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Welding — Arc stud welding of metallic materials

Soudage — Soudage à l'arc des goujons sur les matériaux métalliques

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This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five-month enquiry.

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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.

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ISO 14555 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

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Introduction

The purpose of arc stud welding is to weld predominantly pin-shaped metal parts to metal workpieces. In this International Standard it is referred to simply as stud welding. Amongst other things, stud welding is used in bridge building (especially in composite structures), steel structures, shipbuilding, facade-wall fabrication, vehicle manufacture, equipment design, 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 International Standard 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 International Standard covers arc stud welding of metallic materials subject to static and dynamic 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 International Standard 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 International Standard has been prepared in a comprehensive manner, with a view to its 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).

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 857-1, *Welding and allied processes — Vocabulary — Part 1: Metal welding processes*

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, *Welds — Working positions — Definitions of angles of slope and rotation*

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

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

ISO 13918:2008, *Welding — Studs and ceramic ferrules for arc stud welding*

ISO 14175, *Welding consumables — Shielding gases for arc welding and cutting*

ISO 14731, *Welding coordination — Tasks and responsibilities*

ISO 14732:1998, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials*

ISO 15607:2003, *Specification and qualification of welding procedures for metallic materials — General rules*

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

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 15614-1:2004, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

ISO 15614-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys*

ISO 17636, *Non-destructive testing of welds — Radiographic testing of fusion-welded joints*

ISO 17662, *Welding — Calibration, verification and validation of equipment used for welding, including ancillary activities*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 857-1, ISO 3834-1, ISO 4063, ISO 14731, ISO 14732 and ISO 15607 and the following apply.

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 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 nominal diameter

NOTE See ISO 13918.

3.5

welding diameter

d_w

diameter at the weld base

3.6

weld zone

welded area underneath the welding diameter

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 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

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 For tip ignition, this definition applies to the ignition gap.

NOTE 2 See Figure A.1.

3.10**plunge**

axial movement of the stud towards the surface of the work piece

3.11**protrusion**

P

(unregulated lifting mechanism) distance between the tip of the stud and the face of the support device in their initial positions, where the support device faces the work piece

NOTE 1 A spring-loaded lifting mechanism is an unregulated lifting mechanism.

NOTE 2 See Figure A.1.

3.12**arc blow**

magnetic deflection of the arc from the axial direction of the stud

3.13**flux**

aluminium additive on the weld end of the stud, which improves the ignition and de-oxidizes the weld pool

3.14**dual-material stud**

two-material stud 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 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 International Standard, the following symbols apply.

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)
W	charging energy (expressed in Ws)
a	bending angle (expressed in °)

4.2 Abbreviated terms

For the purposes of this International Standard, 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;
- d) the ratio of stud diameter to sheet metal thickness (avoidance of damage on the reverse side of the sheet);
- e) dimensions and details of the weld preparation and of the finished weld, including the nature of the stud and sheet-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 sheet;
- 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 dynamic 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 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 responsible welding coordinator is allowed to qualify the stud-welding operators.

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 kind of setting 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 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).

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) post-drying equipment for ceramic ferrules;
- f) cleaning facilities for contact points and welding points;
- g) measuring and testing equipment;
- h) equipment for pre- and post-treatment;
- i) equipment and welding plant for retouching.

7.2 Description of the equipment

A list of the stud-welding equipment shall be maintained, which shall serve as evidence of the 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.

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 welding procedure specification (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 9.13 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 thickness of the parent material;
- other relevant dimensions (e.g. thickness and configuration of the steel sheet for through-deck applications).

9.4 Welding process

- designation in accordance with ISO 4063.