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Resistance welding — Procedure for spot welding of uncoated and coated low carbon steels

Soudage par résistance — Mode opératoire pour le soudage par points des aciers à bas carbone revêtus et non revêtus

Reference number
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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.

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 14373 was prepared by the International Institute of Welding, recognized as an international standardizing body in the field of welding in accordance with Council Resolution 42/1999.

Requests for official interpretations of any aspect of this International Standard should be directed to the ISO Central Secretariat, who will forward them to the IIW Secretariat for an official response.

Resistance welding — Procedure for spot welding of uncoated and coated low carbon steels

1 Scope

This International Standard specifies requirements for resistance spot welding in the fabrication of assemblies of uncoated and metallic coated low carbon steel, comprising two or three sheets of metal, where the maximum single sheet thickness of components to be welded is within the range 0,4 mm to 3 mm, for the following materials:

— uncoated steels;

— hot-dip zinc or iron-zinc alloy (galvannealed) coated steel;

— electrolytic zinc, zinc-iron, or zinc-nickel coated steel;

— aluminium coated steel;

— zinc-aluminium coated steel.

This International Standard is applicable to the welding of sheets of the same or 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 equipment is within the scope of this International Standard:

a) pedestal welding equipment;

b) gun welders;

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

d) multi welders;

e) robotic welders.

Information on appropriate welding equipment is given in Annex A, and information on spot welding conditions is given in Annex B. This information is provided for guidance only. Depending on the service conditions of the fabrication, the type of welding equipment, the characteristics of the secondary circuit, the electrode material, and the shape, it is possible that certain modifications are necessary. In such cases, further information may be obtained from the relevant application standard, where one exists.

The welding of organic coated or primer coated steels 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, *Resistance welding — Resistance welding equipment — Mechanical and electrical requirements*

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

ISO 10447, *Welding — Peel and chisel testing of resistance spot, projection and seam welds*

ISO 14270, *Specimen dimensions and procedure for mechanized peel testing resistance spot, seam and embossed projection welds*

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

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

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, ISO 14329, and the following apply.

3.1
corona bond zone
area of the weld at the faying surfaces in which solid phase bonding has occurred

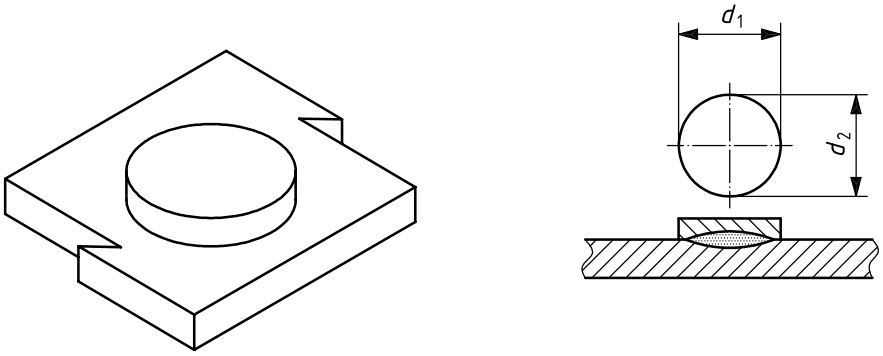
See Figure 2.

3.2
cross-tension test
test to determine the load-carrying capability of a spot welded joint subjected to cross tension loading

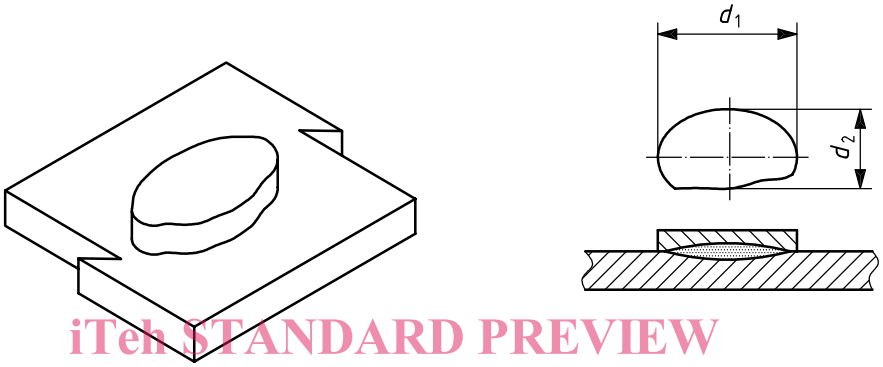
3.3
shear test
tensile shear test
test to determine the load-carrying capability of a spot welded joint subjected to shear tension loading

3.4
weld nugget
lenticular zone in a resistance weld, where metal from both (all) sheets has melted and re-solidified

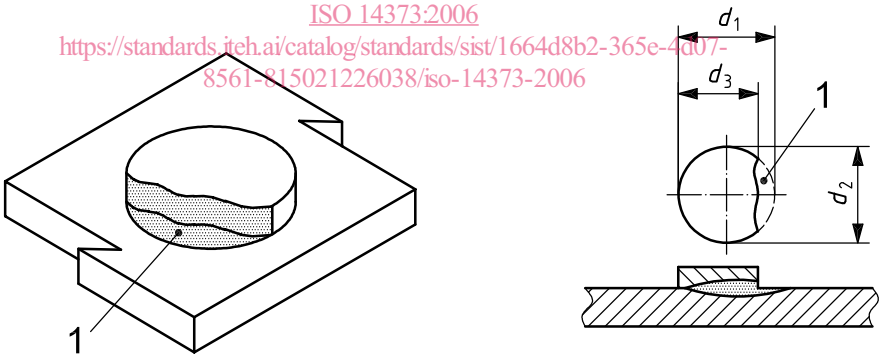
3.5
weld pitch
centre-to-centre distance between adjacent spot welds



a) **Symmetrical** [a]



b) **Asymmetrical** [a]



c) **Partial** [b]

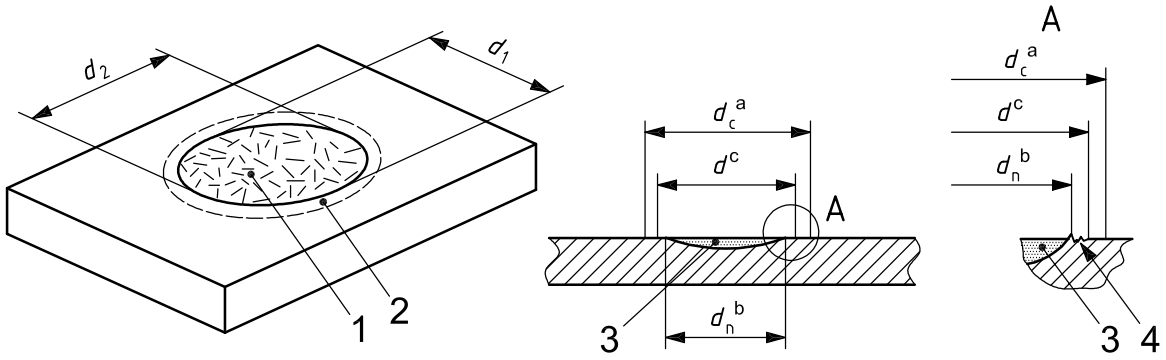
Key

1 interfacial fracture

[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 1 — Measuring of weld size for weld with plug (slug) failure



Key

1 sheared nugget
2 corona bond zone
3 nugget
4 rough fracture zone

a Diameter of the corona.
b Diameter of the nugget.
c d_1 or d_2.

Figure 2 — Measuring of weld size for weld with interface failure, $d < d_c$

4 Symbols and abbreviated terms

Symbol	Term	Dimension
d	weld diameter (see Figures 1 and 2)	mm
d_c	corona diameter	mm
d_e	electrode tip diameter	mm
d_n	nugget diameter	mm
t	sheet thickness	mm
P_s	weld shear strength	kN
R_m	ultimate tensile strength of steel being welded	MPa

5 Material

5.1 Form

The steel shall be flat rolled, in coil or cut to length, and shall be free from harmful imperfections.

5.2 Steel grades

A partial list of steel grades to which this International Standard is applicable is given in Annex C.

6 Surface conditions

Prior to welding, all surfaces of components to be spot-welded shall be free from grease, scale, rust, paint, dirt, or excessive pitting. Uncoated hot rolled steel shall be in the pickled condition [1]. Coated steels can be supplied with a chromate or phosphate passivation treatment. Phosphated mild steel may be used in certain applications. These materials can be spot welded, although adjustment may be required to the welding parameters outlined in Annex B. Generally speaking, only thin phosphate pre-treatment of steel is acceptable prior to spot welding.

7 Edge conditions, form of component, and weld spacing

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

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

The distance between adjacent spot welds (see Figure 3) should not be less than 16 t, and preferably greater. Tolerances for the distance between the centres of two adjacent spot welds should not exceed ± 10 %, provided that it does not fall below the minimum value.

8 Electrodes

8.1 Materials

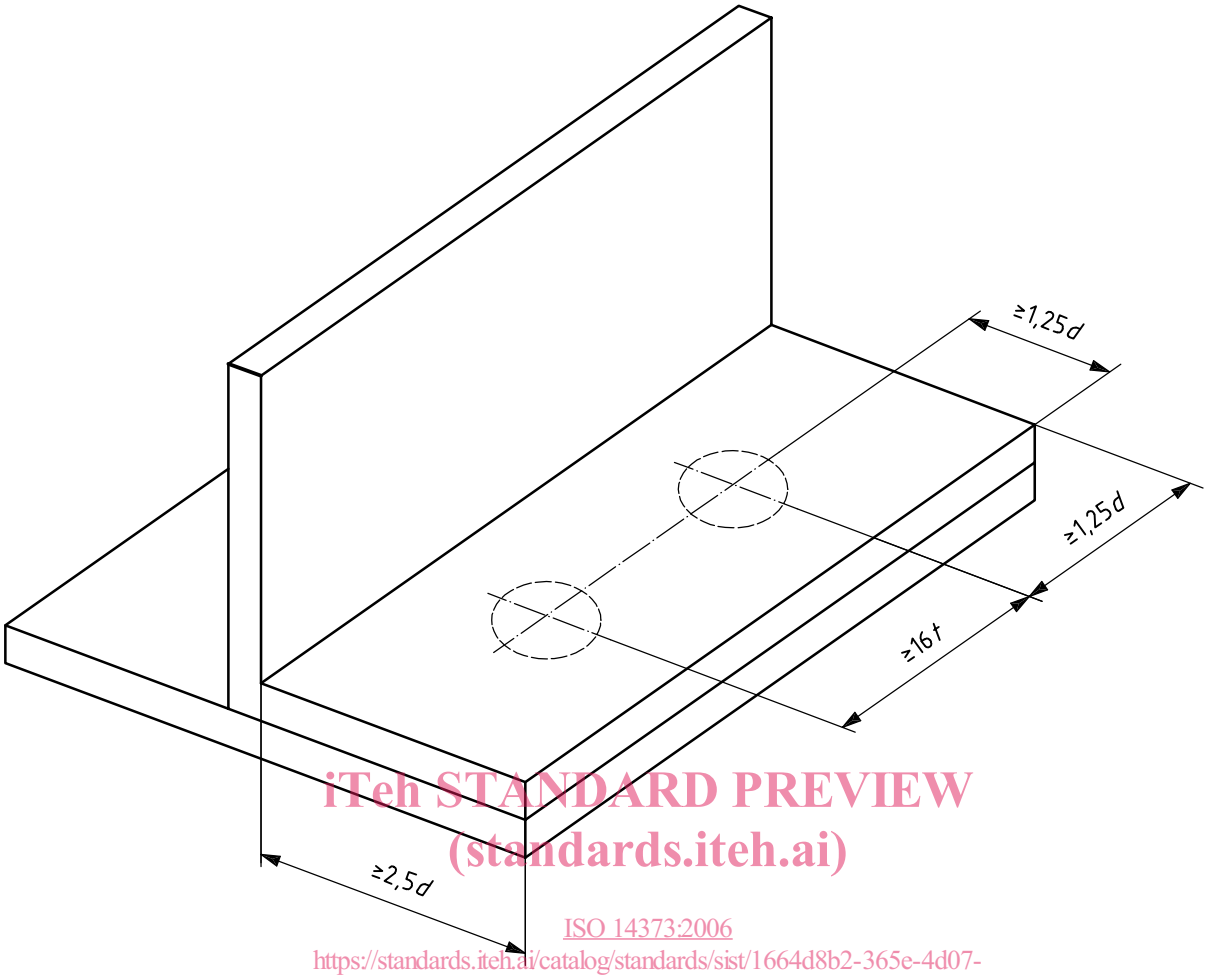
The electrode materials shall be a copper alloy and should possess high thermal and electrical conductivity. They should comply with, and be used in accordance with, ISO 5182.

8.2 Dimensions

The welding electrodes should be of sufficient cross sectional area and strength to carry the welding current and electrode force without overheating, excessive deformation, or excessive deflection.

The electrode dimensions should conform to ISO 5184 for straight electrodes, ISO 5830 for male electrode caps, and ISO 5821 for female electrode caps, as applicable.

1) Certain surface treatments, such as the application of paint primers, rust preventatives, and oils, can be applied before welding, provided that the coating is uniform in thickness and it has been shown that consistent welds conforming to this International Standard can be obtained. Excessive use of surface pre-treatment reduces the length of electrode life.



Key

d weld diameter

t sheet thickness

Figure 3 — Recommended edge conditions and weld pitch

When welding two sheets of thickness of maximum 3 mm using truncated cone type electrodes, the electrode tip diameter should be chosen from standard sizes according to the following equation.

$$d_e = 5\sqrt{t} \quad (1)$$

where

d_e is the initial tip diameter, in mm

t is the thickness of the sheet in contact with the electrode, in mm

When using truncated cone electrodes, the initial (or set-up) weld diameter should be equal to the diameter of the electrode tip; i.e.

$$d = d_e = 5\sqrt{t} \quad (2)$$

where

d is the weld diameter, in mm

CAUTION — The use of a smaller weld size than that given by Equation (2) may result in lower weld strength. This needs to be taken into account in all design calculations (see Table 1).

NOTE 1 When using domed electrodes with small tip radii or electrodes with very small working faces, Equation (1) does not always apply, in which case the electrode dimensions depend on accessibility and flange width. In such cases, the electrode tip dimensions and welding conditions are selected to give a weld diameter as specified in Equation (2), and they meet the minimum requirements outlined in Clause 10.

When welding two sheets of dissimilar thickness, the electrode dimensions and the required weld size should be specified with reference to the thinner sheet thickness. In the case of three thicknesses, the thinner sheet of each combination should be used as the reference.

Where a pad or mandrel is used as the second electrode, its surface shall be maintained to match the profile of the work piece.

During normal production, electrodes tend to mushroom, leading to an increase in electrode tip diameter. The diameter of at least one of the electrodes should not normally be allowed to increase above a value which results in a reduction in weld size to less than the acceptable minimum, e.g. $3.5\sqrt{t}$. When this diameter has been reached (if not before), the electrode should be replaced or redressed to its initial size and contour.

Table 1 — Typical minimum weld shear strength values for low carbon steel

Sheet thickness	Nominal $3.5\sqrt{t}$		Nominal $4\sqrt{t}$		Nominal $5\sqrt{t}$		Nominal $6\sqrt{t}$	
	Weld diameter	Weld strength	Weld diameter	Weld strength	Weld diameter	Weld strength	Weld diameter	Weld strength
mm	mm	kN	mm	kN	mm	kN	mm	kN
0,6	2,7	1,3	3,1	1,6	3,9	2,0	4,6	2,3
0,8	3,1	2,3	3,6	3,0	4,5	3,6	5,4	4,2
1,0	3,5	3,2	4,0	3,7	5,0	4,3	6,0	5,1
1,2	3,8	4,1	4,4	4,6	5,5	5,4	6,6	6,2
1,6	4,4	5,5	5,1	6,0	6,3	7,4	7,6	8,3
2,0	5,0	7,2	5,7	8,4	7,1	10,8	8,5	13,5
2,5	5,5	10,6	6,3	11,8	7,9	14,5	9,5	17,3
3,0	6,0	12,0	6,9	14,0	8,6	17,8	10,4	22,0

NOTE These values can be used for design calculations. Higher values are generally obtained in practice. Higher strengths are also obtained with higher strength steels.

Where electrode tips of different diameters are in contact with the work, the permissible increase over the initial diameter should apply to the smaller of the two electrode tips.

NOTE 2 A greater increase in electrode tip diameter is permissible only if tests prove that the strength of the weld does not fall below the desired requirements.

NOTE 3 In cases where automatic weld current increase is used (i.e. stepper controls), the increase in electrode tip diameter can be greater. The acceptable increase can be determined by empirical means, provided that the weld size does not fall below that specified in Equation (2).

8.3 Cooling of electrodes

The bore of the cooling water hole and pipe should conform to ISO 5184, ISO 5830, or ISO 5821, whichever is applicable.

It is recommended that the water flow be a minimum of 4 l/min per electrode for welding two uncoated steel sheets of thickness up to and including 3,0 mm. Higher flow rates are recommended when welding coated