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Welding for aerospace applications — Fusion welding of metallic components —

Part 1: Process specification

Soudage pour applications aérospatiales — Soudage par fusion des composants métalliques —

Partie 1: Spécification de processus

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Foreword

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

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This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 14, *Welding and brazing in aerospace*.

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.

A list of all parts in the ISO 17297 series can be found on the ISO website.

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Welding for aerospace applications — Fusion welding of metallic components —

Part 1: Process specification

1 Scope

This document specifies the requirements for fusion welding of aerospace hardware. It is to be used in conjunction with the design/engineering authority's design documents or their accepted data.

This document covers the processes given in Table 1 and material groups given in Table 2.

Table 1 — Fusion welding processes covered by this document

Process	Process number (ISO 4063)
Oxyfuel welding	31
Gas-shielded arc welding with non-consumable tungsten electrode, Gas tungsten arc welding	14
Plasma arc welding	15
Electron beam welding	51
Laser welding, Laser beam welding	52

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Table 2 — Material groups covered by this document (see ISO 24394:2018, 4.5)

Material group	Description
A	Unalloyed steel, low-alloyed steels, high-alloyed ferritic steels
B	Austenitic, martensitic and precipitation hardening steels
C	Titanium and titanium alloys, niobium, zirconium and other reactive metals
D	Aluminium and magnesium alloys
E	Materials that do not conform to other material groups (e.g. molybdenum, tungsten, copper alloys)
F	Nickel alloys, cobalt alloys.

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 3452 (all parts), *Non-destructive testing — Penetrant testing*

ISO 4063, *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 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

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ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508 (all parts), *Metallic materials — Rockwell hardness test*

ISO 6892 (all parts), *Metallic materials — Tensile testing*

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

ISO 10863, *Non-destructive testing of welds — Ultrasonic testing — Use of time-of-flight diffraction technique (TOFD)*

ISO 13588, *Non-destructive testing of welds — Ultrasonic testing — Use of automated phased array technology*

ISO 17636 (all parts), *Non-destructive testing of welds — Radiographic testing*

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

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

ISO 17927-2[1)], *Welding for aerospace applications — Fusion welding of metallic components — Part 2: Acceptance criteria*

ISO 19828, *Welding for aerospace applications — Visual inspection of welds*

ISO 24394, *Welding for aerospace applications — Qualification test for welders and welding operators — Fusion welding of metallic components*

ISO/TR 25901-1, *Welding and allied processes — Vocabulary — Part 1: General terms*

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

ASTM E8/E8M, *Test Methods for Tension Testing of Metallic Materials*

ASTM E18, *Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E21, *Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials*

ASTM E384, *Standard Test Method for Microindentation Hardness of Materials*

ASTM E1417/E1417M, *Standard Practice for Liquid Penetrant Testing*

ASTM E1742/E1742M, *Standard Practice for Radiographic Examination*

ASTM E1444/E1444M, *Standard Practice for Magnetic Particle Testing*

SAE AMS 2644, *Inspection Material, Penetrant*

SAE AMS-STD-2154, *Inspection, Ultrasonic, Wrought Metals, Process for*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 25901-1 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 http://www.electropedia.org/

1) Under preparation. (Stage at the time of publication: ISO/FDIS 17927-2:2019.)

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3.1
backgouging
removal of weld metal and base metal from the weld root side of a welded joint to facilitate complete fusion and complete joint penetration upon subsequent welding from that side

3.2
design/engineering authority
organization having the responsibility for the structural integrity or maintenance of airworthiness of the hardware and compliance with all relevant documents

[SOURCE: ISO 24394:2018, 3.8]

3.3
welding procedure specification
WPS
document providing in detail the required variables of the welding procedure to ensure repeatability

3.4
welding procedure qualification record
WPQR
record comprising all necessary data needed for qualification of a preliminary welding procedure specification

3.5
autogenous weld
fusion weld without filler material

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4 Conformance

When conformance to this document is claimed, all provisions of this document are to be complied with, except those for provisions that the design/engineering authority specifically exempts.

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5 Classification and inspection requirements of joints

For the purposes of this document, three classes of welds are defined. This classification shall be stated in the design documents. If there are no other testing requirements defined by the design/engineering authority, the minimum amount of testing shall be as follows.

— Class I: A welded joint whose failure under operating conditions causes the loss of the aircraft/spacecraft or one of its main components, or constitutes a direct hazard to people.

  Visual and dimensional inspection: 100 % of all welds; penetrant or and magnetic particle testing or any other surface test method: 100 % of all welds; testing of the sub-surface characteristics: 100 % of all welds.

— Class II: A welded joint whose failure causes malfunctions without compromising continued safe flight until the end of the mission.

  Visual and dimensional inspection, 100 % of all welds and penetrant or and magnetic particle testing or any other adequate test method, 100 % of all welds.

— Class III: A welded joint whose failure does not affect the safety and the transport function of the aircraft/spacecraft.

  Visual and dimensional inspection, 100 % of all welds.

For the purpose of series preparation/pre-production or in the case of critical welding operations, it can be necessary, also for classes II and III, to increase the scope of testing beyond that specified here. Likewise, in the course of series production, the scope of testing may be reduced if sufficient evidence of process reliability can be provided.

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Refer to design/engineering authority for design documents not specifying a classification and/or inspection requirements.

6 Quality levels

Quality level A weld: Weld with high quality acceptance requirements.

Quality level B weld: Weld with moderate quality acceptance requirements.

Quality level C weld: Weld with typical quality acceptance requirements.

The quality levels are as defined by the engineering/drawing and/or specified by the design/engineering authority.

7 Weldment design

The design/engineering authority is responsible for the design of the weldment and defines the requirements to ensure compliance with all mission and systems requirements. The engineering documentation shall clearly define special requirements, such as fracture critical, durability critical, mission critical, or safety critical, imposed over and above the general requirements. Also, the design/engineering authority shall define process controls to ensure that all design requirements can be met by welds produced in accordance with specified procedure, fabrication, and inspection requirements.

For fillet welds, the weld size specified on the drawing is the minimum.

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8 Welding procedure specification (WPS)

8.1 General

A welding procedure specification is required for each weld. For an example of a WPS, see Annex B.

The welding procedure specification (WPS) shall include the information as given in Table 3.

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Table 3 — Welding procedure specification (WPS) data

Essential variable		Electron beam welding	TIG welding (GTAW[a])	Laser beam welding	Oxyfuel welding	Plasma arc welding
Joint design						
*	Joint type and dimensions	X	X	X	X	X
*	Treatment of backside, method of gouging/preparation	O	O	O	O	O
*	Backing	O	O	O	O	O
Base metal(s)						
*	Base metal(s) designation(s)	X	X	X	X	X
*	Heat treatment condition	X	X	X	X	X
*	Base metal form (sheet, tube etc.)	X	X	X	X	X
*	Thickness	X	X	X	X	X
	Diameter (tubular only)	X	X	X	X	X

X Data that shall be included in a WPS.

O Data that only need to be included in a WPS if used for that particular welding procedure.

[a] Gas tungsten arc welding.

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Table 3 *(continued)*

Essential variable		Electron beam welding	TIG welding (GTAW[a])	Laser beam welding	Oxyfuel welding	Plasma arc welding
*	Coating description or type	O	O	O	O	O
	Material group number according to Table 2	X	X	X	X	X
Filler material						
*	Specification, alloy designation, or the nominal composition	O	O	O	O	O
*	Filler material size or diameter	O	O	O	O	O
*	Flux		O		O	
*	Filler material feed rate	O	O	O		O
*	Consumable insert and type		O			O
*	Hot wire		O	O		O
Position						
*	Welding position(s)	X	X	X	X	X
Preheat and interpass temperature						
	Preheat method	O	O	O	O	O
*	Preheat minimum and/or maximum temperature	O	O	O	O	O
*	Interpass temperature minimum and/or maximum	O	O	O	O	O
Shielding gas						
*	Torch shielding gas and flow rate range		X	X		X
*	Root shielding gas and flow rate range		X	X		X
*	Environmental shielding and vacuum pressure	X	O	O		
*	Shielding gas devices and flow rate ranges		O	O		O
*	Gas cup design/size or gas lens		O			O
Energy characteristics						
*	Current type and polarity		X			X
*	Current range	X	X			X
*	Voltage range	X	O			X
*	Beam power; focus, current; pulse frequency range; filament type, shape, size	X		X		
*	Specification, classification, and diameter of tungsten electrode		X			X
*	Electrode geometry		X			X
*	Control of electrode to work piece distance (mechanized welding)		X			X
*	Pulsed current parameters		O			O

X Data that shall be included in a WPS.

O Data that only need to be included in a WPS if used for that particular welding procedure.

[a] Gas tungsten arc welding.

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