) position.
4. Second pass with 5 or 6 mm size; all other filler and cover passes to be made with the largest diameter electrodes produced, up to a maximum of 8 mm.
2.3.4  The mechanical properties of the welded joints must meet the requirements stated in Table 5.5. For the performance of the tests and the carrying out of retests, see para. 2.2.4 and 2.2.5.

The position of the fracture shall be recorded. Bend test specimens displaying incipient cracks shall be broken open for assessment of the fracture. The Society may stipulate that the bend tests or supplementary bend tests be performed within a set time limit in order to ascertain possible effects of hydrogen.

2.3.5  Fillet-weld test pieces as shown in Fig. 5.7 shall, if necessary according to 2.3.1, be prepared in each of the welding positions applied for approval (cf. 2.3.2).

For the base materials to be used, see 1.7.2. The first fillet weld is to be made with the largest, the second with the smallest electrode diameter recommended by the manufacturer for the particular welding position and throat thickness concerned. Unless otherwise stipulated or agreed, each fillet weld shall be made in a single pass. Electrodes of the maximum length produced are to be used. The amperages used shall be recorded.

The length "L" of the test piece shall be such as to permit the melt-off of at least one complete electrode length - namely, the longest produced - with a throat thickness appropriate to the electrode diameter.

2.3.6  Following visual inspection and assessment, the fillet-weld test pieces shall be sectioned in the manner shown in Fig. 5.7, and the macrographic specimens marked with "M" shall be prepared for evaluation of the weld penetration and measurement of the hardness in accordance with Fig. 5.8. Wherever possible, Vickers hardness measurements 10 HV should be performed.

2.3.7  The hardness of the weld metal obtained with welding consumables and auxiliary materials for higher-strength hull structural steels with minimum yield strengths up to 355 N/mm² (added symbol Y) shall not be less than 150 HV and the corresponding hardness for higher-strength hull structural steels with a minimum yield strength of 390 N/mm² (added symbol Y40) shall not be less than 160 HV. The test report shall also record the hardness values measured in the heat-affected zone and the base material. Equivalent values for other methods of measurement shall be agreed.

After machining off one of the fillet welds, the two remaining pieces of each fillet-weld test piece shall be broken open on alternate sides and the fracture shall be assessed. The specimen must be free from any major defects such as large pores and slag lines in the root, incomplete penetration, lack of fusion at the side walls, cracks, etc., cf. also Chapter 3, Section 1, 7.10.3.4.
2.4 Hydrogen test

2.4.1 The hydrogen test to determine the diffusible hydrogen content of the weld metal should, where possible, be conducted according to the mercury method prescribed in ISO standard 3690-1977 or, with the Society's consent, according to other comparable methods. For an interim period and with the Society's consent, the glycerin method described in para. 2.4.3 may continue to be used as an alternative for the added symbols H15(H) and H10(HH). Depending on the added symbols H15(H), H10(HH) or H5(HHH) to be appended to the quality grade specified in the approval (cf. 1.4.1), the hydrogen content of the weld metal shall not exceed the limits indicated in Table 5.6.

2.4.2 In the mercury method, the quantity of hydrogen related to the fused weld metal $V_F$ shall be determined and recorded in addition to the quantity of diffusible hydrogen related to the deposited weld metal $V_D$ (cf. ISO 3690, Part 1).

Table 5.5 Required properties of welded joints (rod electrodes)

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Minimum notch impact energy [J]</th>
<th>Minimum bending angle, mandrel diameter = $3 \times$ thickness of specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positions</td>
<td>Test temperature [$°C$]</td>
</tr>
<tr>
<td></td>
<td>PA, PC, PE (d, h-v, o)</td>
<td>PF, PG (v-u, v-d)</td>
</tr>
<tr>
<td>1</td>
<td>$\geq 400$</td>
<td>47 (33)</td>
</tr>
<tr>
<td>2</td>
<td>$\geq 490$</td>
<td>47 (33)</td>
</tr>
<tr>
<td>3</td>
<td>$\geq 510$</td>
<td>47 (33)</td>
</tr>
<tr>
<td>2Y40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Y40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4Y40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 For possible higher quality grades, see 2.1.2.
2 Mean value of three specimens, ( ) minimum individual values; for this and retests, see 2.2.4. and 2.2.5.

Table 5.6 Permissible hydrogen content of weld metal

<table>
<thead>
<tr>
<th>Added symbol</th>
<th>Permissible hydrogen content of weld material 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mercury method</td>
</tr>
<tr>
<td>H15(H) 2)</td>
<td>15 cm³/100 g</td>
</tr>
<tr>
<td>H10(HH) 2)</td>
<td>10 cm³/100 g</td>
</tr>
<tr>
<td>H5(HHH) 3)</td>
<td>5 cm³/100 g</td>
</tr>
</tbody>
</table>

1) Mean value of four specimens, related to the deposited weld metal.
2) Previous added symbols H, HH and HHH should no longer be used, wherever possible.
3) Not to be used.
2.4.3 Where the glycerin method of testing for hydrogen is used, the following procedure shall be adopted:

![Image of hardness measurements](image)

**Fig. 5.8  Hardness measurements**

2.4.3.1 Four sample bars of normalized steel measuring 125 x 25 x 12 mm shall be thoroughly cleaned and weighed to the nearest 0.1 g. A single bead of weld, approximately 100 mm long, is to be laid down on one of the 125 x 25 mm faces of each sample bar, on each occasion using a new 4 mm diameter rod electrode. 120 to 150 mm of the electrode length shall be consumed in the process.

2.4.3.2 The welding operation shall be performed with a current of approximately 150 A and the shortest possible arc. Where the welding process is mechanized, the electrode diameter and the amperage shall be so chosen that the thermal input corresponds to that of manual arc welding.

Prior to welding, the consumables may be baked in the normal manner prescribed by the manufacturer.

2.4.3.3 Not later than three seconds after the extinction of the arc, the sample is to be quenched in iced water (0 °C). During the cooling of the sample in water, the slag and weld spatter are to be removed with a steel brush within 30 seconds. Within the space of a further 30 seconds, the sample shall be removed from the water, cleaned and dried, and each sample shall be placed separately into a test vessel (glass volumetric flask) to catch the escaping hydrogen using glycerin as the sealing liquid. After another 30 seconds the zero level adjustment of the gas collecting vessel must be completed and the measuring time must begin.

2.4.3.4 During the test, the temperature of the glycerin is to be held at 45 °C. The sample bars are to be left immersed in the glycerin for 48 hours, after which they are to be taken out and cleaned with water and alcohol. After drying, the sample bars shall again be weighed to the nearest 0.1 g to determine the quantity of deposited weld metal.

2.4.3.5 The volume of gas collected in the test vessel is to be measured to the nearest 0.05 cm³ and corrected for a temperature of 0 °C and a pressure of 760 mm of mercury.

The mean volume of the diffusible hydrogen measured in relation to the deposited weld metal for the four sample bars may not exceed the values indicated in Table 5.6.

2.5 Hot-cracking test

2.5.1 Where the Society requires that a hot-cracking test be performed, two plates shall for that

---

1 Wherever possible, the steel should not contain more than the following components: 0.15 % C, 0.10 % Si, 1.0 % Mn, 0.03 % P, 0.03 % S.
purpose be welded together in the manner shown in Fig. 5.9. The end face of the web plate must be cut
straight and at right angles and must fit snugly against the flat upper surface of the bottom plate. Any
unevenness is to be removed. The base plate shall be stiffened by three transverse web plates.

2.5.2 The first fillet weld is to be laid down in a single pass in the downhand PA (d) position.
During this operation, the current must be at the upper limit of the range prescribed for the electrode.

The second fillet weld on the opposite side shall be laid down immediately after the first,
also in the downhand PA (d) position and starting at the end of the test piece where the first fillet weld
terminated. Both fillet welds are to be laid down at a uniform speed without weaving of the electrode.

2.5.3 For the welding of the complete length of each fillet weld (120 mm), the electrode lengths
indicated in Table 5.7 are to be molten off.

<table>
<thead>
<tr>
<th>Electrode core wire diameter</th>
<th>Molten-off lengths of electrodes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st fillet weld</td>
</tr>
<tr>
<td>[mm]</td>
<td>[mm]</td>
</tr>
<tr>
<td>4</td>
<td>200</td>
</tr>
<tr>
<td>5</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
</tr>
</tbody>
</table>

After welding, the slag shall at once be removed from the fillet welds.

2.5.4 Half an hour after welding, at the earliest, i.e. when the test piece has cooled completely
through its entire thickness, the fillet welds are to be examined for cracks with a magnifying glass or
by a crack-detecting technique.

The first fillet weld shall then be removed by machining and the second fillet weld shall
be fractured by collapsing the plates (with the root in tension). The fractured seam shall then be
examined for hot cracks.

When subjected to testing for hot cracks, the fillet welds may not reveal any superficial or
internal cracks of any kind. Only end crater cracks may be tolerated.
2.6  Annual repeat tests

2.6.1  For rod electrodes for hull structural steels, the annual repeat test called for in 1.3.1 requires the preparation of two weld metal test pieces in accordance with 2.2.1. The test specimens prescribed in 2.2.3 shall be taken from these. For the tests to be applied and the required properties, see 2.2.4 and Table 5.3.

2.6.2  In special cases the Society may stipulate more extensive repeat tests (cf. 1.3.2, 1.7.4 and 1.7.5).

3.  (FLUX-CORED) WIRE-GAS COMBINATIONS AND FLUX-CORED WIRE ELECTRODES FOR SEMI-MECHANIZED WELDING OF HULL STRUCTURAL STEELS

3.1  General

3.1.1  The following provisions apply to (flux-cored) wire-gas combinations and flux-core wire electrodes for semi-mechanized welding of hull structural steels, of corresponding grades of steel forgings and castings and of comparable structural steels. Wire-gas combinations for manual tungste-inert-gas (TIG) welding shall be treated analogously to those for semi-mechanized welding. For wire-gas combinations and flux-cored wire electrodes for fully mechanized welding and mesh-wound wire electrodes, see 4.1.1.

3.1.2  (Flux-cored) wire-gas combinations and flux-cored wires for normal-strength hull structural steels are approved according to quality grades 1S, 2S or 3S, depending on the notch impact energy values achieved during the approval tests. Quality grades 2YS, 3YS and 4YS or, where applicable, 2Y40S, 3Y40S and 4Y40S are awarded to wire-gas combinations and flux-cored wires for higher-strength structural steels. For inclusions and exclusions, see 1.4.

3.1.3  Approval is essentially linked to a specific (commercial) brand of wire - where appropriate, in conjunction with a shielding gas conforming to a standard (e.g. to EN 439/ISO 14175) or defined in terms of its composition and purity. An approval relates exclusively to the wire produced by a particular manufacturer and used for the approval tests. The Society is to be notified of the manufacturer and the brand and standard designations of the wire used for the approval test. The marketing of other wires (wires produced by other manufacturers) under the (commercial) brand name stated in the approval certificate is permitted only after a renewed approval test using the other wire.

3.1.4  Approval may be granted for a (commercial) brand of wire in conjunction with a specific (commercial) brand of shielding gas produced by a particular manufacturer or in conjunction with a shielding gas covered by EN 439/ISO 14175 and defined by its group and code number (e.g. M 21) in accordance with Table 5.8.

3.1.5  Where a (commercial) brand of (flux-cored) wire is approved in conjunction with a standardized shielding gas in accordance with 3.1.4, the wire in question may be used with other standardized gases of the same type, provided that these gases are included in the "List of Approved Welding Consumables" (cf. 1.1.13) on the basis of an initial verification of identity performed on the manufacturer's premises followed by annual repeat tests of composition and purity. Branch works, cylinder filling stations, etc. shall also be covered by these tests. For gas mixing installations (including those on the user's premises) adequate documentary proof shall be submitted to the Society.
Table 5.8  Classification of shielding gases according to EN 439/ISO 14175

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Components in present volume</th>
<th>Typical applications</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oxidizing</td>
<td>Inert</td>
<td>Reducing</td>
</tr>
<tr>
<td>Group</td>
<td>Identification</td>
<td>CO2</td>
<td>O2</td>
</tr>
<tr>
<td></td>
<td>No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>1 2</td>
<td>balance (^2)</td>
<td>balance (^2)</td>
</tr>
<tr>
<td>I</td>
<td>1 2 3</td>
<td>100</td>
<td>balance</td>
</tr>
<tr>
<td>M1</td>
<td>1 2 3 4</td>
<td>&gt; 0 to 5 &gt; 0 to 5 &gt; 0 to 3 &gt; 0 to 3</td>
<td>balance (^2) balance (^2) balance (^2) balance (^2)</td>
</tr>
<tr>
<td>M2</td>
<td>1 2 3 4</td>
<td>&gt; 5 to 25 &gt; 0 to 5 &gt; 3 to 10 &gt; 0 to 8</td>
<td>balance (^2) balance (^2) balance (^2) balance (^2)</td>
</tr>
<tr>
<td>M3</td>
<td>1 2 3</td>
<td>&gt; 25 to 50 &gt; 5 to 25 &gt; 10 to 15 &gt; 8 to 10</td>
<td>balance (^2) balance (^2) balance (^2) balance (^2)</td>
</tr>
<tr>
<td>C</td>
<td>1 2</td>
<td>100</td>
<td>balance</td>
</tr>
<tr>
<td>F</td>
<td>1 2</td>
<td>&gt; 0 to 50</td>
<td>balance</td>
</tr>
</tbody>
</table>

1 Where components not listed are added to one of the groups in this table, the gas mixture is designated as a special gas mixture and carries the prefix S. Details of the S designation are given in clause 4 of the standard.

2 Argon may be replaced by up to 95 % helium. The helium content is designated by an additional identification number, see table 5.27.

3.1.6 If in exceptional cases, e.g. where the gas producer makes application for approval for a (fluxcored) wire-gas combination, approval is required to be granted for a specific standard wire in conjunction with a (commercial) brand of gas produced by a particular manufacturer, the brand of wire used in the test will also be noted in the approval confirmation document. The use of other, equivalent (commercial) brands of (flux-cored) wire or standard wire as part of such an approval is only permitted if the particular wire in question has already been tested and approved elsewhere with a gas of the appropriate composition and is included on the "List of approved welding consumables" (cf. 1.1.13).

3.2 Testing the weld metal

3.2.1 For testing the deposited weld metal, two test pieces are to be prepared in the downhand PA (d) welding position in accordance with 2.2.1 and Fig. 5.1. One of the test pieces is to be welded with wire of 1.2 mm diameter or the smallest diameter produced for use in shipbuilding. The other is to be welded with wire of 2.4 mm diameter or the largest diameter produced. Where wire of only one diameter is produced, a single test piece is sufficient.

The test pieces are to be welded in a manner analogous to that prescribed in 2.2.1 (cf. also EN/440/ISO 14341) in such a way that the thickness of the individual passes is at least 2 mm but not more than 6 mm.

3.2.2 The chemical composition of the deposited weld metal shall be determined and certified in a manner analogous to that prescribed in 2.2.2. The results of the analysis shall not exceed the limiting values specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.
3.2.3 The test specimens defined in 2.2.3 and Figs. 5.2 and 5.3 shall be machined from the weld metal test pieces and subjected to test.

3.2.4 The test results must meet the requirements stated in 2.2.4 and Table 5.3.

3.3 Testing on welded joints

3.3.1 As in the case of rod electrodes for manual arc welding (cf. 2.3.1), tests on the welded joint are generally carried out on butt-welded test pieces in accordance with Fig. 5.4 and Table 5.4 and in certain cases on fillet-weld test pieces in accordance with 2.3.5 and Fig. 5.7.

3.3.2 Depending on the welding positions applied for approval (cf. 1.4.9), the butt-weld test pieces are to be welded in the positions indicated in Table 5.4, but with the wire diameters shown in Table 5.9. For the base materials to be used, see 1.7.2. The test pieces shall be welded in a manner analogous to that prescribed in 2.3.2.

3.3.3 Following the recommended radiographic examination, test specimens in accordance with 2.3.3 and Figs. 5.3 – 5.6 shall be machined from the butt-weld test pieces and subjected to test.

3.3.4 The test results must meet the requirements stated in 2.3.4 and Table 5.5.

3.3.5 If necessary according to 2.3.1, fillet-weld test pieces in accordance with Fig. 5.7 shall be welded in each of the welding positions applied for approval (cf. 1.4.9). For the base materials to be used, see 1.7.2. The test pieces shall be welded in a manner analogous to that prescribed in 2.3.2.

3.3.6 The fillet-weld test pieces are to be sectioned and tested in a manner analogous to that prescribed in 2.3.6 and 2.3.7.

3.4 Hydrogen test

3.4.1 (Flux-cored) wire-gas combinations and flux-cored wires whose composition (core material) or structure (e.g. folded flux-cored wire) may result in moisture uptake and consequently a higher concentration of hydrogen in the weld metal shall be subjected to a hydrogen test, unless otherwise agreed. In the case of solid- wire-gas combinations, a hydrogen test is normally unnecessary.

3.4.2 For the performance of the hydrogen test and the requirements to be met, see 2.4; unless otherwise stipulated in a particular case, a wire electrode 1.2 mm in diameter must be used for this purpose. The welding parameters shall comply with the manufacturer’s recommendations.

<table>
<thead>
<tr>
<th>Table 5.9 Butt-weld test pieces, wire diameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Welding position</strong></td>
</tr>
<tr>
<td>Downhand position PA (d)</td>
</tr>
<tr>
<td>Other position</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

* Where approval is required only for the PA (d) position, a second test piece shall be welded in this position with the various wire diameters recommended by the manufacturer.
Table 5.10 Wire diameters and weld dimensions

<table>
<thead>
<tr>
<th>Wire diameter [mm]</th>
<th>1st fillet weld</th>
<th>2nd fillet weld</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a-dimension [mm]</td>
<td>Weld length [mm]</td>
</tr>
<tr>
<td>1.2</td>
<td>9</td>
<td>250</td>
</tr>
<tr>
<td>1.6</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

3.5 Hot cracking test

3.5.1 Where the Society calls for a hot cracking test (cf. 2.5.1), a test piece conforming to Fig. 5.9 but 250 mm in length shall be welded.

3.5.2 The wire diameters, weld thicknesses and weld lengths must conform to Table 5.10. In all other respects, the provisions of 2.5.2 – 2.5.4 shall be applied in analogous manner.

3.6 Annual repeat tests

3.6.1 For (flux-cored) wire-gas combinations and flux-cored wires for semi-mechanized welding, the annual repeat test in accordance with 1.3.1 shall entail the welding, with medium wire diameters (e.g. 1.2 and 1.6 mm), of a weld metal test piece in accordance with 3.2.1, from which shall be taken the test specimens called for in para. 3.2.3. For the tests to be applied and the requirements to be met, see 3.2.4.

3.6.2 In special cases, the Society may require a more extensive repeat test (cf.1.3.2, 1.7.4 and 1.7.5).

4. WIRE-FLUX COMBINATIONS FOR SUBMERGED-ARC WELDING OF HULL STRUCTURAL STEELS

4.1 General

4.1.1 The following provisions apply to wire-flux combinations for single-pass and multi-pass submerged-arc (SAW) welding of hull structural steels, of the corresponding grades of steel forgings and castings, and of comparable structural steels. Approvals granted in accordance with these provisions are valid for standard single-wire welding. Approval also covering tandem or multi-wire welding and single-side welding using (flux) backings necessitates the performance of a (preliminary) welding procedure test. Wire-gas combinations and flux-cored wires used only for fully mechanized welding and mesh-wound wire electrodes shall be analogously tested and approved in accordance with these Rules.

4.1.2 Where there is a requirement to use multiwire flux combinations of a certain, stipulated composition and structure, the Society may require additional test pieces or tests to be performed over and above the standard test described below. The test pieces submitted for these tests must be of this combination and structure. The composition and structure will then be particularly noted in the approval confirmation.

4.1.3 Wire-flux combinations for normal-strength hull structural steels are approved according to quality grades 1, 2 or 3 depending on the notch impact energy values achieved during the approval tests. Quality grades 1Y, 2Y, 3Y and 4Y or, where applicable, 2Y40, 3Y40 or 4Y40 are awarded to wire-flux combinations for higher-strength hull structural steels. Wire-flux combinations for welding
in a single pass on each side (two-run technique) are designated by the added symbol \( T \). Those used for multi-run welding receive the added symbol \( M \), and those used for both welding techniques the added symbol \( TM \). For inclusions and exclusions, see 1.4.

4.1.4 Approval is essentially linked to a specific (commercial) brand of flux in conjunction with a (commercial) brand of wire produced by a particular manufacturer, or in conjunction with a standardized wire (e.g. to EN 756) or a wire otherwise identified by its chemical composition and other characteristics. The Society is to be notified of the manufacturer and the brand or standard designation of the wire used for the approval test.

4.1.4 Where approval is granted with a standardized wire, the type of flux concerned (the commercial brand) may also be used with other standardized wires of the same type (wires produced by other manufacturers who have been checked by the Society in accordance with 1.1.2), provided that these wires are included in the "List of Approved Welding Consumables and Auxiliary Materials" (cf. 1.1.8) on the basis of an initial verification of identity followed by annual repeat tests of the chemical composition and other qualitative characteristics. The marketing of wires produced by different manufacturers under a single brand designation approved by the Society is not permitted.

4.2 Testing the weld metal

4.2.1 Testing of the deposited weld metal is required only in the case of an approval relating to multi-run welding (added symbol \( M \)) or exclusively to the welding of (double) fillet welds. For this purpose, a weld metal test piece as shown in Fig. 5.10 is to be welded in the downhand PA (d) position using wires at least 4 mm in diameter.

The welding parameters should be as used for ordinary multi-run welding, and individual runs should be laid down in alternate directions. Before each new run, the test piece should be cooled in still air to 250 °C or below, but on no account below 100 °C. The temperature is to be measured at the surface of the centre of the weld. The thickness of the individual runs should be at least equal to the diameter of the welding wire used and shall not be less than 4 mm.

4.2.2 The chemical composition of the weld metal shall be determined and certified in a manner analogous to that prescribed in 2.2.2. The results of the analysis shall not exceed the limit values specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.

4.2.3 Following the recommended radiographic examination, two round tensile test specimens conforming to Fig. 5.2 and three ISO V-notch impact test specimens conforming to Fig. 5.3 shall be machined from the weld metal test piece as shown in Fig. 5.10. For the preparation and heat treatment of the test specimens, see 2.2.3.

4.2.4 The mechanical properties of the weld metal must meet the requirements indicated in Table 5.11. The provisions of 2.2.4 apply in analogous manner to the maintenance of the test temperature, the performance of the notched bar impact tests and the carrying out of retests. With a required minimum mean value of 34 J, the minimum individual value is 24 J, with 41 J it is 29 J.
Fig. 5.10 Weld metal test piece for submerged-arc welding

Fig. 5.11 "M" submerged-arc butt-weld test piece for multi-run welding
Table 5.11  Required properties of the weld metal in submerged-arc welding

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Minimum yield strength [N/mm²]</th>
<th>Tensile strength [N/mm²]</th>
<th>Minimum elongation [%]</th>
<th>Minimum notch impact energy ¹ [J]</th>
<th>Test temperature [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>305</td>
<td>400 to 560</td>
<td>22</td>
<td>34 (24)</td>
<td>+ 20</td>
</tr>
<tr>
<td>2</td>
<td>375</td>
<td>490 to 660</td>
<td>22</td>
<td>34 (24)</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>490</td>
<td>510 ² to 690</td>
<td>22</td>
<td>41 (29)</td>
<td>- 20</td>
</tr>
<tr>
<td>1 Y</td>
<td>305</td>
<td>400 to 560</td>
<td>22</td>
<td>34 (24)</td>
<td>- 20</td>
</tr>
<tr>
<td>2 Y</td>
<td>375</td>
<td>490 to 660</td>
<td>22</td>
<td>34 (24)</td>
<td>0</td>
</tr>
<tr>
<td>3 Y</td>
<td>490</td>
<td>510 ² to 690</td>
<td>22</td>
<td>41 (29)</td>
<td>- 20</td>
</tr>
<tr>
<td>4 Y</td>
<td>490</td>
<td>510 ² to 690</td>
<td>22</td>
<td>41 (29)</td>
<td>- 40</td>
</tr>
<tr>
<td>2Y40</td>
<td>490</td>
<td>510 ² to 690</td>
<td>22</td>
<td>41 (29)</td>
<td>0</td>
</tr>
<tr>
<td>3Y40</td>
<td>490</td>
<td>510 ² to 690</td>
<td>22</td>
<td>41 (29)</td>
<td>- 20</td>
</tr>
<tr>
<td>4Y40</td>
<td>490</td>
<td>510 ² to 690</td>
<td>22</td>
<td>41 (29)</td>
<td>- 40</td>
</tr>
</tbody>
</table>

¹ Mean value of three specimens; ( ) for minimum individual values; for this and retests, see 2.2.4, 2.2.5 and 4.2.4.
² A tensile strength of 500 [N/mm²] is acceptable provided that adequate values are achieved in the welded joint.

Fig. 5.12  "T" submerged-arc butt-weld test piece for one run on each side (two-run technique)
4.3 Testing on welded joints

4.3.1 Tests on the welded joint are generally performed on butt-weld test pieces as shown in Fig. 5.11 for multi-run welding (added symbol M) and/or Fig. 5.12 for the two-run welding technique (added symbol T). Where an application relates only to approval for welding in a single run on each side (T), testing of the deposited weld metal in accordance with 4.2 may be dispensed with.

Where approval is to cover wire-flux combinations used exclusively for fillet welds, the butt-weld test pieces shall be replaced by a fillet-weld test piece analogous to Fig. 5.7 but with dimensions suitable for submerged-arc welding. After inspection for surface cracks, this shall be sectioned and tested in a manner analogous to that described in 2.3.6 and 2.3.7. The Society may also call for fillet-weld test pieces in addition to butt-weld ones.

4.3.2 For multi-run welding (added symbol M), a butt-weld test piece conforming to Fig. 5.11 shall be welded in the downhand PA (d) position. Where a wire-flux combination is also to be approved for other positions (e.g. for welding in the horizontal-vertical position), test pieces shall also be welded in these positions. For the base materials to be used, see 1.7.2, although grade A hull structural steel shall as a rule be used for approvals with quality grades 1 and 2.

The two portions of the test piece shall be juxtaposed with sufficient allowance for angular shrinkage. The weld shall be executed by the multi-run technique using wires of at least 4 mm diameter and the same parameters and method as for the submerged-arc weld metal test piece described in 4.2.1. Before the back pass is laid down, the root is to be grooved at the back of the weld, if possible by machining.

4.3.3 Following the recommended radiographic examination in accordance with Fig. 5.11, two flat tensile test specimens in accordance with Fig. 5.5, four transverse bend test specimens (two with the cover pass, two with the back pass in tension) and three ISO V-notch impact test specimens shall be machined from the M butt-welded test piece (cf. 2.3.3).

4.3.4 The mechanical properties must meet the requirements stated in Table 5.12.

The provisions of 2.2.4 and 2.3.4 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperatures for the notched bar impact tests and the information on retest specimens. With a required minimum mean value of 34 J, the minimum individual value is 24 J, with 41 J it is 29 J.

4.3.5 For welding one run on each side (two-run technique - added symbol T), two butt-weld test pieces as shown in Fig. 5.12 are to be welded in the downhand PA (d) position using the base materials, plate thicknesses, weld shapes and wire diameters shown in Table 5.13. The chemical composition of the base materials used shall be stated in the test report.

The butt-weld test pieces shall be produced by laying down one run on each side. The welding current parameters and the feed rates must be those recommended by the manufacturer for application. After laying down the first run, flux and slag are to be removed and the test piece allowed to cool down to 100 °C in still air. The temperature is to be measured at the surface of the centre of the weld. The root should be grooved prior to laying down the second run only if this is expressly prescribed by the manufacturer for the future application.

4.3.6 Following the recommended radiographic inspection, one round tensile test specimen as shown in Fig. 5.2, two flat tensile test specimens as shown in Fig. 5.5, two transverse bend test specimens (one with the second pass and one with the first pass in tension) and three ISO V-notch test specimens (located as shown in Fig. 5.13) are to be machined from each "T" butt-welded test piece in
accordance with Fig. 5.12 (cf. 2.2.3 and 2.3.3).

The round tensile test specimen can be dispensed with if the wire-flux combination is at the same time also being tested for multi-run welding with an additional weld metal test piece conforming to Fig. 5.10.

4.3.7 The mechanical properties must meet the requirements stated in Table 5.12. The provisions of 2.2.4 and 2.3.4 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperatures for the notched bar impact tests and the information on retest specimens. With a required minimum mean value of 34 J, the minimum individual value is 24 J, with 41 J it is 29 J.

![T" butt-weld test piece; location of notched bar impact test specimens](image)

Table 5.12 Required properties of submerged-arc welded joints

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Tensile strength [N/mm²]</th>
<th>Minimum notch impact energy</th>
<th>Minimum bending angle, mandrel diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>[J]¹</td>
<td>Test temperature [°C]</td>
</tr>
<tr>
<td>1</td>
<td>≥ 400</td>
<td>34 (24)</td>
<td>+ 20</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>34 (24)</td>
<td>+ 20</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>34 (24)</td>
<td>+ 20</td>
</tr>
<tr>
<td>1 Y</td>
<td>≥ 490</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Y</td>
<td></td>
<td>34 (24)</td>
<td>+ 20</td>
</tr>
<tr>
<td>3 Y</td>
<td></td>
<td>34 (24)</td>
<td>+ 20</td>
</tr>
<tr>
<td>4 Y</td>
<td></td>
<td>34 (24)</td>
<td>+ 20</td>
</tr>
<tr>
<td>2Y40</td>
<td>≥ 510</td>
<td>41 (29)</td>
<td></td>
</tr>
<tr>
<td>3Y40</td>
<td></td>
<td>41 (29)</td>
<td></td>
</tr>
<tr>
<td>4Y40</td>
<td></td>
<td>41 (29)</td>
<td></td>
</tr>
</tbody>
</table>

¹ Mean value of three specimens; for minimum individual values and retests see 2.2.4, 2.2.5, as well as 4.3.4 and 4.3.7
Table 5.13 "T" submerged-arc butt-weld test pieces; base materials, plate thicknesses, weld shapes and wire diameters

<table>
<thead>
<tr>
<th>Approval applied for quality grades</th>
<th>Base material 1)</th>
<th>Thickness of test piece t²) [mm]</th>
<th>Recommended weld preparation 3)</th>
<th>Maximum wire diameter [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>12 - 15</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>1Y</td>
<td>A 32, A 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1Y</td>
<td>A 32, A 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A, B, D</td>
<td>20 - 25</td>
<td>![60° Diagram]</td>
<td>6</td>
</tr>
<tr>
<td>2Y</td>
<td>A 32, A 36, D 32, D 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2Y40</td>
<td>A 40, D 40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>A, B, D, E</td>
<td>30 - 35</td>
<td>![70° Diagram]</td>
<td>7</td>
</tr>
<tr>
<td>3Y</td>
<td>A 32 to E 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Y40</td>
<td>A 40 to E 40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4Y</td>
<td>A 32 to F 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4Y40</td>
<td>A 40 to F 40</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) A 32, D 32, E 32, F 32 only with a tensile strength of at least 490 N/mm².

2) For approval with quality grades 1 and 1Y: t = 12 - 15 and 20 - 25 mm.
   For approval with quality grades 2 to 4Y40: t = 20 - 25 and 30 - 35 mm.

A limitation of the approval to the lower and medium thickness range (up to the maximum welded plate thickness) may be agreed to, and the test pieces shall then be welded from plates of thickness t = 12 - 15 mm and 20 - 25 mm irrespective of the quality grade.

3) Minor deviations in the weld preparation are admissible.
4.4  Hydrogen test

4.4.1  Where a hydrogen test is stipulated for a wire-flux combination (or for the flux component), hits shall be performed analogously to 2.4, although with the altered dimensions for the specimens and the clamping device according to ISO 3690, Part 2.

4.4.2  Alternatively, the hydrogen test may, for an interim period, continue to be conducted according to the glycerin method described in 2.4.3. Here too, however, the dimensions of the specimens and the clamping device shall conform to ISO 3690, Part 2.

4.5  Annual repeat tests

4.5.1  For multi-run welding (M), the annual repeat test shall entail testing of the deposited weld metal in accordance with 4.2 (submerged-arc weld metal test piece as shown in Fig. 5.10). However, only one round tensile test specimen and three notched bar impact test specimens need to be tested on these occasions.

4.5.2  For two-run welding (T), a T butt-weld test piece as prescribed in para. 4.3.5 (Fig. 5.12) shall be prepared and tested in accordance with 4.3.6 and 4.3.7. However, only one round tensile test specimen, one flat tensile test specimen, two transverse bend test specimens and three notched bar impact test specimens need to be tested on these occasions.

4.5.3  For two-run and multi-run welding (TM), the weld metal test piece prescribed in para. 4.5.1 and the T butt-welded test piece in accordance with para. 4.5.2 shall be welded and tested. The round tensile test specimen called for in para. 4.5.2 may, however, be dispensed with.

4.5.4  Wire-flux combinations used exclusively for fillet welding (cf. 4.2.1 and 4.3.1) are to be repeat tested in accordance with 4.5.1.

4.5.5  For tandem and multi-wire welding and for single-side welding using (flux) backings, annual repeat tests analogous to those provided for above shall be conducted with the welding method concerned (cf. 5.1.1 and 1.3.7).

4.5.6  In special cases, the Society may require more extensive repeat tests (cf.1.3.2, 1.7.4 and 1.7.5).

5.  WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR ELECTROGAS AND ELECTROSLAG WELDING OF HULL STRUCTURAL STEELS

5.1  General

5.1.1  The following provisions apply to wire-gas combinations, flux-cored wires and wire-flux combinations for fully mechanized electrogas (EG) and electroslag (ES) welding (in the vertical-up position) of hull structural steels, of corresponding grades of steel forgings and castings, and of comparable structural steels. Where consumable nozzle electrodes are used, these are to be included in the test.

5.1.2  The welding consumables and auxiliary materials referred to in para. 5.1.1 and used for normal-strength hull structural steels are approved according to quality grades 1V, 2V and 3V depending on the notch impact energy values achieved during the approval tests. Quality grades 1YV, 2YV, 3YV and 4YV or, where applicable, 2Y40V, 3Y40V and 4Y40V are awarded to such welding consumables and auxiliary materials used for higher-strength hull structural steels. For inclusions and exclusions, see 1.4.
5.2 Testing on welded joints

5.2.1 The testing of welding consumables and auxiliary materials covered by para. 5.1.1 and used for electrogas and electroslag welding is performed exclusively on welded joints in a manner analogous to that prescribed in 4.3.5 – 4.3.7 for wire-flux combinations, using butt-weld test pieces conforming to Fig. 5.14.

5.2.2 Butt-welded test pieces conforming to Fig. 5.14 are to be welded analogously to Table 5.13 using base materials of known composition (to be recorded) and two thicknesses of plate depending on the quality grade applied for. The weld preparation, the wire diameter and the welding parameters must conform to the manufacturer’s recommendations for subsequent practice and are to be recorded. The length of the test pieces shall be suited to the welding appliances used and, where appropriate, to the length of the consumable nozzle electrodes.

Fig. 5.14  Test piece for electrogas/electroslag welding

Z  = Flat tensile test specimen
S  = Side bend test specimen
$K_M$  = ISO V-notch impact test specimen from centre of weld metal
$K_S$  = ISO V-notch impact test specimen from side of weld metal
M  = Macrographic specimen
R  = Round tensile test specimen
5.2.3 Following the recommended radiographic examination, the following shall be removed from each butt-welded test piece according to Fig. 5.14: two flat tensile test specimens to Fig. 5.5, two side bend test specimens (specimen width 10 mm), two round tensile test specimens to Fig. 5.2, three notched bar impact test specimens (ISO V-notch impact test specimens according to Fig. 5.3) each from the centre and side of the weld metal, and two macrographic specimen. When the weld reinforcement has been machined off, the edges of the side bend test specimens may be rounded on the tension side to a radius not greater than 1 mm. The location of the notched bar impact test specimens shall conform to Fig. 5.15. The provisions of 2.2.3 and 2.3.3 apply in analogous manner.

5.2.4 The mechanical properties of the welded joint must meet the requirements indicated in Table 5.12. The provisions of 2.2.4 and 2.3.4 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperature for the notched bar impact test and the carrying out of retests.

5.3 Annual repeat tests

5.3.1 For the annual repeat testing of welding consumables and auxiliary materials covered by 5.1.1, a butt-welded test piece as shown in Fig. 5.14 with a medium plate thickness (20 - 25 mm unless otherwise specified) shall be welded in accordance with 5.2.2.

5.3.2 One round tensile test specimen, one flat tensile test specimen, two side bend test specimens, three notched bar impact test specimens each from the centre of the weld metal and from the side of weld metal and one macrographic specimen in accordance with para. 5.2.3 and Fig. 5.15 shall be taken from the test piece prescribed in 5.3.1.

5.3.3 For the performance of the tests and the requirements to be met, see 5.2.4, 2.2.4, and 2.3.4.

5.3.4 In special cases, the Society may require more extensive repeat tests (cf. 1.3.2, 1.7.4 and 1.7.5).

![Fig. 5.15 Location of notched bar impact test specimen](image-url)
6. WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR HIGH-STRENGTH (QUENCHED AND TEMPERED) STRUCTURAL STEELS

6.1 General

6.1.1 The following provisions apply to welding consumables and auxiliary materials for welding of normalized or quenched and tempered high-strength fine-grained structural steels with minimum yield strengths of more than 390 N/mm². For fine-grained structural steels with minimum yield strengths of up to 390 N/mm², the welding consumables and auxiliary materials for the corresponding hull structural steels (e.g. quality grade 3Y40 or 4Y40) may be used.

Note: The chemical composition of the welding consumables and auxiliary materials for high-strength (quenched and tempered) fine-grained structural steels necessary to obtaining weld metal with adequate mechanical properties often also results in good low-temperature properties. In view of this fact and also bearing in mind the increased resistance to brittle fracture which is desirable when welding these steels, the welding consumables and auxiliary materials referred to in 5.1.1 are generally approved only with a quality grade of 3 or above. Such approval normally also constitutes proof of suitability for low-temperature applications down to a minimum service temperature (design temperature) 5 °C above the respective test temperature. Cf. also 7.

6.1.2 In a manner analogous to that applied to hull structural steels, welding consumables and auxiliary materials covered by 6.1.1 are approved according to quality grades 3 – 10 with the added symbol Y and an appended code number designating the minimum yield strength of the weld metal. The respective base materials will be classified in a manner analogous to that applied to hull structural steels (cf. Chapter 3, Section 1, Table 1.1) depending upon the particular strength and toughness properties in question. For other added symbols, see 1.4.1; for inclusions and exclusions, see 1.4.2.

6.2 Testing of the weld metal

6.2.1 For testing the deposited weld metal, test pieces analogous to those called for in 2.2.1, 3.2.1 or 4.2.1 shall be prepared, depending on the nature of the welding consumables and auxiliary materials (and according to the welding process). The base metal used shall be a fine-grained structural steel compatible with the properties of the weld metal, or the side walls of the weld shall be buffered with a weld metal of the same composition.

6.2.2 The chemical composition of the deposited weld metal shall be determined and certified in a manner analogous to that prescribed in 2.2.2. The results of the analysis shall not exceed the limit values specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.

6.2.3 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the test specimens prescribed in 2.2.3, 3.2.3 or 4.2.3 shall be taken from the weld metal test pieces in a similar manner.

6.2.4 The mechanical properties must meet the requirements stated in Tables 5.14 and 5.15. The provisions of 2.2.4, 3.2.4 and 4.2.4 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperature in the notched bar impact test and the carrying out of retests.
Table 5.14 Required properties of the weld metal, quality grades and test temperature

| Quality grade | Test temperature [°C] | Minimum notch impact energy [J]
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (3*)</td>
<td>– 20 (– 30)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>– 40</td>
<td></td>
</tr>
<tr>
<td>5 (5*)</td>
<td>– 50 (– 60)</td>
<td>≥ 47 (33)</td>
</tr>
<tr>
<td>6</td>
<td>– 60</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>– 70</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>– 80</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>– 90</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>– 100</td>
<td></td>
</tr>
</tbody>
</table>

1. Charpy-V-notch specimens in accordance with EN 10045-1/ISO 148, mean value of three specimens; ( ) minimum individual values; for this and retests, see 2.2.4 and 2.2.5.
2. Corresponding to the test temperatures for the quality grades of welding consumables and auxiliary materials for the welding of hull structural steels, but not conforming to the standards (e.g. EN 757/ISO 11837), in which a test temperature of –30 °C is given for quality grade 3. If the test is performed at a temperature of –30 °C, an asterisk (*) will be added to the quality grade.
3. In line with the IACS "Unified Requirements", the Society may call for a test to be performed at –60 °C for quality grade 5, in which case an asterisk (*) will be added to the quality grade.

Table 5.15 Required properties of the weld metal, added symbols, strength properties and minimum notch impact energy

<table>
<thead>
<tr>
<th>Symbols added to quality grade</th>
<th>Minimum yield strength or 0.2 % proof stress [N/mm²]</th>
<th>Tensile strength reference values [N/mm²]</th>
<th>Minimum elongation A5 [%]</th>
<th>Minimum notch impact energy [J]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y42</td>
<td>420</td>
<td>530 (500 – 640)</td>
<td>20</td>
<td>47 (33)</td>
</tr>
<tr>
<td>Y46</td>
<td>460</td>
<td>570 (530 – 680)</td>
<td>20</td>
<td>47 (33)</td>
</tr>
<tr>
<td>Y50</td>
<td>500</td>
<td>610 (560 – 720)</td>
<td>18</td>
<td>50 (35)</td>
</tr>
<tr>
<td>Y55</td>
<td>550</td>
<td>670 (610 – 780)</td>
<td>18</td>
<td>55 (38)</td>
</tr>
<tr>
<td>Y62</td>
<td>620</td>
<td>720 (690 – 890)</td>
<td>18</td>
<td>62 (43)</td>
</tr>
<tr>
<td>Y69</td>
<td>690</td>
<td>770 (760 – 960)</td>
<td>17</td>
<td>69 (48)</td>
</tr>
</tbody>
</table>

1. The tensile strength of the weld metal may be up to 10 % below the minimum tensile strength of the base material corresponding to the added symbol, provided that the results obtained with the transverse tensile specimens taken from the welded joints meet the minimum tensile strength requirements stated in Table 5.16. The elongation is to be stated in the test report.

Note:
For welding very large plate thicknesses where the "supporting effect" of the base material on either side of the weld no longer applies and the tensile strength of the weld metal also determines the tensile strength of the welded joint, it may be necessary, when applying footnote 1 of Table 5.15, to choose welding consumables and auxiliary materials of the next higher strength category (next higher added symbol).

2. The values in brackets denote the tensile strength requirements specified in the standards, for example EN 499 or EN 757/ISO 11837; in the case of the lower values covered in footnote 1, but also where the tensile strength values are too high, these may also be used to evaluate the results.

3. Mean value of three specimens; for minimum individual values ( ) and retests, see 2.2.4 and 2.2.5.
6.3 Testing on welded joints

6.3.1 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the testing on the welded joints shall be performed on butt-weld test pieces in analogous manner to 2.3.1, 3.3.1 or 4.3.1.

Note: In testing welded joints made with wire-flux combinations for submerged-arc welding, it should be assumed that due to the limits on thermal input (heat input per unit length of weld) which are generally necessary, multi-run welding is the only suitable method. Para. 6.3.1 consequently refers only to the M type butt-welded test piece for multi-run welding in accordance with 4.3.1. Where approval is also solicited in exceptional cases for two-run welding (T, with one run on each side), "T" type butt-weld test pieces shall be welded for this purpose in accordance with 4.3.5 and tested in a manner similar to that prescribed in 4.3.6 and 4.3.7. For the same reasons, no reference is made below to the fillet-weld test pieces.

6.3.2 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the butt-weld test pieces called for in para. 6.3.1 shall be welded in a manner analogous to that prescribed in 2.3.2, 3.3.2 or 4.3.2. The base metal used shall be a high-strength fine-grained structural steel with an appropriate minimum yield strength and tensile strength and compatible with the added symbol for which application is made (cf. Table 5.15).

6.3.3 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the test specimens described in 2.3.3, 3.3.3 and 4.3.3 shall be taken from the butt-weld test pieces.

6.3.4 The mechanical properties must meet the requirements stated in Table 5.16. The provisions of 2.3.4, 3.3.4 and 4.3.4 apply in analogous manner to the performance of the tests, including in particular the maintenance of the test temperatures in the notched bar impact test and the requirements regarding the retest specimens.

6.4 Hydrogen test

6.4.1 Welding consumables and auxiliary materials for welding of high-strength (quenched and tempered) fine-grained structural steels with minimum yield strengths of > 390 N/mm² shall - taking due account of the provisions in 3.4.1 - be subjected in every case to a hydrogen test in accordance with the mercury method to ISO 3690, Part 1 (for rod electrodes, wire-gas combinations and flux-cored wires) or Part 2 (for wire-flux combinations).

6.4.2 The diffusible hydrogen content of the weld metal determined in accordance with the provisions of 2.4.2 shall not exceed the limit of 5 cm³/100 g weld metal (the quantity of metal deposited), specified in Table 5.6 as the maximum for the added symbol H5(HHH).

6.5 Annual repeat tests

5.1 The annual repeat tests specified in 1.3.1 shall entail the preparation and testing of weld metal test pieces as prescribed under 6.2. If the basis used for these tests is a reduced tensile strength of the weld metal as prescribed in footnote 1 to Table 5.15, for if the specified tensile strength is not attained, two transverse tensile specimens taken from the welded joint (in the down-hand position only) must also be tested and these must then meet the requirements stipulated in Table 5.15.

5.2 In special cases, the Society may require more extensive repeat tests (cf. 1.3.2, 1.7.4 and 1.7.5).
Table 5.16 Required properties of welded joints

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Added symbol</th>
<th>Tensile strength [N/mm²]</th>
<th>Minimum notch impact energy, test temperature</th>
<th>Minimum bending angle¹</th>
<th>Mandrel diameter (t = specimen thickness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 to 9 in accordance with Table 5.14</td>
<td>Y42</td>
<td>530 – 680</td>
<td>Depending on the quality grade and added symbol in accordance with Table 5.15</td>
<td>120° or provided that the bending elongation is attained ²</td>
<td>4 t</td>
</tr>
<tr>
<td></td>
<td>Y46</td>
<td>570 – 720</td>
<td></td>
<td></td>
<td>4 t</td>
</tr>
<tr>
<td></td>
<td>Y50</td>
<td>610 – 770</td>
<td></td>
<td></td>
<td>4 t</td>
</tr>
<tr>
<td></td>
<td>Y55</td>
<td>670 – 830</td>
<td></td>
<td></td>
<td>5 t</td>
</tr>
<tr>
<td></td>
<td>Y62</td>
<td>720 – 890</td>
<td></td>
<td></td>
<td>5 t</td>
</tr>
<tr>
<td></td>
<td>Y69</td>
<td>770 – 940</td>
<td></td>
<td></td>
<td>5 t</td>
</tr>
</tbody>
</table>

¹ Bending angle attained before the first incipient crack, minor pore exposures up to a maximum length of 3 mm allowed.

² If the specified bending angle of 120° is not attained, the requirements will still be regarded as having been met provided that the bending elongation attained with a gauge length of \( L_s = L_s + t \) (\( L_s = \) width of weld, \( t = \) thickness of specimen, see sketch below) before the first incipient crack complies with the elongation requirements given in Table 5.15.

7. WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR STEELS TOUGH AT SUBZERO TEMPERATURES

7.1 General

7.1.1 The following provisions apply to welding consumables and auxiliary materials for welding of steels tough at subzero temperatures in accordance with the BRS Rules for Materials governing the fabrication of vessels, pipelines, etc. for liquefied gases.

Note:

According to the Rules for Materials, the steels tough at subzero temperatures used in shipbuilding fall into three categories: low-alloy carbon-manganese steels, nickel alloy steels and austenitic steels. The following paragraphs are therefore concerned with welding consumables and auxiliary materials for these three categories of materials. Other such products are to be treated in analogous manner; for aluminium alloys, see 10.
7.1.2 Depending on their nature and properties (type of alloy), welding consumables and auxiliary materials for welding of steels tough at subzero temperatures are classified and approved in the same way as those for high-strength (quenched and tempered) structural steels in accordance with 6. or those for (austenitic) stainless steels or, where applicable, nickel alloy steels tough at subzero temperatures in accordance with 9. No special indication of suitability for low-temperature service is given (except with the quality grade in accordance with 6.); individual suitability for low-temperature service (test temperature for the notched bar impact test) is indicated in the approval certificate. In general, the minimum service (design) temperature is 5 °C above this test temperature.

7.2 Testing of the weld metal

7.2.1 Testing of the weld metal shall be carried out in accordance with the nature of the welding consumables and auxiliary materials, as described in 6. and 9. Unless otherwise stipulated in a particular case, the test temperatures for the notched bar impact test stated in these provisions shall be replaced by the test temperatures shown in Table 5.17.

### Table 5.17 Minimum design temperatures for the notched bar impact test

<table>
<thead>
<tr>
<th>Welding consumables and auxiliary materials for:</th>
<th>References to Rules and Standards relating to Materials</th>
<th>Minimum design temperature [°C]</th>
<th>Test temperature for the notched bar impact test [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine grain structural steels for ammonia liquefied under pressure</td>
<td>in accordance with – Rules for Materials, Chapter 2, Section 1, 6., Table 1.16</td>
<td>0</td>
<td>– 20</td>
</tr>
<tr>
<td>High-strength (QT) fine grain structural steels with nominal yield strengths of 420 to 690 N/mm²</td>
<td>in accordance with manufacturer's specification and – Rules for Materials, Chapter 2, Section 1, 6., Table 1.17</td>
<td>0</td>
<td>– 20</td>
</tr>
<tr>
<td>Other fine grain structural steels with nominal yield strengths of up to 355 N/mm²</td>
<td>e.g. to EN 10028, Part 3</td>
<td>– 45 ¹</td>
<td>5°C below minimum design temperature, but not above – 20°C</td>
</tr>
<tr>
<td>Nickel steels with:</td>
<td>steels conforming to EN 10028 Part 4:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 % nickel</td>
<td>13MnNi6-3</td>
<td>– 55</td>
<td>– 60</td>
</tr>
<tr>
<td>1.5 % nickel</td>
<td>15NiMn6</td>
<td>– 60 ²</td>
<td>– 65 ²</td>
</tr>
<tr>
<td>3.5 % nickel</td>
<td>12Ni14</td>
<td>– 90 ²</td>
<td>– 95 ²</td>
</tr>
<tr>
<td>5 % nickel</td>
<td>12Ni19</td>
<td>– 105 ², ³</td>
<td>– 110 ² (– 196) ³</td>
</tr>
<tr>
<td>9 % nickel</td>
<td>X8Ni9, X7Ni9</td>
<td>– 165</td>
<td>– 196</td>
</tr>
<tr>
<td>Austenitic steels</td>
<td>e.g., to EN ............(AISI) X2CrNi19-11 / 1.4306 (304L) X2CrNiMo17-13-2 / 1.4404 (316L) X6CrNiTi18-10 / 1.4541 (321) X6CrNiNb18-10 / 1.4550 (347)</td>
<td>– 165</td>
<td>– 196</td>
</tr>
</tbody>
</table>

¹ The Society may approve lower design temperatures (down to a maximum – 55 °C) provided that corresponding properties are demonstrated in the approval test.
² A lower design temperature may be approved for QT steels with a 1.5 %, 3.5 % and 5 % nickel content; in these instances the Society will specify the test temperatures.
³ Steel with a 5 % nickel content may be approved for a minimum design temperature of – 165 °C subject to the provisions stipulated in the Rules for Materials, Chapter 2, Section 1, 6., Table 1.15, footnote 1; the test temperature is then – 196 °C.

7.2.2 The requirements applicable to the strength and elongation of the weld metal are determined by those applying to the base material; cf. Rules for Materials (Part 1, Chapter 2, Section 1, 5, and 9., Section 2, 4., Section 3, 6. and Section 4, 5.). If particular base materials are welded with dissimilar welding consumables and auxiliary materials with strength values below those of the base material (e.g. in welding of 9 % nickel steel), the strength values used in the design calculations for the components shall apply.
Unless otherwise stipulated, the minimum notch impact energy values at the test temperatures shown in Table 5.17 shall be 47 J (mean value) and 39 J (lowest individual value).

7.3 Testing on welded joints

The testing on the welded joints shall be performed in accordance with the nature of the welding consumables and auxiliary materials as described in 6. and 9. In the case of welding consumables and auxiliary materials for nickel alloy steels, the welded joints shall be made with the base material for which approval has been solicited. In the case of such products for (low-alloy) carbon-manganese steels and austenitic steels, a base material of similar composition may be used. In all other respects, 7.2.1 and 7.2.2 apply in analogous manner.

7.4 Hydrogen test

If a hydrogen test is stipulated for the welding consumables and auxiliary materials in question (e.g. according to 6.4), it shall be performed in this case too. The requirements stipulated for each individual case apply.

7.5 Annual repeat tests

The annual repeat tests specified in 1.3.1 shall entail the preparation and testing of weld metal test pieces as prescribed under 7.2. The Society may require more extensive repeat tests (cf. 1.3.2, 1.7.4 and 1.7.5).

8. WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR HIGH-TEMPERATURE STEELS

8.1 General

8.1.1 The following provisions apply to welding consumables and auxiliary materials for welding of high-temperature steels in accordance with the BRS Rules for Materials governing the fabrication of steam boilers, pressure vessels, pipelines, etc. with high service temperatures.

Note:

Under the Society’s Rules for Materials, this essentially applies to the carbon-manganese steels P235GH (H I), P265GH (H II), P295GH (17Mn4), P355GH (19Mn6), the molybdenum alloy steel 16Mo3 (15Mo3) and the chromium-molybdenum alloy steels 13CrMo4-5 (13CrMo4-4), 10CrMo9-10 (10CrMo1-10) and 11CrMo9-10 in accordance with EN 10028 Part 2. The following paragraphs are therefore concerned with welding consumables and auxiliary materials for these steels. Other such products are included if they can be classed among the materials also covered by the approval as shown in Table 5.18. Other welding consumables and auxiliary materials for other high-temperature steels are to be treated in analogous manner.

8.1.2 Welding consumables and auxiliary materials for high-temperature steels are classified into the quality grades shown in Table 5.18 according to their chemical composition (type of alloy) and mechanical (strength) characteristics and approved according to these grades. The testing and approval of a steel in the left-hand columns of Table 5.18 encompasses the steel(s) in the right-hand columns. The different high-temperature strength properties are to be borne in mind. The table applies in analogous manner to the corresponding grades of forgings and steel castings.
### Table 5.18  Welding consumables and auxiliary materials for high-temperature steels

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Testing and approval relating to steel ¹:</th>
<th>Steels also covered by the approval ²:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Designation</td>
<td>Material No.:</td>
</tr>
<tr>
<td>235GH</td>
<td>P235GH</td>
<td>1.0345</td>
</tr>
<tr>
<td>265GH</td>
<td>P265GH</td>
<td>1.0425</td>
</tr>
<tr>
<td>295GH</td>
<td>P295GH</td>
<td>1.0481</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>355GH</td>
<td>P355GH</td>
<td>1.0473</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16Mo3</td>
<td>16Mo3</td>
<td>1.5415</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13CrMo4-5</td>
<td>13CrMo4-5</td>
<td>1.7335</td>
</tr>
<tr>
<td>10CrMo9-10</td>
<td>10CrMo9-10</td>
<td>1.7380</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11CrMo9-10</td>
<td>11CrMo9-10</td>
<td>1.7383</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Steel grades in accordance with the Society’s Rules for Materials or conforming to EN 10028.
² Steel grades in accordance with the Society’s Rules for Materials or conforming to EN 10028 as well as other grades of forgings and steel castings.

#### 8.1.3  Welding consumables and auxiliary materials for components which are to undergo post-weld heat treatment must be tested and approved separately for the untreated condition and for each heat-treated condition. In general, the relevant conditions are:

- **U** = untreated (as-welded condition) and
- **S** = annealed to relieve stresses.

In special cases, normalizing (N) or quenching and tempering (V) may be necessary. The annealing temperatures and times shall be those applicable to the subsequent heat treatment of the components according to the standards, material data sheets, etc. Unless more precise data are given in these documents, the annealing temperatures and times specified in Chapter 2, Section 3, Table 2.3 may be used.

#### 8.2  Testing the weld metal

##### 8.2.1  The testing of the weld metal shall be performed according to the nature of the welding consumable or auxiliary material (and, where applicable, according to the welding process) using test pieces and specimens in analogous manner to the provisions of 2.2, 3.2 or 4.2. In addition, for determining the 0.2 % proof stress at the maximum application temperature and at a second lower temperature according to 8.2.3 two further round tensile specimens are to be taken from each test piece and tested. For this purpose, the test pieces shall be made correspondingly larger.

##### 8.2.2  The chemical composition of the deposited weld metal shall be determined and certified
in a manner analogous to that prescribed in 2.2.2. The results of the analysis shall not exceed the limit values specified in the standards (e.g. EN 12070 of EN 12071, ISO 3580) or by the manufacturer, the narrower tolerances being applicable in each case.

8.2.3 As a minimum requirement, the test specimens prescribed in 2.2.3, 3.2.3 or 4.2.3 shall be taken from the weld metal test pieces and tested at room temperature. In addition, to determine the 0.2 % proof stress at the highest application temperature and at a second test temperature 100 °C lower in accordance with Table 5.20, two further round tensile test specimens shall be taken from the test pieces and tested. The Society may require further specimens to be taken and tests to be performed, e.g. determination of the 1.0 % proof stress, creep tests, notched bar impact tests on specimens subjected to ageing treatment or embrittlement tests.

8.2.4 The mechanical properties at room temperature must meet the requirements stated in Table 5.19, while the 0.2 % proof stresses at elevated temperature must conform to Table 5.20. If further tests are demanded by the Society, the requirements will be stipulated separately on a case-by-case basis. The provisions of 1.7.6, 2.2.4, 3.2.4 and 4.2.4 apply in analogous manner to the performance of the tests and the carrying out of retests.

8.3 Testing on welded joints

8.3.1 Depending on the nature of the welding consumables and auxiliary materials (and on the welding process concerned), the testing on the welded joints shall be performed on butt-weld test pieces in analogous manner to the provisions of 2.3, 3.3, 4.3 or 5.2.

8.3.2 The butt-weld test pieces shall be prepared in analogous manner to the procedures described in 2.3.2, 3.3.2, 4.3.2 or 5.2.2, taking Table 5.19 into account. Wherever possible, the base material should be a high-temperature steel corresponding to the quality grade in question.

8.3.3 Depending on the welding process, the test specimens described in 2.3.3, 3.3.3, 4.3.3 or 5.2.3 shall be taken from the butt-welded test pieces, unless otherwise specified.

8.3.4 The mechanical characteristics of the welded joint must meet the requirements for the weld metal stated in Table 5.19, except in the case of the yield strength. The provisions of 1.7.6, 2.3.4, 3.3.4, 4.3.4 and 5.2.4 apply in analogous manner to the performance of the tests and the carrying out of retests.

8.4 Hydrogen test

If a hydrogen test is required, it shall be performed in accordance with 2.4. The diffusible hydrogen content shall not exceed 10 ml per 100 g of deposited weld metal.

8.5 Testing for hot cracks

If testing for hot cracks is required, this shall be performed in accordance with 2.5 or the relevant standards.

8.6 Annual repeat tests

8.6.1 The annual repeat tests specified in 1.3.1 shall entail the preparation and testing of weld metal test pieces as prescribed under 8.2. The Society may require more extensive repeat tests (cf. 1.3.2, 1.7.4 and 1.7.5).

8.6.2 The annual repeat tests shall be performed according to the prescribed scope for both the untreated condition and the various (approved) heat-treated conditions (cf. 8.1.3).
Table 5.19  Required properties of the weld metal at room temperature (+ 20° C)

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Minimum yield strength or 0,2 %-proof stress $R_{0.2}$ or $R_{p0.2}$ [N/mm²]</th>
<th>Minimum tensile strength $R_m$ [N/mm²]</th>
<th>Minimum elongation $A_5$ [%]</th>
<th>Minimum notch impact energy [J]</th>
</tr>
</thead>
<tbody>
<tr>
<td>235GH, 265GH</td>
<td>285</td>
<td>480</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>295GH, 355GH</td>
<td>360</td>
<td>520</td>
<td>22</td>
<td>47 (33)</td>
</tr>
<tr>
<td>16Mo3</td>
<td>355</td>
<td>510</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>13CrMo4-5</td>
<td>355</td>
<td>510</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>10CrMo9-10, 11CrMo9-10</td>
<td>400</td>
<td>520</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

1 The lower yield strength ($R_{0.2}$) shall apply. Where the yield strength is not clearly defined, the 0,2 % proof stress ($R_{p0.2}$) must be used.

Table 5.20  Yield strength resp. 0,2 % proof stress at elevated temperatures

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Minimum yield strength resp. 0,2 % proof stress $R_{0.2}$ at a temperature of °C [N/mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>235GH</td>
<td>206</td>
</tr>
<tr>
<td>265GH</td>
<td>234</td>
</tr>
<tr>
<td>295GH</td>
<td>272</td>
</tr>
<tr>
<td>355GH</td>
<td>318</td>
</tr>
<tr>
<td>16Mo3</td>
<td></td>
</tr>
<tr>
<td>13CrMo4-5</td>
<td></td>
</tr>
<tr>
<td>10CrMo9-10</td>
<td></td>
</tr>
<tr>
<td>11 CrMo9-10</td>
<td></td>
</tr>
</tbody>
</table>

1 The lower yield strength ($R_{0.2}$) shall apply. Where the yield strength is not clearly defined, the 0,2 % proof stress ($R_{p0.2}$) must be used.

9. AUSTENITIC AND AUSTENITIC-FERRIC WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR STAINLESS STEELS, NON-MAGNETIC STEELS AND NICKEL ALLOY STEELS TOUGH AT SUBZERO TEMPERATURES

9.1 General

9.1.1 The following provisions apply to welding consumables and auxiliary materials for welding of stainless (austenitic) steels and steel castings, plates clad with these materials and joints of these materials with unalloyed and low-alloy (hull) structural steels. They also apply to welding consumables
and auxiliary materials for welding of non-magnetic steels, nickel alloy steels tough at subzero temperatures and other, similar steels. Austenitic welding consumables and auxiliary materials for clad welding and for joining difficult weldable (ferritic) materials are to be treated in analogous manner.

Note:

In (tanker) shipbuilding, the current practice is to use, in the main, the (austenitic or austenitic-ferritic) molybdenum alloy stainless steels listed in the three left-hand columns of Table 5.21. For equipment components, use is also made of, among others, steels of types 5 CrNi 18 10 (mat. no. 1.4301, AISI 304) and X 6 CrNiTi 18 10 (mat. no 1.4541, AISI 321). The following paragraphs therefore relate to welding consumables and auxiliary materials for these base materials including their joints with hull structural steels. Furthermore, the welding consumables and auxiliary materials for which the Society had already granted approval have also been included. Welding consumables and auxiliary materials for other base materials should, where applicable, be allocated to the appropriate categories and treated in analogous manner.

Inert gases with 1 to 3 % of oxygen added or those with a maximum of 2,5 % CO₂ added can be used as shielding gases for welding austenitic welding consumables in the range of application specified in 9.1.1. Those inert gases with a high level of nitrogen added can be used for steels which contain nitrogen. Gas mixtures of the type M 21 (cf. Table 5.8) with a maximum of 18 % of CO₂ added may only be used with slag-forming flux-cored wire electrodes. Approvals for (flux-cored) wire-gas combinations are also granted accordingly.

9.1.2 Welding consumables and auxiliary materials for welded joints uniting (austenitic or austenitic-ferritic) stainless steels to one another are classified into the quality grades shown in Table 5.23 according to the chemical composition (material no.) and mechanical (strength) characteristics of the base materials to be welded. The testing and approval of a steel in the left-hand column of the table encompasses the steel(s) in the right-hand column, subject to separate consideration of the corrosion conditions in each case. The table applies in analogous manner to the corresponding grades of forgings and steel castings.

9.1.3 Welding consumables and auxiliary materials for welding of non-magnetic stainless steels are approved according to a quality grade corresponding to the chemical composition (material no.) of the weld metal. Table 5.22 contains a number of examples. The testing and approval of a steel in the left-hand column encompasses the steel(s) in the right-hand column, subject to separate consideration of the corrosion conditions in each case. The table applies in analogous manner to the corresponding grades of forgings and steel castings.

9.1.4 Welding consumables and auxiliary materials for joining (austenitic or austenitic-ferritic) stainless steels to unalloyed or low-alloy steels, for intermediate runs in welding of clad plates and for clad welds are approved according to a quality grade corresponding to the chemical composition of the weld metal. Table 5.23 gives a number of examples. Approval is granted with due regard to the mechanical and other properties in relation to the base materials concerned and/or for a particular type of application for which suitability has been proved.

9.1.5 Austenitic welding consumables and auxiliary materials for welding of nickel steels tough at subzero temperatures are classified into quality grades as shown in Table 5.24 according to the chemical composition (material no.) and mechanical (strength and toughness) characteristics of the base materials to be welded. The testing and approval of a steel in the left-hand column encompasses the steel(s) in the right-hand column. The table applies in analogous manner to the corresponding grades of forgings and steel castings.
### Table 5.21 Austenitic welding consumables and auxiliary materials for welding of stainless steel

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Testing and approval relating to steel Designation</th>
<th>Mat. No./AISI</th>
<th>Steels also covered by the approval Designation</th>
<th>Mat. No./AISI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4301</td>
<td>X5CrNi18-10</td>
<td>1.4301/304</td>
<td>X5CrNi 18-10</td>
<td>1.4301/304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2CrNi18-9</td>
<td>1.4307/304L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
<tr>
<td>4306</td>
<td>X2CrNi19-11</td>
<td>1.4306/304 L</td>
<td>X5CrNi18-10</td>
<td>1.4301/304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2CrNi18-9</td>
<td>1.4306/304 L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
<tr>
<td>4307</td>
<td>X2CrNi18-9</td>
<td>1.4307/304L</td>
<td>X5CrNi18-10</td>
<td>1.4301/304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2CrNi18-9</td>
<td>1.4306/304 L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
<tr>
<td>4308</td>
<td>X2CrNi18-9</td>
<td>1.4404/316 L</td>
<td>X2CrNi18-10</td>
<td>1.4301/304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2CrNi18-9</td>
<td>1.4306/304 L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
<tr>
<td>4429</td>
<td>X2CrNiMoN17-13-3</td>
<td>1.4429/316 LN</td>
<td>X2CrNiMo17-12-2</td>
<td>1.4311/303 LN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMo17-13-2</td>
<td>1.4404/316 LN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMo17-12-2</td>
<td>1.4406/316 LN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMo17-13-2</td>
<td>1.4408/-</td>
</tr>
<tr>
<td>4435</td>
<td>X2CrNiMo18-14-3</td>
<td>1.4435/316 L</td>
<td>X5CrNi18-10</td>
<td>1.4301/304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2CrNi18-9</td>
<td>1.4306/304 L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
<tr>
<td>4438</td>
<td>X2CrNiMo18-16-4</td>
<td>1.4438/317 L</td>
<td>X5CrNi18-10</td>
<td>1.4301/304</td>
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<td></td>
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<td>C2CrNi18-9</td>
<td>1.4306/304 L</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
<tr>
<td>4439</td>
<td>X3CrNiMoN17-13-5</td>
<td>1.4439/(317 LN)</td>
<td>X2CrNiMo17-13-2</td>
<td>1.4406/316 LN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMo17-13-2</td>
<td>1.4429/316 LN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMo17-13-2</td>
<td>1.4438/317 L</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>X2CrNiMo17-13-2</td>
<td>1.4446/-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMo17-13-2</td>
<td>1.4448/-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X5CrNiMo17-13-3</td>
<td>1.4449/317</td>
</tr>
<tr>
<td>4462</td>
<td>X2CrNiMo22-5</td>
<td>1.4462/-</td>
<td>X6CrNiMo24-8-2</td>
<td>1.4463/-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X6CrNiMo24-8-2</td>
<td>1.4582/-</td>
</tr>
<tr>
<td>4550</td>
<td>X6CrNiNb18-10</td>
<td>1.4550/347</td>
<td>X5CrNi18-10</td>
<td>1.4301/304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2CrNi18-9</td>
<td>1.4306/304 L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
<tr>
<td>4571</td>
<td>X6CrNiMoTi17-12-2</td>
<td>1.4571/316 Ti</td>
<td>X5CrNi18-10</td>
<td>1.4301/304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C2CrNi18-9</td>
<td>1.4306/304 L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GX6CrNi18-9</td>
<td>1.4308/-</td>
</tr>
</tbody>
</table>
Table 5.22  Austenitic welding consumables and auxiliary materials for welding of non-magnetic stainless steels

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Testing and approval relating to steel 1</th>
<th>Mat. No.</th>
<th>Steels also covered by the approval 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3954</td>
<td>X2CrNiMnMoNNb21-16-5-3</td>
<td>1.3964</td>
<td>X4CrNiMnMoN19-13-8 1.3948</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMoN22-15 1.3951</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMoN18-14-3 1.3952</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMoN18-15 1.3953</td>
</tr>
<tr>
<td>3984</td>
<td>X2CrNiMnMoNNb23-17-6-3</td>
<td>1.3974</td>
<td>X2CrNiMnMoNNb21-15-7-3 1.3914</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMoN22-15 1.3951</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMoN18-14-3 1.3952</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X2CrNiMnMoNNb21-6-5-3 1.3964</td>
</tr>
</tbody>
</table>

1 Steels in accordance with the BWB Material Performance Sheets having the corresponding material number.

Table 5.23  Austenitic welding consumables and auxiliary materials for joining stainless steels to unalloyed or low-alloy steels, for intermediate runs and for clad welds (examples)

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Welding consumable (weld metal)</th>
<th>Mat. No./AWS</th>
<th>Usage (instruction) 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>4332</td>
<td>E 23 12 nC X2CrNi24-12</td>
<td>(1.4332) / E 309 L 1.4332 / E 309 L</td>
<td>Intermediate runs for welded joints between clad plates of similar composition. Welded joints between heat resistant CrNi steels, joints between stainless and unalloyed or low-alloy steels. Clad welds.</td>
</tr>
<tr>
<td>4370</td>
<td>E 18 8 Mn 6 X15CrNiMn18-8</td>
<td>(1.4370) / (E 307) 1.4370 / --</td>
<td>Joints between stainless and unalloyed or low-alloy steels.</td>
</tr>
<tr>
<td>4431</td>
<td>E 20 10 3 X12CrNiMo19-10</td>
<td>1.4431 / -- 1.4431 / --</td>
<td>as for 4370</td>
</tr>
<tr>
<td>4459</td>
<td>E 23 12 2 X8CrNiMo23-3</td>
<td>1.4459 / E 309 Mo (1.4459) / (E 309 Mo)</td>
<td>as for 4332</td>
</tr>
</tbody>
</table>

1 First line (E...): Designation for covered electrode, second line: designation for (flux-cored) wire – gas and wire flux combinations
2 The manufacturer's information given for the individual product are decisive abbr. information mentioned in the approval.

Table 5.24  Austenitic welding consumables and auxiliary materials for welding of nickel steels tough at subzero temperatures (examples)

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Testing and approval relating to steel 1</th>
<th>Mat. No.</th>
<th>Steels also covered by the approval 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>5637</td>
<td>12Ni14 (3.5 % Ni)</td>
<td>1.5637</td>
<td>12Ni14 (3.5 % Ni) 1.5637</td>
</tr>
<tr>
<td>5680</td>
<td>12Ni19 (5 % Ni)</td>
<td>1.5680</td>
<td>12Ni14 (3.5 % Ni) 1.5637</td>
</tr>
<tr>
<td>5662</td>
<td>X8Ni9 (9 % Ni)</td>
<td>1.5662</td>
<td>G9Ni14 (3.5 % Ni) 1.5663</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12Ni19 (5 % Ni)</td>
</tr>
<tr>
<td>5663</td>
<td>X7Ni9 (9 % Ni)</td>
<td>1.5663</td>
<td>12Ni14 (3.5 % Ni) 1.5637</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G9Ni14 (3.5 % Ni) 1.5663</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12Ni19 (5 % Ni) 1.5680</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X8Ni9 (9 % Ni) 1.5662</td>
</tr>
</tbody>
</table>

1 Steels conforming to EN 10028-4.
9.2 Testing of the weld metal

9.2.1 For testing the deposited weld metal, test pieces analogous to those called for in 2.2.1, 3.2.1 or 4.2.1 shall be prepared, depending on the nature of the welding consumables and auxiliary materials (and according to the welding process). The base material used shall be a stainless steel of the same composition, or the side walls of the weld shall be buffered with a weld metal of such composition.

9.2.2 The chemical composition of the deposited weld metal shall be determined and certified in a manner analogous to that prescribed in 2.2.2. As an alternative, the chemical composition may be determined in a manner analogous by analysis of a build-up weld. The results of the analysis shall not exceed the limits specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.

For the welding consumables and auxiliary materials specified in Tables 5.23 and 5.24, the pitting resistance equivalent (% Cr + 3.3 % Mo) shall be at least 1 % higher than that of the base material on which the test was carried out resp. on which approval was based. The analysis of the weld metal and an average chemical composition determined from the data given in the standards shall be the determining factors in such a case.

9.2.3 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the test specimens shall be taken from the weld metal test pieces in a manner analogous to the provisions of 2.2.3, 3.2.3 or 4.2.3.

9.2.4 The mechanical properties must meet the requirements stated in Table 5.25. The provisions of 2.2.4, 3.2.4 and 4.2.4 apply in analogous manner to the performance of the tests and the carrying out of retests. For the welding consumables and auxiliary materials referred to in 9.1.4, the requirements depend on the particular application and are determined on a case-by-case basis. The notch impact energy values demonstrated during the test and also the test temperatures are indicated in the approval certificate. Welding consumables and auxiliary materials for joining stainless to normal-strength or higher-strength hull structural steels must, as a minimum requirement, meet the requirements relating to those for the latter. For those referred to in 9.1.5, 7.2.2 and Table 5.17 should also be noted.

9.3 Testing on welded joints

9.3.1 Depending on their nature (and on the welding process concerned), the testing on welded joints made with the welding consumables and auxiliary materials referred to in 9.1.2, 9.1.3 and 9.1.5 shall be performed on butt-weld test pieces analogous to those prescribed in 2.3.1, 3.3.1 or 4.3.1. For the welding consumables and auxiliary materials covered by para. 9.1.4, testing of welded joints is required only if the products are used wholly or chiefly for making welded joints or where, in welded joints, they constitute a substantial proportion of the weld section (as in the case of the intermediate runs of welds joining clad plates). However, the Society may call for specimen welds to prove the satisfactory performance of these products in the various positions for which approval is solicited (see also 1.6.). For welding consumables and auxiliary materials covered by 9.1.3 which are used exclusively for clad welding, the scope of the tests to be applied shall be determined on a case-by-case basis.

9.3.2 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the butt-weld test pieces called for in para. 9.3.1 shall be welded in a manner analogous to that prescribed in 2.3.2, 3.3.2 or 4.3.2. The base material used shall be a steel of the same or similar composition in accordance with Tables 5.21, 5.22 and 5.24 and shall possess at least the mechanical properties indicated in Table 5.25. An analogous procedure shall be adopted in the case of the welding consumables and auxiliary materials covered by para. 9.1.4 and Table 5.25.
Table 5.25  Required properties of the weld metal

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Minimum 0.2 % proof stress [N/mm²]</th>
<th>Tensile Strength [N/mm²]</th>
<th>Minimum Elongation [%]</th>
<th>Minimum notch impact energy [J]</th>
<th>Test temperature [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4306</td>
<td>195</td>
<td>500 – 700</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4404</td>
<td>205</td>
<td>510 – 710</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4429</td>
<td>295</td>
<td>580 – 800</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4435</td>
<td>205</td>
<td>510 – 710</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4438</td>
<td>205</td>
<td>510 – 710</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4439</td>
<td>295</td>
<td>580 – 800</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4462</td>
<td>480</td>
<td>680 – 900</td>
<td>25</td>
<td>35 (24)</td>
<td>– 30</td>
</tr>
<tr>
<td>4550</td>
<td>205</td>
<td>510 – 740</td>
<td>30</td>
<td>47 (33)</td>
<td>+ 20</td>
</tr>
<tr>
<td>4751</td>
<td>225</td>
<td>500 – 740</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3954</td>
<td>430</td>
<td>700 – 950</td>
<td>30</td>
<td>70 (49)</td>
<td>+ 20</td>
</tr>
<tr>
<td>3984</td>
<td>510</td>
<td>850 – 1050</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5637</td>
<td>355</td>
<td>490 – 640</td>
<td>22</td>
<td></td>
<td>– 95</td>
</tr>
<tr>
<td>5680</td>
<td>390</td>
<td>530 – 840</td>
<td>20</td>
<td>47 (33)</td>
<td>– 196</td>
</tr>
<tr>
<td>5662</td>
<td>490 ⁵</td>
<td>640 ⁵ – 840</td>
<td>18</td>
<td></td>
<td>– 110 (– 196) ⁴</td>
</tr>
<tr>
<td>5663</td>
<td>585</td>
<td>680 – 820</td>
<td>18</td>
<td></td>
<td>– 196 ³</td>
</tr>
</tbody>
</table>

¹ Means value of three specimens; for individual values ( ) and retests, see 9.2.4.
² In the case of low-temperature applications, special requirements apply: cf. 7. (Table 5.17 and 7.2.2).
³ Cf. 7. (Table 5.17 and 7.2.2).
⁴ If quality grade 5680 (welding of 5 % nickel steel) is to be applied at a minimum design temperature of – 165 °C. The test temperature shall be – 196 °C.
⁵ If the "as delivered" condition (of the base material) is HT 640, this welding consumable shall also be approved for the as-delivered condition HT 680 of the base materials. In such a case the same minimum requirements as stated for quality grade 5663 shall apply.

9.3.3 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the test specimens prescribed in 2.3.3, 3.3.3 or 4.3.3 shall be taken from the butt-welded test pieces.

9.3.4 The mechanical properties must meet the requirements stated in Table 5.25. The provisions of 1.7.6, 2.3.4, 3.3.4 and 4.3.4 apply in analogous manner to the performance of the tests and the carrying out of retests. The Society may agree to the application in analogous manner of footnote 1) in Table 5.15 also for the austenitic welding consumables and auxiliary materials covered by this section. The provisions of 1.7.6, 2.3.4, 3.3.4 and 4.3.4 apply in analogous manner to the performance of the tests and carrying out of retests.

9.4 Testing of resistance to intergranular corrosion

9.4.1 Testing of resistance to intergranular corrosion (IC) shall be performed in accordance with DIN 50 914 on test specimens with intersecting butt welds using the copper sulphate - sulphuric acid method (Strauss test). No cracks may be detected and the metallographically measured depth of penetration of the attack at the grain boundaries shall not exceed 0.05 mm.

9.4.2 In the case of special corrosion conditions or particular materials, the Society may stipulate other corrosion tests as an additional or alternative measure, e.g. testing of resistance to pitting under corrosive attack by chlorides, e.g. by seawater.

9.5 Testing for hot cracks

9.5.1 Testing for hot cracks is to be performed in analogous manner to the provisions of 2.5 or DIN 50 129 on the (shape 2) test piece prescribed for austenitic welding consumables and auxiliary materials.
9.5.2 Other methods of testing for hot cracks may be agreed with the Society.

9.6 Annual repeat tests

9.6.1 The annual repeat tests specified in 1.3.1 shall entail the preparation and testing of weld metal test pieces as prescribed under 9.2 (determination of the mechanical properties and chemical composition of the weld metal). If the tensile strengths prescribed in Table 5.25 are not attained and footnote 1) in Table 5.15 applies analogously, the repeat test, too, shall include the testing of flat tensile specimens taken from the welded joint.

9.6.2 In special cases, the Society may require more extensive repeat tests (cf. 1.3.2, 1.7.4 and 1.7.5).

10. WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR ALUMINIUM ALLOYS

10.1 General

10.1.1 The following provisions apply to welding consumables and auxiliary materials for the welding of aluminium alloys for structural components and equipment parts used in shipbuilding and mechanical engineering. Welding consumables and auxiliary materials for the welding of aluminium alloy for low-temperature applications are dealt with separately, the requirements being specified on a case-by-case basis in accordance with the application conditions. Cf. 7.

Note: In the present state of shipbuilding technology only inert gas welding using argon or helium or their mixtures (MIG and TIG welding) and plasma arc welding are of practical significance. Because of their suitability for seawater applications, the wrought alloys AlMg 3, AlMg 4.5 Mn, AlMgSi 0.5, AlMgSi 0.7 and AlMgSi 1 are mainly used. Cast alloys are hardly ever used for load-bearing structural components in shipbuilding. The following paragraphs therefore relate chiefly to wire-gas combinations for the aforementioned wrought alloys. Other welding consumables and auxiliary materials or those for other base materials shall be treated in analogous manner.

10.1.2 In accordance with European standards drafts existing up to now, welding consumables and auxiliary materials (wire (electrode) or filler rod shielding gas combinations) for the welding of aluminium alloys are classified into the quality grades shown in Table 5.26 on the basis of their chemical composition and mechanical (strength) properties. Testing and approval of the base material in the left-hand columns of the table also encompasses the base material(s) shown in the right-hand columns.

10.1.3 Approval is tied up with a specific shielding gas as prescribed in Table 5.27 or with a "special gas" which is defined separately according to its composition and purity. The composition of the shielding gas used in the test is to be recorded.

10.2 Testing of the weld metal

10.2.1 Unless otherwise specified (e.g. testing the strength properties of the pure weld metal for the welding together of large wall thicknesses), the testing of the weld metal shall consist of an analysis of the deposited weld metal.
Table 5.26  Welding consumables for aluminium alloys

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Testing and approval relating to the base material ¹</th>
<th>Base material alloys also covered by the approval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alloy No.</td>
<td>Mat. Designation</td>
</tr>
<tr>
<td>RAlMg3 ²</td>
<td>EN AW-5754</td>
<td>EN AW AlMg3</td>
</tr>
<tr>
<td>RAlMg4 ³</td>
<td>EN AW-5086</td>
<td>EN AW AlMg4</td>
</tr>
<tr>
<td>RAlMg4,5 ⁴</td>
<td>EN AW-5083</td>
<td>EN AW AlMg4,5Mn0,7</td>
</tr>
<tr>
<td>RAlSi5 ⁵</td>
<td>EN AW-6082</td>
<td>EN AW AlSiMgMn</td>
</tr>
<tr>
<td>RAlMg5,5 mod.</td>
<td>EN AW-5383</td>
<td>AlMg4,5Mn0,7 mod</td>
</tr>
<tr>
<td>RAlMg5,5</td>
<td>—</td>
<td>AlMg5,5Mn0,8ZnZr</td>
</tr>
</tbody>
</table>

¹ In respect to the bend test (see Table 5.28) it is recommended to carry out the test with base material in soft conditions
² e.g. welding consumables RAlMg3Mn0,4 / R5018 conforming to EN ...... (at the moment draft European Standard without no.)
³ e.g. welding consumables RAlMg5 / R5119 conforming to EN ...... (at the moment draft European Standard without no.)
⁴ e.g. welding consumables RAlMg4,5Mn0,7(A) / R5183 or RAlMg4,5MnZr / R5087 conforming to EN ...... (at the moment draft European Standard without no.)
⁵ e.g. welding consumables RAlSi5(A) / R4043 conforming to EN ...... (at the moment draft European Standard without no.)
⁶ In the case of less exacting strength requirements, the strength values established during the welding procedure tests shall apply for dimensioning purposes. The values given in Table 5.28 provide an indication.

Table 5.27  Shielding gases for the welding of aluminium alloys

<table>
<thead>
<tr>
<th>Group</th>
<th>Composition of shielding gas (Vol. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Argon</td>
</tr>
<tr>
<td>I-1</td>
<td>100</td>
</tr>
<tr>
<td>I-2</td>
<td>—</td>
</tr>
<tr>
<td>I-3(1)</td>
<td>Remainder</td>
</tr>
<tr>
<td>I-3(2)</td>
<td>Remainder</td>
</tr>
<tr>
<td>I-3(3)</td>
<td>Remainder</td>
</tr>
<tr>
<td>S</td>
<td>&quot;Special gas&quot;, Composition specified, cf. 9.1.3</td>
</tr>
</tbody>
</table>

¹ The purity and other properties of the shielding gases must comply with EN 439/ISO 14175.
² Where argon (up to a max. 95 %) is replaced by helium and the helium content is marked by means of an added symbol, a gas with the following composition must be used for the test:
  - (1) = > 0 to 33 % He:
    - an argon-helium mixture containing approx. 15 % helium
  - (2) = > 33 to 66 % He:
    - an argon-helium mixture containing approx. 50 % helium
  - (3) = > 66 to 95 % He:
    - an argon-helium mixture containing approx. 75 % helium, Group I-2 is included in this case.
10.2.2 The chemical composition shall be determined and certified in a manner analogous to that prescribed in 2.2.2 using a build-up weld in accordance with EN 26847/ISO6847. The results of the analysis shall not exceed the limits specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.

10.3 Testing on welded joints

10.3.1 The testing on welded joints shall be performed in a manner analogous to that prescribed in para. 2.3 or 3.3, as applicable, on butt-weld test pieces conforming to Fig. 5.16. The base materials indicated in Table 5.28 shall be used. The plate thicknesses shall be 10 – 12 mm for MIG and plasma arc welding and 4 – 6 mm for TIG welding.

10.3.2 Depending on the welding positions for which approval is solicited (cf. 1.4.4), the butt-weld test pieces shown in Fig. 5.16 shall be welded in the positions indicated in Table 5.4, including as a minimum requirement the downhand (d) and vertical-up (v) positions.

The wire diameters shall conform to Table 5.9 and the welding parameters to the manufacturer's or supplier's recommendations. The composition of the shielding gas used for the test shall be stated in the report. For the welding of the test pieces, see also DIN 1732, Part 2. The root may be mechanically grooved and back welded. Post-weld heat treatment of the test piece (e.g. in the case of age-hardenable alloys) is only allowed if such heat treatment may and is to be carried out in the future production of welded components (cf. the preliminary remarks to Section 5). Where necessary, the heat treatment must be agreed prior to the test and is to be recorded in the test report.

10.3.3 Following the recommended radiographic examination, the following test specimens shall be taken from each butt-weld test piece in accordance with Fig. 5.16: four flat tensile test specimens conforming to EN 895/ISO 4136, four transverse bend test specimens conforming to EN 910/ISO 5173, Part 1, and a macrographic specimen. Of the four flat tensile specimens, two shall be tested with the weld reinforcement in place and two with the weld reinforcement machined off. Of the transverse bend tests (with the weld reinforcement machined off), two are to be tested with the cover pass in tension and two with the back pass in tension.

10.3.4 The mechanical characteristics must meet the requirements stated in Table 5.28. The provisions of 1.7.6, 2.3.4 and 3.3.4 apply in analogous manner to the performance of the tests and the carrying out of retests. The position of the fractures is to be stated in the test report. With the transverse bend test specimens the bending elongation is to be determined. The macrographic specimen shall be examined for defects (such as lack of fusion, cavities, inclusions, pores and cracks).

10.3.5 Fillet-weld test pieces analogous to those called for in 2.3.5 or 3.3.5, as applicable, shall be provided for those welding consumables and auxiliary materials (wire-gas combinations) which are to be approved or used exclusively for the execution of fillet welds. In special cases, the Society may call for fillet-weld test pieces in addition to the butt-weld test pieces prescribed in para. 10.3.1.

10.4 Annual repeat tests

10.4.1 The annual repeat tests called for in 1.3.1 shall entail the preparation and testing of a butt-weld test piece in accordance with 10.3 welded in the downhand position with wire of 1.2 mm diameter. Half as many specimens may be used in the repeat tests as in the initial test (Fig. 5.16).

10.4.2 In special cases, the Society may require more extensive repeat tests (e.g. analysis of the weld metal as an additional measure) (cf. 1.3.2, 1.7.4 and 1.7.5).
## Requirements applicable to welded joints

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Minimum tensile strength (^1) [N/mm(^2)]</th>
<th>Diameter of mandrel (t = \text{specimen thickness})</th>
<th>Minimum bending angle (^2)</th>
<th>Bending elongation (^3) [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAlMg3</td>
<td>190</td>
<td>3 (t)</td>
<td>180°</td>
<td>20</td>
</tr>
<tr>
<td>RAlMg4</td>
<td>240</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAlMg4,5</td>
<td>275</td>
<td>6 (t)</td>
<td>20°</td>
<td>17</td>
</tr>
<tr>
<td>RAlSi5</td>
<td>160</td>
<td></td>
<td>180°</td>
<td>8</td>
</tr>
<tr>
<td>RAlMg4,5Mnmod.</td>
<td>290</td>
<td></td>
<td>or bending elongation achieved (^3)</td>
<td>17</td>
</tr>
<tr>
<td>RAlMg5,5</td>
<td>300</td>
<td></td>
<td>180°</td>
<td>17</td>
</tr>
</tbody>
</table>

1. Using the base materials shown in Table 5.26, columns 2 and 3.
2. Bending angle achieved before first incipient crack, minor pore exposures permitted up to a max. length of 3 mm.
3. Where the bending angle is not achieved, the requirements shall still be regarded as having been met if the elongation achieved with a gauge length \(L_0 = L_s + t\) before the first incipient crack meets the requirements

\[0.7d < L_s < 0.9d\]

**Note:**

Because of the different flow behavior of the base material and the weld metal, incipient cracking of the specimens may occur prematurely - especially with too rapid deformation - when the “free” bending test according to DIN 50121, Part 1 is carried out. It is recommended that a test rig of the type shown in the following sketch be used in which the bending test specimen, clamped at one end, is “rolled” around the mandrel.
11. WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR COPPER AND COPPER ALLOYS

11.1 General

11.1.1 The following provisions apply to welding consumables and auxiliary materials for the welding of copper and copper alloys conforming to the Society's Rules for Materials and used for structural components in shipbuilding (e.g. rudders) and especially for pipelines conveying seawater.

Note:

According to the Society's Rules for Materials, besides copper and aluminium brass the copper-nickel alloys CuNi 10 Fe 1 Mn and CuNi 30 Mn 1 Fe as well as certain copper (used in manucture of propellers) alloys are mainly used for welding purposes. In accordance with current approval practice, the following paragraphs therefore relate to welding consumables and auxiliary materials for these base materials; other such products are to be treated in analogous manner.

11.1.2 Welding consumables and auxiliary materials for welding of copper and copper alloys are classified into the quality grades shown in Table 5.29 on the basis of their chemical composition (type of alloy) and mechanical (strength) properties. Testing and approval in respect of a base material in the left-hand column of the table also encompasses the base material(s) shown in the right-hand column.

11.2 Testing of the weld metal

11.2.1 Unless otherwise stipulated, the testing of the weld metal shall consist of a chemical analysis of the deposited weld metal and tensile test analogous to that described in 2.2 (only one test piece to be welded in the down-hand position).

11.2.2 The chemical composition shall be determined and certified in a manner analogous to that prescribed in 2.2.2. The results of the analysis shall not exceed the limits specified in the standards (e.g. DIN 1733) or by the manufacturer, the narrower tolerances being applicable in each case.
11.3 Testing on welded joints

11.3.1 The testing on welded joints shall be performed in a manner analogous to that prescribed in 10.3. for welding consumables and auxiliary materials for aluminium alloys or, with the Society's consent, in accordance with the standards (e.g. DIN 1733, Part 2).

11.3.2 The mechanical properties must conform to the required properties of the base materials shown in Table 5.30. Different values for these properties are only permissible with the Society's consent and are to be taken into account where applicable when dimensioning the components.

11.4 Annual repeat tests

The annual repeat tests called for in 1.3.1 shall entail the preparation and testing of a butt-weld test piece welded in the downhand position as in the case of aluminium alloys (cf. 10.4.1).

Table 5.29 Welding consumables and auxiliary materials for copper and copper alloys

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Testing and approval related to Designation</th>
<th>Mat. No.</th>
<th>Materials also covered by the approval Designation</th>
<th>Mat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuNi30Fe</td>
<td>CuNi30Mn1Fe</td>
<td>2.0882</td>
<td>CuNi5Fe</td>
<td>2.0872</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CuNi10Fe1Mn</td>
<td>2.0878</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CuNi20Fe</td>
<td>2.0878</td>
</tr>
<tr>
<td>CuNi30Mn</td>
<td>CuNi30Mn1Fe</td>
<td>2.0882</td>
<td>CuNi5Fe</td>
<td>2.0872</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CuNi10Fe1Mn</td>
<td>2.0878</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CuNi20Fe</td>
<td>2.0878</td>
</tr>
<tr>
<td>SCU1 ¹</td>
<td>CU1 ⁵</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>SCU2 ²</td>
<td>CU2 ⁵</td>
<td>—</td>
<td>CU1 ¹</td>
<td>—</td>
</tr>
<tr>
<td>SCU3 ³</td>
<td>CU3 ⁵</td>
<td>—</td>
<td>CU1 ¹</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CU2 ²</td>
<td>—</td>
</tr>
<tr>
<td>SCU4 ⁴</td>
<td>CU4 ⁵</td>
<td>—</td>
<td>CU1 ¹</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CU2 ¹</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CU3 ¹</td>
<td>—</td>
</tr>
</tbody>
</table>

¹ e.g. Al-bronze or Mn-bronze
² e.g. Al-bronze or Ni-Mn-bronze
³ e.g. Al-bronze, Ni-Al-bronze or Mn-Al-bronze
⁴ e.g. Mn-Al-bronze
⁵ Cast copper alloys (for propeller manufacture) in accordance with the Society's Rules for Materials or other comparable alloys with the appropriate strength properties.

Table 5.30 Required properties of welded joints

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Minimum 0,2 %-proof stress [N/mm²]</th>
<th>Tensile strength [N/mm²]</th>
<th>Minimum elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuNi30Fe</td>
<td>120</td>
<td>360 – 490</td>
<td>30</td>
</tr>
<tr>
<td>CuNi30Mn</td>
<td>120</td>
<td>360 – 490</td>
<td>30</td>
</tr>
<tr>
<td>SCU1</td>
<td>175</td>
<td>370 min.</td>
<td>20</td>
</tr>
<tr>
<td>SCU2</td>
<td>195</td>
<td>410 min.</td>
<td>18</td>
</tr>
<tr>
<td>SCU3</td>
<td>245</td>
<td>500 min.</td>
<td>16</td>
</tr>
<tr>
<td>SCU4</td>
<td>275</td>
<td>550 min.</td>
<td>18</td>
</tr>
</tbody>
</table>
12. WELDING CONSUMABLES AND AUXILIARY MATERIALS FOR NICKEL AND NICKEL ALLOYS

12.1 General

12.1.1 The following provisions apply to welding consumables and auxiliary materials for welding of nickel and nickel alloys.

Note:

According to current approval practice, the welding consumables and auxiliary materials shown in the left-hand column of Table 5.31 are used. The following paragraphs therefore relate to welding consumables and auxiliary materials for these materials, but also cover such products for joining of different materials by welding (e.g. austenitic steels to ferritic/ perlitic steels) and especially for nickel steels tough at subzero temperatures.

12.1.2 Welding consumables and auxiliary materials for welding of nickel and nickel alloys, for joining of different materials by welding and for welding of nickel steels tough at subzero temperatures are classified into the quality grades shown in Table 5.31 according to their chemical composition (type of alloy) and mechanical (strength and toughness) properties. The testing and approval of a base material in the left-hand columns of Table 5.31 encompasses the material(s) in the right-hand columns. Suitability for welding of the nickel steels tough at subzero temperatures in low-temperature applications is indicated separately in the approval certificate; cf. 7.

12.2 Testing of the weld metal

12.2.1 For testing the deposited weld metal, the test pieces described in the standards (e.g. DIN 1736, Part 2 and DIN 32 525) shall be prepared according to the provisions of 2.2., 3.2., and 4.2. The provisions of the standards with regard to the base materials to be used, including, where applicable, the buffering of the side walls of the weld, and to the welding parameters shall be complied with.

12.2.2 The chemical composition of the deposited weld metal shall be determined and certified in a manner analogous to the provisions of 2.2.2, taking into account the provisions of the standards. The results of the analysis shall not exceed the limits specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case.

12.2.3 Depending on the nature of the welding consumables and auxiliary materials (and according to the welding process), the test specimens shall be taken from the weld metal test pieces in accordance with the standards and the provisions of 2.2.3, 3.2.3 and 4.2.3.

12.2.4 The mechanical properties must meet the requirements stated in Table 5.32. For welding of nickel steels tough at subzero temperatures, the notch impact energy requirements stated in 7.2.1 and 7.2.2 apply. The provisions of 1.7.6, 2.2.4, 3.2.4 and 4.2.4 apply in analogous manner to the performance of the tests and the carrying out of retests.

12.2.5 The Society may require other tests to be performed or stipulate other values for the required properties if they are more appropriate to the character of the welding consumables and auxiliary materials or are necessitated by the intended use of the material.

12.3 Testing on welded joints

12.3.1 Depending on the nature of the welding consumables and auxiliary materials (and on the welding process concerned), the tests are to be performed on butt-weld test pieces in a manner analogous to 2.3., 3.3., or 4.3.
### Table 5.31  Welding consumables and auxiliary material for nickel and nickel alloys

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Testing approval relating to: Designation</th>
<th>Mat. No.</th>
<th>Materials also covered by the approval: Designation</th>
<th>Mat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NiTi3 (2.4156)</td>
<td>Ni 99,6</td>
<td>2.4060</td>
<td>Ni99,2</td>
<td>2.4066</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ni99,6</td>
<td>2.4056</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LCNi99,6</td>
<td>2.4061</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LCNi99</td>
<td>2.4068</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and joints between different non-ferrous metal alloys and with steels</td>
<td></td>
</tr>
<tr>
<td>NiTi4 (2.4155)</td>
<td>Ni 99,6</td>
<td>2.4060</td>
<td>NiCr15Fe</td>
<td>2.4816</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LC-NiCr15Fe</td>
<td>2.4817</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr20Ti</td>
<td>2.4951</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr20TiAl</td>
<td>2.4952</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr23Fe</td>
<td>2.4851</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and welded joints between different nickel alloys (except for NiCu) and with steels; welded joints in nickel steels tough at subzero temperatures.</td>
<td></td>
</tr>
<tr>
<td>NiCr19Nb (2.4648)</td>
<td>NiCr15Fe</td>
<td>2.4816</td>
<td>NiCr21Mo</td>
<td>2.4858</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr22Mo6Cu</td>
<td>2.4618</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr22Mo7Cu</td>
<td>2.4619</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr21Mo6Cu</td>
<td>2.4641</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>nickel steels tough at subzero temperatures</td>
<td></td>
</tr>
<tr>
<td>NiCr20Nb (2.4806)</td>
<td>NiCr15Fe</td>
<td>2.4816</td>
<td>NiCr21Mo</td>
<td>2.4858</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr22Mo6Cu</td>
<td>2.4618</td>
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<td></td>
<td></td>
<td></td>
<td>NiCr22Mo7Cu</td>
<td>2.4619</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr21Mo6Cu</td>
<td>2.4641</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>nickel steels tough at subzero temperatures</td>
<td></td>
</tr>
<tr>
<td>NiCr16FeMn (2.4620)</td>
<td>NiCr15Fe</td>
<td>2.4816</td>
<td>NiCr20Mo9Nb</td>
<td>2.4831</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr22Mo9Nb</td>
<td>2.4856</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr22Mo9Nb</td>
<td>2.4856</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr20Mo9Nb</td>
<td>2.4831</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>NiCr20Mo9Nb</td>
<td>2.4831</td>
</tr>
<tr>
<td>NiCr21Mo9Nb (2.4831)</td>
<td>NiCr22Mo9Nb</td>
<td>2.4856</td>
<td>NiCr20Mo9Nb</td>
<td>2.4831</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr22Mo9Nb</td>
<td>2.4856</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NiCr20Mo9Nb</td>
<td>2.4831</td>
</tr>
<tr>
<td>NiCu30MnTi (2.4377)</td>
<td>NiCu30Fe</td>
<td>2.4360</td>
<td>Joints with dissimilar materials, namely with unalloyed structural steels to EN 10025 and boiler steels to DIN 17155</td>
<td></td>
</tr>
</tbody>
</table>

12.3.2  The butt-weld test pieces shall be welded in accordance with 2.3.2, 3.3.2 or 4.3.2, taking into account the provisions of the above-mentioned standards (cf. 12.2.1). Wherever possible, the base materials shall be the materials to be welded in the future application; in any case, however, materials of adequate strength must be used.

12.3.3  Unless otherwise stipulated, the test specimens prescribed in 2.3.3, 3.3.3 and 4.3.3 for the various types of welding consumables and auxiliary materials (and, where applicable, the various welding processes) shall be taken from the butt-weld test pieces.
12.3.4 The mechanical properties must meet the requirements stated in 12.2.4 and Table 5.32, with the exception of the proof stresses. The Society may stipulate other values for the required properties; cf. 12.2.4.

12.4 Annual repeat tests

The annual repeat test specified in 1.3.1 shall entail the preparation and testing of a weld metal test piece in accordance with 12.2. The Society may require more extensive repeat tests (cf. 1.3.2, 1.7.4 and 1.7.5).

Table 5.32 Required properties of the weld metal

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Proof stresses</th>
<th>Tensile strength</th>
<th>Elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rp_{0.2} [N/mm²] min</td>
<td>Rp_{1.0} [N/mm²] min</td>
<td>Rm [N/mm²] min</td>
</tr>
<tr>
<td>NiTi3 NiTi4</td>
<td>200</td>
<td>220</td>
<td>410</td>
</tr>
<tr>
<td>NiCr19Nb NiCr20Nb</td>
<td>360</td>
<td>380</td>
<td>600</td>
</tr>
<tr>
<td>NiCr16FeMn</td>
<td>360</td>
<td>380</td>
<td>600</td>
</tr>
<tr>
<td>NiCr20Mo9Nb NiCr21Mo9Nb</td>
<td>420</td>
<td>440</td>
<td>700</td>
</tr>
<tr>
<td>NiCu30Mn NiCu30MnTi</td>
<td>200</td>
<td>220</td>
<td>460</td>
</tr>
</tbody>
</table>

1 The notch impact energy stated in 12.2.4 and, where applicable, 7.2.1 and 7.2.2.
Section 6

OVERWELDABLE SHOP PRIMERS

1. GENERAL

1.1 Overweldable shop primers applied to plates, sections, etc. before welding shall not significantly impair the quality of welded joints.

*Note:* Research and practical experience hitherto indicate that the characteristics of welded joints suffer practically no deleterious effects apart from an increased tendency towards porosity in fillet welds. Tests, approvals and supervisory measures are therefore exclusively concerned with this increased tendency towards porosity.

1.2 Only those overweldable shop primers may be used for which the Society has issued a confirmation of acceptability based on a porosity test relating to overwelding.

1.3 The requirements relating to shop primers in respect of corrosion protection are covered in the Rules for Classification and Construction, I – Ship Technology, Part 1, Chapter 1, Section 35.

1.4 Even where a confirmation of acceptability has been issued, overweldable shop primers may only be approved for fully mechanized double fillet welding after a special welding procedure test in the user's works.

2. TESTING AND APPROVAL OF SHOP PRIMERS

2.1 Application for a confirmation of acceptability shall be made to the Society's head office together with the following information and supporting documents:

- Manufacturer (and licensor, where applicable)
- Brand name (and licensor's brand name, where applicable) together with the original brand name in the case of commercial designations used for marketing
- Code number/symbol identifying the formulation or product
- Characteristic pigment base
- Characteristic binding agent base
- Data sheet with instructions for use (preparation of surface, methods of application, dry coat thickness, etc.)
- Instructions for use (preparation of surface, methods of application, dry coat thickness, etc.)
- Documentation relating to previous tests, approvals, etc.
- Place and date of proposed tests.
2.2 The Society reserves the right to carry out an inspection of the manufacturer’s work. To this end, the Society’s Surveyor shall be granted access to all production and test departments and laboratories. An explanation of the production conditions is to be given to the Surveyor and particularly satisfactory quality assurance measures demonstrated.

2.3 The porosity test shall be performed by neutral, properly equipped testing authorities recognized by the Society.

2.4 The identity of the sample submitted for testing shall be established and recorded in the test report. This may be done by, for instance, stating the batch number and date of manufacture. In case of doubt, the Society may require a test (e.g. of the chemical composition) to verify the identity of the sample.

2.5 The mean total pore area to be determined in accordance with the standards not exceed 150 mm$^2$. Shop primers giving a mean total pore area greater than 150 mm$^2$ but not exceeding 250 mm$^2$ may continue to be used in specific cases for less highly stressed components with the Society's consent, but require increased supervision as prescribed under 3. in the user's works. Shop primers giving a mean total pore area greater than 250 mm$^2$ may no longer be used.

2.6 With the issue by the Society of a confirmation of acceptability, the manufacturer (or, where applicable, the marketing company) assumes responsibility for ensuring that the composition and characteristics of the shop primer remain constant (cf. Section 1, 6.1). Any modifications shall automatically be drawn to the Society’s attention and shall normally necessitate a new test in accordance with para. 2.2.

2.7 All shop primers for which confirmation of acceptability has been granted by the Society shall be subjected to tests at approximately yearly intervals to establish that the product is identical. In doubtful cases, a new test in accordance with para. 2.2 shall be performed. The requirement for tests relating to the identical nature of the product may be satisfied by submission of the manufacturer's own quality assurance records or a confirmation of outside supervision from a testing authority recognized by the Society for that purpose.

3. SUPERVISING THE USE OF SHOP PRIMERS, PRODUCTION TESTS

3.1 By suitable checks carried out in the course of normal production (e.g. measurements of coat thickness, production specimens), workshops using shop primers shall ensure that the conditions of use on which the confirmation of acceptability was based are adhered to and that, in fillet welding, no pore formation occurs which adversely affects the application.

Note:

*The pores in fillet welds due to overweldable shop primers occur mainly as strings of pores made up of round or elongated individual pores. They originate at the gap between the web plate and the plating or flange, to which they are usually joined, and seldom extend to the surface. They can therefore practically only be detected by non-destructive or destructive inspection methods.*

3.2 Production tests are to be performed under the Society's supervision on a random basis during normal fabrication, when a shop primer is changed or when the conditions of use are altered. The Society may demand production tests in doubtful cases. The conditions in which the production test pieces are welded shall be the same as those prevailing in normal fabrication. Fabrication off-cuts may be used as production specimens.
3.3 T-joints as shown in Fig. 6.1 shall be welded as production test pieces. To facilitate the breaking open of the two welds (if possible, on the bisector of the angle made by the web plate and the plating or flange), the test piece shall be grooved in the manner shown in Fig. 6.1 and shall be divided into test sections each 100 mm long. Alternatively, fillet weld (cruciform) test pieces may be welded in accordance with Chapter 3, Section 1, 6.3.2 (Fig. 1.1) and tested in accordance with 6.4.5.

![Fig. 6.1 Production test piece with double fillet weld](image)

3.4 The production test piece shall be broken open for assessment. The fracture surfaces of the weld revealing the largest number of pores shall be assessed. The number of pores over a 100 mm weld length shall be established and the individual pore areas shall be measured (e.g. as ellipses with the length and breadth of the pore providing the main axes). Pores whose largest main axis is less than 0.5 mm are ignored.

3.5 The number of pores and individual pore areas are used to calculate the total pore area and this is then related to the area of the weld fracture. The percentage pore area arrived at in this way shall be stated in the test report. The test report shall also state the shop primer material, the coat thickness and the welding parameters.
Appendix 1

APPLICATION FOR APPROVAL

Application for Approval in accordance with the Rules for Welding

We,

COMPANY: ……………………………………………………………………………………………
ADDRESS: ……………………………………………………………………………………………

hereby make application for approval by Bulgarian Register of Shipping

☐ for the welding shop
☐ for the welding consumables and auxiliary materials

for the welding shop named in the attached description or the products specified in the Appendices, as applicable.

The applicant accepts the following conditions:

• The Rules for Classification and Construction (particularly, in this instance, the Rules for Welding) issued by Bulgarian Register of Shipping (The Society) in the version applicable at the time application is made.

• The applicant will ensure that all the information required for the approval, and specified in the rules is provided and documents, test results etc. are submitted as applicable and that access to all the relevant workshops and production areas is at all times allowed to the Society's Surveyor to enable him to carry out his inspection functions.

• In the absence of any written arrangements to the contrary, fees will be calculated based on the Society's rate of charges at the time approval is granted. Fees are payable even if approval fails to be granted due to unsatisfactory test results.

• Any withdrawal of this application for approval requires notice in writing and will be subject to a charge in line with the scope of services provided at the time of notification of withdrawal.

The documents marked with a cross the attached list (Appendix) are enclosed with the application for approval of the welding shop; the documents stipulated in the Rules for Welding, Chapter 1, Section 5, 1.1.6 are enclosed with the application for approval of the welding consumables and auxiliary materials.

_________________                 _________________           __________________________________
Place     Date                                  Applicant
## Appendix to the Application for Welding Approval

List of documents to be submitted or enclosed with the application for approval

<table>
<thead>
<tr>
<th>Nature of the approval sought:</th>
<th>Approval for welding shop</th>
<th>Extension</th>
<th>Approval for welding procedure</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Application from welding shop</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. Description of welding shop in accordance with Appendix 2, together with Annexes</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. &quot;Range of application&quot; annex(es) to description of welding shop</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Proof of qualification for welding supervisor</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Proof of qualifications for deputy welding supervisor</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Welder qualification test certificates (or list of valid welder qualification tests verified by Surveyor)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Descriptions of welding procedures (WPS)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Standard submerged-arc welding procedure test record</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Records of welding procedure tests</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Records of production tests performed</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. Documents/information on inspection (supervisory) personnel</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. Other available documentary proof, approvals etc.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. Other (e.g. proof of compliance with the quality requirements conforming to EN 729/ISO 3834)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

For Society use only:

- Surveyor's report following inspection of welding shop
- Statement of fees

1) Only if changes have been made since the first approval.
2) If stipulated for certain ranges of application e.g. steam boiler and pressure vessel construction.
3) If tests which have already been performed elsewhere are to be used as a basis for approval.
Appendix 2

DESCRIPTION OF WELDING SHOP

Description of Welding Shop for Approval of Welding

Company:

Full address:

Work/work's division:

Full address:

Telephone no.: Fax-Nr.: Telex no.: E-mail address:

Manager (name) responsible for the works/work's division:

Work's authority (name) (for container repair works only):

Number of employees (total): of which welders/operators:

Approval sought for the range of application:

☐ Welding of hull structures
☐ Welding of steam boilers
☐ Welding of pressure vessels
☐ Welding of pipelines
☐ Welding of machinery components
☐ Welding of containers (including repairs)
☐ Welding of ................................................

Past activities in the range of application for which application is made (welding production schedule; components, materials, welding process etc. Where applicable attach separate reference list):

1. Workshop facilities ¹)

1.1 Assembly/welding shops and covered assembly bays (number and size):

¹) Summary, for general information about the work's production capabilities. Alternative or additionally add brochure, leaflet etc.
1.2 Storage facilities for materials and welding consumables (description, e.g. open/covered/heated storage):

1.3 Lifting gear (lifting capacity, lifting height):

1.4 Machining equipment and tools:

1.5 Welding and cutting equipment, machines and plant:

1.6 Baking ovens and heatable containers for welding consumables (type, number, maximum temperature):

1.7 Welding jigs (e.g. turntables, manipulators):

1.8 Equipment for preheating, post-weld heat treatment and temperature measurement:

1.9 Available test equipment and test media (for destructive and non-destructive testing, container test bed etc.):

1.10 Other information (e.g. flame descaling/priming facilities):
2. **Scope of approval sought** (classification of materials, welding processes [details in accordance with EN 24063/ISO 4063], welding consumables and auxiliary materials etc. If necessary continue on separate sheets):

<table>
<thead>
<tr>
<th>Components:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Weld factor 1):</td>
<td></td>
</tr>
<tr>
<td>Material(s):</td>
<td></td>
</tr>
<tr>
<td>Plate/wall thicknesses; pipe diameters:</td>
<td></td>
</tr>
<tr>
<td>Types of weld, weld forms:</td>
<td></td>
</tr>
<tr>
<td>WPS No.:</td>
<td></td>
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<tr>
<td>Welding process:</td>
<td></td>
</tr>
<tr>
<td>Welding position(s):</td>
<td></td>
</tr>
<tr>
<td>Welding consumables and auxiliary materials:</td>
<td></td>
</tr>
<tr>
<td>Heat treatment 2):</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
</tbody>
</table>

1) Where applicable, e.g. for pressure vessels
2) Where applicable, e.g. stress-relief annealing

3. **Welding Personnel**

3.1 Welding Supervisor(s) (surname(s) and first name(s)):

- Welding qualifications 1) given as:
  - Date: Place:
  - Area of responsibility:
  - Reporting to (relationship):

3.2 Deputy welding supervisor(s) (surname(s) and first name(s)):

- Welding qualifications 1) given as:
  - Date: Place:
  - Area of responsibility:
  - Reporting to (relationship):

1) Vocational training and employment are listed in tabular form and enclosed; copies of certificates are attached.
3.3 Welders/operators (if necessary, continue on separate sheet):

<table>
<thead>
<tr>
<th>Surname, first name</th>
<th>No.:</th>
<th>Test basis (Rules, standard etc.)</th>
<th>Test designation (e.g. conforming to EN 287/ISO 9606)</th>
<th>Initial test date</th>
<th>Testing body</th>
<th>Last repeat test date</th>
<th>Testing body</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

3.4 In-house training for welders: yes □ no □ 3)

4. Inspection supervisors and inspection personnel 4):

5. Existing recognitions, verifications, confirmations, aptitude certificates, certificates, awards, approvals, etc.:

Welding supervisor(s)

Place ___________________ Date ___________________ Company stamp / signature

Annex(es):

3) Tick as applicable
4) Proof of qualification attached
Appendix 3

ASSESSMENT FORM FOR WELDER QUALIFICATION TEST CERTIFICATION

Welder’s qualification test according to BRS Rules for Welding ISO 9606 / EN 287-1

<table>
<thead>
<tr>
<th>Manufacturer’s Welding Procedure Specification:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference No. (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Test group:</td>
<td></td>
</tr>
<tr>
<td>Name:</td>
<td>_______________________</td>
</tr>
<tr>
<td>First Name:</td>
<td>_______________________</td>
</tr>
<tr>
<td>Date of birth:</td>
<td>_______________________</td>
</tr>
<tr>
<td>Place of birth:</td>
<td>_______________________</td>
</tr>
<tr>
<td>Method of identification:</td>
<td>_______________________</td>
</tr>
<tr>
<td>Kind:</td>
<td>_______________________</td>
</tr>
<tr>
<td>Test by order of:</td>
<td>_______________________</td>
</tr>
<tr>
<td>carried out on:</td>
<td>_______________________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test piece</th>
<th>Weld test details</th>
<th>Other information to material, filler metal, shielding gas etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plate / Tube</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filler metal type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shielding gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliaries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test piece thickness (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe outside diameter (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welding position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backing / Gouging</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of the test pieces to EN 25817 / ISO 5817 (Steel) EN 30042 / ISO 10042 (Aluminum)

<table>
<thead>
<tr>
<th>Material test</th>
<th>Material test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiography</td>
<td>Bend test</td>
</tr>
<tr>
<td>Visual test</td>
<td>Fillet weld (a)</td>
</tr>
<tr>
<td>Magnetic practical test</td>
<td>Additional test</td>
</tr>
<tr>
<td>Penetrant test</td>
<td>Job knowledge</td>
</tr>
</tbody>
</table>

MarcoFracture test

Signature

Following additional rules were considered (TRD, AD-leaflet, etc.)

<table>
<thead>
<tr>
<th>Place</th>
<th>Date</th>
<th>Signature</th>
</tr>
</thead>
</table>

- 95 -
Appendix 4

WELDING PROCEDURE

I. Manufacturer’s Welding Procedure Specification (WPS)

Company:
Full address:
Works/work's division:
Full address:
Telephone No. Fax No.: Telex: E-mail address:
Responsible welding supervisor:

Welding Procedure Specification (WPS) No.: Parent material(s) specification:
Test report (WPAR) No.: Material thickness [mm]:
Welding Process: Outside diameter [mm]:
Joint type:
Welding position(s): Method of preparation and cleaning:

Joint preparation details (sketch):

<table>
<thead>
<tr>
<th>Joint design</th>
<th>Welding sequences</th>
</tr>
</thead>
</table>

Welding details:

<table>
<thead>
<tr>
<th>Run</th>
<th>Process</th>
<th>Size of filler metal</th>
<th>Current [A]</th>
<th>Voltage [V]</th>
<th>Type of current/polarity</th>
<th>Wire feed speed</th>
<th>Travel speed* [cm/min]</th>
<th>Heat input * [J/cm]</th>
</tr>
</thead>
</table>

Filler metal classification:
– Brand name: Manufacturer:
– Any special baking or drying:

Gas / flux;
– shielding: backing;
– Brand name: Manufacturer
– flux: backing

Gas flow rate
– shielding: backing

Tungsten electrode type/diameter:

Gouging/backing:

Preheating temperature:

Interpass temperature:

Post-weld treatment and/or aging*:
– Time, temperature, method:
– Heating and cooling rate:

Other information*, e.g.:
– Weaving (max. width of run):
– Oscillation: amplitude, frequency, dwell time:
– Pulse welding details:
– Stand-off distance:
– Plasma welding details:
– Touch angle:

Welding over shop primer*:
– Brand name:

Other:

____________________________________
Manufacturer’s welding supervisor
(Name, date, signature)

* If required
II. Welding procedure test / production test – details relating to specimen welds

Company: Test report (WPAR) Nr.: Location (of specimen welding), works/works division: Welding Procedure Specification (WPS) No.: Welding supervisor: Parent material(s) specification: Welder's name: Material thickness [mm]: Date of test: Outside diameter [mm]: Examiner or test body: Joint type: Welding Process: Method of preparation and cleaning:

Joint preparation details (sketch):

<table>
<thead>
<tr>
<th>Joint design</th>
<th>Welding sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Welding details:

<table>
<thead>
<tr>
<th>Run</th>
<th>Process</th>
<th>Size of filler metal</th>
<th>Current [A]</th>
<th>Voltage [V]</th>
<th>Type of current/polarity</th>
<th>Wire feed speed [cm/min]</th>
<th>Travel speed* [J/cm]</th>
<th>Heat input * [J/cm]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Filler metal classification: Post-weld treatment and/or aging*:
– Brand name: Manufacturer: – Time, temperature, method:
– Any special baking or drying: – Heating and cooling rate:
Gas / flux:
– shielding: backing; Other information*, e.g.:
– Brand name: Manufacturer – Weaving (max. width of run):
– flux: backing;
Gas flow rate
– shielding: backing: – Oscillation: amplitude, frequency, dwell time:
Tungsten electrode type/diameter:
Gouging/backing:
Preheating temperature:
Interpass temperature:
– Touch angle:
– Plasma welding details:
– Stand-off distance:
Shop primer*:
Other:

We hereby confirm that the specimen welds have been prepared and performed satisfactorily using the data listed above, in accordance with the Rules for Welding issued by Bulgarian Register of Shipping.

________________________________________  __________________________________
Welding supervisor                              Society's Surveyor
(Name, date, signature)                                                  (Name, date signature)
### III. Welding procedure test / production test – test results

#### Company:

Test report (WPAR) Nr.:

Examiner or test body:

Welding Procedure Specification (WPS) No.:

<table>
<thead>
<tr>
<th>Non-destructive testing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test method</td>
<td>Results</td>
</tr>
<tr>
<td>Visual inspection:</td>
<td></td>
</tr>
<tr>
<td>Radiographic test:</td>
<td></td>
</tr>
<tr>
<td>Ultrasonic test:</td>
<td></td>
</tr>
<tr>
<td>Magnetic particle test:</td>
<td></td>
</tr>
<tr>
<td>Dye penetrant test:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test method</th>
<th>Results</th>
<th>Test report no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual inspection:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiographic test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultrasonic test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic particle test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dye penetrant test:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tensile tests</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimen Form/No.:</td>
<td>Dimen-</td>
</tr>
<tr>
<td></td>
<td>sions</td>
</tr>
<tr>
<td>Requirements</td>
<td></td>
</tr>
</tbody>
</table>

| Requirements | | | | | | | | | |

<table>
<thead>
<tr>
<th>Bend tests</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimen, From/No.:</td>
<td>Dimension</td>
</tr>
<tr>
<td></td>
<td>[mm]</td>
</tr>
<tr>
<td>Requirements</td>
<td></td>
</tr>
</tbody>
</table>

| Requirements | | | | | |

<table>
<thead>
<tr>
<th>Notched bar impact test:</th>
<th>Shape of specimen;</th>
<th>Sizes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Requirements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Requirements | | | | | |
Hardness tests

<table>
<thead>
<tr>
<th>Position of measurement (sketch/diagram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base material</td>
</tr>
</tbody>
</table>

Fracture tests:

- [ ] butt weld
- [ ] fillet weld

Position of fracture:

Results:

Metallographic examinations:

Results (if necessary attach photographs/explanations on a separate sheet):

Other tests:

Type:

Results:

The trial welds were made and the tests performed in accordance with the requirements of the Rules for Welding issued by Bulgarian Register of Shipping and also the following Rules:

- [ ] The results meet the requirements
- [ ] The results do not meet the requirements

Welding supervisor
(Name, date, signature)

Examiner or test body
(Name, date, signature)

Society's Surveyor
(Name, date, signature)
Appendix 5

WELDING CONSUMABLES AND AUXILIARY MATERIALS

Welding Consumables and Auxiliary Materials

Information for approval purposes – Appendix to the Application in accordance with Appendix 1

Electrode/Wire  □ Manufacturer □ Supplier □ Distributor □ Licenses (where applicable):
Company name, full address:
Full address:
Telephone No.:         Fax No.:           E-mail address:
Address for approval certification:
Contact / Department:

Flux/shielding gas  □ Manufacturer □ Supplier □ Distributor □ Licenses (where applicable):
Company name, full address:
Telephone No.:         Fax No.:           E-mail address:
Address for approval certification:
Contact / Department:
Details relating to consumable/auxiliary material:
Type of consumable/auxiliary material:

☐ Filler wire         ☐ Solid wire-gas combination
☐ Welding rod        ☐ Flux-cored wire-gas combination
☐ Covered electrode  ☐ Solid-wire flux combination
☐ Flux-cored wire    ☐ Flux-cored wire-flux combination
☐ Other (describe)

Brand designation of welding consumable ((flux-cored) wire, electrode, etc.):
Brand designation of auxiliary material (shielding gas, flux, etc.):
Classification to standards (EN, ISO etc.):

Intended scope of approval / range of application:
Quality grade for which application is made and added symbol:
Base materials to be joined by welding:
Welding positions for which approval is sought:
Dimensions for which approval is sought (diameters, lengths of products):
Welding current, polarity:
(Post-weld) heat treatment conditions:
Special application conditions (e.g. minimum or maximum application temperature):
Rules for Application (e.g. re-baking, post-weld heat treatment):
Marking, Packing:

Other information, attached documents.
Preconditions for awarting the "Ü"-symbol for the construction supervision field also checked?  ☐ yes ☐ no
Verifications of identity ("Affidavits") for transfers of approval attached?  ☐ yes ☐ no
Approval test programme attached?  ☐ yes ☐ no
Approval test records attached?  ☐ yes ☐ no