
**Welding — Laser-arc hybrid welding
of steels, nickel and nickel alloys —
Quality levels for imperfections**

*Soudage — Soudage hybride laser-arc des aciers, du nickel et des
alliages de nickel — Niveaux de qualité par rapport aux défauts*

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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 12932 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

Requests for official interpretation of any aspect of this International Standard 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.

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Introduction

This International Standard is intended to be used as a reference in drafting application codes and/or other application standards. It contains a simplified selection of laser-arc hybrid welding imperfections based on the designations given in ISO 6520-1.

Some imperfections described in ISO 6520-1 have been used directly and some have been grouped together. The basic numerical referencing system from ISO 6520-1 has been used.

The purpose of this International Standard is to define the dimensions of typical imperfections which can be expected in normal fabrication. It can be used within a quality system for the production of welded joints. It provides three sets of dimensional values from which a selection can be made for a particular application. The quality level necessary in each case is defined by the application standard or the responsible designer in conjunction with the manufacturer, user and/or other parties concerned. The quality level is expected to be prescribed prior to the start of production, preferably at the enquiry or order stage. For special purposes, additional details can be prescribed.

The quality levels given in this International Standard provide basic reference data and are not specifically related to any particular application. They refer to the types of welded joint in fabrication and not to the complete product or component itself. It is possible, therefore, that different quality levels are applied to individual welded joints in the same product or component.

It would normally be expected that for a particular welded joint the dimensional limits for imperfections can all be covered by specifying one quality level. In some cases, it can be necessary to specify different quality levels for different imperfections in the same welded joint.

The choice of quality level for any application is expected to take account of design considerations, subsequent processing (e.g. surfacing), mode of stressing (e.g. static, dynamic), service conditions (e.g. temperature, environment) and consequences of failure. Economic factors are also important and are intended to include not only the cost of welding, but also of inspection, test and repair.

Although this International Standard includes types of imperfection relevant to the laser-arc hybrid welding processes given in [Clause 1](#), only those which are applicable to the process and application in question need to be considered.

Imperfections are quoted in terms of their actual dimensions, and their detection and evaluation may require the use of one or more methods of non-destructive testing. The detection and sizing of imperfections are dependent on the inspection methods and the extent of testing specified in the application standard or contract.

This International Standard does not address the methods used for the detection of imperfections. However, ISO 17635 contains a correlation between the quality level and acceptance level for different NDT methods.

This International Standard is directly applicable to visual examination of welds and does not include details of recommended methods of detection or sizing by other non-destructive means. There are difficulties in using these limits to establish appropriate criteria applicable to non-destructive testing methods, such as ultrasonic, radiographic and penetrant testing, and they can need to be supplemented by requirements for inspection, examination and testing.

The values given for imperfections are for welds produced using normal welding practice. More stringent requirements as stated in quality level B can include additional manufacturing processes, e.g. grinding, TIG dressing.

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Welding — Laser-arc hybrid welding of steels, nickel and nickel alloys — Quality levels for imperfections

1 Scope

This International Standard specifies quality levels of imperfections in laser-arc hybrid welded joints for all types of steel, nickel and its alloys. It applies to material thickness $\geq 0,5$ mm.

Three quality levels are given in order to permit application for a wide range of welded fabrication. They are designated by B, C and D. Quality level B corresponds to the highest requirement on the finished weld. The quality levels refer to production quality and not to the fitness-for-purpose (see 3.3) of the product manufactured.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable to 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 2553, *Welding and allied processes — Symbolic representation on drawings — Welded, brazed and soldered joints*

ISO 5817:2003, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

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

3 Terms and definitions

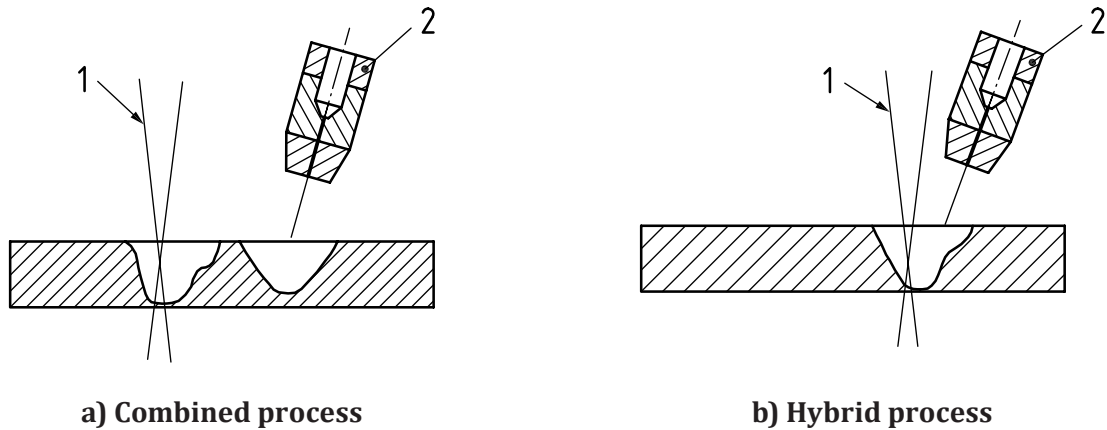
For the purposes of this document, the following terms and definitions apply.

3.1

hybrid welding

welding in which two or more welding processes are used simultaneously in the same weld pool

Note 1 to entry: Hybrid welding differs from 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 combined process (a) and a laser-arc hybrid welding process (b) are given in [Figure 1](#) by using a laser beam and the additional energy source of an arc.



Key
 1 laser beam
 2 torch

Figure 1 — Combination of welding processes

3.2 quality level
 description of the quality of a weld on the basis of type, size and amount of selected imperfections
 [SOURCE: ISO 5817:2003, 3.1]

3.3 fitness-for-purpose
 ability of a product, process or service to serve a defined purpose under specific conditions
 [SOURCE: ISO 5817:2003, 3.2]

3.4 short imperfection
 <cases when the weld is 100 mm long or longer> imperfection for which, in the 100 mm which contains the greatest number of imperfections, the total length of the imperfections is not greater than 25 mm
 [SOURCE: ISO 5817:2003, 3.3, modified.]

3.5 short imperfection
 <cases when the weld is less than 100 mm long> imperfection in which the total length of the imperfections is not greater than 25 % of the length of the weld
 [SOURCE: ISO 5817:2003, 3.3, modified.]

3.6 systematic imperfection
 imperfection that is repeatedly distributed in the weld over the weld length to be examined, the size of the single imperfection being within the specified limits
 [SOURCE: ISO 5817:2003, 3.4, modified.]

3.7 projected area

area where imperfections distributed along the volume of the weld under consideration are imaged two-dimensionally

Note 1 to entry: In contrast to the cross-sectional area, the occurrence of imperfections is dependent on the weld thickness when exposed radiographically (see [Figure 2](#)).

[SOURCE: ISO 5817:2003, 3.5, modified — “[Figure 1](#)” has been replaced by “[Figure 2](#)”.]

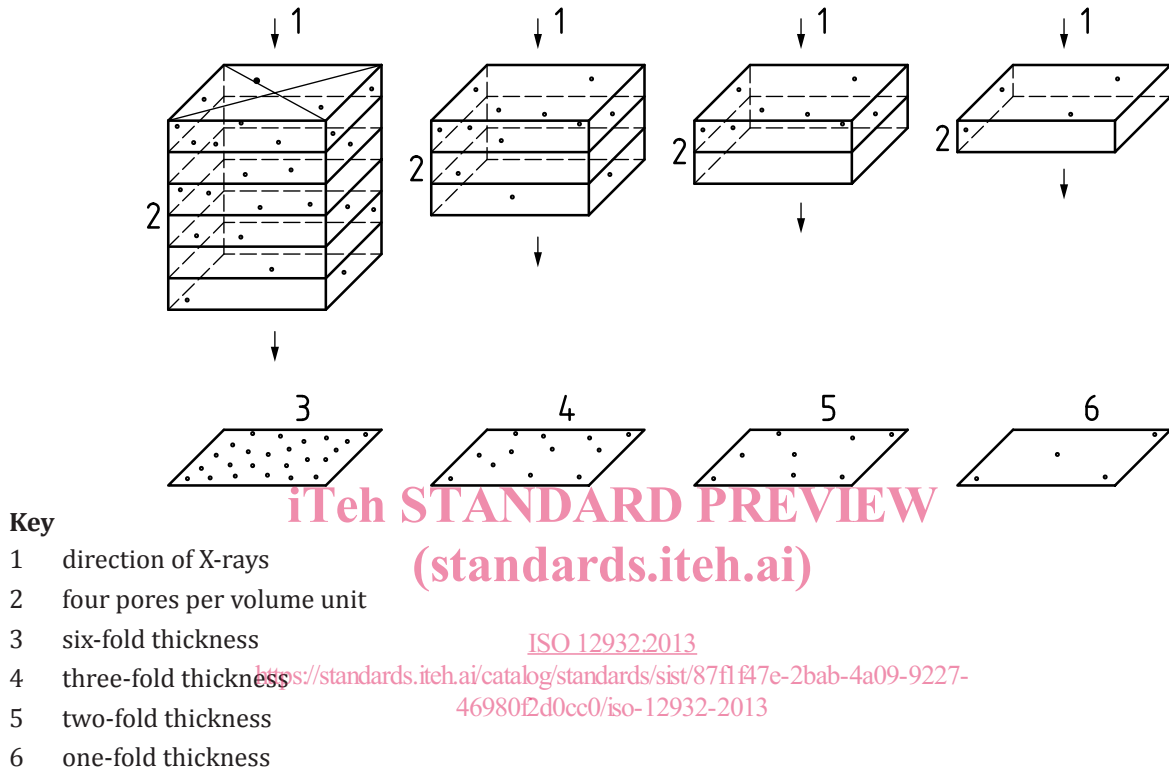


Figure 2 — Radiographic films of specimens with identical occurrence of pores per volume unit

3.8 cross-sectional area

area to be considered after fracture or sectioning

[SOURCE: ISO 5817:2003, 3.6.]

4 Symbols

For the purposes of this document, the following symbols apply.

- a* nominal throat thickness of the fillet weld (given in ISO 2553)
- A* area surrounded by pores
- b* width of weld reinforcement
- d* diameter of pore
- d_A* diameter of pore within area surrounded by pores
- h* height or width of imperfection

l	length of imperfection in longitudinal direction of the weld
l_p	length of projected or fracture surface area
s	connected cross-section or nominal butt weld thickness (given in ISO 2553)
t	wall or plate thickness (nominal size)
w_p	width of the weld or width or height in case of fracture area
z	leg length of a fillet weld (given in ISO 2553)
α	angle of weld toe
β	angle of angular misalignment

5 Assessment of imperfections

Limits to imperfections are given in [Table 1](#). These limits apply to the finished weld and may also be applied to an intermediate stage of fabrication.

If a method other than macro examination is used for the detection of imperfections, only those imperfections which can be detected with a maximum magnification of tenfold, shall be considered. Microcracks (see [Table 1](#), No 2.2) and micro lack of fusion (see [Table 1](#), No 1.5) are excluded.

Systematic imperfections are only permitted in quality level D, provided other requirements of [Table 1](#) are fulfilled.

A welded joint should normally be assessed separately for each individual type of imperfection.

Different types of imperfection occurring at any cross-section of the joint, which weaken the cross-section, may need special consideration (see [Table 1](#), multiple imperfections).

The limits for multiple imperfections (see [Table 1](#)) are only applicable to cases where the requirements for a single imperfection are not exceeded.

Any two adjacent imperfections separated by a distance lesser than the major dimension of the smaller imperfection shall be considered a single imperfection.

Table 1 — Limits to imperfections

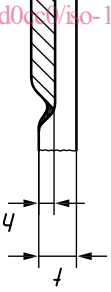
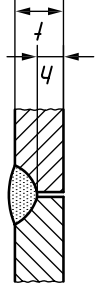
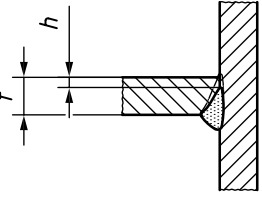
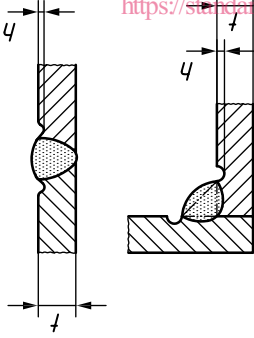
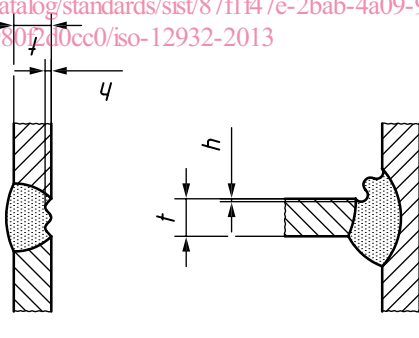
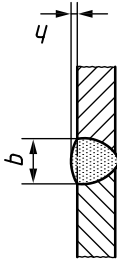
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1 Surface imperfections							
1.1	100	Crack	—		Not permitted	Not permitted	Not permitted
1.2	104	Crater crack	—		Permitted	Not permitted	Not permitted
1.3	2017	Surface pore	Maximum dimension of a single pore for — butt welds — fillet welds	≤ 3	$d \leq 0,3 s$ $d \leq 0,5 a$	Not permitted	Not permitted
				> 3	$d \leq 0,3 s$, but max. 3 mm or width of weld, whichever is smaller $d \leq 0,5 a$, but max. 3 mm	Not permitted	$d \leq 0,2 s$, but max. 2 mm $d \leq 0,4 a$, but max. 2 mm
1.4	2025	End crater pipe		≤ 3	$h \leq 0,2 t$	Not permitted	Not permitted
1.5	401	Lack of fusion (incomplete fusion)	—	> 3	$h \leq 0,2 t$, but max. 2 mm	Not permitted	$h \leq 0,1 t$, but max. 1 mm
				$\geq 0,5$	Not permitted	Not permitted	Not permitted
1.6	4021	Incomplete root penetration	Usually only visible under the microscope (50 ×) For single-side butt welds  For single-side T-joint welds (butt welds) 		Permitted	Permitted	Not permitted
					Short imperfections: $h \leq 0,15 t$, but max. 1 mm	Not permitted	Not permitted

Table 1 (continued)

No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1.7	5011 5012	Continuous undercut Intermittent undercut	<p>Smooth transition is required. This is not regarded as a systematic imperfection.</p> 		$h \leq 0,2 t$, but max. 1 mm	$h \leq 0,1 t$, but max. 0,5 mm	$h \leq 0,05 t$, but max. 0,5 mm
1.8	5013	Shrinkage groove (butt weld) Shrinkage groove (T-joint, full penetration)	<p>Smooth transition is required</p> 		$h \leq 0,2 t$, but max. 1 mm	$h \leq 0,1 t$, but max. 0,5 mm	$h \leq 0,05 t$, but max. 0,5 mm
1.9	502	Excess weld metal (butt weld, parallel joint, overlap joint)	<p>Smooth transition is required</p> 		$h \leq 1 \text{ mm} + 0,25 b$, but max. 10 mm	$h \leq 1 \text{ mm} + 0,15 b$, but max. 7 mm	$h \leq 1 \text{ mm} + 0,1 b$, but max. 5 mm

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