INTERNATIONAL STANDARD

ISO 15626

Second edition
2018-07

Non-destructive testing of welds — Time-of-flight diffraction technique (TOFD) — Acceptance levels

Essais non destructifs des assemblages soudés — Technique de diffraction des temps de vol (méthode TOFD) — Niveaux d'acceptation

Reference number
ISO 15626:2018(E)

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Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*..

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This second edition cancels and replaces the first edition (ISO 15626:2011), which has been technically revised. The main changes compared to the previous edition are as follows:

— in 6.3.1, method 4 has been described;

— for all figures, the keys have been completed.

Non-destructive testing of welds — Time-of-flight diffraction technique (TOFD) — Acceptance levels

1 Scope

This document specifies acceptance levels for the time-of-flight diffraction technique (TOFD) of full penetration welds in ferritic steels from 6 mm up to 300 mm thickness which correspond to the quality levels of ISO 5817.

These acceptance levels are applicable to indications classified in accordance with ISO 10863.

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 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577 and the following apply.

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

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

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

3.1
embedded discontinuity
discontinuity within the volume of the material, separated from the surfaces

3.2
surface-breaking discontinuity
discontinuity connected to the near (scanning) surface or far (opposite) surface

4 Symbols

h height of an indication

l length of an indication

t nominal wall thickness in accordance with construction drawing or dimension table

5 Relation between quality levels and acceptance levels

Three different acceptance levels are defined. The relation between these acceptance levels and the quality levels as mentioned in ISO 5817 are given in Table 1.

Table 1 — Acceptance levels

Quality level according to ISO 5817	Examination level according to ISO 10863	Acceptance level
B (Stringent)	C	1
C (Intermediate)	at least B	2
D (Moderate)	at least A	3

6 Definition and determination of length and height

6.1 General

The size of a discontinuity is described by the length and height of its indication.

Length is defined by the difference of the *x*-coordinates of the indication.

The height is defined as the maximum difference of the *z*-coordinates at any given *x*-position.

6.2 Determination of length

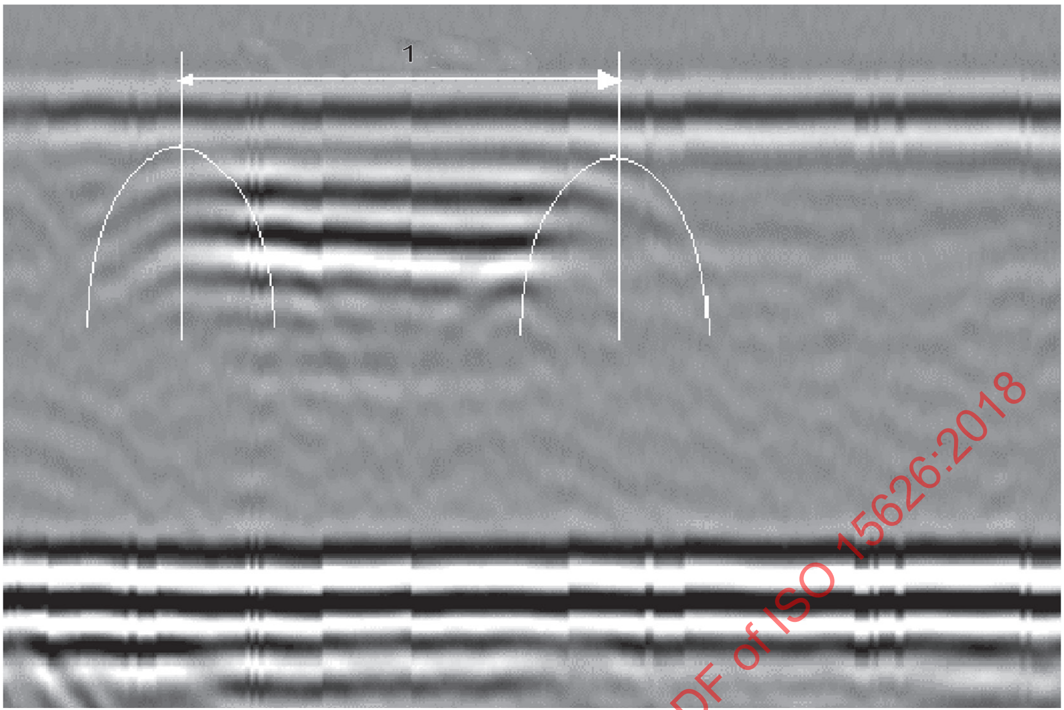
6.2.1 General

Depending on the type of indication, one of the techniques for length sizing according to 6.2.2 or 6.2.3 shall be applied.

6.2.2 Length sizing of elongated straight indications

This type of indication does not change significantly in the through-wall direction.

A hyperbolic cursor is fitted to the indication. Assuming the discontinuity is elongated and has a finite length, this is only possible at each end. The distance moved between acceptable fits at each end of the indication is taken to represent the length of the discontinuity (see Figure 1).



Key

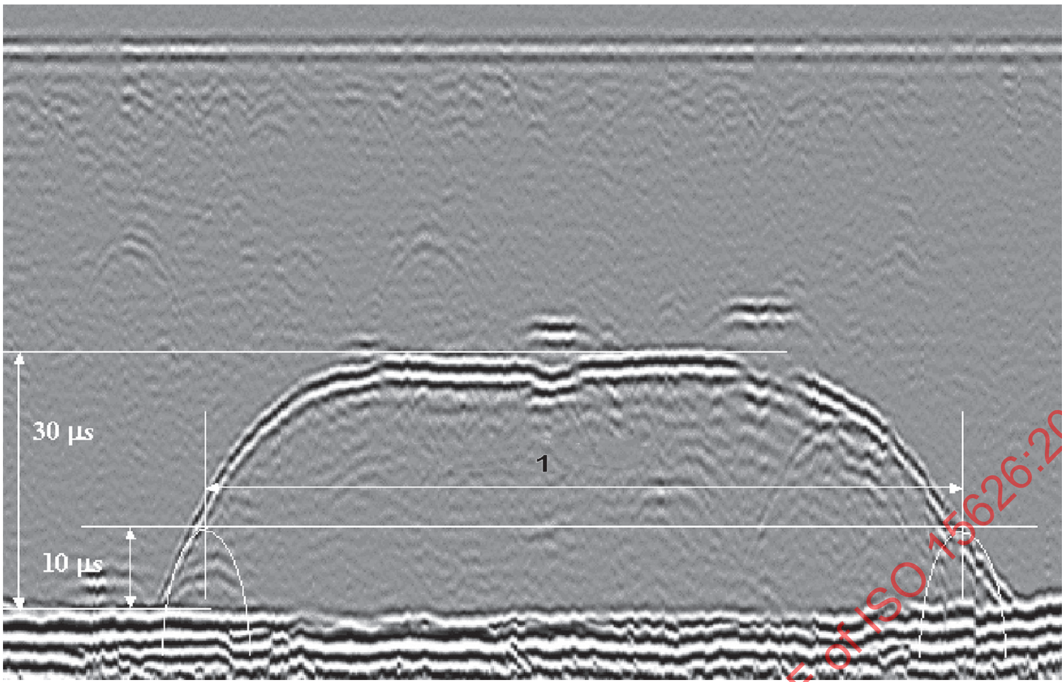
1 length of indication

Figure 1 — Length sizing by fitting arc-shaped cursors

6.2.3 Length sizing of elongated curved indications

This type of indication does change significantly in the through-wall direction.

A hyperbolic cursor is positioned at either end of the indication at a time delay of one third of the indication penetration. The distance moved between the cursor positions at each end of the indication is taken to represent the length of the discontinuity (see Figure 2).



Key

1 length of indication

Figure 2 — Length sizing of elongated curved indication

6.3 Determination of height

6.3.1 General

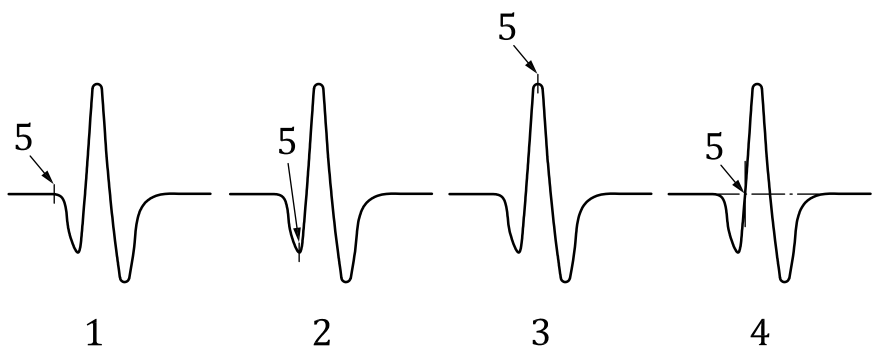
The height measurement shall be done from the A-scan and by choosing a consistent position on the signals, considering phase reversals. It is recommended to use one of the following methods (as shown in Figure 3):

— Method 1: by measuring the transit time between the leading edges of the signals;

— Method 2: by measuring the transit time between the first peaks;

— Method 3: by measuring the transit time between the maximum amplitudes;

— Method 4: by measuring the transit time between the first zero crossings of the signals.



Key

1 method 1

2 method 2

3 method 3

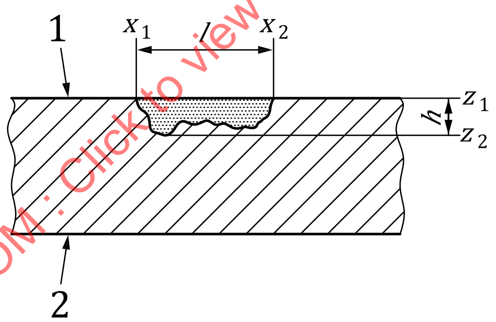
4 method 4

5 positions for measuring the transit time

Figure 3 — Position of the cursor for time measurement — Methods 1, 2, 3 and 4

6.3.2 Surface-breaking discontinuities

The height of an indication of a surface-breaking discontinuity is determined by the maximum difference between the lateral wave and the lower-tip diffraction signal.



Key

1 scanning surface

2 opposite surface

x_1 start position of discontinuity

x_2 end position of discontinuity

z_1 start depth of discontinuity

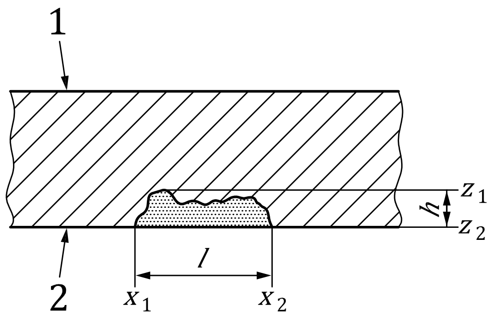
z_2 end depth of discontinuity

h height (= $z_2 - z_1$)

l length (= $x_2 - x_1$)

Figure 4 — Height definition of a scanning surface-breaking discontinuity

For an opposite surface-breaking discontinuity, the height is determined by the maximum difference between the upper-tip diffraction signal and the back wall reflection (see Figure 5).



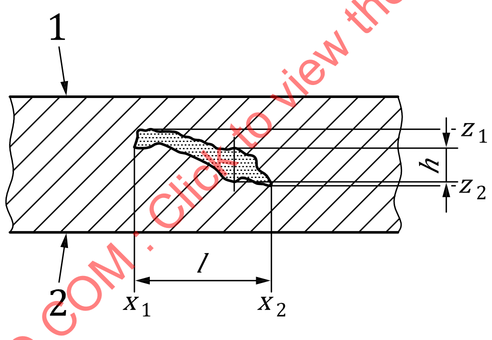
Key

1	scanning surface	z_1	start depth of discontinuity
2	opposite surface	z_2	end depth of discontinuity
x_1	start position of discontinuity	h	height (= $z_2 - z_1$)
x_2	end position of discontinuity	l	length (= $x_2 - x_1$)

Figure 5 — Height definition of an opposite surface-breaking discontinuity

6.3.3 Embedded discontinuities

The height of an indication of an embedded discontinuity is determined by the maximum difference between the upper-tip diffraction signal and the lower-tip diffraction signal at the same *x*-position (see Figure 6).



Key

1	scanning surface	z_1	start depth of discontinuity
2	opposite surface	z_2	end depth of discontinuity
x_1	start position of discontinuity	h	height (not necessarily equal to $z_2 - z_1$)
x_2	end position of discontinuity	l	length (= $x_2 - x_1$)

Figure 6 — Height definition of an embedded discontinuity

7 Acceptance levels

7.1 General

Classified indications are evaluated according to one of the acceptance levels listed in 7.2 and 7.3 considering the additional explanations for groups of indications and for point-like indications in 7.4 and 7.5, respectively.

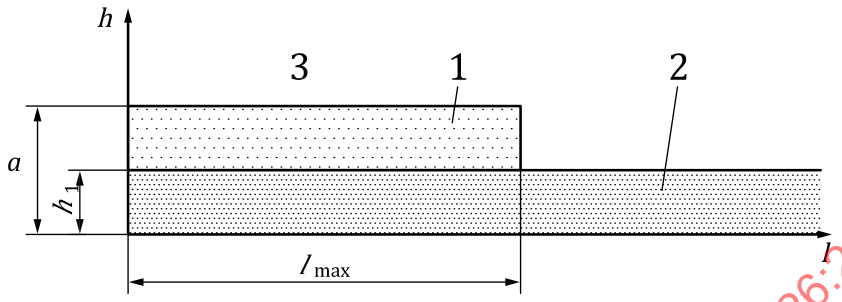
For welds joining two different thicknesses, the acceptance levels are based on the thinner of the two.

For welds subject to dynamic loading or being sensitive to cracking (e.g. longitudinal, transverse), more stringent near-surface acceptance levels or the use of additional NDT techniques may be specified.

7.2 Indications from single discontinuities

7.2.1 General

The symbols h_1, h_2 and h_3 used in Tables 2, 3 and 4 are explained in Figure 7.



Key

1 acceptance for $l \leq l_{max}$

2 acceptance for $l > l_{max}$

3 rejection

h_1 maximum acceptable height for any discontinuity if $l > l_{max}$

[a] Height:

— h_2 for embedded discontinuity;

— h_3 for surface-breaking discontinuity.

Figure 7 — General scheme for acceptance conditions

7.2.2 Acceptance level 1

Table 2 — Acceptance level 1

Thickness range	Maximum acceptable length if $h < h_2$ or h_3 l_{max}	Maximum acceptable height if $l \leq l_{max}$ Surface-breaking discontinuity [a] h_3 mm	Embedded discontinuity h_2 mm	Maximum acceptable height if $l > l_{max}$ h_1 [b] mm
6 mm < t ≤ 15 mm	0,75 t	1,5	2	1
15 mm < t ≤ 50 mm	0,75 t	2	3	1
50 mm < t ≤ 100 mm	40 mm	2,5	4	2
t > 100 mm	50 mm	3	5	2

[a] When indications from surface-breaking discontinuities are detected, and the resolution is not sufficient to resolve the depth, different techniques or methods shall be applied to determine the acceptability. If it is not possible to apply other techniques or methods all indications from surface-breaking discontinuities shall be considered unacceptable.

[b] Indications with height less than h_1 shall not be considered.

7.2.3 Acceptance level 2

Table 3 — Acceptance level 2

Thickness range	Maximum acceptable length if $h < h_2$ or h_3	Maximum acceptable height if $l \leq l_{max}$		Maximum acceptable height if $l > l_{max}$
		Surface-breaking discontinuity [a]	Embedded discontinuity	
	l_{max}	h_3 mm	h_2 mm	h_1 [b] mm
6 mm < t ≤ 15 mm	t	2	2	1
15 mm < t ≤ 50 mm	t	2	4	1
50 mm < t ≤ 100 mm	50 mm	3	5	2
t > 100 mm	60 mm	4	6	3

[a] When indications from surface-breaking discontinuities are detected, and the resolution is not sufficient to resolve the depth, different techniques or methods shall be applied to determine the acceptability. If it is not possible to apply other techniques or methods, all indications from surface-breaking discontinuities shall be considered unacceptable.

[b] Indications with height less than h_1 shall not be considered.

7.2.4 Acceptance level 3

Table 4 — Acceptance level 3

Thickness range	Maximum acceptable length if $h < h_2$ or h_3	Maximum acceptable height if $l \leq l_{max}$		Maximum acceptable height if $l > l_{max}$
		Surface-breaking discontinuity [a]	Embedded discontinuity	
	l_{max}	h_3 mm	h_2 mm	h_1 [b] mm
6 mm < t ≤ 15 mm	1,5 t (maximum 20 mm)	2	2	1
15 mm < t ≤ 50 mm	1,5 t (maximum 60 mm)	2,5	4,5	2
50 mm < t ≤ 100 mm	60 mm	4	6	3
t > 100 mm	75 mm	5	8	4

[a] When indications from surface-breaking discontinuities are detected, and the resolution is not sufficient to resolve the depth, different techniques or methods shall be applied to determine the acceptability. If it is not possible to apply other techniques or methods, all indications from surface-breaking discontinuities shall be considered unacceptable.

[b] Indications with height less than h_1 shall not be considered.

7.3 Total length of indications

The sum of the lengths of the individual indications with height larger than h_1 measured along the weld over a length of 12 t shall be less than or equal to:

— 3,5 t with a maximum of 150 mm, for acceptance level 1;

— 4,0 t with a maximum of 200 mm, for acceptance level 2;

— 4,5 t with a maximum of 250 mm, for acceptance level 3.

