INTERNATIONAL STANDARD

ISO 25239-1

Second edition
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Friction stir welding — Aluminium —

Part 1: **Vocabulary**

Soudage par friction-malaxage — Aluminium —

Partie 1: Vocabulaire

Reference number
ISO 25239-1:2020(E)

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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 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.

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:

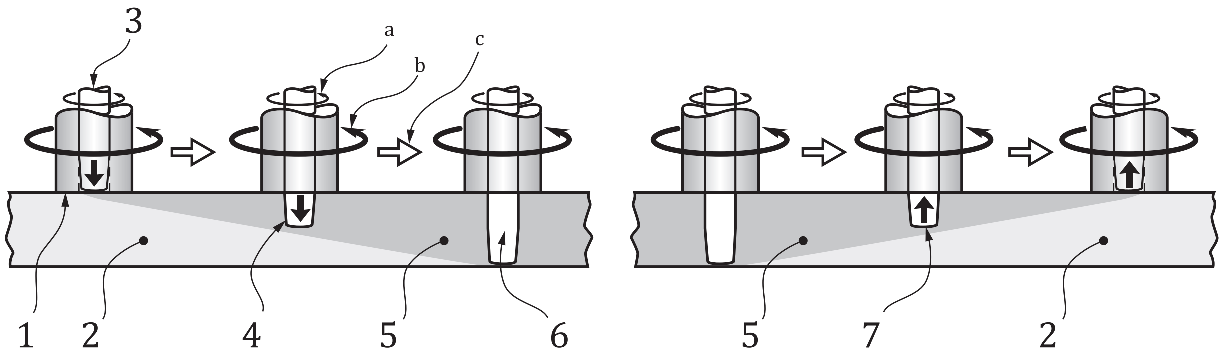
— ISO Online browsing platform: available at https://www.iso.org/obp

— 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.



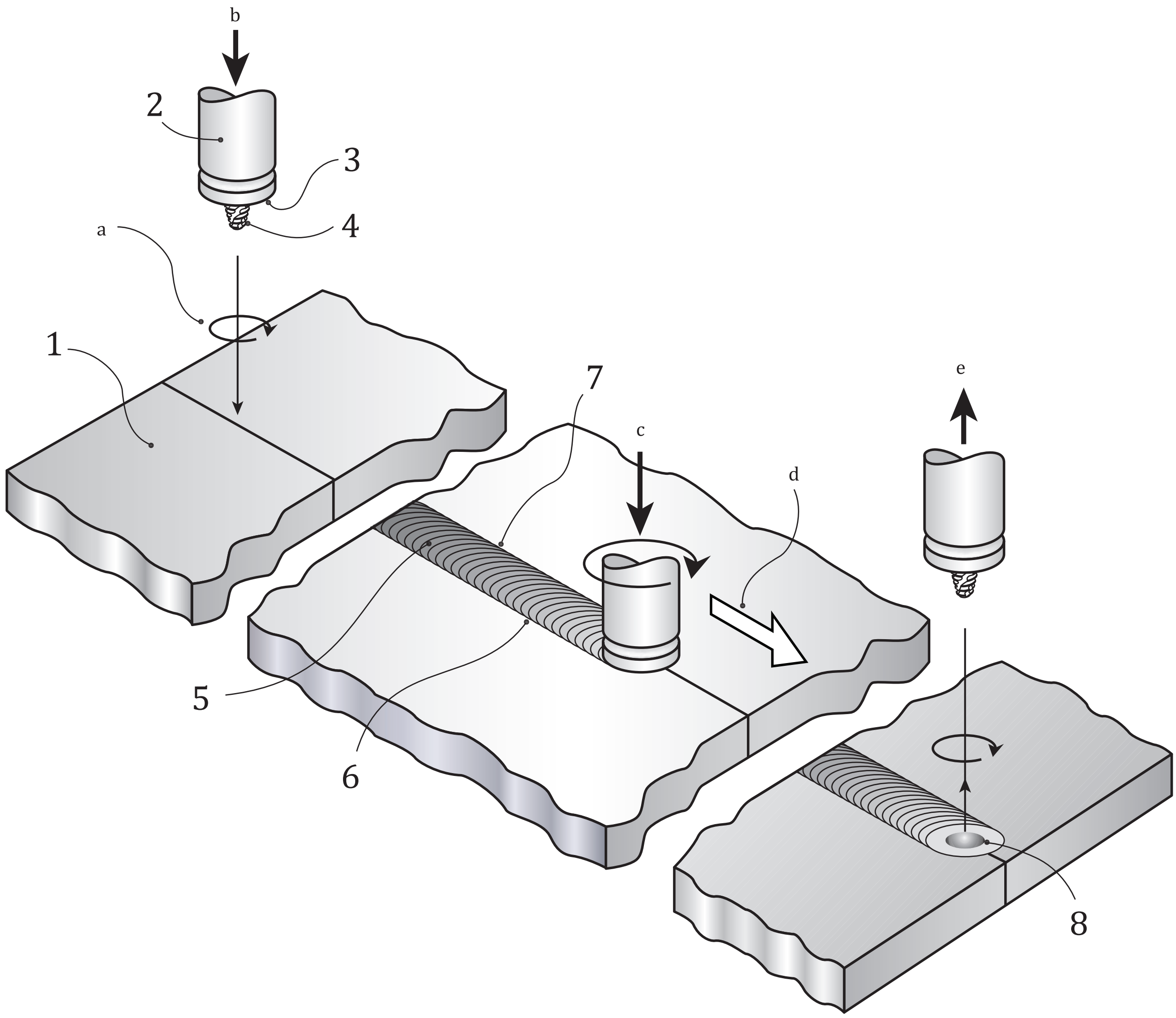
Key

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



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

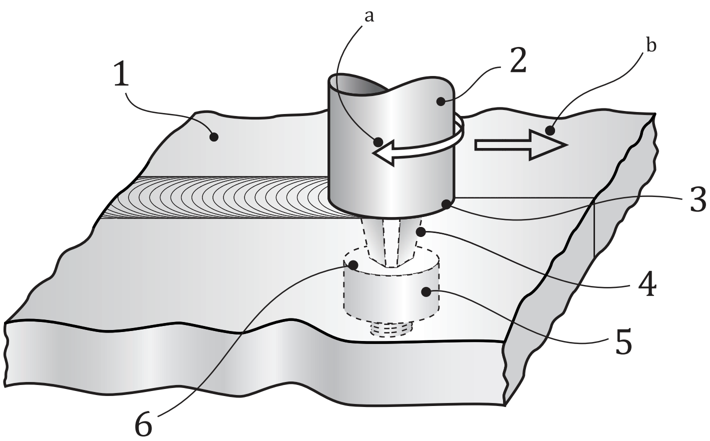
Note 1 to entry: See t_5 in Figure 4.

3.6
dwell time at start of weld
<friction stir welding> interval between the end of the plunge phase and the start of travel

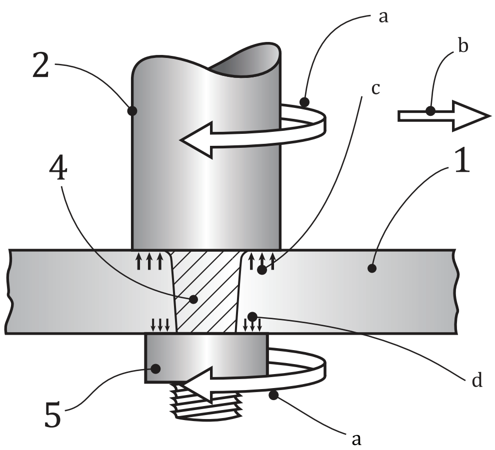
Note 1 to entry: See t_3 in Figure 4.

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.



a) Isometric view

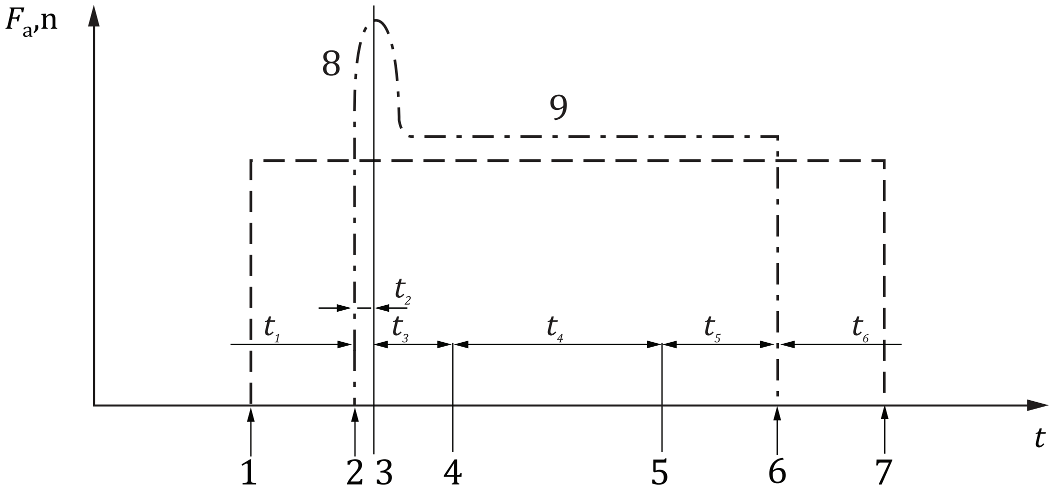


b) Side view

Key

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

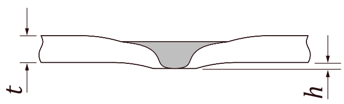
[SOURCE: ISO 17659:2002, 3.4]

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

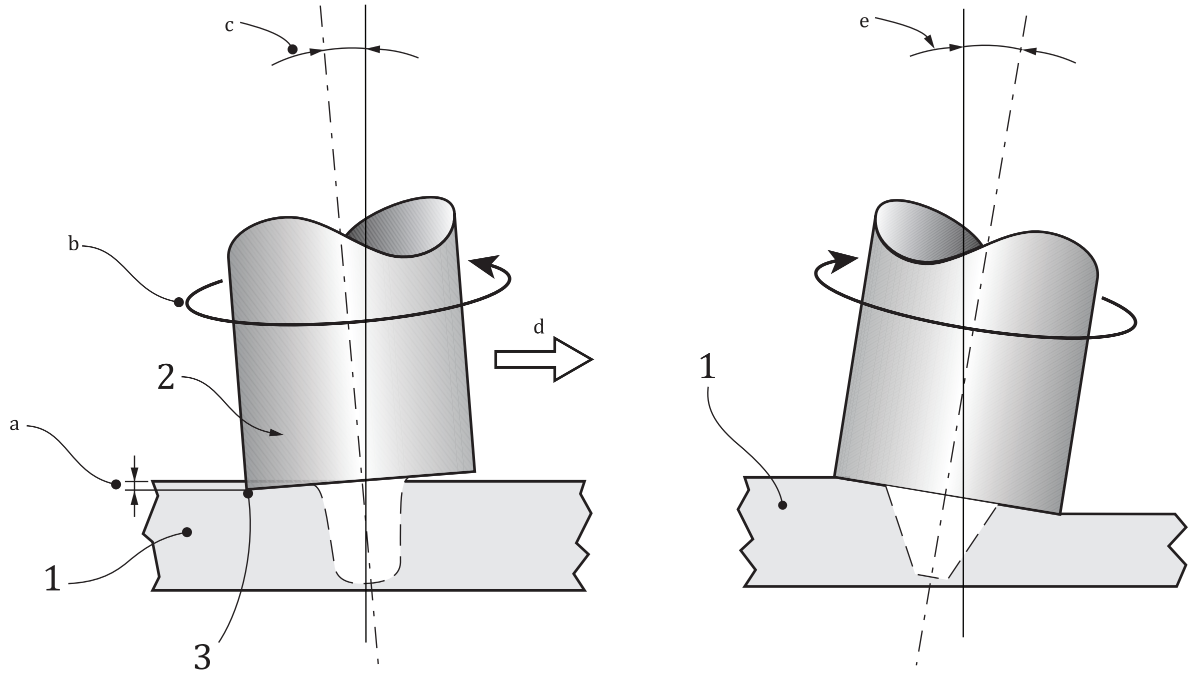
Note 1 to entry: See Figures 2 and 4.

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.



a) Side view of butt joint

b) View in the direction of welding of a tailor welded blank

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.

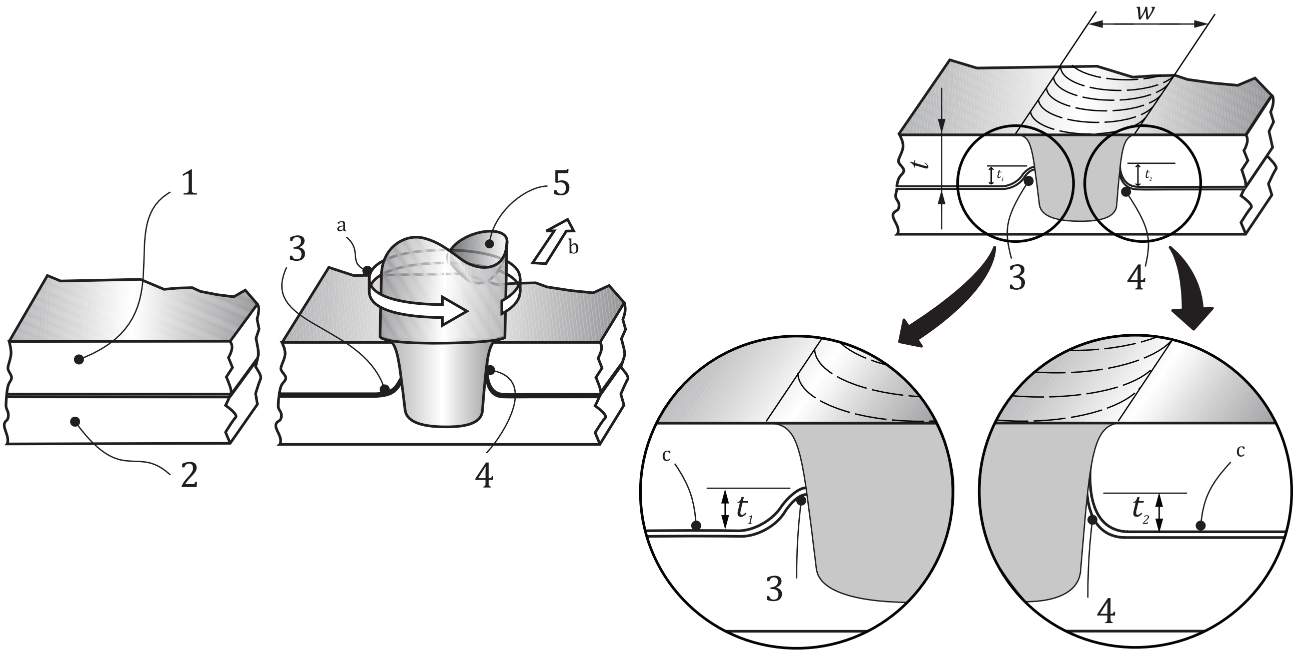
Figure 6 — Side tilt angle, heel, heel plunge depth, and tilt angle

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.

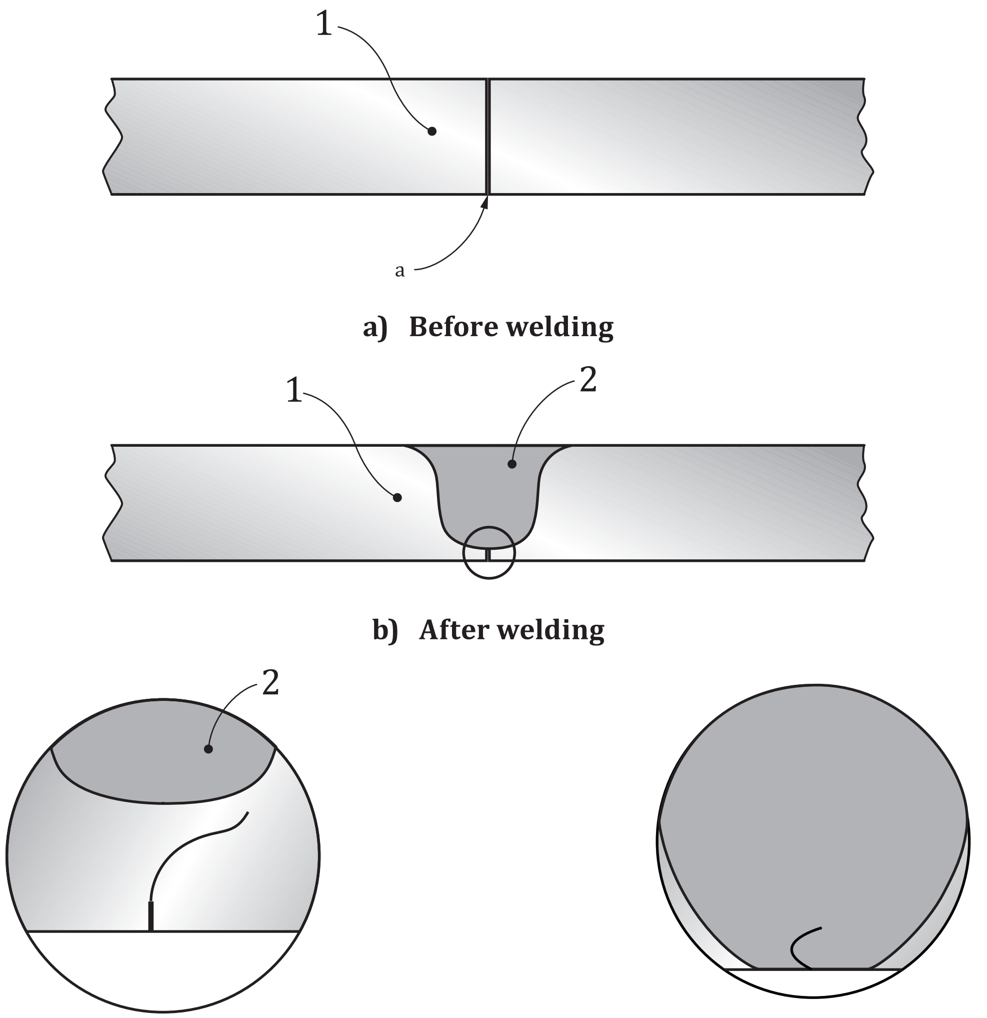


a) Before welding **b) During welding** **c) After welding**

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



a) Before welding

b) After welding

c) Unbonded joint remnant

d) Bonded joint remnant

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.

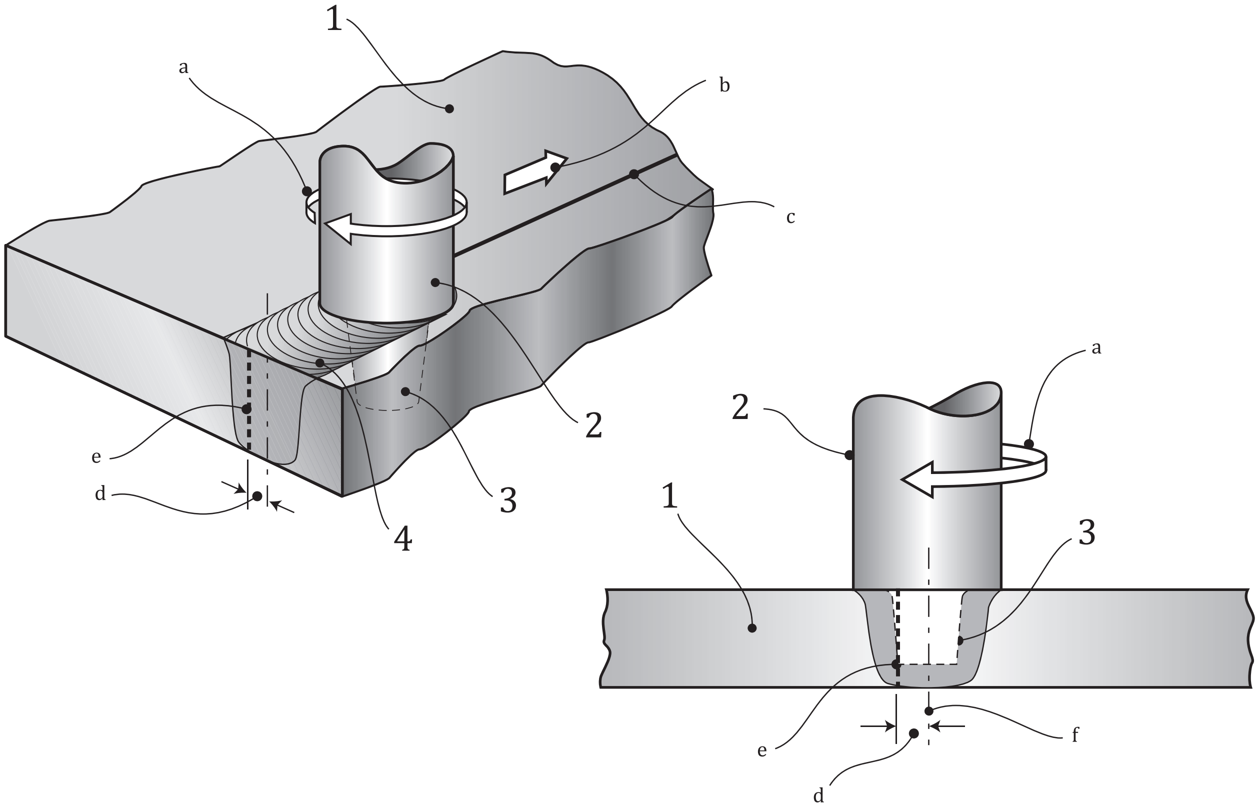
3.25
shoulder
<friction stir welding> portion of the tool in contact with the surface of the workpiece during welding

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

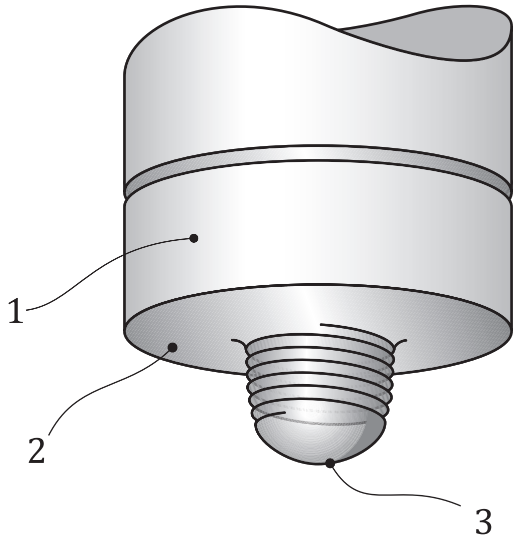
Note 1 to entry: See Figure 6.



Key

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

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



Key

1 tool

2 shoulder

3 probe

Figure 10 — Example of a friction stir welding tool

3.27
single spindle
<friction stir welding> friction stir welding system with one spindle

3.28
standard welding test
welding and testing of a standardized test piece in order to qualify a welding operator

3.29
stationary shoulder tool
tool having a shoulder that travels with the probe but does not rotate

3.30
stirred zone
region in the centre of the weld where a fine-grained, equiaxed microstructure exists

3.31
temperature control
<friction stir welding> method of maintaining the required temperature during welding

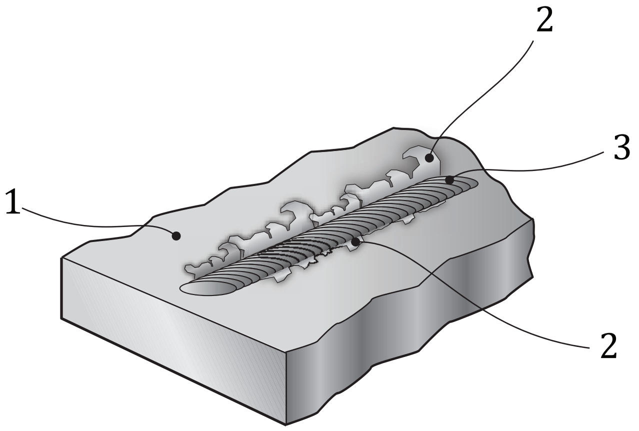
3.32
tilt angle
<friction stir welding> angle between the centreline of the tool and a line perpendicular to the surface of the work piece, opposite to the direction of welding

Note 1 to entry: See Figure 6.

Note 2 to entry: Typical tilt angles are 0° to 5°.

3.33
toe flash
imperfection consisting of excessive metal protruding above the weld face or material expelled along the toe during welding

Note 1 to entry: See Figure 11.



Key

1 workpiece

2 toe flash

3 weld face

Figure 11 — Toe flash

3.34
tool
<friction stir welding> component that includes the shoulder and probe

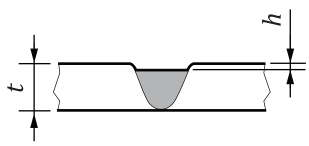
Note 1 to entry: A tool usually has a shoulder and a probe, but a tool can have more than one shoulder or more than one probe. In addition, a tool may not have a shoulder or a probe.

Note 2 to entry: See Figure 10.

3.35
underfill
depression resulting when the weld face is below the adjacent parent material surface

Note 1 to entry: See Figure 12.

Note 2 to entry: This is a common characteristic of the friction stir welding process.



Key

h depth of underfill

t thickness

Figure 12 — Underfill

3.36
weld overlap area
WOA
area where a subsequent weld overlaps a portion of a previous weld

Note 1 to entry: A WOA where the end of the weld overlaps the start of the weld is common during pipe welding.

3.37
welding operator
<friction stir welding> person who can perform fully mechanized and automatic friction stir welding and can have direct influence on the welded joint quality

Note 1 to entry: A welding operator requires qualification in accordance with ISO 25239-3.

3.38
welding procedure specification
WPS
document that provides the qualified welding procedure

Bibliography

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[3] ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

[4] ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

[5] ISO 17659:2002, *Welding — Multilingual terms for welded joints with illustrations*

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[7] ISO 25239 (all parts), *Friction stir welding — Aluminium*

ICS 01.040.25; 25.160.10
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