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Resistance welding — Spot welding of aluminium and aluminium alloys — Weldability, welding and testing

Soudage par résistance — Soudage par points de l'aluminium et des alliages d'aluminium — Soudabilité, soudage et essais

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Contents

Page

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ISO 18595:2007
https://standards.iteh.ai/catalog/standards/sist/3d513b3f-f921-4bda-b889-28cee052251b/iso-18595-2007

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Foreword

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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 18595 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding*.

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Resistance welding — Spot welding of aluminium and aluminium alloys — Weldability, welding and testing

1 Scope

This International Standard specifies requirements for resistance spot welding in the fabrication of assemblies of aluminium sheet, extrusions (both work- and age-hardening alloys) and/or cast material comprising two or three thicknesses of metal, where the maximum single (sheet) thickness of components to be welded is within the range 0,6 mm to 6 mm.

This International Standard is applicable to the welding of sheets or plates of dissimilar thickness where the thickness ratio is less than or equal to 3:1. It applies to the welding of three thicknesses where the total thickness is less than or equal to 9 mm.

Welding with the following types of machines is within the scope of this International Standard:

— pedestal welding machines;

— gun welders;

— automatic welding equipment where the components are fed by robots or automatic feeding equipment;

— multi-welders;

— robotic welders.

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Information on appropriate welding equipment is given in Annex A and on spot welding conditions in Annex B. The latter are for guidance only and may require modification depending on service conditions of the fabrication, type of welding equipment, characteristics of the secondary circuit, electrode material and geometry.

The welding of coated material, e.g. zinc-coated or anodised material, is not within the scope of 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 669:2000, *Resistance welding — Resistance welding equipment — Mechanical and electrical requirements*

ISO 5182, *Welding — Materials for resistance welding electrodes and ancillary equipment*

ISO 5184, *Straight resistance spot welding electrodes*

ISO 5821, *Resistance spot welding electrode caps*

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ISO 5830, *Resistance spot welding — Male electrode caps*

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

ISO 14329:2003, *Resistance welding — Destructive tests of welds — Failure types and geometric measurements for resistance spot, seam, and projection welds*

ISO 15614-12, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 12: Spot, seam and projection welding*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 669:2000 and ISO 14329:2003 and the following apply.

3.1
corona bond zone
zone outside the weld nugget in which solid phase bonding has occurred

NOTE 1 See Figure 1.

NOTE 2 This zone can contribute towards the strength of the joints but may not be considered for design purposes.

3.2
corona bond diameter
d_c
outer diameter of the corona bond zone

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NOTE See Figure 1.

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3.3
cross-tension test
test to determine the load-carrying behaviour of a spot-welded joint subjected to cross-tension loading

3.4
interface failure
fracture through the weld nugget between the sheets in the plane of the interface

NOTE See Figure 1.

3.5
nugget diameter
d_n
mean of the maximum and minimum diameters of the fused nugget in the plane of the interface between the pieces joined, measured on a metallographic section taken transversely through the centre of the nugget

NOTE See Figure 1. The nugget diameter is the parameter on which the mechanical behaviour of a structure is based. Other parameters such as the plug or weld diameter can be influenced by the type of destructive test.

3.6
plug failure
slug/button failure
fracture in the base metal, the heat-affected zone, or the nugget leaving attached metal pulled through thickness from the opposing sheet

NOTE See Figure 2.

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3.7
partial plug failure
fracture partly in the base material or the heat-affected zone and partly in the nugget leaving attached metal pulled through thickness from the opposing sheet

NOTE See Figure 2.

3.8
shear test
tensile shear test
test to determine the load-carrying behaviour of a spot-welded joint subjected to shear tension loading

3.9
weld diameter
d
⟨in an interface failure⟩ mean diameter of the fused zone measured at the interface omitting the corona bond

3.10
weld diameter
d
⟨in a plug failure⟩ mean diameter of the plug

NOTE See Figure 2 a) and b).

3.11
weld diameter
d
⟨in a partial plug failure⟩ mean diameter of the fused zone measured at the interface, omitting the corona bond area and the maximum diameter of the plug component of the failure

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NOTE 1 See Figure 2 c).

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NOTE 2 The minimum diameter of the plug component of the fracture is reported separately (see Figures 1 and 2).

NOTE 3 The plug diameter in aluminium spot welds is generally less than or equal to the diameter of the (weld) nugget.

3.12
weld nugget
lenticular zone in a resistance weld where metal from both (all) sheets has melted and resolidified

3.13
plug diameter
d_p
mean diameter of the plug in both plug and partial plug failure modes

NOTE See Figure 2.

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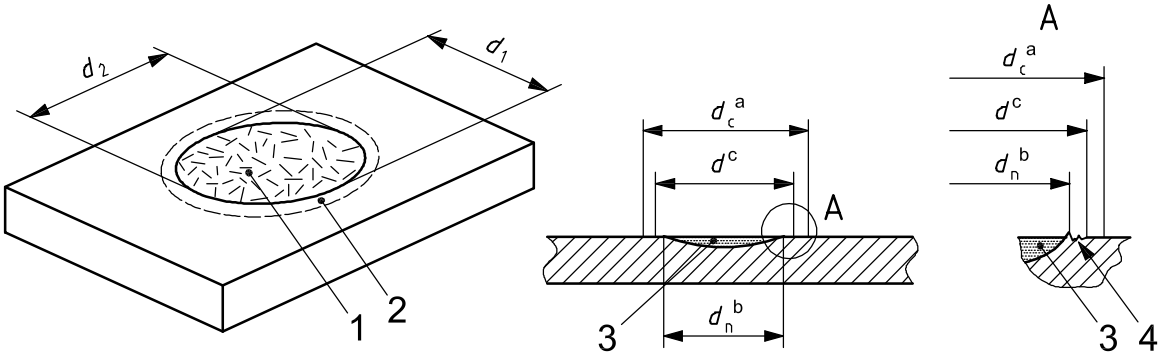

Key

1 weld with interfacial fracture ($d \approx d_n$)
2 corona bond zone
3 molten material of the nugget
4 rough fracture zone

a Corona bond diameter.
b Nugget diameter.
c Weld diameter (d_1 or d_2).

Figure 1 — Measurement of weld size — Weld with interface failure

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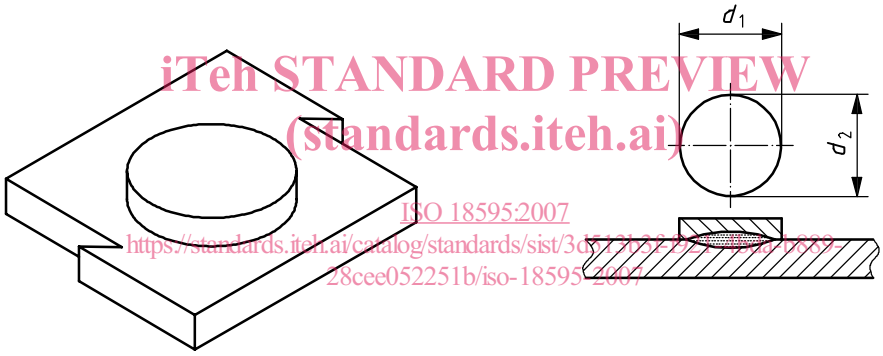
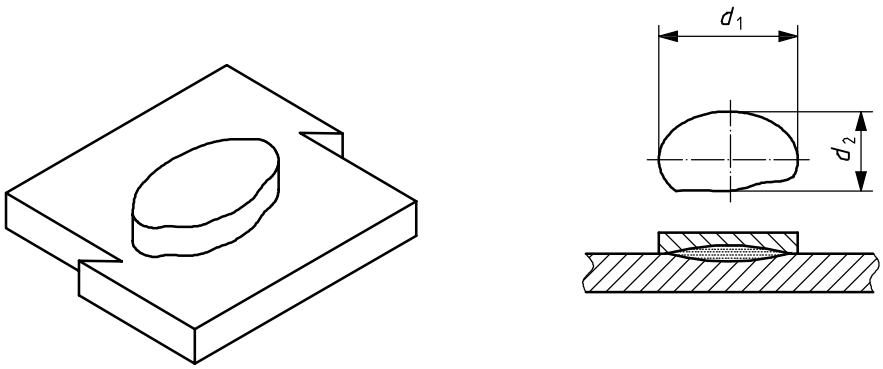


a) Symmetrical plug failure[a]



b) Asymmetrical plug failure[a]

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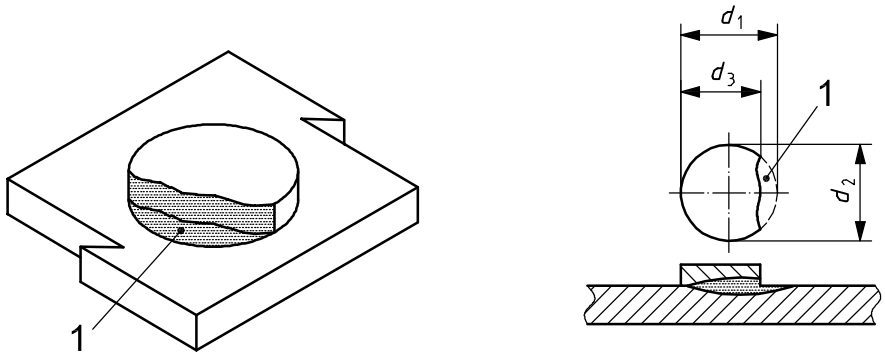

c) Partial plug failure[b]

a $d = d_p = (d_1 + d_2)/2$

b $d = (d_1 + d_2)/2$ and $d_p = (d_2 + d_3)/2$

Figure 2 — Measurement of weld size — Weld with plug (slug) failure

4 Symbols

Symbol	Term	Unit
d	weld diameter	mm
d_c	corona bond diameter	mm
d_i	initial or set-up weld diameter	mm
d_n	nugget diameter	mm
d_p	plug diameter	mm
d_t	initial electrode tip diameter	mm
t	sheet thickness	mm
P_s	shear strength of weld	kN
R_m	ultimate strength of aluminium being welded	MPa

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5 Material

5.1 Form

The material shall be flat rolled, extruded or cast and shall be free from harmful imperfections.

5.2 Types of aluminium alloys

A partial list of aluminium alloys is given in Annex C.

6 Surface conditions

Prior to welding, all surfaces shall be checked for their suitability for spot welding. The surfaces should be free from oil, grease, lubricant, visible oxidation, paint, dirt, or excessive scratches. If necessary, appropriate surface treatment, e.g. chemical etching, shall be carried out. Mill-finish surfaces are generally not suitable for spot welding; however, aluminium manufacturers can supply surface-treated material suitable for spot welding, e.g. with TiZr conversion coating. Extrusions shall also be in the mill-finish condition and will generally require pre-treatment. Die-cast material shall be free from excessive surface roughness and imperfections, e.g. as caused by washing out of the die material. Excessive quantities of dissolved gases in die-cast material shall be avoided. In addition, coated material can be supplied with chromate or phosphate passivation. Phosphated aluminium may be used in certain applications. These materials can be spot welded, although adjustment to the welding parameters will generally be necessary as outlined in Annex B.

NOTE In most countries, chromate passivation treatment will be prohibited in the near future to avoid health risks.

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7 Edge distance, edge conditions, form of component and weld spacing

The components to be welded shall be free from burrs or other defects, which may, in any way, interfere with interface contact or require excessive force to fit the parts together.

The shape of the component shall be such that there is satisfactory interfacial contact in the area where welds are to be made. The distance from the edge of the component to the centre of the weld (edge distance) shall be not less than 1,25d (see Figure 3), where d is the initial weld diameter as defined in 8.2. The use of edge distances lower than the recommended values will adversely influence weld quality. Edge distances lower than the recommended values should be used only when expressly specified. In this case the nominal weld size specified may be less than that given in 8.2, and therefore due allowance needs to be made for a lower weld strength (see 10.4).

The weld pitch, i.e. the centre-to-centre distance between adjacent spot welds (see Figure 3), shall not be less than 6d and preferably larger. Tolerances for distances between the centres of two adjacent spot welds should not exceed ± 10 % provided that the pitch does not fall below the minimum value. Smaller weld pitches may be specified provided that the current is increased after the first weld to compensate for the effect of shunting and the required weld quality can be achieved.

NOTE In the case of aluminium alloys, the shunting effect is much greater due to the higher electrical conductivity as compared to steel.

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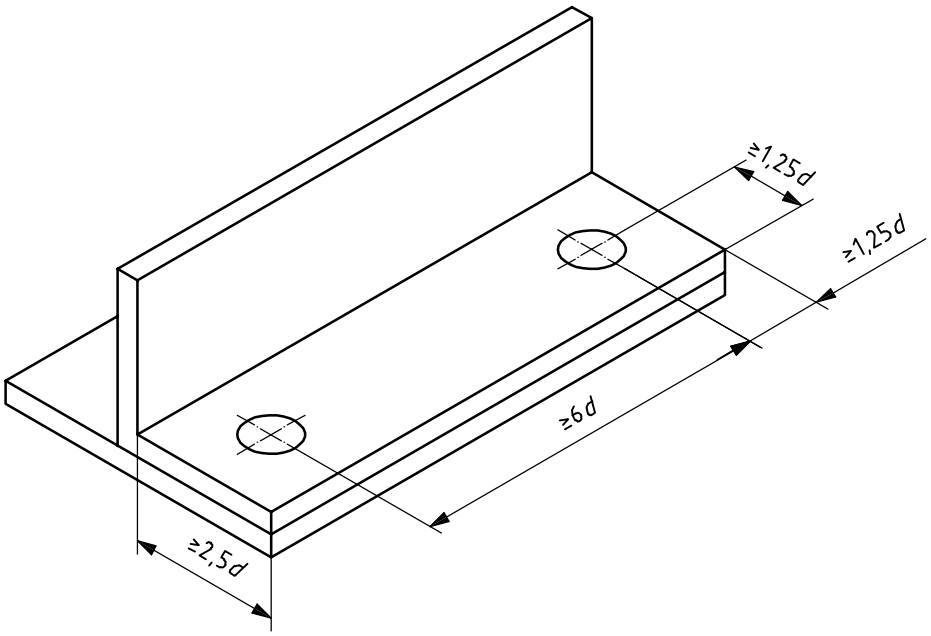

Key

d weld diameter

Figure 3 — Recommended edge distance and weld pitch

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8 Electrodes

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8.1 Materials

The electrode materials shall be copper alloy and should possess high thermal and electrical conductivity and shall comply with, and be used in accordance with ISO 5182.

8.2 Dimensions

The welding electrodes shall be of sufficient cross-sectional area and strength to carry the welding current and electrode force without overheating, excessive deformation, or excessive deflection. If possible, from the point of accessibility, electrodes with a minimum diameter, D, of 20 mm should be used.

The electrode dimensions shall, where practicable, conform to ISO 5184 for straight electrodes, ISO 5821 for female electrode caps, or ISO 5830 for male electrode caps, as applicable. In cases where these standards do not apply, the dimensions of the electrode shall be specified such that welds conforming to this International Standard are produced.

When welding two sheets of thickness up to 3 mm using truncated cone-type electrodes, the initial electrode tip diameter, d_t, in millimetres, shall be chosen according to the following equation unless otherwise specified:

$$d_t = 6\sqrt{t} + 2 \tag{1}$$

where t is the thickness, in millimetres, of the sheet in contact with the electrode.

When using truncated cone electrodes, the initial or set-up weld diameter, d_i, in millimetres, should be greater than or equal to the diameter of the electrode tip, in accordance with Expression (2):

$$d_i \geqslant d_t = 6\sqrt{t} + 2 \tag{2}$$

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