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

*Soudage — Assemblages en acier, nickel, titane et leurs alliages  
soudés par fusion (soudage par faisceau exclu) — 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. [www.iso.org/directives](http://www.iso.org/directives)

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. [www.iso.org/patents](http://www.iso.org/patents)

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

This third edition cancels and replaces the second edition (ISO 5817:2003), which has been technically revised. It also incorporates Technical Corrigendum ISO 5817:2003/Cor 1:2006.

Requests for official interpretations 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](http://www.iso.org).

## Introduction

This International Standard should be used as a reference in the drafting of application codes and/or other application standards. It contains a simplified selection of fusion weld imperfections based on the designations given in ISO 6520-1.

Some of the 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 dimensions of typical imperfections which might be expected in normal fabrication. It may 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 should be defined by the application standard or the responsible designer in conjunction with the manufacturer, user and/or other parties concerned. The quality level shall be prescribed before the start of production, preferably at the enquiry or order stage. For special purposes, additional details may 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 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 could all be covered by specifying one quality level. In some cases, it may be necessary to specify different quality levels for different imperfections in the same welded joint.

The choice of quality level for any application should 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 should include not only the cost of welding but also of inspection, testing and repair.

Although this International Standard includes types of imperfection relevant to the fusion welding processes listed 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 is 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 testing of welds and does not include details of recommended methods of detection or sizing by non-destructive means. It should be considered that there are difficulties in using these limits to establish appropriate criteria applicable to non-destructive testing methods such as ultrasonic, radiographic, eddy current, penetrant, magnetic particle testing and may need to be supplemented by requirements for inspection, examining and testing.

The values given for imperfections are for welds produced using normal welding practice. Requirements for smaller (more stringent) values as stated in quality level B may include additional manufacturing processes, e.g. grinding, TIG dressing.

[Annex C](#) gives additional guidance for welds subject to fatigue.

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# Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections

## 1 Scope

This International Standard provides quality levels of imperfections in fusion-welded joints (except for beam welding) in all types of steel, nickel, titanium and their alloys. It applies to material thickness  $\geq 0,5$  mm. It covers fully penetrated butt welds and all fillet welds. Its principles can also be applied to partial-penetration butt welds.

(Quality levels for beam welded joints in steel are presented in ISO 13919-1.)

Three quality levels are given in order to permit application to a wide range of welded fabrication. They are designated by symbols B, C and D. Quality level B corresponds to the highest requirement on the finished weld.

Several types of loads are considered, e.g. static load, thermal load, corrosion load, pressure load. Additional guidance on fatigue loads is given in [Annex C](#).

The quality levels refer to production and good workmanship.

This International Standard is applicable to

- a) non-alloy and alloy steels, [ISO 5817:2014](https://standards.iteh.ai/catalog/standards/sist/a5394763-a4f9-47db-8182-5635240d33dc/iso-5817-2014)
- b) nickel and nickel alloys, <https://standards.iteh.ai/catalog/standards/sist/a5394763-a4f9-47db-8182-5635240d33dc/iso-5817-2014>
- c) titanium and titanium alloys,
- d) manual, mechanized and automatic welding,
- e) all welding positions,
- f) all types of welds, e.g. butt welds, fillet welds and branch connections, and
- g) the following welding processes and their sub-processes, as defined in ISO 4063:
  - 11 metal-arc welding without gas protection;
  - 12 submerged-arc welding;
  - 13 gas-shielded metal-arc welding;
  - 14 gas-shielded arc welding with non-consumable tungsten electrodes;
  - 15 plasma arc welding;
  - 31 oxy-fuel gas welding (for steel only).

Metallurgical aspects, e.g. grain size, hardness, are not covered by this International Standard.

## 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 6520-1:2007, *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

##### **quality level**

description of the quality of a weld on the basis of type, size and amount of selected imperfections

#### 3.2

##### **fitness-for-purpose**

ability of a product, process or service to serve a defined purpose under specific conditions

#### 3.3

##### **short imperfections**

<weld 100 mm long or longer> imperfections whose total length is not greater than 25 mm in the 100 mm of the weld which contains the greatest number of imperfections

#### 3.4

##### **short imperfections**

<weld less than 100 mm long> imperfections whose total length is not greater than 25 % of the length of the weld

#### 3.5

##### **systematic imperfections**

imperfections that are repeatedly distributed in the weld over the weld length to be examined, the size of a single imperfection being within the specified limits

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#### 3.6

##### **projected area**

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

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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 1](#)).

#### 3.7

##### **cross-sectional area**

area to be considered after fracture or sectioning

#### 3.8

##### **smooth weld transition**

even surface with no irregularities or sharpness at the transition between the weld bead and the parent material

#### 3.9

##### **fatigue class**

##### **FAT<sub>x</sub>**

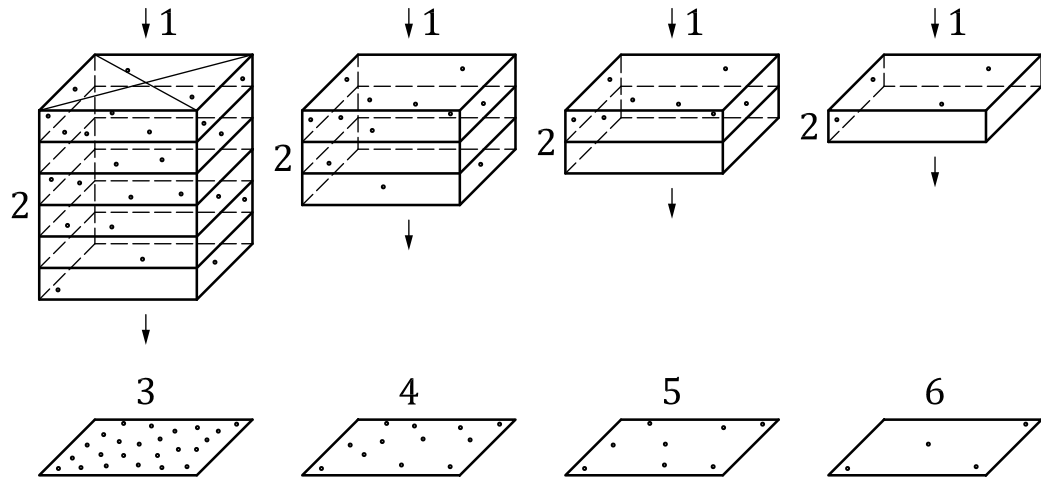
classification reference to S-N curve, in which x is the stress range in MPa at  $2 \cdot 10^6$  cycles

Note 1 to entry: Fatigue properties are described by S-N-Curves (Stress-Number of cycle- curves).

Note 2 to entry: See [Annex C](#).

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**Key**

1	direction of X-rays	3	6-fold thickness	5	2-fold thickness
2	4 pores per volume unit	4	3-fold thickness	6	1-fold thickness

**Figure 1 — Radiographic films of specimens with identical occurrence of pores per volume unit**

#### 4 Symbols

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The following symbols are used in Table 1 and Table C.1.

$a$	nominal throat thickness of the fillet weld (see also ISO 2553)
$A$	area surrounding the gas pores
$b$	width of weld reinforcement
$d$	diameter of gas pore
$d_A$	diameter of area surrounding the gas pores
$h$	height or width of imperfection
$l$	length of imperfection in longitudinal direction of the weld
$l_p$	length of projected or cross-sectional area
$s$	nominal butt weld thickness (see also ISO 2553)
$t$	wall or plate thickness (nominal size)
$w_p$	width of the weld or width or height of the cross-sectional area
$z$	leg length of a fillet weld (see also ISO 2553)
$\alpha$	angle of weld toe
$\beta$	angle of angular misalignment
$i$	penetration in fillet welds
$r$	radius of weld toe

## 5 Assessment of imperfections

Limits for imperfections are given in [Table 1](#).

If, for the detection of imperfections, macro-examination is used, only those imperfections shall be considered which can be detected with a maximum of tenfold magnification. Excluded from this are micro lack of fusion (see [Table 1](#), 1.5) and microcracks (see [Table 1](#), 2.2).

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

A welded joint should usually be assessed separately for each individual type of imperfection (see [Table 1](#), 1.1 to 3.2).

Different types of imperfection occurring at any cross-section of the joint need special consideration (see multiple imperfections in [Table 1](#), 4.1).

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

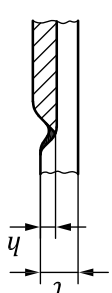
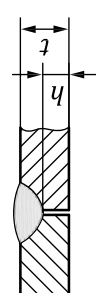
Any two adjacent imperfections separated by a distance smaller than the major dimension of the smaller imperfection shall be considered as a single imperfection.

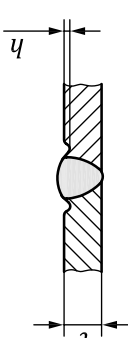
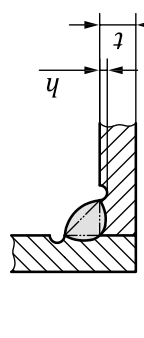
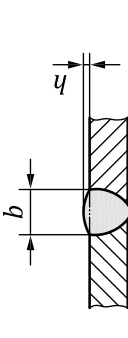
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Table 1 — Limits for imperfections

No.	Reference to ISO 6520-1	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
<b>1 Surface imperfections</b>							
1.1	100	Crack		≥ 0,5	Not permitted	Not permitted	Not permitted
1.2	104	Crater crack		≥ 0,5	Not permitted	Not permitted	Not permitted
1.3	2017	Surface pore	Maximum dimension of a single pore for — butt welds — fillet welds	0,5 to 3	$d \leq 0,3 s$ $d \leq 0,3 a$	Not permitted	Not permitted
			Maximum dimension of a single pore for — butt welds — fillet welds	> 3	$d \leq 0,3 s$ , but max. 3 mm $d \leq 0,3 a$ , but max. 3 mm	$d \leq 0,2 s$ , but max. 2 mm $d \leq 0,2 a$ , but max. 2 mm	Not permitted
1.4	2025	End crater pipe		0,5 to 3 > 3	$h \leq 0,2 t$ $h \leq 0,2 t$ , but max. 2 mm	Not permitted $h \leq 0,1 t$ , but max. 1 mm	Not permitted Not permitted
1.5	401	Lack of fusion (incomplete fusion) Micro lack of fusion	— Only detectable by micro examination	≥ 0,5	Not permitted	Not permitted	Not permitted
1.6	4021	Incomplete root penetration	Only for single side butt welds 	≥ 0,5	Permitted Short imperfections: $h \leq 0,2 t$ but max. 2 mm	Permitted Not permitted	Not permitted Not permitted

No.	Reference to ISO 6520-1	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1.7	5011	Continuous undercut	Smooth transition is required. This is not regarded as a systematic imperfection. 	$0,5 \text{ to } 3$ $h \leq 0,2 t$	$h \leq 0,1 t$	Not permitted	
	5012	Intermittent undercut		$> 3$ $h \leq 0,2 t$ , 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	Smooth transition is required. 	$0,5 \text{ to } 3$ $h \leq 0,2 \text{ mm} + 0,1 t$	$h \leq 0,1 t$	Not permitted	
				$> 3$ $h \leq 0,2 t$ , but max. 2 mm	$h \leq 0,1 t$ , but max. 1 mm	Short imperfections: $h \leq 0,05 t$ , but max. 0,5 mm	
1.9	502	Excess weld metal (butt weld)	Smooth transition is required. 	$\geq 0,5$ $h \leq 1 \text{ mm} + 0,25 b$ , 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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