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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.

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 documents 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).

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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 14, *Welding and brazing in aerospace*.

Any feedback, question or request for official interpretation related to any aspect of this document should be directed to the Secretariat of ISO/TC 44/SC 14 via your national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations, where they exist, are available from this page: <https://committee.iso.org/sites/tc44/home/interpretation.html>.

This third edition cancels and replaces the second edition (ISO 24394:2018).

The main changes compared to the previous edition are:

- [Table 4](#) has been refined;
- Note to [3.8](#) added;
- editorially revised.

Introduction

A welder or welding operator qualification test properly passed in accordance with this document 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 document specifies requirements for the qualification of welders and welding operators for the fusion welding of metallic materials for aerospace applications.

NOTE Success in the test is an essential precondition for the qualification of welders (3.2) and welding operators (3.3) in new production and repair work in aerospace. However, welding equipment operators (3.4) do not need to be qualified according to this document.

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

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

ISO 6947, *Welding and allied processes — Welding positions*

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

ISO 14731, *Welding coordination — Tasks and responsibilities*

ISO 18490, *Non-destructive testing — Evaluation of vision acuity of NDT personnel*

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

SAE AMS 2694C, *In-Process Welding of Castings*

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.

ISO and IEC maintain terminological 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/>

3.1

parent material form

type of the semi-finished product

Note 1 to entry: 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

Note 1 to entry: In this document, a blowpipe is considered to be a gas welding torch.

[SOURCE: ISO/TR 25901-1:2016, 2.5.24, modified — In the definition, the word “welding” has been added before “torch” and “during welding” has been replaced with “by hand” at the end. Also, Note 1 to entry has been added.]

**3.3
welding operator**

<welding for aerospace applications> person who prepares the joint and sets up mechanized or automated welding equipment and thereby has direct influence on the welded joint quality

**3.4
welding equipment operator**

<welding for aerospace applications> person who only operates automatic welding equipment and has no direct influence on the welded joint quality

**3.5
examiner**

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

Note 1 to entry: In certain cases, an external independent examiner can be required.

[SOURCE: ISO/TR 25901-1:2016, 2.5.29]

**3.6
examining body**

organization that has been appointed to verify compliance with the applicable standard

Note 1 to entry: In certain cases, an external independent examining body can be required.

[SOURCE: ISO/TR 25901-1:2016, 2.5.30]

**3.7
rework**

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

**3.8
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

Note 1 to entry: In the case of a welded product, the engineering authority is usually the organization that has responsibility for the engineering definition of the product. Examples for engineering definition are: Drawings, 3D models, specifications for manufacturing.

**3.9
backing**

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

**3.10
welding procedure specification
WPS**

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

[SOURCE: ISO/TR 25901-1:2016, 2.5.4]

3.11 preliminary welding procedure specification pWPS

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

[SOURCE: ISO/TR 25901-1:2016, 2.5.6, modified — In the definition, “has to” has been changed to “needs to”.]

3.12 automatic welding

welding in which all operations are performed without welding operator intervention during the process

Note 1 to entry: Manual adjustment of welding variables by the welding operator during welding is not possible.

[SOURCE: ISO 14732:2013, 3.1]

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.

The welding coordinator of the plant or the fabricator shall select from [Table 6](#) the test piece as required for the production work on which the welder is to be employed. Two complementary specific test pieces (TP5 and TP6) may also be chosen as defined in [4.4](#) and [4.7.1](#).

4.1.2 Specific to the welding operator qualification test

The welding operator qualification tests are classified according to welding process and welding machine type.

NOTE Machine type within the scope of this document stands for longitudinal, orbital, circumferential and robotic welding machines.

For multiple welding machine types, additional qualification shall be at the discretion of the responsible welding coordinator.

The welding operator has to show theoretical knowledge of the welding process.

In the practical part of the qualification test, the welding operator shall demonstrate competency in operating the welding machine according to an established WPS.

A test weld of any type of weld with a process on a given welding machine type shall qualify for all product types/semi-finished products and all types of welds with this process and this machine type.

The test weld can be performed on dedicated test pieces or production parts.

When substituting test pieces with actual production parts, testing shall be carried out according to [Table 7](#).

4.2 Welding processes

This document 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)¹⁾
- 12 Submerged arc welding¹
- 13 Gas-shielded metal arc welding
- 141 TIG welding with solid filler material (wire/rod)
- 15 Plasma arc welding
- 31 Oxy-fuel gas welding
- 51 Electron beam welding
- 52 Laser beam welding

NOTE 1 Other fusion welding processes not yet specified in ISO 4063 can be covered.

NOTE 2 Attention is drawn to the fact that ISO 4063:1998 and ISO 4063:2009 sometimes have different processes for the same process number. The main differences are as follows (see [Table 1](#)):

- a) process designation was changed or modified for processes 121, 131, 135, 136 and 141;
- b) process 137 was split into processes 132 and 133;
- c) process 136 was split into processes 136 and 138.

Table 1 — Equivalent process numbers and designations between ISO 4063:1998 and ISO 4063:2009

Process number	Process designation in ISO 4063:1998	Process designation ISO 4063:2009
121	Submerged arc welding with one wire electrode	Submerged arc welding with solid wire electrode
131	Metal inert gas welding; MIG welding	MIG welding with solid wire electrode
132	—	MIG welding with flux cored electrode
133	—	MIG welding with metal cored electrode
135	Metal active gas welding; MAG welding	MAG welding with solid wire electrode
136	Tubular cored metal arc welding with active gas shield	MAG welding with flux cored electrode
137	Tubular cored metal arc welding with inert gas shield	—
138	—	MAG welding with metal cored electrode
141	Tungsten inert gas welding; TIG welding	TIG welding with solid filler material (wire/rod)

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 2](#), [Table 3](#), [Table 4](#) and/or [Table 5](#).

- 1) This process can require a special qualification test as defined in [4.7](#).

A test piece welded in the fixed position also qualifies for welding parts when not in the fixed position, e.g. rotational turntable for tubes.

TP6 shall be welded in PA or PB, which qualifies for all welding positions for in-process welding of castings in casting facilities.

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

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).

Test pieces with tube (TP3, TP4 and TP5) do not qualify for sheet/plate.

NOTE 1 Tube welding has overlapping start and stop points. This is not the case for sheet or plate welding. Therefore, test pieces with tube (TP3, TP4 and TP5) do not qualify for sheet/plate.

The range of qualification for each welding position is given in [Table 2](#), [Table 3](#), [Table 4](#) and [Table 5](#). 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 6](#)) is mandatory for structural tube frameworks of outside diameter, $D < 26$ mm. It is optional for structural tube frameworks of $D \geq 26$ mm.

Test piece TP 6 is required for in-process welding of castings in casting facilities.

NOTE 2 Within the scope of this document, in-process welding is welding on castings to correct casting defects.


Excluding in-process welding in casting facilities, a welder who is qualified to weld sheet/plate or tube is also qualified to weld on castings within his/her range of qualification regarding the welding position and geometric shape of the work piece (planar or tubular).

NOTE 3 Casting facilities are excluded because casting methods and in-process welding of castings are subject to specific engineering requirements.

In instances of structural welding of castings requiring specific welding techniques, e.g. Nickel Alloy 718, the welder qualification test pieces (TP1 to TP4) shall be of the same casting alloy.

As an alternative, qualifications per SAE AMS 2694C are acceptable for in-process welding of castings, but the period of validity according to [Clause 11](#) applies.

Table 2 — Range of qualification for welding positions, joint type and base metal form for TP1

Test weld		Qualified welding position(s)								
		Sheet/Plate				Tube				
Form/Joint type	Test piece welding position (ISO 6947)	Butt weld								
		PA	PC	PE	PF	PA	PC	PE	PF	H-L 045
Sheet/Plate/Butt weld	<p>PA</p> 	X				X ^{a,b}				

NOTE 1 X indicates for which the welder is qualified.

NOTE 2 Arrows of PA, PB and PC show the welding position.

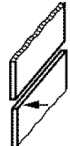


NOTE 3 Arrow to PF shows the weld progression or direction.

^a Applicable for longitudinal weld on a tube.

^b Applicable for circumferential weld on rotating tube, if tube diameter is $D > 26$ mm.

^c Applicable for circumferential weld on tube in fixed position, if tube diameter is $D > 26$ mm.

Table 2 (continued)

Test weld		Qualified welding position(s)								
		Sheet/Plate				Tube				
Form/Joint type	Test piece welding position (ISO 6947)	Butt weld								
		PA	PC	PE	PF	PA	PC	PE	PF	H-L 045
Sheet/ Plate/ Butt weld	PC 	X	X			X ^{a,b}	X ^{a,b,c}			
	PE 	X		X		X ^{a,b}		X ^{a,b}		
	PF 	X			X	X ^{a,b}			X ^{a,b}	

NOTE 1 X indicates for which the welder is qualified.

NOTE 2 Arrows of PA, PB and PC show the welding position.



NOTE 3 Arrow to PF shows the weld progression or direction.

^a Applicable for longitudinal weld on a tube.

^b Applicable for circumferential weld on rotating tube, if tube diameter is $D > 26$ mm.

^c Applicable for circumferential weld on tube in fixed position, if tube diameter is $D > 26$ mm.

Table 3 — Range of qualification for welding positions, joint type and base metal form for TP2

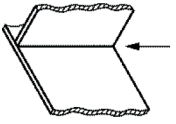
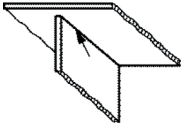
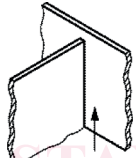
Test weld		Qualified welding position(s)				
		Sheet/Plate				
Form/Joint type	Test piece welding position (ISO 6947)	Fillet weld				
		PA	PB	PC	PD	PF
Sheet/ Plate/ Fillet weld	PA 	X				
	PB 	X	X			

NOTE 1 X indicates for which the welder is qualified.

NOTE 2 Arrows of PA, PB, PC and PD show the welding position

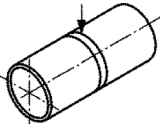
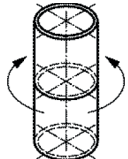
NOTE 3 Arrow to PF shows the weld progression or direction.

Table 3 (continued)

Test weld		Qualified welding position(s)				
Form/Joint type	Test piece welding position (ISO 6947)	Sheet/Plate				
		Fillet weld				
		PA	PB	PC	PD	PF
Sheet/ Plate/ Fillet weld	PC 	X	X	X		
	PD 	X	X		X	
	PF 	X	X			X

NOTE 1 X indicates for which the welder is qualified.
 NOTE 2 Arrows of PA, PB, PC and PD show the welding position
 NOTE 3 Arrow to PF shows the weld progression or direction.

Table 4 — Range of qualification for welding positions, joint type and base metal form for TP3

Test weld		Qualified welding position(s)					
Form/Joint type	Test piece welding position (ISO 6947)	Butt weld on tube			Butt weld on sheet/plate ^b		
		PA	PC	PH	PA	PC	PF
Tube/ Butt weld	PA ^a 	X					
	PC ^c 	X ^a	X				

NOTE 1 The qualification is valid for any tube of outer diameter equal to or larger than the outer diameter of the test piece.
 NOTE 2 Arrows of PA and PC show the welding position
 NOTE 3 Arrow to PH and H-L045 show the weld progression or direction.

^a Only applicable for a rotated tube with the torch in welding position PA.
^b Qualification is only valid for sheet/plate, if run-on and run-off tabs are used in production.
^c Pipe is not rotating during welding. Only one welding direction is required.