

**DIN EN ISO 5817**

ICS 25.160.40

Replacement for  
DIN EN ISO 5817:2014-06**Welding -****Fusion-welded joints on steel, nickel, titanium and their alloys (without beam welding)****Assessment groups of irregularities (ISO 5817:2023); German version  
EN ISO 5817:2023**

## Welding -

Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) -

Quality levels for imperfections (ISO 5817:2023);

German version EN ISO 5817:2023

## Soudage -

Assemblages en acier, nickel, titane et leurs alliages soudés par fusion (soudage par faisceau exclu) -

Niveaux de qualité par rapport aux défauts (ISO 5817:2023);

Version allemande EN ISO 5817:2023

Total length 44 pages

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National foreword

This document (EN ISO 5817:2023) has been prepared by Technical Committee ISO/TC 44 "Welding and allied processes" in collaboration with Technical Committee CEN/TC 121 "Welding and allied processes", the secretariat of which is held by DIN (Germany).

The responsible German standardization body is the working committee NA 092-00-04 AA "Quality assurance in welding (DVS AG Q 2)" in the DIN Standards Committee for Welding and Allied Processes (NAS).

For the documents cited in this document, reference is made below to the corresponding German documents:

ISO 2553	see	DIN EN ISO 2553
ISO 4063	see	DIN EN ISO 4063
ISO 6520-1	see	DIN EN ISO 6520-1
ISO 8501-3	see	DIN EN ISO 8501-3
ISO 13919-1	see	DIN EN ISO 13919-1
ISO 17635	see	DIN EN ISO 17635
ISO 25901 (all parts)	see	DIN EN ISO 25901 (all parts)

Up-to-date information on this document can be found on the DIN website ([www.din.de](http://www.din.de)) by searching for the document number.

Annex NA explains the relationship between the surface irregularities according to DIN EN ISO 5817 and the general surface irregularities according to DIN EN ISO 8501-3.

Changes

The following changes have been made compared to DIN EN ISO 5817:2014-06:

- a) normative references updated;
- b) in Table 1, Nos. 1.3, 1.4, 1.16 and 3.2, the actual fillet weld thickness  $a_A$  is used;
- c) the images for Table 1, Nos. 1.4, 1.5, 1.6, 1.11, 1.14, 1.16, 1.19, 2.12, 2.13 and 4.1, have been changed or added;
- d) Table 1, No. 4.1: Exclusion of several irregularities and modification of the acceptance criteria;
- e) Former Annex B deleted;
- f) Literature references updated;
- g) Document editorially revised.

**Previous issues**

DIN 1912-1: 1927-04, 1932-05, 1937-05, 1956-05, 1960-07, 1976-06

DIN 8563-1: 1964-06, 1973-03, 1978-10

DIN 8563-3: 1972-04, 1975-07, 1979-01, 1985-10

DIN EN 25817: 1992-09

DIN EN ISO 5817: 2003-12, 2006-10, 2014-06

DIN EN ISO 5817 Corrigendum 1: 2007-10

National Annex NA  
(informative)

Relationship between the assessment groups of DIN EN ISO 5817 and DIN EN ISO 8501-3

Table NA.1 shows the relationship between the surface irregularities according to DIN EN ISO 5817 and the general surface irregularities according to DIN EN ISO 8501-3. These do not correspond in all quality levels.

If there is a surface weld seam irregularity, it may be necessary to further process the surface for a subsequent coating if a certain degree of preparation is required.

Table NA.1 - Relationship between DIN EN ISO 5817 and DIN EN ISO 8501-3

Serial number according to DIN EN ISO 6520-1	Designation according to DIN EN ISO 6520-1	Description according to DIN EN ISO 8501-3	DIN EN ISO 5817			DIN EN ISO 8501-3		
			D	C	B	P1	P2	P3
602	Splash	Welding spatter	+	+	+	*	*	-
514	Irregular seam pattern	Fluted /profiled weld seam	+	+	+	+	*	-
615	Slag residue	Welding slag	+	+	+	-	-	-
501	Burn-in notch	Edge notch	*	*	*	+	*	-
2017	Surface pore	Welding porosity	*	*	-	+	*	-
516	Root porosity		*	-	-	+	*	-
2025	Open end crater blowhole	Crater at the end of the weld seam	*	*	-	+	*	-
<div><div>+</div>permitted Restriction or not covered by the regulations</div> <div><div>*</div>conditionally permissible: permissible in compliance with limit values</div> <div><div>-</div>inadmissible</div>								

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## National Annex NL (informative)

### References

DIN EN ISO 2553, *Welding and allied processes - Symbolic representation in drawings - Welded joints*

DIN EN ISO 4063, *Welding and allied processes - List of processes and classification numbers*

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

DIN EN ISO 8501-3, *Preparation of steel surfaces before application of paints and varnishes - Visual assessment of surface cleanliness - Part 3: Degree of preparation of welds, edges and other surfaces with surface irregularities*

DIN EN ISO 13919-1, *Electron and laser beam welded joints - Requirements and recommendations for assessment groups for irregularities - Part 1: Steel, nickel, titanium and their alloys*

DIN EN ISO 17635, *Non-destructive testing of welded joints - General rules for metallic materials*

DIN EN ISO 25901 (all parts), *Welding and allied processes - Terminology*

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EUROPEAN

EN ISO 5817

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ICS 25.160.  
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German version

**Welding -**  
**Fusion-welded joints on steel, nickel, titanium and their alloys**  
**(without beam welding)**  
**Assessment groups of irregularities (ISO**  
**5817:2023)**

Welding -  
 Fusion-welded joints in steel, nickel, titanium and their  
 alloys (beam welding excluded) -  
 Quality levels for imperfections (ISO 5817:2023)

Soudage -  
 Assemblages en acier, nickel, titane et leurs alliages  
 soudés par fusion (soudage par faisceau exclu) -  
 Niveaux de qualité par rapport aux défauts  
 (ISO 5817:2023)

This European Standard was adopted by CEN on February 10, 2023.

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**CEN-CENELEC Management Center: Rue de la Science 23, B-1040 Brussels**



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## European foreword

This document (EN ISO 5817:2023) has been prepared by Technical Committee ISO/TC 44 "Welding and allied processes" in collaboration with Technical Committee CEN/TC 121 "Welding and allied processes", the secretariat of which is held by DIN.

This European Standard must be given the status of a national standard, either by publication of an identical text or by endorsement by September 2023, and any conflicting national standards must be withdrawn by September 2023.

Attention is drawn to the possibility that some elements of this document may infringe patent rights. CEN is not responsible for identifying any or all such patent rights.

This document replaces EN ISO 5817:2014.

Feedback or questions concerning this document should be addressed to the relevant national standards institute/national body of the user. A complete list of these institutes is available on the CEN website.

In accordance with the CEN CENELEC Internal Regulations, the national standards bodies of the following countries are required to adopt 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, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

### Recognition note

The text of ISO 5817:2023 has been approved by CEN as EN ISO 5817:2023 without any modification.

## Foreword

ISO (the International Organization for Standardization) is a worldwide association of national standards institutes (ISO member organizations). The preparation of International Standards is usually carried out by ISO Technical Committees. Any member organization interested in a subject for which a Technical Committee has been established has the right to be represented on that committee. International governmental and non-governmental organizations that are in close contact with ISO also participate in the work. ISO works closely with the International Electrotechnical Commission (IEC) on all electrotechnical standardization issues.

The procedures that were used in the development of this document and that are intended for further maintenance are described in the ISO/IEC Directives, Part 1. Particular attention should be paid to the different acceptance criteria for the various ISO document types. This document has been prepared in accordance with the design rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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For an explanation of the voluntary nature of standards, the meaning of ISO-specific terms and expressions in relation to conformity assessments, and information on how ISO takes into account the World Trade Organization (WTO) principles on technical barriers to trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document has been prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*, in collaboration with the European Committee for Standardization (CEN), Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition replaces the third edition (ISO 5817:2014), which has been technically revised. The main changes are as follows:

- editorial revision;
- in Table 1, Nos. 1.3, 1.4, 1.16 and 3.2, the actual fillet weld thickness  $a_A$  was used;
- the images for Table 1, Nos. 1.4, 1.5, 1.6, 1.11, 1.14, 1.16, 1.19, 2.12, 2.13 and 4.1, have been changed or added;
- Table 1, No. 4.1: Exclusion of several irregularities and modification of the acceptance criteria;
- Former Annex B has been deleted.

Feedback or questions regarding this document should be directed to the user's national standards institute. A complete list of these institutes can be found at [www.iso.org/members.html](http://www.iso.org/members.html). Official interpretations of documents from ISO/TC 44, if available, are on this website available at: <https://committee.iso.org/sites/tc44/home/interpretation.html>.

## Introduction

This document is intended for reference in the preparation of application rules and/or other application standards. It contains a simplified selection of irregularities on fusion-welded joints with designations in accordance with ISO 6520-1.

Some irregularities according to ISO 6520-1 have been used directly and others as groups. The basic number reference system according to ISO 6520-1 has been applied.

The purpose of this document is to define typical irregularities that can be expected in normal production. It can be used in a quality system for the manufacture of welded joints. It specifies three groups of values for the dimensions from which a selection can be made for a particular application. The evaluation group required for the individual case should be determined by the application standard or by the responsible designer together with the manufacturer, user and/or other bodies concerned. The evaluation group must be defined before the start of production, preferably at the quotation or order stage. In special cases, additional information may be specified. If the welds are subsequently coated with a protective layer, lining or paint, the welds may require a more thorough post-treatment or surface treatment to meet the requirements of ISO 8501-3.

Evaluation groups according to this document are intended to provide basic reference data and do not refer to any specific application. They refer to the welds in production and not to the whole product or component itself. It is therefore possible that different evaluation groups are prescribed for the respective weld seam on the same component or product.

The main body of the document does not consider suitability or appropriate design. Annex B provides a means of considering the suitability of the design for applications subject to vibration.

Normally, it can be assumed that the tolerance values for the irregularities can be determined for a single weld seam by defining an evaluation group. In some cases, it may be necessary to define different evaluation groups for different irregularities in the same weld. When selecting the evaluation groups for a particular application, the design conditions, the subsequent processes (e.g. surface treatment), the types of stress (e.g. static, dynamic), the operating conditions (e.g. temperature, environment) and the consequences of defects should be taken into account. Economic factors are also important and should include not only the cost of welding, but also the cost of supervision, testing and repair.

Although this document contains various types of irregularities that apply to fusion welding processes according to section 1, only those that are relevant to the process and application in question need to be considered.

The irregularities are indicated with their actual size and their detection and assessment may require the use of one or more non-destructive testing methods. The detection and sizing of irregularities depends on the test methods and the extent of the test as specified in the application standard or contract.

The procedures for the detection of irregularities are not covered by this document. However, ISO 17635 contains information on interactions between the assessment groups and the acceptability limits for various non-destructive testing methods.

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This document is directly applicable to the visual inspection of welds. It does not provide details of the methods to be recommended for detection or non-destructive testing for size determination. It should be recognized that there are difficulties in applying these limits to establish appropriate criteria applicable to non-destructive testing methods such as ultrasonic testing (UT), radiographic testing (RT), eddy current testing (ET), penetrant testing (PT) and magnetic particle testing (MT) and that these may need to be supplemented by recommendations for examination, monitoring and testing.

The specified values for irregularities of weld seams take into account standard welding practice. Requirements for smaller (stricter) values as specified in evaluation group B may require additional manufacturing processes, e.g. grinding, smoothing with the TIG process.

Annex B contains additional requirements for fatigue stresses.

## 1 Area of application

This document specifies assessment groups for irregularities in fusion welded joints (excluding beam welding) for all types of steel, nickel, titanium and their alloys. It is applicable for workpiece thicknesses  $\geq 0.5$  mm. It deals with full penetration butt welds and all types of fillet welds. The principles of this document can also be applied to partially through-welded butt welds.

ISO 13919-1 contains evaluation groups for beam-welded joints on steel.

The three evaluation groups are defined in such a way that they allow a wide range of applications in welding production. They are designated by the code letters B, C and D. Assessment group B corresponds to the highest requirements for the weld seam.

Some types of loads are considered, e.g. static load, thermal load, corrosive load, compressive load. Additional guidelines for fatigue loading are given in Annex B.

The evaluation groups refer to production and good manufacturing quality. This document is applicable for:

- a) unalloyed and alloyed steels;
- b) Nickel and nickel alloys;
- c) Titanium and titanium alloys;
- d) manual, mechanized and automatic welding;
- e) all welding positions;
- f) all welded joints, e.g. butt welds, fillet welds and pipe branches;
- g) the following welding processes and their assigned individual processes in accordance with ISO 4063:
  - 11 Metal arc welding without gas protection;
  - 12 Submerged arc welding;
  - 13 Gas metal arc welding;
  - 14 Gas tungsten arc welding;
  - 15 Plasma welding;
  - 31 Gas welding with oxygen-fuel gas flame (only for steel).

Metallurgical aspects such as grain size and hardness are not covered by this document.

## 2 Normative references

The following documents are referred to in the text in such a way that some parts of them or their entire content constitute requirements of this document. In the case of dated references, only the edition referred to applies. For undated references, the latest edition of the referenced document (including all amendments) applies.

ISO 25901 (all parts), *Welding and allied processes - Vocabulary*

## 3 Terms

For the application of this document, the terms according to the ISO 25901 series of standards and the following terms apply.

ISO and IEC provide terminological databases for use in standardization at the following addresses:

- ISO Online Browsing Platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

### 3.1

#### **Evaluation group**

Description of the quality of a weld based on the type, size and number of selected irregularities

### 3.2

#### **short irregularity**

<welds 100 mm long or longer> Irregularity that does not exceed the total length of irregularities of 25 mm in a section of 100 mm containing most of the irregularities

### 3.3

#### **short irregularity**

<Weld seams less than 100 mm long> Irregularity whose total length does not exceed 25 % of the length of the weld seam

### 3.4

#### **Systematic irregularity**

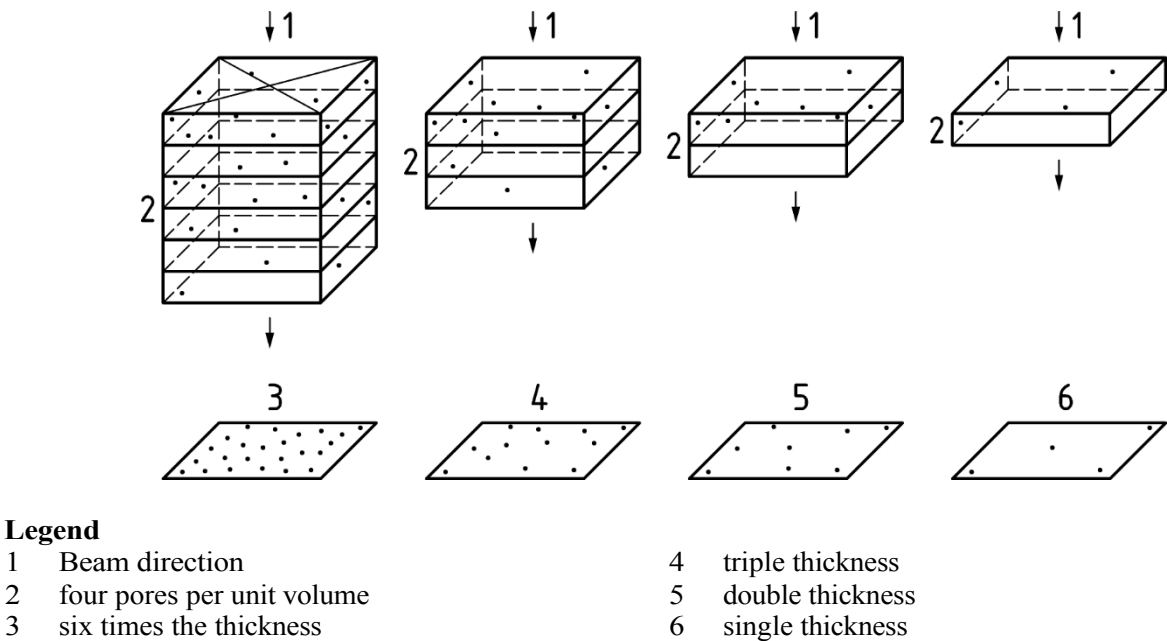
Irregularity that is repeated at regular intervals in the weld seam over the weld seam length to be tested; the dimensions of the individual irregularities are within the specified acceptability limits

### 3.5

#### **Projected area**

Surface on which the irregularities distributed over the volume of the weld seam under consideration are mapped in two dimensions

Note 1 on the term: In contrast to the cross-sectional area, the occurrence of irregularities in the radiographic image depends on the thickness of the weld (see Figure 1).



**Figure 1 - Radiographic images of samples with identical pore frequency per unit volume 3.6**  
**Cross-sectional area**

Fracture surface or grinding plane to be considered

3.7

**Smooth transition**

smooth surface without irregularities or sharpness at the transition between the melt pool and the base material and/or the adjacent melt pool(s)

3.8

**Vibration resistance class**

**FATx**

Classification for the S-N curve

Note 1 to the term: x is the stress range, in MPa, at  $2 \cdot 10^6$  cycles.

Note 2 to the term: Fatigue properties are described as S-N curves (stress-number of cycle curves).

Note 3 to entry: See Appendix B.

**4 Symbols**

a Seam thickness of the fillet weld (see also ISO 2553)

aA Actual seam thickness (seam thickness of the finished weld) (see ISO/TR 25901-1)

A Surrounding surface of pores

b Width of the seam rise

d Diameter of a pore



$d_A$  Diameter of the area surrounding the pores

$h$  Height or width of the irregularity

$i$  Full penetration welding of fillet welds

$l$  Length of the irregularity in the longitudinal direction of the weld

$l_p$  Length of the projected area or cross-sectional area

$r$  Seam transition radius

$s$  Seam thickness of the butt seam

$t$  Pipe wall or sheet thickness (nominal size)

$w_p$  Width of the weld seam or width or height for a cross-sectional area

$z$  Side length of a fillet weld (see also ISO 2553)

$\alpha$  Seam transition angle

$\beta$  Angle of the angular offset

## **5 Assessment of irregularities**

The limits for irregularities according to ISO 6520-1 are given in Table 1.

If macrosection examination is used to detect irregularities, only those irregularities that can be detected with a maximum magnification of ten times must be taken into account. Exceptions to this are microbond defects (see Table 1, 1.5) and microcracks (see Table 1, 2.2).

Systematic irregularities are only permitted for assessment group D, provided that the other requirements in Table 1 are met.

A weld should normally be assessed separately for each irregularity (see Table 1, 1.1 to 3.2).

If different types of irregularities occur in a seam cross-section, a special assessment is necessary (see multiple irregularities in Table 1, 4.1).

The limits for multiple irregularities (see Table 1) only apply to cases where the requirements for a single irregularity are not exceeded.

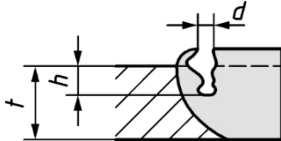
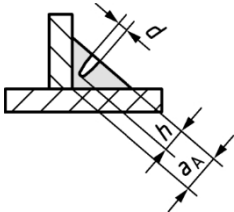
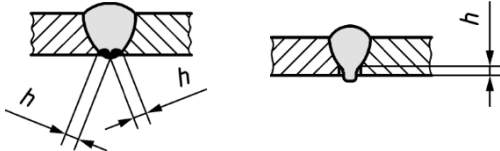
Every two adjacent irregularities with a distance smaller than the main dimension of the smaller irregularity must be regarded as one irregularity.

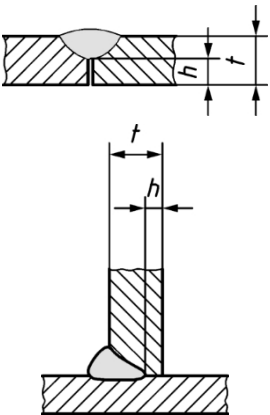
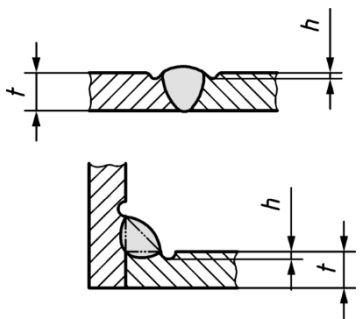
Table 1 - Limits for irregularities

No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	<i>t</i>  mm	Limit values for irregularities in valuation groups		
					D	C	B
1 Surface irregularities							
1.1	100	Tear		≥ 0,5	Not permitted	Not permitted	Not permitted
1.2	104	End crater crack		≥ 0,5	Not permitted	Not permitted	Not permitted
1.3	2017	Surface pore	On the weld seam surface or in the weld seam root  Largest dimension of a single pore	0.5 to 3	Butt seams: <i>d</i> ≤ 0.3 <i>s</i>  Fillet welds: <i>d</i> ≤ 0.3 <sub>aA</sub>	Not permitted	Not permitted
				>3	Butt seams: <i>d</i> ≤ 0.3 <i>s</i> , but max. 3 mm  Fillet welds: <i>d</i> ≤ 0.3 <sub>aA</sub> , but max. 3 mm	Butt seams: <i>d</i> ≤ 0.2 <i>s</i> , but max. 2 mm  Fillet welds: <i>d</i> ≤ 0.2 <sub>aA</sub> , but max. 2 mm	Not permitted

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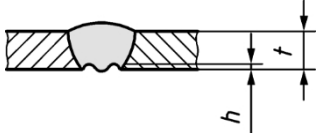
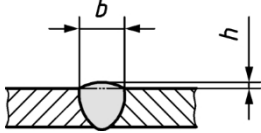
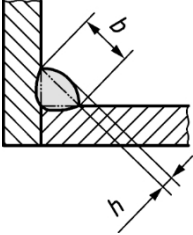
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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
1.4	2025	Open end crater blowhole	- Butt seams 	0.5 to 3	Butt seams: $h \leq 0.2$ $s \ d \leq$ $0.3 \ s$ Fillet welds: $h \leq 0.2_{aA}$ , $d \leq 0.3_{aA}$	Not permitted	Not permitted
			- Fillet welds 	>3	Butt seams: $h \leq 0.2 \ s$ , but max. 2 mm $d \leq 0.3 \ s$ , but max. 3 mm Fillet welds: $h \leq 0.2_{aA}$ , but max. 2 mm $d \leq 0.3_{aA}$ , but max. 3 mm	Butt seams: $h \leq 0.1 \ s$ , but max. 1 mm $d \leq 0.2 \ s$ , but max. 2 mm Fillet welds: $h \leq 0.1_{aA}$ , but max. 1 mm $d \leq 0.2_{aA}$ , but max. 2 mm	Not permitted
1.5	401	Binding error (incomplete binding)		≥ 0,5	Not permitted	Not permitted	Not permitted
	4014	Micro- connection error	Can only be detected by microscopic examination (≥ 50x magnification)	≥ 0,5	Permitted	Permitted	Not permitted

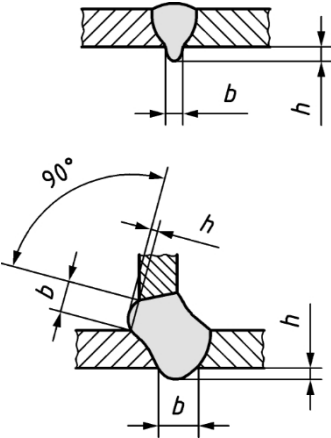
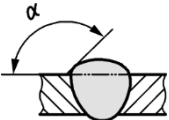
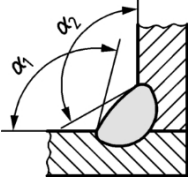
No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	$t$ mm	Limit values for irregularities in valuation groups		
					D	C	B
1.6	4021	Insufficient root fusion	Only for single-sided welded butt welds (through-welded) 	$\geq 0,5$	Short irregularity: $h \leq 0.2 t$ , but max. 2 mm	Not permitted	Not permitted
1.7	5011	Continuous single-edge notch	A smooth transition is required. Not considered a systematic irregularity. 	0.5 to 3	Short irregularity: $h \leq 0.2 t$	Short irregularity: $h \leq 0.1 t$	Not permitted
	5012	Non-continuous single notch (short irregularity)		$>3$	$h \leq 0.2 t$ , but max. 1 mm	$h \leq 0.1 t$ , but max. 0.5 mm	$h \leq 0.05 t$ , but max. 0.5 mm

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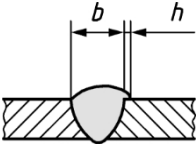
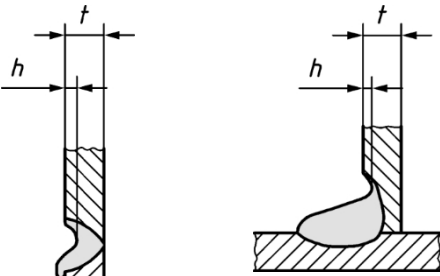
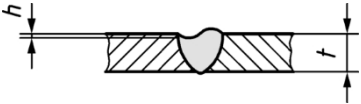
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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
1.8	5013	Root notches	A smooth transition is required.  	0.5 to 3	Short irregularity: $h \leq 0.1 t + 0.2 \text{ mm}$	Short irregularity: $h \leq 0.1 t$	Not permitted
				>3	Short irregularity: $h \leq 0.2 t$ , but max. 2 mm	Short irregularity: $h \leq 0.1 t$ , but max. 1 mm	Short irregularity: $h \leq 0.05 t$ , but max. 0.5 mm
1.9	502	Excessive seam rise (butt seam)	Smooth transition between the cover layer(s) of the weld seam and the sheet surface and/or the adjacent weld pool(s) is required.  	≥ 0,5	$h \leq 0.25 b + 1 \text{ mm}$ , but max. 10 mm	$h \leq 0.15 b + 1 \text{ mm}$ , but max. 7 mm	$h \leq 0.1 b + 1$ mm, but max. 5 mm
1.10	503	Excessive seam camber (fillet weld)	Smooth transition between the top layer of the weld seam and the sheet surface and/or the adjacent weld pool(s) is required.  	≥ 0,5	$h \leq 0.25 b + 1 \text{ mm}$ , but max. 5 mm	$h \leq 0.15 b + 1 \text{ mm}$ , but max. 4 mm	$h \leq 0.1 b + 1$ mm, but max. 3 mm

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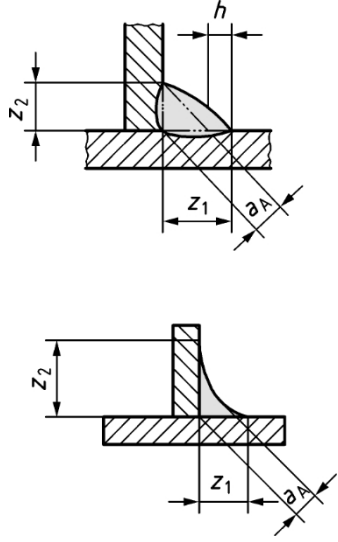
No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t mm	Limit values for irregularities in valuation groups		
					D	C	B
1.11	504	Excessive root elevation		0.5 to 3	$h \leq 0.6 b + 1 \text{ mm}$	$h \leq 0.3 b + 1 \text{ mm}$	$h \leq 0.1 b + 1 \text{ mm}$
				>3	$h \leq 1.0 b + 1 \text{ mm}$ , but max. 5 mm	$h \leq 0.45 b + 1 \text{ mm}$ , but max. 4 mm	$h \leq 0.2 b + 1 \text{ mm}$ , but max. 3 mm
1.12	505	Rough seam transition (faulty seam profile)	- Butt seams   Not applicable for the weld root	≥ 0,5	$\alpha \geq 90^\circ$	$\alpha \geq 110^\circ$	$\alpha \geq 150^\circ$
			- Fillet welds  $\alpha_1 \geq \alpha$ and $\alpha_2 \geq \alpha$	≥ 0,5	$\alpha \geq 90^\circ$	$\alpha \geq 100^\circ$	$\alpha \geq 110^\circ$

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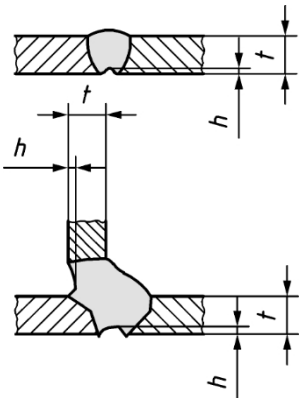
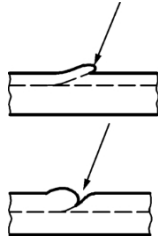
No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	<i>t</i> mm	Limit values for irregularities in valuation groups		
					D	C	B
1.13	506	Weld metal overflow		≥ 0,5	$h \leq 0.2 b$	Not permitted	Not permitted
1.14	509	Lost weld metal	A smooth transition is required. 	0.5 to 3	Short irregularity: $h \leq 0.25 t$	Short irregularity: $h \leq 0.1 t$	Not permitted
	511	Top layer under camber		>3	Short irregularity: $h \leq 0.25 t$ , but max. 2 mm	Short irregularity: $h \leq 0.1 t$ , but max. 1 mm	Short irregularity: $h \leq 0.05 t$ , but max. 0.5 mm
1.15	510	Burn-through	-	≥ 0,5	Not permitted	Not permitted	Not permitted

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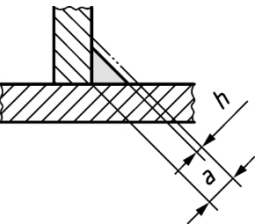
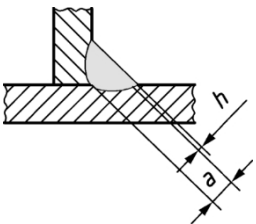
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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
1.16	512	Excessive unevenness in fillet welds	<div>In cases where an asymmetrical fillet weld has not been specified.</div> <div></div> <div><math>h =  z_1 - z_2 </math></div>	≥ 0,5	$h \leq 0.2_{aA} + 2 \text{ mm}$	$h \leq 0.15_{aA} + 2 \text{ mm}$	$h \leq 0.15_{aA} + 1.5 \text{ mm}$



No.	Order no. according to ISO 6520-1	Irregularity Designation	Remarks	t mm	Limit values for irregularities in valuation groups		
					D	C	B
1.17	515	Root relapse	A smooth transition is required. 	0.5 to 3	$h \leq 0.1 t + 0.2 \text{ mm}$	Short irregularity: $h \leq 0.1 t$	Not permitted
				>3	Short irregularity: $h \leq 0.2 t$ , but max. 2 mm	Short irregularity: $h \leq 0.1 t$ , but max. 1 mm	Short irregularity: $h \leq 0.05 t$ , but max. 0.5 mm
1.18	516	Root porosity	Spongy formation of the weld root as a result of blistering of the weld metal during solidification (e.g. insufficient gas protection of the root).	$\geq 0,5$	Admissibility depends on the application, e.g. material, corrosion protection	Not permitted	Not permitted
1.19	517	Attachment error		$\geq 0,5$	Permitted The limit depends on the type of irregularity that occurs at restart.	Not permitted	Not permitted

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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
1.20	5213	Fillet weld thickness too small	Not applicable to processes with evidence of major burn-in  	0.5 to 3	Short irregularity: $h \leq 0.1 a + 0.2 \text{ mm}$	Short irregularity: $h \leq 0.2 \text{ mm}$	Not permitted
				>3	Short irregularity: $h \leq 0.1 a + 0.3 \text{ mm}$ , but max. 2 mm	Short irregularity: $h \leq 0.1 a + 0.3 \text{ mm}$ , but max. 1 mm	Not permitted
1.21	5214	Fillet weld thickness too large	Actual fillet weld thickness is too great  	≥ 0,5	Permitted	$h \leq 0.2 a + 1 \text{ mm}$ , but max. 4 mm	$h \leq 0.15 a + 1 \text{ mm}$ , but max. 3 mm
1.22	601	Ignition point	-	≥ 0,5	Permitted if the properties of the base material are not affected	Not permitted	Not permitted
1.23	602	Splash	-	≥ 0,5	Admissibility depends on the application, e.g. material, corrosion protection	Admissibility depends on the application, e.g. material, corrosion protection	Admissibility depends on the application, e.g. material, corrosion protection

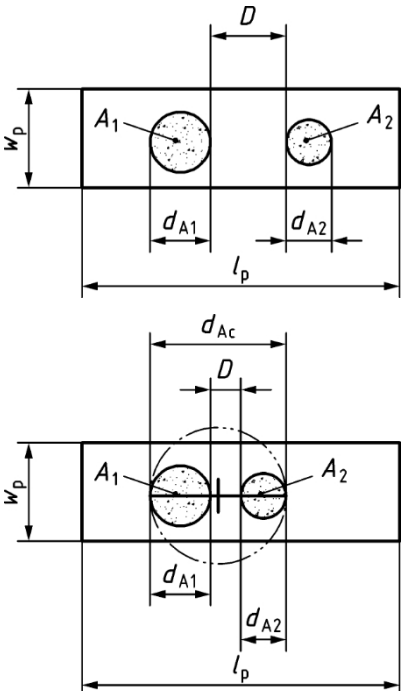
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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	<i>t</i>  mm	Limit values for irregularities in valuation groups		
					D	C	B
1.24	610	Tarnishing (visible oxide layer)	-	≥ 0,5	Admissibility depends on the application, e.g. material, corrosion protection	Admissibility depends on the application, e.g. material, corrosion protection	Admissibility depends on the application, e.g. material, corrosion protection
2 Internal irregularities							
2.1	100	Crack	All crack types except microcracks and end crater cracks	≥ 0,5	Not permitted	Not permitted	Not permitted
2.2	1001	Microcrack	Usually a crack that is only visible under a microscope (≥ 50x magnification)	≥ 0,5	Permitted	Admissibility depends on the type of base material and above all on the susceptibility to cracking	Admissibility depends on the type of base material and above all on the susceptibility to cracking
2.3	2011 2012	Pore  Porosity (evenly distributed)	The following conditions and limits for irregularities must be met. For information see also Appendix A.  a1) Largest dimension of the area of irregularities (including systematic irregularity) in relation to the projected area. The porosity in the projected area depends on the number of layers (volume of the weld).	≥ 0,5	Single layer: ≤ 2.5 % Multi-layer: ≤ 5 %	Single layer: ≤ 1.5 % Multi-layer: ≤ 3 %	Single layer: ≤ 1 % Multi-layer: ≤ 2 %
			a2) Maximum dimension of irregularities in the cross-sectional area (including systematic irregularity) in relation to the broken surface (only applicable to test pieces for production, welding or procedure qualification)	≥ 0,5	≤ 2,5 %	≤ 1,5 %	≤ 1 %

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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
			b) Largest dimension of a single pore for — Butt seams  — Fillet welds	≥ 0,5	$d \leq 0.4 s$ , but max. 5 mm  $d \leq 0.4 a_A$ , but max. 5 mm	$d \leq 0.3 s$ , but max. 4 mm  $d \leq 0.3 a_A$ , but max. 4 mm	$d \leq 0.2 s$ , but max. 3 mm  $d \leq 0.2 a_A$ , but max. 3 mm
2.4	2013	Pore nest	<div></div> <p>Reference length for <math>l_p</math> is 100 mm.</p> <p>The entire pore area within a pore nest is represented by an envelope curve with the diameter <math>d_A</math>.</p>	≥ 0,5	$d_A \leq 25$ mm or $dA_{, \max} \leq w_p$	$d_A \leq 20$ mm or $dA_{, \max} \leq w_p$	$d_A \leq 15$ mm or $dA_{, \max} \leq w_p/2$

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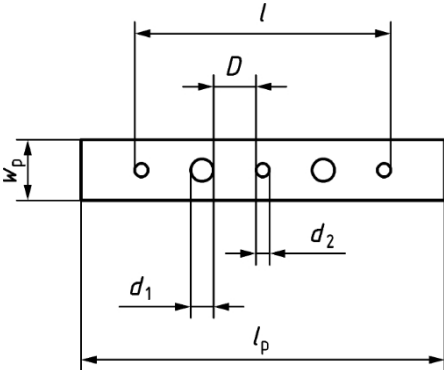
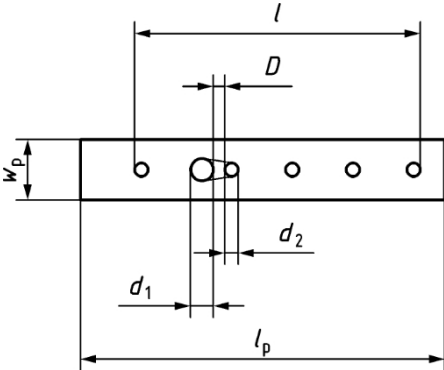
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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	<i>t</i> mm	Limit values for irregularities in valuation groups		
					D	C	B
			<p>The conditions for the individual pore must be observed for the pores in the envelope curve.</p> <p>The permissible pore area must be locally limited. The possibility that other irregularities are concealed must be taken into account.</p> <p>If <i>D</i> is smaller than <math>d_{A1}</math> or <math>d_{A2}</math>, with the smaller value applying, then the diameter <math>d_{AC}</math> of the envelope is formed around the entire pore area with <math>d_{AC} = d_{A1} + d_{A2} + D</math>.</p> <p>Systematic pore nests are not permitted.</p> <p><math>d_A</math> corresponds to <math>d_{A1}</math>, <math>d_{A2}</math> or <math>d_{AC}</math>, whichever is applicable.</p>				
2.5	2014	Pore line	- Butt seams	≥ 0,5	$h \leq 0.4 s$ , but max. 4 mm $l \leq s$ , but max. 75 mm	$h \leq 0.3 s$ , but max. 3 mm $l \leq s$ , but max. 50 mm	$h \leq 0.2 s$ , but max. 2 mm $l \leq s$ , but max. 25 mm
			- Fillet welds	≥ 0,5	$h \leq 0.4 a$ , but max. 4 mm $l \leq a$ , but max. 75 mm	$h \leq 0.3 a$ , but max. 3 mm $l \leq a$ , but max. 50 mm	$h \leq 0.2 a$ , but max. 2 mm $l \leq a$ , but max. 25 mm

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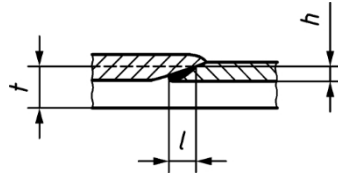


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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
			<p>Case 1 (<math>D &gt; d_2</math>)</p>  <p>Case 2 (<math>D &lt; d_2</math>)</p>  <p>Reference length for <math>l_p</math> is 100 mm. For case 1: <math>d_1 = h</math> For case 2: <math>d_1 + d_2 + D = h</math></p>				

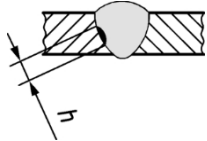
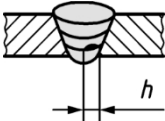
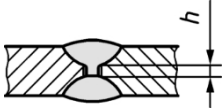


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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	$t$ mm	Limit values for irregularities in valuation groups		
					D	C	B
2.6	2015  2016	Gas duct  Tube pore	- Butt seams	$\geq 0,5$	$h \leq 0.4 s$ , but max. 4 mm  $l \leq s$ , but max. 75 mm	$h \leq 0.3 s$ , but max. 3 mm  $l \leq s$ , but max. 50 mm	$h \leq 0.2 s$ , but max. 2 mm  $l \leq s$ , but max. 25 mm
			- Fillet welds	$\geq 0,5$	$h \leq 0.4 a$ , but max. 4 mm  $l \leq a$ , but max. 75 mm	$h \leq 0.3 a$ , but max. 3 mm  $l \leq a$ , but max. 50 mm	$h \leq 0.2 a$ , but max. 2 mm  $l \leq a$ , but max. 25 mm
2.7	202	Blowhole	-	$\geq 0,5$	Short irregularity permissible, but not up to the surface:  Butt seams: $h \leq 0.4 s$ , but max. 4 mm  Fillet welds: $h \leq 0.4 a$ , but max. 4 mm	Not permitted	Not permitted
2.8	2024	End crater blowhole	  The larger of the dimensions $h$ or $l$ is measured	0.5 to 3	$h \text{ or } l \leq 0.2 t$	Not permitted	Not permitted
				>3	$h \text{ or } l \leq 0.2 t$ , but max. 2 mm	Not permitted	Not permitted

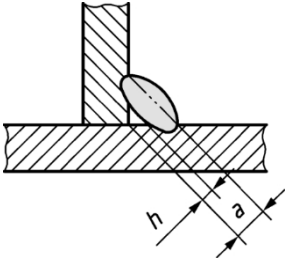
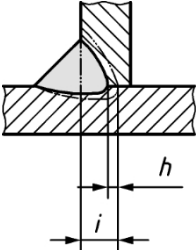
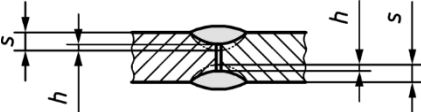
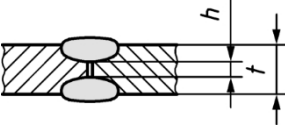
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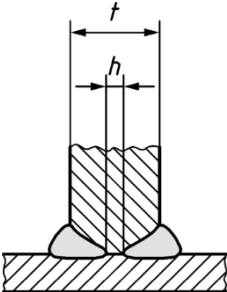
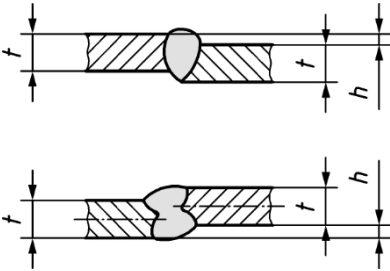


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					D	C	B
2.9	300	Fixed inclusion	- Butt seams	≥ 0,5	$h \leq 0.4 s$ , but max. 4 mm	$h \leq 0.3 s$ , but max. 3 mm	$h \leq 0.2 s$ , but max. 2 mm
	301	Slag inclusion			$l \leq s$ , but max. 75 mm	$l \leq s$ , but max. 50 mm	$l \leq s$ , but max. 25 mm
	302	Flux inclusion	- Fillet welds	≥ 0,5	$h \leq 0.4 a$ , but max. 4 mm	$h \leq 0.3 a$ , but max. 3 mm	$h \leq 0.2 a$ , but max. 2 mm
	303	Oxide inclusion			$l \leq a$ , but max. 75 mm	$l \leq a$ , but max. 50 mm	$l \leq a$ , but max. 25 mm
2.10	304	Metallic inclusion other than copper	- Butt seams	≥ 0,5	$h \leq 0.4 s$ , but max. 4 mm	$h \leq 0.3 s$ , but max. 3 mm	$h \leq 0.2 s$ , but max. 2 mm
			- Fillet welds	≥ 0,5	$h \leq 0.4 a$ , but max. 4 mm	$h \leq 0.3 a$ , but max. 3 mm	$h \leq 0.2 a$ , but max. 2 mm
2.11	3042	Copper inclusion	-	≥ 0,5	Not permitted	Not permitted	Not permitted
2.12	401	Binding error (incomplete binding)		≥ 0,5	Short irregularity permitted: Butt seams: $h \leq 0.4 s$ , but max. 4 mm Fillet welds: $h \leq 0.4 a$ but max. 4 mm	Not permitted	Not permitted
	4011	Edge binding error					
	4012	Layer bonding error					
	4013	Root binding error					

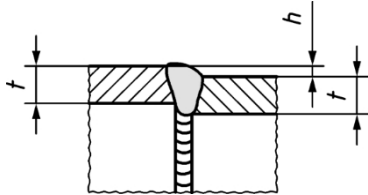
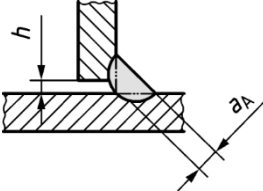
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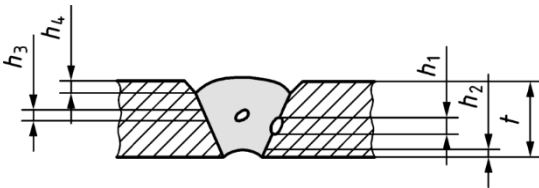
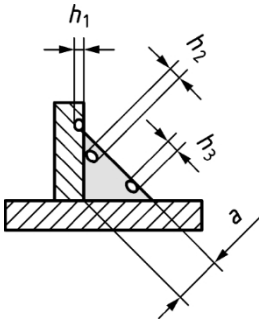
No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	$t$ mm	Limit values for irregularities in valuation groups		
					D	C	B
2.13	4021	Insufficient root fusion	 T-joint (fillet weld)	> 0,5	Short irregularity: $h \leq 0.2 a$ , but max. 2 mm	Not permitted	Not permitted
	402	Insufficient welding penetration	 T-joint (not fully welded)	$\geq 0,5$	Short irregularity: $h \leq 0.2 s$ or $h \leq 0.2 i$ , but max. 2 mm	Short irregularity: $h \leq 0.1 s$ or $h \leq 0.1 i$ , but max. 1.5 mm	Not permitted
			 Butt joint (not fully welded)				
			 Butt joint (through-welded)	$\geq 0,5$	Short irregularity: $h \leq 0.2 t$ , but max. 2 mm	Not permitted	Not permitted

No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	<i>t</i>  mm	Limit values for irregularities in valuation groups		
					D	C	B
			 T-joint (welded through)				
3 Irregularities in the seam geometry							
3.1	507	Edge offset	The limit values for the deviations refer to the perfect position. Unless otherwise specified, the perfect position is given if the center lines match (see also section 1). <i>t</i> refers to the smaller thickness.				
	5071	Edge offset for sheet metal	 Applies to sheet metal and hollow profiles with longitudinal welds	0.5 to 3  >3	$h \leq 0.25 t + 0.2 \text{ mm}$  $h \leq 0.25 t$ , but max. 5 mm	$h \leq 0.15 t + 0.2 \text{ mm}$  $h \leq 0.15 t$ , but max. 4 mm	$h \leq 0.1 t + 0.2 \text{ mm}$  $h \leq 0.1 t$ , but max. 3 mm

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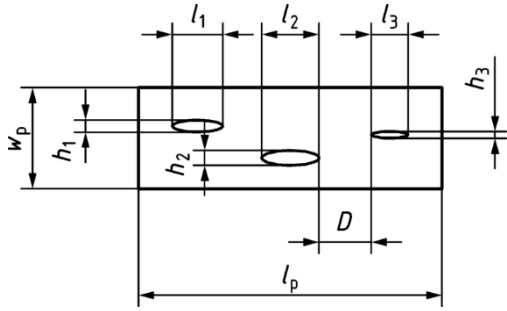
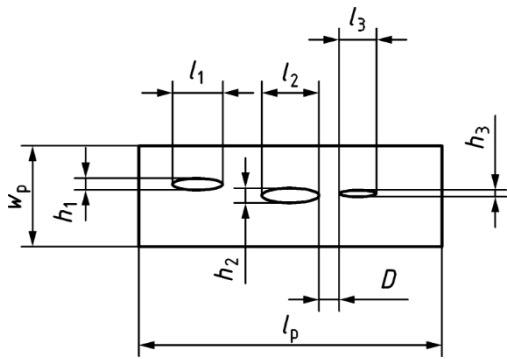
No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	$t$ mm	Limit values for irregularities in valuation groups		
					D	C	B
	5072	Edge offset for pipes	  Applies to pipes and hollow profiles with circumferential welds	$\geq 0,5$	$h \leq 0.5 t$ , but max. 4 mm	$h \leq 0.5 t$ , but max. 3 mm	$h \leq 0.5 t$ , but max. 2 mm
3.2	617	Poor fit with fillet welds	Distance between the parts to be joined. Distances that exceed the permissible limit may be compensated for in special cases by increasing the fillet weld thickness. 	0.5 to 3	$h \leq 0.1 a_A + 0.5 \text{ mm}$	$h \leq 0.1 a_A + 0.3 \text{ mm}$	$h \leq 0.1 a_A + 0.2 \text{ mm}$
				>3	$h \leq 0.3 a_A + 1 \text{ mm}$ , but max. 4 mm	$h \leq 0.2 a_A + 0.5 \text{ mm}$ , but max. 3 mm	$h \leq 0.1 a_A + 0.5 \text{ mm}$ , but max. 2 mm

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No.	Order no. according to ISO	Irregularity Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
4 Multiple irregularities							
4.1	None	Multiple irregularities in any cross-section that reduce the cross-section	502 Excessive seam camber, 503 Excessive seam camber, 504 Excessive root camber, 505 Rough seam transition, 506 Weld metal overflow, 512 Excessive unevenness in fillet welds and 5214 Excessive fillet weld thickness are excluded.   $h_1 + h_2 + h_3 + h_4 = \Sigma h$  $h_1 + h_2 + h_3 = \Sigma h$	0.5 to 3	Not permitted	Not permitted	Not permitted
				>3	Maximum total amount of irregularities: $\Sigma h \leq 0.4 t$ or $\leq 0.4 a$	Maximum total amount of irregularities: $\Sigma h \leq 0.3 t$ or $\leq 0.3 a$	Maximum total amount of irregularities: $\Sigma h \leq 0.2 t$ or $\leq 0.2 a$

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No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	t  mm	Limit values for irregularities in valuation groups		
					D	C	B
4.2	None	Imaging area or cross- sectional area in longitudinal direction	<p>Case 1 (<math>D &gt; l_3</math>)</p>  $h_1 \times l_1 + h_2 \times l_2 + h_3 \times l_3 = \sum h \times l$ <p>Case 2 (<math>D &lt; l_3</math>)</p>  $h_1 \times l_1 + h_2 \times l_2 + \frac{(h_2 + h_3)}{2} \times D + h_3 \times l_3 = \sum h \times l$	$\geq 0,5$	$\Sigma h \times l \leq 16 \%$	$\Sigma h \times l \leq 8 \%$	$\Sigma h \times l \leq 4 \%$



No.	Order no. according to ISO 6520-1	Irregularit y Designation	Remarks	<i>t</i>  mm	Limit values for irregularities in valuation groups		
					D	C	B
			<p>The sum of the surfaces <math>\Sigma h \times l</math> must be calculated as a percentage of the evaluation surface <math>lp \times wp</math> (case 1).</p> <p>If <math>D</math> is smaller than the smallest length of one of the neighboring irregularities, the full connection of two irregularities must be taken as the sum of the irregularities (case 2).</p> <p>For information see also Appendix A.</p>				

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## Appendix A (informative)

### Examples for determining the percentage (%) of porosity

Figure A.1 to Figure A.9 show different percentages of porosity. These should support the evaluation of porosity in projected surfaces (radiographic images) or in cross-sectional surfaces.



Figure A.1 - 1 % surface area, 15 pores,  $d = 1$  mm

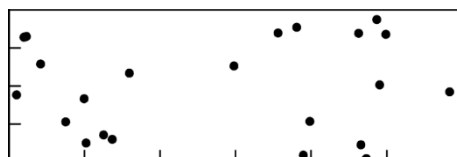


Figure A.2 - 1.5 % surface area, 23 pores,  $d = 1$  mm

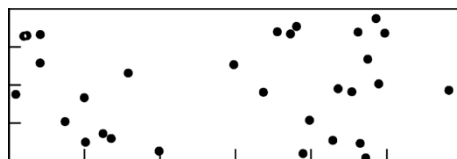


Figure A.3 - 2 % surface area, 30 pores,  $d = 1$  mm



Figure A.4 - 2.5 % surface area, 38 pores,  $d = 1$  mm



Figure A.5 - 3 % surface area, 45 pores,  $d = 1$  mm

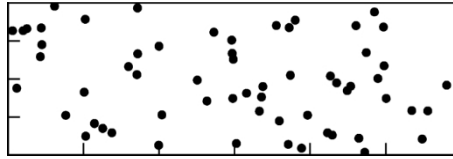


Figure A.6 - 4 % surface area, 61 pores,  $d = 1 \text{ mm}$

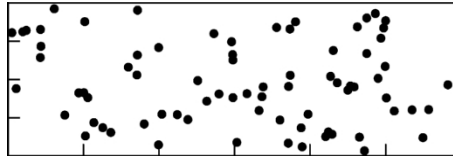


Figure A.7 - 5 % surface area, 76 pores,  $d = 1 \text{ mm}$

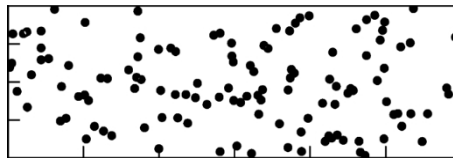


Figure A.8 - 8 % surface area, 122 pores,  $d = 1 \text{ mm}$

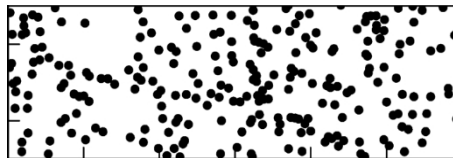


Figure A.9 - 16 % surface area, 244 pores,  $d = 1 \text{ mm}$

## Appendix B (informative)

### Additional criteria for welds in consideration of fatigue strength

#### B.1 General information

This annex contains additional criteria for compliance with the fatigue strength classes (FAT).

In several application areas, the codes refer to the mean value minus two standard deviations, which corresponds to a survival probability of 97.7%. Based on a survival probability of 95 % with a two-sided confidence level of the mean value of 75 % (one-sided 87.5 %, sometimes 95 %), the difference under stress is less than 2 %, taking into account the usual scatter of fatigue tests, and can therefore be neglected.

For weld seams under vibration load, the criteria from Table 1 should be supplemented in accordance with Section B.2 to Section B.5.

#### B.2 Valuation groups

The additional criteria for assessment groups B and C are to be adjusted to the limits for irregularities of FAT 90 for assessment group B specified as B90 and FAT 63 for assessment group C specified as C63.

Assessment group B125 represents FAT 125, which contains additional criteria for some irregularities of assessment group B. Assessment group B125 is generally not achieved by welding alone.

Fillet welds are not part of assessment group B125. Annex B does not apply to assessment group D.

Additional criteria do not apply to assessment group D.

NOTE Rating group C63 includes FAT 63 and lower, rating group B90 includes FAT 90 and lower, and rating group B125 includes FAT 125 and lower.

Table B.1 contains additional criteria for assessment groups C and B for welds subject to vibration. In the column for assessment group B125 additional criteria for assessment group B are given. If no restrictions are specified, assessment group B125 corresponds to assessment group B.

#### B.3 Smooth transition

For a soft seam transition in Table 1, the transition radius according to Table B.1, 1.12, must be applied.

## B.4 Butt and fillet welds that are not fully welded through

For butt and fillet welds that are not fully welded through, the design value for the weld penetration should be taken into account together with the limit values for irregularities so that they apply according to the assessment group.

NOTE If no values are available for the weld penetration, the limit values for the irregularities can be disregarded as long as the fatigue strength is influenced by a design-related root crack.

To apply the FAT to the evaluation groups, the penetration depth on the inside of the weld seam (root side), specified by information from the drawing, should be determined using suitable analysis methods and evaluated by inspection at a later date.

## B.5 Designation

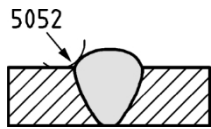
To indicate that the quality criteria also contain the criteria from Annex B, the characteristic FAT is also noted in the designation for assessment groups B and C.

EXAMPLE 1 ISO 5817-C63.

EXAMPLE 2 ISO 5817-B90.

EXAMPLE 3 ISO 5817-B125.

**Table B.1 - Additional criteria to Table 1 for welds under fatigue loading**

No.	Order no. according to ISO 6520-1	Irregularity Designation	$t$ mm	Limit values for irregularities in valuation groups		
				C 63c	B 90c	B 125
1.5	401	Microbinding error	$\geq 0,5$	a	a	a
1.7	5011 5012	Continuous single-edge notch Non-continuous single notch	$> 3$	a	a	Not permitted
1.8	5013	Root notch	$> 3$	a	a	Not permitted
1.9	502	Excessive seam camber (butt seam)	$\geq 0,5$	a	a	$h \leq 0.2 \text{ mm} + 0.1 b$ , max. 2 mm
1.10	503	Excessive seam camber (fillet weld)	$\geq 0,5$	a	a	b
1.11	504	Excessive root elevation	0.5 to 3 $> 3$	a a	a a	$h \leq 0.2 \text{ mm} + 0.05 b$ $h \leq 0.2 \text{ mm} + 0.05 b$ , but max. 1 mm
1.12	505	Rough seam transition, seam transition angle for fillet welds	$\geq 0,5$	a	a	a
-	5052	Rough seam transition, seam transition radius  	$> 3$	b	$r \geq 1 \text{ mm}$	$r \geq 4 \text{ mm}$

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**EN ISO 5817:2023 (D)**

No.	Order no. according to ISO 6520-1	Irregularity Designation	<i>t</i> mm	Limit values for irregularities in valuation groups		
				C <sup>63c</sup>	B <sup>90c</sup>	B 125
1.14	509 511	Lost weld metal Top layer arching	> 3	a	a	Not permitted
1.16	512	Excessive unevenness in fillet welds	≥ 0,5	a	a	b
1.17	515	Root relapse	> 3	a	a	Not permitted
1.23	602	Splash	≥ 0,5	a	a	Not permitted
2.3	2011 2012	Pore Porosity (evenly distributed)	≥ 0,5	a	a	Single layer: ≤ 1 % Multi-layer: ≤ 2 % <i>d</i> ≤ 0.1 <i>s</i> , max. 1 mm
2.4	2013	Pore nest	≥ 0,5	a	≤ 3 % <sup>d</sup> <i>d</i> ≤ 0.2 <i>s</i> , <i>d</i> ≤ 0.2 <i>a</i> , <i>d</i> ≤ 2.5 mm	≤ 2 % <sup>d</sup> <i>d</i> ≤ 0.1 <i>s</i> , max. 0.5 mm
2.5	2014	Pore line	≥ 0,5	a	a	Single layer: ≤ 1 % <sup>d</sup> Multi-layer: ≤ 2 % <sup>d</sup> <i>d</i> ≤ 0.1 <i>s</i> , max. 1 mm
2.6	2015 2016	Gas duct Tube pore	≥ 0,5	a	<i>h</i> ≤ 0.2 <i>s</i> or 0.2 <i>a</i> max. <i>h</i> = 2 mm as welded; max. <i>l</i> = 2.5 mm; low stress: <i>l</i> ≤ 20 mm	a
2.9	300 301 302 303	Fixed inclusion Slag inclusion Flux inclusion Oxide inclusion	≥ 0,5	a	<i>h</i> ≤ 0.2 <i>s</i> or 0.2 <i>a</i> max. <i>h</i> = 2 mm as welded; max. <i>l</i> = 2.5 mm low stress: <i>l</i> ≤ 20 mm	Not permitted

No.	Order no. according to ISO 6520-1	Irregularity Designation	$t$ mm	Limit values for irregularities in valuation groups		
				C <sup>63c</sup>	B <sup>90c</sup>	B 125
3.1	5071	Edge offset for sheet metal	$\geq 0,5$	a	$h \leq 0.1 t$ max. 3 mm	$h \leq 0.05 t$ max. 1.5 mm
	5072	Edge offset for pipes (applies to pipes and hollow profiles with circumferential welds)	$\geq 0,5$	a	$h \leq 0.5 t$ max. 1 mm	a
3.3	508	Angle offset	$\geq 0,5$	$\beta \leq 2^\circ$	$\beta \leq 1^\circ$	$\beta \leq 1^\circ$
<p>a Same values as for assessment groups B and C in Table 1.</p> <p>b Not specified.</p> <p>c Identical values according to IIW-Doc. XIII-2323-10 The values were tested by IIW for material thicknesses of 10 mm and above. They may also be used for smaller material thicknesses.</p> <p>d The limits for the irregularities correspond to the ratio between the sum of the different pore areas and the evaluated area. If the distance between two pore areas is smaller than the diameter of the smallest pore area, the surrounding envelope of the two pore areas is more decisive than the single area of irregularity. If the distance between two pores is smaller than the diameter of the neighboring pores, then the fully connected area of two pores is the sum of the two areas of irregularity.</p>						

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