BRITISH STANDARD

BS EN
12517-1:2006

Non-destructive testing of welds —

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

The European Standard EN 12517-1:2006 has the status of a British Standard

ICS 25.160.40

BSI
British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing, which has the responsibility to:

— aid enquirers to understand the text;

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— monitor related international and European developments and promulgate them in the UK.

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

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 15 and a back cover.

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2006

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 48044 5

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12517-1

March 2006

ICS 25.160.40

Supersedes EN 12517:1998

English Version

Non-destructive testing of welds - Part 1: Evaluation of welded joints in steel, nickel, titanium and their alloys by radiography - Acceptance levels

Essais non destructifs des assemblages soudés - Partie 1: Évaluation par radiographie des assemblage soudés en acier, nickel, titane et leurs alliages - Niveaux d'acceptation

Zerstörungsfreie Prüfung von Schweißverbindungen - Teil 1: Bewertung von Schweißverbindungen in Stahl, Nickel, Titan und ihren Legierungen mit Durchstrahlung - Zulässigkeitsgrenzen

This European Standard was approved by CEN on 6 February 2006.

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Ref. No. EN 12517-1:2006: E

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Foreword

This document (EN 12517-1:2006) 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of an identical text or by endorsement, at the latest by September 2006, and conflicting national standards shall be withdrawn at the latest by September 2006.

This document supersedes EN 12517:1998.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

EN 12517 comprises a series of European Standards for industrial radiographic films which is made up of the following:

EN 12517-1 Non-destructive testing of welds – Part 1: Evaluation of welded joints in steel, nickel, titanium and their alloys by radiography – Acceptance levels

EN 12517-2 Non-destructive testing of welds – Part 2: Evaluation of welded joints in aluminium and its alloys by radiography – Acceptance levels

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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 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 European Standard. 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 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003)*

EN ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:1998)*

3 Radiographic technique

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

Table 1 – Radiographic testing

Quality levels in accordance with EN ISO 5817	Testing techniques and classes in accordance with EN 1435	Acceptance levels in accordance with EN 12517
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 and evaluated in accordance with EN 970 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. 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 EN ISO 5817 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 5817. This shall be specified.

5 Acceptance levels

The acceptance levels for indications are shown in Table 2 and Table 3. The types of imperfections are selected from EN ISO 5817 and defined in EN 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 material thickness, in millimetres;
- L any 100 mm testing length, in millimetres;
- w_p width of the weld, or cross surface imperfection, in millimetres
- h width of indication, the width or height of surface imperfection, in millimetres;
- d diameter of pore; in millimetres;
- b width of excess penetration of weld, in millimetres;
- A sum of projected areas of indications related to L x w_p, in %;
- 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 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	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)	$A \leq 16$% $d \leq 0{,}4s$, max. 4 mm L = 100 mm	$A \leq 8$% d $\leq 0{,}3s$, max. 3 mm L = 100 mm	$A \leq 4$% $d \leq 0{,}2s$, max. 2 mm L = 100 mm
4a[c]	Linear porosity (2014) Single layer	$A \leq 8$ % $d \leq 0{,}4s$, max. 4 mm L = 100 mm	$A \leq 4$ % $d \leq 0{,}3s$, max. 3 mm L = 100 mm	$A \leq 2$ % $d \leq 0{,}2s$, max. 2 mm L = 100 mm
4b[c]	Linear porosity (2014) Multilayer	$A \leq 16$ % $d \leq 0{,}4s$, max. 4 mm L = 100 mm	$A \leq 8$ % $d \leq 0{,}3s$, max. 3 mm L = 100 mm	$A \leq 4$ % $d \leq 0{,}2s$, 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

(to be continued)

Table 2 (*concluded*)

No.	Type of internal imperfections in accordance with EN ISO 6520-1	Acceptance level 3 [a]	Acceptance level 2 [a]	Acceptance level 1
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 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, then 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 defects 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
13	Crater cracks (104)	Not permitted	Not permitted	Not permitted
14a	Undercut, continues and intermittent (5011,5012)	Smooth transition is required For $t > 3$ mm $h \leq 0{,}2t$, max. 1 mm For 0,5 mm ≤ t ≤ 3 mm $l \leq 25$ mm, $h \leq 0{,}2t$	Smooth transition is required For $t > 3$ mm $h \leq 0{,}1t$, max. 0,5 mm *For* 0,5 mm ≤ t ≤ 3 mm $l \leq 25$ mm, $h \leq 0{,}1t$	Smooth transition is required For $t > 3$ mm $h \leq 0{,}05t$, max. 0,5 mm For 0,5 mm ≤ t ≤ 3 mm not permitted
14b	Shrinkage groove (root undercut 5013)	Smooth transition is required For $t > 3$ mm $l \leq 25$ mm, $h \leq 0{,}2t$, max. 2 mm, For 0,5 mm ≤ t ≤ 3 mm $h \leq 0{,}2$ mm + $0{,}1t$	Smooth transition is required For t > 3 mm $l \leq 25$ mm, $h \leq 0{,}1t$, max. 1 mm For 0,5 mm ≤ t ≤ 3 mm $l \leq 25$ mm, $h \leq 0{,}1t$	Smooth transition is required For $t > 3$ mm $l \leq 25$ mm, $h \leq 0{,}05t$, max. 0,5 mm For 0,5 mm ≤ t ≤ 3 mm Not permitted
15a	Excess penetration (504) 0,5 mm ≤ t ≤ 3 mm	$h \leq 1$ mm + $0{,}6\,b$	$h \leq 1$ mm + $0{,}3\,b$	$h \leq 1$ mm + $0{,}1\,b$
15b	Excess penetration (504) $t > 3$mm	$h \leq 1$ mm + $1{,}0\,b$, max. 5 mm	$h \leq 1$ mm + $0{,}6\,b$, max. 4 mm	$h \leq 1$ mm + $0{,}2\,b$, max. 3 mm
16	Stray arc (601)	Permitted, if the properties of the parent metal are not affected	Not permitted	Not permitted
17	Spatter (602)	Acceptance depends on application, e.g. material, corrosion protection		
18a	Root concavity (515) 0,5 mm ≤ s ≤ 3 mm	$h \leq$ 0,2 mm + $0{,}1\,t$	$l \leq 25$ mm: $h \leq 0{,}1\,t$	Not permitted

(to be continued)

Table 3 (*concluded*)

No.	Type of surface imperfections in accordance with EN ISO 6520-1	Acceptance level 3 [a]	Acceptance level 2 [a]	Acceptance level 1
18b	Root concavity (515) $s > 3$ mm	$l \leq 25$ mm, $h \leq 0{,}2\ t$, max. 2 mm	$l \leq 25$ mm, $h \leq 0{,}1\ t$, max. 1 mm	$l \leq 25$ mm, $h \leq 0{,}05\ t$, max. 0,5 mm
19	Poor restart (517) $s \geq 0{,}5$ mm	Permitted, The limit depends on the type of imperfection (see EN ISO 5817)	Not permitted	Not permitted
20a	Sagging (509) Incompletely filled groove (511) 0,5 mm ≤ s ≤ 3 mm	$l \leq 25$ mm, $h \leq 0{,}25$ t	$l \leq 25$ mm, $h \leq 0{,}1\ t$	Not permitted
20b	Sagging (509) Incompletely filled groove (511) $s > 3$ mm	$l \leq 25$ mm, $h \leq 0{,}25$ t, max. 2 mm	$l \leq 25$ mm, $h \leq 0{,}1$ t, max. 1 mm	$l \leq 25$ mm, $h \leq 0{,}05$ t, max. 0,5 mm
21a	Linear misalignment (507) 0,5 mm ≤ s ≤ 3 mm	$h \leq 0{,}2$ mm + $0{,}25\ t$	$h \leq 0{,}2$ mm + $0{,}15\ t$	$h \leq 0{,}2$ mm + $0{,}1\ t$
21b	Linear misalignment, longitudinal welds (507) $s > 3$ mm	$h \leq 0{,}25$ t, max. 5 mm	$h \leq 0{,}15$ t, max. 4 mm	$h \leq 0{,}1$ t, max. 3 mm
21c	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

[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

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

A.1 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 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.

Annex B
(informative)

Examples for determination of area 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.

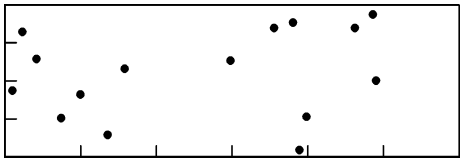

Figure B.1 — 1 %

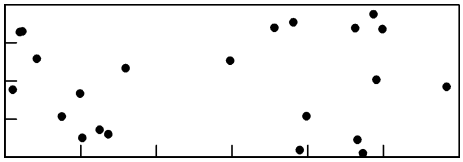

Figure B.2 — 1,5 %

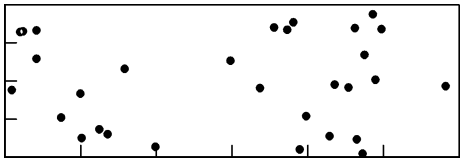

Figure B.3 — 2 %

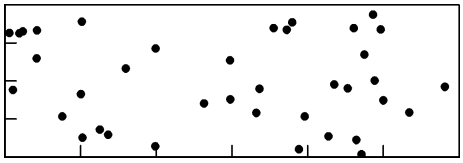

Figure B.4 — 2,5 %

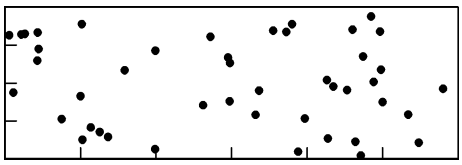

Figure B.5 — 3 %

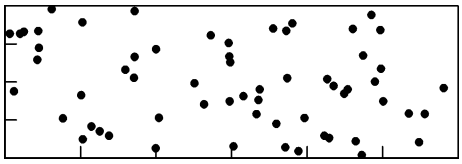

Figure B.6 — 4 %

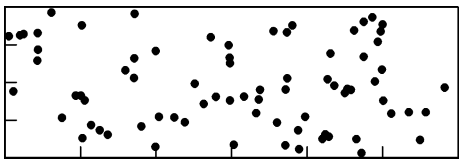

Figure B.7 — 5 %

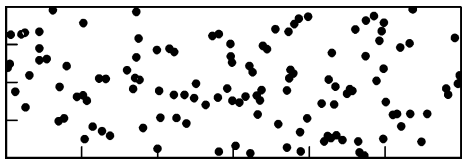

Figure B.8 — 8 %

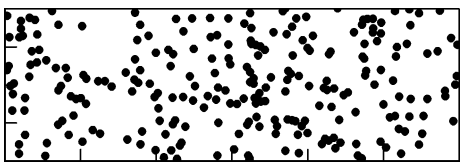

Figure B.9 — 16 %

Annex C
(normative)

Sum of acceptable areas

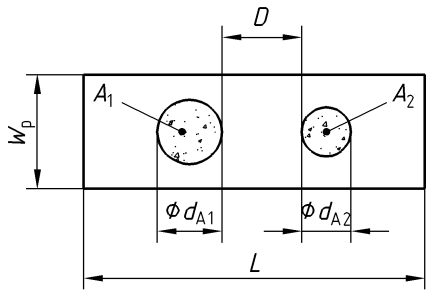

Figure C.1 — Clustered porosity, $D > d_{A2}$

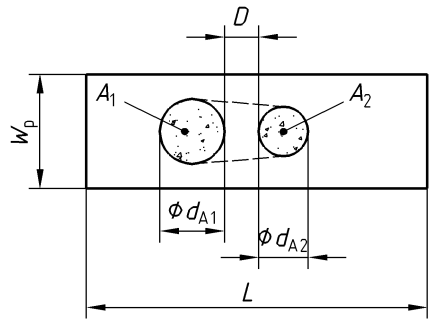

Figure C.2 — Clustered porosity, $D < d_{A2}$

The sum of the different pore areas (A_1+A_2….) related to the evaluation area L X 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).

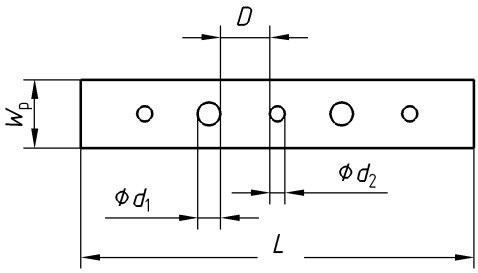

Figure C.3 — Linear porosity, $D > d_2$

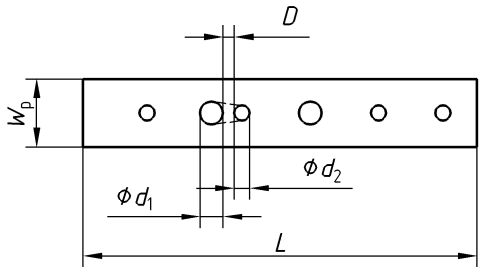

Figure C.4 — Linear porosity, $D < d_2$

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

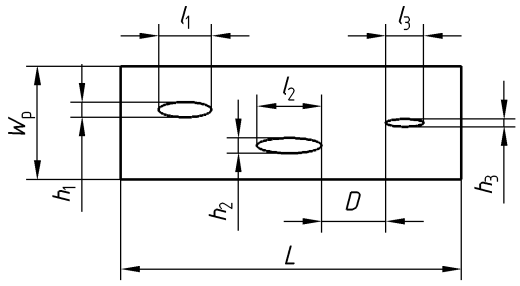

Figure C.5 — Elongated cavities and wormholes, $D > l_3$

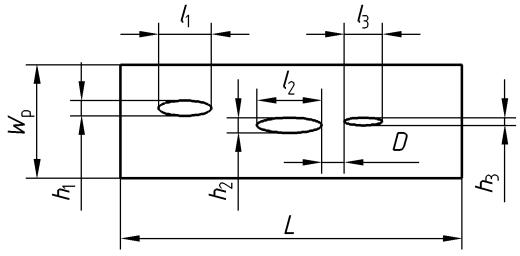

Figure C.6 — Elongated cavities and wormholes, $D < l_3$

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*

[3] IIW catalogue of reference radiographs for assessment of weld imperfections according to ISO 5817

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