
**Specification and qualification of welding
procedures for metallic materials —
Welding procedure test —**

**Part 13:
Resistance butt and flash welding**

*Descriptif et qualification d'un mode opératoire de soudage pour les
matériaux métalliques — Épreuve de qualification d'un mode opératoire
de soudage —*

*Partie 13: Soudage en bout par résistance pure et soudage par
étincelage*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15614-13 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding*, in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*, in accordance with the Agreement on Technical cooperation between ISO and CEN (Vienna Agreement).

ISO 15614 consists of the following parts, under the general title *Specification and qualification of welding procedures for metallic materials — Welding procedure test*:

- *Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*
- *Part 2: Arc welding of aluminium and its alloys*
- *Part 3: Arc welding of cast iron*
- *Part 4: Finishing welding of aluminium castings*
- *Part 5: Arc welding of titanium, zirconium and their alloys*
- *Part 6: Arc welding of copper and its alloys*
- *Part 7: Overlay welding*
- *Part 8: Welding of tubes to tube-plate joints*
- *Part 9: Arc underwater hyperbaric wet welding*
- *Part 10: Hyperbaric dry welding:*
- *Part 11: Electron and laser beam welding*
- *Part 12: Spot, seam and projection welding*
- *Part 13: Resistance butt and flash welding*

For the purposes of this part of ISO 15614, the CEN annex regarding fulfilment of European Council Directives has been removed.

Introduction

All new welding procedure qualifications are to be carried out in accordance with this part of ISO 15614 from the date of its issue.

However, this part of ISO 15614 does not invalidate previous welding procedure qualifications made to standards or specifications, provided the intent of the technical requirements is satisfied and the previous welding procedure qualifications are relevant to the application and production work on which they are to be employed.

Also, where additional tests have to be carried out to make the qualification technically equivalent, it is only necessary to do the additional tests on a test piece which should be made in accordance with this part of ISO 15614.

Requests for official interpretations of any aspect of this part of ISO 15614 should be directed to the Secretariat of ISO/TC 44/SC 10 via the national standards body, a complete listing of which can be found at www.iso.org.

Specification and qualification of welding procedures for metallic materials — Welding procedure test —

Part 13: Resistance butt and flash welding

1 Scope

This part of ISO 15614 specifies the tests which should be used for qualification of welding procedure specifications.

It applies to resistance butt welding and flash welding of metallic materials, e.g. with solid, tubular, flat or circular cross-section. The basic principles of this part of ISO 15614 may be applied to other resistance welding processes when this is specified in the specification.

NOTE This part of ISO 15614 is a part of a series of standards. Details of this series are given in ISO 15607:2003, Annex A.

This part of ISO 15614 defines the conditions for carrying out tests and the limits of validity of a qualified welding procedure for all practical welding operations covered by this part of ISO 15614.

The tests required to qualify the procedure for a particular component/assembly depend on the performance and quality requirements of the component/assembly and should be defined in the design specification.

The tests should be carried out in accordance with this part of ISO 15614, unless more severe tests are specified by the relevant application standard or specification, when these apply.

NOTE Specific service, material, or manufacturing conditions may require more comprehensive testing than is specified by this part of ISO 15614.

Such tests may include:

- microsections;
- fatigue or endurance tests;
- impact test;
- radiographic test;
- ultrasonic test;
- corrosion test;
- tests of components or complete welded assemblies.

This part of ISO 15614 covers the following resistance welding processes as defined in ISO 4063:

- 24 flash welding, using direct current or alternating current with various movement sequences, constant flashing and pulsed flashing;
- 25 resistance butt welding, using direct current or alternating current with various pressure sequences.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1289, *Non-destructive examination of welds — Penetrant testing of welds — Acceptance levels*

EN 1291, *Non-destructive examination of welds — Magnetic particle testing of welds — Acceptance levels*

EN 1418, *Welding personnel — Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials*

EN 1711, *Non-destructive examination of welds — Eddy current examination of welds by complex plane analysis*

EN 1712, *Non-destructive examination of welds — Ultrasonic examination of welded joints — Acceptance levels*

EN 1713, *Non-destructive examination of welds — Ultrasonic examination — Characterization of indications in welds*

ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 4136¹⁾, *Destructive tests on welds in metallic materials — Transverse tensile test*

ISO 5173²⁾, *Destructive tests on welds in metallic materials — Bend tests*

ISO 6520-2, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 2: Welding with pressure*

ISO 9015-1³⁾, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints*

ISO 9015-2⁴⁾, *Destructive tests on welds in metallic materials — Hardness testing — Part 2: Microhardness testing of welded joints*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*

ISO 14271, *Vickers hardness testing of resistance spot, projection and seam welds (low load and microhardness)*

ISO 15607:2003, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO/TR 15608:2000, *Welding — Guidelines for a metallic materials grouping system*

1) Standard equivalent to EN 895.

2) Standard equivalent to EN 910.

3) Standard equivalent to EN 1043-1.

4) Standard equivalent to EN 1043-2.

ISO 15609-5, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 5: Resistance welding*

ISO 15620:2000, *Welding — Friction welding of metallic materials*

ISO 17637⁵⁾, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17638⁶⁾, *Non-destructive testing of welds — Magnetic particle testing*

ISO 17639⁷⁾, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

ISO 17640⁸⁾, *Non-destructive examination of welds — Ultrasonic examination of welded joints*

ISO 20482, *Metallic materials — Sheet and strip — Erichsen cupping test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15607 and ISO 6520-2 apply.

4 Preliminary welding procedure specification (pWPS)

The preliminary welding procedure specification shall be prepared in accordance with ISO 15609-5. It shall specify all relevant parameters and requirements.

5 Welding procedure test

The manufacturing and testing of components and/or test pieces representing the type of welding used in production shall be in accordance with Clauses 6 and 7.

The resistance-weld setter, who undertakes the welding procedure test satisfactorily in accordance to this part of ISO 14614, shall be qualified for the appropriate range of qualification given in EN 1418.

6 Test piece and test specimen

6.1 General

The welded assembly, to which the welding process will relate in production, shall be represented by actual components or by manufacturing a standardized test piece, according to 6.2.

Test specimens shall be cut from actual components; the test pieces are welded separately according to 6.2. In some cases, e.g. small solid bars or small tubes, the work piece will be tested directly.

5) Standard equivalent to EN 970.

6) Standard equivalent to EN 12903.

7) Standard equivalent to EN 1321.

8) Standard equivalent to EN 1714.

6.2 Shape and dimensions of test specimens

6.2.1 General

The specimens or the test pieces shall be of sufficient number and/or size to allow all required tests to be carried out. They shall correspond to the test procedure and the component to be welded.

Additional test pieces/specimens, which are larger than the minimum allowed, can be manufactured for subsequent tests and for back-up tests. The type and number of tests can be seen in Table 1.

If not otherwise specified, test specimens of the shape and dimensions stipulated in 6.2.2 to 6.2.6 shall be used.

Table 1 — Testing and examination of the test specimens

Test specimen	Test type	Extent of test		Footnote
		A	B	
Bars/rods	Visual examination Penetrant test Tensile test Bend test Macrosection Hardness test	every weld every weld 3 specimens 6 specimens 1 weld 1 meas.row	every weld every weld — 2 specimens — —	a a b b, g
Hollow profile	Visual examination Penetrant test Tensile test Bend test Macrosection Hardness test	every weld every weld 3 specimens 6 specimens 1 weld 1 meas.row	every weld every weld 2 specimens 2 specimens — —	a a, c, f g
Sheet metal and strips	Visual examination Penetrant test Tensile test Bend test Cupping test Macrosection Hardness test	every weld every weld 3 /weld 3 /weld 3 /weld 3 /weld 1 meas.row	every weld — 2 /weld 2 /weld — — —	d d d, e d, e, f d, e, f d, e b, g
Depending on the application, two optional test classes should be distinguished according to the load:				
— Column A: For application under static stress up to the highest fatigue stress for the parent material.				
— Column B: For application under static stress of up to 50 % of the level allowed for the parent material.				
Abbreviations: 3 /weld = 3 specimens for each weld joint.				
<p>^a When the used test pieces are large enough, more than one specimen can be taken from one weld joint.</p> <p>^b Not required for steels in group 1 in accordance with ISO/TR 15608:2000 under static loading except for low temperature applications.</p> <p>^c With thin wall thicknesses, it is an advantage to carry out the cupping test instead of the bend test. A level surface of 70 mm in diameter is required for the cupping test (see 7.3.3). Circular tubes with thin walls can be tested using the petal test (see 7.3.4).</p> <p>^d At least two welds shall be carried out.</p> <p>^e One test specimen from each edge and one from the middle; if column B is relevant, one specimen from the edge and one from the middle.</p> <p>^f The cupping test is preferred for steels which have a tensile strength up to 450 N/mm² and wall thicknesses up to 5 mm. For higher tensile strength(s) and/or thicker materials, use the bend test. With aluminium materials, the deformation capacity of the unaffected parent material determines the wall thickness, up to which the cupping test can be used for the welded joints.</p> <p>^g Measuring row in a macrosection transverse to the weld.</p>				

6.2.2 Test specimen for the tensile test

The test specimen shall be prepared in accordance with EN 10002-1, while also taking into account ISO 4136, always provided this is applicable to butt-welded joints.

6.2.3 Test specimen for the bend test

The test specimen shall be prepared in accordance with ISO 5173.

6.2.4 Test specimen for the cupping test

The test specimen shall be prepared in accordance with ISO 20482.

6.2.5 Test specimen for the hardness test

The test specimen shall be prepared in accordance with ISO 9015-1 and ISO 9015-2.

A macrosection transverse to the weld shall be prepared and etched in order to show clearly the weld zone, the heat-affected zones (HAZ) and the unaffected parent material.

6.2.6 Test specimen for the petal test on thin sheets

The test specimen shall be prepared in accordance with ISO 15620:2000, 7.2, Figure 8.

Any deviations from these requirements have to be defined in the design specification.

6.3 Welding of components, test pieces or test specimens

Preparation of components, test pieces or test specimens and welding of the test pieces or specimens shall be carried out in accordance to the pWPS and the general requirements of the corresponding manufacturing process. Welding and testing of the test pieces or specimens shall be witnessed by an examiner or an examining body as defined in the specification.

7 Testing and examination

7.1 Extent of testing

The testing includes both non-destructive and destructive testing. It also shall correspond with the quality requirements of the component to be welded, as well as the requirements stated in Table 1.

The size of the test specimens shall include the zone which is liable to failure, even outside the heat affected zone (HAZ).

7.2 Non-destructive testing

7.2.1 General

For an effective testing of the specimens, their condition shall comply with the specifications in the respective standards, e.g. complete burr removal for the penetrant test.

7.2.2 Visual examination

Visual examination shall be carried out in accordance with ISO 17637. Use a magnifying glass (six- to ten-fold magnification) to inspect the welds for visible imperfections, such as surface cracks. Metal expulsion and weld burr shall also be taken into consideration if they have not been removed directly after the welding process.

7.2.3 Penetrant test

Penetrant testing shall be carried out in accordance with EN 1289.

7.2.4 Magnetic particle test

Magnetic particle testing of ferromagnetic materials shall be carried out in accordance with ISO 17638 and EN 1291 in place of penetrant testing (see 7.2.3).

7.2.5 Eddy current test

Eddy current testing of ferritic materials shall be carried out in accordance with EN 1711 in place of penetrant testing and magnetic particle testing (see 7.2.3 and 7.2.4).

7.2.6 Ultrasonic test

Ultrasonic testing shall be carried out in accordance with EN 1712, EN 1713 and EN 17640.

7.3 Destructive tests

7.3.1 Tensile test

Tensile testing shall be carried out in accordance with EN 10002-1.

7.3.2 Bend test

Bend testing shall be carried out in accordance with ISO 5173.

7.3.3 Cupping test

The cupping test shall be carried out in accordance with ISO 20482.

7.3.4 Petal test

Petal testing shall be carried out in accordance with ISO 15620.

7.4 Macrosection

The test specimen shall be prepared as a cross-section cut through the weld, it shall then be etched to show the weld, the heat-affected zone (HAZ) and the unaffected parent material. The test shall be carried out in accordance with ISO 17639.

7.5 Hardness distribution

The surface of the cross-section to be tested shall be properly prepared and preferably etched, so that accurate measurements of the diagonal of the indentations can be obtained in the different zones of the welded joint. The hardness can be determined in one or more traces. A trace consists of a row of hardness indentations, whereby all individual indentations are in a straight line. In the case of a circular cross-section, if only one trace has been defined in the design specification, the trace shall be arranged as a parallel at 0,6 times the radius to the centre axis. With a steel sheet section, the trace shall be of 0,6 times the sheet thickness and positioned parallel to the sheet surface. The hardness measurement shall be carried out in accordance with ISO 14271.

7.6 Re-testing

If the component or test piece fails to comply with any of the requirements for visual examination or non-destructive testing (NDT) specified, one further component or test piece shall be welded and subjected to the

same tests. If the test results of this additional component or test piece also do not comply with the requirements, the welding procedure test has failed.

If any test specimen fails to comply with the requirements for destructive testing, but only due to weld imperfections, two further test specimens shall be obtained for each one that failed. Each additional test specimen shall be subjected to the same tests as the initial test specimen that failed. If either of the additional test specimens does not comply with the requirements, the welding procedure test has failed.

8 Range of qualification

8.1 General

All of the conditions of 8.1 to 8.5 shall be met independently of each other.

Changes outside the ranges specified require a new welding procedure test.

8.2 Related to the manufacturer

A qualification of a welding procedure specification (WPS) obtained by a manufacturer is valid for welding in workshops or sites under the same technical and quality control of that manufacturer.

8.3 Related to the parent metal

All tests shall be carried out with materials as used in production (shape, thickness, chemical analysis, mechanical properties, heat treatment). Any modification shall be defined in the specification.

8.4 Welding procedures

8.4.1 Welding process

The qualification only applies to the welding process used in the welding procedure test.

8.4.2 Welding equipment

The qualification only applies to the welding equipment actually used in the welding procedure test.

8.4.3 Postweld heat treatment

The qualification only applies for heat treatment used in the welding procedure test. Changes to the heat treatment, or deletion of heat treatment, requires requalification of the WPS.

8.5 Test certificate

An example of the form of a test certificate is shown in Annex A.

9 Welding procedure qualification record (WPQR)

The result of every test performed for each welded assembly, including additional tests, shall be recorded in a Welding Procedure Qualification Record (WPQR). All relevant items listed for the WPS in ISO 15609-5 shall be included, together with details for causes for rejection under Clause 7. On completion of satisfactory tests, the WPS shall be signed and dated by the examiner or examining body.

A WPQR-form should be used for entering details of the welding process and test results. This enables easier attainment of a uniform description and assessment of the information in this document. Annex B contains an example of a WPQR form.

Annex A
(informative)

Example of welding procedure qualification — Test certificate

Manufacturer's welding procedure test

Flash welding ⁹⁾

Resistance butt welding ⁹⁾

Document No.:

Date of welding procedure test:

Examiner or examining body:

Address:

Manufacturer:

Address:

Regulation/test standards:

Extent of testing:

Parent material(s):

Pretreatment of the materials:

Welding process:

Weld cross-section (mm²):

Average thickness (mm):

Average width (mm):

If tube or circular bar material:

Outside diameter (mm):

Wall thickness (mm):

Welding equipment/machine :

Manufacturer:

Type:

Year of manufacture:

Inventory No.:

Current mode: alternating current ⁹⁾ direct current ⁹⁾

Weld program:

Postweld heat treatment:

⁹⁾ Cross out what is not applicable.

Additional information :

We hereby confirm that the test welds have been carried out in accordance with the conditions required by the given regulations and test standards. Test pieces have been satisfactorily prepared, welded and tested.

Place

Examiner or examining body

Date

Name and signature

Annex B (informative)

Example of welding procedure qualifications record form (WPQR)

B.1 General

WPQR – No.:

Date:

Manufacturer:

Place:

Weld setter

Name:

Qualification:

Examiner or examining body:

Document No.:

Welding process:

Flash welding ¹⁰⁾

Resistance butt welding ¹⁰⁾

B.2 Welding equipment

Welding machine manufacturer:

Type:

Inventory No.:

Current mode:

AC ¹⁰⁾

DC ¹⁰⁾

B.3 Welding task

Drawing No.:

Sketch of the weld cross-section:

Cross-section (mm²):

Average wall thickness (mm):

Component in closed shape (ring): no ¹⁰⁾

yes ¹⁰⁾

¹⁰⁾ Cross out what is not applicable.

Throat length h (mm):

(according to Figure B.1, if base cross-sections are different)

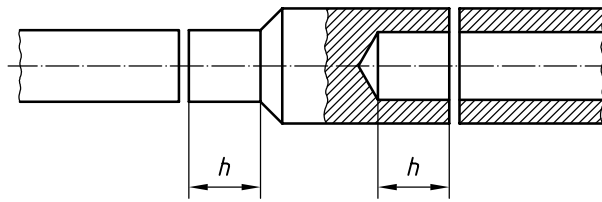
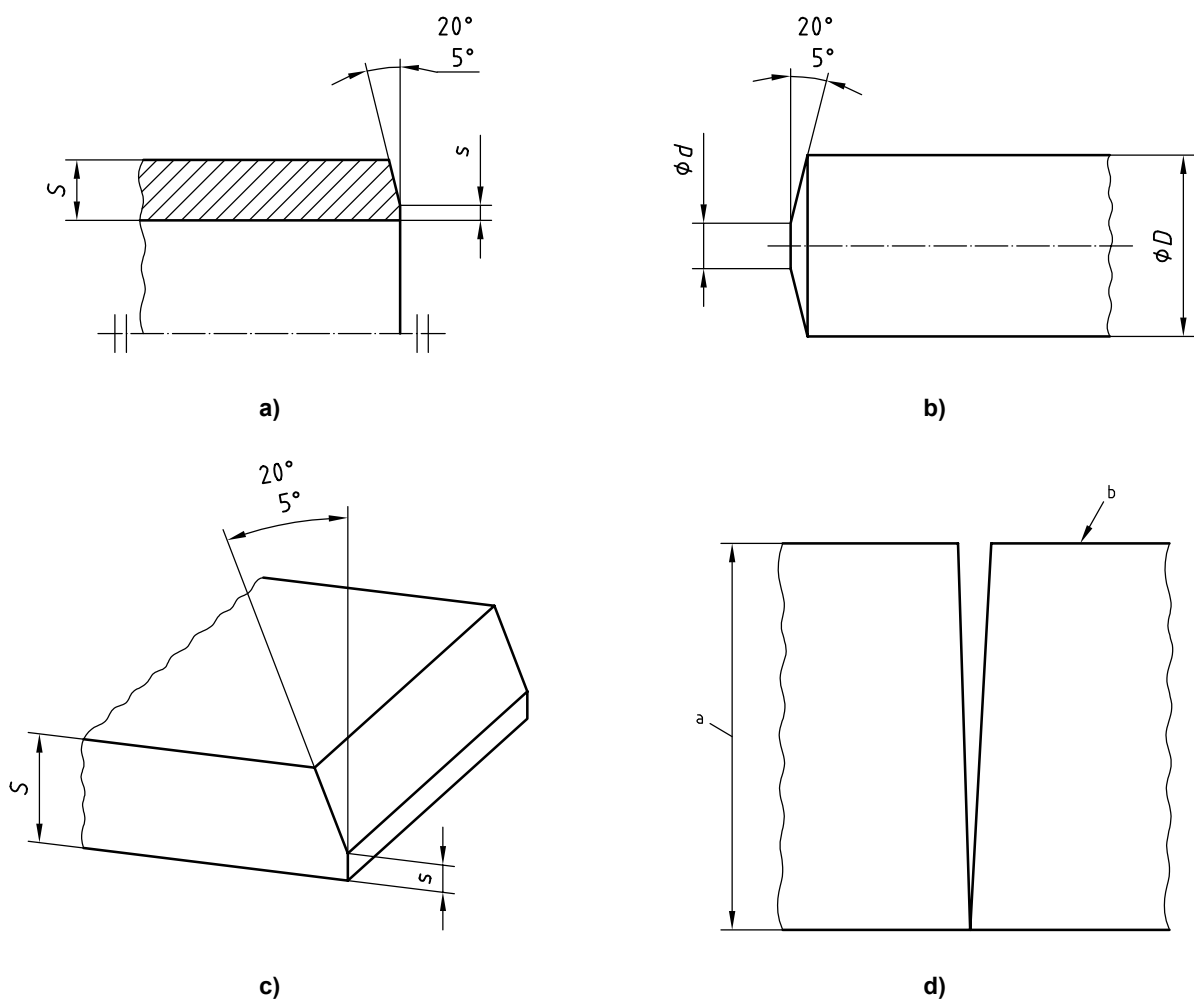


Figure B.1 — Throat depth in the case of different cross-sections

Edge preparation according to Figures B.2 a) to B.2 d) :



$$\frac{s}{S} = \frac{1}{4}$$

$$\frac{d}{D} = \frac{1}{4}$$

a Sheet width.

b Side nearest power supply.

Figure B.2 — Edge preparation for resistance butt or flash welding

Parent material(s):

Preparation and/or cleaning method:

B.4 Machine settings

Electrical settings :

Transformer tap:

Secondary voltage (V): (open circuit)

Mechanical settings :

Initial electrode distance (mm):

Clamping length left side (mm):

Clamping length right side (mm):

Clamping pressure/force left side (bar/N):

Clamping pressure/force right side (bar/N):

Welding parameter:

Welding parameter for flash welding according to Table B.1.

Welding parameter for resistance butt welding according to Table B.2.

Table B.1 — Welding parameter settings for flash welding

Process step	Welding parameter settings								
	Force kN	Secondary voltage %	Step limitation		Current on/off sequence			Plate speed	
			Travel mm	Time s	On-time s	Off-time s	No. of cycles	v_o mm/s	v_e mm/s
Initial flashing		100	3					0,4	0,8
Pause time				—					
Preheating	5	50	4	3,5	0,5	0,2	5	—	—
Linear flashing		100	8	—				0,8	1,4
Progressive flashing		100	11	—				1,4	3
Upsetting	10	70	16	1,4	1,2	0,2	1		
Postheating	8	30	—	1,8	0,3	0,3	3		

Table B.2 — Welding parameter settings for resistance butt welding

Process step	Welding parameter settings								
	Force kN	Secondary voltage %	Step limitation		Current on/off sequence			Plate speed	
			Travel mm	Time s	On-time s	Off-time s	No. of cycles	v_o mm/s	v_e mm/s
Force increase time	5		—	1				5	
Heating	5	60	4	3	3	0	1		
Upsetting	12	85	10	3,5	0,5	0,8	1	60	—
Postheating	6	30	—	—	0,2	0,3	3	—	—

Data in the parameter list or measuring units (e.g. scale divisions) should be in accordance with the machine settings.

Additional information:

Postheating outside the machine:

Manufacturer / Weld setter

Examiner or examining body:

Name, Date, Signature

Name, Date, Signature

B.5 Testing and examination

Non-destructive examination

Visual examination

Penetrant testing ¹¹⁾

Magnetic particle examination/testing ¹¹⁾

Eddy current examination ¹¹⁾

Ultrasonic examination ¹¹⁾:

Destructive tests

Temperature:

Tensile test:

Test specimen form:

Test specimen thickness (mm):

Test specimen width (mm):

Test specimen diameter (mm):

Test specimen	Yield stress R_{eH} N/mm ²	Tensile strength R_m N/mm ²	Reduction of area Z %	Fracture location	Imperfection	Remarks

Bend test :

Test specimen thickness (mm):

Test specimen width (mm):

Bending former diameter (mm):

Distance between rollers (mm):

Roller diameter (mm):

¹¹⁾ If required.

Specimen	Bending angle °	Fracture location ¹¹⁾	Imperfection	Remarks

Cupping test ¹¹⁾

Ball diameter (mm): Cupping (mm):

Metallographic examination

Macrosection:

Microsection ¹¹⁾:

Hardness test

Load factor: HV

Measuring point position (sketch):

Measured values:

Additional tests:

Remarks:

These tests were carried out in accordance with the requirements of:

Laboratory report No.:

The test results are satisfactory/not satisfactory. ¹²⁾

The tests were carried out in the presence of:

(Examiner or examining body)

Name, Date and Signature

¹²⁾ Cross out what is not applicable.

