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

~~*Soudage par résistance — Procédure pour le soudage par points des aciers à bas carbone revêtus et non revêtus*~~

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding and allied mechanical joining*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 14373:2015), which has been technically revised.

The main changes are as follows:

— ~~—~~figures showing failure types and modes for tensile shear and cross tension testing removed;

— ~~—~~new coating types added;

— ~~—~~cross-tension strength (CTS) values added;

— ~~—~~tensile shear strength (TSS ~~equation~~) formula removed;

— ~~—~~tolerance for distortions ~~was~~ reduced;

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.

Introduction

Information on appropriate welding equipment is given in Annex A~~Annex A,~~ and information on spot-welding conditions is given in Annex B~~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 force actuation system, the electrode material and the shape, it is possible that certain modifications will be necessary. In such cases, further information can be obtained from the relevant application standard, where one exists.

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

1 Scope

This document specifies requirements for resistance spot welding in the fabrication of assemblies of uncoated and metallic-coated or weldable non-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.

This document is applicable to welding of sheets of the same or unequal thickness, where the thickness ratio is less than or equal to 3:1.

Welding with the following types of equipment is within the scope of this document:

a) ~~a)~~ pedestal welding equipment;

b) ~~b)~~ portable welding guns;

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

d) ~~d)~~ multi-spot-welding machines;

e) ~~e)~~ robotic welding machines.

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 1089, *Resistance welding equipment — Electrode taper fits for spot welding equipment — Dimensions*~~

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17677-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
weld pitch
centre-to-centre distance between adjacent spot welds

3.2
edge distance
distance from the edge of the component to the centre of a weld

4 Symbols

Symbol	Term	Unit
d_w	weld diameter (see ISO 17677--1)	mm
d_e	electrode tip diameter	mm
t	sheet thickness	mm

5 Materials

5.1 Form

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

5.2 Coatings

A partial list of coatings to which this document is applicable is given in Annex C~~Annex C.~~

6 Surface conditions

Prior to welding, all surfaces of components to be welded shall be free from grease, scale, rust, paint, dirt or excessive pitting. Standard oiling from rolling or stamping operations is not detrimental to welding.

When the steel sheet has been hot formed, it shall be sandblasted (or processed by any equivalent cleaning process) prior to welding to remove the oxides formed during the hot forming operation. Steel sheets coated with aluminium-silicon coatings can be welded directly after hot forming without sandblasting.

Uncoated hot-rolled steel shall be in the pickled condition.

Coated steels can be supplied with a chromate or phosphate passivation treatment. Phosphated uncoated steel may also be used. These materials can be welded, although adjustment can be required to the welding parameters outlined in Annex B~~Annex B.~~ Generally speaking, only thin phosphate pre-treatment of steel is acceptable prior to spot welding.

Certain surface treatments, such as the application of paint primers, weldable organic coatings, 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 document can be obtained. Excessive use of surface pre-treatment reduces the length of electrode life.

7 Edge conditions, form of component and weld pitch

The components to be welded shall be free from any burrs or other defects which could interfere with interface contact in some way or which could 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 edge distance should not be less than 1,25 d_w (see Figure 1~~Figure 1),~~, where d_w is the weld diameter as defined in 10.1~~10.1.~~ 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 10.1~~10.1,~~ therefore due allowance is needed for a lower weld strength (see 10.4~~10.4).~~).

The weld pitch (see Figure 1~~Figure 1))~~ should be greater than 16 t and 3 d_w. Tolerances for the weld pitch should not exceed~~±~~ ± 10 %, provided that it does not fall below the minimum value. If the weld pitch is too short, the shunting current through the previous weld will reduce the size of the following weld. An increase of the welding current can partially ~~compensate~~mitigate the problem.

8 Electrodes

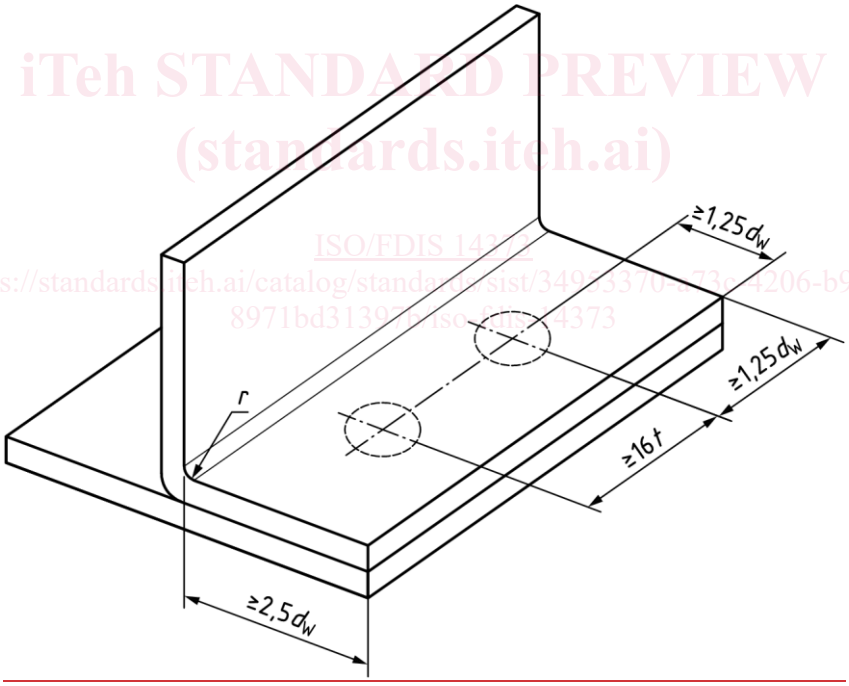
8.1 Materials

The electrode materials shall be a copper alloy and should possess high thermal and electrical conductivity. They should conform to 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 1089 for taper fits, ISO 5184 for straight electrodes, ISO 5830 for male electrode caps and ISO 5821 for female electrode caps, as applicable.



Key

d_w weld diameter

t sheet thickness

r corner radius

~~Corner radius r should be between one and three times the sheet thickness t.~~

Corner radius r should be between one and three times the sheet thickness t.

Figure 1 — Recommended edge conditions and weld pitch

When welding two sheets of thickness up to and including 3 mm using truncated cone type electrodes, the electrode tip diameter should be chosen from standard sizes according to Formula (1)~~Formula (1).~~.

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

where

d_e is the initial tip diameter, in mm;

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

a is a factor usually between 5 and 7.

When using domed electrodes (e.g. Type F0 according to ISO 5821) with small tip radii or electrodes with very small working faces, Formula (1)~~Formula (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 10.1~~10.1.~~.

When welding two sheets of unequal thickness, the electrode dimensions 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 alloy, dimple or 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, as specified in 10.1~~10.1.~~ When this diameter has been reached (if not before), the electrode should be replaced or redressed to its initial size and contour.

Installation of an automatic electrode tip dressing system is recommended in high-volume production lines.

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.

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.

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 10.1~~10.1.~~.

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 steels. The internal water-cooling feed tube should be arranged to ensure that the water impinges onto the back working face of the electrode. The distance between the back and the working face of the electrode should be in the range given in the relevant International Standard. If the distance becomes too small after several dressing operations, the electrode can collapse.

9 Weld assessment

9.1 General

Before the following weld assessments, the welding equipment, materials to be welded and joint designs shall be confirmed in accordance with the requirements of ISO 15609-5. The testing to assess the weld quality shall be performed in accordance with the requirements of ISO 15614-12.

9.2 Weldability testing

The weldability of a particular steel can be assessed by determining weldability lobes and the electrode life in accordance with ISO 18278-1 and ISO 18278-2. These tests are also used to assess whether a particular set of welding equipment is suitable for producing specific components.

Guidelines for the welding equipment and welding conditions are given in Annexes A and B.

9.3 Production testing

The following tests shall be carried out to ensure consistent spot weld quality under production conditions:

a) a visual examination, in accordance with Clause 10;

b) either a peel test or a chisel test, in accordance with ISO 10447; alternatively, other equivalent non-destructive tests may be used (e.g. ultrasonic testing).

In addition, other tests, such as tensile shear tests, may be carried out.

9.4 Frequency of testing

When practicable, actual components shall be used for testing. When it is not practicable to use actual components, test pieces of the same material with relevant flange widths shall be used and there shall be sufficient material of the same type or types associated with the test piece in the throat of the machine to approximate the magnetic effect of the work piece under production conditions.

Tests should be carried out on each of the following occasions:

a) at the beginning of each shift or daily work period;

b) immediately before and after new or reconditioned electrodes are fitted to the machine;

c) whenever any of the following occurs: major maintenance, repairs, change in key machine components or machine settings;

d) immediately following a change of supply sources for materials or components to be welded.

Manufacturing shall not start until a satisfactory test weld has been obtained at the beginning of each of these specified periods. In the event of the test piece failing at the end of the shift or work period, 2 % or 10 pieces (whichever is greater) shall be selected from the production during the period following the previous test on that machine and shall be tested in accordance with Clause 10. In the event of any of the selected components failing, the whole of the production during that period shall be deemed not to have conformed to this document.

For visual examination, no dressing, painting or other operation interfering with the examination of the weld zone shall be carried out on the assemblies until after the welding has been inspected. The surface of the work pieces shall be at least of the same quality as the test pieces in conformity with 10.4.1.

10 Weld quality requirements

10.1 Weld diameter

The weld diameter shall be determined according to ISO 17677-1.

The weld diameter should approximate to $5\sqrt{t}$ and shall not fall below $3{,}5\sqrt{t}$, where t is the sheet thickness in mm, unless the application standard permits this.