BS EN ISO 25239-5:2011

BSI Standards Publication

Friction stir welding — Aluminium

Part 5: Quality and inspection requirements (ISO 25239-5:2011)

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National foreword

This British Standard is the UK implementation of EN ISO 25239-5:2011.

The UK participation in its preparation was entrusted to Technical Committee WEE/41, Friction welding.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

This document (EN ISO 25239-5:2011) has been prepared by the International Institute of Welding in collaboration with Technical Committee CEN/TC 121 “Welding” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2012, and conflicting national standards shall be withdrawn at the latest by June 2012.

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Endorsement notice

The text of ISO 25239-5:2011 has been approved by CEN as a EN ISO 25239-5:2011 without any modification.

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Foreword

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ISO 25239-5 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 friction stir weld 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 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.

INTERNATIONAL STANDARD **ISO 25239-5:2011(E)**

Friction stir welding — Aluminium —

Part 5: Quality and inspection requirements

1 Scope

This part of ISO 25239 specifies a method for determining the capability of a manufacturer to use the friction stir welding (FSW) process for the production of products of the specified quality. It specifies quality requirements, but does not assign those requirements to any specific product group.

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 3452-1, *Non-destructive testing — Penetrant testing — Part 1: General principles*

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

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

ISO 9015-1, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints*

ISO 9015-2, *Destructive tests on welds in metallic materials — Hardness testing — Part 2: Microhardness testing of welded joints*

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

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

ISO 17636 (all parts), *Non-destructive testing of welds — Radiographic testing*[1)]

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

ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

ISO 20807, *Non-destructive testing — Qualification of personnel for limited application of non-destructive testing*

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

1) To be published. (Revision of ISO 17636:2003)

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

ISO 25239-4:2011, *Friction stir welding — Aluminium — Part 4: Specification and qualification of welding procedures*

3 Terms and definitions

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

4 Quality requirements

4.1 General

These requirements relate only to those aspects of product quality that may be influenced by FSW.

4.2 Welding personnel

4.2.1 General

Manufacturers shall have at their disposal sufficient competent personnel for the planning, performance and supervision of FSW production operations in accordance with specified requirements.

4.2.2 Welding operator

Welding operators shall be qualified in accordance with ISO 25239-3. Qualification records shall be kept up to date.

4.3 Inspection and testing personnel

4.3.1 General

Manufacturers shall have sufficient competent personnel for the planning, performance, and supervision of inspection and testing operations during the production of friction stir welded parts in accordance with specified requirements.

4.3.2 Personnel performing non-destructive testing and visual testing

Non-destructive and visual testing personnel shall be qualified in accordance with ISO 9712 or ISO 20807. When the use of an examination method not currently incorporated in ISO 9712 or ISO 20807 is specified, the manufacturer shall be responsible for developing the training programme, written practice, examination, and practical demonstrations equivalent to the requirements of ISO 9712 or ISO 20807. These shall establish the capability of the personnel performing the required examination.

4.3.3 Destructive testing personnel

Personnel performing destructive testing shall be trained for those test methods.

4.4 Equipment

4.4.1 Suitability of equipment

The equipment shall be adequate for the application concerned.

Welding equipment (e.g. welding machines and FSW tools) shall be capable of producing welds that meet the acceptance levels specified in Annex A. Welding equipment shall be maintained in good condition and shall be repaired or adjusted when a welding operator, inspector or welding coordinator is concerned about the capability of the equipment to operate satisfactorily.

4.4.2 New equipment

After installation of new or refurbished equipment, appropriate tests shall be performed. Such tests shall verify the equipment functions correctly.

4.4.3 Reproducibility tests for qualified machine welding settings

Reproducibility tests shall be performed to demonstrate that the welding equipment can repeatedly produce welds that meet the acceptance levels in Annex A. Reproducibility tests shall be carried out when any of the following occurs:

— a critical component of the equipment is damaged, repaired, or replaced;

— equipment is dislodged or moved in a manner for which it was not designed;

— stationary equipment is moved from one location to another.

The reproducibility test shall be performed in accordance with a WPS that is used in production for that machine.

A minimum of three test welds shall be made and found satisfactory.

4.4.4 Equipment maintenance

The manufacturer shall have a documented plan for equipment maintenance. The plan shall ensure that maintenance checks are performed on the equipment that controls variables listed in the relevant WPSs. The maintenance plan may be limited to those items that are essential for producing welds that meet the quality requirements of this part of ISO 25239.

Examples of these items are as follows:

— condition of guides and mechanized fixtures;

— condition of meters and gauges that are used for the operation of the welding equipment;

— condition of cables, hoses, and connectors;

— condition of the control systems in mechanized or automatic welding equipment;

— condition of thermocouples and other temperature measurement instruments;

— condition of clamps, jigs, and fixtures.

Before welding, clamps, jigs, and fixtures that contact the workpieces shall be clean and sufficiently free of contaminants (e.g. oil, grease, and dirt) that could have a detrimental effect on the weld.

Defective equipment shall not be used.

4.5 Welding procedure specification

The manufacturer shall ensure the WPS is used correctly in production.

4.6 Friction stir welding tool

4.6.1 Identification

The FSW tool that is used in production shall be permanently marked for identification prior to use.

4.6.2 Friction stir welding tool inspection

Before welding, the FSW tool shall be clean and sufficiently free of contaminants (e.g. oil, grease or dirt) that could have a detrimental effect on weld quality. The correct tool geometry is critical for producing a quality friction stir weld. Because the FSW tool wears with use, it shall be inspected for wear at appropriate intervals and in accordance with a written procedure.

4.7 Preweld joint preparation and fit-up

4.7.1 Joint preparation

The edge of each joint member shall be prepared in accordance with the WPS.

The root gap shall be set in accordance with the WPS.

4.7.2 Preweld cleaning

Preweld cleaning shall be carried out in accordance with the WPS. Parent material shall be sufficiently free of surface oxides, protective finishes, adhesives, oils, grease, dirt, and any other contaminants that could have a detrimental effect on weld quality.

4.8 Preheating and interpass temperature control

Requirements for preheating and interpass temperature control shall be in accordance with a WPS.

4.9 Tack welds

If tack welds are required, they shall be made in accordance with a WPS.

4.10 Welding

All welding shall be done in accordance with a WPS.

4.11 Postweld heat treatment

If postweld heat treatment is required, it shall be done in accordance with a WPS.

The manufacturer shall be fully responsible for the specification and performance of any postweld heat treatment (e.g. solution heat-treating, stress relieving, or ageing). The procedure shall be compatible with the parent material, welded joint, and weldment, in accordance with the product standard or specified requirements. A record of the heat treatment shall be made during the heat-treating process. The record shall demonstrate that this part of ISO 25239 has been followed and shall be traceable to the heat-treated part.

4.12 Inspection and testing

4.12.1 General

The location and frequency of applicable inspections and tests depends on the product standard and the type of construction.

4.12.2 Inspection and testing before welding

Before the start of welding, the following shall be verified:

— suitability and validity of the welding operator's qualification certificate;

— suitability of the WPS;

— parent material alloy and temper;

— joint preparation (e.g. shape and dimensions);

— joint fit-up, jigging, and tacking;

— welding parameters set in accordance with the WPS;

— preheating and interpass temperature.

4.12.3 Inspection and testing during welding

During welding, the welding sequence shall be checked at suitable intervals or by continuous monitoring.

4.12.4 Inspection and testing after welding

4.12.4.1 General

After welding, compliance with the relevant application standards or relevant requirements shall be verified for:

— visual testing;

— non-destructive testing;

— destructive testing;

— form, shape, and dimensions of the weldment;

— results and records of postweld operations (e.g. postweld heat treatment, ageing).

4.12.4.2 Visual testing

Visual testing shall be performed in accordance with ISO 17637.

4.12.4.3 Penetrant inspection

Penetrant inspection shall be performed in accordance with ISO 3452-1.

4.12.4.4 Radiographic testing

Radiographic testing shall be performed in accordance with ISO 17636.

Ultrasonic examination may be used instead of radiographic testing when specified by the design specification or by relevant requirements.

When radiographic testing of lap joints or partial-penetration butt welds is required, the design specification shall determine the acceptance levels.

4.12.4.5 Ultrasonic examination

Ultrasonic examination shall be performed in accordance with ISO 17640.

When immersion ultrasonic examination or phased-array ultrasonic examination is used, the design specification or relevant requirements shall determine the applicable standard(s) or requirements.

4.12.4.6 Proof testing

Proof testing may be used in conjunction with, or in lieu of, the testing methods listed in 4.12.4.3 (penetrant), 4.12.4.4 (radiographic) and 4.12.4.5 (ultrasonic), when specified by the design specification or relevant requirements.

4.12.4.7 Tensile testing

Tensile testing and the preparation of tensile test specimens shall be performed in accordance with ISO 4136.

4.12.4.8 Bend testing

Bend testing and the preparation of bend test specimens shall be performed in accordance with ISO 5173.

For all parent materials, the minimum bend angle shall be 150° using the calculated former diameter based upon the parent material elongation as specified in ISO 25239-4:2011, 6.3.3.4.

4.12.4.9 Hardness testing

Hardness testing shall be performed in accordance with ISO 9015-1 or ISO 9015-2, as applicable.

4.12.4.10 Fracture testing

Fracture testing shall be performed in accordance with ISO 9017.

4.12.4.11 Other destructive tests

Other destructive tests, procedures or techniques (e.g. impact tests, fatigue tests or macrographic and micrographic examination) not specifically addressed in this part of ISO 25239 may be used in conjunction with the tests stated herein. When one or more of these other testing methods is indicated, then they shall be carried out in accordance with the relevant International Standard.

4.12.5 Damaged and non-conforming welds

If the repair of a damaged weld involves welding, then the repair shall be performed in accordance with a WPS. Repair shall bring the weld into full conformity with the requirements of this specification.

4.12.6 Weld geometry correction

Toe flash or other protruding material along the edges of a friction stir weld and excess penetration may be removed by a method that does not degrade parent metal properties. This operation shall be carried out in such a manner that the thickness of the weld and parent material remain within tolerance.

4.13 Identification and traceability

Identification and traceability of a weld to a WPS and welding operator or operators shall be maintained throughout the manufacturing process.

Annex A
(normative)

Imperfections, testing and examination, acceptance levels, and ISO 6520-1 reference number

Table A.1 — Imperfections, testing and examination, acceptance levels, and ISO 6520-1[3] reference number

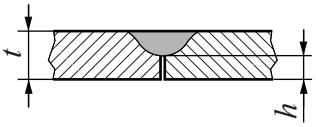
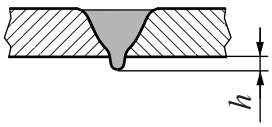
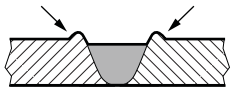
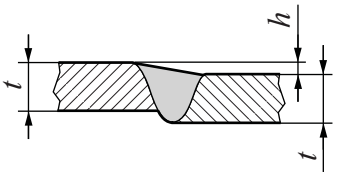
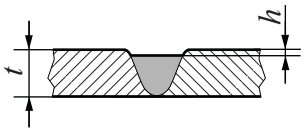
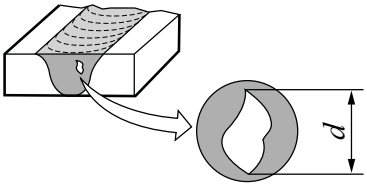
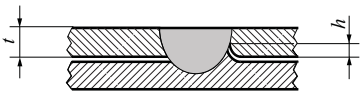
Designation of imperfection	Remarks	Testing and examination in ISO 25239-4[a]	Acceptance levels[a]	Reference number in ISO 6520-1[3]
Surface imperfections				
Incomplete penetration		ME	Not permitted	—[c]
Excess penetration		VT, ME	$h \leq 3$ mm	504
Toe flash		VT, ME	—[b]	—[c]
Linear misalignment		VT, ME	$h \leq 0{,}2t$ or 2 mm, whichever is less	507
Underfill		VT, ME	$h \leq 0{,}2$ mm $+ 0{,}1t$ for $t \geq 2$ mm: $h \leq 0{,}15t$ for $t < 2$ mm	—[c]
Irregular width	Excessive variation in width of the weld	VT	—[b]	513
Irregular surface	Excessive surface roughness	VT	—[b]	514

Table A.1 (*continued*)

Designation of imperfection	Remarks	Testing and examination in ISO 25239-4[a]	Acceptance levels[a]	Reference number in ISO 6520-1[3]
Internal imperfections				
Cavity		ME	$d \leq 0{,}2s$ or 4 mm, whichever is less	200
Hook		ME	—[b]	—[c]

Symbols and abbreviated terms

d maximum transverse cross-sectional dimension of cavity (mm)

h height of an imperfection (mm)

s nominal butt weld thickness (penetration) (mm)

t nominal thickness of the parent material (mm)

ME macroscopic examination

VT visual testing

[a] When required, non-destructive testing should be carried out in accordance with ISO 3452-1 (penetrant inspection), ISO 17636 (radiographic testing) and ISO 17640 (ultrasonic examination). Testing and examination of other imperfections and their acceptance levels shall be in accordance with the relevant requirements or the design specification.

[b] Acceptance levels shall be within the specified limit of the relevant requirements or the design specification.

[c] See ISO 25239-1.

Bibliography

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

[2] ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

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

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