BS EN ISO 14555:2017

BSI Standards Publication

Welding — Arc stud welding of metallic materials

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National foreword

This British Standard is the UK implementation of EN ISO 14555:2017. It is identical to ISO 14555:2017. It supersedes BS EN ISO 14555:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/36, Qualification of welding personnel and welding procedures.

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

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Welding - Arc stud welding of metallic materials (ISO 14555:2017)

Soudage - Soudage à l'arc des goujons sur les matériaux métalliques (ISO 14555:2017)

Schweißen - Lichtbogenbolzenschweißen von metallischen Werkstoffen (ISO 14555:2017)

This European Standard was approved by CEN on 23 March 2017.

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European foreword

This document (EN ISO 14555:2017) 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of an identical text or by endorsement, at the latest by November 2017 and conflicting national standards shall be withdrawn at the latest by November 2017.

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Endorsement notice

The text of ISO 14555:2017 has been approved by CEN as EN ISO 14555:2017 without any modification.

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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.

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 voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*.

This fourth edition cancels and replaces the third edition (ISO 14555:2014), of which it constitutes a minor revision and contains the following changes:

— undated references to ISO 14732, ISO 13918 and ISO 15607;

— the expression "welding diameter" has been changed to "welded cross-section" in 3.6;

— the word "deformability" has been changed to "deformation" in the last sentence of 12.3;

— the second and third paragraphs of 12.4 have been combined;

— the expression "welding diameter" has been changed to "visible width of the welding zone" in 12.6;

— the appearance "Collar off-centre with unacceptable undercut" is now given under "Visual examination or macro cut" in Table A.5;

— the missing symbol "≤" in Annex D has been introduced for application ≤100 °C.

Requests for official interpretations of any aspect of this document should be directed to the Secretariat of ISO/TC 44/SC 10 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

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Introduction

The purpose of arc stud welding is to weld predominantly pin-shaped metal parts to metal workpieces. In this document, it is referred to simply as stud welding. Among other things, stud welding is used in bridge building (especially in composite structures), steel structures, shipbuilding, facade-wall fabrication, vehicle manufacture, apparatus engineering, steam-boiler construction, and the manufacture of household appliances.

The quality of a stud weld depends not only on strict compliance with the welding procedure specification but also on the correct function of the actuating mechanism (e.g. welding guns), and on the condition of the components, of the accessories and of the power supply.

This document does not invalidate former specifications, providing the technical requirements are equivalent and satisfied.

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Welding — Arc stud welding of metallic materials

1 Scope

This document covers arc stud welding of metallic materials subject to static and fatigue loading. It specifies requirements that are particular to stud welding, in relation to welding knowledge, quality requirements, welding procedure specification, welding procedure qualification, qualification testing of operators and testing of production welds.

This document is appropriate where it is necessary to demonstrate the capability of a manufacturer to produce welded construction of a specified quality.

NOTE General quality requirements for fusion welding of metallic materials are given in ISO 3834-1, ISO 3834-2, ISO 3834-3, ISO 3834-4 and ISO 3834-5.

This document has been prepared in a comprehensive manner, with a view to it being used as a reference in contracts. The requirements contained within it can be adopted in full, or partially, if certain requirements are not relevant to a particular construction (see Annex B). For processing of stud welding, see Annex A.

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 3834-1, *Quality requirements for fusion welding of metallic materials — Part 1: Criteria for the selection of the appropriate level of quality requirements*

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

ISO 3834-3, *Quality requirements for fusion welding of metallic materials — Part 3: Standard quality requirements*

ISO 3834-4, *Quality requirements for fusion welding of metallic materials — Part 4: Elementary quality requirements*

ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 6947, *Welding and allied processes — Welding positions*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 9606-2, *Qualification test of welders — Fusion welding — Part 2: Aluminium and aluminium alloys*

ISO 13918, *Welding — Studs and ceramic ferrules for arc stud welding*

ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

ISO 14731, *Welding coordination — Tasks and responsibilities*

ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO/TR 15608, *Welding — Guidelines for a metallic materials grouping system*

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ISO 15611, *Specification and qualification of welding procedures for metallic materials — Qualification based on previous welding experience*

ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

ISO 17636 (all parts), *Non-destructive testing of welds — Radiographic testing*

ISO/TR 25901-3, *Welding and allied processes — Vocabulary — Part 3: Welding processes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3834-1, ISO 4063, ISO 14731, ISO 14732, ISO 15607 and ISO/TR 25901-3 and the following apply.

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

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

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

3.1
stud
fastener to be attached by stud welding

3.2
auxiliaries
ceramic ferrules and shielding gases

3.3
stud-welding operator
operating personnel for stud-welding equipment

Note 1 to entry: In special cases (e.g. mass production at the manufacturer's factory), the welding can be carried out by suitable auxiliary personnel, appropriately trained and supervised.

3.4
stud diameter
d
stud (3.1) nominal diameter

Note 1 to entry: See ISO 13918.

3.5
welding diameter
d_w
diameter at the weld base

3.6
weld zone
welded area underneath the welded cross-section

3.7
current intensity
root-mean-square (RMS) value of the welding current in the steady state during the burning time of the arc

Note 1 to entry: Current intensity is not applicable to capacitor discharge.

3.8
welding time
time difference between the ignition and the final extinction of the main arc

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3.9
lift
L
distance between the stud tip and the work piece surface with the stud-lifting mechanism in position and activated

Note 1 to entry: For tip ignition, this definition applies to the ignition gap.

Note 2 to entry: See Figure A.1.

3.10
plunge
axial movement of the *stud* (3.1) towards the surface of the work piece

3.11
protrusion
P
<unregulated lifting mechanism> distance between the tip of the *stud* (3.1) and the face of the support device in their initial positions, where the support device faces the work piece

Note 1 to entry: A spring-loaded lifting mechanism is an unregulated lifting mechanism.

Note 2 to entry: See Figure A.1.

3.12
arc blow
magnetic deflection of the arc from the axial direction of the *stud* (3.1)

3.13
flux
aluminium additive on the weld end of the *stud* (3.1), which improves the ignition and de-oxidizes the weld pool

3.14
dual-material stud
two-material *stud* (3.1) composed of a material at the weld tip, similar to that of the parent material, and a dissimilar material outside the weld tip, which are joined by a friction weld, thus avoiding a mixed structure in the *weld zone* (3.6) when stud welding

3.15
structure subjected to fatigue loading
structure subject to a set of typical load events described by the positions or movements of loads, their variation in intensity and their frequency and sequence of occurrence

3.16
through-deck stud-welding
application where shear connectors are welded to a steel structure through thin steel sheet with a thickness of less than 3 mm

4 Symbols and abbreviated terms

4.1 Symbols

For the purposes of this document, the following symbols apply.

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C capacitance (expressed in mF)

d stud diameter (expressed in mm)

d_w welding diameter (expressed in mm)

h length of the threaded part of the nut

I current intensity (expressed in A)

L lift

P protrusion

t thickness of plate

t_w welding time (expressed in ms or s)

T torque (expressed in Nm)

U charging voltage (expressed in V)

E charging energy (expressed in Ws)

α bending angle (expressed in °)

4.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

CF ceramic ferrule

HAZ heat-affected zone

NP no protection

PA flat welding position

PC horizontal welding position

PE overhead welding position

pWPS preliminary welding procedure specification

SG shielding gas

WPS welding procedure specification

WPQR welding procedure qualification record

5 Technical review

When a technical review is required by an application standard, by specification or by use of ISO 3834-2, ISO 3834-3 or ISO 3834-4, the manufacturer shall check, as appropriate, the following aspects:

a) the accessibility and welding position of the stud weld;

b) the nature of the surface and the collar shape of the welded joint;

c) materials and combinations of materials (see Tables A.3 and A.4); including decking material where the through-deck technique is being proposed;

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d) the ratio of stud diameter to parent material thickness (avoidance of damage on the reverse side of the parent material);

e) dimensions and details of the weld preparation and of the finished weld, including the nature of the stud and parent-metal surfaces, positional and angular accuracy and the length tolerance of the welded stud;

f) the use of special techniques to avoid damage to the reverse side of the parent material;

g) techniques to assure the angular position of the welded stud.

NOTE Consideration is paid to the multi-axial stress state arising from localized heating/cooling. This stress concentration reduces the fatigue strength of a component with welded studs.

6 Welding personnel

6.1 Stud-welding operators

The qualification can be done by a welding procedure test (see 10.2) or a pre-production test (see 10.3) and shall include testing in accordance with the acceptance criteria specified in Clause 12, if relevant.

Stud-welding operators shall have appropriate knowledge to operate the equipment, to adjust it properly, to carry out the welding correctly and, while doing so, to pay attention to good contact and suitable connection between the work piece cables and uniform distribution of ferromagnetic materials (see Table A.8).

The welding personnel shall be qualified in accordance with ISO 14732.

The qualified operator shall be deemed to be qualified for any stud-welding equipment with the same mode of selecting the parameters which was used in the qualification test. Change in the welding process variant (numbers 783, 784, 785, 786 of ISO 4063) requires a new qualification.

A test of job knowledge is required for all qualification methods. This test shall cover, as a minimum:

a) setting up the welding equipment in accordance with the welding procedure specification;

b) basic knowledge of the way in which suitable connection of work piece cables, the polarity of the stud, and arc blowing can influence the weld result (see Table A.8);

c) basic assessment of the welded joint for imperfections (see Tables A.5, A.6 and A.7);

d) safe execution of the welding operations, i.e. good contact of the stud in the stud holder, no movement during the welding process, operation checking and correct positioning of the welding gun).

6.2 Welding coordination

Welding coordination shall be performed in accordance with ISO 14731. Refer to Annex B for quality level according ISO 3834-2, ISO 3834-3 and ISO 3834-4 for the welding coordinator.

Welding coordination personnel for stud welding shall have knowledge of and experience in the relevant stud-welding process, and shall be able to select and set the correct parameters, e.g. lift, protrusion (plunge), current intensity, and welding time.

A welding coordinator is not required for stud welding to structures subjected to unspecified static loading (see Annex B).

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7 Equipment

7.1 Production equipment

Suitable stud-welding equipment shall be used, with power supplies of sufficient capacity to weld the stud properly to the parent material when the equipment is correctly set up. The following equipment shall be available, as required:

a) power sources, control unit and movable fixtures;

b) cables with sufficient cross-section, solid connection terminals and sufficient earth connection;

c) handling equipment for the technical aspects of welding fabrication (jigs, fixtures);

d) weld data monitoring equipment;

e) cleaning facilities for contact points and welding points;

f) measuring and testing equipment;

g) equipment for pre- and post-treatment;

h) equipment and welding plant for retouching.

7.2 Description of the equipment

A list of the stud-welding equipment shall be maintained, which shall document performance and stud-welding application field. It shall include:

a) details of the smallest and largest weldable stud diameter;

b) the maximum number of studs to be welded per unit of time;

c) the regulating range of the power supply;

d) the mode of operation and performance of mechanized or automatic stud-welding equipment;

e) details of the available test equipment.

7.3 Maintenance

The correct functioning of the equipment shall be ensured. During production, a function check of the actuation mechanisms shall be performed at fixed intervals. Cables, terminals, stud and ceramic ferrule holders shall be regularly checked and replaced at the appropriate time. For mass production and comprehensive quality requirements in accordance with ISO 3834-2, a maintenance plan for additional essential systems shall be drawn up. Examples of such systems are:

a) stud sorting and feeding systems;

b) stud and ceramic ferrule holders;

c) mechanical guides and fixtures;

d) measuring equipment;

e) cables, hoses, connecting elements;

f) a monitoring system.

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8 Production planning

For stud welding, the production planning shall also contain the following elements:

a) a definition of the required stud-welding procedures and equipment;

b) details of which jigs and fixtures are used;

c) the surface preparation method.

9 Welding procedure specification (WPS)

9.1 General

The WPS shall give details of how a welding operation shall be performed and shall contain all relevant information about the welding work.

Information listed in 9.2 to 9.12 is adequate for most welding operations. For some applications, it may be necessary to supplement or reduce the list. The relevant information shall be specified in the WPS.

Ranges and tolerances shall be specified when appropriate. An example of the WPS format is given in Annex C.

9.2 Information related to the manufacturer

9.2.1 Identification of the manufacturer

— unambiguous identification.

9.2.2 Identification of the WPS

— alphanumeric designation (reference code).

9.2.3 Reference to the welding procedure qualification record (WPQR) or other relevant documents

— alphanumeric designation (reference code).

9.3 Information related to the parent material

9.3.1 Parent material type

— identification of material, preferably by reference to an appropriate standard;

— parent material(s) delivery condition;

— identification of coating or any other surface condition.

NOTE A WPS can cover a material group in accordance with ISO/TR 15608. See also ISO/TR 20172, ISO/TR 20173 and ISO/TR 20174.

9.3.2 Dimensions

— the thickness or range of thicknesses of the parent material;

— other relevant dimensions (e.g. thickness and configuration of the steel sheet for through-deck applications).

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9.4 Welding process

— designation in accordance with ISO 4063.

9.5 Joint

9.5.1 Joint design

— sketch of the joint design showing the relative positions of studs and tolerances;

— the sequence of the welding of studs shall be indicated on the sketch if essential for application.

9.5.2 Welding position

— welding positions shall be specified in accordance with ISO 6947.

9.5.3 Preparation of parent material surface

— method of surface preparation, if necessary (e.g. cleaning, degreasing, pickling);

— maximum time permitted between preparation and welding (if required).

9.5.4 Jigs and fixtures

— the methods to be used (if required);

— fixture details, templates, etc.

9.5.5 Support

— the method of support;

— specification of supporting material;

— dimensions of support (when welding thin plates).

9.6 Studs

9.6.1 Designation

— designation according to standard, supplier or trade name; non-standard studs shall be specified.

9.6.2 Handling

— if the studs are to be treated (e.g. by cleaning) before use, this shall be specified.

9.7 Auxiliaries

9.7.1 Ceramic ferrules (if any)

— designation according to standard, supplier or trade name; non-standard ceramic ferrules shall be specified;

— ceramic ferrules shall be stored in a clean and dry environment.

9.7.2 Protective gas (if any)

— designation in accordance with ISO 14175.

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9.8 Power source

— manufacturer, type.

9.9 Movable fixtures

9.9.1 Welding gun/lift mechanism

— manufacturer, type;

— damper.

9.9.2 Shielding gas system (if used)

— gas flow rate;

— (schematic) description showing nozzle dimensions and position of nozzle(s) in relation to stud and work piece.

9.9.3 Stud feeding system (if any)

— description of stud feeding system including sketch.

9.10 Welding variables

9.10.1 Drawn-arc stud welding with ceramic ferrule or shielding gas and short-cycle drawn-arc stud welding

a) polarity;

b) welding current;

c) welding time;

d) lift;

e) protrusion;

f) damper;

g) number and position of earth clamps.

9.10.2 Capacitor discharge drawn-arc stud welding or capacitor discharge stud welding with tip ignition

a) polarity;

b) capacitance;

c) charging voltage;

d) spring force and/or gap length;

e) number and position of earth clamps;

f) welding cable configuration (if used for current control).

9.11 Thermal conditions

a) preheat temperature (if required);

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b) if preheating is not required, the lowest permitted ambient temperature.

9.12 Post-weld heat-treatment

If, in special cases, any post-weld heat-treatment or ageing is necessary, specification of the procedure or reference to a separate post-weld heat-treatment or ageing specification is required. This should include specification of the entire thermal cycle.

9.13 Non-thermal treatment after welding

a) grinding, machining or any other mechanical treatment;

b) pickling or any other chemical treatment;

c) any special procedure for removal of ferrules.

10 Welding procedure qualification

10.1 Principles

Preliminary welding procedure specifications (pWPS) for arc stud welding shall be prepared in accordance with Clause 9 and qualified prior to production, whenever required. They shall specify the range for all the relevant parameters. In principle, the following methods of qualification are permitted, but specification or application code requirements can restrict the choice of method:

a) qualification by welding procedure test in accordance with 10.2;

b) qualification by pre-production tests in accordance with 10.3;

c) qualification based on previous experience in accordance with 10.4.

All new welding procedure qualifications are to be in accordance with this document from the date of its issue. However, this document does not invalidate previous welding procedure qualifications made to former national standards or specifications, provided the technical requirements are satisfied and the previous procedure qualifications are relevant to the application and production work on which they are to be employed. Previous procedure qualifications to former national standards or specifications should be considered at the time of the enquiry or contract stage and agreed between the contracting parties.

10.2 Welding procedure tests

10.2.1 Application

When welding procedure tests are required, these shall be carried out in accordance with the provisions in 10.2, unless more severe tests are specified.

10.2.2 Proof of conformity of parent materials and stud materials

For the parent material and the stud material to be used, proof of conformity shall be available.

In the absence of such proof, the parent material and/or stud material shall be subjected to additional material tests before the welding procedure tests. For this purpose, sufficient amounts of parent material and stud material from the same melt as used in the test shall be made available.

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10.2.3 Shape and dimensions of test pieces

The dimension of the test piece(s) shall be sufficient to carry out all tests. The thickness of the test pieces shall be chosen so that the plate or flange thickness proposed for production is covered (see 10.2.8.6).

10.2.4 Welding

Preparation, set-up and welding of test pieces shall be carried out in accordance with the pWPS, under the general conditions of production welding that they represent. The same welding positions shall be observed as on the actual work piece. There shall be sufficient distance from the lateral earth clamps to avoid arc blow.

Welding procedure tests shall be carried out on the smallest and largest stud diameters used in practice.

As a minimum, the numbers of studs indicated in Tables 1 and 2 shall be welded in the welding procedure test.

10.2.5 Scope of examination and testing

The examination and testing includes non-destructive and destructive tests, which shall be in accordance with the requirements of Tables 1, 2 and 3.

All inspection and tests shall be performed in accordance with the procedures specified in Clause 11. The number and type of test stated in Tables 1, 2 and 3 shall only be used in the case of the qualification of a pWPS based on the use of stud material and parent material, as specified in Table A.3.

10.2.6 Acceptance criteria

The acceptance criteria described in Clause 12 shall be fulfilled unless otherwise specified.

Table 1 — Examination and testing of test pieces welded by drawn-arc stud welding with ceramic ferrule or shielding gas

Type of test	Number of studs to be tested			
	Application ≤ 100 °C Comprehensive quality requirements according to ISO 3834-2		Application ≤ 100 °C Standard quality requirements according to ISO 3834-3	Application > 100 °C All quality requirements according to ISO 3834-2, ISO 3834-3 and ISO 3834-4
	d_w ≤ 12 mm	d_w > 12 mm	All diameters (d_w)	All diameters (d_w)
Visual examination	All			
Bend testing [see Figure 2 a), b) or c)]	10 (60° bending angle)	5 (60° bending angle)	10 (60° bending angle)	5 (30° bending angle)
Bend testing by means of torque wrench (see Figure 3, applies to boiler pins only)	Not applied			10
[a] Only for welds on a tube subjected to pressure.				

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Table 1 *(continued)*

Type of test	Number of studds to be tested			
	Application ≤ 100 °C Comprehensive quality requirements according to ISO 3834-2		Application ≤ 100 °C Standard quality requirements accord-ing to ISO 3834-3	Application > 100 °C All quality requirements according to ISO 3834-2, ISO 3834-3 and ISO 3834-4
	d_w ≤ 12 mm	d_w > 12 mm	All diameters (d_w)	All diameters (d_w)
Tensile testing (see Figures 4, 5 or 6)	—	5	—	—
Radiographic examination	Not applied	5 (optional in-stead of tensile testing)	—	—
Macro examination (off-set 90° through the centre of the stud)	—	2	—	2[a]

[a] Only for welds on a tube subjected to pressure.

Table 2 — Examination and testing of test pieces welded by short-cycle drawn-arc stud welding with d_w ≤ 12 mm

Type of test	Number of studs to be tested
Visual examination	All
Bend testing 60° [see Figure 2 a), b) or c)]	10
Torque test (see Figure 6) or macro examination (off-set 90° through the centre of the stud)	10 (torque test)
	2 (macro examination)

Table 3 — Examination and testing of test pieces welded by capacitor discharge stud welding with tip ignition and capacitor discharge drawn-arc stud welding

Type of test	Number of studs to be tested
Visual examination	All
Tensile testing (see Figure 4 or 5)	10
Bend testing 30° [see Figure 2 a), b) or c)]	20

10.2.7 Re-testing

If one of the studs fails to meet the requirements, two similar replacement studs can be taken from the associated test pieces. If this is not possible, equivalent studs shall be welded subsequently. It is therefore recommended that a sufficient number of replacement studs be provided for the welding procedure tests.

If more than one stud, or one of the two replacement studs, does not satisfy the requirements, the test has failed.

10.2.8 Range of qualification

10.2.8.1 General

All the conditions of validity stated below shall be met independently of each other. Changes outside of the ranges specified shall require a new welding procedure test.

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There is no limit to the duration of the validity of the welding procedure qualification, provided that no quality changes are made and that a production surveillance record is kept in accordance with 14.6.

However, since the result of stud welding depends not only on compliance with the welding procedure specification, but also, for example, the skillness/experience of the operator is critical in terms of weld quality, a production test shall be carried out at least once a year, as specified in 14.2. Any stud with a diameter within the range of validity may be used for the production test.

In the event of production being suspended for more than 1 year, the validity of the welding procedure qualification shall be confirmed in a production test. Qualification according to 10.3.2 is valid until weld parameters change.

10.2.8.2 Conditions related to the manufacturer

The qualification of a pWPS obtained by a manufacturer is valid for welding in workshops or sites under the same technical and quality control of that manufacturer.

10.2.8.3 Conditions related to the welding process

The qualification is valid only for the welding process used in welding procedure test.

10.2.8.4 Conditions related to the welding parameters

The qualification is valid for changes of the welding parameters within the recommendations of the supplier of the welding equipment.

10.2.8.5 Conditions related to the parent material

A welding procedure test carried out with one of the steels of a material group, in accordance with ISO/TR 15608, covers the steels with lower specified yield strength of this material group, or the lower alloyed steels of the same material group for the intentional added elements, but not for fortuitous impurities. In accordance with ISO/TR 15608, material group 8 or 10 cover material group 1 and material group 2, and vice versa, while material group 21 covers material group 22, and vice versa.

10.2.8.6 Stud material

Welding procedure tests cover all materials of the same material group in accordance with ISO/TR 15608 with the following addition.

a) For drawn-arc stud-welding processes up to 13 mm diameter, material groups 8 or 10 cover material groups 1 and 2.1 and vice versa.

b) For capacitor discharge stud-welding processes, material group 8 covers material groups 1 to 6 and 11.1 and vice versa.

c) Material group 21 covers material group 22 and vice versa.

10.2.8.7 Parent material thickness

As recommended in Table A.1, the material thickness used for the welding procedure test applies to all thicknesses which exceed those specified in Table A.1, providing the pWPS used in the welding procedure test applies.

For material thicknesses below the recommended minimum thickness, a new welding procedure test is required.

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10.2.8.8 Steel sheet thickness for through-deck applications

For through-deck stud-welding, qualification of the thickest steel sheet used in production qualifies all thinner steel sheets.

10.2.8.9 Conditions related to the stud cross-section and shape

A single welding procedure test covers all stud shapes, but only the welding cross-section used in the test.

Two welding procedure tests on different welding cross-sections cover the range between the two cross-sections and all stud shapes.

10.2.8.10 Conditions related to the welding position

Using drawn-arc stud welding with ceramic ferrule or shielding gas and short-cycle drawn-arc stud welding, welding position PC covers welding positions PE and PA, but not vice versa. For welding position PC, special ceramic ferrules can be used. Welding position PE covers welding position PA, but not vice versa. Welding positions refer to ISO 6947.

Through-deck stud welding shall be carried out in the PA position only.

Using capacitor discharge stud welding with tip ignition and capacitor discharge drawn-arc stud welding, a welding procedure test carried out in any one welding position is valid for welding in all welding positions.

10.2.8.11 Conditions related to the welding equipment

If there is a change in the type of welding gun or head, and/or power source, or welding equipment manufacturer, the welding procedure specification shall be verified by a production test.

10.2.8.12 Preheating

Welding procedure specifications that have been qualified by a welding procedure test without preheating are also valid for those for welding with preheating, but not vice versa.

10.3 Pre-production tests

10.3.1 Pre-production test for workshop applications

The general provisions of ISO 15613 shall be adhered to, with the following additions and modifications:

a) welding procedure specifications, pWPS and WPS, shall conform to the provisions of Clause 9;

b) the actual production shall be controlled by a suitable scheme for process control;

c) the number of studs (produced items) tested shall meet the requirements of 10.2.4, if possible;

d) qualification is limited to the same type of equipment, the same type and thickness of the parent material and the same diameter of studs as used during the pre-production test.

10.3.2 Pre-production test for stud welding on site (for through-deck stud welding)

This test shall be carried out for building constructions with principally static loads. This test is applicable to an individual site under prevailing conditions.

a) Welding procedure specifications, pWPS and WPS, shall conform to the provisions of Clause 9.

b) A minimum of 10 studs shall be welded.

c) Visual examination shall be carried out on all studs.

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