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**Welding for aerospace applications —
Qualification test for welders and welding
operators — Fusion welding of metallic
components**

*Soudage pour applications aérospatiales — Épreuve de qualification
pour soudeurs et opérateurs — Soudage par fusion des composants
métalliques*

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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 24394 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*.

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

This corrected version of ISO 24394:2008 incorporates the following corrections:

- *page 1, Clause 2* — “:2007” has been added to ISO/TR 25901 and the reference transferred to the bibliography, with consequent renumbering of the bibliography entries;
- *page 5, Table 1* — thicker section separation lines have been added;
- *page 6, 4.7* — the heading and wording have been updated;
- *page 6, 4.8.1, last paragraph* — “piece” has been deleted;
- *page 9, 6.2* — “theoretical” has been deleted and “theory” added in two places;
- *page 13, Table 3, TP 1, paragraph 4* — “(see (8.4))” has been deleted, and “(see 8.4)” added;
- *page 14, 8.7* — “fracture examination” has been deleted, and “fracture surface examination” added in three places;
- *page 15, Clause 9* — addition of a new 1st sentence to the 4th paragraph;
- *page 16, penultimate paragraph* — “re-qualification” has been deleted and “requalification” added;
- *page 21, Table A.4* — in the last row, “ $\geq 0,2$ mm” has been deleted and “ $\leq 0,2$ mm” added;
- *page 23, Annex C and page 24, Annex D* — under “Description of special test conditions...”, the phrases “1. Notes on material and test piece dimensions” and “2. Notes on reservations and particulars” have been deleted.

Introduction

A welder or welding operator qualification test properly passed in accordance with this International Standard demonstrates that the welder or welding operator concerned has been proved to possess the minimum degree of skill and knowledge required for the fusion welding of aerospace hardware.

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Welding for aerospace applications — Qualification test for welders and welding operators — Fusion welding of metallic components

1 Scope

This International Standard specifies requirements for the qualification of welders and welding operators for the fusion welding of metallic materials for aerospace applications.

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, *Welding and allied processes — Nomenclature of processes and reference numbers*¹⁾

ISO 5173, *Destructive tests on welds in metallic materials — Bend tests*

ISO 6520-1:2007, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding*

ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation*²⁾

ISO 8596, *Ophthalmic optics — Visual acuity testing — Standard optotype and its presentation*

ISO 9606-2, *Qualification test of welders — Fusion welding — Part 2: Aluminium and aluminium alloys*

ISO 14731, *Welding coordination — Tasks and responsibilities*

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

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*

ASTM E 1742, *Standard practice for radiographic examination*

EN 462-1, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality indicators (wire type) — Determination of image quality value*

EN 462-2, *Non-destructive testing — Image quality of radiographs — Part 2: Image quality indicators (step/hole type) — Determination of image quality value*

EN 462-3, *Non-destructive testing — Image quality of radiographs — Part 3: Image quality classes for ferrous metals*

1) To be published. (Revision of ISO 4063:1998)

2) To be published. (Revision of ISO 6947:1990)

EN 462-4, *Non-destructive testing — Image quality of radiographs — Part 4: Experimental evaluation of image quality values and image quality tables*

EN 4179, *Aerospace series — Qualification and approval of personnel for non-destructive testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6520-1, ISO 9606-2, ISO 14731 and the following apply.

3.1

parent material form

type of the semi-finished product

NOTE Semi-finished products are sheets/plates, tubes and castings.

3.2

welder

person who holds and manipulates the electrode holder, welding torch or blowpipe by hand

[ISO/TR 25901:2007 [2]]

NOTE In this International Standard a blowpipe is considered to be a gas welding torch.

3.3

welding operator

(welding for aerospace applications) person who operates adaptive control, automatic, mechanized, or robotic welding equipment

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3.4

examiner

person who has been appointed to verify compliance with the applicable standard

NOTE In certain cases, an external independent examiner can be required.

[ISO/TR 25901:2007 [2]]

3.5

examining body

organization appointed to verify compliance with the applicable standard

NOTE In certain cases, an external independent examining body can be required.

[ISO/TR 25901:2007 [2]]

3.6

rework

any corrective action made to a weldment in the as-welded condition

3.7

design/engineering authority

organization that has the responsibility for the structural integrity or maintenance of airworthiness of the hardware and compliance with all relevant documents

3.8

backing

material placed at the reverse side of a joint preparation for the purpose of supporting molten weld metal

[ISO/TR 25901:2007 [2]]

3.9 welding procedure specification WPS

document that has been qualified and provides the required variables of the welding procedure to ensure repeatability during production welding

[ISO/TR 25901:2007 ^[2]]

3.10 preliminary welding procedure specification pWPS

document containing the required variables of the welding procedure which has to be qualified

[ISO/TR 25901:2007 ^[2]]

4 Qualification test requirements

4.1 General

4.1.1 Specific to the welder qualification test

The welder qualification tests are classified according to:

- a) parent material form;
- b) types of welds (butt/fillet);
- c) welding processes;
- d) material groups;
- e) thickness ranges;
- f) welding positions.

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4.1.2 Specific to the welding operator qualification test

The welding operator qualification tests are classified according to:

- a) welding processes;
- b) material groups;
- c) thickness ranges.

In the practical part of the welding operator qualification test, a test weld of any product type/semi-finished product of any weld type shall qualify for all product types/semi-finished products and all weld types.

4.1.3 Common to the welder and welding operator qualification test

The welding coordinator of the plant or the fabricator selects from Table 2 the test piece as required for the production work on which the welder or welding operator will be employed. Two complementary specific test pieces (TP5 and TP6) may also be chosen as defined in 4.4 and 4.8.1.

4.2 Welding processes

This International Standard covers qualification testing for the following welding processes with their reference numbers in accordance with ISO 4063:1998:

- 111 Manual metal arc welding (metal arc welding with covered electrode)³⁾
- 12 Submerged arc welding³⁾
- 13 Gas-shielded metal arc welding
- 141 Tungsten inert gas welding (TIG welding)
- 15 Plasma arc welding
- 31 Oxy-fuel gas welding
- 51 Electron beam welding
- 52 Laser beam welding

NOTE Other fusion welding processes not yet specified in ISO 4063 may be covered.

4.3 Welding positions

Depending on welding positions in actual production, the welding position of the test piece shall be chosen in accordance with Table 1.

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4.4 Product types/semi-finished products applicable to welder qualification tests

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Depending on the types of products in actual production, a distinction is made between welder qualification tests for sheet/plate (S), tube (T), and castings (C).

A welder qualification test for sheet/plate (S) and tube (T) may be combined, see Table 1.

The range of qualification for each welding position is given in Table 1. The welding positions are specified in ISO 6947. The test pieces shall be welded in accordance with the nominal angles of the welding positions in accordance with ISO 6947.





Test piece TP5 (see Table 2) is mandatory for structural tube frameworks of outside diameter, $D < 26$ mm. It is optional for structural tube frameworks of $D \geq 26$ mm.

The welder qualification test for casting is intended for the repair of castings. Test piece TP6 (see Table 2) shall be used for qualification. Welds shall be made in welding positions PA or PB, which qualifies for all welding positions for casting repairs only.

Alternatively, a welder who is qualified to weld sheet/plate and tube is also authorized to repair castings, within his/her range of qualification.

3) This process may require a special qualification test as defined in 4.8.

Table 1 — Range of qualification for welding positions

Test piece (see Table 2)	Welding position of test piece according to ISO 6947:1990	Qualified welding position														
		Plate or tube $D > 26$ mm										Tube $D \leq 26$ mm				
		Butt weld				Fillet weld						Butt weld			Fillet weld	
		PA	PC	PE	PF	PA	PB	PC	PD	PF	PA	PC	PF	PB	PD	PF
	PA	X	—	—	—	—	—	—	—	—	X ^a	—	—	—	—	—
	PC	X	X	—	—	—	—	—	—	—	—	X ^a	—	—	—	—
	PE	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—
	PF	X	—	—	X	—	—	—	—	—	—	—	—	—	—	—
	PA	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—
	PB	—	—	—	—	X	X	—	—	—	—	—	—	—	—	—
	PC	—	—	—	—	X	X	X	—	—	—	—	—	—	—	—
	PD	—	—	—	—	X	X	—	X	—	—	—	—	—	—	—
	PF	—	—	—	—	X	X	—	—	X	—	—	—	—	—	—
	PA	—	—	—	—	—	—	—	—	—	X ^b	—	—	—	—	—
	PC	X	X	—	—	—	—	—	—	—	—	X	—	—	—	—
	PF	X	—	X	X	—	—	—	—	—	X	—	X	—	—	—
	PB	—	—	—	—	(X)	(X)	—	—	—	—	—	—	X	—	—
	PD	—	—	—	—	(X)	(X)	—	(X)	—	—	—	—	X	X	—
	PF	—	—	—	—	(X)	(X)	—	—	(X)	—	—	—	X	—	X

X indicates those welding positions for which the welder is qualified.
(X) indicates those welding positions for which the welder is qualified for welding on tube $D > 26$ mm, but not on plate.
— indicates those welding positions for which the welder is not qualified.
^a Only applicable for a longitudinal weld on a tube.
^b Only applicable for a rotating tube with the torch in welding position PA.

4.5 Material groups

Depending on the application, the welder and welding operator qualification tests are subdivided into the following material groups.

Material group A: Unalloyed steel, low-alloyed steels, high-alloyed ferritic steels.

Material group B.1: Non precipitation hardenable high-alloyed austenitic steels, nickel alloys, cobalt alloys.

Material group B.2: Precipitation hardenable high-alloyed austenitic steels, nickel alloys, and cobalt alloys.

Material group C: Titanium and titanium alloys, niobium, zirconium and other reactive metals.

Material group D: Aluminium and magnesium alloys.

Material group E: Materials that do not conform to material groups A to D (e.g. molybdenum, tungsten, copper alloys).

Qualification of material group B.2 also qualifies material group B.1, but not vice versa.

4.6 Butt weld material thickness

A test piece of thickness, t , shall qualify a welder or welding operator to weld a thickness range of $0,67t$ to $4t$, except that when $t \geq 25$ mm, the qualification range is $0,67t$ to unlimited. Two independent test welds, of different material thicknesses, shall qualify all material thicknesses from the minimum to the maximum parent material thicknesses tested.

4.7 Fillet weld material thickness

A test piece of thickness, t_1 , shall qualify a welder or welding operator to weld a thickness range of $0,67t_1$ to $4t_1$, of the thinner material, except that when $t_1 \geq 25$ mm, the qualification range is $0,67t_1$ to unlimited. Two independent test welds, of different material thicknesses, shall qualify all material thicknesses from the minimum to the maximum parent material thicknesses tested.

4.8 Special qualification tests

4.8.1 General requirements

Any changes to the requirements defined in this International Standard are classified as special qualification tests.

As required by actual production, the welding coordinator shall specify the geometry of the test pieces, welding process, material, and material thickness range. A special qualification test only qualifies for welding under the specific conditions represented by the special qualification test.

If test methods are not in accordance with this International Standard, they shall be defined by the welding coordinator. The welding coordinator shall define additional test methods and also increase the quality requirements as defined by the design/engineering authority.

A special qualification test shall be marked with an "X" in the designation.

4.8.2 Special qualification tests for welders

Examples are:

- a) qualification for surfacing/cladding welds;
- b) qualification for welds with special condition for welding position and/or accessibility;
- c) qualification for restriction to weld only tack welds;
- d) qualification for welding test where start and end of weld seam is on additional material, to be cut off;
- e) qualification for butt welds without filler material;
- f) qualification for welds on dissimilar material groups;
- g) qualification for welds with backing.

A welder qualified for welding with backing may only weld using backing in production.

A welder qualified without using backing may weld with or without using backing in production.