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

**Part 13:
Upset (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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding and allied mechanical joining*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 15614-13:2021), which has been technically revised.

The main changes are as follows:

- petal test changed to bend test and bend test changed to three-point bend test;
- scope aligned with ISO 15614-1;
- [Clauses 2, 3, 7 and 8](#) updated;
- clause numbering revised;
- [Annex A](#) and Annex B combined into a new [Annex A](#).
- [Table 1](#) modified;
- Clause 9 aligned with ISO 15614-1;

A list of all parts in the ISO 15614 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: <https://committee.iso.org/sites/tc44/home/interpretation.html>.

Introduction

It is intended that all new welding procedure qualifications be carried out in accordance with this document from the date of its publication.

However, this document 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.

The primary purpose of welding procedure qualification is to demonstrate that the joining process proposed for construction is capable of producing joints having the required mechanical properties for the intended application.

Details of the ISO 15614 series are given in ISO 15607:2019, Annex A.

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

Part 13: Upset (resistance butt) and flash welding

1 Scope

This document specifies how a preliminary welding procedure specification (pWPS) is qualified by welding procedure tests.

This document defines the conditions for the execution of welding procedure tests and the range of qualification for welding procedures for all welding operations within the qualification of this document.

Two classes of welding procedure tests are given in order to permit application to a wide range of welded fabrication. They are designated by classes A and B. In class A, the extent of testing is greater and the ranges of qualification are more restrictive than in class B.

Procedure tests carried out to class A automatically qualify for class B requirements, but not vice-versa.

When no class is specified in a contract or application standard, all the requirements of class A apply.

NOTE Class B corresponds to level 1 and class A corresponds to level 2 in accordance with ISO 15614-1.

This document applies to upset (resistance butt) welding and flash welding of any metallic materials in all product forms (e.g. with solid, tubular, flat or circular cross-sections). It covers the following resistance welding processes, as defined in ISO 4063:2023:

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 669, *Resistance welding — Resistance welding equipment — Mechanical and electrical requirements*

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 9015-2, *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 — Acceptance levels*

ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 15607:2019, *Specification and qualification of welding procedures for metallic materials — General rules*

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

ISO 15620:2019, *Welding — Friction welding of metallic materials*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 669, ISO 6520-2 and ISO 15607 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Preliminary welding procedure specification

The pWPS shall be prepared in accordance with ISO 15609-5. It shall specify all relevant parameters and requirements.

5 Welding procedure test

The welding and testing of test pieces shall be in accordance with [Clauses 6](#) and [7](#).

Any weld setter for resistance welding who satisfactorily undertakes the welding procedure test in accordance with this document 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. Test specimens shall be cut from the actual component.

If not possible, comparable welds shall be performed on test specimens according to references included in [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 class A or B, 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

Work piece	Test type	Extent of test ^a	
		Class B	Class A
Bars/rods	Visual test	Every weld	Every weld
	Penetrant test ^b	Every weld	Every weld
	Tensile test	—	Three specimens ^c
	Three-point bend test	Two specimens ^c	Six specimens ^c
	Macrosection ^d	—	One weld
	Hardness test ^d	—	One measuring row ^e
Hollow profile	Visual test	Every weld	Every weld
	Penetrant test ^b	Every weld	Every weld
	Tensile test	Two specimens	Three specimens
	Bend test	Two specimens ^c	Six specimens ^c
	Macrosection ^{d,f}	—	One weld ^c
	Hardness test ^d	—	One measuring row ^e
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 For statistical analysis, a higher number of samples, for example 11, shall be tested to compute average and standard deviation. ^b See 7.2.3. For ferromagnetic materials, magnetic particle testing can be used instead of penetrant testing (see 7.2.4). ^c When the used test pieces are large enough, more than one specimen can be taken from one weld joint. ^d Not required for steels in group 1 in accordance with ISO/TR 15608 under static loading, except for low-temperature applications. ^e Measuring row in a macrosection transverse to the weld. ^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 three-point bend test. With aluminium materials, the deformation capacity of the unaffected parent material determines the sheet thickness up to which the cupping test can be used for the welded joints. ^g At least two welds shall be carried out. ^h 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.			

Table 1 (continued)

Work piece	Test type	Extent of test ^a	
		Class B	Class A
Sheet metal and strips	Visual test	Every weld ^g	Every weld ^g
	Penetrant test ^b	—	Every weld ^g
	Tensile test ^h	Two specimens per weld joint ^g	Three specimens per weld joint ^g
	Three-point bend test ^{f,h}	Two specimens per weld joint ^g	Three specimens per weld joint ^g
	Cupping test ^{f,h}	—	Three specimens per weld joint ^g
	Macrosection ^{d,h}	—	Three specimens per weld joint ^g
	Hardness test ^d	—	One measuring row ^e

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 For statistical analysis, a higher number of samples, for example 11, shall be tested to compute average and standard deviation.

^b See 7.2.3. For ferromagnetic materials, magnetic particle testing can be used instead of penetrant testing (see 7.2.4).

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

^d Not required for steels in group 1 in accordance with ISO/TR 15608 under static loading, except for low-temperature applications.

^e Measuring row in a macrosection transverse to the weld.

^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 three-point bend test. With aluminium materials, the deformation capacity of the unaffected parent material determines the sheet thickness up to which the cupping test can be used for the welded joints.

^g At least two welds shall be carried out.

^h 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.

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 specimen dimensions should be such that they can be tested on Erichsen cupping test equipment.¹⁾

6.2.5 Hardness test specimen

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

A macrosection transverse to the weld shall be prepared and etched in accordance with 7.4.

1) This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

6.2.6 Bend test specimen using thin sheets

The test specimen shall be prepared in accordance with ISO 15620:2019, 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 application of non-destructive testing of specimens, the condition of the specimens shall conform to the specifications in the respective standards, e.g. complete burr removal for the penetrant test.

7.2.2 Visual test

Visual testing should be carried out in accordance with ISO 17637. Use a magnifying glass (sixfold to tenfold 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 can 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

For ferritic materials, penetrant testing ([7.2.3](#)) or magnetic particle testing ([7.2.4](#)) can be substituted with eddy current testing in accordance with ISO 17643, if applicable.

7.2.6 Ultrasonic test

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

7.3 Destructive tests

7.3.1 Tensile test

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

7.3.2 Three-point bend test

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

7.3.3 Cupping test

The cupping test should be carried out using Erichsen cupping test equipment.²⁾

7.3.4 Bend test

Bend testing shall be carried out in accordance with ISO 15620:2019, Figure 8. Circular tubes with thin walls can be tested using the bend test.

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 zone with 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 0,6 times the sheet thickness and positioned parallel to the sheet surface. The hardness measurement shall be carried out in accordance with ISO 9015-2.

7.6 Retesting

If the component or test piece fails to conform to 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 conform to the requirements, the welding procedure test is considered to have been failed.

If any test specimen fails to conform to 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 conform to 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 [8.4](#) shall be met independently of each other.

2) This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Changes outside the ranges specified require another 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).

For a qualification of different materials on the same machine, the tests shall be carried out with each material group used in production (see ISO/TR 15608).

Qualification of different work piece geometries may be carried out through testing the minimum and maximum cross-sections.

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 and identical machines (e.g. same make and type, mechanical and electrical parts, tooling).

8.4.3 Pre- or post-weld heat treatment

The qualification applies only for heat treatment used in the welding procedure test. Changes to the heat treatment require requalification of the WPS.

9 Welding procedure qualification record (WPQR)

The welding procedure qualification record (WPQR) is a statement of the results of assessing each test piece, including retests. The relevant items listed for the WPS in ISO 15609-5 shall be included, together with details of any features that would be rejectable by the requirements of [Clause 7](#). If no rejectable features or unacceptable test results are found, a WPQR detailing the welding procedure test piece results is qualified and shall be signed and dated by the examiner or the examining body.

A WPQR form shall be used to record details and class for the welding procedure and the test results, in order to facilitate uniform presentation and assessment of the data.

An example of WPQR format is shown in [Annex A](#) (see [Tables A.1](#) to [A.6](#)), which may be modified by the user.

Annex A (informative)

Example of a welding procedure qualification record (WPQR) form

Welding procedure qualification — Test certificate

Manufacturer's welding procedure

Examiner or examining body**

Reference no.:

Reference no.**:

Manufacturer:

** If applicable

Address:

Code/testing standard:

Date of welding:

Extent of qualification

Welding process: flash welding/upset (resistance butt) welding *[cross out whichever is not applicable.]*

Extent of testing:

Joint type:

Parent material(s):

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 of the machine:

Year of manufacture:

Type of current: alternating current/direct current

[cross out whichever is not applicable.]

Weld programme:

Post-weld heat treatment:

Other information:

Certified that test welds prepared, welded and tested satisfactorily in accordance with the requirements of the code/testing standard indicated above.

 Location

 Date of issue

 Examiner or examining body **

Name, date and signature

** manufacturer can be examiner/examining body instead if possible

Record of weld test

Location of testing:

Weld setter name:

Manufacturer's pWPS no.:

Parent material specification:

Manufacturer:

If applicable, examiner or examining body:

Welding process:

Flash welding/upset (resistance butt) welding [cross out whichever is not applicable.]

Joint type (if required):

Joint design	Welding sequence/welding programme

Welding machine name and type:

Manufacturer's name of the machine:

Type of current: alternating current/direct current

[cross out whichever is not applicable.]

Weld cross-section (mm²):

Average thickness (mm):

Average width (mm):

If tube or circular bar material, outside diameter (mm):

Wall thickness(mm):

Component in closed shape like ring: no/yes

[cross out whichever is not applicable.]

Parent material(s):

Joint preparation details (sketch), if required:

Machine setting:

Table A.1 — Setting parameters for welding machine

Electrical setting		Mechanical setting					
No-load voltage	Input voltage	Initial die opening	Final die opening	Initial gap	Flash loss ^a	Total loss	Clamping force
V	V	mm	mm	mm	mm	mm	kN
							Left Right

^a Applicable only for flash welding.

Welding parameters (select one table depending on the welding process used).

Table A.2 — Welding parameter settings for flash welding^{a,b}

Process stage	Force kN	Current kA	No-load voltage V	Current on/off sequence			Flashing travel mm	Total travel mm	Moving mode and speed of platen or description of welding sequence
				No. of impulse	On- time s	Off- time s			
Preheating									
Flashing									
Upsetting									
Post heating									
^a ISO 4063:2023, process 24.									
^b When preheating and/or flashing are necessary, add row(s).									

Table A.3 — Welding parameter settings for upset welding^{a,b,c}

Process stage	Force kN	Current kA	Time s	Current on/off sequence			Moving speed of platen mm/s	Displacement mm
				No. of im- pulses	On- time s	Off- time s		
Squeeze				—	—	—		
Heat 1..n			—					
Forging			—					
Post heating			—					
^a ISO 4063:2023, process 25.								
^b If more stages are necessary, add rows.								
^c If up-slope and/or down-slope heating are included in the sequence, add column(s).								

Location

Date of issue

Examiner or examining body **

Name, date and signature

** manufacturer can be examiner/examining body instead if possible