INTERNATIONAL STANDARD

ISO 25239-4

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Friction stir welding — Aluminium

Part 4: Specification and qualification of welding procedures

Soudage par friction-malaxage — Aluminium

Partie 4: Descriptif et qualification des modes opératoires de soudage

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.

ISO 25239-4 was prepared by the International Institute of Welding, which has been approved as an international standardizing body in the field of welding by the ISO Council.

ISO 25239 consists of the following parts, under the general title *Friction stir welding — Aluminium*:

— *Part 1: Vocabulary*

— *Part 2: Design of weld joints*

— *Part 3: Qualification of welding operators*

— *Part 4: Specification and qualification of welding procedures*

— *Part 5: Quality and inspection requirements*

Requests for official interpretations of any aspect of this part of ISO 25239 should be directed to the ISO Central Secretariat, who will forward them to the IIW Secretariat for an official response.

Introduction

Welding processes are widely used in the fabrication of engineered structures. During the second half of the twentieth century, fusion welding processes, wherein fusion is obtained by the melting of parent material and usually a filler metal, dominated the welding of large structures. Then, in 1991, Wayne Thomas at TWI invented friction stir welding (FSW), which is carried out entirely in the solid phase (no melting).

The increasing use of FSW has created the need for this International Standard in order to ensure that welding is carried out in the most effective way and that appropriate control is exercised over all aspects of the operation. This International Standard focuses on the FSW of aluminium because, at the time of publication, the majority of commercial applications for FSW involved aluminium. Examples include railway carriages, consumer products, food processing equipment, aerospace structures, and marine vessels.

To parts of this International Standard are listed in the foreword.

Part 1 defines terms specific to FSW.

Part 2 specifies design requirements for FSW joints in aluminium.

Part 3 specifies requirements for the qualification of an operator for the FSW of aluminium.

Part 4 specifies requirements for the specification and qualification of welding procedures for the FSW of aluminium. A welding procedure specification (WPS) is needed to provide a basis for planning welding operations and for quality control during welding. Welding is considered a special process in the terminology of standards for quality systems. Standards for quality systems usually require that special processes be carried out in accordance with written procedure specifications. Metallurgical deviations constitute a special problem. Because non-destructive testing of the mechanical properties is impossible at the present level of technology, this has resulted in the establishment of a set of rules for qualification of the welding procedure prior to the release of the WPS to actual production. This part of ISO 25239 defines these rules.

Part 5 specifies a method for determining the capability of a manufacturer to use the FSW process for the production of aluminium products of the specified quality. It defines specific quality requirements, but does not assign those requirements to any specific product group. To be effective, welded structures should be free from serious problems in production and in service. To achieve that goal, it is necessary to provide controls from the design phase through material selection, fabrication, and inspection. For example, poor design can create serious and costly difficulties in the workshop, on site, or in service. Incorrect material selection can result in welding problems, such as cracking. Welding procedures have to be correctly formulated and qualified to avoid imperfections. To ensure the fabrication of a quality product, management should understand the sources of potential trouble and introduce appropriate quality and inspection procedures. Supervision should be implemented to ensure that the specified quality is achieved.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning friction stir welding given in Clauses 5 to 7.

ISO takes no position concerning the evidence, validity and scope of this patent right.

The following holder of this patent right has assured ISO that it is willing to negotiate licenses under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Further information may be obtained from:

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. ISO shall not be held responsible for identifying any or all such patent rights.

Friction stir welding — Aluminium

Part 4: Specification and qualification of welding procedures

1 Scope

This part of ISO 25239 specifies the requirements for the specification and qualification of welding procedures for the friction stir welding (FSW) of aluminium. In this part of ISO 25239, the term “aluminium” refers to aluminium and its alloys.

This part of ISO 25239 does not apply to friction stir spot welding.

NOTE Service requirements, materials or manufacturing conditions can require more comprehensive testing than is specified in this part of ISO 25239.

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 209, *Aluminium and aluminium alloys — Chemical composition*

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

ISO 2107, *Aluminium and aluminium alloys — Wrought products — Temper designations*

ISO 3134 (all parts), *Light metals and their alloys — Terms and definitions*

ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test*

ISO 5173, *Destructive tests on welds in metallic materials — Bend tests*

ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding*

ISO 9017, *Destructive tests on welds in metallic materials — Fracture test*

ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections*

ISO 13916, *Welding — Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature*

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

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

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

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 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

ISO/TR 17671-1, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding*

ISO 25239-1, *Friction stir welding — Aluminium — Part 1: Vocabulary*

ISO 25239-5:2011, *Friction stir welding — Aluminium — Part 5: Quality and inspection requirements*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 209, ISO 857-1, ISO 3134, ISO 6520-1, ISO 10042, ISO 15607, ISO 15613, ISO 15614-2, ISO/TR 17671-1, and ISO 25239-1 apply.

4 Symbols and abbreviated terms

For the purposes of qualification of welding procedures, the abbreviations listed in ISO 15607:2003, Table 1, apply.

5 Development and qualification of welding procedures

5.1 General

Qualification of welding procedures shall be performed prior to production welding.

The manufacturer shall prepare a preliminary welding procedure specification (pWPS) and shall ensure that it is applicable for production using experience from previous production jobs and the general fund of knowledge of welding technology.

A pWPS shall be used as the basis for the establishment of a welding procedure qualification record (WPQR). The pWPS shall be tested in accordance with one of the methods listed in Clause 6 (welding procedure test) or Clause 7 (pre-production welding test). Clause 6 shall be used when the production part or joint geometry is accurately represented by a standardized test piece or pieces, as shown in 6.2. Clause 7 shall be used when the production part or joint geometry is not accurately represented by the standardized test pieces, as shown in 6.2. The information required in a pWPS is given in 5.2.

NOTE For some applications, it can be necessary to supplement or reduce the list.

A welding procedure specification (WPS) covers a certain range of parent material thicknesses as well as a range of aluminium alloys.

Ranges and tolerances in accordance with the relevant International Standard (see Clause 2) and the manufacturer's experience shall be specified when appropriate.

An example of a pWPS form is shown in Annex A.

5.2 Technical content of a pWPS

5.2.1 General

The following information, as a minimum, shall be included in a pWPS.

5.2.2 Manufacturer information

— identification of the manufacturer

— identification of the pWPS

5.2.3 Parent material type(s), temper(s), and reference standard(s)

5.2.4 Parent material dimensions

— thickness of the members comprising the welded joint

— outside diameter of tube

5.2.5 Equipment identification

— model

— serial number

— manufacturer

5.2.6 Tool identification

— material

— drawing or drawing number

5.2.7 Clamping arrangement

— method and type of jigging, fixtures, rollers, and backing (dimensions and material)

— tack welding process and conditions, when required — the pWPS shall indicate any required tack welding or prohibited tack welding

5.2.8 Joint design

— sketch of the welded joint design and dimensions

— weld run sequence and direction, if applicable

— run-on and run-off plates, material type, reference standard, and dimensions of run-on and run-off plates

— placement of exit hole

5.2.9 Joint preparation and cleaning methods

5.2.10 Welding details

— tool motion (e.g. rotation in either the clockwise or anticlockwise direction, rotation speed including downward and upward motion)

— tool position (e.g. heel plunge depth) or axial force, as applicable

— tool cooling (internal, external, cooling medium), if applicable

— tilt angle

— side tilt angle, lateral offset

— dwell time at start of weld

— dwell time at end of weld

— joint configuration

— weld overlap area (WOA) for a butt joint or lap joint in tube

— lap joint: advancing or retreating side near the upper sheet edge, direction of welding

5.2.11 Welding speed

— welding speed, including details of any changes during welding

— ramp-up/ramp-down or upslope/downslope speeds when applied

5.2.12 Welding position

— applicable welding positions

5.2.13 Pre-weld heat treatment

— when pre-weld heat treatment should be applied

5.2.14 Preheating temperature

— when preheating should be applied

— use of ISO 13916 for the application of this subclause, 5.2.15 and 5.2.16

— when preheating of the friction stir welding tool should be applied

5.2.15 Preheat maintenance temperature

— when preheat maintenance should be applied

5.2.16 Interpass temperature

— when an interpass temperature should be maintained

5.2.17 Shielding gas

— designation in accordance with ISO 14175 and, when applicable, the composition, manufacturer and name, and gas flow rate

5.2.18 postweld processing

— solution heat treatment, ageing, stress relieving (or the methods to correct distortion and straighten distorted parts), removal of toe flash or any other postweld processing of the weldment

— postweld heat treatment

— temperature range and minimum time for postweld heat treatment or ageing shall be specified or reference shall be made to other standards which specify this information

6 Qualification based on a welding procedure test

6.1 General

The preparation, welding, and testing of test pieces shall be in accordance with 6.2 and 6.3.

Fulfilment of the requirements of this part of ISO 15239 can also serve to qualify the welding operator (see ISO 25239-3).

6.2 Test pieces

6.2.1 Shape and dimensions of test pieces

6.2.1.1 General

The length or number of test pieces shall be sufficient to allow all required tests to be performed.

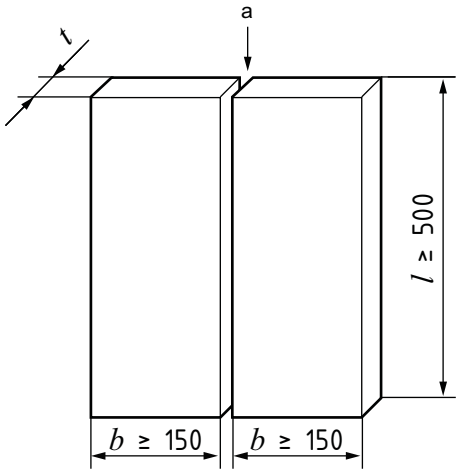
Test pieces longer than the minimum size may be used to allow for the provision of extra specimens, for re-testing specimens or both (see 6.3.4).

The rolling direction or extrusion direction shall be marked on the test piece.

6.2.1.2 Butt joint in sheet with full penetration

The test piece shall be prepared in accordance with Figure 1.

Dimensions in millimetres



Key

b width of components
l length of components
t material thickness

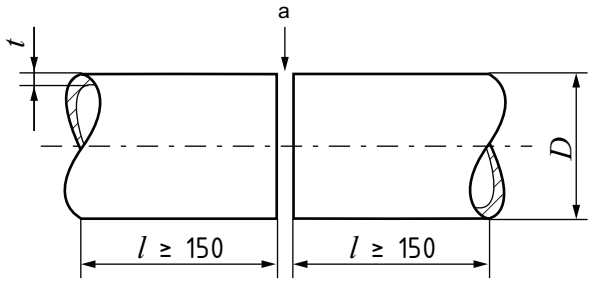
a Joint preparation and fit-up, as specified in the pWPS.

Figure 1 — Test piece for a butt joint in sheet with full penetration

6.2.1.3 Butt joint in tube with full penetration

The test piece shall be prepared in accordance with Figure 2.

Dimensions in millimetres



Key

D outside diameter of tube
l length of components
t material thickness

a Joint preparation and fit-up, as specified in the pWPS.

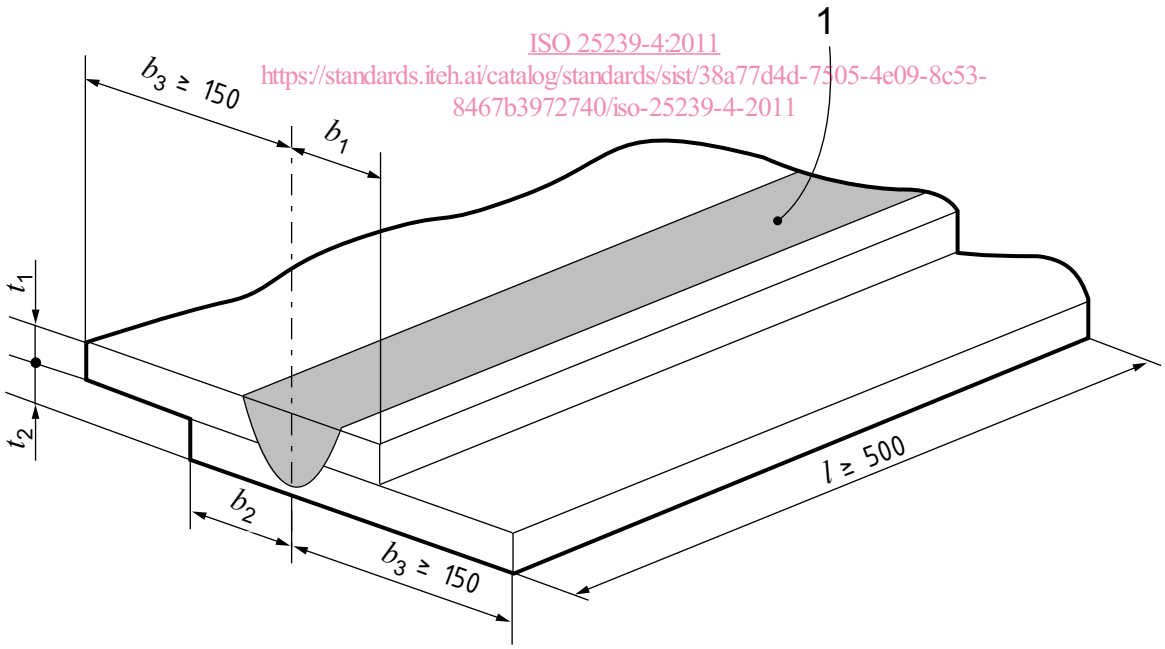
Figure 2 — Test piece for a butt joint in tube with full penetration

6.2.1.4 Lap joint

The test piece shall be prepared in accordance with Figure 3.

The weld may be either partial or full penetration through all the sheets.

Dimensions in millimetres



Key

1 weld
b_1 edge to weld centreline distance of upper sheet, as specified in the pWPS
b_2 edge to weld centreline distance of lower sheet, as specified in the pWPS
b_3 distance between weld centre and edge of test piece
l test piece length
t_1 parent material thickness of upper sheet
t_2 parent material thickness of lower sheet

Figure 3 — Test piece for a lap joint