INTERNATIONAL STANDARD

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Friction stir welding — Aluminium —

Part 2: Design of weld joints

Soudage par friction-malaxage — Aluminium —

Partie 2: Conception des assemblages soudés

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.

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

ISO 25239-2 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.

The 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. ISO 25239-4 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 may 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.

Friction stir welding — Aluminium —

Part 2: Design of weld joints

1 Scope

This part of ISO 25239 specifies design requirements for friction stir weld joints. 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.

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 2553, *Welded, brazed and soldered joints — Symbolic representation on drawings*

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

ISO 25239-3, *Friction stir welding — Aluminium — Part 3: Qualification of welding operators*

ISO 25239-4, *Friction stir welding — Aluminium — Part 4: Specification and qualification of welding procedures*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 25239-1 apply.

4 Design requirements

4.1 Documentation

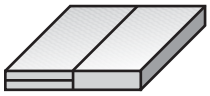
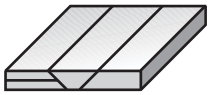
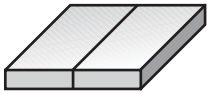
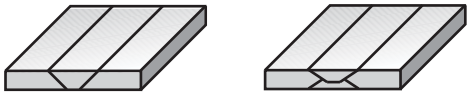
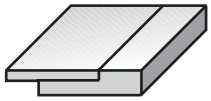
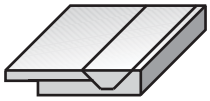
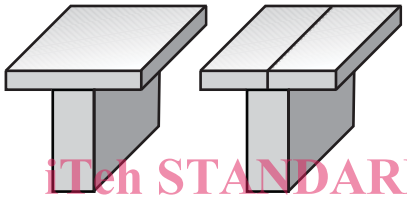
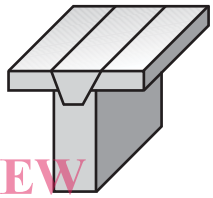
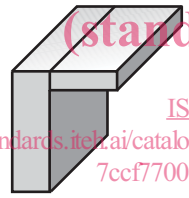
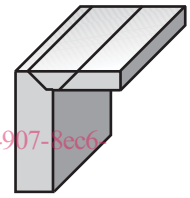
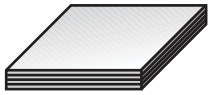
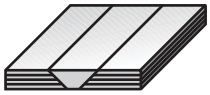
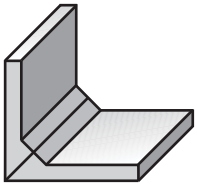
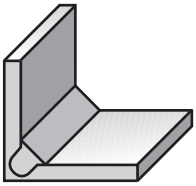
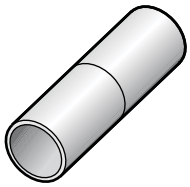
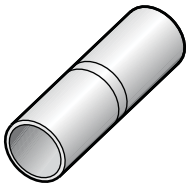
The weldment shall be designed in accordance with defined requirements that support the end use of the product. Documentation shall clearly define the essential information of the weld and any special requirements, e.g. fracture critical, durability critical, mission critical, or safety critical, that are imposed over and above the general requirements. Essential process controls shall be defined to substantiate that all design requirements can be met by the welds that were produced in accordance with the welding procedure specification (WPS) and inspection requirements.

Weld symbols shall be those shown in ISO 2553.

4.2 Joint design

The weld joint design shall take into account the necessary material property data. Some examples of weld joints are shown in Table 1.

Table 1 — Various weld joints shown before and after friction stir welding

Joint design	Before welding	After welding
Combination of a lap joint and butt joint		
Butt joint		
Combination of a lap joint and butt joint		
T-joint		
Corner joint		
Lap joint		
Corner joint		
Butt joint		

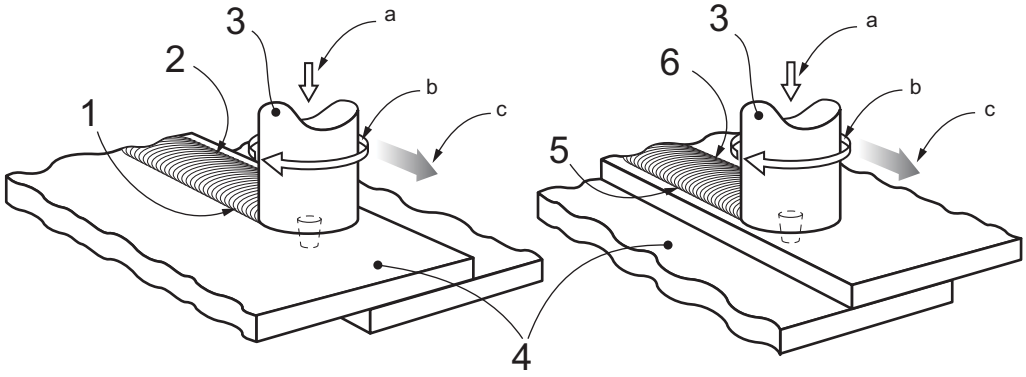
4.2.1 Butt joints

The depth of penetration of butt joints shall be specified in the WPS.

4.2.2 Lap joints

The distance from the centreline of the tool to the edge of each overlapping member shall be specified in the WPS. The depth of penetration of the probe into the lap joint shall be specified in the WPS.

A friction stir lap weld needs to be differentiated from all other lap welds to avoid any misunderstanding of its uniqueness. Conventional FSW is an asymmetric process. For example, one side of the weld is heated more than the other side. Another example of its asymmetry is the difference in strength between the advancing side and the retreating side of the weld. Depending on whether the advancing side or the retreating side of the weld is near the edge of the sheet (see Figure 1), the stronger or weaker side of the joint can be placed on the stressed side of the weld, as shown in Figure 2. This is critically important and depends on the advancing near edge or retreating near edge configuration, as shown in Figure 1.



Key

1 retreating side
2 advancing side near the weld face sheet edge (ANE)
3 tool
4 workpiece
5 retreating side near the weld face sheet edge (RNE)
6 advancing side

a Axial force.
b Direction of tool rotation.
c Direction of welding.

Figure 1 — Advancing side and retreating side placement in lap joints