SLOVENSKI STANDARD
SIST EN 17290:2021

01-december-2021

Neporušitvene preiskave - 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

Ta slovenski standard je istoveten z: **EN 17290:2021**

ICS:

19.100	Neporušitveno preskušanje	Non-destructive testing

SIST EN 17290:2021 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 17290

October 2021

ICS 19.100

English Version

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

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

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

This European Standard was approved by CEN on 5 March 2021.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN 17290:2021 E

Contents

Page

European foreword ... 3

1 Scope ... 4

2 Normative references ... 4

3 Terms and definitions ... 5

4 General specifications ... 5
4.1 General ... 5
4.2 Limits of the test technique ... 5

5 Qualification of personnel ... 5

6 Test equipment ... 5
6.1 Instrument ... 5
6.2 Probes and TOFD set-up ... 5
6.3 Encoder ... 6
6.4 Combined equipment ... 6
6.5 Reference blocks ... 6
6.6 Couplant ... 6

7 Application of the technique ... 6
7.1 Surface condition ... 6
7.2 Temperature ... 6
7.3 Marking ... 6
7.4 Selection of probes and PCS ... 7
7.5 Instrument settings ... 8
7.6 Testing ... 9

8 Interpretation and analysis of TOFD images ... 10
8.1 Validation of TOFD images ... 10
8.2 Relevant indications ... 10
8.3 Determination of dimensions and location ... 11

9 Test report ... 15

Annex A (informative) Example of a reference block ... 17

Annex B (informative) Examples of typical TOFD images of loss of thickness due to erosion and/or corrosion ... 19

Bibliography ... 22

European foreword

This document (EN 17290:2021) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

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 April 2022, and conflicting national standards shall be withdrawn at the latest by April 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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

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 and/or erosion damage, particularly those defined in EN ISO 16809.

This document applies to unalloyed or low-alloyed steels.

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

For other materials, feasibility tests are essential, too.

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

This technique is based on analysis of TOFD images 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 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 10863:2020, *Non-destructive testing of welds — Ultrasonic testing — Use of time-of-flight diffraction technique (TOFD) (ISO 10863:2020)*

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)*

EN ISO 22232-1, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 1: Instruments (ISO 22232-1)*

EN ISO 22232-2, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 2: Probes (ISO 22232-2)*

EN ISO 22232-3, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 3: Combined equipment (ISO 22232-3)*

3 Terms and definitions

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

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

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

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

4 General specifications

4.1 General

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

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

4.2 Limits of the test technique

For testing pipes and components 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 shall be taken for the following situations:

a) misalignment;

b) tapering; and

c) weld on permanent support.

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

5 Qualification of personnel

The personnel performing the testing and interpreting the results shall have corresponding training and experience in the field of ultrasonic testing. Additionally, the personnel shall be qualified to properly perform TOFD UT in accordance with the requirements in EN ISO 9712 or equivalent.

6 Test equipment

6.1 Instrument

The ultrasonic instrument used for testing shall comply with the requirements of EN ISO 22232-1.

6.2 Probes and TOFD set-up

The ultrasonic probes used for the TOFD technique shall comply with the requirements of EN ISO 22232-2.

The selection of probe characteristics is covered in 7.4.

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 constant probe centre separation (PCS) within ± 1 mm and constant alignment between the index points.

6.3 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.

6.4 Combined equipment

Any combined equipment (instrument, probes and cables) that is used shall comply with the requirements of EN ISO 16828 and EN ISO 22232-3.

6.5 Reference blocks

The use of one or more reference blocks is recommended.

The reference block(s) 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.

The thickness of reference blocks is recommended to be between 0,8 and 1,5 times the thickness of the test object with a maximum difference in thickness of 20 mm compared to the test object.

The characteristics of the reference reflectors (type, size, geometry, dimensions, position, accuracy of implementation) shall be in accordance with the expected erosion and/or corrosion. They may be flat-bottomed holes, hemispherically-bottomed holes, side-drilled holes, EDM notches, or other shapes, if applicable.

An example of a reference block is given in Annex A, Figures A.1, A.2, A.3 and A.4.

6.6 Couplant

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

7 Application of the technique

7.1 Surface condition

The test surface shall be free of 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, R_a, shall not be greater than 12,5 µm. The surface should be ground if needed.

It is possible to perform testing through adhered paint or coating, provided that the test performance is checked.

7.2 Temperature

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

7.3 Marking

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

7.4 Selection of probes and PCS

The TOFD setup (transmitter probe, receiver probe and PCS) depends on the thickness of the zone to be tested.

The thickness value to be considered for the probe selections and the settings can be determined by one of the following cases:

1) Nominal thickness (specified by the client);

2) Reference thickness (determined by an earlier measurement);

3) Thickness measured next to the eroded and/or corroded zone, but not affected by corrosion and/or erosion.

The value of the chosen thickness shall be reported together with the used case.

For welds joining two different thicknesses, the settings shall be based on the thinner of the two.

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 probe angle (°)	Transducer dimensions (mm)
6 to 10	15	70	2 to 3
10 to 15	10 to 15	70	2 to 3
15 to 35	5 to 10	60 to 70	2 to 6
35 to 50	3 to 5	60 to 70	3 to 6
50 to 100	3 to 5	45 to 60	6 to 12
100 to 200	2 to 5	45 to 60	6 to 20
200 to 300	1 to 3	40 to 50	10 to 20

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

Other TOFD setups may be used for additional testing. In that case the PCS shall be selected depending on the geometry and progress of corrosion and/or erosion, such that the beam intersection point is located at a smaller depth. 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 setups are required to meet the required coverage and accuracy depending on the application.

If possible and in accordance with the required application:

a) the highest possible frequency shall be chosen which is compatible with the grain structure, the thickness and the surface condition of the test object;

b) the lowest possible beam angle shall be chosen to provide a short PCS (this results in a better resolution in depth).

7.5 Instrument settings

7.5.1 Time window

The area of interest shall be chosen from one of the following cases:

a) the lateral wave, the back-wall echo and the first mode-converted back-wall echo;

b) the measurable minimum residual wall thickness, the back-wall echo and the first mode-converted back-wall echo;

c) the requirements of the customer.

The time window shall start at least 1 µs before the area of interest and shall end at least 1 µs after the area of interest.

7.5.2 Time-to-depth conversion

For a given PCS, the time-to-depth conversion shall be set using one or more time reference signals (lateral wave, back-wall echo, reflector at a known depth) with a known material velocity.

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

Corrections are necessary for components with complex geometry.

7.5.3 Sensitivity setting

The test sensitivity shall be set by one of the following alternatives:

a) on the reference block;

b) on the test object.

When using 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 (full screen height).

Differences in signal amplitude between the reference block and the test object could require compensation, e.g. a transfer correction.

When using b):

If the back-wall echo is applicable, 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 signal from the lateral wave shall be used and set to 40 % to 80 % of FSH.

For both cases the material grain noise shall not exceed 10 % of FSH.

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

7.5.4 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 setup, 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.

Table 2 — Sensitivity and time base corrections

Sensitivity	
Deviations ≤ 6 dB	No corrective action required (data may be corrected by software)
Deviations > 6 dB	Settings shall be corrected and all tests carried out since the last valid check shall be repeated.
Time base	
Deviations ≤ 0,2 mm or 2 % of depth range (whichever is greater)	No corrective action required
Deviations > 0,2 mm or 2 % of depth range (whichever is greater)	Settings shall be corrected and all tests carried out since the last valid check shall be repeated.

7.6 Testing

7.6.1 General

Testing using the TOFD technique shall be carried out in accordance with 7.6.2 to 7.6.5 so that the quality of the recorded data and associated images allow for the analysis of the results at the expected performance level according the specification, if applicable.

7.6.2 Scan plan

The test shall be performed using scans, e.g. parallel or non-parallel, adapted to the characteristics of the expected loss of thickness and the extent of the test zone, or scanning according to a grid defined by the areas of interest.

The grid increment shall be adapted to the contour of the expected loss of thickness.

For better coverage and/or to determine the left-right position of indications, additional scans with different centreline positions shall be performed, so called offset scanning.

7.6.3 Complementary evaluation

Complementary evaluation shall be done:

a) if there is an indication between the back-wall echo and the first mode-converted echo;

b) to optimize determination of the characteristics of the erosion and/or corrosion damage (extent, position, and depth).