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Welding for aerospace applications — Resistance spot and seam welding

Soudage pour applications aérospatiales — Soudage par résistance par points et à la molette

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Contents

Page

Foreword ... v

1 Scope ... 1

2 Normative references ... 1

3 Terms and definitions ... 1

4 Symbols and abbreviated terms ... 4

5 Specific engineering requirements ... 4

6 Classification of the joint ... 4

7 Production requirements ... 4

8 Welding personnel requirements ... 5

9 Person responsible for welding procedure qualification and welding machine qualification tests ... 5

10 Material groups ... 5

11 Preparation of parts to be welded ... 5
11.1 General ... 5
11.2 Cleaning requirements ... 5
11.3 Surface coatings ... 6
11.4 Assembly ... 6

12 Equipment requirements ... 6
12.1 Welding machines ... 6
12.2 Electrodes ... 6
12.3 Shear testing machines ... 6
12.4 Jigs and fixtures ... 6

13 Welding machines ... 6
13.1 Qualification requirements ... 6
13.2 Test piece configuration and examination requirements ... 8

14 Welding procedure (pWPS) ... 9
14.1 Qualification requirements ... 9
14.2 Test piece configuration and examination requirements ... 11

15 Quality requirements for production ... 12
15.1 General ... 12
15.2 Production witness testing ... 12
15.3 Production parts ... 15

16 Test pieces ... 16
16.1 Standard test pieces ... 16
16.2 Test pieces for specific purposes ... 19

17 Examination, testing and acceptance criteria ... 19
17.1 General ... 19
17.2 Visual examination ... 19
17.3 Radiographic examination ... 21
17.4 Metallographic examination ... 22
17.5 Mechanical testing ... 26

18 Welding procedure qualification record (WPQR) ... 30

Annex A (informative) **Machine qualification test report form** ... 31

Annex B (informative) **WPS form** ... 33

Annex C (informative) **Forms for welding procedure qualification record (WPQR) — Examples** ... 34

Annex D (informative) **Commentary on machine qualification** **36**
Bibliography **40**

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 16338 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 of which can be found at www.iso.org.

Welding for aerospace applications — Resistance spot and seam welding

1 Scope

This International Standard specifies requirements for resistance spot and seam welding for aerospace applications.

This International Standard does not apply if resistance welding is simply an intermediate operation and does not affect the quality of the end product, for example when tacking basic parts prior to assembly with another process.

Resistance welding of dissimilar material group combinations is not covered by this International Standard.

Safety and health issues and concerns are not covered by this International Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6520-2, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 2: Welding with pressure*

ISO 10447:2006, *Resistance welding — Peel and chisel testing of resistance spot and projection welds*

ISO 14373:2006, *Resistance welding — Procedure for spot welding of uncoated and coated low carbon steels*

ISO 14731, *Welding coordination — Tasks and responsibilities*

ISO 14732, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials*

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

ISO 17677-1:2009, *Resistance welding — Vocabulary — Part 1: Spot, projection and seam welding*

ISO/TR 25901:2007, *Welding and related processes — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6520-2, ISO 14731, ISO 17677-1, ISO/TR 25901 and the following apply.

3.1
chisel test
destructive or non-destructive test in which welds are tested by applying a predominantly tensile force that results in stresses primarily normal to the surface of the joint interface

[SOURCE: ISO 10447:2006, 3.1]

3.2
close spaced welds
spot welds with weld pitch of less than two diameters

3.3
coring
incipient melting
melting and resolidification of material at the grain boundaries of the heat affected zone and/or in the weld nugget

Note 1 to entry: These features appear to be cracks when examined at low magnification, but when examined at high magnification, are seen to be completely filled. This occurs primarily in nickel alloys.

3.4
design authority
engineering authority
organization having the responsibility for the structural integrity or maintenance of airworthiness of the hardware and compliance with all relevant documents

3.5
foil
joint member with a thickness of 0,20 mm or less

3.6
metallographic section
<resistance welding for aerospace applications> transverse cut on the diameter of a spot weld or across a seam weld, or a longitudinal cut down the centre of a seam weld

3.7
nugget
zone in spot, projection or seam weld where the metal has been melted

[SOURCE: ISO 17677-1:2009, 4.10, modified — "See Figure 2." following the term has been deleted.]

3.8
nugget diameter
diameter of nugget measured at the faying surface

3.9
nugget penetration
extent of the nugget or fusion zone into the thickness of a joined member

3.10
peel test
destructive test in which a resistance-welded lap joint is tested by applying a peel force which results in stresses mainly in the thickness direction of the weld

[SOURCE: ISO/TR 25901:2007, 2.265]

3.11
preliminary welding procedure specification
pWPS
document containing the required variables of the welding procedure which has to be qualified

[SOURCE: ISO/TR 25901:2007, 2.280]

3.12
production witness test specimen
weld of test specimen made in production setups and destructively tested to provide data on the qualities of production welds

3.13
resistance seam welding
<resistance welding for aerospace applications> resistance welding process which produces coalescence at the faying surfaces by the heat obtained from resistance to electric current through the work parts held together under pressure by electrodes

Note 1 to entry: The resulting weld is a series of overlapping resistance spot welds made progressively along a joint by turning wheel electrodes or indexing the part under fixed electrodes.

3.14
resistance spot welding
resistance welding process that produces a weld at the faying surfaces between overlapping parts by the heat obtained from resistance to the flow of welding current through the workpieces from electrodes that serve to concentrate the welding current and pressure at the weld area

[SOURCE: ISO 17677-1:2009, 1.12]

3.15
roll spot welding
resistance welding process variant that makes intermittent spot welds using one or more rotating circular electrodes

Note 1 to entry: The rotation of the electrodes might or might not be stopped during the making of a weld.

[SOURCE: ISO 17677-1:2009, 3.5]

3.16
seam weld width
width of the weld metal in the plane of the faying surfaces in a direction normal to the longitudinal axis of the linear seam weld

[SOURCE: ISO 17677-1:2009, 4.14]

3.17
sheet
<resistance welding for aerospace applications> joint member with a thickness of more than 0,20 mm

3.18
weld pitch
centre-to-centre distance between adjacent spot welds

[SOURCE: ISO 14373:2006, 3.5]

3.19
welding condition
<resistance welding for aerospace applications> provision for the manufacture of a given weld, including material, configuration, material preparation, cooling, electrode material, electrode geometry, welding machine number, and all weld parameters that have a direct influence on the quality of the weld

3.20
welding parameter
<resistance welding for aerospace applications> machine setting or adjustment

EXAMPLE Examples are electrode force, welding current, welding speed, welding time.

3.21
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 25901:2007, 2.457]

4 Symbols and abbreviated terms

D_S	minimum required nugget diameter or seam weld width (see Table 11)
e_l	lower electrode indentation
e_u	upper electrode indentation
F	force
l	length of test specimen
s_M	actual nugget diameter or seam weld width, as determined by metallographic examination
t	thickness of the thinner sheet
t_o	thickness of outer member
w	test specimen width/overlap
Ac	test lot average
NDT	non-destructive testing
pWPS	preliminary welding procedure specification
QA	quality assurance
SPC	statistical process control
WPQR	welding procedure qualification record
WPS	welding procedure specification

5 Specific engineering requirements

In the event of any conflict between the requirements of this specification and those requirements specified in the engineering definition, the engineering definition shall take precedence.

The classification of the joint (see Clause 6) shall be designated on the part specification or drawing.

6 Classification of the joint

Classification of the joint is based on the following.

— 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.

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

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

7 Production requirements

Prior to production, the following requirements shall be met:

a) personnel qualification,

b) welding machine qualification,

c) welding procedure qualification.

8 Welding personnel requirements

The welding personnel shall be trained and be competent for the process. If requested by the design/engineering authority, ISO 14732 may be invoked.

9 Person responsible for welding procedure qualification and welding machine qualification tests

The welding coordinator (see ISO 14731) shall be designated, in writing, as responsible for welding procedure qualification and welding machine qualification test. The welding coordinator shall have knowledge and experience relevant to the welding process, and be acceptable to the responsible design/engineering authority or recognized examining body.

It is recommended that the welding coordinator be qualified as International Welding Engineer (IWE) according to IIW IAB-252-11.

The welding coordinator may authorize another person to administer the welding procedure qualification or welding machine qualification test.

10 Material groups

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

Material group B: high-alloyed austenitic and martensitic steels, nickel and nickel alloys, cobalt alloys.

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

Material group D: aluminium and aluminium alloys, magnesium and magnesium alloys.

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

11 Preparation of parts to be welded

11.1 General

External and faying surfaces of the parts to be welded shall be free from contaminants, such as heavy oxides, scale, ink, grease, dirt or other substances, or surface conditions detrimental to the welding process. The surfaces shall be regular, this being a determining factor in ensuring good reproducibility of the weld.

11.2 Cleaning requirements

A specific cleaning procedure (e.g. pickling) shall be determined according to the materials and precisely defined by each manufacturer in line with the design/engineering authority requirements.

The cleaning procedure used to prepare materials for welding procedure qualification shall be specified on the pWPS. For materials in group D, surface resistance requirements shall be specified by the design/engineering authority.

Time limits between cleaning and welding shall be specified in the pWPS or other manufacturing documentation.

11.3 Surface coatings

Surface coatings, specified by the design/engineering authority, shall be identified in the pWPS.

11.4 Assembly

Mating parts assembled for welding shall fit so that before the first and each subsequent weld is made, the surfaces to be joined by the weld are in contact with one another or can be made to contact one another by manual pressure.

12 Equipment requirements

12.1 Welding machines

The welding machine shall be qualified according to Clause 13, calibrated and maintained according to manufacturer recommendations and/or any other requirements as defined by the design/engineering authority.

A preventative maintenance procedure shall be established and maintenance records kept.

12.2 Electrodes

All electrodes in use shall be permanently marked with the electrode material designator, as a minimum.

12.3 Shear testing machines

12.3.1 General

Shear testing machines shall be accurate to within ±2 % of the indicated reading. The shear testing speed shall not exceed 13 mm/min.

12.3.2 Stationary shear testing machines

Stationary shear testing machines shall be calibrated for accuracy at intervals not to exceed one year.

12.3.3 Portable shear testing machines

Portable shear testing machines shall be calibrated for accuracy at intervals not to exceed two months.

12.4 Jigs and fixtures

Jigs and fixtures shall be so designed as to minimize the shunting of welding current through them instead of passing through the workpieces. All tooling that is required to locate welds or assist in the assembly of welded parts that passes through the magnetic field during the welding operation should be made of nonmagnetic materials insofar as possible.

13 Welding machines

13.1 Qualification requirements

13.1.1 General

Existing machine qualifications to other standards prior to the release of this International Standard are considered qualified, unless otherwise specified by the design/engineering authority.

Prior to production, qualification shall be performed on each resistance spot or seam welding machine to determine its ability and consistency of operation. The purpose of qualification is to identify and verify the range of welding for which a welding machine may be considered capable. Welding conditions shall be documented on a WPS as part of a machine qualification test report. Typical examples of report forms are given in Annexes A and B. Such forms may be modified or expanded as required. After approval is obtained, these reports shall be available for review.

Machines shall be qualified to meet the weld requirements for the most critical class (see Clause 6) in each material group (see Clause 10) for which it is intended to be used in production. A welding machine qualified to weld to the requirements of one class in a material group shall be automatically considered qualified for less critical classes in the same material group. A spot welding machine qualified for spot welding is also qualified for overlap spot welding. Machines used for class III foil welding may be qualified by establishing a WPS. Machines qualified to a class for seam welding shall be considered qualified for roll spot welding to the same class.

13.1.2 Method of welding machine qualification

13.1.2.1 General

No maintenance work or control adjustments are permitted during the welding of test specimens.

13.1.2.2 Test materials

Test materials for material groups A, B, C and D qualification may be any material from that group commonly used in production.

Qualification with material of group A qualifies for welding material of group A only.

Qualification with material of group B qualifies for welding material of group B only.

Qualification with material of group C qualifies for welding material of group C only.

Qualification with material of group D qualifies for welding material of group D only.

Qualification with a specific material of group E qualifies for welding with the same material only.

13.1.2.3 Test requirements

Weld tests listed in 13.2 shall be performed and shall meet applicable acceptance criteria. For each material group, two test sets shall be required: the high-end (thickest) machine qualification test and the low-end (thinnest) machine qualification test. Typically, the high-end and low-end machine qualification tests are each made up of two members of equal thickness. Alternatively, members of different thicknesses and/or a weld combination of more than two members may be used. The following requirements shall be used to determine the required machine qualification tests to cover production work:

a) The total thickness of all members in a production weld combination shall not be more than the total thickness of all members in the high-end machine qualification test and shall not be less than the total thickness of all members in the low-end machine qualification test.

b) The thinnest contact member (member in contact with the electrode) of any production weld combination shall not be thicker than the thinnest member in the high-end machine qualification test

c) The thinnest contact member (member in contact with the electrode) of any production weld combination shall not be thinner than the thinnest member in the low-end machine qualification test.

d) If a machine is used for a specific weld combination then it need only be qualified for that weld combination according to the quantities and methods specified in 13.2.

NOTE 1 For examples of the application of rules stated in this subclause, see Annex D.