
Friction stir welding — Aluminium —
Part 1:
Vocabulary

Soudage par friction-malaxage — Aluminium —
Partie 1: Vocabulaire

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 www.iso.org/iso/foreword.html.

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 processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 25239-1:2011), which has been technically revised.

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

- new definitions have been added for joint area deformation, operator, plunge phase, root flaw, stationary shoulder tool and temperature control;
- definitions of incomplete penetration, multi run welding, production welding test and single run welding have been deleted.

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.

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Friction stir welding — Aluminium —

Part 1: Vocabulary

1 Scope

This document defines terms related to friction stir welding.

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

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/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/TR 25901 (all parts) and the following 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/>

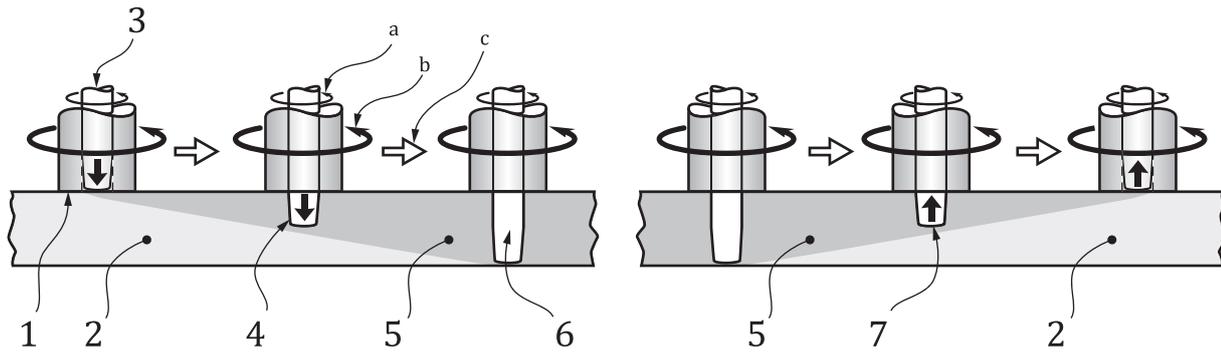
3.1

adjustable tool probe

tool whose probe length, rotation speed and direction of probe rotation are adjustable. Rotation speed and direction of probe rotation may be different from those of the shoulder during welding

Note 1 to entry: See [Figure 1](#).

Note 2 to entry: This tool enables joining to be accomplished without creating excessive toe flash at the start and exit hole.



Key

- | | | | |
|---|-----------------------|---|--|
| 1 | shoulder | 6 | probe at required position for welding |
| 2 | unwelded workpiece | 7 | probe moving upward |
| 3 | probe | a | Direction of probe rotation. |
| 4 | probe moving downward | b | Direction of shoulder rotation. |
| 5 | welded workpiece | c | Direction of welding. |

Figure 1 — Adjustable tool probe

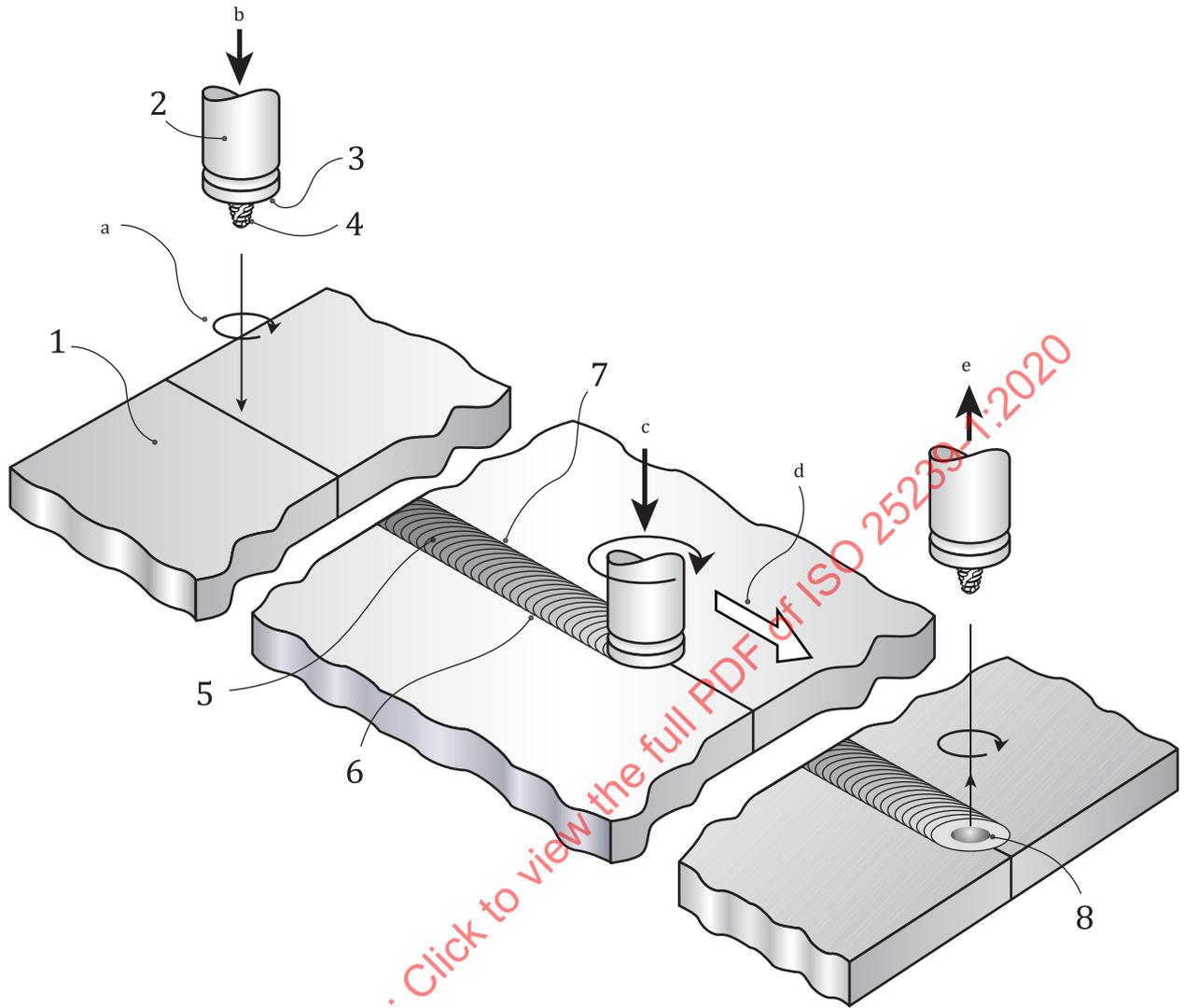
3.2

advancing side

side of the weld where the direction of tool rotation is the same as the direction of welding

Note 1 to entry: See [Figure 2](#).

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Key

- 1 workpiece
- 2 tool
- 3 shoulder
- 4 probe
- 5 weld face
- 6 retreating side of weld
- 7 advancing side of weld
- 8 exit hole

- a Direction of tool rotation.
NOTE A clock-wise rotation is shown in this figure.
- b Downward motion of tool.
- c Axial force.
- d Direction of welding.
- e Upward motion of tool.

Figure 2 — Basic principle of friction stir welding

3.3 axial force

<friction stir welding> force applied to the workpiece along the axis of tool rotation

Note 1 to entry: See [Figure 2](#).

**3.4
bobbin tool**

tool with two shoulders separated by a fixed length or an adjustable length probe

Note 1 to entry: The self-reacting bobbin tool allows the shoulders to automatically maintain contact with the workpiece.

Note 2 to entry: See [Figure 3](#).

**3.5
dwell time at end of weld**

<friction stir welding> time interval after travel has stopped, but before the rotating tool has begun to withdraw from the weld

Note 1 to entry: See t_5 in [Figure 4](#).

**3.6
dwell time at start of weld**

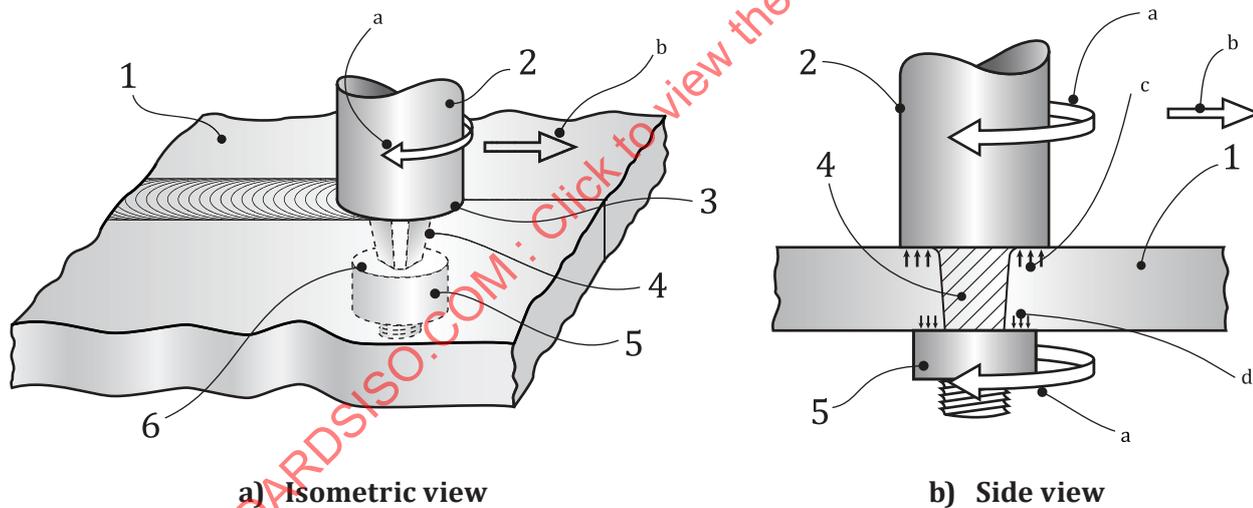
<friction stir welding> interval between the end of the plunge phase and the start of travel

Note 1 to entry: See t_3 in [Figure 4](#).

**3.7
exit hole**

hole remaining at the end of a weld after the withdrawal of the tool

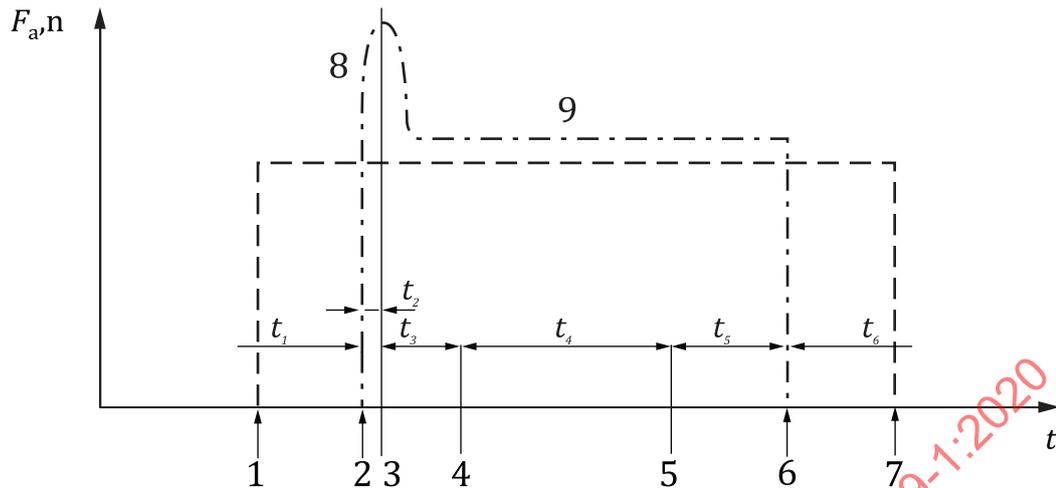
Note 1 to entry: See [Figure 2](#).



Key

- | | | | |
|---|----------------|---|------------------------------|
| 1 | workpiece | 6 | lower shoulder |
| 2 | upper tool | a | Direction of tool rotation. |
| 3 | upper shoulder | b | Direction of welding. |
| 4 | probe | c | Force on the upper shoulder. |
| 5 | lower tool | d | Force on the lower shoulder. |

Figure 3 — Bobbin tool

**Key**

F_a	axial force (chain dotted line)	1	start rotation
n	rotational speed (dashed line)	2	tool contacts workpiece
t	time	3	shoulder contacts workpiece
t_1	time where the tool moves toward workpiece	4	start travel
t_2	time of plunge phase	5	stop travel
t_3	dwell time at start of weld	6	tool retracts from the weld
t_4	tool travel time	7	stop rotation
t_5	dwell time at end of weld	8	rise in axial force
t_6	time where the tool moves away from workpiece	9	constant axial force

NOTE The schematic is representation of the basic process. In general, the individual parameters can vary during the process.

Figure 4 — Generalized diagram of friction stir welding as shown in [Figure 2](#)

3.8**faying surface**

surface of one component that is intended to be in contact with a surface of another component to form a joint

[SOURCE: ISO 17659:2002, 3.4]

3.9**fixed probe**

fixed length probe protruding from the shoulder, whose rotation and movement are the same as the shoulder

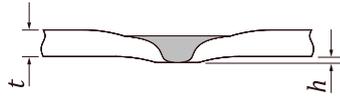
3.10**force control**

<friction stir welding> method of maintaining the required force on the tool during welding

3.11**joint area deformation**

<friction stir welding> deformation produced during welding near the joint at one or both sides of the weld

Note 1 to entry: See [Figure 5](#).



Key

h depth of joint area deformation

t thickness

Figure 5 — Joint area deformation

3.12

friction stir welding

FSW

joining process producing a weld by the friction heating and mixing of material in the plastic state caused by a rotating tool that traverses along the tool path

Note 1 to entry: See [Figures 2](#) and [4](#).

3.13

heel

<friction stir welding> portion of the tool shoulder at the rear of the tool relative to its forward motion

Note 1 to entry: See [Figure 6](#).

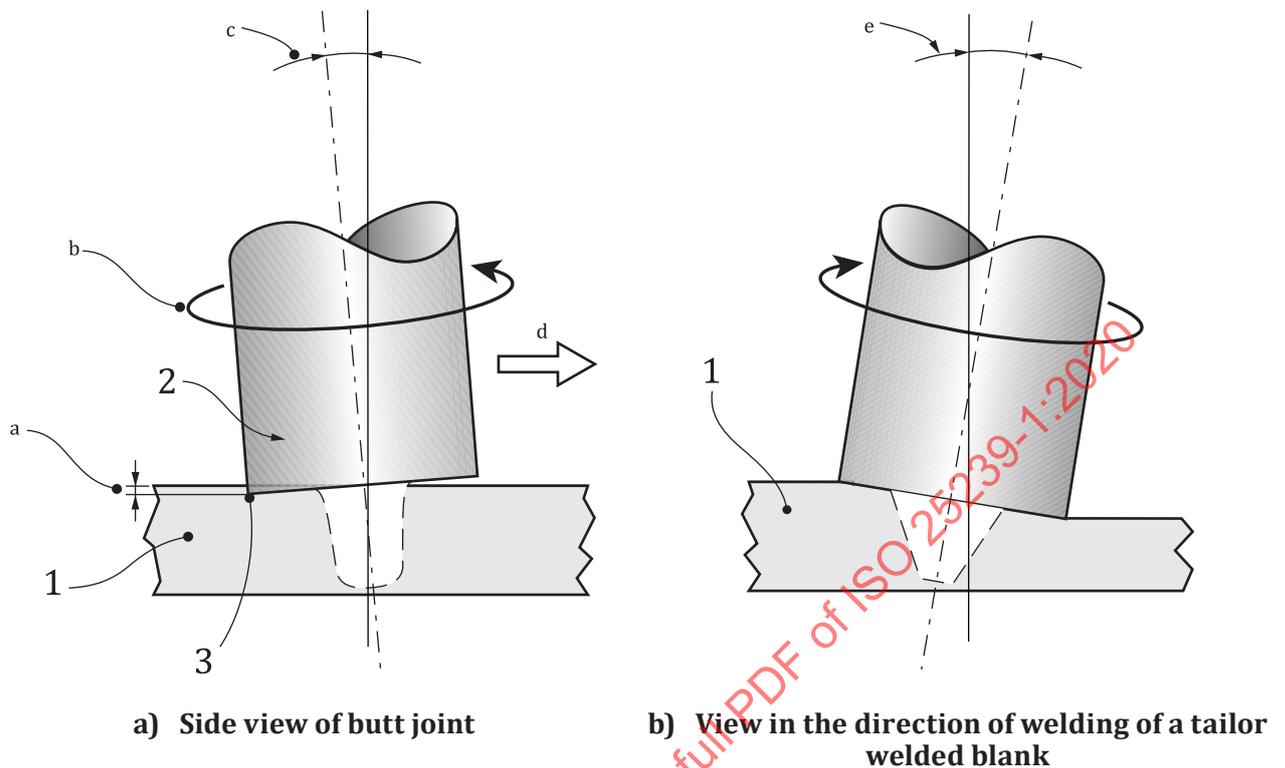
3.14

heel plunge depth

distance the heel extends into the weld metal

Note 1 to entry: See [Figure 6](#).

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**Key**

- 1 workpiece
- 2 tool
- 3 heel
- a Heel plunge depth.

- b Tool rotation.
- c Tilt angle.
- d Direction of welding.
- e Side tilt angle.

Figure 6 — Side tilt angle, heel, heel plunge depth, and tilt angle

3.15 hook

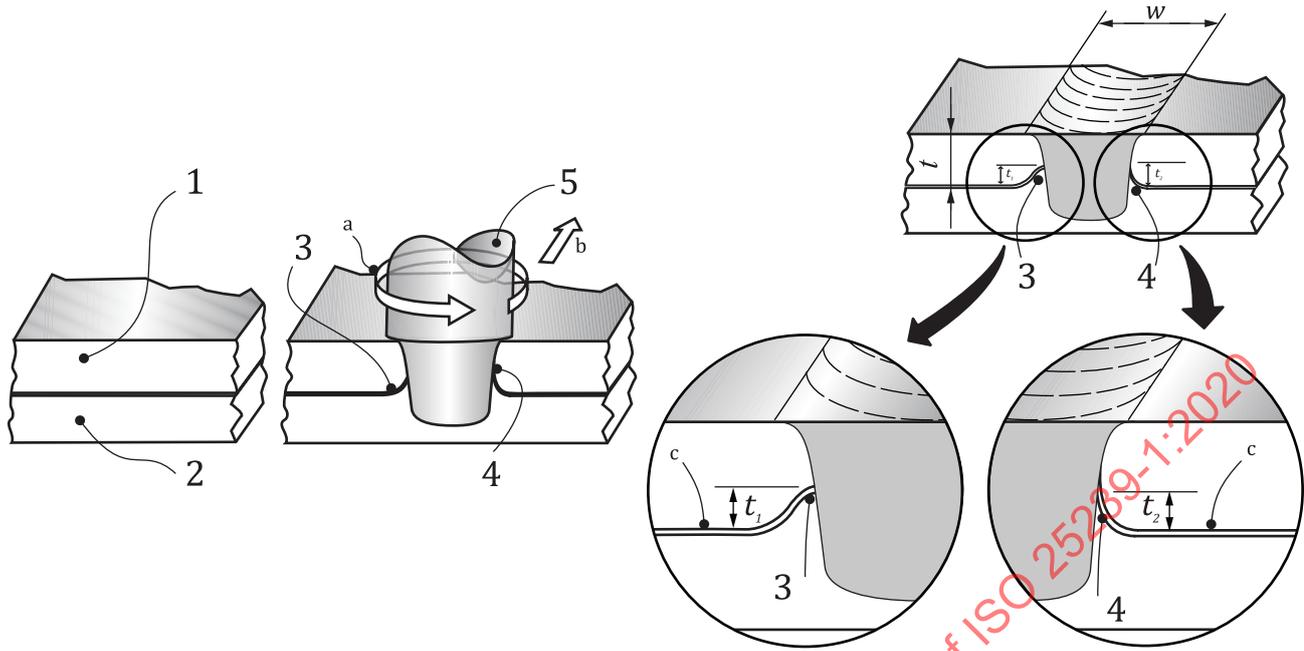
<friction stir welding> un-bonded and curved faying surfaces on the advancing or retreating side of a lap weld

Note 1 to entry: The hook can either turn upward or downward. [Figure 7 c\)](#) shows a hook turning upward.

3.16 lateral offset

<friction stir welding> typically in a butt weld it is the lateral distance from the tool axis to the faying surface

Note 1 to entry: See [Figure 9](#).



a) Before welding

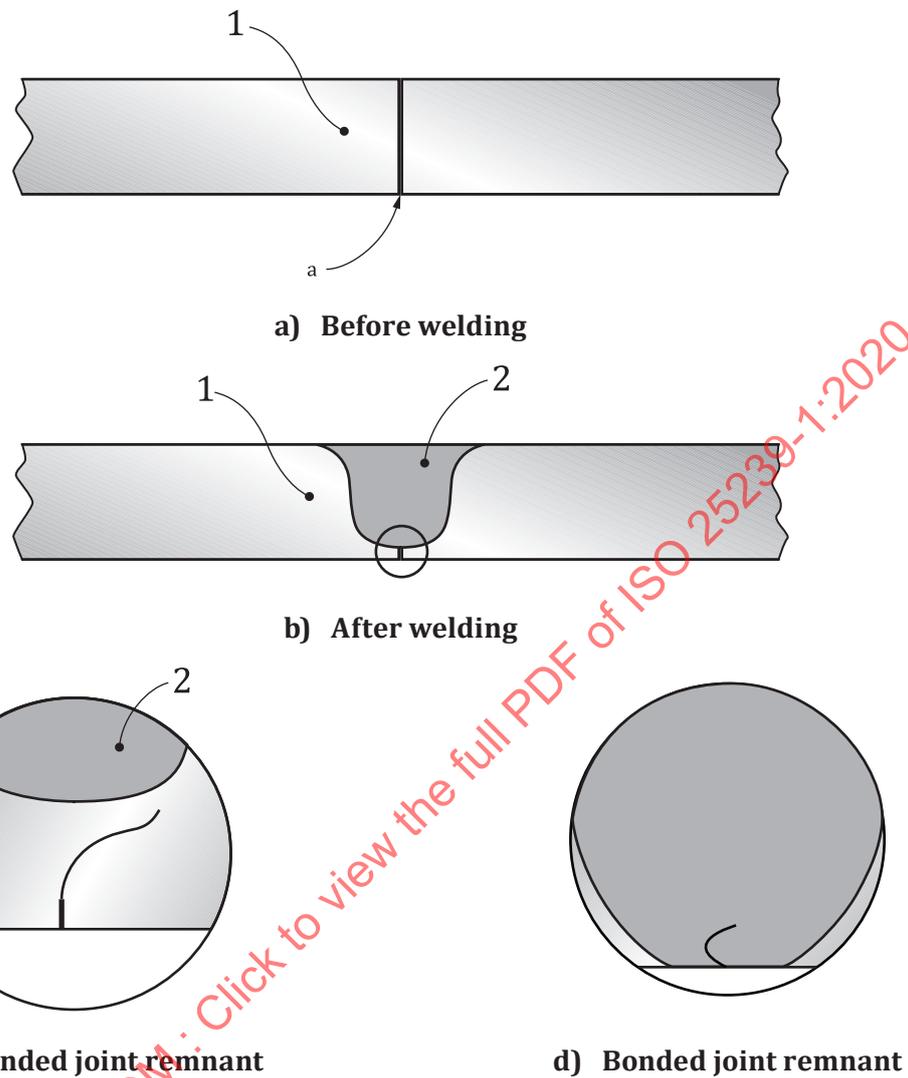
b) During welding

c) After welding

Key

- | | | | |
|-------|---|---|--|
| w | width | 3 | retreating side hook (upper workpiece) |
| t | original thickness of the upper workpiece | 4 | advancing side hook (upper workpiece) |
| t_1 | size of the hook on the retreating side | 5 | tool |
| t_2 | size of the hook on the advancing side | a | Direction of tool rotation. |
| 1 | upper workpiece | b | Direction of welding. |
| 2 | lower workpiece | c | Interface between faying surfaces. |

Figure 7 — Cross-section of friction stir lap weld showing hook

**Key**

- 1 workpiece
 2 weld
 a Joint (faying surfaces).

Figure 8 — Cross-section showing example of root flaws in full thickness butt weld

3.17 multiple spindles

friction stir welding system with two or more spindles

3.18 operator

<friction stir welding> person who operates automatic friction stir welding equipment only and has no direct influence on the welded joint quality

Note 1 to entry: An operator does not require qualification in accordance with ISO 25239-3.

Note 2 to entry: For welding operators, see [3.37](#).

3.19

plunge phase

<friction stir welding> tool penetration sequence from probe contact to a programmed value e.g. penetration depth, axial force

3.20

position control

<friction stir welding> method of maintaining the required position of the tool during welding

3.21

probe

<friction stir welding> part of the tool extending into the parent material to make the weld

Note 1 to entry: The probe can be either fixed or adjustable, see [Figures 1, 2, and 10](#).

3.22

production sample welding test

test of a welded product from production

3.23

retreating side

side of the weld where the direction of tool rotation is opposite to the direction of welding

Note 1 to entry: See [Figure 2](#).

3.24

root flaw

<friction stir welding> region at the root of the weld with insufficient mixing

Note 1 to entry: See [Figure 8](#).

3.25

shoulder

<friction stir welding> portion of the tool in contact with the surface of the workpiece during welding

Note 1 to entry: The rotational speed and/or rotational direction can differ from that of the probe.

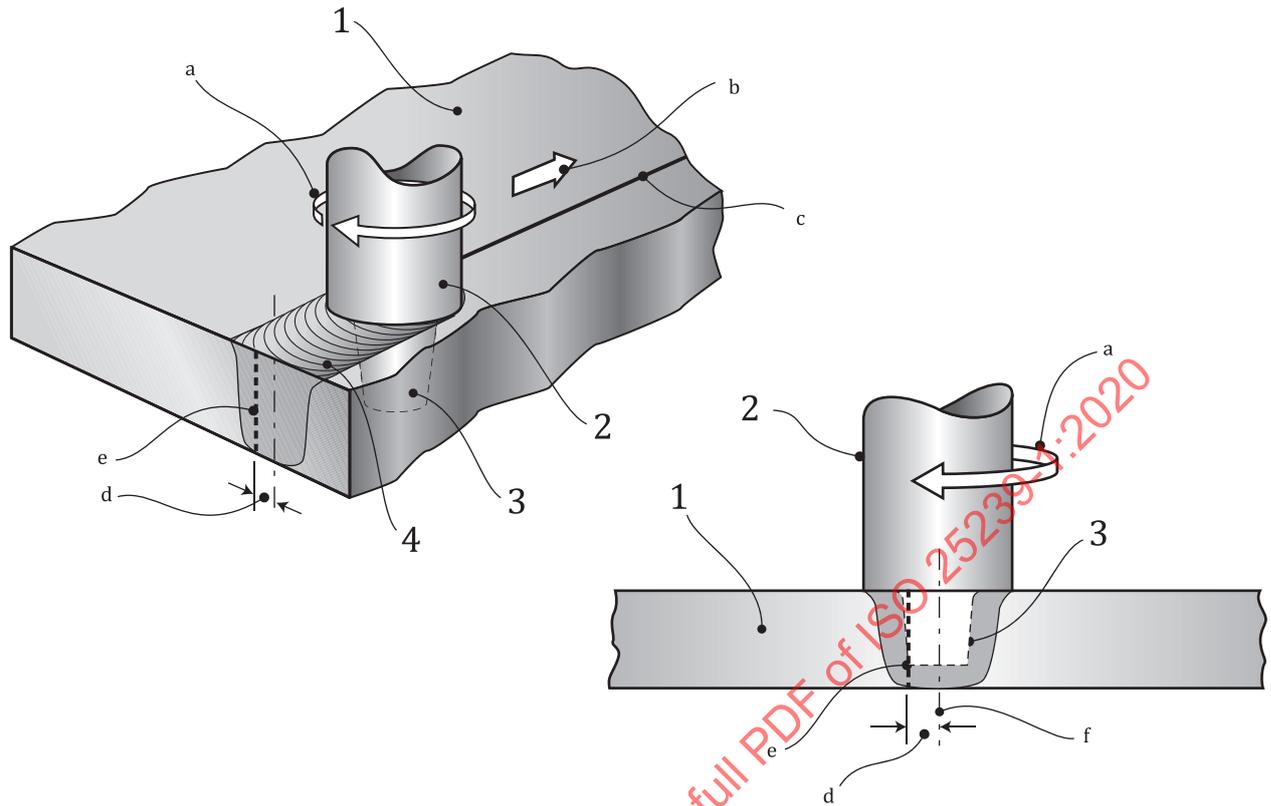
Note 2 to entry: See [Figure 10](#).

3.26

side tilt angle

angle between the centreline of the tool and a line perpendicular to the surface of the work piece, measured in a plane perpendicular to the direction of welding

Note 1 to entry: See [Figure 6](#).



Key

- | | | | |
|---|-----------------------------|---|-----------------------------------|
| 1 | workpiece | b | Direction of welding. |
| 2 | tool | c | Joint (faying surfaces). |
| 3 | probe | d | Lateral offset. |
| 4 | weld face | e | Location of joint before welding. |
| a | Direction of tool rotation. | f | Tool centreline. |

Figure 9 — Lateral offset showing the centreline of the tool not centred on the joint