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Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 13: Upset (resistance butt) and flash welding (ISO 15614-13:2012)

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 (ISO 15614-13:2012)

Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe - Schweißverfahrensprüfung - Teil 13: Pressstumpf- und Abbrennstumpfschweißen (ISO 15614-13:2012)

This European Standard was approved by CEN on 30 June 2012.

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Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN ISO 15614-13:2012) has been prepared by Technical Committee ISO/TC 44 “Welding and allied processes” in collaboration with Technical Committee CEN/TC 121 “Welding” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2013, and conflicting national standards shall be withdrawn at the latest by January 2013.

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

This document supersedes EN ISO 15614-13:2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 15614-13:2012 has been approved by CEN as a EN ISO 15614-13:2012 without any modification.

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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 Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding and allied mechanical joining*.

This second edition cancels and replaces the first edition (ISO 15614-13:2005), which has been technically revised.

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: Fusion welding of non-alloyed and low-alloyed cast irons*

— *Part 4: Finishing welding of aluminium castings*

— *Part 5: Arc welding of titanium, zirconium and their alloys*

— *Part 6: Arc and gas 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: Upset (resistance butt) and flash welding*

— *Part 14: Laser-arc hybrid welding of steels, nickel and nickel alloys*

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 your national standards body. A complete listing of these bodies can be found at www.iso.org.

Introduction

It is intended that all new welding procedure qualifications 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 other standards or specifications, provided the intent of its 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 necessary only to perform the additional tests on a test piece made in accordance with this part of ISO 15614.

The various parts of ISO 15614 comprise, in their turn, a series of International Standards on welding, details of which are given in ISO 15607:2003, Annex A.

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

Part 13: Upset (resistance butt) and flash welding

1 Scope

This part of ISO 15614 specifies tests for the qualification of welding procedure specifications applicable to upset (resistance butt) welding and flash welding of metallic materials, e.g. with solid, tubular, flat or circular cross-section. Its basic principles can also be applied to other resistance welding processes when this is stated in the specification.

This part of ISO 15614 defines the conditions for carrying out tests and the limits of validity of a qualified welding procedure for all the practical welding operations that it covers. The tests required to qualify the procedure for a particular component or assembly depend on the performance and quality requirements of the component or assembly, as defined in the design specification. The tests are intended to be carried out in accordance with the requirements of this part of ISO 15614, unless more severe tests are specified by the relevant application standard or specification and when these apply.

NOTE Specific service, material, or manufacturing conditions can require more comprehensive testing than specified by this part of ISO 15614. Such tests can include microsections, fatigue or endurance tests, impact tests, radiographic testing, ultrasonic testing, corrosion testing and 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 upset 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.

ISO 4063:2009, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test*

ISO 5173, *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 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

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

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

ISO 11666, *Non-destructive testing of welds — Ultrasonic testing of welded joints — Acceptance levels*

ISO 14271, Resistance welding — *Vickers hardness testing (low force and microhardness) of resistance spot, projection, and seam welds*

ISO 14732, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials*

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

ISO/TR 15608:2005, *Welding — Guidelines for a metallic materials grouping system*

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 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17638, *Non-destructive testing of welds — Magnetic particle testing*

ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

ISO 17643, *Non-destructive testing of welds — Eddy current testing of welds by complex-plane analysis*

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

ISO 23277, *Non-destructive testing of welds — Penetrant testing of welds — Acceptance levels*

ISO 23278, *Non-destructive testing of welds — Magnetic particle testing of welds — Acceptance levels*

ISO 23279, *Non-destructive testing of welds — Ultrasonic testing — Characterization of indications in welds*

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

The preliminary welding procedure specification (pWPS) 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 satisfactorily undertakes the welding procedure test in accordance with this part of ISO 15614 shall be qualified for the appropriate range of qualification given in ISO 14732.

6 Test pieces and test specimens

6.1 General

The welded assembly tested shall be the actual component used in production or a standardized test piece according to references included in 6.2.

Test specimens may be cut from the actual component if required. Test pieces are to be tested separately, in accordance with 6.2.

6.2 Shape and dimensions of test specimens

6.2.1 General

The testing includes non-destructive testing (NDT) and/or destructive testing.

The selection of test types and the number of test specimens depends on the performance, safety and quality requirements of the component or assembly and shall be established before any qualification is undertaken. Examples are given 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 — Examples for testing and examination of test specimens

Test specimen	Test type	Extent of test	
		Test class A	Test class B
Bars/rods	Visual examination	Every weld	Every weld
	Penetrant test	Every weld	Every weld
	Tensile test	Three specimens[a]	—
	Bend test	Six specimens[a]	Two specimens[a]
	Macrosection[b]	One weld	—
	Hardness test[b]	One measuring row[g]	—
Hollow profile	Visual examination	Every weld	Every weld
	Penetrant test	Every weld	Every weld
	Tensile test	Three specimens	Two specimens
	Bend test	Six specimens[a]	Two specimens[a]
	Macrosection[c f]	One weld[a]	—
	Hardness test	One measuring row[g]	—
Sheet metal and strips	Visual examination	Every weld[d]	Every weld[d]
	Penetrant test	Every weld[d]	—
	Tensile test[e]	Three specimens per weld joint[d]	Two specimens per weld joint[d]
	Bend test[e f]	Three specimens per weld joint[d,]	Two specimens per weld joint[d]
	Cupping test[e f]	Three specimens per weld joint[d]	—
	Macrosection[e]	Three specimens per weld joint[d]	—
	Hardness test[b]	One measuring row[g]	—
Depending on the application, two optional test classes should be distinguished, according to the load: A: For application under static stress up to the highest fatigue stress for the parent material. B: For application under static stress of up to 50 % of the level allowed for the parent material.			

[a] When the used test pieces are large enough, more than one specimen can be taken from one weld joint.

[b] Not required for steels in group 1 in accordance with ISO/TR 15608:2005 under static loading except for low temperature applications.

[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).

[d] At least two welds shall be carried out.

[e] One test specimen from each edge and one from the middle; if test class B is relevant, one specimen from the edge and one from the middle.

[f] The cupping test is preferred for steels which have a tensile strength up to 450 N/mm^2 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.

[g] Measuring row in a macrosection transverse to the weld.

6.2.2 Tensile test specimen

The test specimen shall be prepared taking into consideration ISO 4136 and ISO 6892-1 and any standard referenced by the applicable contract or specification.

6.2.3 Bend test specimen

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

6.2.4 Cupping test specimen

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

6.2.5 Hardness test specimen

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 clearly show the weld zone, the heat-affected zones (HAZ) and the unaffected parent material.

6.2.6 Petal test specimen using thin sheets

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

Any deviations from the requirements shall 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 the welding of the test pieces shall be carried out in accordance with the welding procedure specification (WPS) and the general requirements of the corresponding manufacturing process.

7 Testing and examination

7.1 Extent of testing

The testing includes non-destructive and/or destructive testing (see examples in Table 1). It shall meet the quality requirements of the component to be welded.

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

7.2 Non-destructive testing (NDT)

7.2.1 General

For effective testing of specimens, the condition of the specimens 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 ISO 23277.

7.2.4 Magnetic particle test

Ferromagnetic materials shall be subjected to magnetic particle testing in accordance with ISO 17638 and ISO 23278, instead of penetrant testing (7.2.3).

7.2.5 Eddy current test

Ferritic materials shall be subjected to eddy current testing in accordance with ISO 17643, instead of penetrant testing (7.2.3) or magnetic particle testing (7.2.4).

7.2.6 Ultrasonic test

Ultrasonic testing shall be carried out in accordance with ISO 11666, ISO 23279 and ISO 17640.

7.3 Destructive tests

7.3.1 Tensile test

Tensile testing shall be carried out in accordance with ISO 6892-1.

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, which shall then be etched to show the weld, the 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, where 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 the visual examination or 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 is considered to have been failed.

If any test specimen fails to comply with the requirements for destructive testing, due only 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, failed, test specimen. If either of the additional test specimens fails to comply with the requirements, the welding procedure test is considered to have been 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 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 they are used in production (shape, thickness, chemical analysis, mechanical properties and 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 applies only for heat treatment used in the welding procedure test. Changes to the heat treatment, or deletion of heat treatment, require requalification of the WPS.

8.5 Test certificate

An example of the form of a test certificate is shown in Annex A, which may be copied by the user.

9 Welding procedure qualification record

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 in accordance with 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 given. Annex B contains an example of a WPQR form, which may be copied by the user.

Annex A
(informative)

Example of welding procedure qualification — Test certificate

Manufacturer's welding procedure test

Flash welding/Upset (resistance butt) welding [*Cross out whichever is not applicable.*]

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 (mm^2):

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/Direct current [*Cross out whichever is not applicable.*]

Weld program:

Postweld heat treatment:

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/Upset (resistance welding) [*Cross out whichever is not applicable.*]

B.2 Welding equipment

Welding machine manufacturer:

Type:

Inventory No.:

Current mode: Alternating current/Direct current [*Cross out whichever is not applicable.*]

B.3 Welding task

Drawing no.:

Sketch of the weld cross-section:

Cross-section (mm^2):

Average wall thickness (mm):

Component in closed shape (ring): No/Yes [*Cross out whichever is not applicable.*]

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):
Final electrode distance (mm):

Clamping length left side (mm):
Clamping length right side (mm):

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

Welding parameter:

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

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

Table B.1 — Welding parameter settings for flash welding

Process step	Welding parameter settings								
	Force	Secondary voltage	Step limitation		Current on/off sequence			Plate speed	
			Travel	Time	On-time	Off-time	No. of cycles	v_o	v_e
	kN	%	mm	s	s	s		mm/s	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 upset welding

Process step	Welding parameter settings								
	Force	Secondary voltage	Step limitation		Current on/off sequence			Plate speed	
			Travel	Time	On-time	Off-time	No. of cycles	v_o	v_e
	kN	%	mm	s	s	s		mm/s	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 (if required)

Magnetic particle examination/testing (if required)

Eddy current examination (if required)

Ultrasonic examination (if required):

Destructive tests

Temperature:

Tensile test:

Test specimen form:

Test specimen thickness (mm):

Test specimen width (mm):

Test specimen diameter (mm):

Test specimen	Yield strength R_{eH} MPa	Tensile strength R_m MPa	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):

Specimen	Bending angle °	Fracture location (if required)	Imperfection	Remarks

Cupping test (if required)

Ball diameter (mm): Cupping (mm):

Metallographic examination

Macrosection:

Microsection (if required):

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 [*Cross out whichever is not applicable.*]

The tests were carried out in the presence of:

_____

(Examiner or examining body)

_____

Name Date Signature