BS EN ISO 18278-1:2015

BSI Standards Publication

Resistance welding — Weldability

Part 1: General requirements for the evaluation of weldability for resistance spot, seam and projection welding of metallic materials

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National foreword

This British Standard is the UK implementation of EN ISO 18278-1:2015. It supersedes BS EN ISO 18278-1:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/29, Resistance welding.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Soudage par résistance - Soudabilité - Partie 1: Exigences générales pour l'évaluation de la soudabilité pour le soudage par résistance par points, à la molette et par bossages des matériaux métalliques (ISO 18278-1:2015)

Widerstandsschweißen - Schweißeignung - Teil 1: Bewerten der Schweißeignung zum Widerstandspunkt-, Rollennaht- und Buckelschweißen von metallischen Werkstoffen (ISO 18278-1:2015)

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Foreword

This document (EN ISO 18278-1:2015) has been prepared by Technical Committee ISO/TC 44 “Welding and allied processes” in collaboration with Technical Committee CEN/TC 121 “Welding and allied processes” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2015, and conflicting national standards shall be withdrawn at the latest by October 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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Endorsement notice

The text of ISO 18278-1:2015 has been approved by CEN as EN ISO 18278-1:2015 without any modification.

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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 documents 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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary Information.

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding and allied mechanical joining*.

This second edition cancels and replaces the first edition (ISO 18278-1:2004), which has been technically revised.

ISO 18278 consists of the following parts, under the general title *Resistance welding — Weldability*:

— *Part 1: General requirements for the evaluation of weldability for resistance spot, seam and projection welding of metallic materials*

— *Part 2: Evaluation procedures for weldability in spot welding*

INTERNATIONAL STANDARD **ISO 18278-1:2015(E)**

Resistance welding — Weldability —

Part 1: General requirements for the evaluation of weldability for resistance spot, seam and projection welding of metallic materials

1 Scope

This part of ISO 18278 specifies procedures for assessing the generic weldability for resistance welding of uncoated and coated metals.

It is assumed for this and other linked standards that their application is entrusted to appropriately trained, skilled, and experienced personnel.

For the quality of welded structures, the relevant part of ISO 14554 is applicable. The specification of procedures is to follow guidelines as in ISO 15609-5.

The purpose of the tests are to

a) compare the metallurgical weldability of different metals,

b) assess the weldability of differing component designs, e.g. dimensional configuration, stack-up, projection geometry, etc.,

c) investigate the effect of changes in welding parameters such as welding current, weld time, electrode force or complex welding schedules including pulse welding, current stepping etc. on weldability, and/or

d) compare the performance of resistance welding equipment.

Precise details of the test procedure to be used will depend on which aspect of items a) to d) will be evaluated relative to the welding result obtained.

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 669, *Resistance welding — Resistance welding equipment — Mechanical and electrical requirements*

ISO 693, *Dimensions of seam welding wheel blanks*

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

ISO 5821, *Resistance welding — Spot welding electrode caps*

ISO 8167, *Projections for resistance welding*

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

ISO 14270, *Resistance welding — Destructive testing of welds — Specimen dimensions and procedure for mechanized peel testing resistance spot, seam and embossed projection welds*

ISO 14271, *Resistance welding — Vickers hardness testing (low-force and microhardness) of resistance spot, projection, and seam welds*

ISO 14272, *Resistance welding — Destructive testing of welds — Specimen dimensions and procedure for cross tension testing of resistance spot and embossed projection welds*

ISO 14273, *Resistance welding — Destructive testing of welds — Specimen dimensions and procedure for tensile shear testing resistance spot, seam and embossed projection welds*

ISO 14323, *Resistance welding — Destructive testing of welds— Specimen dimensions and procedure for impact tensile shear test and cross-tension testing of resistance spot and embossed projection welds*

ISO 14324, *Resistance spot welding — Destructive tests of welds — Method for the fatigue testing of spot welded joints*

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 15614-13, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 13: Upset (resistance butt) and flash welding*

ISO 16432, *Resistance welding — Procedure for projection welding of uncoated and coated low carbon steels using embossed projection(s)*

ISO 17653, *Resistance welding — Destructive tests on welds in metallic materials — Torsion test of resistance spot welds*

ISO 17654, *Resistance welding — Destructive tests of welds — Pressure test of resistance seam welds*

ISO 17657-2, *Resistance welding — Welding current measurement for resistance welding — Part 2: Welding current meter with current sensing coil*

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

ISO 18592, *Resistance welding — Destructive testing of welds — Method for the fatigue testing of multi-spot-welded specimens*

ISO/TR 581:2005, *Weldability — Metallic materials — General principles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17677-1, ISO 669, ISO/TR 581:2005, and the following apply.

3.1
weldability
<resistance welding> capacity of the component to be welded under the imposed fabrication conditions into a specific suitability designed structure and to perform satisfactorily in the intended service

3.2
welding current range
welding current domain allowing the production of spot welds without expulsion and of a diameter equal or more than a pre-determined value under constant machine settings

4 Weldability

4.1 Weldability of a component

4.1.1 General

Weldability of a component is governed by three factors; material, design, and production (see Figure 1).

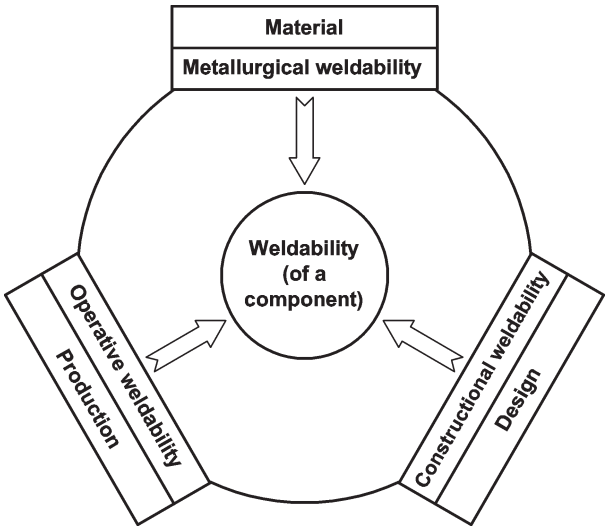


Figure 1 — Weldability

4.1.2 Metallurgical weldability

The less the factors governed by the material have to be taken into account when determining the welding procedure for a given construction, the better is the metallurgical weldability of a material group.

The ease by which a material can be welded determines its metallurgical weldability.

4.1.3 Operative weldability

Operative weldability exists for a welding procedure if the welds envisaged for a particular construction can be made properly under the chosen conditions of production.

The less the factors governed by the welding procedure have to be taken into account in designing a construction for a specific material, the better is the operative weldability of a procedure intended for a specific structure or component.

4.1.4 Constructional weldability

Constructional weldability exists in a construction if the material concerned and the component remain capable of functioning under the envisaged operating conditions by virtue of their design.

The less the factors governed by the design have to be taken into account when selecting the material for a specific welding procedure, the greater is the constructional weldability of a specific structure or component.

4.2 Criteria for the evaluation of weldability

Weldabilty in resistance welding requires the ability to make a weld in the first place, the ability to continue making welds, and the ability of the weld to withstand the imposed service stresses.

Criteria for the evaluation of the weldability in resistance welding are typically as follows:

— welding current range which quantifies ability to make a weld (see NOTE);

— electrode wear and life which quantifies the ability to continue making welds (see NOTE);

— strength of joints under different load directions;

— material hardness modifications;

— presence, number, and size of the surface or inner cracks, pores, shrink holes, and other defects;

— fracture behaviour under different load directions;

— resistance to service stresses such as corrosion, humidity, low, elevated, or fluctuating temperatures etc.

NOTE Results of welding current range and electrode life investigations do not only reflect material characteristics, but are also highly related to the characteristics of the welding equipment employed.

A final evaluation of weldability in each case can only be estimated by considering the prioritized criteria laid down by the end user.

5 Preparation of welding equipment

5.1 Welding machine

The electrical and mechanical characteristics of the welding machine used for the tests shall meet the requirements specified in accordance with ISO 669.

In AC-welding machines and single-phase DC-welding machines, wherever possible, a transformer tap setting should be selected which allows the secondary welding current to be achieved using a conduction angle greater than 120°. The water supply to the transformer and/or rectifier and welding controller cooling circuits should be independent of cooling water to the electrodes. If this is not possible, the water should flow from the electrode to the welding controller/transformer circuits and not vice versa.

The mass and static friction properties of the welding head can be determined in accordance with Annex A of this part of ISO 18278. It is recommended to record the test results to evaluate the mechanical characteristics of the welding machine.

5.2 Welding electrodes

5.2.1 General

The welding electrodes shall conform to alloys as specified in ISO 5182 unless otherwise agreed between contracting parties. Electrodes should be of sufficient cross-sectional area and strength to carry the welding current and electrode force without overheating, deformation, or excessive deflection.

5.2.2 Spot welding

In the case of spot welding, the electrode dimensions shall conform to the requirements of ISO 5821. Alternative electrode shapes and dimensions may be used by agreement between contracting parties.

5.2.3 Seam welding

In the case of wide wheel seam welding, the electrode dimensions shall conform to the requirements of ISO 693. Alternative wheel electrode shape and dimensions may be used by agreement between contracting parties.

5.2.4 Projection welding

In the case of embossed projection welding, the electrode dimensions shall conform to the requirements of ISO 16432. Alternative electrode shapes and dimensions may be used by agreement between contracting parties.

5.3 Measurement of parameters

5.3.1 Welding current

The welding current shall be measured with a current measuring system of high accuracy class in accordance with ISO 17657-2. The welding current value shall be measured over the total weld time.

The shape of the welding current waveform shall be measured using a suitable device to determine the regularity of welding current peak values and conformity of the actual welding cycle with the programmed welding cycle.

5.3.2 Electrode force

The electrode force shall be expressed in kilonewtons with an accuracy of ±3 % and measured without current flow.

6 Test procedures

6.1 General

Tests which are considered necessary by the user for assessing the weldability shall be specified.

Acceptance criteria for each test will depend on the requirements of the product being welded and shall be specified before commencing the test programme.

The evaluation of weldability requires the following steps:

— ensure the welding equipment is within specifications;

— analyse and determine material properties;

— carry out the test procedure according to pWPS (ISO 15614-12, ISO 15614-13, ISO 15609-5);

— document and evaluate the test results.

6.2 Basic test procedures

6.2.1 Essential variables

The welding current range and the electrode life are influenced by the following:

a) the electrical and mechanical characteristics of the welding equipment, including cooling conditions;

b) welding parameters, including welding rate for electrode life;

c) the electrical, mechanical, and physical properties of the material being welded;

d) the welding configuration used;

e) the electrode material and design of the welding electrode;

f) the test specimen or component being welded.

6.2.2 Welding current range test

For the determination of the ability to make a weld, a welding current range shall be determined according to the procedures agreed to between the contracting parties. In producing a welding current range, electrode wear can occur due to heavy expulsion, surface expulsion, mushrooming, or alloying. This can have an adverse effect on the reproducibility and validity of the results, particularly when welding coated steels or aluminium and aluminium alloys. To control this, the testing procedure shall specify the following:

— electrode alignment and conditioning procedure;

— the number of welds and their order for the determination of the welding range limits;

— the welding parameters to be used for the test (except the welding current), including electrode shape, size and material, welding force and sequence, as well as holding time;

— the shape, size of the workpieces to be welded, and their preparation if needed (i.e. projection shape and size in the case of projection welding according to ISO 8167);

— starting current level for the test;

— the number of welds to be done for each current setting;

— welding current increments (increasing or decreasing) in each phase of the test;

— the criteria to determine if a current setting is in the welding current range (for example, if all the welds done at this current level should meet the no-expulsion requirement or only the majority or other such requirements by the WPS). The upper limit of the welding current range is the maximum current setting without expulsion;

— number of welds to be produced (and at which place in the procedure), if any, for metallographic examination or mechanical testing.

NOTE Other criteria can be specified for upper limit upon agreement of contracting parties, for example, maximum weld size, maximum indentation depth, or the onset of surface cracking in the weld or electrode-to-workpiece sticking.

In addition, testing procedures should consider scatter analysis of the welding current range results, for example, through specifying a number of test replicates for standard deviation calculation, or through regression analysis of the points used to perform an individual test.

6.2.3 Electrode life test

The ability to continue making acceptable welds shall be determined by electrode life tests according to the procedures agreed to between the contracting parties.

The electrode life testing procedure shall specify the following:

— the welding parameters to be used for the test, including electrode shape, size and material, welding force and sequence, hold time, welding rate, and cooling conditions;

— the procedure to determine the testing welding current, for example, just below the expulsion limit;

— the procedures to increase or decrease current during the test, for example, in case of expulsion or current stepping;

— the shape and size of the work pieces to be welded and their preparation if needed (i.e. projection shape and size in the case of projection welding);

— the arrangement of the welds on testing sheets, including weld spacing and distance from edges.

Testing procedures should consider scatter analysis of the electrode life test results, for example, through specifying a number of test replicates for standard deviation calculation, or through regression analysis of the points used to perform an individual test.

In other cases (seam welding, projection welding, multi-sheet spot welding), criteria for the end of electrode life have to be defined between the contracting parties. Alternative procedures shall be specified or developed for the evaluation of electrodes for seam welding. Generally, special variants of the seam welding process are used to weld coated steels which eliminate the problems associated with electrode contamination, for example, in narrow wheel welding and wire seam welding.

6.3 Evaluation of weld properties

6.3.1 General

The relevant tests to be used according 6.3.2 to 6.3.7 shall be specified, if necessary.

The failure mode and imperfections observed in a test depend on the material being welded and on the type of test, for example:

a) rephosphorised steels, some high-strength and ultra-high-strength steels can promote interface failures, partial plug fractures, and partial thickness fractures or mixed combinations of those modes depending on the welding parameters and the applied testing conditions;

b) in the case of aluminium and aluminium alloys, porosity and internal cracks can occur;

c) with nickel alloys, hot cracking can occur;

d) for the same type of material, increasing the thickness favours interfacial failures;

e) for zinc-coated materials, liquid metal embrittlement can occur (surface cracks within electrode indentation).

6.3.2 Shop floor tests

Shop floor tests are used to determine the failure mode and the weld diameter by chisel or peel tests according to ISO 10447, or torsion test according to ISO 17653 can be used. The results obtained from such tests give information on the ability to control weld quality on the shop floor.

6.3.3 Tensile shear testing

The tensile shear testing shall be carried out according to ISO 14273.

The purpose of this test is to determine the failure mode and the maximum shear force that the test specimen can sustain.

6.3.4 Mechanized peel testing

The mechanized peel testing shall be carried out according to ISO 14270.

The purpose of this test is to determine the failure mode and the maximum peel force that the test specimen can sustain.

6.3.5 Cross tension testing

The cross tension testing shall be carried out according to ISO 14272.

The purpose of this test is to determine the failure mode and the maximum tensile force that the test specimen can sustain.

6.3.6 Macro-sections and hardness test

The shape and dimension of the weld nugget, together with hardness values, shall be determined on etched macro-sections according to ISO 14271 and ISO 17677-1.

6.3.7 Further weld properties

Further weld properties can be determined by using the following tests:

— fatigue testing according to either ISO 14324 or ISO 18592;

— impact shear test according to ISO 14323;

— pressure testing of seam welds according to ISO 17654.

The influence of hold time should be determined if brittle fractures in test specimen are observed in the weld zone.

7 Test report

7.1 General

The results of the assessment shall be given in tabular form as stipulated in ISO 15609-5 and ISO 15614-12.

7.2 Welding current range test

The test report for welding current range shall contain at least the following information:

a) a reference to this part of ISO 18278, i.e. ISO 18278-1;

b) applicable document number;

c) criteria to determine the minimum welding current;

d) criteria to determine the maximum welding current;

e) minimum current value;

f) maximum current value;

g) weld diameter, current, and failure mode as determined;

h) occurrence of expulsion or not, for each weld;

i) welding process;

j) welding conditions and equipment;

k) electrode material and its condition;

l) workpiece material and its condition;

m) other information by agreement.

7.3 Electrode life test

The test report for electrode life shall contain at least the following information:

a) a reference to this part of ISO 18278, i.e. ISO 18278-1;

b) applicable document number;

c) criteria for evaluation of the weld quality;

d) electrode life (described in number);

e) scatter range of weld quality level and the average value;

f) weld diameter, current, and failure mode as determined;

g) welding process;

h) welding conditions and equipment;

i) electrode material and its condition;

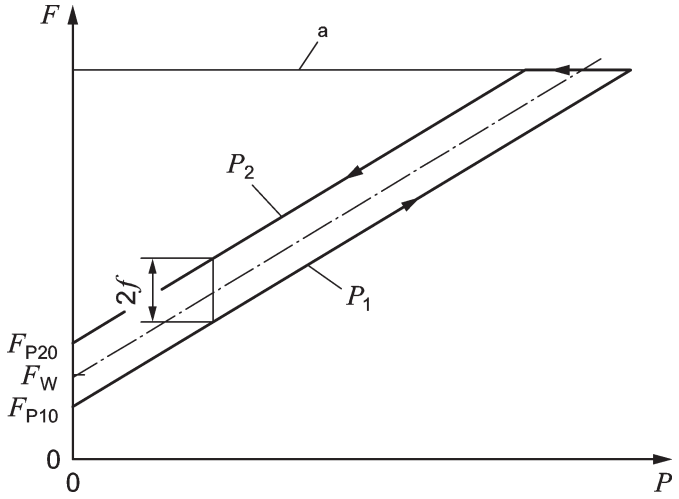
j) work piece material and its condition;

k) any additional remarks and any deviations from this part of ISO 18278.

Annex A
(informative)

How to evaluate the mass and friction of the welding head

When using oil or air cylinder as the force actuator, the mass (M) and static friction (f) of the upper movable parts can be determined from the hysteresis curve of electrode force vs. the inlet pressure of the upper cylinder (see Figure A.1).



Key

F	electrode force
P	air pressure in cylinder
f	force induced by static friction
f_0	force induced by static friction at zero air pressure
F_{P10}	electrode force at zero air pressure in case of increasing air pressure
F_{P20}	electrode force at zero air pressure in case of decreasing air pressure
F_W	weight of upper moveable head
g	gravitational constant
M	mass of upper moveable head
a	Nominal electrode force.

$$F_W + f = F_{P20} \qquad M = \frac{F_W}{g}$$

$$F_W - f = F_{P10}$$

$$F_{P20} - F_{P10} = 2f \qquad F_W = \frac{F_{P20} + F_{P10}}{2}$$

$$F_{P20} + F_{P10} = 2F_W \qquad f_0 = \frac{F_{P20} - F_{P10}}{2}$$

Figure A.1 — Example of the hysteresis curve for electrode force vs. cylinder air pressure

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[3] ISO 14554-2, *Quality requirements for welding — Resistance welding of metallic materials — Part 2: Elementary quality requirements*

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[6] AWS D8.9M, Recommended Practices for Test Methods for Evaluating the Resistance Spot Welding Behavior of Automotive Sheet Steel Materials

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