BRITISH STANDARD

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Non-destructive testing of welds

Part 2: Evaluation of welded joints in aluminium and its alloys by radiography — Acceptance levels

ICS 25.160.40

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 12517-2:2008.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN 12517-2:2008) has been prepared by Technical Committee CEN/TC 121 “Welding”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2009, and conflicting national standards shall be withdrawn at the latest by February 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

EN 12517 *Non-destructive testing of welds* comprises a series of European Standards for acceptance levels for radiographic testing which is made up of the following parts:

— *Part 1: Evaluation of welded joints in steel, nickel, titanium and their alloys by radiography — Acceptance levels*

— *Part 2: Evaluation of welded joints in aluminium and its alloys by radiography — Acceptance levels*

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1 Scope

This European Standard specifies acceptance levels for indications from imperfections in aluminium butt welds detected by radiographic testing. If agreed, the acceptance levels may be applied to other types of welds or materials.

The acceptance levels may be related to welding standards, application standards, specifications or codes.

This European Standard assumes that the radiographic testing has been carried out in accordance with EN 1435.

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 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.

EN 1435, *Non-destructive examination of welds — Radiographic examination of welded joints*

EN ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections (ISO 10042:2005)*

EN ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:2007)*

3 Radiographic technique

Depending on the weld quality level, radiographic technique A or B in accordance with EN 1435 shall be used as shown in Table 1.

Table 1 — Radiographic testing

Quality levels in accordance with EN ISO 10042	Testing techniques and classes in accordance with EN 1435	Acceptance levels in accordance with EN 12517-2
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 EN 1435.		

4 General

Welded joints should be visually tested in accordance with EN 970 and evaluated before radiographic testing.

The acceptance levels in this European Standard are basically valid for evaluation of imperfections which cannot be detected and evaluated by visual testing (Table 2). Surface imperfections (Table 3; 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 EN 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 EN ISO 10042. This shall be specified.

5 Acceptance levels

The acceptance levels for indications are shown in Tables 2 and 3. The types of imperfections are selected from EN ISO 10042 and defined in EN ISO 6520-1.

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

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

b width of excess penetration of weld, in millimetres;

d diameter of pore, in millimetres;

d_A diameter of area surrounding a cluster, in millimetres;

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

l length of indication, in millimetres;

L any 100 mm testing length, in millimetres;

s nominal butt weld thickness, in millimetres;

t material thickness, in millimetres;

w_p width of the weld in millimetres;

Σl 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 2 — Acceptance levels for indications in butt welds

No	Type of internal imperfections in accordance with EN 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)	$d \leq 0{,}4s$, max. 6 mm	$d \leq 0{,}3s$, max. 5 mm	$d \leq 0{,}2s$, max. 4 mm
2b	Porosity (2012) material thickness 0,5 mm to 3 mm	$A \leq 6$ % $L = 100$ mm	$A \leq 2$ % $L = 100$ mm	$A \leq 1$ % $L = 100$ mm
2c	Porosity (2012) material thickness > 3 mm to 12 mm	$A \leq 10$ % $L = 100$ mm	$A \leq 4$ % $L = 100$ mm	$A \leq 2$ % $L = 100$ mm
2d	Porosity (2012) material thickness > 12 mm to 30 mm	$A \leq 15$ % $L = 100$ mm	$A \leq 6$ % $L = 100$ mm	$A \leq 3$ % $L = 100$ mm
2e	Porosity (2012) material thickness > 30 mm	$A \leq 20$ % $L = 100$ mm	$A \leq 8$ % $L = 100$ mm	$A \leq 4$ % $L = 100$ mm
3 [b]	Clustered (localized) porosity (2013)	$d_A \leq 25$ mm or $d_{A,max} \leq w_p$	$d_A \leq 20$ mm or $d_{A,max} \leq w_p$	$d_A \leq 15$ mm or $d_{A,max} \leq w_p/2$
4 [c]	Linear porosity (2014)	$l \leq 25$ mm $L = 100$ mm	Not permitted	Not permitted
5 [d]	Elongated cavities (2015) and wormholes (2016)	$l \leq 0{,}4s$, 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
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 Annex C, Figure C.1 and Figure C.2 (normative).

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

[d] See Annex C, 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 — Surface imperfections: The acceptance levels are those defined for visual testing. These imperfections are normally evaluated by visual testing

No	Type of surface imperfections in accordance with EN 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

[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[1)]

A.1 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 2 will be readily detected using radiographic technique A or B of EN 1435 as shown in Table 1 of this European Standard.

A.2 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 EN 1435, will provide better crack detectability than radiographic technique A.

A.3 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.

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

Annex B
(informative)

Examples for determination of percentage (%) of imperfections

The following figures give a presentation of different area percentage (%) of imperfections. This should assist the assessment of imperfections on radiographs and fracture surfaces.

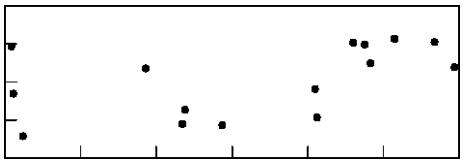

Figure B.1 — 1 %

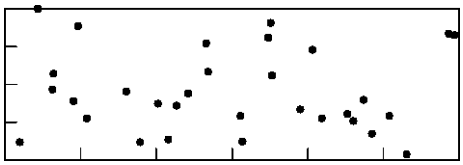

Figure B.2 — 2 %

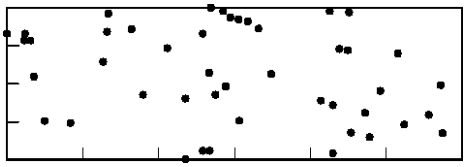

Figure B.3 — 3 %

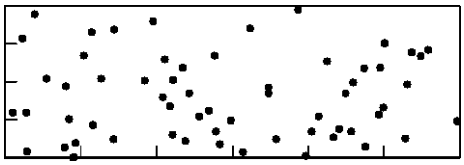

Figure B.4 — 4 %

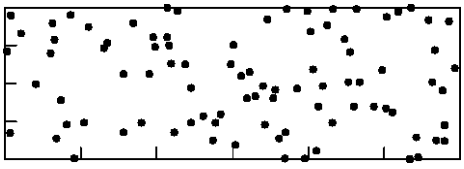

Figure B.5 — 6 %

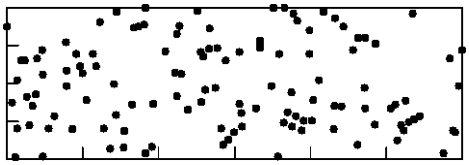

Figure B.6 — 8 %

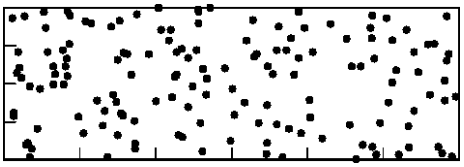

Figure B.7 — 10 %

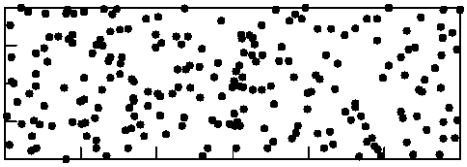

Figure B.8 — 15 %

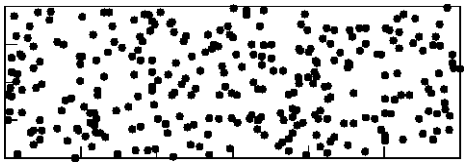

Figure B.9 — 20 %

Annex C
(informative)

Sum of acceptable areas

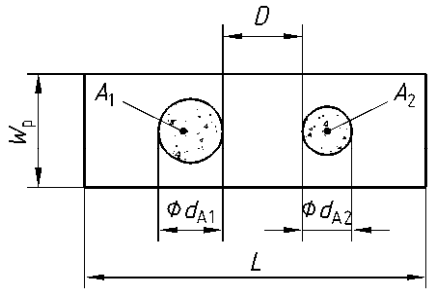

Figure C.1 — Clustered porosity, $D > d_{A2}$

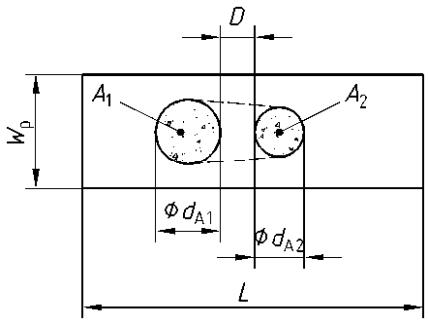

Figure C.2 — Clustered porosity, $D \leq d_{A2}$

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).

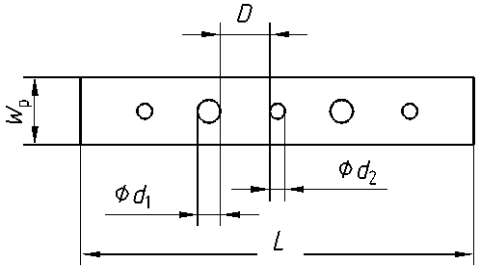

Figure C.3 — Linear porosity, $D > d_2$

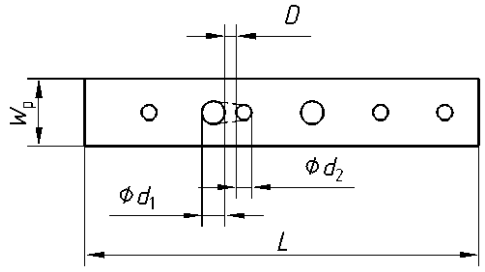

Figure C.4 — Linear porosity, $D \leq d_2$

The sum of the different pore areas $\left(\frac{{d_1}^2 \times \pi}{4} + \frac{{d_2}^2 \times \pi}{4} + ...\right)$ related to the evaluation area $L \times w_p$ (Figure C.3).

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

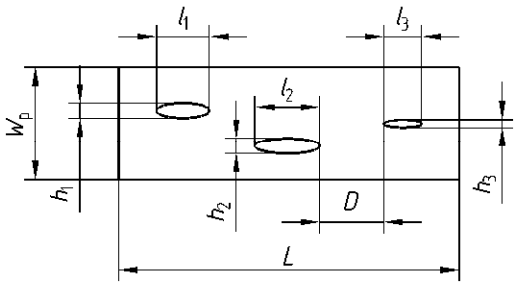

Figure C.5 — Elongated cavities and wormholes, $D > l_3$

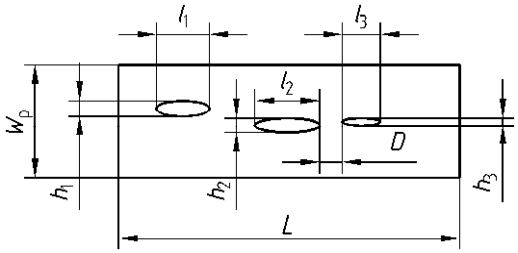

Figure C.6 — Elongated cavities and wormholes, $D \leq l_3$

The sum of the length of indications Σl shall be determined for each testing length L (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 (Figure C.6).

Bibliography

[1] EN 970, *Non-destructive examination of fusion welds — Visual examination*

[2] EN 12062, *Non-destructive examination of welds — General rules for metallic materials*

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