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

Part 2: Aluminium and its alloys

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

Partie 2: Aluminium et ses 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).

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For an explanation on 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 the following URL: 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*.

This second edition cancels and replaces the first edition (ISO 10675-2:2010), of which it constitutes a minor revision and contains the following main changes:

— the normative references have been updated;

— Table 1 has been split into two separate tables.

Request 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.

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

Part 2: Aluminium and its alloys

1 Scope

This document specifies acceptance levels for indications from imperfections in aluminium butt welds 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 for RT-F (F = film) or ISO 17636-2 for RT-S (S = radioscopy) and RT-D (D = digital detectors).

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

ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections*

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*

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:

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

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

4 Radiographic technique

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

Table 1 — Radiographic testing for RT-F

Quality levels in accordance with ISO 10042	Testing techniques and classes in accordance with ISO 17636-1 for RT-F[a]	Acceptance levels in accordance with this document
B	B	1
C	B[a,b]	2
D	A	3

[a] RT-F = Radiographic testing with film

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

Table 2 — Radiographic testing for RT-S and RT-D

Quality levels in accordance with ISO 10042	Testing techniques and classes in accordance with ISO 17636-2 for RT-S[a] and RT-D[b]	Acceptance levels in accordance with this document
B	B	1
C	B[c]	2
D	A	3

[a] RT-S = Radioscopic testing

[b] RT-D = Radiographic testing with digital detectors

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

5 General

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

The acceptance levels in this document are basically valid for evaluation of imperfections which cannot be detected and evaluated by visual testing (see Table 3). Surface imperfections (see Table 4; 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 10042 quality levels are not fulfilled, shall be subject to more specific testing.

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 10042. This shall be specified.

6 Acceptance levels

The acceptance levels for indications are shown in Table 3 and Table 4. The types of imperfections are selected from ISO 10042 and defined in ISO 6520-1.

The symbols used in Table 3 and Table 4 are the following:

A is the sum of projected areas of indications related to $L \times w_p$ in %;

b is the width of excess penetration of weld, in millimetres;

d is the diameter of pore, in millimetres;

d_A is the diameter of area surrounding a cluster, 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;

L any 100 mm testing length, in millimetres;

s is the nominal butt weld thickness, in millimetres;

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.

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

Indications shall not be divided into different ranges L.

Table 3 — Acceptance levels for 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	Gas pores (2011)	$d \le 0{,}4s$, max. 6 mm	$d \le 0{,}3s$, max. 5 mm	$d \le 0{,}2s$, max. 4 mm
2b	Porosity (2012) material thickness 0,5 mm to 3 mm	$A \le 6$ % $L = 100$ mm	$A \le 2$ % $L = 100$ mm	$A \le 1$ % $L = 100$ mm
2c	Porosity (2012) material thickness >3 mm to 12 mm	$A \le 10$ % $L = 100$ mm	$A \le 4$ % $L = 100$ mm	$A \le 2$ % $L = 100$ mm
2d	Porosity (2012) material thickness >12 mm to 30 mm	$A \le 15$ % $L = 100$ mm	$A \le 6$ % $L = 100$ mm	$A \le 3$ % $L = 100$ mm
2e	Porosity (2012) material thickness >30 mm	$A \le 20$ % $L = 100$ mm	$A \le 8$ % $L = 100$ mm	$A \le 4$ % $L = 100$ mm
3[b]	Clustered (localized) porosity (2013)	$d_A \le 25$ mm or $d_{A,max} \le w_p$	$d_A \le 20$ mm or $d_{A,max} \le w_p$	$d_A \le 15$ mm or $d_{A,max} \le w_p/2$
4[c]	Linear porosity (2014)	$l \le 25$ mm $L = 100$ mm	Not permitted	Not permitted
5[d]	Elongated cavities (2015) and wormholes (2016)	$l \le 0{,}4s$, max. 6 mm	$l < 0{,}3s$, max. 4 mm	$l < 0{,}2s$, max. 3 mm
6	Oxide inclusion (303)	$l < s$, max. 10 mm	$l < 0{,}5s$, max. 5 mm	$l < 0{,}2s$, max. 3 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 (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, the maximum length of indications shall not exceed 25 % of that weld.

Table 3 *(continued)*

No.	Type of internal imperfections in accordance with ISO 6520-1	Acceptance level 3[a]	Acceptance level 2[a]	Acceptance level 1
7	Tungsten inclusions (3041)	$l < 0{,}4s$, max. 6 mm	$l < 0{,}3s$, max. 4 mm	$l < 0{,}2s$, max. 3 mm
8[e]	Lack of fusion (401)	Permitted, but only intermittently and not breaking the surface $l \leq 25$ mm, $L = 100$ mm	Not permitted	Not permitted
9[e]	Lack of penetration (402)	$l < 25$ mm, $L = 100$ mm	Permitted provided welded from both sides and not breaking the surface $l \leq 25$ mm, $L = 100$ mm	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, the maximum length of indications shall not exceed 25 % of that weld.

Table 4 — Surface imperfections

No.	Type of surface imperfections in accordance with ISO 6520-1	Acceptance level 3[a]	Acceptance level 2[a]	Acceptance level 1
10	Crater cracks (104)	$l \leq 0{,}4s$	Not permitted	Not permitted
11a	Continuous undercut (5011)	Smooth transition is required $h \leq 0{,}2t$, max. 1 mm	Smooth transition is required $h \leq 0{,}1t$, max. 0,5 mm	Not permitted
11b	Intermittent undercut (5012)	Smooth transition is required $h \leq 0{,}2t$, max. 1,5 mm $l \leq 25$ mm	Smooth transition is required $h \leq 0{,}1t$, max. 1 mm $l \leq 25$ mm	Smooth transition is required $h \leq 0{,}1t$, max. 0,5 mm $l \leq 25$ mm
12	Excess penetration (504)	$h \leq 5$ mm	$h \leq 4$ mm	$h \leq 3$ mm
13	Root concavity (515)	$l \leq 25$ mm $h \leq 0{,}2t$, max. 1,5 mm	$l \leq 25$ mm $h \leq 0{,}1t$, max. 1 mm	$l \leq 25$ mm $h \leq 0{,}05t$, max. 0,5 mm
14	Shrinkage groove (5013)	$l \leq 25$ mm $h \leq 0{,}2t$, max. 1,5 mm	$l \leq 25$ mm $h \leq 0{,}1t$, max. 1 mm	$l \leq 25$ mm $h \leq 0{,}05t$, max. 0,5 mm

NOTE The acceptance levels are those defined for visual testing. These imperfections 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.

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)

— Oxide inclusions (303)

— Tungsten inclusions (3041)

The above imperfections listed in Table 3 will be readily detected using radiographic technique A or B of ISO 17636-1 for RT-F as shown in Table 1, or ISO 17636-2 for RT-S or RT-D as shown in Table 2.

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 and 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 direction of the side wall.

Annex B
(informative)

Examples for determination of 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.

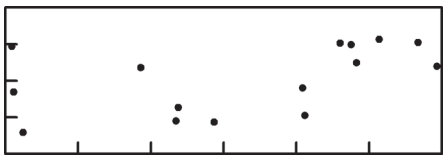

Figure B.1 — 1 %

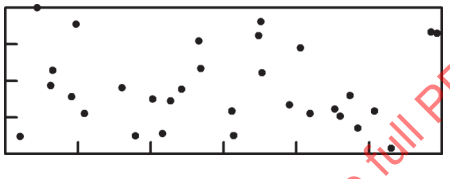

Figure B.2 — 2 %

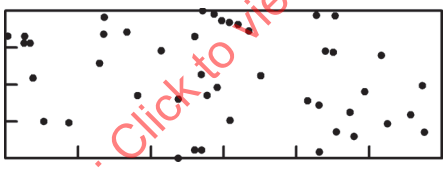

Figure B.3 — 3 %

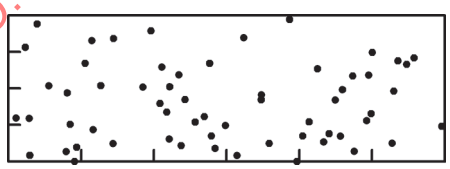

Figure B.4 — 4 %

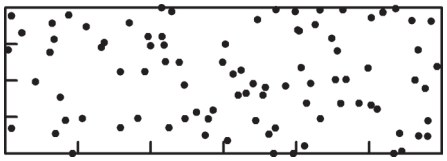

Figure B.5 — 6 %

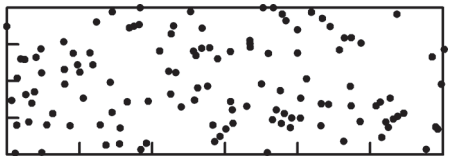

Figure B.6 — 8 %

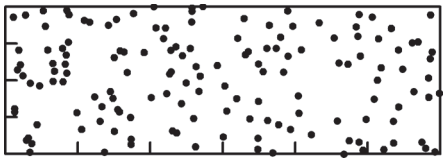

Figure B.7 — 10 %

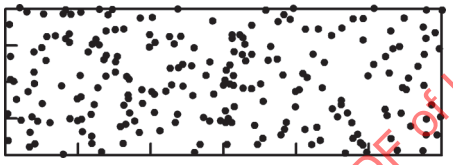

Figure B.8 — 15 %

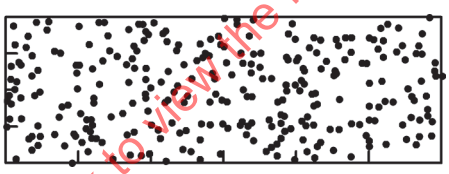

Figure B.9 — 20 %

Annex C
(informative)

Sums of acceptable areas

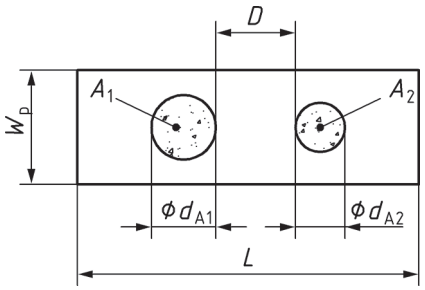

Figure C.1 — Clustered porosity, $D > d_{A2}$

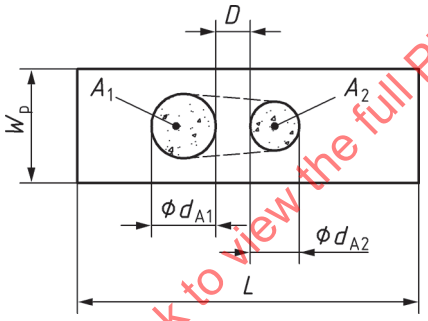

Figure C.2 — Clustered porosity, $D = d_{A2}$

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

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

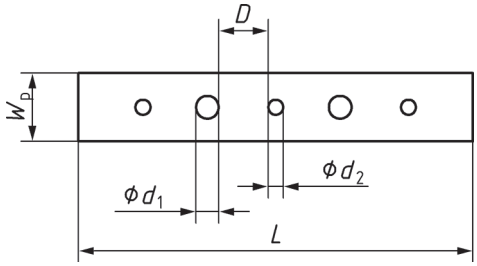

Figure C.3 — Linear porosity, $D > d_2$