BS EN 18007-5:2024

BSI Standards Publication

Electromagnetic pulse welding

Part 5: Quality and inspection requirements

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European foreword

This document (EN 18007-5:2024) has been prepared by Technical Committee CEN/TC 121 “Welding and allied processes”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by January 2025, and conflicting national standards shall be withdrawn at the latest by January 2025.

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

The EN 18007 series of standards, under the general title *Electromagnetic pulse welding*, consists of the following parts:

— *Part 1: Welding knowledge, terminology and vocabulary*,

— *Part 2: Design of welded joints*,

— *Part 3: Qualification of welding operators and weld setters*,

— *Part 4: Specification and qualification of welding procedures*,

— *Part 5: Quality and inspection requirements*.

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Introduction

Electromagnetic pulse welding is an innovative solid-state welding technology that belongs to the group of pressure welding processes and is based on the use of electromagnetic forces to deform, accelerate and weld workpieces. No external heat source is used, the connection is only created by a high-velocity impact.

The increasing use of the electromagnetic pulse welding process has created the need for a standard, to ensure that the welding operations are carried out in the most effective manner and that appropriate controls are performed on all aspects of the implementation.

To be effective, welded products should be free from problems in production and in service. To achieve this goal, it is recommended to provide controls from the design phase through material selection, choice of parameters, the fabrication itself, and inspection. For example, poor design can create serious and costly difficulties in the workshop or in service. Incorrect process parameters and/or material selection can result in welding defects. Welding procedures should be correctly formulated and approved to avoid weld discontinuities. To ensure the manufacture of a quality product, management should understand the causes of potential problems and implement appropriate inspection procedures and subsequent quality measures. Supervision should be implemented to ensure that the specified quality is achieved.

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1 Scope

This document specifies a method to determine the capability of a manufacturer to use the electromagnetic pulse welding process for production of products of the specified quality. It specifies quality requirements but does not assign those requirements to any specific product or product group.

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.

EN 18007-1, *Electromagnetic pulse welding — Part 1: Welding knowledge, terminology and vocabulary*

EN 18007-3, *Electromagnetic pulse welding — Part 3: Qualification of welding operators and weld setters*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 18007-1 apply.

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

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

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

4 Quality requirements

4.1 General

These requirements relate only to those aspects of product quality that can be influenced by electromagnetic pulse welding.

4.2 Welding personnel

4.2.1 General

Manufacturers shall have at their disposal sufficient and competent personnel for the planning, performing and supervising of the electromagnetic pulse welding production operations in accordance with specified requirements.

4.2.2 Welding operators

Welding operators shall be qualified in accordance with the specifications detailed in EN 18007-3. Qualification records shall be kept up to date.

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4.3 Inspection and testing personnel

4.3.1 General

The manufacturer shall have sufficient and competent personnel for the planning, performing, and supervising of inspecting and testing operations during the production of electromagnetic pulse 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 EN ISO 9712 or EN ISO 20807. When the use of an examination method not presently incorporated in these EN ISO standards is specified, the manufacturer shall be responsible for developing the training program, written practice, examination, and practical demonstrations equivalent to the requirements of these EN ISO standard(s). 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 concerned application. Welding equipment shall be capable of producing welds that meet the acceptance levels specified in 4.8.4. 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 of the equipment shall be performed. Such tests shall verify that the equipment functions correctly.

4.4.3 Reproducibility and validation 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 4.8.4. Reproducibility tests shall be carried out when any of the following occurs:

— after installation of a new or refurbished welding equipment,

— a critical component of the equipment is damaged, repaired, or replaced; or after failing to operate properly,

— 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 3 test welds shall be made and documented.

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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 WPS's. The maintenance plan may be limited to those items that are essential for producing welds that meet the quality requirements of this document.

Examples of these items are as follows:

— condition of guides and mechanised fixtures,

— condition of meters and gages that are used for the operation of the welding equipment,

— condition of cables, hoses, and connectors,

— condition of the control systems in mechanised and/or automatic welding equipment,

— condition of thermocouples and other temperature measurement instruments,

— condition of clamps, jigs, insulations and fixtures.

Before welding, clamps, jigs, and fixtures that contact the workpieces shall be clean and sufficiently free of contaminants (for example, oil, grease, and dirt) that could have a detrimental effect on the weld. Defective equipment shall not be used.

4.4.5 Electromagnetic pulse welding tool

4.4.5.1 Identification

The tools (coil, field shaper and clamping parts) that are used in production shall be permanently marked with its drawing or part number.

4.4.5.2 Tool inspection

Before welding, the tool (coil, field shaper and clamping parts) shall be 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 quality welds. Because a tool wears with use, it shall be inspected for wear at appropriate intervals and in accordance with a written procedure.

The manufacturer shall determine the useful life-time of the electromagnetic pulse welding tool, i.e. maximum number of welds at a certain maximum current amplitude, which shall be recorded on the WPS.

4.5 Welding Procedure Specification (WPS)

The manufacturer shall ensure that the WPS is used correctly in production. See EN 18007-4.

4.6 Pre-weld joint preparation and fit-up

4.6.1 Joint preparation

The faying surface shall be prepared in accordance with the WPS.

4.6.2 Pre-weld cleaning

Pre-weld cleaning shall be carried out in accordance with the WPS. The base 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.

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4.7 Welding

All welding shall be performed in accordance with a qualified WPS.

4.8 Inspection and testing

4.8.1 General

The location and frequency of applicable inspections and tests will depend on the product standard and the type of construction. The testing standards referenced below are not specific to the electromagnetic pulse welding process. Deviations may be required when applied to electromagnetic pulse welding.

4.8.2 Inspection and testing before welding

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

— suitability and validity of the operator's qualification certificate,

— suitability of the WPS,

— parent and flyer material alloy and temper,

— joint preparation (for example, shape and dimensions),

— joint fit-up, jigging, and tacking,

— welding parameters set in accordance with the WPS.

4.8.3 Inspection and testing during welding

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

4.8.4 Inspection and testing after welding and acceptance criteria

4.8.4.1 General

The required tests and acceptance levels shall be established before production is initiated. Compliance with the relevant application standard or relevant requirements shall be verified.

Examples of conformance methods are the following and are detailed in EN 18007-4:2024, Annex A:

— visual testing,

— non-destructive testing,

— destructive testing,

— form, shape, and dimensions of the weldment,

— results and records of post-weld operations (for example, post-weld heat treatment, ageing).

Examples of common imperfections are detailed in Annex A.

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4.8.4.2 Non-destructive testing

Prior to testing, permissible and non-permissible characteristics and imperfections shall be specified in the test specifications.

Each testing method has its restrictions which are dependent on the welding process variant, materials and the component geometry. It is therefore sometimes necessary to determine a suitable test procedure to be used for a particular welded assembly.

See also EN 18007-4:2024, A.2.

4.8.4.3 Destructive testing

Destructive testing shall be applied to production welds or, where appropriate, to welded test specimens representative of the actual weldment.

Each specimen should be representative. Attention should be paid to any possible changes in the material characteristics. Methods of cutting which seriously affect the metallurgical structure of the specimen shall not be used.

See also EN 18007-4:2024, A.3.

4.8.5 Proof testing

Where practical considerations allow it and when specified in the test specification, an approved method of proof testing can be applied to an agreed percentage of production welds. Where such methods are employed, the applied loads should be greater than those expected in service. The component tested shall subsequently show no damage likely to cause failure in service.

4.8.6 Damaged and non-conforming welds

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

4.9 Identification and traceability

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

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