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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

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 10675-1 was prepared by the European Committee for Standardization (as EN 12517-1:2006) and was adopted, under a special "fast-track procedure", by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*, in parallel with its approval by the ISO member bodies.

Requests for official interpretations of any aspect of this part of ISO 10675 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](http://www.iso.org).

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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 part of ISO 10675 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 part of ISO 10675 assumes that the radiographic testing has been carried out in accordance with ISO 17636.

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.

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, *Non-destructive testing of welds — Radiographic testing of fusion-welded joints*

### 3 Radiographic technique

Depending on the weld quality level, radiographic technique A or B in accordance with ISO 17636 is 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	Acceptance levels in accordance with this part of ISO 10675
B	B	1
C	B <sup>a</sup>	2
D	A	3

<sup>a</sup> However, the minimum number of exposure for circumferential weld testing may correspond to the requirements of class A of ISO 17636.

**4 General**

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

The acceptance levels in this part of ISO 10675 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.

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.

**5 Acceptance levels**

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* material thickness, in millimetres;
- L* any 100 mm testing length, in millimetres;
- w<sub>p</sub>* 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  $L \times w_p$ , in %;
- $\Sigma l$  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 <sup>a</sup>	Acceptance level 2 <sup>a</sup>	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
3b	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 <sup>c</sup>	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 <sup>c</sup>	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 <sup>d</sup>	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 <sup>e</sup>	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 <sup>d</sup>	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

(continued)

Table 2 (concluded)

No.	Type of internal imperfections in accordance with ISO 6520-1	Acceptance level 3 <sup>a</sup>	Acceptance level 2 <sup>a</sup>	Acceptance level 1
10	Copper inclusions (3042)	Not permitted	Not permitted	Not permitted
11 <sup>e</sup>	Lack of fusion (401)	Permitted, but only intermittently and not breaking the surface $\Sigma l \leq 25 \text{ mm}, L = 100 \text{ mm}$	Not permitted	Not permitted
12 <sup>e</sup>	Lack of penetration (402)	$\Sigma l \leq 25 \text{ mm}, L = 100 \text{ mm}$	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.

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**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 ISO 6520-1	Acceptance level 3 <sup>a</sup>	Acceptance level 2 <sup>a</sup>	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 $0,5 \text{ mm} \leq t \leq 3$ 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 $0,5 \text{ mm} \leq t \leq 3$ 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 $0,5 \text{ mm} \leq t \leq 3$ 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 $0,5 \text{ mm} \leq t \leq 3$ mm  $h \leq 0,2 \text{ mm} + 0,1t$	Smooth transition is required For $t > 3$ mm  $l \leq 25$ mm,  $h \leq 0,1t$ , max. 1 mm  For $0,5 \text{ mm} \leq t \leq 3$ 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 $0,5 \text{ mm} \leq t \leq 3$ mm  Not permitted
15a	Excess penetration (504) $0,5 \text{ mm} \leq t \leq 3$ mm	$h \leq 1 \text{ mm} + 0,6 b$	$h \leq 1 \text{ mm} + 0,3 b$	$h \leq 1 \text{ mm} + 0,1 b$
15b	Excess penetration (504) $t > 3$ mm	$h \leq 1 \text{ mm} + 1,0 b$ , max. 5 mm	$h \leq 1 \text{ mm} + 0,6 b$ , max. 4 mm	$h \leq 1 \text{ mm} + 0,2 b$ , 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) $0,5 \text{ mm} \leq s \leq 3$ mm	$h \leq 0,2 \text{ mm} + 0,1 t$	$l \leq 25$ mm:  $h \leq 0,1 t$	Not permitted

(continued)

Table 3 (concluded)

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

<sup>a</sup> 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 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 ISO 17636 as shown in Table 1 of this part of ISO 10675.

#### 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 ISO 17636, 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 %

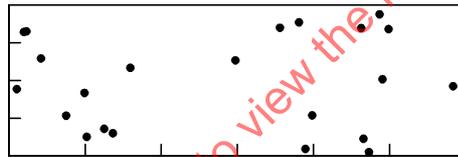


Figure B.2 — 1,5 %

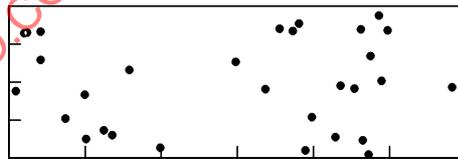


Figure B.3 — 2 %

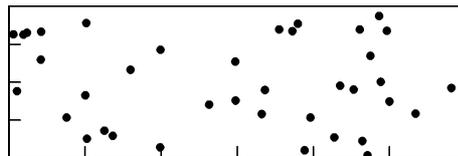


Figure B.4 — 2,5 %

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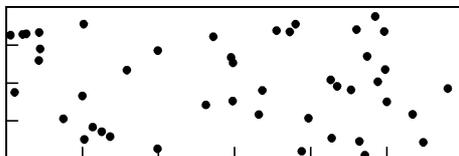


Figure B.5 — 3 %

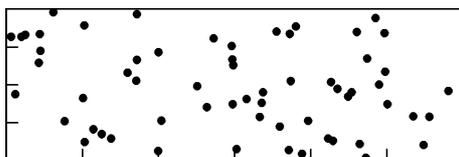


Figure B.6 — 4 %

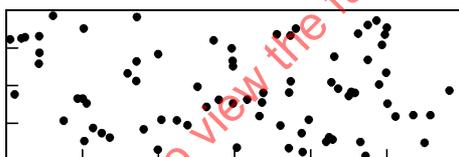


Figure B.7 — 5 %

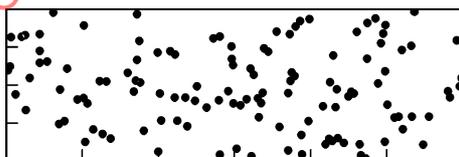


Figure B.8 — 8 %

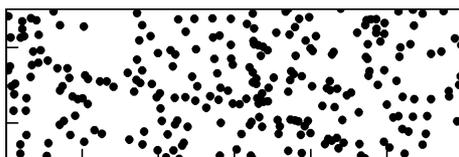
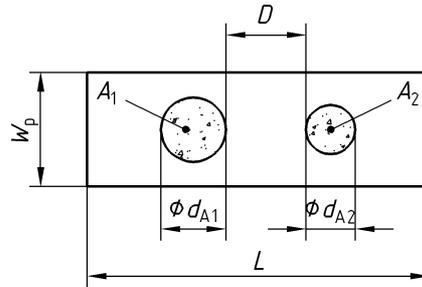


Figure B.9 — 16 %

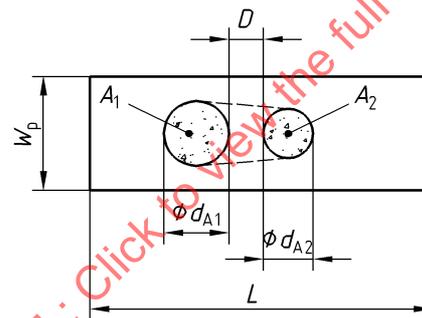
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**Annex C**  
(normative)

**Sum of acceptable areas**



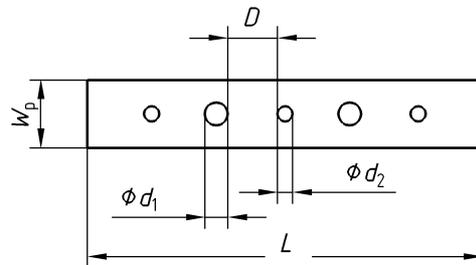
**Figure C.1 — Clustered porosity,  $D > d_{A2}$**



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

The sum of the different pore areas ( $A_1 + A_2 \dots$ ) 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,  $D > d_2$**