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

**Part 4:
Finishing welding of aluminium castings**

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

*Partie 4: Réparation par soudage pour les travaux de finition des pièces
moulées en aluminium*



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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 15614-4 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

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: 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*

Annex ZZ provides a list of corresponding International and European Standards for which equivalents are not given in the text.

Requests for official interpretations of any aspects 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.

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

Part 4: Finishing welding of aluminium castings

1 Scope

This part of ISO 15614 is one of a series of standards, details of which are given in ISO 15607:2003, Annex A.

It specifies how a welding procedure specification for finishing welding of aluminium castings is qualified by welding procedure tests. It does not apply to repair welding.

For joint welding, ISO 15614-2 applies.

Arc welding of aluminium castings is covered by the following processes as defined in ISO 4063:

- 131 metal inert gas welding, MIG welding;
- 141 tungsten inert gas arc welding; TIG welding;
- 15 plasma arc welding.

Other fusion welding processes by agreement.

Shielding gases used in these processes are:

- argon ISO 14175 I1;
- helium ISO 14175 I2;
- argon-helium mixture ISO 14175 I3.

Other shielding gases by agreement.

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 571-1, *Non destructive testing — Penetrant testing — Part 1: General principles*

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

ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation*

ISO 9017, *Destructive tests on welds in metallic materials — Fracture test*

ISO 15614-4:2005(E)

ISO 10042, *Arc-welded joints in aluminium and its weldable alloys — Guidance on quality levels for imperfections*

ISO 14175, *Welding consumables — Shielding gases for arc welding and cutting*

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

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

ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding*

ISO 15614-2:2005, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys*

ISO 17635, *Non-destructive testing of welds — General rules for fusion welds in metallic materials*

ISO 17636, *Non-destructive testing of welds — Radiographic testing of fusion-welded joints*

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

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

3 Terms and definitions

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

3.1

production welding

any welding carried out before final delivery to the end user

3.1.1

joint welding

production welding used to assemble components together to obtain an integral unit

NOTE This includes the welding of cast or wrought components as well as combinations of cast and wrought materials.

3.1.2

finishing welding

welding carried out during production in order to remove casting defects and core openings to ensure the agreed quality of castings

4 Preliminary welding procedure specification (pWPS)

The preliminary welding procedure specification shall be prepared in accordance with ISO 15609-1.

5 Welding procedure test

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

The welder shall only be qualified by welding test pieces in accordance with Clause 6.

6 Test pieces

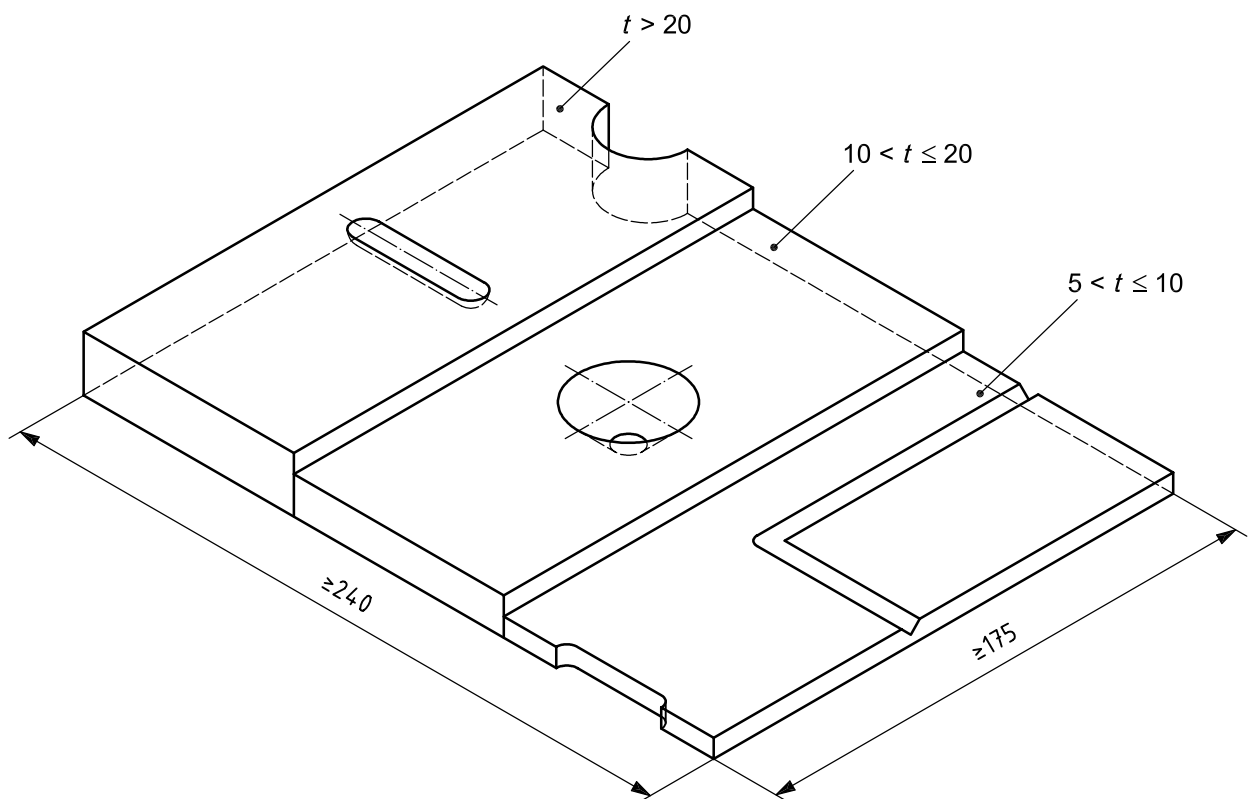
6.1 General

Test pieces shall be cast as one test piece in accordance with Figure 1 or three separate test pieces in accordance with Figure 2 or may be taken from a production casting which exhibits the same features as Figure 1 or 2 (slot, hole and groove). Machining of the test pieces is permitted.

6.2 Shape and dimensions of test pieces

The shape and minimum dimensions shall be in accordance with Figures 1 and 2.

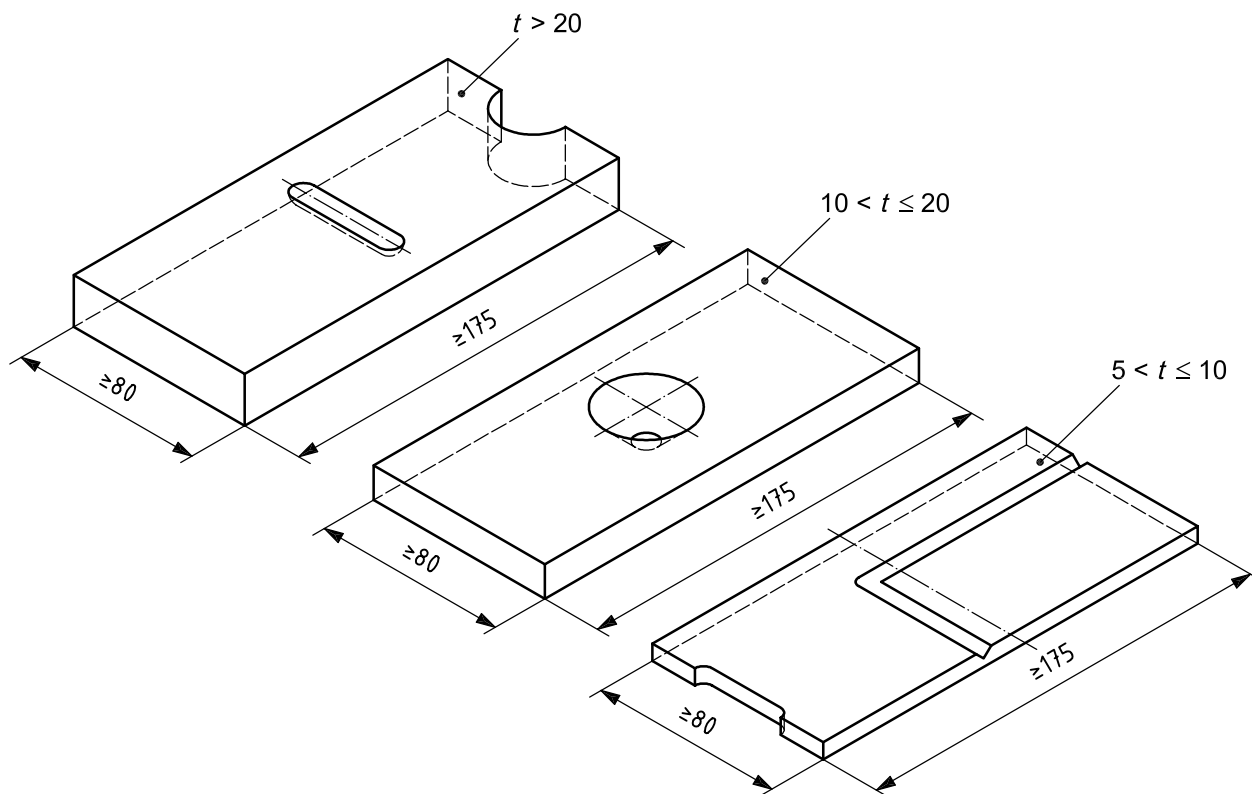
Dimensions in millimetres



Key

t material thickness

Figure 1 — Combined test piece with slot, hole and groove



Key

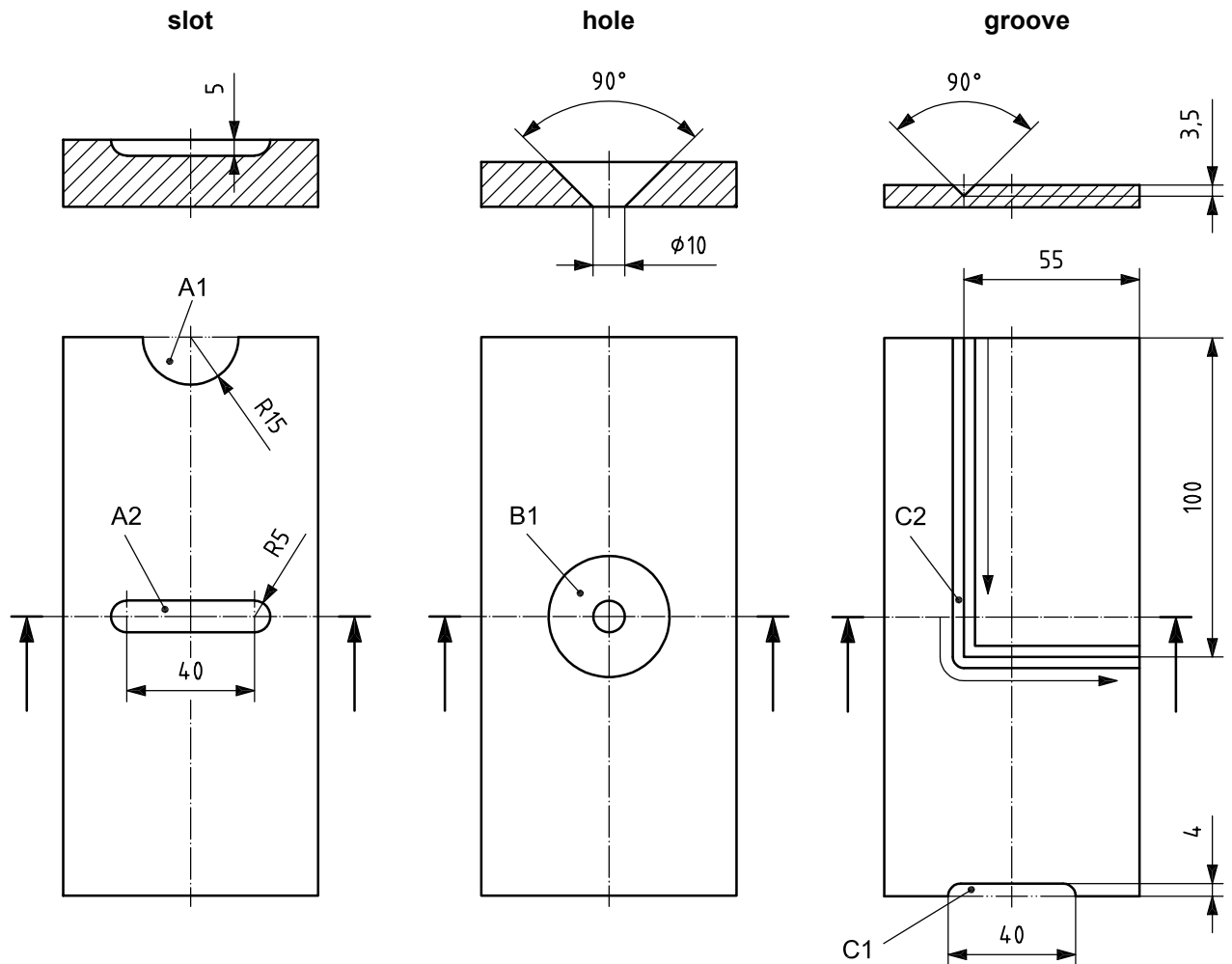
t material thickness

Figure 2 — Single test pieces with slot, hole and groove

6.3 Welding of test pieces

Preparation and welding of test pieces shall be carried out in accordance with the pWPS and under the general conditions of welding in production which they shall represent. The demonstration shall be as shown in Figure 3. In each case one stop and restart is required.

Dimensions in millimetres

**Key**

- A1 shall show the filling up of a slot. Normally the test piece shall be welded in “vertical up” position PF or “flat” position PA as defined in ISO 6947. Undercuts on the corner and lack of fusion are critical.
- A2 shall show the filling up of a slot. Normally the test piece shall be welded in position PA. Cracks, crater pipes, crater cracks, undercuts and lack of fusion are critical.
- B1 shall show the filling up of a hole. Normally the test piece shall be welded in position PA, in which it demonstrates the welding of a hole in a casting. Normally a backing will be used. Inclusions and lack of fusion are critical.
- C1 shows the production welding of a rib. Normally the test piece shall be welded in position PF or PA. Undercuts on the corner and lack of fusion are critical.
- C2 shall be welded in the direction shown in the figure. One stop and restart is required. Normally the test piece shall be welded in position PA. Undercuts, crater cracks and lack of fusion are critical.

NOTE Chain-dotted lines indicate fracture lines.

Figure 3 — Dimensions of test pieces and weld locations for finishing weld tests

7 Examination and testing

7.1 Extent of testing

The test pieces shall be tested as follows:

- visual examination in accordance with 7.2;
- penetrant testing in accordance with 7.2;
- radiographic testing in accordance with 7.2;
- fracture testing in accordance with 7.3.1;
- micro examination in accordance with 7.3.2.

7.2 Non-destructive testing

The non-destructive testing specified in 7.1 shall be carried out in accordance with the following standards:

- visual examination in accordance with ISO 17637;
- penetrant testing in accordance with EN 571-1;
- radiographic testing in accordance with ISO 17636.

7.3 Destructive testing

7.3.1 Fracture testing

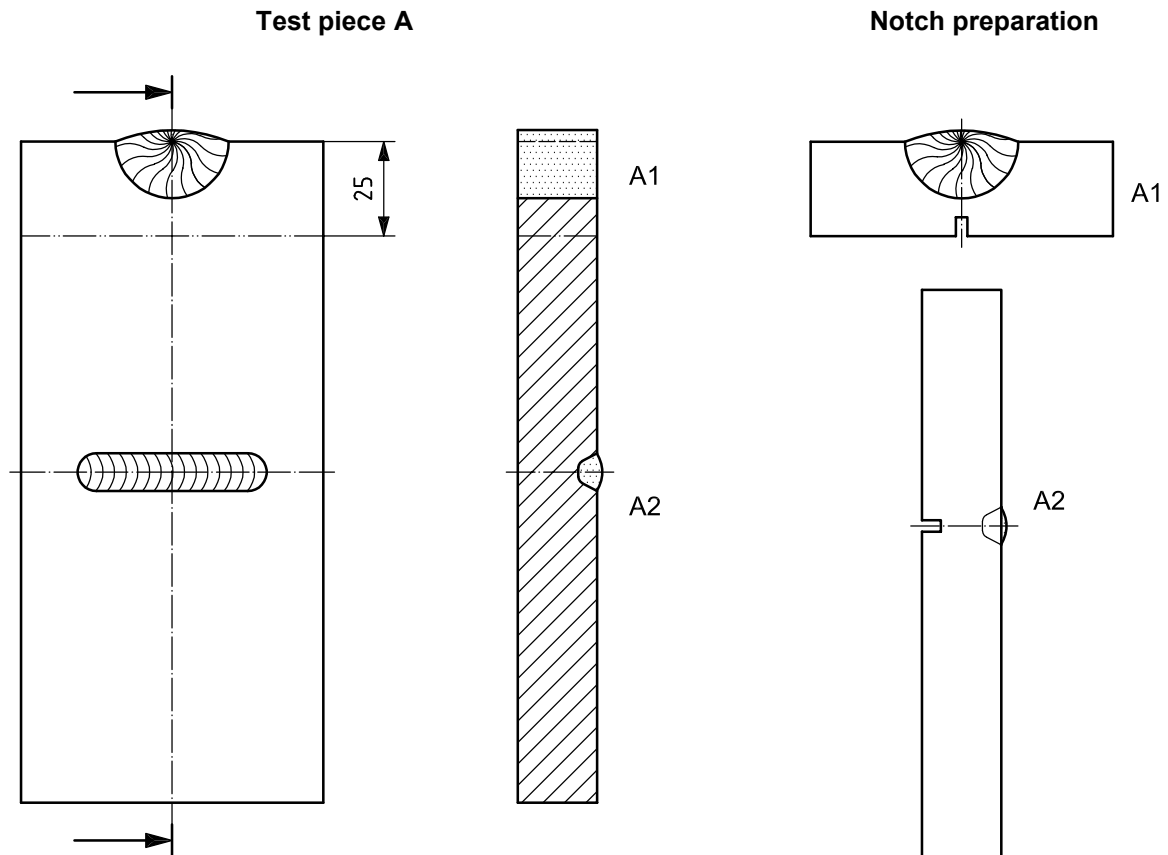
7.3.1.1 Method

Fracture testing shall be carried out in accordance with ISO 9017 using test pieces prepared in accordance with 7.3.1.2.

7.3.1.2 Preparation of test pieces

The test pieces shall be prepared for fracture testing as shown in Figures 4a), 4b) and 4c). To ensure fracture occurs in the weld deposit, it is recommended that the test pieces be notched as shown in the figures. Otherwise, the test pieces shall be tested in accordance with ISO 9017.

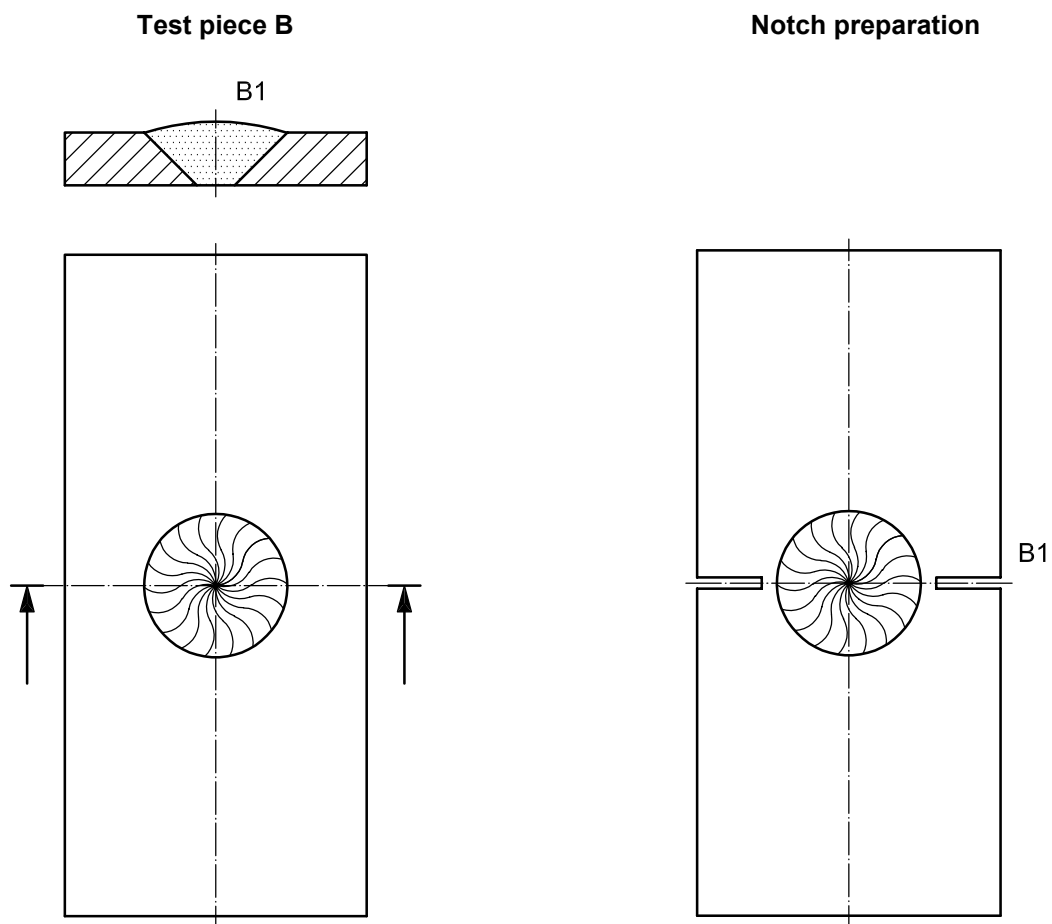
Dimensions in millimetres



Key

- A1 shall show the filling up of a slot. Normally the test piece shall be welded in position PF or PA. Undercuts on the corner and lack of fusion are critical.
- A2 shall show the filling up of a slot. Normally the test piece shall be welded in position PA. Cracks, crater pipes, crater cracks, undercuts and lack of fusion are critical.

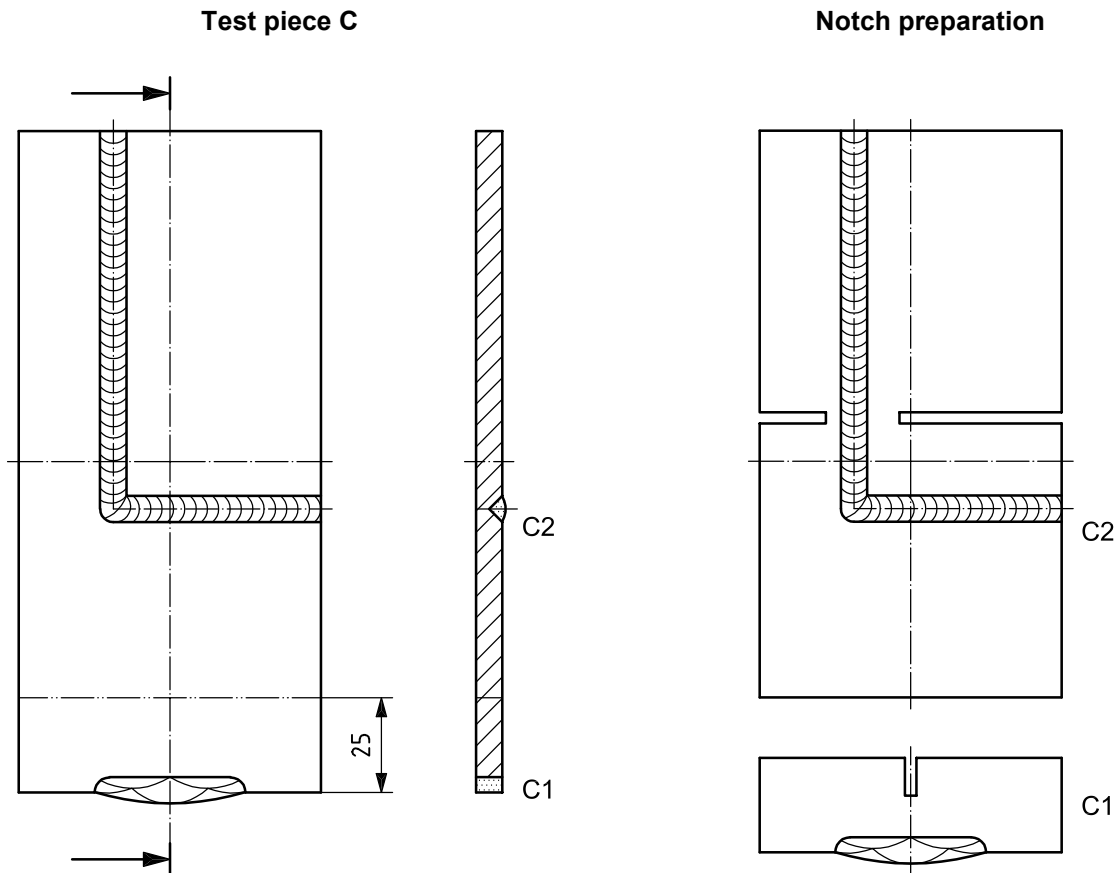
a) Preparation of test piece A



Key

B1 shall show the filling up of a hole. Normally the test piece shall be welded in position PA, in which it demonstrates the welding of a hole in a casting. Normally a backing will be used. Inclusions and lack of fusion are critical.

b) Preparation of test piece B

**Key**

- C1 shows the production welding of a rib. Normally the test piece shall be welded in position PF or PA. Undercuts on the corner and lack of fusion are critical.
- C2 shall be welded in the direction shown in the figure. One stop and restart is required. Normally the test piece shall be welded in position PA. Undercuts, crater cracks and lack of fusion are critical.

c) Preparation of test piece C**Figure 4 — Preparation of test pieces****7.3.2 Micro examination**

The micro examination shall be carried out in accordance with ISO 17639.

7.4 Acceptance levels

The permitted welding imperfections shall be in accordance with ISO 10042, level C, but for pressure components level B in accordance with ISO 10042 shall be used. Other acceptance levels may be required by the relevant application standard or as defined in the design specification.

The correlation between the quality levels of ISO 10042 and the acceptance levels of the different non-destructive testing techniques is given in ISO 17635.

7.5 Re-testing

If a test piece fails to comply with any of the requirements for non-destructive tests specified in 7.2 or for destructive tests specified in 7.3, one further test piece shall be welded and subjected to the same examinations/tests. If this additional test piece does not comply with the relevant requirements, the pWPS shall be regarded as not capable of complying with the requirements of this part of ISO 15614 without modification.

8 Range of qualification

8.1 General

Each of the conditions given in this clause shall be met in order to comply with this part of ISO 15614.

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

8.2 Related to the manufacturer

Qualification, obtained by a manufacturer, of a pWPS by a welding procedure test as specified in this part of ISO 15614 is valid for welding in workshops or sites under the same technical and quality control of the manufacturer.

8.3 Related to the parent material

8.3.1 Parent material grouping

In order to minimize the number of welding procedure tests, aluminium castings are grouped in accordance with ISO/TR 15608.

Separate welding procedure qualifications are required for each parent material or parent material combinations not covered by the grouping system.

Permanent backing material shall be considered as a parent material.

8.3.2 Parent material thickness

8.3.2.1 General

t is the thickness of the material of the test piece.

8.3.2.2 Range of qualification

The qualification of a welding procedure test on material of thickness t shall include qualification for thicknesses in the ranges given in ISO 15614-2:2005, Table 5.

If components have already been heat-treated and/or machined, there shall be a minimum thickness of $t \geq 3$ mm.

8.4 Common to all welding procedures

See ISO 15614-2:2005, 8.4.

8.5 Specific to processes

See ISO 15614-2:2005, 8.5.

9 Welding procedure qualification record (WPQR)

The welding procedure qualification record (WPQR) is a statement of the results of assessing each test piece, including re-tests. The relevant items listed for the WPS in ISO 15609-1 shall be included, together with details of any features that would be rejectable under the requirements of Clause 7. If no rejectable features or unacceptable test results are found, a WPQR detailing the welding procedure test piece results shall be prepared and shall be signed and dated by the examiner or examining body.

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

An example of a WPQR form is given in Annex A.

Annex A
(informative)

Welding procedure qualification record (WPQR) form

Welding procedure qualification — Test certificate

Manufacturer's welding procedure: Examiner or examining body:
Reference No: Reference No:.....
Manufacturer:
Address:
Code/Testing standard:.....
Date of welding:.....

Extent of qualification

Welding process:.....
Joint type:
Parent material(s):.....
Material thickness (mm):
Outside diameter (mm):
Filler metal type:
Shielding gas:.....
Type of welding current:
Welding position:
Preheat:
Post-weld heat treatment and/or ageing:
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

Details of weld test

Location:..... Examiner or examining body:

Manufacturer's welding procedure

Reference No.:

WPQR No.: Method of preparation and cleaning:

Parent material specification:

Manufacturer: Material thickness (mm):

Welder's name:

Welding process:

Joint type:..... Outside diameter (mm):

Welding position:

Weld preparation details sketch ²⁾

Joint design	Welding sequences

Welding details

Run	Welding process	Size of filler metal	Current A	Voltage V	Type of current/ polarity	Wire feed speed	Travel speed ¹⁾	Heat input ²⁾

Filler metal classification and trade name:..... Other information ²⁾

Any special baking or drying:..... e.g. weaving (maximum width of run):.....

Gas shielding: Oscillation: amplitude, frequency, dwell time:

backing: Pulse welding details:

Gas flow rate shielding: Distance contact tube/workpiece:.....

Plasma welding details:

Tungsten electrode type/size:..... Torch angle:.....

Details of back gouging/ backing:

Preheat temperature:

Interpass temperature:

Post-weld heat treatment and/or ageing:

Time, temperature, method:.....

Heating and cooling rates ²⁾:.....

Manufacturer Examiner or examining body

.....

Name, date and signature Name, date and signature

1) If required.

Test results

Manufacturer's welding procedure

Examiner or examining body

Reference No.:

Reference No.:

Visual examination

without results <input type="checkbox"/>	with results <input type="checkbox"/>	Remarks
--	---------------------------------------	---------

Penetrant testing

without results <input type="checkbox"/>	with results <input type="checkbox"/>	Remarks
--	---------------------------------------	---------

Radiographic testing

without results <input type="checkbox"/>	with results <input type="checkbox"/>	Remarks
--	---------------------------------------	---------

Fracture test

without results <input type="checkbox"/>	with results <input type="checkbox"/>	Remarks
--	---------------------------------------	---------

Micro examination

without results <input type="checkbox"/>	with results <input type="checkbox"/>	Remarks
--	---------------------------------------	---------

Other tests:

Remarks:

Tests carried out in accordance with the requirements of:

Laboratory report reference No.:

The test results were: acceptable not acceptable

Test carried out in the presence of:

Examiner or examining body

.....
Name, date and signature

Annex ZZ (normative)

Normative references to international publications with their relevant European publications

This part of ISO 15614 incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this part of ISO 15614 only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

Publication	Year	Title	EN	Year
ISO 4063		<i>Welding and allied processes — Nomenclature of processes and reference numbers</i>	EN ISO 4063	
ISO 9017		<i>Destructive tests on welds in metallic materials — Fracture test</i>	EN 1320	
ISO 10042		<i>Arc-welded joints in aluminium and its weldable alloys — Guidance on quality levels for imperfections</i>	EN 30042	
ISO 14175		<i>Welding consumables — Shielding gases for arc welding and cutting</i>	EN 439	
ISO 15607	2003	<i>Specification and qualification of welding procedures for metallic materials — General rules</i>	EN ISO 15607	2003
ISO/TR 15608		<i>Welding — Guidelines for a metallic materials grouping system</i>	CR ISO 15608	
ISO 15609-1		<i>Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding</i>	EN ISO 15609-1	
ISO 15614-2	2005	<i>Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys</i>	EN ISO 15614-2	2005
ISO 17635		<i>Non-destructive testing of welds — General rules for fusion welds in metallic materials</i>	EN 12062	
ISO 17636		<i>Non-destructive testing of welds — Radiographic testing of fusion-welded joints</i>	EN 1435	
ISO 17637		<i>Non-destructive testing of welds — Visual testing of fusion-welded joints</i>	EN 970	
ISO 17639		<i>Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds</i>	EN 1321	

