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

Part 6: Laser-arc hybrid welding

Descriptif et qualification d'un mode opératoire de soudage pour les matériaux métalliques — Descriptif d'un mode opératoire de soudage —

Partie 6: Soudage hybride laser-arc

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 15609-6 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

ISO 15609 consists of the following parts, under the general title *Specification and qualification of welding procedures for metallic materials — Welding procedure specification*:

— *Part 1: Arc welding*

— *Part 2: Gas welding*

— *Part 3: Electron beam welding*

— *Part 4: Laser beam welding and cladding*

— *Part 5: Resistance welding*

— *Part 6: Laser-arc hybrid welding*

Requests for official interpretations of any aspect of this part of ISO 15609 should be directed to the Secretariat of ISO/TC 44/SC 10 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

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

Part 6: Laser-arc hybrid welding

1 Scope

This part of ISO 15609 specifies requirements for the content of welding procedure specifications for laser-arc hybrid welding processes.

Variables listed in this part of ISO 15609 are those influencing the quality and the properties of the welded joint.

NOTE Details of ISO 15609 (all parts) are given in ISO 15607:2003, Annex A.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4063:2009, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 6947, *Welding and allied processes — Welding positions*

ISO 11145, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

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

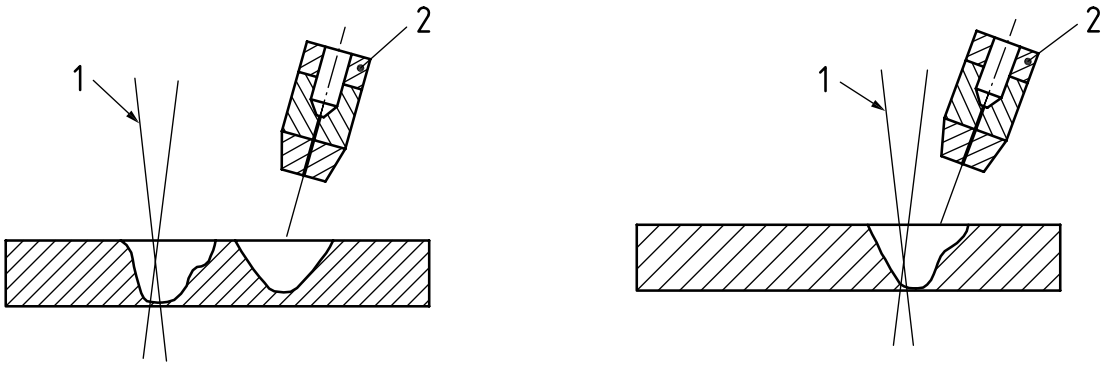
ISO/TR 25901:2007, *Welding and related processes — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145, ISO 15607 and ISO/TR 25901 and the following apply.

3.1
hybrid welding
two or more fusion welding processes which interact in a single melt pool

Note 1 to entry: Hybrid welding is different than combinations of processes where at least two melt pools exist which are completely separated by a solid component in the solidification phases. Examples of a) a combined process and b)a laser-arc hybrid welding process are given in Figure 1 by the use of a laser beam and the additional energy source of an arc.



a) Combined process **b) Hybrid process**

Key
1 laser beam
2 torch

Figure 1 — Combination of welding processes

3.2
slope up
controlled increase of the laser beam power and/or the arc power at the beginning of welding

[ISO/TR 25901:2007; 2.337, modified]

3.3
slope down
controlled decrease of the laser beam power and/or the arc power at the end of welding

[ISO/TR 25901:2007; 2.336, modified]

3.4
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

[ISO/TR 25901:2007, 2.472]

Note 1 to entry: This is a practical reference distance only.

3.5
geometrical parameters
all dimensions and tolerances for description of the relative positions of laser beam, arc and joint

3.6
tacking run
run made to hold the parts to be welded in proper alignment until the final welds are made

[ISO/TR 25901:2007, 2.370]

Note 1 to entry: This may be produced by a continuous or discontinuous run with partial penetration.

3.7
overlap
portion of the welding run re-melted prior to the slope down

[ISO/TR 25901:2007, 2.249]

4 Technical contents of welding procedure specification (WPS)

4.1 General

The welding procedure specification (WPS) shall give details of how a welding operation is to be performed and shall contain all relevant information about the welding work.

Welding procedure specifications may cover a certain range of thickness 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.

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

4.2 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.

4.3 Related to the parent materials

4.3.1 Material

Identification of the parent materials (and permanent backing, if any), preferably by reference to an appropriate standard, and for information, type of product (rolled, forged, cast, etc.) shall be provided.

A WPS may cover more than one material.

4.3.2 Material dimensions

The following dimensions shall be provided:

— the thickness range of the joint;

— the range of outer diameters of the workpiece.

4.4 Welding process

The applied processes shall be described using the designations for each process separated by a plus symbol "+" in accordance with ISO 4063.

EXAMPLE For solid state laser welding combined with MIG welding with solid wire electrode:

521+131

4.5 Joint design

A sketch showing the joint design/configuration, dimensions and tolerances shall be provided, including surface finish or reference to another International Standard or relevant national standard with this information.

4.6 Welding position

The welding positions shall be designated as specified in ISO 6947.

4.7 Joint preparation

The following regarding joint preparation shall be provided:

— joint preparation method, cleaning, degreasing;

— protection of joint preparation (if necessary).

4.8 Welding technique

The welding technique sketch shall show details of all runs (tacking run, welding run, cosmetic run). The following information shall be included:

— with or without oscillation;

oscillation (value of oscillation or amplitude, frequency and dwell during oscillation of laser and/or wire electrode).

4.9 Fixtures, jigs and tooling

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

4.10 Backing

The following information shall be included as appropriate:

— type(s) and procedure of backing (material backing, gas backing, flux backing, etc.);

dimensions;

— material of backing;

— designation of shielding gas and, if necessary, supplier and trademark;

— gas flow rate, if required;

classification, type of flux material and, if necessary, supplier and trademark;

— need for drying or any treatment of flux, preferably with reference to relevant International Standards.

4.11 Filler material

The following shall be specified:

— classification, if necessary supplier and trademark;

— diameter of wire electrode or width and thickness of strip electrode (flatted wire);

— need for drying or any treatment of filler material, preferably with reference to relevant International Standards.

4.12 Equipment used

4.12.1 Laser beam welding equipment

The following information shall be provided:

— type (for example Nd:YAG or CO_2), model, manufacturer;

— nominal power;

— continuous wave or pulsed;

— number of lasers combined;

— nominal values for the following parameters shall be specified:

  — beam quality

  — wavelength;

  — beam polarization.

4.12.2 Beam delivery and focusing system

The following information shall be provided:

— method of transmission (fibres, mirrors, including beam collimators, if used);

— distance from beam source to focusing system, if necessary;

— beam diameter on entrance of focusing system;

— beam transmission and focusing system (e.g. fibre diameter, collimating length, focal length);

— nominal focal point size.

4.12.3 Arc welding equipment

The following information shall be provided:

— Type, model, manufacturer.

4.12.4 Handling system

The following information shall be provided:

— Type, model, manufacturer;

— type, model, manufacturer of seam tracking system, if used.

4.13 Welding parameters

4.13.1 Laser beam process parameters

The following information shall be provided:

— laser beam power at the workpiece, including specification of the measuring procedure;

— pulse parameters including (if used):

  — peak power;

  - repetition rate;
  - pulse length;
  - pulse shape;
- working/shielding gas (flow rate, designation, purity), if used;
- power ramping details (including slope down or slope up procedure, if used);
- oscillation pattern, amplitude, frequency and dwell time (if applied).

4.13.2 Arc process parameters

The following information shall be provided:

- transfer mode (as specified in ISO 4063:2009, 2.2.2) and polarity, type of current (AC/DC);
- power ramping details (including slope down or slope up procedure, if used);
- pulse parameters and, if necessary, synergetic settings of the power source, depending on the welding process;
- wire feed speed;
- range of current;
- range of voltage;
- shielding gas (flow, designation, purity and nozzle diameter).

4.13.3 Mechanical parameters

The following information shall be provided:

- welding speed;
- welding speed ramping details, if used.

4.13.4 Geometric parameters

Geometric parameters shall be documented by a sketch or photograph indicating the following, if applicable:

- laser beam:
  - focal position;
  - beam position (transversal offset of the laser beam axis on workpiece surface related to the weld centre line);
  - laser beam orientation in relation to joint and welding direction (angles in two planes);
- arc/electrode:
  - stick out (consumable electrodes) or arc length (non-consumable electrodes);

    electrode position (transversal offset of electrode axis on workpiece surface related to the weld centre line);

    arc orientation in relation to joint and welding direction (angles in two planes);
- hybrid:
  - welding direction (leading/trailing arc);

— distance between laser beam and electrode axis on workpiece surface related to weld centre line;

— angle between laser beam and electrode axes.

4.14 Thermal conditions

4.14.1 General

If preheating and/or post-weld heat treatment (PWHT) are required, the respective conditions shall be defined on WPS. If the laser beam is used for preheating or PWHT, the relevant conditions shall be recorded in Annex A.

4.14.2 Preheating temperature

— Set-point temperature at the beginning of the welding process;

— if no preheating necessary, lowest temperature of workpiece before welding.

4.14.3 Interpass temperature

The maximum interpass temperature shall be specified.

4.14.4 Post-weld heat treatment

Any PWHT shall be specified according to relevant standards or regulations.

4.15 Operations between runs and after welding

Any mechanical and/or chemical treatment shall be defined in the WPS.