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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

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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).

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

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*.

This second edition cancels and replaces the first edition (ISO 10675-1:2008), which has been technically revised.

Requests for official interpretations of any aspect of this document should be directed to the Secretariat of ISO/TC 44/SC 5 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

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

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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 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 and ISO 17636-2.

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

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

No terms and definitions are listed in this document.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

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4 Radiographic technique

Welded joints shall be visually tested and evaluated in accordance with ISO 17637 before radiographic testing.

Depending on the weld quality level, radiographic technique A or B in accordance with ISO 17636-1 or ISO 17636-2 shall be used, as shown in Table 1.

Table 1 — Radiographic testing

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

[a] However, the minimum number of exposure for circumferential weld testing may correspond to the requirements of class A of ISO 17636-1 or ISO 17636-2.

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.

5 Acceptance levels

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

The acceptance levels for indications are shown in Table 2 and Table 3. The types of imperfections are selected from ISO 5817 and defined in ISO 6520-1.

The symbols used in Table 2 and Table 3 are the following:

— l length of indication, in millimetres;

— s nominal butt weld thickness, in millimetres;

— t base material thickness, in millimetres;

— L any 100 mm testing length;

— w_p width of the weld, in millimetres;

— h width of indication, the width or height of surface imperfection, in millimetres;

— d diameter of pore, in millimetres;

— d_A diameter of pore envelope area;

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— b width of excess penetration of weld, in millimetres;

— A sum of projected areas of indications related to each $L \times w_p$, in % (see Annex B);

— Σl summary length of imperfections within L, in millimetres (indications shall not be divided into different ranges L).

Table 2 — 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 $L = 100$ mm	$d_A \leq w_p$, max. 20 mm $L = 100$ mm	$d_A \leq w_p/2$, max. 15 mm $L = 100$ mm
4	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 $\Sigma l \leq s$, max. 75 mm $L = 100$ mm	$h < 0{,}3s$, max. 3 mm $\Sigma l \leq s$, max. 50 mm $L = 100$ mm	$h < 0{,}2s$, max. 2 mm $\Sigma l \leq s$, max. 25 mm $L = 100$ mm
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 $\Sigma l \leq s$, max. 75 mm $L = 100$ mm	$h < 0{,}3s$, max. 3 mm $\Sigma l \leq s$, max. 50 mm $L = 100$ mm	$h < 0{,}2s$, max. 2 mm $\Sigma l \leq s$, 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)	Permitted, but only intermittently and not breaking the surface $\Sigma l \leq 25$ mm, $L = 100$ mm	Not permitted	Not permitted
12[e]	Lack of penetration (402)	$\Sigma l \leq 25$ 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 (normative).

[c] See Figure C.3 and Figure C.4 (normative).

[d] See Figure C.5 and Figure C.6 (normative).

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

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Table 3 — 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, continues 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	Undercut, continues and intermittent (5011,5012) 0,5 mm ≤ t ≤ 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
15a	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	Shrinkage groove (root undercut 5013) 0,5 mm ≤ t ≤ 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 ≤ 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	Root concavity (515) 0,5 mm ≤ s ≤ 3 mm	$h \leq 0{,}2$ mm + $0{,}1t$	$l \leq 25$ mm, $h \leq 0{,}1t$	Not permitted
19b	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	Sagging (509) Incompletely filled groove (511) 0,5 mm ≤ s ≤ 3 mm	$l \leq 25$ mm, $h \leq 0{,}25t$	$l \leq 25$ mm, $h \leq 0{,}1t$	Not permitted
21b	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 ≤ 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 defined for visual testing. These defects are normally evaluated by visual testing.

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

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Annex A
(informative)

Guide to the limitations of radiographic testing

A.1 General

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

A.2 Volumetric imperfections in butt welds

— Porosities and gas pores (2011, 2013, 2015 and 2017)

— Wormholes and elongated cavities (2016 and 2015)

— Solid inclusions (300)

— Copper inclusions (3042)

The above imperfections listed in Table 2 will be readily detected using radiographic technique A or B of ISO 17636-1 or ISO 17636-2 as shown in Table 1.

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 technique B or better, as specified in ISO 17636-1 or ISO 17636-2, will provide better crack detectability than radiographic technique 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 will 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.

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Annex B
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Examples for determination of area percentage (%) of imperfections

Figure B.1 to Figure B.9 give a presentation of different area percentage (%) of imperfections. This should assist the assessment of imperfections on radiographs and fracture surfaces.

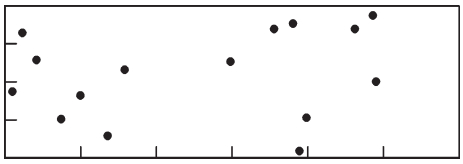

Figure B.1 — A = 1 %

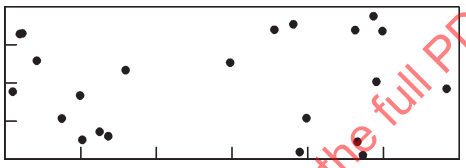

Figure B.2 — A = 1,5 %

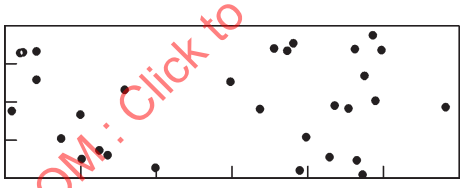

Figure B.3 — A = 2 %

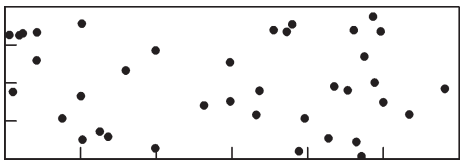

Figure B.4 — A = 2,5 %

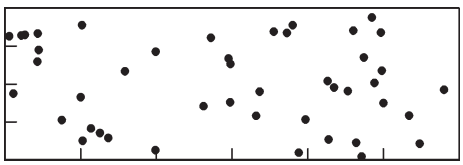

Figure B.5 — A = 3 %

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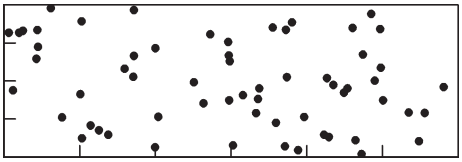

Figure B.6 — A = 4 %

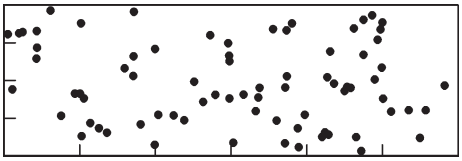

Figure B.7 — A = 5 %

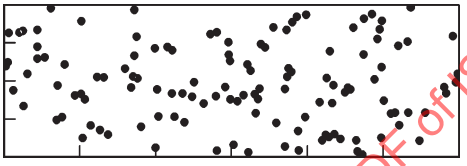

Figure B.8 — A = 8 %

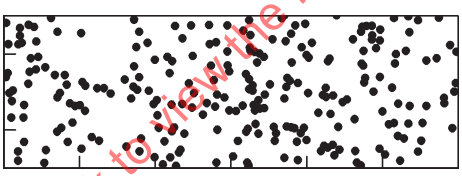

Figure B.9 — A = 16 %

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Annex C
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Calculation of the sum of acceptable areas

C.1 Clustered porosity

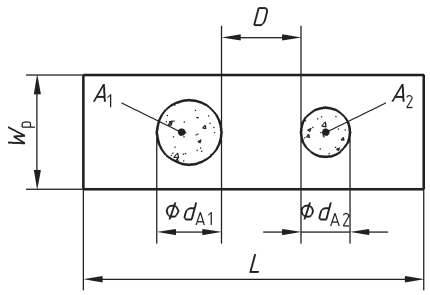

Figure C.1 — Clustered porosity, $D > d_{A2}$

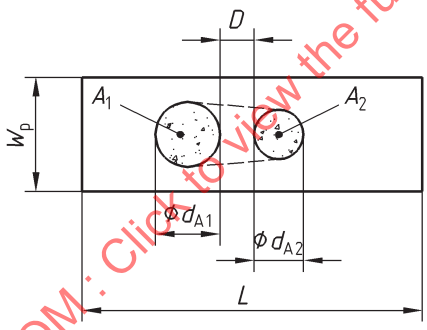

Figure C.2 — Clustered porosity, $D < d_{A2}$

The sum of the different pore envelop areas ($A_1 + A_2$ ...) related to the evaluation area, $L \times w_p$ (see Figure C.1), shall be calculated.

If D is less than d_{A1} or d_{A2}, whatever is smaller, an envelope surrounding the porosity areas, $A_1 + A_2$, shall be considered as one area of imperfection (see Figure C.2).

C.2 Linear porosity

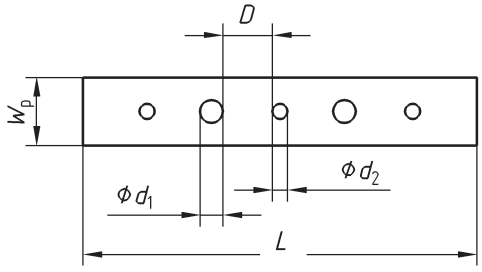

Figure C.3 — Linear porosity, $D > d_2$

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