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ISO 10675-1

Third edition
2021-12

Non-destructive testing of welds — Acceptance levels for radiographic testing —

Part 1: Steel, nickel, titanium and their alloys

Essais non destructifs des assemblages soudés — Niveaux d'acceptation pour évaluation par radiographie —

Partie 1: Acier, nickel, titane et leurs alliages

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes,* Subcommittee SC 5, *Testing and inspection of welds,* 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 third edition cancels and replaces the second edition (ISO 10675-1:2016), which has been technically revised.

The main changes compared to the previous edition are as follows:

— new Table 1 added with abbreviations;

— old Table 1 has been split into Table 2 and Table 3;

— in Table 4 (former Table 2), acceptance levels for maximum permissible pore sizes of porosity, clustered porosity, linear porosity and for lack of fusion have been added;

— the acceptance levels in Clause 6 have been extended (General and tables);

— the captures of Figure B.1 to B.9 have been revised to conform with ISO 5817:2014;

— Figures C.1 and C.2 and the text have been revised to conform with ISO 5817:2014;

— the document has been editorially revised.

A list of all parts of the ISO 10675 series can be found on the ISO website.

Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Non-destructive testing of welds — Acceptance levels for radiographic testing —

Part 1: Steel, nickel, titanium and their alloys

1 Scope

This document specifies acceptance levels for indications from imperfections in butt welds of steel, nickel, titanium and their alloys detected by radiographic testing. If agreed, the acceptance levels can be applied to other types of welds (such as fillet welds, etc.) or materials.

The acceptance levels can be related to welding standards, application standards, specifications or codes. This document assumes that the radiographic testing has been carried out in accordance with ISO 17636-1 for RT-F (F = film) or ISO 17636-2 for RT-S (S = radioscopy) and RT-D (D = digital detectors).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

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

ISO 17636-1, *Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film*

ISO 17636-2, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5817 apply.

ISO and IEC maintain 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/

4 Symbols and abbreviations

For the purposes of this document, the symbols given in Table 1 apply

Table 1 — Symbols

A	is the sum of projected areas of indications related to each $L \times w_p$ in percentage (see Annex B)
b	is the width of excess penetration of weld, in millimetres
D	is the distance between indications
d	is the diameter of pore, in millimetres
d_A	is the diameter of area surrounding a group of gas holes (e.g. clustered porosity), in millimetres
h	is the width of indication, the width or height of surface or cross surface imperfection, in millimetres
l	is the length of indication, in millimetres (see also Figure C.3 and Figure C.4 for linear porosity)
L	is any 100 mm testing length, in millimetres (equivalent to l_p in ISO 5817)
s	is the nominal butt weld thickness, in millimetres (see also ISO 2553)
t	is the material thickness, in millimetres
w_p	is the width of the weld, in millimetres
$\sum l$	is the summary length of imperfections within L (indications shall not be divided into different ranges L)

5 Radiographic technique

Depending on the weld quality level, radiographic techniques class A or class B in accordance with ISO 17636-1 shall be used for RT-F as shown in Table 2 and radiographic techniques class A or class B in accordance with ISO 17636-2 shall be used for RT-S or RT-D as shown in Table 3.

Table 2 — Radiographic testing with film (RT-F)

Quality levels in accordance with ISO 5817	Testing techniques and classes in accordance with ISO 17636-1 for RT-F	Acceptance levels in accordance with this document
B	B	1
C	B[a]	2
D	A	3

[a] However, the minimum number of exposures for circumferential weld testing can correspond to the requirements of class A of ISO 17636-1.

Table 3 — Radiographic testing with radioscopy (RT-S) and radiographic testing with digital detectors (RT-D)

Quality levels in accordance with ISO 5817	Testing techniques and classes in accordance with ISO 17636-2 for RT-S and RT-D	Acceptance levels in accordance with this document
B	B	1
C	B[a]	2
D	A	3

[a] However, the minimum number of exposures for circumferential weld testing can correspond to the requirements of class A of ISO 17636-2.

6 General

Accessible areas of welded joints shall be visually tested in accordance with ISO 17637 and evaluated before radiographic testing. ISO 17635 provides information on the NDT for testing and evaluation of fusion welds in metallic materials. The IIW Reference radiographs[3] may be used for assessment of weld imperfections according to ISO 5817 with examples of weld imperfections and its evaluation.

The acceptance levels of this document are basically valid for evaluation of imperfections which cannot be detected and evaluated by visual testing (see Table 4). Surface imperfections (see Table 5; such as undercut and excessive penetration, surface damage, weld spatter, etc.) which cannot be evaluated by visual testing due to object geometry, but where the interpreter suspects that the ISO 5817 quality levels are not fulfilled, shall be subject to more specific testing for quantification.

When quantification of undercut and/or excessive penetration by radiographic testing is required, specific procedures using test exposures may be applied in order to establish a basis for approximate quantification in accordance with the requirements of ISO 5817. This shall be specified in the adopted specification/procedure.

When assessing whether a weld meets the requirements specified for a weld quality level, the sizes of imperfections permitted by this document are compared with the dimensions of indications revealed by a radiograph made of the weld.

7 Acceptance levels

The acceptance levels for indications are shown in Table 4 and Table 5. The types of imperfections are selected from ISO 5817 and specified in ISO 6520-1 (see Annex A).

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

Annex B supports the visual evaluation of porosity.

Indications shall not be divided into different ranges, L.

Table 4 — Acceptance levels for internal indications in butt welds

No.	Type of internal imperfections in accordance with ISO 6520-1	Acceptance level 3[a]	Acceptance level 2[a]	Acceptance level 1
1	Cracks (100)	Not permitted	Not permitted	Not permitted
2a	Porosity and gas pores (2012, 2011) Single layer	$A \leq 2{,}5$ % $d \leq 0{,}4s$, max. 5 mm $L = 100$ mm	$A \leq 1{,}5$ % $d \leq 0{,}3s$, max. 4 mm $L = 100$ mm	$A \leq 1$ % $d \leq 0{,}2s$, max. 3 mm $L = 100$ mm
2b	Porosity and gas pores (2012, 2011) Multilayer	$A \leq 5$ % $d \leq 0{,}4s$, max. 5 mm $L = 100$ mm	$A \leq 3$ % $d \leq 0{,}3s$, max. 4 mm $L = 100$ mm	$A \leq 2$ % $d \leq 0{,}2s$, max. 3 mm $L = 100$ mm
3[b]	Clustered (localized) porosity (2013)	$d_A \leq w_p$, max. 25 mm $d \leq 0{,}4s$, max. 5 mm	$d_A \leq w_p$, max. 20 mm $d \leq 0{,}3s$, max. 4 mm	$d_A \leq w_p/2$, max. 15 mm $d \leq 0{,}2s$, max. 3 mm
4[c]	Linear porosity (2014)	$l \leq s$, max. 75 mm $d \leq 0{,}4s$, max. 4 mm $L = 100$ mm	$l \leq s$, max. 50 mm $d \leq 0{,}3s$, max. 3 mm $L = 100$ mm	$l \leq s$, max. 25 mm $d \leq 0{,}2s$, max. 2 mm $L = 100$ mm
5[d]	Elongated cavities (2015) and wormholes (2016)	$h < 0{,}4s$, max. 4 mm $\sum l \leq s$, max. 75 mm $L = 100$ mm	$h < 0{,}3s$, max. 3 mm $\sum l \leq s$, max. 50 mm $L = 100$ mm	$h < 0{,}2s$, max. 2 mm $\sum l \leq s$, max. 25 mm $L = 100$ mm

[a] Acceptance levels 3 and 2 may be specified with suffix X, which denotes that all indications over 25 mm are unacceptable.

[b] See Figure C.1 and Figure C.2.

[c] See Figure C.3 and Figure C.4.

[d] See Figure C.5 and Figure C.6.

[e] If the length of the weld is below 100 mm, then the maximum length of indications shall not exceed 25 % of that weld length.

Table 4 *(continued)*

No.	Type of internal imperfections in accordance with ISO 6520-1	Acceptance level 3[a]	Acceptance level 2[a]	Acceptance level 1
6[e]	Shrinkage cavity (202) (other than crater pipes)	$h < 0{,}4s$, max. 4 mm $l \leq 25$ mm	Not permitted	Not permitted
7	Crater pipe (2024)	$h \leq 0{,}2t$, max. 2 mm $l \leq 0{,}2t$, max. 2 mm	Not permitted	Not permitted
8[d]	Slag inclusions (301), flux inclusions (302) and oxide inclusions (303)	$h < 0{,}4s$, max. 4 mm $\sum l \leq s$, max. 75 mm $L = 100$ mm	$h < 0{,}3s$, max. 3 mm $\sum l \leq s$, max. 50 mm $L = 100$ mm	$h < 0{,}2s$, max. 2 mm $\sum l \leq s$, max. 25 mm $L = 100$ mm
9	Metallic inclusions (304) (other than copper)	$l \leq 0{,}4s$, max. 4 mm	$l \leq 0{,}3s$, max. 3 mm	$l \leq 0{,}2s$, max. 2 mm
10	Copper inclusions (3042)	Not permitted	Not permitted	Not permitted
11[e]	Lack of fusion (401)	Not breaking the surface $l \leq 0{,}4$s, max. 4 mm Only intermittently and not breaking the surface $\sum l \leq 25$ mm, $L = 100$ mm	Not permitted	Not permitted
12[e]	Lack of penetration (402)	$\sum l \leq 25$ mm, $L = 100$ mm	Not permitted	Not permitted

[a] Acceptance levels 3 and 2 may be specified with suffix X, which denotes that all indications over 25 mm are unacceptable.

[b] See Figure C.1 and Figure C.2.

[c] See Figure C.3 and Figure C.4.

[d] See Figure C.5 and Figure C.6.

[e] If the length of the weld is below 100 mm, then the maximum length of indications shall not exceed 25 % of that weld length.

Table 5 — Acceptance levels for surface imperfections

No.	Type of surface imperfections in accordance with ISO 6520-1	Acceptance level 3[a]	Acceptance level 2[a]	Acceptance level 1
13	Crater cracks (104)	Not permitted	Not permitted	Not permitted
14a	Undercut, continuous and intermittent (5011,5012) $t > 3$ mm	Smooth transition is required $h \leq 0{,}2t$, max. 1 mm	Smooth transition is required $h \leq 0{,}1t$, max. 0,5 mm	Smooth transition is required $h \leq 0{,}05t$, max. 0,5 mm
14b[b]	Undercut, continuous and intermittent (5011,5012) 0,5 mm $\leq t \leq$ 3 mm	Smooth transition is required $l \leq 25$ mm, $h \leq 0{,}2t$	Smooth transition is required $l \leq 25$ mm, $h \leq 0{,}1t$	Smooth transition is required Not permitted

NOTE The acceptance levels are those specified for visual testing. These defects are normally evaluated by visual testing.

[a] Acceptance levels 3 and 2 can be specified with suffix X, which denotes that all indications over 25 mm are unacceptable.

[b] If the length of the weld is below 100 mm, then the maximum length of indications shall not exceed 25 % of that weld length.

Table 5 *(continued)*

No.	Type of surface imperfections in accordance with ISO 6520-1	Acceptance level 3[a]	Acceptance level 2[a]	Acceptance level 1
15a[b]	Shrinkage groove (root undercut 5013) $t > 3$ mm	Smooth transition is required $l \leq 25$ mm, $h \leq 0{,}2t$, max. 2 mm	Smooth transition is required $l \leq 25$ mm, $h \leq 0{,}1t$, max. 1 mm	Smooth transition is required $l \leq 25$ mm, $h \leq 0{,}05t$, max. 0,5 mm
15b[b]	Shrinkage groove (root undercut 5013) 0,5 mm ≤ $t \leq 3$ mm	Smooth transition is required $h \leq 0{,}2$ mm + $0{,}1t$	Smooth transition is required $l \leq 25$ mm, $h \leq 0{,}1t$	Smooth transition required Not permitted
16a	Excess penetration (504) 0,5 mm ≤ $t \leq 3$ mm	$h \leq 1$ mm + $0{,}6b$	$h \leq 1$ mm + $0{,}3b$	$h \leq 1$ mm + $0{,}1b$
16b	Excess penetration (504) $t > 3$ mm	$h \leq 1$ mm + $1{,}0b$, max. 5 mm	$h \leq 1$ mm + $0{,}6b$, max. 4 mm	$h \leq 1$ mm + $0{,}2b$, max. 3 mm
17	Stray arc (601)	Permitted, if the properties of the parent metal are not affected.	Not permitted	Not permitted
18	Spatter (602)	Acceptance depends on application, e.g. material, corrosion protection.		
19a[b]	Root concavity (515) 0,5 mm ≤ $s \leq 3$ mm	$h \leq 0{,}2$ mm + $0{,}1t$	$l \leq 25$ mm, $h \leq 0{,}1t$	Not permitted
19b[b]	Root concavity (515) $s > 3$ mm	$l \leq 25$ mm, $h \leq 0{,}2t$, max. 2 mm	$l \leq 25$ mm, $h \leq 0{,}1t$, max. 1 mm	$l \leq 25$ mm, $h \leq 0{,}05t$, max. 0,5 mm
20	Poor restart (517) $s \geq 0{,}5$ mm	Permitted, The limit depends on the type of imperfection (see ISO 5817).	Not permitted	Not permitted
21a[b]	Sagging (509) Incompletely filled groove (511) 0,5 mm ≤ $s \leq 3$ mm	$l \leq 25$ mm, $h \leq 0{,}25t$	$l \leq 25$ mm, $h \leq 0{,}1t$	Not permitted
21b[b]	Sagging (509) Incompletely filled groove (511) $s > 3$ mm	$l \leq 25$ mm, $h \leq 0{,}25t$, max. 2 mm	$l \leq 25$ mm, $h \leq 0{,}1t$, max. 1 mm	$l \leq 25$ mm, $h \leq 0{,}05t$, max. 0,5 mm
22a	Linear misalignment (507) 0,5 mm ≤ $s \leq 3$ mm	$h \leq 0{,}2$ mm + $0{,}25t$	$h \leq 0{,}2$ mm + $0{,}15t$	$h \leq 0{,}2$ mm + $0{,}1t$
22b	Linear misalignment, longitudinal welds (507) $s > 3$ mm	$h \leq 0{,}25t$, max. 5 mm	$h \leq 0{,}15t$, max. 4 mm	$h \leq 0{,}1t$, max. 3 mm
22c	Linear misalignment, circumferential welds (507) $s \geq 0{,}5$ mm	$h \leq 0{,}5\ t$, max. 4 mm	$h \leq 0{,}5\ t$, max. 3 mm	$h \leq 0{,}5\ t$, max. 2 mm

NOTE The acceptance levels are those specified for visual testing. These defects are normally evaluated by visual testing.

[a] Acceptance levels 3 and 2 can be specified with suffix X, which denotes that all indications over 25 mm are unacceptable.

[b] If the length of the weld is below 100 mm, then the maximum length of indications shall not exceed 25 % of that weld length.

Annex A
(informative)

Guidance to the limitations of radiographic testing

A.1 General

The numbers between brackets conform to those used in ISO 6520-1.

A.2 Volumetric imperfections in butt welds

— Porosities and gas pores (2011, 2012, 2013, 2014 and 2017)

— Wormholes and elongated cavities (2016 and 2015)

— Shrinkage, crater pipe (202, 2024)

— Solid inclusions (300)

— Copper inclusions (3042)

The above imperfections listed in Table 4 and Table 5 are readily detected using radiographic techniques class A or class B of ISO 17636-1 for RT-F as shown in Table 2, or ISO 17636-2 for RT-S or RT-D as shown in Table 3.

A.3 Cracks in butt welds

— Crater cracks (104)

— Cracks (100)

The detectability of cracks by radiographic testing depends on the crack height, the ramification (presence of branching parts), opening width, direction of the X-ray beam to crack orientation and radiographic technique parameters.

Reliable detection of all cracks is therefore limited. The use of radiographic techniques class B or better, as specified in ISO 17636-1 or ISO 17636-2, provide better crack detectability than radiographic techniques class A.

A.4 Planar imperfections in butt welds

— Lack of fusion (401)

— Lack of penetration (402)

The detection of lack of fusion and lack of penetration depends on characteristics of imperfections and radiographic technique parameters.

Lack of side wall fusion is probably not be detected (except it is associated with other imperfections such as slag inclusions), unless it is radiographed in the direction of the side wall.

Annex B
(informative)

Examples for determination of area percentage (%) of imperfections

Figure B.1 to Figure B.9 give a presentation of different area percentage (%) of imperfections in an area of 60 mm × 20 mm. This should assist the assessment of imperfections on radiographs.

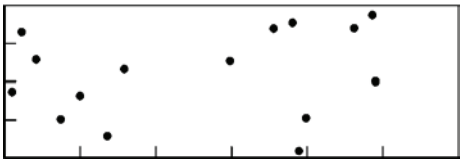


Figure B.1 — A =1 %, d = 1 mm, 15 pores

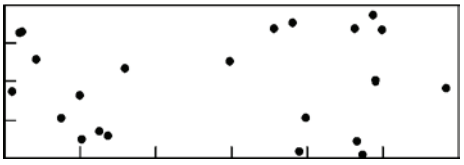


Figure B.2 — A = 1,5 %, d = 1 mm, 23 pores

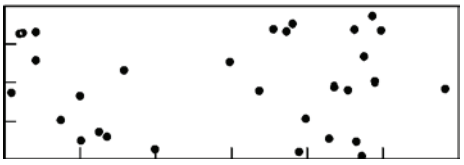


Figure B.3 — A = 2 %, d = 1 mm, 30 pores

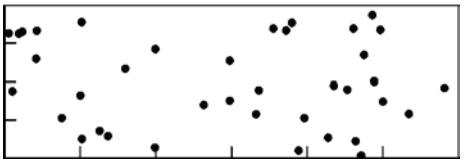


Figure B.4 — A = 2,5 %, d = 1 mm, 38 pores

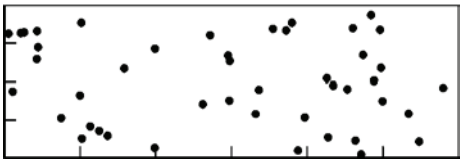


Figure B.5 — A = 3 %, d = 1 mm, 45 pores

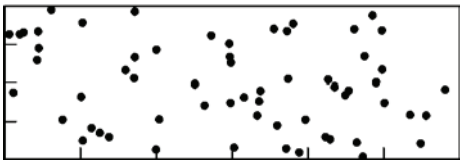


Figure B.6 — A = 4 %, d = 1 mm, 61 pores

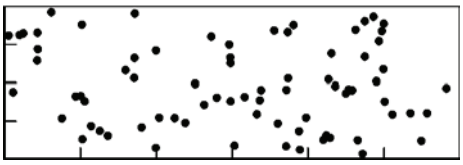


Figure B.7 — A = 5 %, d = 1 mm, 76 pores

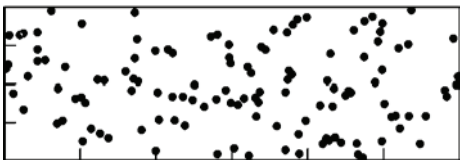


Figure B.8 — A =8 %, d = 1 mm, 122 pores

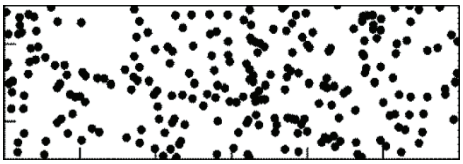


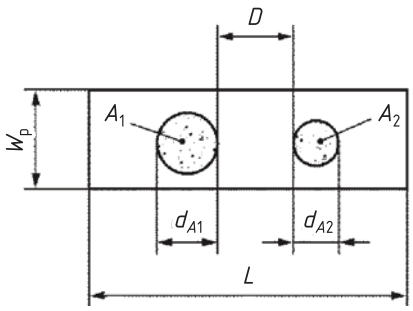
Figure B.9 — A = 16 %, d = 1 mm, 244 pores

NOTE Figures B.1 to B.9 correspond to ISO 5817:2014, Figures A.1 to A.9. The figures have been generated with a random generator for the pore position and sometimes pores overlap, resulting in fewer countable pores than expected.

Annex C
(informative)

Calculation of the sum of acceptable areas

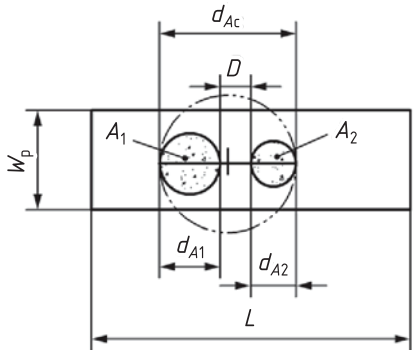
C.1 Clustered porosity



Key

A_1 area of clustered porosity indication 1
A_2 area of clustered porosity indication 2
d_{A1} diameter of A_1
d_{A2} diameter of A_2
D distance between indications
w_p width of the weld
L any 100 mm testing length

Figure C.1 — Clustered porosity, $D \geq d_{A2}$



Key

A_1 area of clustered porosity indication 1
A_2 area of clustered porosity indication 2
d_{A1} diameter of A_1
d_{A2} diameter of A_2
d_{Ac} diameter of circle, surrounding all gas pores
D distance between indications
w_p width of the weld
L any 100 mm testing length

Figure C.2 — Clustered porosity, $D < d_{A2}$

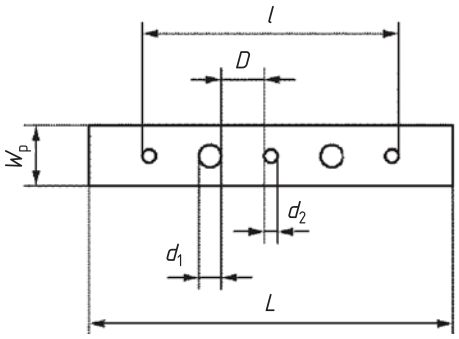
The total gas pore area within the cluster is represented by a circle of diameter, $d_{Ac,}$ surrounding all the gas pores.

The requirement for a single gas pore shall be met by all the gas pores within this circle. A permitted porous area shall be local. The possibility of the pore cluster masking other imperfections shall be taken into consideration.

If D is less than d_{A1} or d_{A2}, whichever is smaller, then the total gas pore area is represented by a circle of diameter d_{Ac}, where $d_{Ac} = d_{A1} + d_{A2} + D$.

Systematic clustered porosity is not permitted. d_A corresponds to d_{A1}, d_{A2} or d_{Ac}, whichever is applicable.

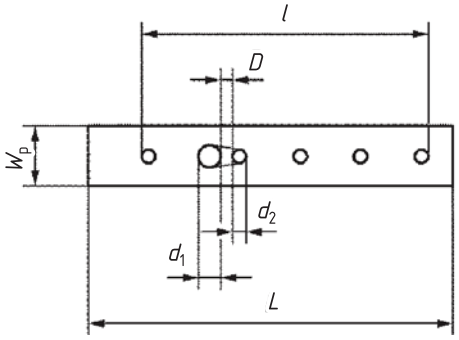
C.2 Linear porosity and gas holes (pores)



Key

d_1 diameter of pore indication 1
d_2 diameter of pore indication 2
D distance between indications
l length of indication
L any 100 mm testing length
w_p width of the weld

Figure C.3 — Linear porosity and gas holes (pores), $D \geq d_2$



Key

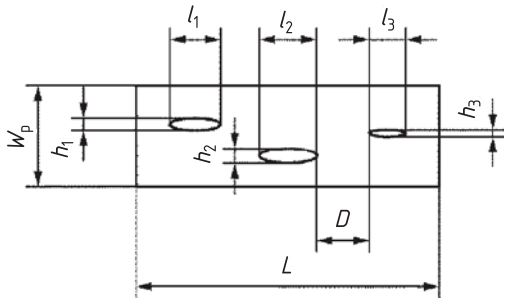
d_1 diameter of pore indication 1
d_2 diameter of pore indication 2
D distance between indications
l length of indication
L any 100 mm testing length
w_p width of the weld

Figure C.4 — Linear porosity and gas holes (pores), $D < d_2$

The sum of the different pore areas related to the evaluation area, $L \times w_p$ (see Figure C.3), shall be calculated.

If D is smaller than the smaller diameter of one of the neighbouring pores, the full connected area of the two pores shall be taken into the sum of imperfections (see Figure C.4).

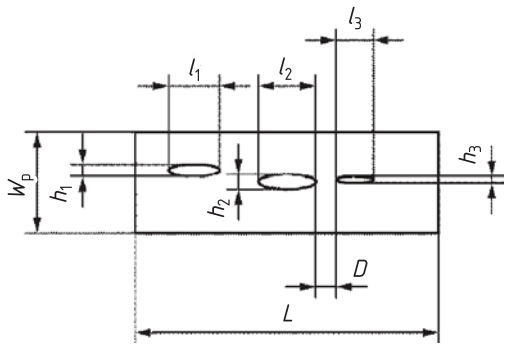
C.3 Elongated cavities and wormholes



Key

l_1 length of cavity indication 1
l_2 length of cavity indication 2
l_3 length of cavity indication 3
h_1 height of cavity indication 1
h_2 height of cavity indication 2
h_3 height of cavity indication 3
D distance between indications
L any 100 mm testing length
w_p width of the weld

Figure C.5 — Elongated cavities and wormholes, $D > l_3$



Key

l_1 length of cavity indication 1
l_2 length of cavity indication 2
l_3 length of cavity indication 3
h_1 height of cavity indication 1
h_2 height of cavity indication 2
h_3 height of cavity indication 3
D distance between indications
L any 100 mm testing length
w_p width of the weld

Figure C.6 — Elongated cavities and wormholes, $D < l_3$

The sum of the length of indications, Σl, shall be determined for each testing length, L (see Figure C.5).

If *D* is smaller than the shorter length of one of the neighbouring imperfections, the full connection of the two imperfections is to be taken into the sum of imperfections (see Figure C.6).

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