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Elektromagnetno utripno varjenje - 4. del: Popis in kvalifikacija varilnih postopkov

Electromagnetic pulse welding - Part 4: Specification and qualification of welding procedures

Schweißen und verwandte Verfahren - Elektromagnetisches Pulsschweißen - Teil 4: Spezifikation und Qualifizierung von Schweißverfahren

Soudage par impulsion électromagnétique - Partie 4 : Descriptif et qualification des modes opératoires de soudage

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Electromagnetic pulse welding - Part 4: Specification and qualification of welding procedures

Soudage par impulsion électromagnétique - Partie 4 :
Descriptif et qualification des modes opératoires de
soudage

Elektromagnetisches Pulsschweißen - Teil 4:
Spezifikation und Qualifizierung von Schweißverfahren

This European Standard was approved by CEN on 7 June 2024.

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EN 18007-4:2024 (E)**European foreword**

This document (EN 18007-4:2024) 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of an identical text or by endorsement, at the latest by January 2025, and conflicting national standards shall be withdrawn at the latest by January 2025.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.*

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

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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EN 18007-4:2024 (E)**1 Scope**

This document specifies the requirements for the specification and qualification of welding procedures for electromagnetic pulse welding.

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 18007-5:2024, *Electromagnetic pulse welding — Part 5: Quality and inspection requirements*

EN ISO 4063, *Welding, brazing, soldering and cutting — Nomenclature of processes and reference numbers (ISO 4063)*

EN ISO 14270:2016, *Resistance welding — Destructive testing of welds — Specimen dimensions and procedure for mechanized peel testing resistance spot, seam and embossed projection welds (ISO 14270:2016)*

EN ISO 14273:2016, *Resistance welding — Destructive testing of welds — Specimen dimensions and procedure for tensile shear testing resistance spot and embossed projection welds (ISO 14273:2016)*

EN ISO 15607:2019, *Specification and qualification of welding procedures for metallic materials — General rules (ISO 15607:2019)*

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

EN ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds (ISO 17639)*

3 Terms and definitions, symbols and abbreviated terms**3.1 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/>

3.2 Symbols and abbreviated terms

For the purposes of qualification of welding procedures, the abbreviations listed in EN ISO 15607:2019, Table 1 apply.

Table 1 — Symbols and abbreviated terms

Symbol	Term	Unit
b	width of the parallel length	mm
b_1	width of the shoulder	mm
L_c	parallel length	mm
L_0	original gauge length	mm
L_s	maximum width of the weld after machining	mm
L_t	total length of the test specimen	mm
r	radius of shoulder	mm
t_s	thickness of the test specimen	mm

4 Development and qualification of welding procedures

4.1 General

A Welding Procedure Specification (WPS) is of extreme importance to industry, since it is the document that describes how a weld should be carried out. It is a document that has been qualified by a specific method and provides the required variables of the welding procedure to ensure repeatability during production welding. The document should contain welding parameters, materials used, configuration of the joint, equipment characteristics and weld configuration. For more information, see EN ISO 15607.

Qualification of welding procedures shall be performed prior to production welding. The manufacturer shall prepare a preliminary welding procedure specification (pWPS) and shall ensure that it is applicable for production using experience from previous production jobs and the general knowledge of the welding technology.

A pWPS shall be used as the basis for the establishment of a welding procedure qualification record (WPQR). The pWPS shall be tested in accordance with one of the methods listed in Clause 5 or Clause 6. Five shall be used when the production part or joint geometry is accurately represented by a standardized test piece or pieces, as shown in 5.2. However, Clause 6 shall be used when the production part or joint geometry is not accurately represented by standardized test specimens.

The minimum information required in a pWPS is given in 4.2. For some applications, it may be necessary to supplement or reduce the list.

A WPS covers a certain range of base materials, joint configurations and thicknesses. Ranges and tolerances in accordance with the relevant standard and the manufacturer's experience shall be specified when appropriate.

Annex B shows an example of a pWPS form. Two different types of joints are possible; joints of overlapping sheets and joints of overlapping tubes. The first one presents a preliminary WPS for electromagnetic pulse welding of sheets regarding the parameters found. The second one is based on the first, but adapted to overlapping tubes.

EN 18007-4:2024 (E)**4.2 Technical content of a pWPS****4.2.1 General**

The following information, as a minimum, shall be included in a pWPS.

4.2.2 Manufacturer information

- identification of the manufacturer,
- identification of the pWPS.

4.2.3 Base material type(s), temper(s), and reference standard(s)

- designation of the material(s) and referenced standard(s).

4.2.4 Base material dimensions and geometry

Dimensions and geometry of the parts comprising the welded joint:

- general geometry of the parts to be welded,
- outer diameter and wall thickness of tubes,
- dimensions of the sheets (length, width, thicknesses),
- geometrical specifics like chamfers, if applicable.

4.2.5 Equipment identification

- type of machine used and appropriate identification (model, serial number, manufacturer),
- ...

4.2.6 Tool coil identification

- materials,
- drawing or drawing number,
- description.

4.2.7 Clamping arrangement

- method and type of clamps and fixtures (dimensions and material).

4.2.8 Joint design

- sketch of the joint design including dimensions (overlap distance, distance between flyer and stationary part, ...),
- joint configuration.

4.2.9 Joint preparation and cleaning methods

For example:

- degreasing,
- removal of edge burrs,
- grinding and polishing, if needed,
- ...

4.2.10 Welding details

- the welding process shall be designated as listed in EN ISO 4063,
- welding method; welding of sheets or tubular parts,
- process parameters:
 - charging voltage,
 - energy,
 - geometrical process parameters like position in the tool coil,
 - ...

5 Qualification based on a welding procedure test

5.1 General

This method specifies how a welding procedure can be qualified by welding and testing of standardized test specimens.

The welded assembly, to which the welding procedure will relate to in production, shall be represented by actual components or by preparing a standardized test piece in accordance with 5.2.

The welding operator who undertakes the welding procedure test satisfactorily in accordance with this document is qualified according to EN 18007-3.

Test specimens shall be cut from the actual components, subscale test component or welded separately according to 5.3.

5.2 Shape and dimensions of test specimens

5.2.1 General

The test pieces shall be designed to represent, as far as possible, the component and joint geometry.

The length or number of test specimens shall be sufficient to allow for all required tests to be performed. Test specimens longer than the minimum size may be used, to allow for additional specimens, for re-testing of specimens, or both (see 5.4.6). If relevant, the rolling direction or extrusion direction shall be marked on the test specimens.