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Neporušitveno preskušanje - Preskušanje z ultrazvokom - Preiskava za ugotavljanje izgube debeline zaradi erozije in/ali korozije z uporabo tehnike TOFD

Non-destructive testing - Ultrasonic testing - Examination for loss of thickness due to erosion and/or corrosion using the TOFD technique

Zerstörungsfreie Prüfung - Ultraschallprüfung - Prüfung für den Verlust der Dicke aufgrund von Erosion und/oder Korrosion unter Anwendung der Beugungslaufzeittechnik (TOFD)

Essais non destructifs - Contrôle par ultrasons - Examen de la perte d'épaisseur due à l'érosion et/ou à la corrosion par la technique TOFD

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Essais non destructifs - Contrôle par ultrasons - Examen de la perte d'épaisseur due à l'érosion et/ou à la corrosion par la technique TOFD

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European foreword

This document (prEN 17290:2018) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

1 Scope

This document specifies the application of the time-of-flight diffraction (TOFD) technique in testing of metals for quantifying loss of thickness due to erosion and/or corrosion.

This document applies to all types of corrosion or erosion damage, particularly those defined in ISO 16809.

This test applies to unalloyed or low-alloyed steel materials.

It applies to components with a nominal thickness ≥ 6 mm. For smaller thicknesses feasibility tests will be performed to validate the technique.

For other materials, feasibility tests are essential too.

The TOFD technique can be used here as a stand-alone technique or in combination with other non-destructive testing techniques, during manufacturing and for testing in-service, in order to detect material loss caused by erosion and/or corrosion.

This technique is based on analysis of TOFD images established using reflected and/or diffracted ultrasonic signals.

This document does not specify acceptance levels.

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.

EN 12668-1, *Non-destructive testing - Characterization and verification of ultrasonic examination equipment – Part 1: Instruments*

EN 12668-2, *Non-destructive testing - Characterization and verification of ultrasonic examination equipment – Part 2: Probes*

EN 12668-3:2013, *Non-destructive testing - Characterization and verification of ultrasonic examination equipment – Part 3: Combined equipment*

EN ISO 5577, *Non-destructive testing - Ultrasonic testing - Vocabulary (ISO 5577)*

EN ISO 9712, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712)*

EN ISO 10863:2011, *Non-destructive testing of welds - Ultrasonic testing - Use of time-of-flight diffraction technique (TOFD) (ISO 10863:2011)*

EN ISO 15626:2013, *Non-destructive testing of welds - Time-of-flight diffraction technique (TOFD) - Acceptance levels (ISO 15626:2011)*

EN ISO 16828:2014, *Non-destructive testing - Ultrasonic testing - Time-of-flight diffraction technique as a method for detection and sizing of discontinuities (ISO 16828:2012)*

EN ISO 17659, *Welding - Multilingual terms for welded joints with illustrations (ISO 17659)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 5577, EN ISO 16828 and EN ISO 10863 apply.

4 General specifications

4.1 General

The TOFD technique can be applied for thickness measurement on the body of components, pipes and along welded joints.

Testing and determination of thickness shall be carried out from the opposite side of the corroded surface.

4.2 Limits of the technique

For pipes, components and instrument sleeves in service, the limits described in EN ISO 16828 apply. The presence of internal discontinuities can hamper the testing for loss of wall thickness.

When applied on welded joints, special precautions for use shall be taken when discontinuities of the following types are present:

a) separation;

b) misalignment;

c) tapering; and

d) weld on permanent support.

Feasibility tests on representative welds are recommended before using the TOFD technique.

5 Test equipment

5.1 Instrument

The ultrasonic instrument used for the examination complies with the requirements of EN 12668-1 and EN ISO 16828.

5.2 Probes and TOFD set-up

The ultrasonic probes used for the TOFD technique shall comply with the requirements of EN 12668-2 and EN ISO 16828. The selection of probe characteristics is covered in 6.4.

The maximum diffraction efficiency occurs when the included angle is about 120°. The probes should be arranged such that the beam axes intersect at about this angle in the depth region to be tested.

Deviations of more than – 35° or + 45° from this value may cause the diffracted echoes to be weak and should not be used unless detection capabilities can be demonstrated.

The probe support mechanism shall ensure probe centre separation (PCS) within ± 1 mm and constant alignment between the index points.

5.3 Encoder

Information on the position shall be provided by an encoding system.

The encoding system shall be compatible with the acceptance levels specified for the spatial resolution.

5.4 Combined equipment

Any combined equipment (instrument, probes and cables) that is used shall comply with the requirements of EN ISO 16828 and at least fulfil the checks specified in EN 12668-3:2013, 3.2.1, 3.2.2, 3.4.2, 3.4.3, 3.4.4, and 5.7.4 of this document.

5.5 Reference blocks

The use of one or more reference blocks is recommended.

The reference blocks should be made of a material with acoustic properties equivalent to those of the test object, at least with regard to sound velocity, surface condition, and geometry.

When using the TOFD technique for thickness measurement of welded joints, at least one reference block with a weld is recommended.

Thickness of reference blocks is recommended to be between 0,8 and 1,2 times the thickness of the test object with a maximum difference in thickness of 20 mm compared to the test object.

The geometry of reference reflectors depends on the profile of corrosion to be covered by the test. They may be flat-bottomed holes, hemispherically-bottomed holes, side-drilled holes, EDM notches.

The characteristics of the reference reflectors (type, size, geometry, dimensions, position, accuracy of implementation) shall be in accordance with the expected performance levels.

An example of a reference block is given in Annex A.

5.6 Couplant

The same couplant shall be used for the settings and for the testing.

6 Application of the technique

6.1 Surface condition

The test surface being examined shall be free of paint, loose scale, dried coupling medium and any other product or surface irregularity that may interfere with the transmission of ultrasound into the test object, or that may hinder free movement of the probes or probe holders. The surface roughness, Ra, shall not be greater than 12,5 µm. The surface should be ground if needed.

It is allowed to perform testing through the paint (adherent coating) on parts of piping, provided that the test performance is checked.

6.2 Temperature

The surface temperature of the object shall not exceed 50 °C, unless suitable probes and couplant are used and a correction for the temperature is performed.

6.3 Marking

The tested zones examined shall be marked and the references used shall be documented to allow the zones to be identified and any discontinuities to be located.

6.4 Selection of probes and PCS

The TOFD set-up (transmitter probe, receiver probe and PCS) is defined by the thickness of the zone to be tested. The thickness is determined by one of the following three cases:

— Case 1: Nominal thickness;

— Case 2: Reference thickness (base measurement);

— Case 3: Thickness next to the corroded zone, but not affected by corrosion.

As a guideline, Table 1 provides recommended parameters for probe selection, when using longitudinal waves.

Table 1 — Recommended TOFD probe parameters

Wall thickness t (mm)	Centre frequency (MHz)	Nominal angle α (°)	Transducer dimensions (mm)
6 - 10	15	70	2 - 3
10 - 15	10 - 15	70	2 - 3
15 - 35	5 - 10	60 - 70	2 - 6
35 - 50	3 - 5	60 - 70	3 - 6
50 - 100	3 - 5	45 - 60	6 - 12
100 - 200	2 - 5	45 - 60	6 - 20
200 - 300	1 - 3	40 - 50	10 - 20

The PCS shall be selected such that the beam intersection point is located at the value of the thickness.

Other TOFD set-ups may be used for further testing.

In that case the PCS shall be selected depending on the geometry and degradation mechanism, such that the beam intersection point is located at a smaller thickness. The combination of nominal beam angle and PCS determines the intersection point, but also the depth resolution (accuracy) and the shape of the locus curve (detection of off-set indications).

Possibly multiple set-ups are required to meet the required coverage and accuracy depending on the application.

If possible and in accordance with the required application:

a) Choose the highest possible frequency compatible with the grain structure, the thickness and the surface condition of the test object;

b) Choose a short PCS (gives better resolution at depth).

6.5 Instrument settings

6.5.1 Time window

The area of interest is defined by one of the following three cases:

a) by the lateral wave and the back-wall echo;

b) by the measurable minimum residual wall thickness, and the back-wall echo;

c) by the requirements of the customer.

The time window starts at least 1 µs before the area of interest and ends at least 1 µs after the area of interest.

This window can be extended to the first mode-converted echo (detection of thickness loss that are deflected with respect to the tandem).

6.5.2 Time-to-depth conversion

For a given PCS, the time-depth conversion is set using one or more time reference signals (lateral wave, back-wall echo, reflector at a known depth) with a known material velocity. This shall comply with EN ISO 15626:2013, 5.3.

After conversion, the thickness or depth measured on the reference block shall be within ± 0,2 mm of the thickness or depth of the block.

Corrections are necessary for components with complex geometry.

6.5.3 Sensitivity setting

The test sensitivity is set by one of the following alternatives:

a) on the reflectors of the reference block;

b) on the test object.

When using Case a):

The height of the echo from the reference reflector closest to the thickness of the test object shall be set to at least 80 % of FSH.

When using Case b):

The sensitivity shall be set such that the amplitude of the back-wall signal is between 18 dB and 30 dB above FSH. When the use of a back-wall signal is not appropriate, the sensitivity shall be set such that the material grain noise is between 5 % and 10 % of FSH.

Typically this sensitivity setting is suitable for detecting diffraction signals. In case only reflection signals are required a lower sensitivity setting maybe suitable.

For both cases the signal-to-noise ratio shall be at least 6 dB. Otherwise different probes and / or settings shall be used according to Table 1.

6.5.4 Checking of the combined equipment

Checks to confirm the time base and sensitivity settings shall be performed at least every 4 hours and on completion of the testing.

Checks shall also be carried out whenever a system parameter is changed or changes in the settings are suspected.

If a reference block was used for the initial set-up, the same reference block should be used for subsequent checks. A different block may be used, provided that it has been cross-referenced with the initial reference block.

If deviations from the initial settings are found during the checks, the corrections given in Table 2 shall be carried out.