



SLOVENSKI STANDARD

SIST EN 4678:2011

01-december-2011

Aeronavtika - Varjeni in trdo spajkani sestavi za konstrukcije v aeronavtiki - Spoji kovinskih materialov pri varjenju z laserskim snopom - Kakovost varjenih sestavov

Aerospace series - Weldments and brazements for aerospace structures - Joints of metallic materials by laser beam welding - Quality of weldments

Luft- und Raumfahrt - Schweiß- und Lötverbindungen für die Luft- und Raumfahrt - Lasers strahlschweißen - Qualität der Schweißverbindungen

Série aérospatiale - Assemblages soudés et brasés pour constructions aérospatiales - Assemblages de matériaux métalliques soudés par faisceaux laser - Qualité des assemblages soudés

Ta slovenski standard je istoveten z: EN 4678:2011

ICS:

49.025.05 Železove zlitine na splošno Ferrous alloys in general

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 4678

July 2011

ICS 49.025.05

English Version

Aerospace series - Weldments and brazements for aerospace structures - Joints of metallic materials by laser beam welding - Quality of weldments

Série aérospatiale - Assemblages soudés et brasés pour constructions aérospatiales - Assemblages de matériaux métalliques soudés par faisceaux laser - Qualité des assemblages soudés

Luft- und Raumfahrt - Schweiß- und Lötverbindungen für die Luft- und Raumfahrt - Laserstrahlschweißen - Qualität der Schweißverbindungen

This European Standard was approved by CEN on 9 July 2010.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 4678:2011) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

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of an identical text or by endorsement, at the latest by January 2012, and conflicting national standards shall be withdrawn at the latest by January 2012.

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

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

According to the CEN/CENELEC Internal Regulations, the national standards organizations 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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

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EN 4678:2011 (E)

1 Scope

This European Standard defines the rules to be observed to ensure the quality of aerospace structures in metallic materials by (solid reference number **521** and gas reference number **522** and diode laser Semiconductor **523** according to EN ISO 4063) laser beam welding, implemented automatically, semi-automatically or manually.

It is applicable without any restriction for the manufacturing of new parts or repair parts, these operations being under the responsibility of an approved design authority or repairer.

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 reference document (including any amendments) applies.

EN 1011-6, *Welding — Recommendation for welding of metallic materials — Part 6: Laser beam weld*

EN 1435, *Non-destructive examination of welds — Radiographic examination of welded joints*

EN 4179, *Aerospace series — Qualification and approval of personnel for non-destructive testing*

EN 4632-001, *Aerospace series — Welded and brazed assemblies for aerospace constructions — Weldability and brazeability of materials — Part 001: General requirements*

EN 4632-002, *Aerospace series — Welded and brazed assemblies for aerospace constructions — Weldability and brazeability of materials — Part 002: Homogeneous assemblies aluminium and aluminium alloys*

EN 4632-003, *Aerospace series — Weldability and brazeability of materials in aerospace constructions — Part 003: Welding and brazing of homogeneous assemblies of unalloyed and low alloy steels¹⁾*

EN 4632-004, *Aerospace series — Welded and brazed assemblies for aerospace constructions - Weldability and brazeability of materials — Part 004: Homogeneous assemblies highly alloyed steels* Error! Bookmark not defined.)

EN 4632-005, *Aerospace series — Weldability and brazeability of materials in aerospace constructions — Part 005: Homogeneous assemblies of heat resisting Ni or Co base alloys* Error! Bookmark not defined.)

EN 4632-006, *Aerospace series — Weldability and brazeability of materials in aerospace constructions — Part 006: Homogeneous assemblies of titanium alloys* Error! Bookmark not defined.)

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

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063:2009, Corrected version 2010-03-01)*

EN ISO 4136, *Destructive tests on welds in metallic materials - Transverse tensile test (ISO 4136:2001)*

ISO 4969, *Steel — Macroscopic examination by etching with strong mineral acids*

EN ISO 5173, *Destructive tests on welds in metallic materials - Bend tests (ISO 5173:2009)*

1) Published as ASD-STAN Prestandard at the date of publication of this standard by Aerospace and Defense Industries Association of Europe-Standardization (ASD-STAN), (www.asd-stan.org).

EN ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:2007)*

EN ISO 6947, *Welding and allied processes - Welding positions (ISO 6947:2011)*

EN ISO 9015-2, *Destructive tests on welds in metallic materials - Hardness testing - Part 2: Microhardness testing of welded joints (ISO 9015-2:2003)*

EN ISO 9016, *Destructive tests on welds in metallic materials - Impact tests - Test specimen location, notch orientation and examination (ISO 9016:2001)*

EN ISO 11145, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols (ISO 11145:2006)*

EN ISO 14731, *Welding coordination — Tasks and responsibilities (ISO 14731:2006)*

EN ISO 15609-4, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 4: Laser beam welding (ISO 15609-4:2009)*

EN ISO 15616-1, *Acceptance tests for CO₂-laser beam machines for high quality welding and cutting — Part 1: General principles, acceptance conditions (ISO 15616-1:2003)*

EN ISO 15616-2, *Acceptance tests for CO₂-laser beam machines for high quality welding and cutting — Part 2: Measurement of static and dynamic accuracy (ISO 15616-2:2003)*

EN ISO 15616-3, *Acceptance tests for CO₂-laser beam machines for high quality welding and cutting — Part 3: Calibration of instruments for measurement of gas flow and pressure (ISO 15616-3:2003)*

ISO 17636, *Non-destructive testing of welds — Radiographic testing of fusion-welded joints*

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

EN ISO 17640:2, *Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment (ISO 17640:2010)*

ISO 22826, *Destructive tests on welds in metallic materials — Hardness testing of narrow joints welded by laser and electron beam (Vickers and Knoop hardness tests)*

EN ISO 22827-1, *Acceptance tests for Nd:YAG laser beam welding machines — Machines with optical fibre delivery — Part 1: Laser assembly (ISO 22827-1:2005)*

EN ISO 22827-2, *Acceptance tests for Nd:YAG laser beam welding machines — Machines with optical fibre delivery — Part 2: Moving mechanism (ISO 22827-2:2005)*

ISO 24394, *Welding for aerospace applications — Qualification test for welders and welding operators — Fusion welding of metallic components*

ISO/TR 25901, *Welding and related processes — Vocabulary*

NAS 410, *Certification and qualification of non-destructive test personnel*²⁾

2) Published by: National Standards Association, Inc., 1200 Quince Orchard Blvd, Gaithersburg, MD 20878, United States.

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3 Terms and definitions

For the purposes of this document, the following terms and definitions given in ISO 857-1 and EN ISO 11145 standards apply.

3.1 General

3.1.1 Laser beam welding

Fusion welding process (using radiation) in which the heat required for the fusion is provided by the coherent and monochromatic light emitted by a laser focused by an optical system either:

- solid (FLS or 521 according to EN ISO 4063);
- Example: YAG: (Yttrium Aluminium Garnet) doped with neodymium. The wavelength λ of corresponding radiation is 1,06 μm ; or
- gas (FLG or 522 according to EN ISO 4063);
- Example: CO₂ wavelength λ of corresponding radiation is 10,6 μm ;
- Diode laser welding (Semi-conductor laser welding or 523 according to EN ISO 4063).

The word laser is the acronym for "Light Amplification by Stimulated Emission of Radiation".

3.2 Technical terms

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3.2.1 Welding parameters

3.2.1.1 Run-on or run-off plates

See ISO/TR 25901.

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NOTE This interval is measured on the detail parts, positioned in their welding setup, and is used as a reference to determine the minimum width of the weld zone.

3.2.1.2 Beam shift

Deviation of beam position compared with the effective position of joint plane in certain heterogeneous welds (materials and/or dissimilar thicknesses).

3.2.1.3 Firing distance

Distance between the impact point of the beam on detail parts and a reference surface linked to the machine

EXAMPLE End of nozzle.

3.2.1.4 Specific welding energy

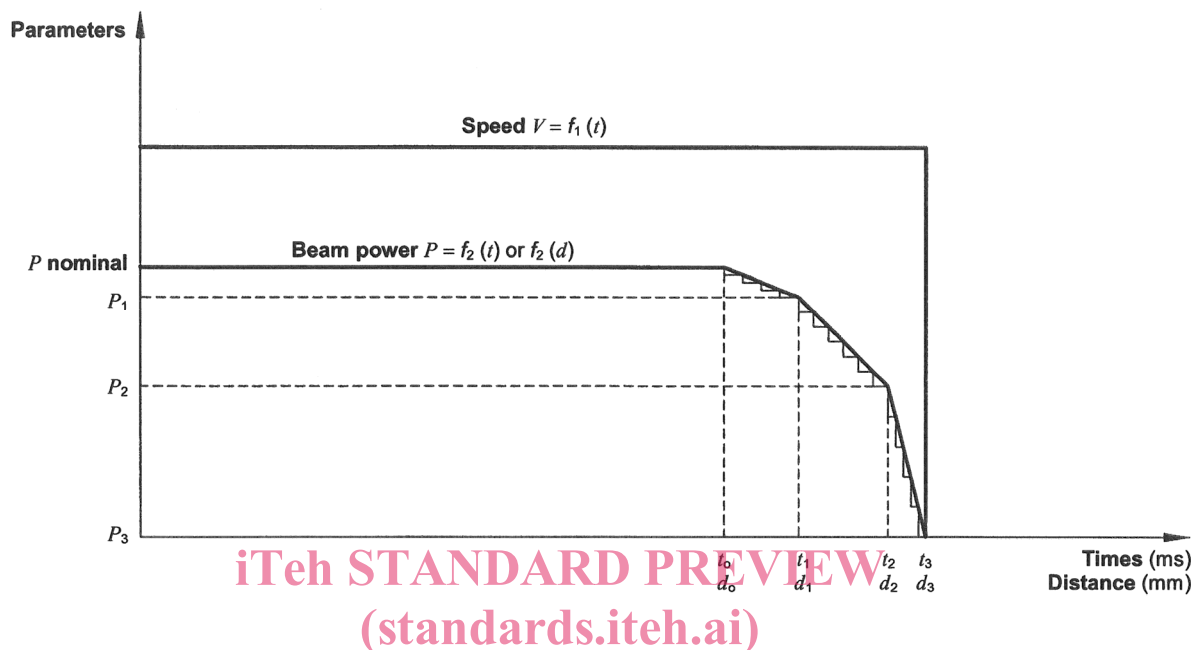
Ratio between the beam power over the welding speed, multiplied by 60. P_{average} (W) is measured at nozzle exit side.

$$E_{\text{average}} = \frac{P_{\text{average}} (W) \times 60}{1000 \times V (\text{cm/min})} \text{ (kJ/cm)}$$

3.2.1.5 Slope (or ramp) down

Operating conditions for which the depth of penetration differs in a decreasing manner according to a slope, a series of ramps or steps.

NOTE Slope down occurs either according to time or distance, see Figure 1.



SIST EN **Figure 1**

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3.2.1.6 Slope (or ramp) up

Controlled increase of the beam power at the beginning of the welding

3.2.1.7 Clearance before welding

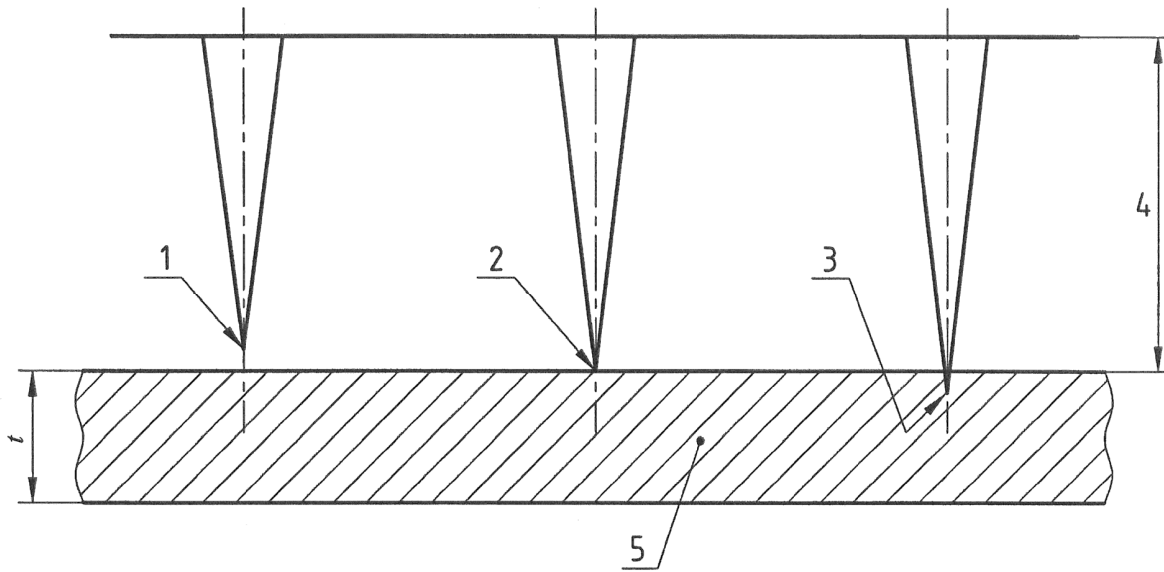
Distance measured on a straight section of the joint between the sides to weld.

NOTE The clearance depends on the design of the welded joint (for circular axial welds or circular welds see EN 1011-6).

3.2.1.8 Focusing level

Distance between the beam impact point on the detail parts and the focusing point.

NOTE Conventionally, this distance is negative when the focusing point is within the detail parts, see Figure 2.

**Key**

- 1 Positive focusing level (+ 1 mm)
- 2 Focusing level 0
- 3 Negative focusing level (- 1 mm)
- 4 Firing distance
- 5 Detail part

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Figure 2

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3.2.1.9 Beam power

The laser beam power is measured with a calorimeter which absorbs all or part of the beam

3.2.1.10 Welding speed

Length of the weld on beam impact side produced per time unit.

3.2.2 Other technical terms**3.2.2.1 Welding campaign**

Series of welding operations on identical parts, executed on the same machine, without any changes to adjustments, without performing other welds on the machine, without interrupting manufacturing for more than a week (working days).

3.2.2.2 Tacking pass

Pre-assembling of elementary detail parts using the same process as the one used for welding, consisting of making slightly penetrating, narrow weld, continuous or discontinuous along the joint plane. The purpose is to maintain detail parts in position.

3.2.2.3 Adjustment verification specimen

A flat or round test specimen of the same material, subjected to the same heat treatments as the detail parts, on which a melt run will be made in the middle using the parameters identical to those used for parts, and for which the relation between the micrographic shape of the cross section cut of the bead and that obtained on test specimens or real parts has been previously defined.

3.2.2.4 Structural state

State of the crystalline metal structure

3.2.2.5 Manufacturing

Execution of welding operations on new parts or parts being repaired

3.2.2.6 Stabilized manufacturing

Manufacturing for which the reliability can be established without doubt over several welding campaigns, of which the number is previously defined by the design authority.

3.2.2.7 Smoothing pass or cosmetic pass

Surface new fusion of the welded zone

3.2.2.8 Batch of parts

Set of parts with the same reference from:

- the same welding campaign;
- the same heat treatment batch;
- traceable material (processing, chemical analysis, etc).

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3.2.2.9 Parent material

Material or metal used to make the detail parts.

3.2.2.10 Filler material

Additional alloy or metal used to make a weld of an assembly or a deposit.

3.2.2.11 Tooling

Equipment required to hold and position parts before and during welding.

3.2.2.12 Detail part

Individual element to be assembled with other elements to make up a complete part.

3.2.2.13 Part

Assembly comprising several assembled detail parts.

3.2.2.14 Tack welding

Pre-assembly of detail parts by welding consisting of a set of tacks (by laser or an alternative process, for example TIG) along the joint plane, intended to hold the detail parts in position.

EN 4678:2011 (E)**3.2.2.15 Pre-heating**

Heating of detail parts before welding without fusion.

NOTE This operation may be carried out with an defocused beam or any other process.

3.2.2.16 Blind weld

Case where the beam only crosses part of the thickness of the parts to be welded.

3.2.2.17 Qualification test specimen – Manufacturing test specimen

- Test specimen representing manufactured parts to be welded under the same conditions as these parts;
- Test specimen made from the same material grade, in the same structural state, with the same dimensions as the manufactured part.

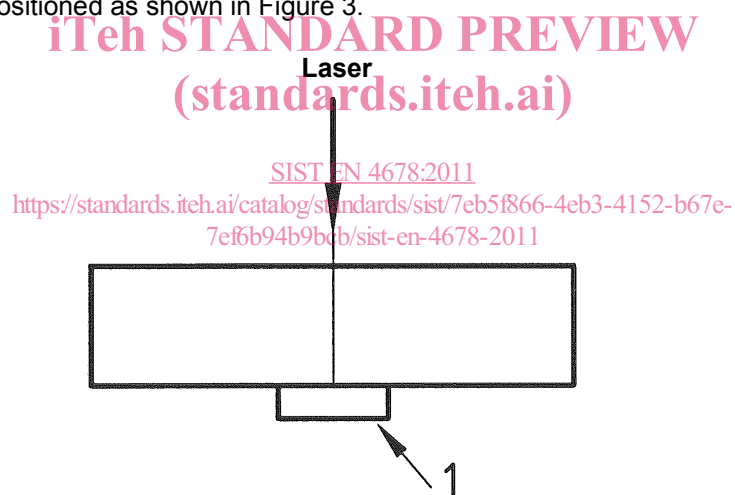
NOTE Manufacturing test specimens may be real parts.

3.2.2.18 Pool support

Element positioned on detail parts to prevent the fused metal from overflowing.

NOTE The material making up the pool support shall be of the same base alloy as the detail parts, to prevent any weld contamination.

The pool support may be positioned as shown in Figure 3.

**Key**

1 Pool support

Figure 3

3.2.2.19 Heat treatment

Treatment intended to provide the base material and the welded zone with the required characteristics and structural state

3.3 General terms**3.3.1 Customer**

Individual or company placing a contract or order and who may or may not be the design authority.