INTERNATIONAL STANDARD

ISO 5817

Second edition
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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.

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 5817 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

This second edition cancels and replaces the first edition (ISO 5817:1992), which has been technically revised.

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 factory-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 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 the types of welded joint in a fabricated structure and not to the complete product or component itself. It is possible, therefore, that different quality levels be 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, test 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.

The need for detecting imperfections is not subject of this International Standard. 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, penetrate, magnetic particle testing and may need to be supplemented by requirements for inspection, examining and testing.

The values for imperfections take into consideration normal welding practice. Higher specifications require additional manufacturing processes, e.g. grinding or welding under stringent laboratory conditions or special welding processes.

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. For a complete listing consult www.iso.org.

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 above 0,5 mm.

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. The quality levels refer to production quality and not to the fitness-for-purpose (see 3.2) of the product manufactured.

This International Standard applies to:

— unalloyed and alloy steels;

— nickel and nickel alloys;

— titanium and titanium alloys;

— manual, mechanized and automatic welding;

— all welding positions;

— all types of welds, e.g. butt welds, fillet welds and branch connections;

— the following welding processes and their defined sub-processes in accordance with ISO 4063:

  — 11 metal-arc welding without gas protection;

  — 12 submerged-arc welding;

  — 13 gas-shielded metal-arc welding;

  — 14 gas-shielded welding with non-consumable 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2553:1992, *Welded, brazed and soldered joints — Symbolic representation on drawings*

ISO 4063:1998, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 6520-1:1998, *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 and size of selected imperfections

3.2
fitness-for-purpose
ability of a product, process or service to serve a defined purpose under specific conditions

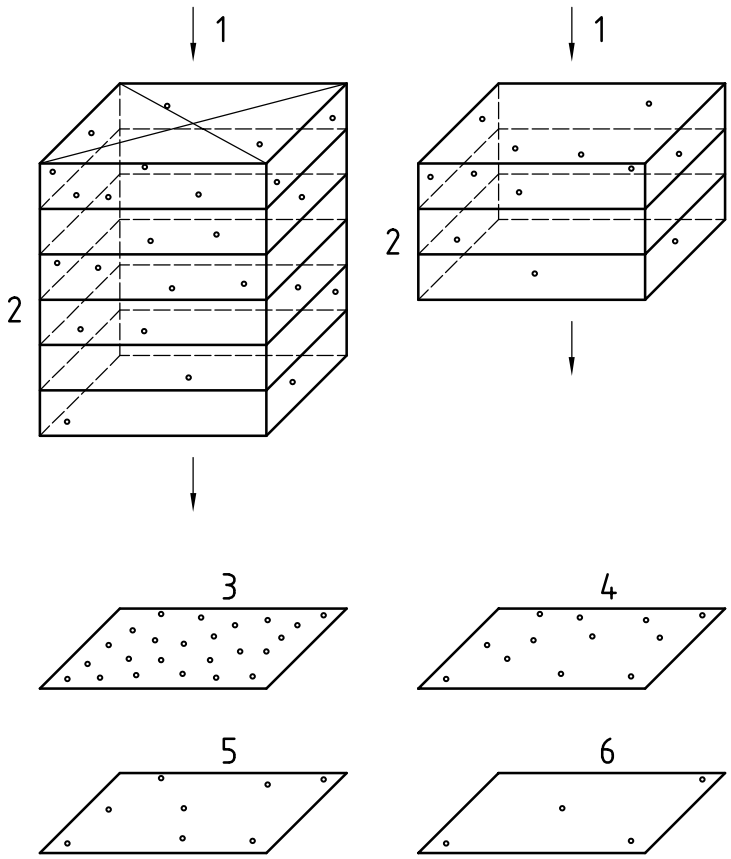
3.3
short imperfections
one or more imperfections of total length not greater than 25 mm in any 100 mm length of the weld or a maximum of 25 % of the weld length for a weld shorter than 100 mm, the range with most imperfections being applicable

3.4
systematic imperfection
imperfections that are distributed at regular distances in the weld over the weld lengths to be examined, the sizes of the single imperfections being within the limits of the imperfections given in Table 1

3.5
projected area
area where imperfections distributed along the volume of the weld under consideration are imaged two-dimensionally

In contrast to the surface crack area the occurrence of imperfections is dependent on the weld thickness when exposed radiographically (see Figure 1).

3.6
cross-section area
area to be considered after fracture or sectioning



Key

1	X-ray	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

The following symbols are used in Table 1.

- a nominal throat thickness of the fillet weld (see also ISO 2553)
- b width of weld reinforcement
- d diameter of pore
- h height or width of imperfection
- l length of imperfection in longitudinal direction of the weld
- l_p length of projected or cross-section 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 in case of fracture area
- z leg length of a fillet weld (see also ISO 2553)
- α angle of weld toe
- β angle of angular misalignment

5 Assessment of imperfections

Limits for 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, for the detection of imperfections, a method other than macro examination is used, only those imperfections shall be considered which can be detected using a magnification equal to or less than tenfold.

Excluded herefrom are cold laps (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 shall 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 multiple imperfections).

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.

Table 1 — Limits for imperfections

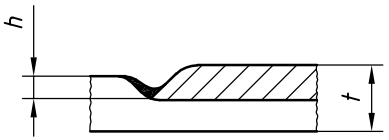
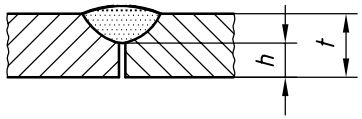
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1 Surface imperfections							
1.1	100	Crack	—	$\geqslant 0{,}5$	Not permitted	Not permitted	Not permitted
1.2	104	Crater crack	—	$\geqslant 0{,}5$	Not permitted	Not permitted	Not permitted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

Table 1 (*continued*)

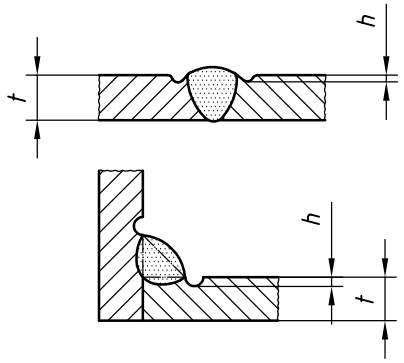
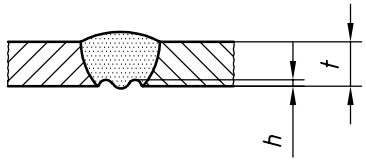
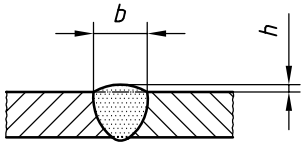
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1.7	5011 5012	Continuous undercut Intermittent undercut	Smooth transition is required. This is not regarded as a systematic imperfection. 	0,5 to 3	Short imperfections: $h \leqslant 0{,}2\ t$	Short imperfections: $h \leqslant 0{,}1\ t$	Not permitted
				> 3	$h \leqslant 0{,}2\ t$, but max. 1 mm	$h \leqslant 0{,}1\ t$, but max. 0,5 mm	$h \leqslant 0{,}05\ t$, but max. 0,5 mm
1.8	5013	Shrinkage groove	Smooth transition is required. 	0,5 to 3	$h \leqslant 0{,}2$ mm + $0{,}1\ t$	Short imperfections: $h \leqslant 0{,}1\ t$	Not permitted
				> 3	Short imperfections: $h \leqslant 0{,}2\ t$, but max. 2 mm	Short imperfections: $h \leqslant 0{,}1\ t$, but max.1 mm	Short imperfections: $h \leqslant 0{,}05\ t$, but max. 0,5 mm
1.9	502	Excess weld metal (butt weld)	Smooth transition is required. 	$\geqslant 0{,}5$	$h \leqslant 1$ mm + $0{,}25\ b$, but max. 10 mm	$h \leqslant 1$ mm + $0{,}15\ b$, but max. 7 mm	$h \leqslant 1$ mm + $0{,}1\ b$, but max. 5 mm

Table 1 (*continued*)

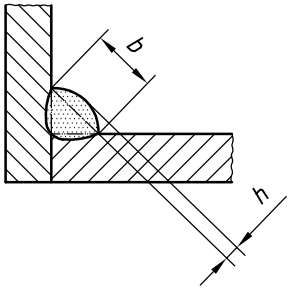
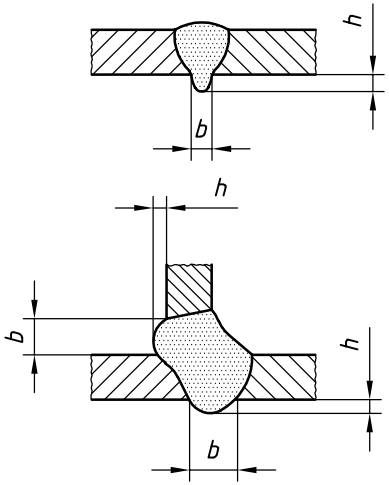
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1.10	503	Excessive convexity (fillet weld)		⩾ 0,5	$h \leqslant 1$ mm + 0,25 b, but max. 5 mm	$h \leqslant 1$ mm + 0,15 b, but max. 4 mm	$h \leqslant 1$ mm + 0,1 b, but max. 3 mm
1.11	504	Excess penetration		0,5 to 3	$h \leqslant 1$ mm + 0,6 b	$h \leqslant 1$ mm + 0,3 b	$h \leqslant 1$ mm + 0,1 b
				> 3	$h \leqslant 1$ mm + 1,0 b, but max. 5 mm	$h \leqslant 1$ mm + 0,6 b, but max. 4 mm	$h \leqslant 1$ mm + 0,2 b, but max. 3 mm

Table 1 (*continued*)

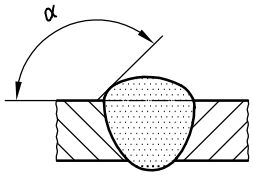
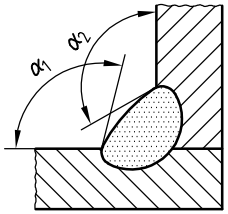
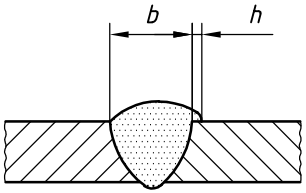
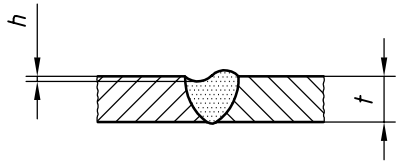
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1.12	505	Incorrect weld toe	— butt welds 	⩾ 0,5	$\alpha \geqslant 90°$	$\alpha \geqslant 110°$	$\alpha \geqslant 150°$
			— fillet welds  $\alpha_1 \geqslant \alpha$ $\alpha_2 \geqslant \alpha$	⩾ 0,5	$\alpha \geqslant 90°$	$\alpha \geqslant 110°$	$\alpha \geqslant 110°$
1.13	506	Overlap		⩾ 0,5	$h \leqslant 0{,}2\ b$	Not permitted	Not permitted
1.14	509 511	Sagging Incompletely filled groove	Smooth transition is required 	0,5 to 3	Short imperfections: $h \leqslant 0{,}25\ t$	Short imperfections: $h \leqslant 0{,}1\ t$	Not permitted
				> 3	Short imperfections: $h \leqslant 0{,}25\ t$ but max. 2 mm	Short imperfections: $h \leqslant 0{,}1\ t$ but max. 1 mm	Short imperfections: $h \leqslant 0{,}05\ t$ but max. 0,5 mm
1.15	510	Burn through	—	⩾ 0,5	Not permitted	Not permitted	Not permitted

Table 1 (*continued*)

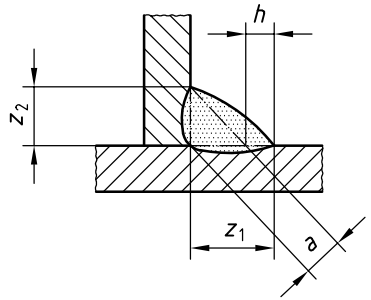
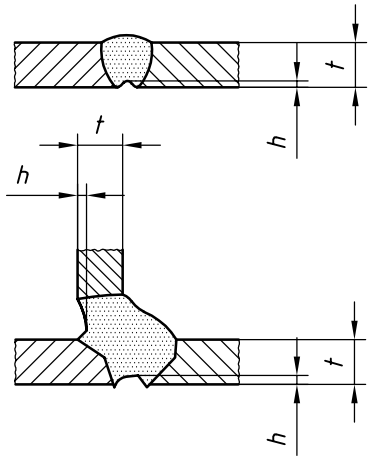
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1.16	512	Excessive asymmetry of fillet weld (excessive unequal leg length)	In cases where a symmetric fillet weld has not been prescribed. 	⩾ 0,5	$h \leqslant$ 2 mm + 0,2 a	$h \leqslant$ 2 mm + 0,15 a	$h \leqslant$ 1,5 mm + 0,15 a
1.17	515	Root concavity	Smooth transition is required. 	0,5 to 3	$h \leqslant$ 0,2 mm + 0,1 t	Short imperfections: $h \leqslant$ 0,1 t	Not permitted
				> 3	Short imperfections: $h \leqslant$ 0,2 t, but max. 2 mm	Short imperfections: $h \leqslant$ 0,1 t, but max. 1 mm	Short imperfections: $h \leqslant$ 0,05 t, but max. 0,5 mm
1.18	516	Root porosity	Spongy formation at the root of a weld due to bubbling of the weld metal at the moment of solidification (e. g. lack of gas backing)	⩾ 0,5	Locally permitted	Not permitted	Not permitted

Table 1 (*continued*)

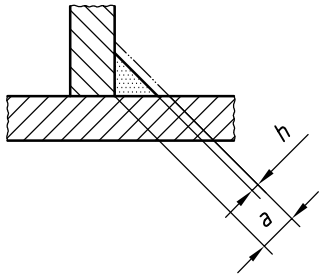
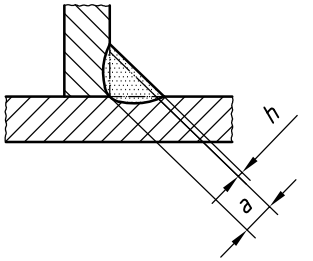
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
1.19	517	Poor restart	—	⩾ 0,5	Permitted. The limit depends on the type of imperfection occurred due to restart	Not permitted	Not permitted
1.20	5213	Insufficient throat thickness	Not applicable to processes with proof of greater depth of penetration 	0,5 to 3	Short imperfections: $h \leqslant 0{,}2$ mm + 0,1 a	Short imperfections: $h \leqslant 0{,}2$ mm	Not permitted
				> 3	Short imperfections: $h \leqslant 0{,}3$ mm + 0,1 a, but max. 2 mm	Short imperfections: $h \leqslant 0{,}3$ mm + 0,1 a, but max. 1 mm	Not permitted
1.21	5214	Excessive throat thickness	The actual throat thickness of the fillet weld is too large. 	⩾ 0,5	Unlimited.	$h \leqslant 1$ mm + 0,2 a, but max. 4 mm	$h \leqslant 1$ mm + 0,15 a, but max. 3 mm
1.22	601	Stray arc	—	⩾ 0,5	Permitted, if the properties of the parent metal are not affected.	Not permitted	Not permitted
1.23	602	Spatter	—	⩾ 0,5	Acceptance depends on application, e.g. material, corrosion protection		

Table 1 (*continued*)

No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
2 Internal imperfections							
2.1	100	Cracks	All types of crack except microcracks and crater cracks	$\geqslant$ 0,5	Not permitted	Not permitted	Not permitted
2.2	1001	Microcracks	A crack usually only visible under the microscope (50 ×)	$\geqslant$ 0,5	Permitted	Acceptance depends on type of parent metal with particular reference to crack sensitivity	
2.3	2011 2012	Gas pore Uniformly distributed porosity	The following conditions and limits for imperfections shall be fulfilled. See also Annex A for information.				
			a1) Maximum dimension of the area of the imperfections (inclusive of systematic imperfection) related to the projected area NOTE The porosity in the project area depends on the numbers of layers (volume of the weld).	$\geqslant$ 0,5	for single layer: $\leqslant$ 2,5 % for multi-layer: $\leqslant$ 5 %	for single layer: $\leqslant$ 1,5 % for multi-layer: $\leqslant$ 3 %	for single layer: $\leqslant$ 1 % for multi-layer: $\leqslant$ 2 %
			a2) Maximum dimension of the cross section area of the imperfections (inclusive of systematic imperfection) related to the fracture area (only applicable to production, welder or procedure tests)	$\geqslant$ 0,5	$\leqslant$ 2,5 %	$\leqslant$ 1,5 %	$\leqslant$ 1 %
			b) Maximum dimension for a single pore for — butt welds — fillet welds	$\geqslant$ 0,5	$d \leqslant 0{,}4\ s$, but max. 5 mm $d \leqslant 0{,}4\ a$, but max. 5 mm	$d \leqslant 0{,}3\ s$, but max. 4 mm $d \leqslant 0{,}3\ a$, but max. 4 mm	$d \leqslant 0{,}2\ s$, but max. 3 mm $d \leqslant 0{,}2\ a$, but max. 3 mm

Table 1 (*continued*)

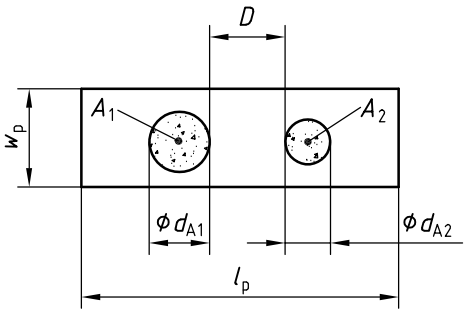
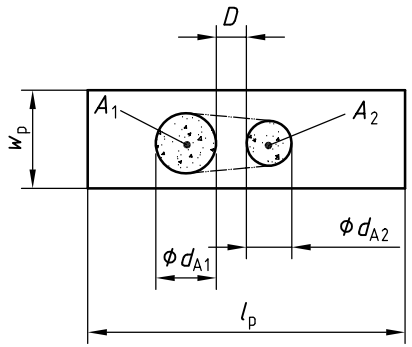
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
2.4	2013	Clustered (localized) porosity	case 1 ($D > d_{A2}$)  case 2 ($D < d_{A2}$)  The sum of the different pore areas ($A_1 + A_2 + ...$) related to the evaluation area $l_p \times w_p$ (case 1). Reference length for l_p is 100 mm. If D is less than d_{A1} or d_{A2}, whichever is smaller, an envelope surrounding the porosity areas $A_1 + A_2$ shall be considered as one area of imperfection (case 2).				

Table 1 (*continued*)

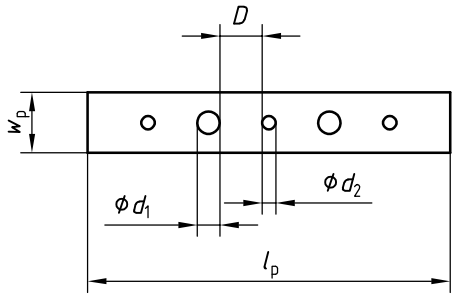
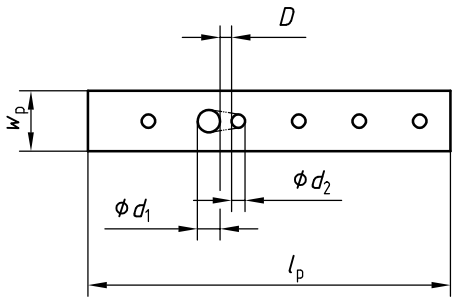
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
2.4	2013	Clustered (localized) porosity	The following dimension conditions and limits for imperfections shall be fulfilled. See also Annex A for information.				
			a) Maximum dimension of the summation of the projected area of the imperfection (inclusive of systematic imperfection)	$\geqslant 0{,}5$	$\leqslant$ 16 %	$\leqslant$ 8 %	$\leqslant$ 4 %
			b) Maximum dimension for a single pore for — butt welds — fillet welds	$\geqslant 0{,}5$	$d \leqslant 0{,}4\ s$, but max. 4 mm $d \leqslant 0{,}4\ a$, but max. 4 mm	$d \leqslant 0{,}3\ s$, but max. 3 mm $d \leqslant 0{,}3\ a$, but max. 3 mm	$d \leqslant 0{,}2\ s$, but max. 2 mm $d \leqslant 0{,}2\ a$, but max. 2 mm
2.5	2014	Linear porosity	case 1 ($D > d_2$)  case 2 ($D < d_2$)  				

Table 1 (*continued*)

No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels D	C	B
2.5	2014	Linear porosity	The sum of the different pore areas $\left(\frac{d_1^2 \times \pi}{4} + \frac{d_2^2 \times \pi}{4} + \dots\right)$ related to the evaluation area $l_p \times w_p$ (case 1). If D is smaller than the smaller diameter of one of the neighbouring pores, the full connected area of the two pores shall be applied to the sum of imperfections (case 2). The following conditions and limits for imperfections shall be fulfilled. See also Annex A for information.				
			a1) Maximum dimension of the area of the imperfections (inclusive of systematic imperfection) related to the projected area NOTE The porosity in the project area depends on the numbers of layers (volume of the weld).	$\geqslant$ 0,5	for single layer: $\leqslant$ 8 % for multi-layer: $\leqslant$ 16 %	for single layer: $\leqslant$ 4 % for multi-layer: $\leqslant$ 8 %	for single layer: $\leqslant$ 2 % for multi-layer: $\leqslant$ 4 %
			a2) Maximum dimension of the cross section area of the imperfections (inclusive of systematic imperfection) related to the fracture area (only applicable to production, welder or procedure tests)	$\geqslant$ 0,5	$\leqslant$ 8 %	$\leqslant$ 4 %	$\leqslant$ 2 %
			b) Maximum dimension for a single pore for — butt welds — fillet welds	$\geqslant$ 0,5	$d \leqslant 0{,}4\,s$, but max. 4 mm $d \leqslant 0{,}4\,a$, but max. 4 mm	$d \leqslant 0{,}3\,s$, but max. 3 mm $d \leqslant 0{,}3\,a$, but max. 3 mm	$d \leqslant 0{,}2\,s$, but max. 2 mm $d \leqslant 0{,}2\,a$, but max. 2 mm

Table 1 (*continued*)

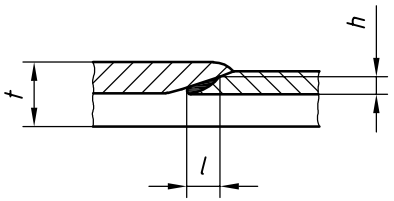
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
2.6	2015 2016	Elongated cavity Wormholes	— butt welds	$\geqslant 0{,}5$	$h \leqslant 0{,}4\ s$, but max. 4 mm $l \leqslant s$, but max. 75 mm	$h \leqslant 0{,}3\ s$, but max. 3 mm $l \leqslant s$, but max. 50 mm	$h \leqslant 0{,}2\ s$, but max. 2 mm $l \leqslant s$, but max. 25 mm
			— fillet welds	$\geqslant 0{,}5$	$h \leqslant 0{,}4\ a$, but max. 4 mm $l \leqslant a$, but max. 75 mm	$h \leqslant 0{,}3\ a$, but max. 3 mm $l \leqslant a$, but max. 50 mm	$h \leqslant 0{,}2\ a$, but max. 2 mm $l \leqslant a$, but max. 25 mm
2.7	202	Shrinkage cavity	—	$\geqslant 0{,}5$	Short imperfections permitted, but not breaking of the surfaces — butt welds: $h \leqslant 0{,}4\ s$, but max. 4 mm — fillet welds: $h \leqslant 0{,}4\ a$, but max. 4 mm	Not permitted	Not permitted
2.8	2024	Crater pipe	 The larger value of h or l will be measured	0,5 to 3 > 3	$h/l \leqslant 0{,}2\ t$ $h/l \leqslant 0{,}2\ t$, but max. 2 mm	Not permitted	Not permitted
2.9	300 301 302 303	Solid inclusions Slag inclusions Flux inclusions Oxide inclusions	— butt welds	$\geqslant 0{,}5$	$h \leqslant 0{,}4\ s$, but max. 4 mm $l \leqslant s$, but max. 75 mm	$h \leqslant 0{,}3\ s$, but max. 3 mm $l \leqslant s$, but max. 50 mm	$h \leqslant 0{,}2\ s$, but max. 2 mm $l \leqslant s$, but max. 25 mm
			— fillet welds	$\geqslant 0{,}5$	$h \leqslant 0{,}4\ a$, but max. 4 mm $l \leqslant a$, but max. 75 mm	$h \leqslant 0{,}3\ a$, but max. 3 mm $l \leqslant a$, but max. 50 mm	$h \leqslant 0{,}2\ a$, but max. 2 mm $l \leqslant a$, but max. 25 mm

Table 1 (*continued*)

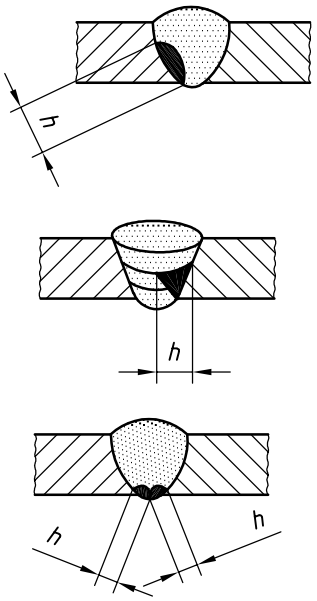
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
2.10	304	Metallic inclusions other than copper	— butt welds	$\geqslant 0{,}5$	$h \leqslant 0{,}4\ s$, but max. 4 mm	$h \leqslant 0{,}3\ s$, but max. 3 mm	$h \leqslant 0{,}2\ s$, but max. 2 mm
			— fillet welds	$\geqslant 0{,}5$	$h \leqslant 0{,}4\ a$, but max. 4 mm	$h \leqslant 0{,}3\ a$, but max. 3 mm	$h \leqslant 0{,}2\ a$, but max. 2 mm
2.11	3042	Copper inclusions	—	$\geqslant 0{,}5$	Not permitted	Not permitted	Not permitted
2.12	401	Lack of fusion (incomplete fusion)		$\geqslant 0{,}5$	Short imperfections permitted, but not breaking of the surfaces — butt welds: $h \leqslant 0{,}4\ s$, but max. 4 mm — fillet welds: $h \leqslant 0{,}4\ a$, but max. 4 mm	Not permitted	Not permitted
	4011	Lack of side wall fusion					
	4012	Lack of inter-run fusion					
	4013	Lack of root fusion					

Table 1 (*continued*)

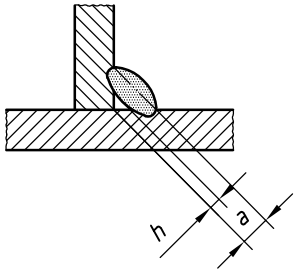
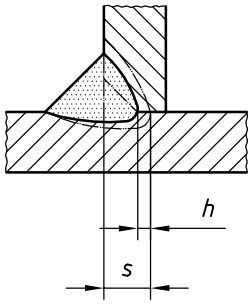
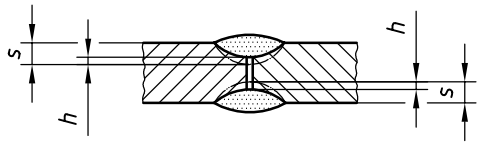
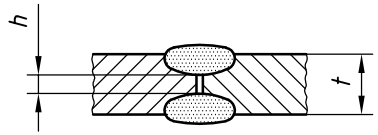
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
2.13	402	Lack of penetration	 T-joint (fillet weld)	> 0,5	Short imperfection: $h \leqslant 0{,}2\ a$, but max. 2 mm	Not permitted	Not permitted
			 T-joint (partial penetration)				
			 Butt joint (partial penetration)	⩾ 0,5	Short imperfections: — butt joint: $h \leqslant 0{,}2$ s, but max. 2 mm — T-joint: $h \leqslant 0{,}2$ a, but max. 2 mm	Short imperfections: — butt joint: $h \leqslant 0{,}1\ s$, but max. 1,5 mm — fillet joint: $h \leqslant 0{,}1\ a$, but max. 1,5 mm	Not permitted
			 Butt joint (full penetration)	⩾ 0,5	Short imperfection: $h \leqslant 0{,}2\ t$, but max. 2 mm	Not permitted	Not permitted

Table 1 (*continued*)

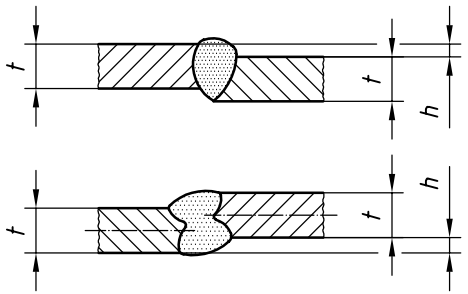
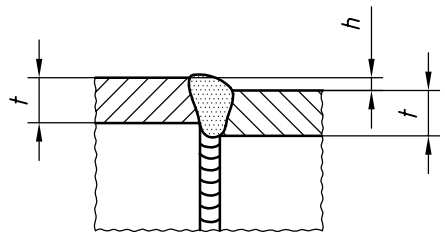
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
3 Imperfections in joint geometry							
3.1	507	Linear misalignment	The limits relate to deviations from the correct position. Unless otherwise specified, the correct position is that when the centrelines coincide (see also Clause 1). t refers to the smaller thickness. Linear misalignment within the given limits are not regarded as systematic imperfection (applicable to Figures A and B).	0,5 to 3	$h \leqslant 0{,}2$ mm + 0,25 t	$h \leqslant 0{,}2$ mm + 0,15 t	$h \leqslant 0{,}2$ mm + 0,1 t
			 Figure A: Plates and longitudinal welds	> 3	$h \leqslant 0{,}25\ t$, but max. 5 mm	$h \leqslant 0{,}15\ t$, but max. 4 mm	$h \leqslant 0{,}1\ t$, but max. 3 mm
			 Figure B: Circumferential welds	$\geqslant 0{,}5$	$h \leqslant 0{,}5\ t$, but max. 4 mm	$h \leqslant 0{,}5\ t$, but max. 3 mm	$h \leqslant 0{,}5\ t$, but max. 2 mm

Table 1 (*continued*)

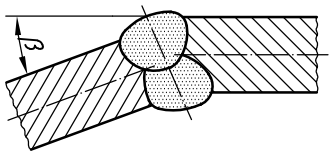
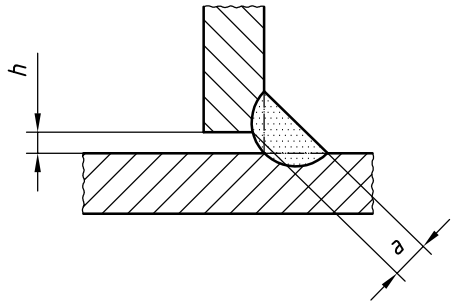
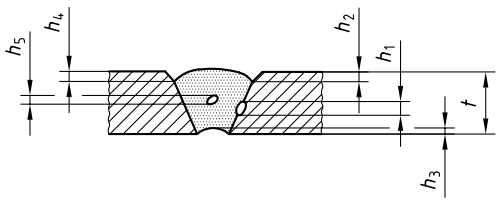
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
3.2	508	Angular misalignment		⩾ 0,5	$\beta \leqslant 4°$	$\beta \leqslant 2°$	$\beta \leqslant 1°$
3.3	617	Incorrect root gap for fillet welds	The limitation of Clause 5 as regards systematic imperfection does not apply. 	0,5 to 3	$h \leqslant 0,5$ mm + 0,1 a	$h \leqslant 0,3$ mm + 0,1 a	$h \leqslant 0,2$ mm + 0,1 a
				> 3	$h \leqslant 1$ mm + 0,3 a, but max. 4 mm	$h \leqslant 0,5$ mm + 0,2 a, but max. 3 mm	$h \leqslant 0,5$ mm + 0,1 a, but max. 2 mm
4 Multiple imperfections							
4.1	None	Multiple imperfections in any cross section [a] Cross section (macrograph) in the most unfavourable joint range	 $h_1 + h_2 + h_3 + h_4 + h_5 = \Sigma h$	0,5 to 3	Not permitted	Not permitted	Not permitted
				> 3	Maximum total height of imperfections $\Sigma h \leqslant 0,4\ t$ or $\leqslant 0,25\ a$	Maximum total height of imperfections $\Sigma h \leqslant 0,3\ t$ or $\leqslant 0,2\ a$	Maximum total height of imperfections $\Sigma h \leqslant 0,2\ t$ or $\leqslant 0,15\ a$

Table 1 (*continued*)

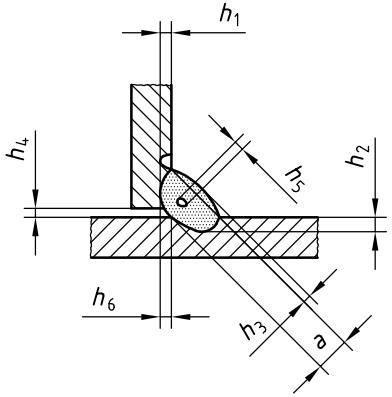
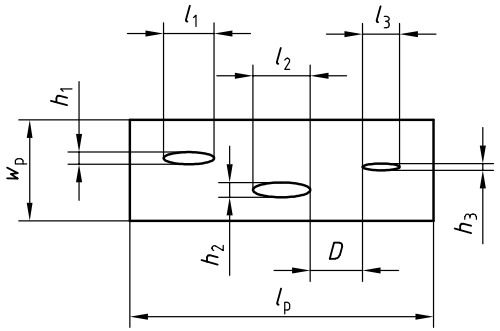
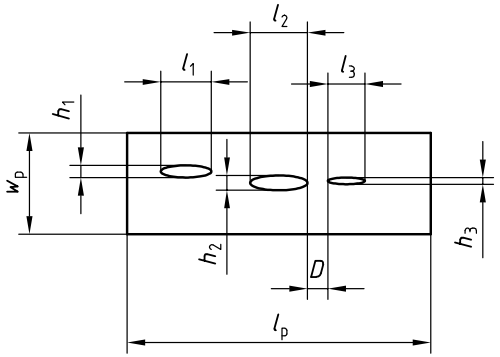
No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
4.1			 $h_1 + h_2 + h_3 + h_4 + h_5 = \Sigma h$				
4.2	None	Projected or cross-section area in longitudinal direction	case 1 ($D > l_3$)  $h_1 \times l_1 + h_2 \times l_2 + h_3 \times l_3 = \Sigma h \times l$				

Table 1 (*continued*)

No.	ISO 6520-1 reference	Imperfection designation	Remarks	t mm	Limits for imperfections for quality levels		
					D	C	B
4.2			case 2 ($D < l_3$)  $h_1 \times l_1 + h_2 \times l_2 + \left(\frac{h_2 + h_3}{2}\right) + D + h_3 \times l_3 = \Sigma h \times l$ The sum of the areas $\Sigma\ h \times l$ shall be calculated as a percentage to the evaluation area $l_p \times w_p$ (case 1). If D is smaller than the shorter length of one of the neighbouring imperfections, the full connection of the two imperfections shall be applied to the sum of imperfections (case 2). NOTE See also Annex A for information.	$\geqslant$ 0,5	$\Sigma\ h \times l \leqslant$ 16 %	$\Sigma\ h \times l \leqslant$ 8 %	$\Sigma\ h \times l \leqslant$ 4 %
a See Annex B.							

Annex A
(informative)

Examples for determination of percentage imperfections

The following figures give a presentation of different percentages of imperfection. This should assist the assessment of imperfections on radiographs and fracture surfaces.

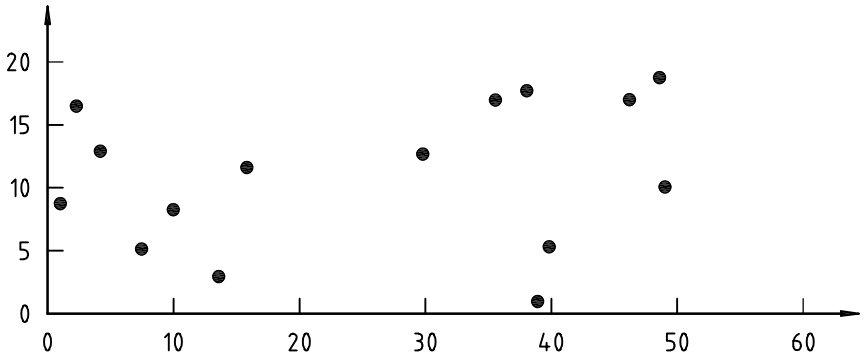


Figure A.1 — 1 surface percent, 15 pores, d = 1 mm

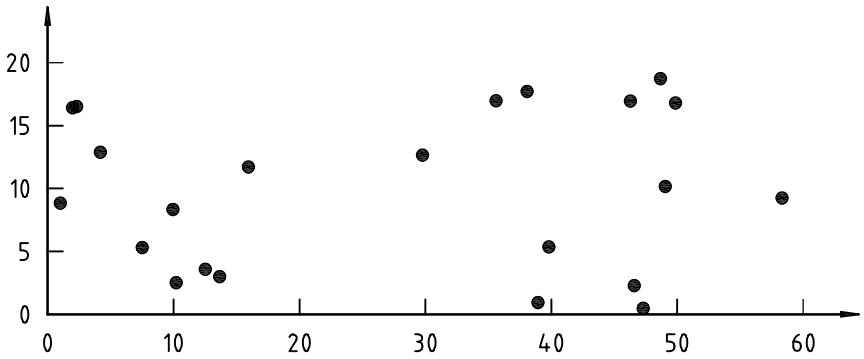


Figure A.2 — 1,5 surface percent, 23 pores, d = 1 mm

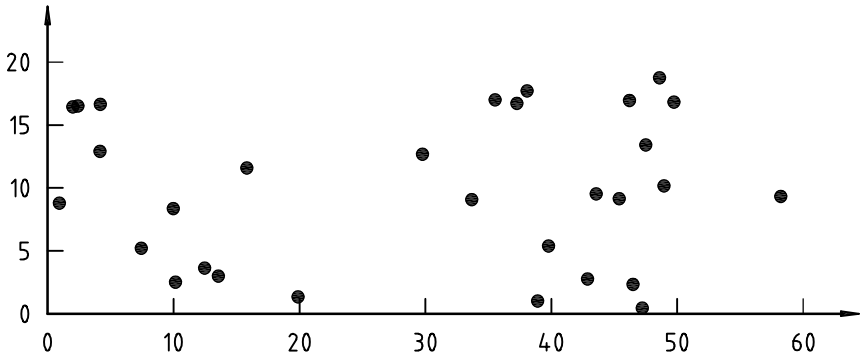


Figure A.3 — 2 surface percent, 30 pores, d = 1 mm

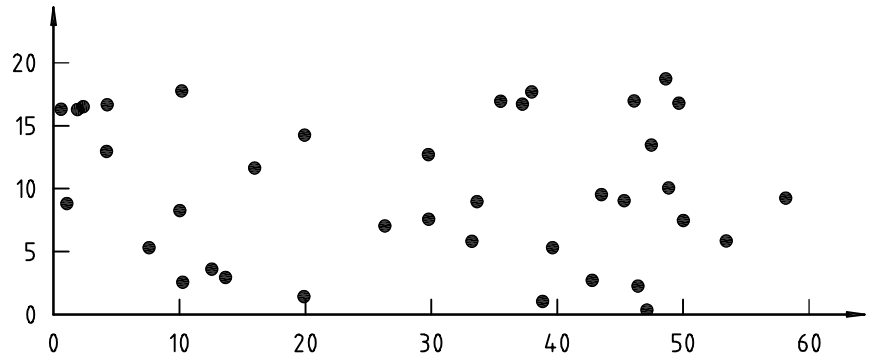


Figure A.4 — 2,5 surface percent, 38 pores, d = 1 mm

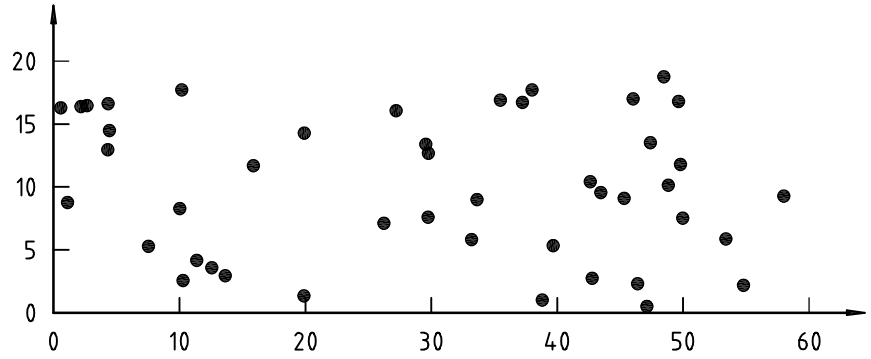


Figure A.5 — 3 surface percent, 45 pores, d = 1 mm

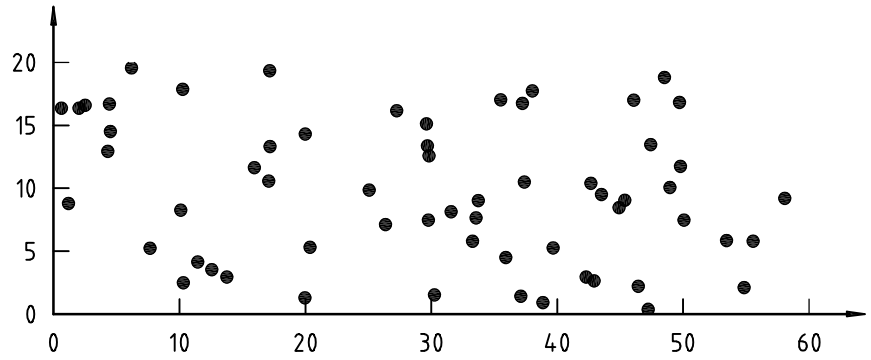


Figure A.6 — 4 surface percent, 61 pores, d = 1 mm

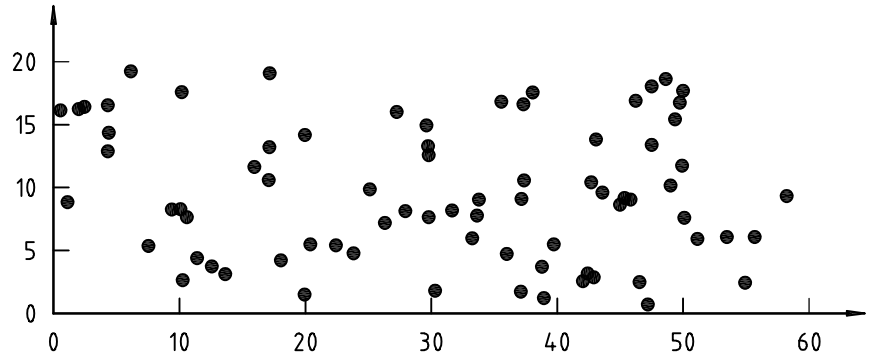


Figure A.7 — 5 surface percent, 76 pores, d = 1 mm

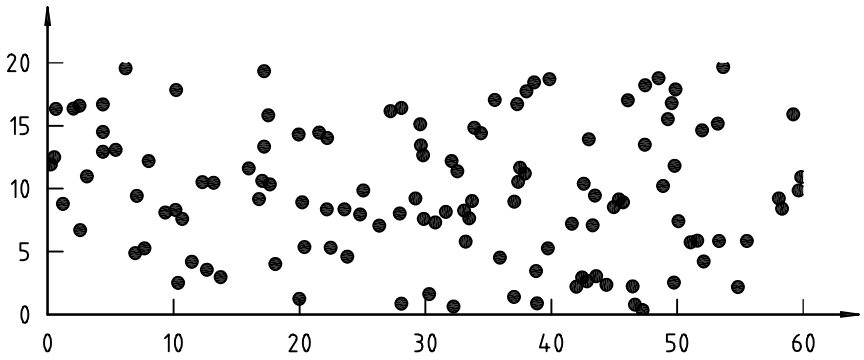


Figure A.8 — 8 surface percent, 122 pores, d = 1 mm

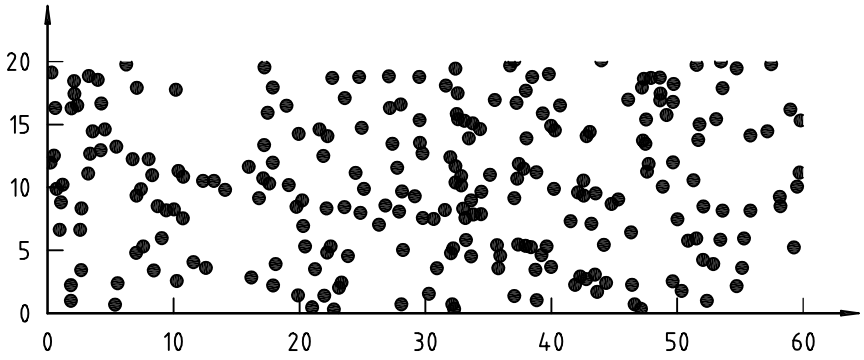


Figure A.9 — 16 surface percent, 244 pores, d = 1 mm

Annex B
(informative)

Additional information and guidelines for use of this International Standard

This International Standard specifies requirements for three quality levels for imperfections in welded joints of steel, nickel, titanium and their alloys for fusion welding processes (beam welding excluded) for weld thickness $\geqslant$ 0,5 mm. It may be used, where applicable, for other fusion welding processes or weld thicknesses.

Different components are very often produced for different applications, but to similar requirements. The same requirements should, however, apply to identical components produced in different workshops to ensure that work is carried out using the same criteria. The consistent application of this international Standard is one of the fundamental cornerstones of a quality management system for use in the production of welded structures.

The summary of multiple imperfections shows a theoretical possibility of superimposed individual imperfections. In such a case, the total summation of all permitted deviations shall be restricted by the stipulated values for the different imperfections, i.e., the limit value of a single imperfection $\leqslant h$, e.g., for a single pore, shall not be exceeded.

This International Standard may be used in conjunction with a catalogue of realistic illustrations showing the size of the permissible imperfections for the various quality levels, by means of photographs showing the face and root side and/or reproductions of radiographs and of photomacrographs showing the cross-section of the weld. An example of such a catalogue is given with “Reference radiographs for the assessment of weld imperfections in accordance with ISO 5817”, published by International Institute of Welding (IIW) and Deutscher Verlag für Schweißen und verwandte Verfahren, Düsseldorf. This catalogue may be used with reference cards to assess the various imperfections and may also be used when opinions differ as to the permissible size of imperfections.

Bibliography

[1] ISO 13919-1:1996, *Welding — Electron and laser-beam welded joints — Guidance on quality levels for imperfections — Part 1: Steel*

[2] ISO 17635, *Non-destructive examination of welds — General rules for fusion welds in metallic materials*

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