INTERNATIONAL STANDARD

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Second edition
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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

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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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This document was prepared by IIW, *International Institute of Welding*, Commission III, *Resistance Welding, Solid State Welding and Allied Joining Process*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied proceses*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 25239-2:2011), which has been technically revised.

The main changes compared to the previous edition are as follows:

— half overlap joint has been taken into consideration;

— Figure 2 has been improved.

A list of all parts in the ISO 25239 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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. 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 document 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 document 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.

Friction stir welding — Aluminium —

Part 2: Design of weld joints

1 Scope

This document specifies design requirements for friction stir weld joints.

In this document, the term "aluminium" refers to aluminium and its alloys.

This document does not apply to friction stir spot welding which is covered by the ISO 18785 series.

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 2553, *Welding and allied processes — Symbolic representation on drawings — Welded joints*

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

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*

ISO/TR 25901 (all parts), *Welding and allied processes — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 25239-1 and ISO/TR 25901 (all parts) apply.

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

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

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

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 define all requirements for the weld. 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 in accordance with ISO 2553.

4.2 Joint design

4.2.1 General

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

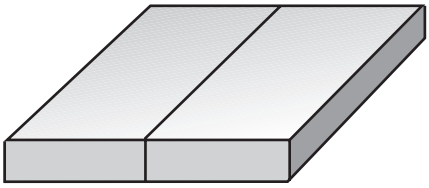
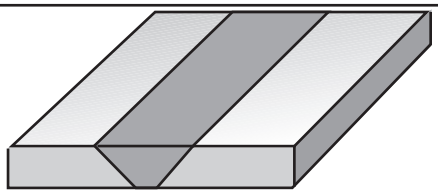
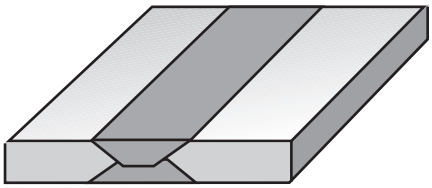
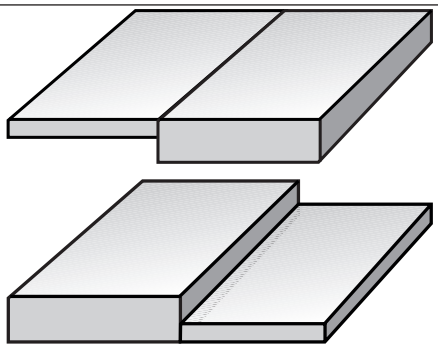
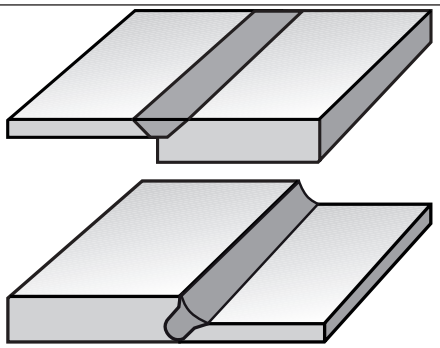
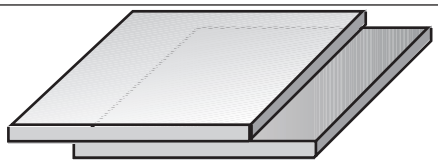
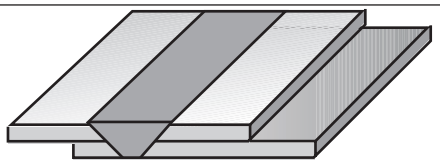
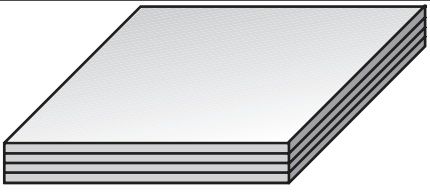
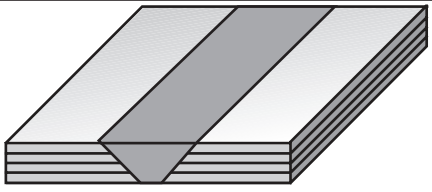
	Joint design	Before welding	After welding
1	Butt joint		 Single sided weld  Double sided weld
2	Butt joint with different thicknesses		
3	Lap joint		
4	Multi sheet lap joint		

Table 1 *(continued)*

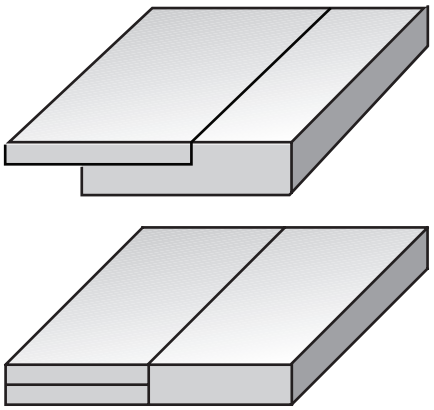
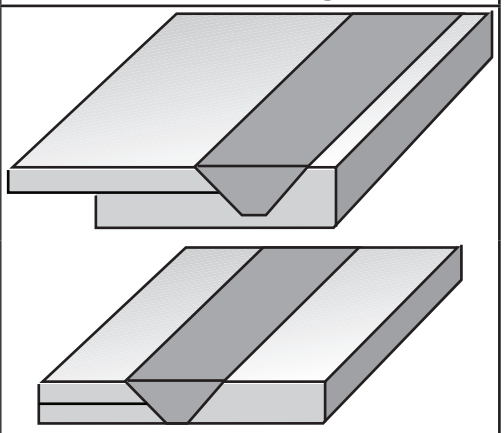
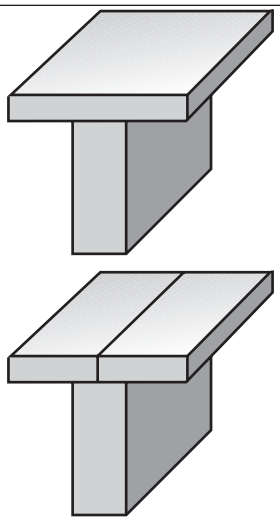
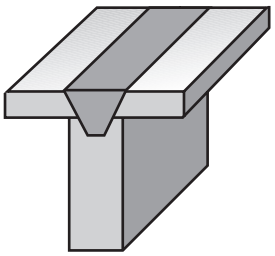
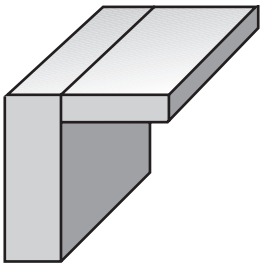
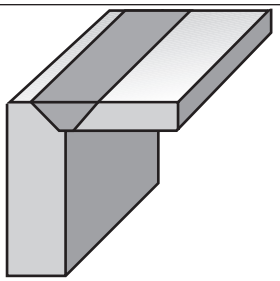
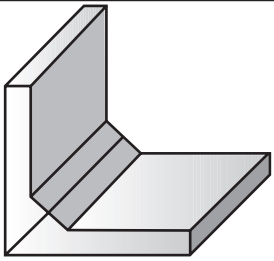
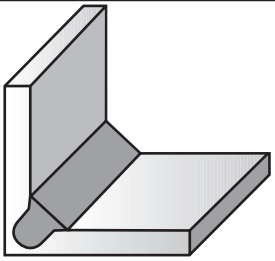
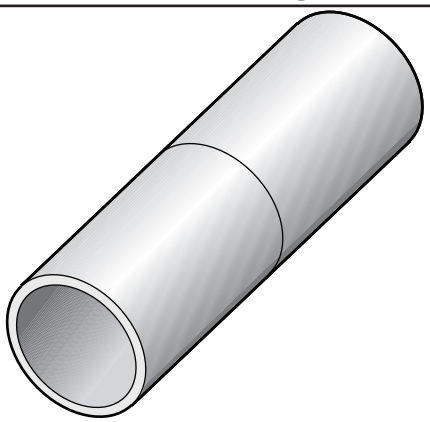
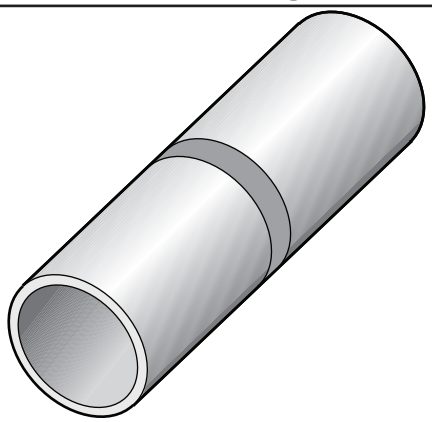
	Joint design	Before welding	After welding
5	Half overlap		
6	T-joint		
7	Corner joint		
8	Fillet joint		

Table 1 *(continued)*

	Joint design	Before welding	After welding
9	Circumferential butt joint		

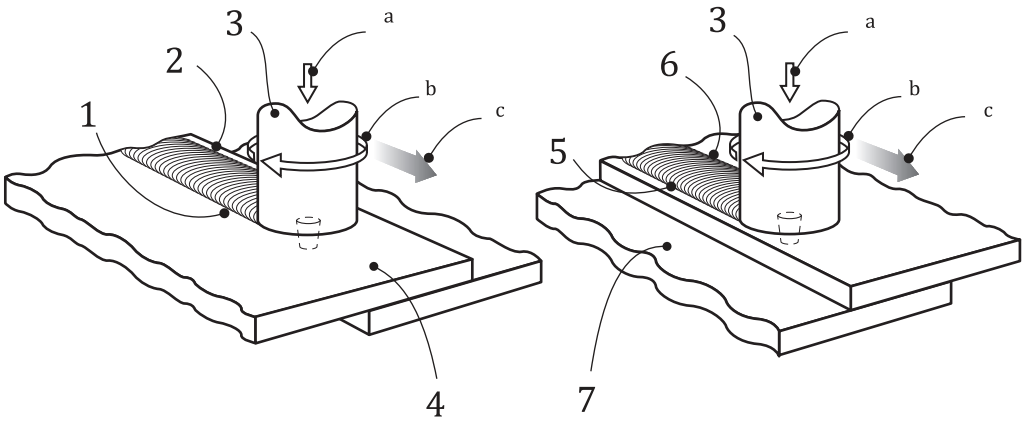
4.2.2 Butt joints

Essential variables shall be defined in the WPS in accordance with ISO 25239-4.

4.2.3 Lap joints

The distance from the centreline of the tool to the edge of each overlapping member shall be specified in the WPS.

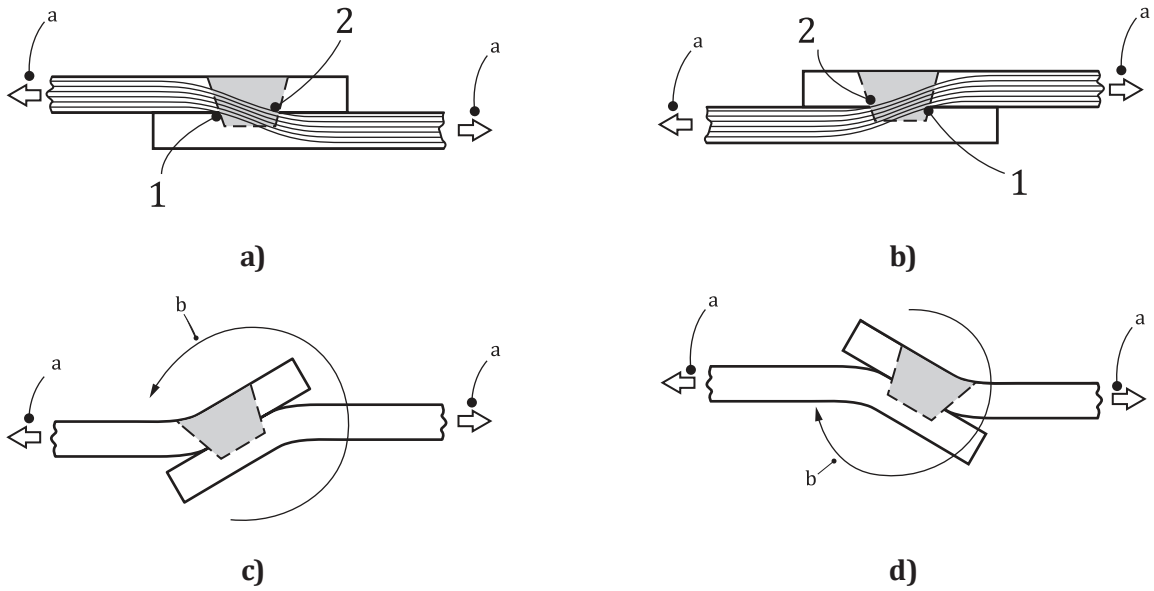
A friction stir lap weld shall be differentiated from all other lap welds to avoid any misunderstanding of its uniqueness. Conventional FSW is an asymmetric process. For example, one side of the weld is heated more than the other side. Another example of its asymmetry is the difference in strength between 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	6	advancing side
2	advancing side near the weld face sheet edge (ANE)	7	lower workpiece
3	tool	a	Axial force.
4	upper workpiece	b	Direction of tool rotation.
5	retreating side near the weld face sheet edge (RNE)	c	Direction of welding.

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



Key

1 tensile-stressed side of upper workpiece

2 tensile-stressed side of lower workpiece

[a] Tensile force.

[b] Joint rotation.

Figure 2 — Load paths in lap joints

4.3 Additional information

4.3.1 Essential information

The following shall be specified for each weld:

a) parent material specification, alloy, temper and product form;

b) pre-weld surface condition, including any coating;

c) weld location on the component and tool path;

d) weld finishing requirements (as-welded or subsequently finished);

e) postweld heat treatment.

4.3.2 Weldment dimensions

The dimensions of the weldment on the engineering drawing shall be the final dimensions and shall not include allowances for shrinkage.

4.3.3 Inspection

The documentation shall define the weld inspection requirements, inspection methods, and acceptance level. Welds shall be inspected and tested in accordance with ISO 25239-5.

Bibliography

[1] ISO 18785 (all parts), *Friction stir spot welding — Aluminium*

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

ICS 25.160.40; 25.160.10

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