

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

ICS 25.160.40

National foreword

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**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

Zerstörungsfreie Prüfung von Schweißverbindungen -
Beugungslaufzeittechnik (TOFD) - Zulässigkeitsgrenzen

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Foreword

This document (EN 15617:2009) has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DIN.

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1 Scope

This European standard 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 EN ISO 5817.

These acceptance levels are applicable to indications classified in accordance with CEN/TS 14751.

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.

CEN/TS 14751, *Welding — Use of time-of-flight diffraction technique (TOFD) for examination of welds*

EN ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003, corrected version:2005, including Technical Corrigendum 1:2006)*

3 Symbols, terms and definitions

3.1 Symbols

h height of an indication (see Figures 1, 2 and 3)

l length of an indication (see Figures 1, 2 and 3)

t nominal wall thickness in accordance with construction drawing or dimension table (see Figures 1, 2 and 3)

3.2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.2.1

embedded discontinuity

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

3.2.2

surface-breaking discontinuity

discontinuity connected to the near (contact) surface or far (reflecting) surface

4 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 EN ISO 5817 are given in Table 1.

Table 1 — Acceptance levels

Quality level according to EN ISO 5817	Examination level in accordance with CEN/TS 14751	Acceptance level
B (Stringent)	C	1
C (Intermediate)	at least B	2
D (Moderate)	at least A	3

5 Definition and determination of length and height

5.1 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.

5.2 Determination of length

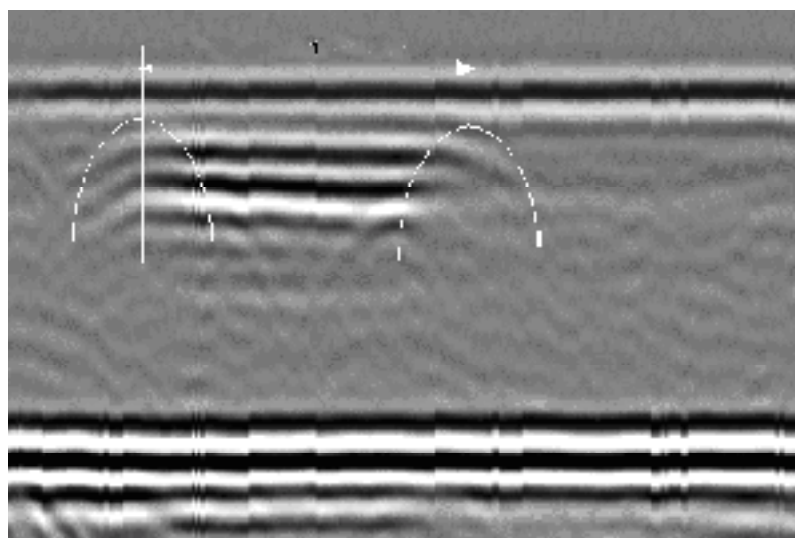
5.2.1 General

Dependent upon the type of indication, one of the techniques for length sizing according to 5.2.2 or 5.2.3 shall be applied:

5.2.2 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 will only be 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

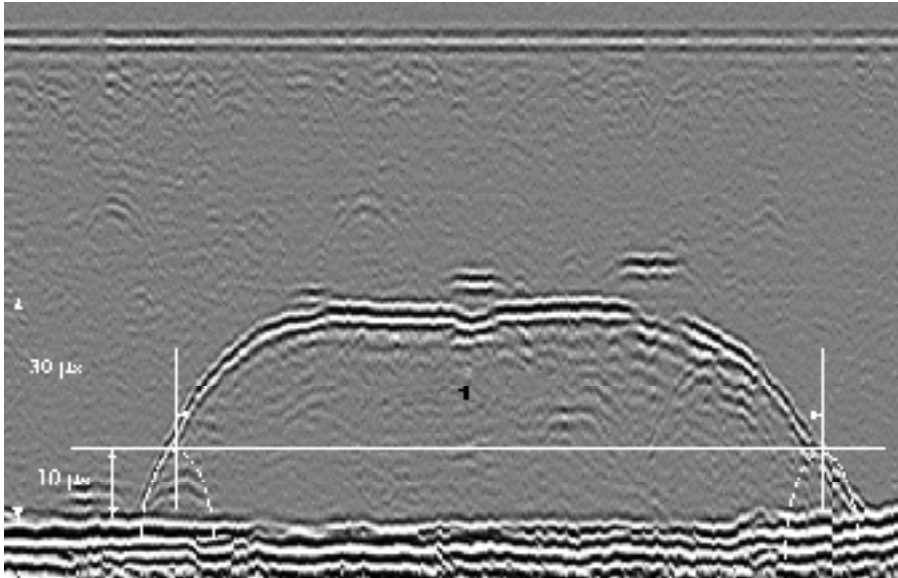
1 Length of indication

Figure 1 — Length sizing by fitting arc-shaped cursors

5.2.3 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

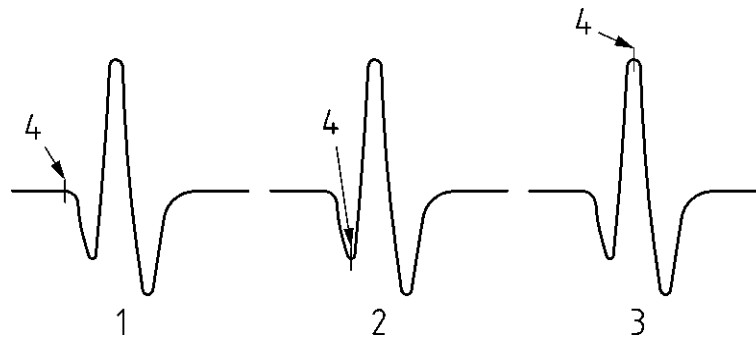
Figure 2 — Length sizing of elongated curved indication

5.3 Determination of height

5.3.1 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:

- 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.



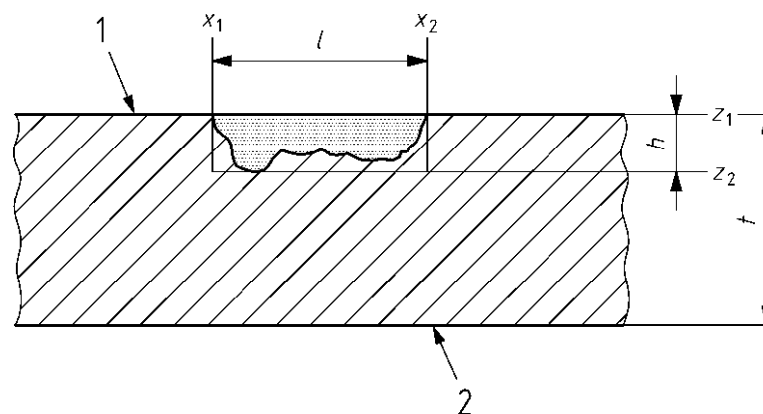
Key

- 1 Method 1
- 2 Method 2
- 3 Method 3
- 4 Positions for measuring the transit time

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

5.3.2 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.

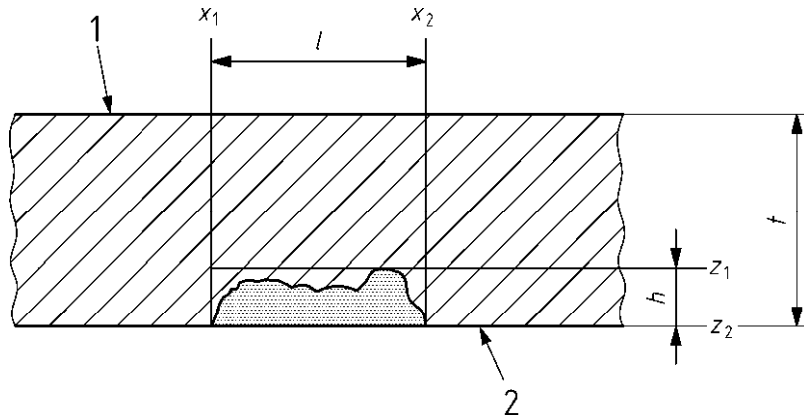


Key

- | | |
|---------------------------------------|------------------------------------|
| 1 Scanning surface | z_1 Start depth of discontinuity |
| 2 Opposite surface | z_2 End depth of discontinuity |
| x_1 Start position of discontinuity | h Height |
| x_2 End position of discontinuity | $l = x_2 - x_1$ length |

Figure 4 — Height measurement 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).



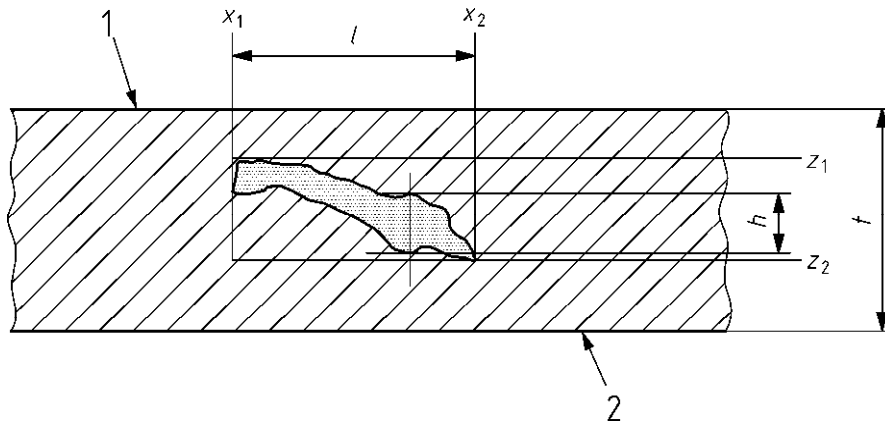
Key

- | | | | |
|-----------------|---------------------------------|-------|------------------------------|
| x_1 | Start position of discontinuity | z_1 | Start depth of discontinuity |
| x_2 | End position of discontinuity | z_2 | End depth of discontinuity |
| $l = x_2 - x_1$ | length | h | Height |

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

5.3.3 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

- | | | | |
|-----------------|---------------------------------|-------|------------------------------|
| x_1 | Start position of discontinuity | z_1 | Start depth of discontinuity |
| x_2 | End position of discontinuity | z_2 | End depth of discontinuity |
| $l = x_2 - x_1$ | length | h | Height |

Figure 6 — Height definition of an embedded discontinuity

6 Acceptance levels

6.1 General

Classified indications are evaluated according to one of the acceptance levels listed in 6.2, 6.3 and 6.4.

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.

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

6.2 Indications from single discontinuities

6.2.1 Acceptance level 1

Table 2 — Acceptance level 1

Thickness range	Maximum allowable length if $h < h_2$ or h_3 l_{\max}	Maximum allowable height if $l \leq l_{\max}$		Maximum allowable height if $l > l_{\max}$ h_1 mm
		Surface-breaking indication ^a h_3 mm	Embedded indication h_2 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.

6.2.2 Acceptance level 2

Table 3 — Acceptance level 2

Thickness range	Maximum allowable length if $h < h_2$ or h_3 l_{\max}	Maximum allowable height if $l \leq l_{\max}$		Maximum allowable height if $l > l_{\max}$ h_1 mm
		Surface-breaking indication ^a h_3 mm	Embedded indication h_2 mm	
$6 \text{ mm} < t \leq 15 \text{ mm}$	t	2	2	1
$15 \text{ mm} < t \leq 50 \text{ mm}$	t	2	4	1
$50 \text{ mm} < t \leq 100 \text{ mm}$	50 mm	3	5	2
$t > 100 \text{ mm}$	60 mm	4	6	3

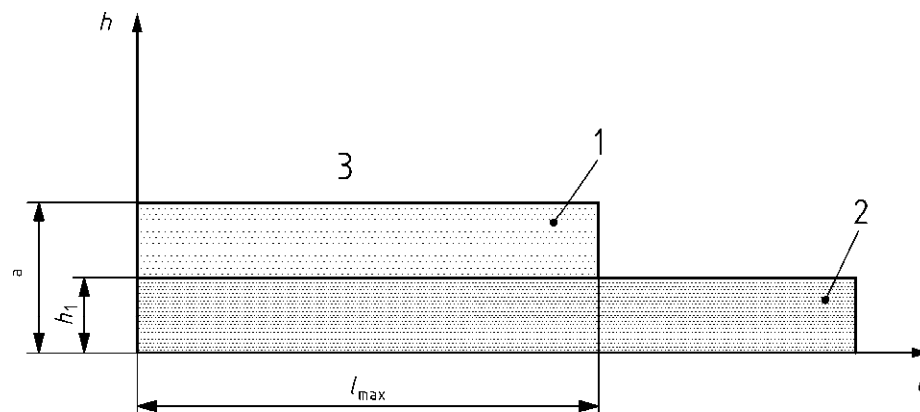
^a When indications from surface-breaking discontinuities are detected, and the resolution is not sufficient to resolve the depth, different techniques or methods shall be applied to determine the acceptability. If it is not possible to apply other techniques or methods all indications from surface-breaking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

6.2.3 Acceptance level 3

Table 4 — Acceptance level 3

Thickness range	Maximum allowable length if $h < h_2$ or h_3 l_{\max}	Maximum allowable height if $l \leq l_{\max}$		Maximum allowable height if $l > l_{\max}$ h_1 mm
		Surface-breaking indication ^a h_3 mm	Embedded indication h_2 mm	
$6 \text{ mm} < t \leq 15 \text{ mm}$	$1,5 t$ (max. 20 mm)	2	2	1
$15 \text{ mm} < t \leq 50 \text{ mm}$	$1,5 t$ (max. 60 mm)	2,5	4,5	2
$50 \text{ mm} < t \leq 100 \text{ mm}$	60 mm	4	6	3
$t > 100 \text{ mm}$	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.



Key

- 1 Acceptance for $l \leq l_{\max}$
- 2 Acceptance for $l > l_{\max}$
- 3 Rejection
- h_1 Maximum allowable height for any discontinuity if $l > l_{\max}$
- $a = h_2$ Height for embedded discontinuity
- $a = h_3$ Height for surface-breaking discontinuity

Figure 7 — General scheme for acceptance conditions

6.3 Total length of indications

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

- for acceptance level 1: $3,5 t$ with a maximum of 150 mm,
- for acceptance level 2: $4,0 t$ with a maximum of 200 mm,
- for acceptance level 3: $4,5 t$ with a maximum of 250 mm.

6.4 Grouping of indications

Point-like indications are not considered for grouping.

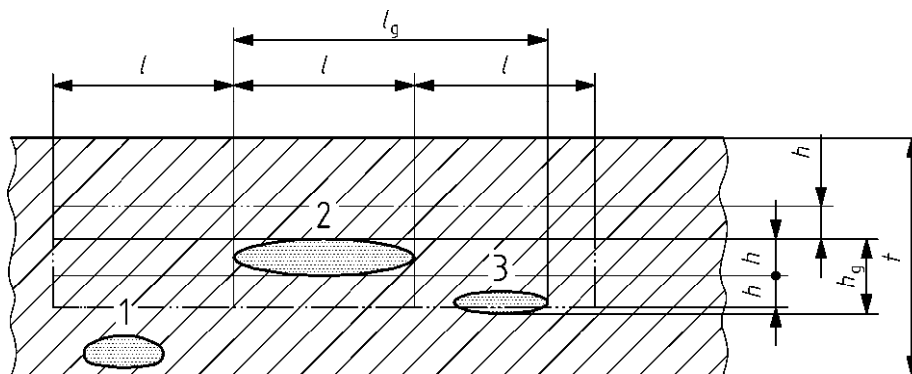
Grouping of indications is based on the size and the separation of individual indications. The length and the size of a group shall not be used for further grouping.

For evaluation a group of indications shall be considered as a single one if:

- the distance between two individual indications along the weld is less than the length of the longer indication; and
- the distance between two individual indications in thickness direction of the weld is less than the height of the higher indication.

h_g for a grouped indication is defined as the sum of the heights of the individual indications plus the distance between them (see Figure 8).

l_g for a grouped indication is defined as the sum of the lengths of the individual indications plus the distance between them (see Figure 8).



Note h and l refer to the larger indication.

Figure 8 — Dimensions of grouped indications

Indications 2 and 3 shown in Figure 8 have to be treated as a single one, because their separation in x-direction is smaller than l and their separation in z-direction is smaller than h .

Indication 1 is not included in the group, because the separation in z-direction is larger than h .

6.5 Point-like indications

The following applies to all acceptance levels.

The maximum allowable number (N) of single diffraction signals in any 150 mm of weld length can be calculated with:

$$N = 1,2 t / \text{mm}$$

where

N is rounded to the higher integer and
thickness (t) is given in millimetre.

Bibliography

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

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