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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

ICS 25.160.01

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Foreword

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ISO 16338 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*.

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

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 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 and the following apply.

3.1

close spaced welds

spot welds with centre to centre distance of less than two diameters between adjacent spots

3.2
coring
indications appearing like a crack which when examined under high magnification are shown to be filled with material

3.3
design/engineering authority
organization having the responsibility for the structural integrity or maintenance of airworthiness of the hardware and compliance with all relevant documents

3.4
foil
joint member with a thickness of 0,20 mm or less

3.5
metallographic section
<resistance welding for aerospace applications> a 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

3.6
nugget
zone in spot, projection or seam weld where the metal has been melted
[ISO 17677-1:2009]

3.7
nugget diameter
diameter of nugget measured at the faying surface

3.8
nugget penetration
the extent of the nugget or fusion zone into the thickness of a joined member

3.9
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
[ISO/TR 25901:2007]

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]

3.11
production witness test specimen
welds of test specimens made in production setups and destructively tested to provide data on the qualities of production welds

3.12
resistance seam welding (22)
<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 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.

3.13**resistance spot welding (21)**

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

[ISO 17677-1:2009]

3.14**roll spot welding**

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

NOTE The rotation of the electrodes might or might not be stopped during the making of a weld.

[ISO 17677-1:2009]

3.15**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

[ISO 17677-1:2009]

3.16**sheet**

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

3.17**welding condition**

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

3.18**welding parameter**

<resistance welding for aerospace applications> machine setting or adjustment

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

3.19**welding procedure specification****WPS**

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

[ISO/TR 25901:2007]

3.20**weld pitch**

centre-to-centre distance between adjacent spot welds

[ISO 14373:2006]

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
- N_o recommended (standard) number of spots per 25 mm
- N_p actual number of spots per 25 mm on a production part or representative specimen or test piece
- s_M actual nugget diameter or seam weld width, as determined by metallographic examination
- S_o minimum shear force of test specimen (see Table 15), N/mm
- S_x modified minimum shear force of test specimen when the difference of N_p is $> 15\%$ of N_o , N/mm
- 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.

NOTE Example of relevant knowledge is 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, 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 per 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 within $\pm 2\%$ 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 to minimize the shunting of welding current through them instead of passing through the work pieces. 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.