

Specification and qualification of welding procedures for metallic materials — Welding procedure specification —

Part 4: Laser beam welding

The European Standard EN ISO 15609-4:2004 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN ISO 15609-4:2004. It is identical with ISO 15609-4:2004. It supersedes BS EN ISO 9956-11:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/36, Approval of welding procedures and welders, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe - Schweißanweisung - Teil 4: Laserstrahlschweißen (ISO 15609-4:2004)

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Foreword

This document (EN ISO 15609-4:2004) has been prepared by Technical Committee CEN /TC 121, "Welding", the secretariat of which is held by DS, in collaboration with ISO/TC 44 "Welding and allied processes".

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of an identical text or by endorsement, at the latest by February 2005, and conflicting national standards shall be withdrawn at the latest by February 2005.

This document supersedes EN ISO 9956-11:1996.

Annex A is informative. Normative references to International Standards are listed in annex ZA.

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

1 Scope

This standard specifies requirements for the content of welding procedure specifications for laser beam welding processes.

This standard is part of a series of standards, details of this series are given in EN ISO 15607:2003, annex A.

Variables listed in this standard are those influencing the quality and properties of the welded joint.

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.

EN 439, *Welding consumables — Shielding gases for arc welding and cutting*.

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063:1998)*.

EN ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation (ISO 6947:1993)*.

EN ISO 11145:2001, *Optics and optical instruments — Lasers and laser-related equipment — Vocabulary and symbols (ISO 11145:2001)*.

EN ISO 15607:2003, *Specification and qualification of welding procedures for metallic materials — General rules (ISO 15607:2003)*.

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN ISO 15607:2003 and in EN ISO 11145:2001 and the following apply.

3.1

slope up

controlled increase of the beam power at the beginning of welding

3.2**slope down**

controlled decrease of the beam power at the end of welding. The slope down region is the region on the workpiece in which the effects of slope down occur. It can consist of one or two areas, depending on the selected welding mode:

- a) in full penetration welding:
 - a region where beam penetration is still complete;
 - a region where penetration is partial or decreasing.
- b) in partial penetration welding :
 - a region where penetration decreases continuously

3.3**working distance**

distance between the surface of the workpiece and a standard reference point of the equipment which is traceable to the true focusing lens or mirror centre

NOTE This is a practical reference distance only.

3.4**tacking pass**

pass made to hold the parts to be welded in proper alignment until the final welds are made

NOTE This may be produced by a continuous or discontinuous pass with partial penetration.

3.5**welding pass**

pass ensuring fusion to the required depth

3.6**cosmetic pass**

pass for superficial remelting of the weld in order to enhance its appearance

NOTE This pass is made with a defocused or oscillating beam.

3.7**overlap**

portion of the welding pass remelted prior to the slope down

3.8**back or front support**

plate placed against the workpiece on either the back or front face of the joint in order to retain the molten weld metal

3.9**focal length**

in a lens or lens system, the distance from the principal plane, the surface at which the projection of entering and exiting rays intersect, to the focal spot

NOTE In a thick lens or system of lenses, the principal plane is often inside the lens. For set-up purposes, operators often use the 'back focal length', which is the distance from the front surface of a focusing lens or mirror system to the focal spot.

3.10**focal spot**

part of the beam beyond the focusing system where the beam comes to a minimum cross-sectional area

4 Technical content of welding procedure specification (WPS)

4.1 General

The welding procedure specification (WPS) shall provide all information required to make a weld.

Welding procedure specifications may cover a certain range of thicknesses of the joined parts and may also cover a range of parent metals and even filler metals. Some manufacturers may additionally prefer to prepare work instructions for each specific job as part of the detailed production planning.

Information listed below is adequate for most welding operations. For some applications it may be necessary to supplement or reduce the list. The relevant information shall be specified in the WPS.

Ranges and tolerances, according to the manufacturer's experience, shall be specified when appropriate.

An example of a typical WPS-format is shown in annex A.

4.2 Welding process

The welding process is 52 in accordance with EN ISO 4063.

4.3 Related to the manufacturer

- Identification of the manufacturer;
- Identification of the WPS;
- Reference to the welding procedure qualification record (WPQR) or other documents, as required.

4.4 Equipment used

4.4.1 General

Identification of any equipment.

4.4.2 Laser welding equipment

- Type (for example YAG or CO₂), model, make;
- nominal power;
- continuous wave or pulsed;
- number of lasers combined;
- manufacturer's or measured values for the following parameters:
 - 1) beam mode;
 - 2) beam divergence ;
 - 3) wave length ;
 - 4) beam polarisation and orientation.

4.4.3 Beam delivery and focusing system

- method of transmission (fibres, mirrors, including beam collimators, if used);
- distance from beam source to focusing system, if necessary;
- beam diameter on entrance to focusing system;
- beam transmission and focusing system;
- focal length;
- if required, nominal focal spot size and method of measuring;
- beam path protection system.

4.4.4 Plasma suppression gas and shielding gas system

Description (schematic) showing design, position of nozzle(s) in relation to joint, welding direction and welding point.

4.4.5 Filler material(s) feeding system (if any)

Description (schematic) showing design, position of the filler material(s) feeding system in relation to joint, welding direction and welding point.

4.5 Related to the parent materials**4.5.1 Parent material type/grade**

- Designation of the material(s) and any backing plates or supports used and any reference standard(s);
- identification of the type of product (e.g. forged, cast, rolled, extruded).

A WPS may cover a group of materials.

4.5.2 Dimensions of materials

- Thickness range of the joint;
- for circular workpieces the range of outside diameters.

4.6 Filler or other additional material(s)

- the designation and reference standard for any filler material(s) or other additional material(s) used in the joint;
- the dimensions of any filler material(s) or other additional material(s) used in the joint;
- any special handling instructions for any filler material(s) or other additional material(s) used in the joint.

If a filler or other additional material is to be cleaned before used, this shall be specified.

4.7 Joint design

A sketch showing the joint design/configuration, dimensions and tolerances, including surface finish, or reference to another standard which provides this information.

4.8 Joint preparation

- Joint preparation method, cleaning, degreasing, etc.;
- protection of joint preparation (if necessary);
- any necessary protection/shielding of the prepared joint.

4.9 Jigs, fixtures and tooling

The methods to be used for workpiece fixturing (including manual tack welding and arrangements for containment of the backing gas, if used).

4.10 Welding position

Applicable welding positions in accordance with EN ISO 6947.

4.11 Backing

4.11.1 Back support

Type(s) and dimensions (if any).

4.11.2 Backing gas

- Classification and type in accordance with the relevant standard, e.g. EN 439.
- gas flow rate.

4.12 Welding technique

The welding technique sketch showing details of all welding passes (tacking pass, welding pass, cosmetic pass).

4.13 Welding parameters

4.13.1 Beam parameters

- Laser beam power at the workpiece;
- F-number (nominal focal length/beam diameter) for CO₂ lasers;
- pulse parameters if pulsing used including :
 - 1) peak power;
 - 2) pulse energy;
 - 3) repetition rate;
 - 4) pulse duration;
 - 5) pulse shape;
- power ramping details (including slope down or slope up procedure, if used);
- tacking pass details;
- oscillation pattern, amplitude, frequency and dwell time (if applied);

— laser beam orientation, polarization and position in relation to joint and welding direction:

- 1) angles (in two directions);
- 2) position in transverse direction (if relevant).

4.13.2 Mechanical parameters

- Travel speed;
- travel speed ramping details, if necessary;
- wire/filler feed rate direction, position to be defined and angle (if any).

4.13.3 Plasma suppression gas, shielding and backing gas parameters

- Classification and type in accordance with EN 439;
- gas flow rate ;
- check of gas purity;
- purge procedure.

4.13.4 Other parameters

- Working distance in millimetres (mm);
- location and orientation of shielding gas nozzle with respect to the work piece.

4.14 Pre and post weld heating

If preheating and/or post heating and/or post weld heat treatment are required, the temperature and time at temperature shall be included on the WPS complete with any other instructions related to the heat treatment. If the laser beam is to be used for pre or post heating, the relevant parameters shall be recorded on the WPS.

4.15 Operations after welding

Any mechanical and/or chemical and/or heat treatment.

Annex A (informative)

Example of a Welding Procedure Specification for laser beam welding (process 52)

WPS identification:

Manufacturer:

WPQR N°:

Equipment identification:

- laser welding machine:
- beam polarisation:
- beam delivery system:
- beam focusing system:
- plasma suppression gas system:
- plasma shielding gas system:
- filler material(s) feeding system:

Parent material specification: 1:
2:

— material thickness (mm): 1: — outside diameter (mm):
2:

Filler or other additional material : — designation : — dimensions : — handling :

Joint type : — sheet or plate ☐ — cylindrical ☐ — axial ☐
— radial ☐
— other ☐

Joint design	Welding technique

Jigs, fixtures and tooling : Yes ☐ No ☐

- ☐ Mechanically fixed :
- ☐ Tack weld; process :

Back support : Yes ☐ No ☐

Backing gas:

Preparation :			
Procedure			
	Tacking pass	Welding pass	Cosmetic pass
Welding position			
Welding technique			
Beam power at workpiece — continuous (W): — F-number (for CO ₂ lasers): - peak power (W): - pulse energy (J): - repetition rate: - pulse duration (ms): - shape :			
Power ramping details: — slope up (mm or deg) — overlap (mm or deg) — slope down (mm or deg) — slope profile			
Oscillation — pattern — amplitude — frequency — dwell time			
Beam orientation angle : — longitudinal : — transverse : — (position)			
Travel speed (mm/min)			
Travel speed ramping			
Wire/filler feed rate			
Working gas — classification and type: — flow rate (l/min)			
Shielding gas — classification and type: — flow rate: — purge procedure:			
Working distance (mm)			
Shielding gas nozzle — location (mm): — orientation:			
— Preheating ^a — Postheating ^a			
Operations after welding ^a			
^a If required.			

.....
 Manufacturer
 (name, signature, date)

Annex ZA
(normative)

Normative references to international publications with their relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE Where an International Publication has been modified by common modifications, indicated by (mod.), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN</u>	<u>Year</u>
ISO 14175	1997	Welding consumables — Shielding gases for arc welding and cutting	EN 439	1994

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