

Non-destructive testing — Ultrasonic examination —

Part 6: Time-of-flight diffraction technique as a method for detection and sizing of discontinuities

ICS 19.100

National foreword

This Draft for Development is the official English language version of ENV 583-6:2000. During the development of ENV 583-6, the UK expressed concern about some of its provisions. Particular attention is drawn to the points outlined in national annex NA. Attention is also drawn to the related British Standard BS 7706:1993.

This publication is not to be regarded as a British Standard.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

Summary of pages

This document comprises a front cover, an inside front cover, the ENV title page, pages 2 to 15 and a back cover.

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This Draft for Development, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 July 2000

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ISBN 0 580 34871 7

Amendments issued since publication

Amd. No.	Date	Comments

English version

Non-destructive testing — Ultrasonic examination — Part 6: Time-of-flight diffraction technique as a method for detection and sizing of discontinuities

Essais non destructifs — Contrôle ultrasonore —
Partie 6: Technique de diffraction du temps de vol
utilisée comme méthode de détection et de
dimensionnement des discontinuités

Zerstörungsfreie Prüfung — Ultraschallprüfung —
Teil 6: Beugungslaufzeittechnik, ein Technik zum
Auffinden und Ausmessen von Inhomogenitäten

This European Prestandard (ENV) was approved by CEN on 21 May 1997 as a prospective standard for provisional application.

The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard.

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

This European Prestandard has been prepared by Technical Committee CEN/TC 138, Non-destructive testing, the Secretariat of which is held by AFNOR.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this European Prestandard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

EN 583, *Non-destructive testing — Ultrasonic examination* consists of the following parts:

- EN 583-1, *Non-destructive testing — Ultrasonic examination — Part 1: General principles.*
- EN 583-2, *Non-destructive testing — Ultrasonic examination — Part 2: Sensitivity and range setting.*
- EN 583-3, *Non-destructive testing — Ultrasonic examination — Part 3: Transmission technique.*
- EN 583-4, *Non-destructive testing — Ultrasonic examination — Part 4: Examination for discontinuities perpendicular to the surface.*
- EN 583-5, *Non-destructive testing — Ultrasonic examination — Part 5: Characterization and sizing of discontinuities.*
- ENV 583-6, *Non-destructive testing — Ultrasonic examination — Part 6: Time-of-flight diffraction technique as a method for detection and sizing of discontinuities.*

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1 Scope

This European Prestandard defines the general principles for the application of the Time-of-flight diffraction (TOFD) technique for both detection and sizing of discontinuities in low alloyed carbon steel components. It could also be used for other types of materials, provided the application of the TOFD technique is performed with necessary consideration of geometry, acoustical properties of the materials and the sensitivity of the examination.

Although it is applicable, in general terms, to discontinuities in materials and applications covered by EN 583-1, it contains references to the application on welds. This approach has been chosen for reasons of clarity as to the ultrasonic probe positions and directions of scanning.

Unless otherwise specified in the referencing documents, the minimum requirements of this Prestandard are applicable.

Unless explicitly stated otherwise, this Prestandard is applicable to the following product classes as defined in EN 583-2:

- class 1, without restrictions;
- classes 2 and 3, restrictions will apply as stated in clause 9.

The inspection of products of classes 4 and 5 will require special procedures. These are addressed in clause 9 as well.

2 Normative references

This European Prestandard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 473, *Qualification and certification of NDT personnel — General principles*.

EN 583-1, *Non-destructive testing — Ultrasonic examination — Part 1: General principles*.

EN 583-2, *Non-destructive testing — Ultrasonic examination — Part 2: Sensitivity and range setting*.

EN 12668-1, *Ultrasonic examination — Characterization and verification of ultrasonic examination equipment — Part 1: Instruments*.

EN 12668-2, *Ultrasonic examination — Characterization and verification of ultrasonic examination equipment — Part 2: Probes*.

EN 12668-3, *Ultrasonic examination — Characterization and verification of ultrasonic examination equipment — Part 3: Combined equipment*.

3 Definitions and symbols

— TOFD Time-of-flight diffraction.

x	coordinate parallel to the scanning surface, and parallel to a predetermined reference line. In case of weld inspection this reference line should coincide with the weld. The origin of the axes may be defined as best suits the specimen under examination (see Figure 1);
Δx	imperfection length;
y	coordinate parallel to the scanning surface, perpendicular to the predetermined reference line (see Figure 1);
δy	error in lateral position;
z	coordinate perpendicular to the scanning surface (see Figure 1);
Δz	imperfection height;
d	depth of a imperfection tip below the scanning surface;
δd	error in depth;
D_{ds}	scanning-surface dead zone;
D_{dw}	backwall dead zone;
c	sound velocity;
δc	error in sound velocity;
R	spatial resolution;
t	time-of-flight from the transmitter to the receiver;
Δt	time-of-flight difference between the lateral wave and a second ultrasonic signal;
δt	error in time-of-flight;
t_d	time-of-flight at depth d ;
t_p	length (in time) of the acoustical pulse up to an amplitude of 10 % of the maximum;
t_w	time-of-flight of the backwall echo;
S	half the distance between the index points of two ultrasonic probes;
δS	error in half the probe separation;
W	wall thickness;
dead zone	zone where indications may be obscured due to the presence of signals of geometrical origin;
back wall dead zone	extra dead zone where signals may be obscured by the presence of the back wall echo;
A-scan	display of the ultrasonic signal amplitude as a function of time;
B-scan	display of the time-of-flight of the ultrasonic signal as a function of probe displacement;
non-parallel scan	scan perpendicular to the ultrasonic beam direction (see Figure 4);
parallel scan	scan parallel to the ultrasonic beam direction (see Figure 5).

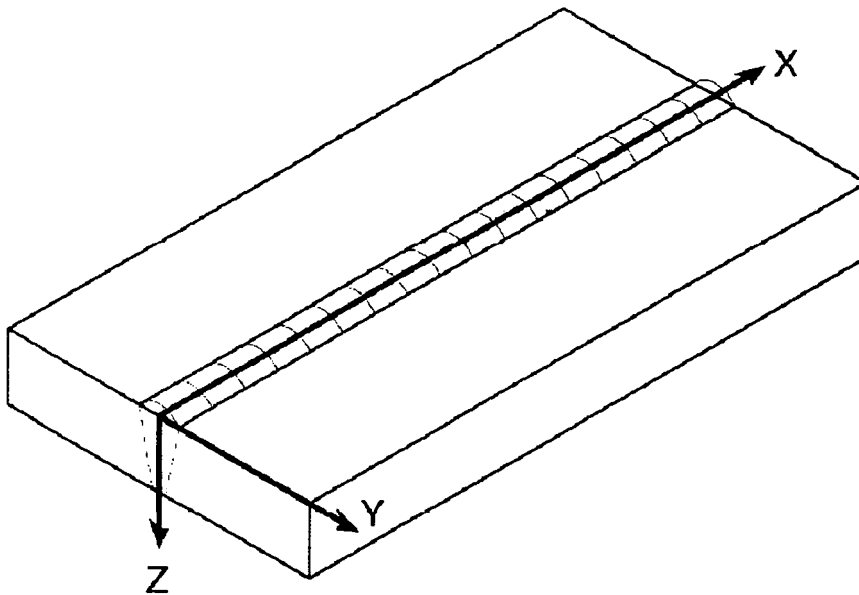


Figure 1 — Coordinate definition

4 General

4.1 Principle of the technique

The TOFD technique relies on the interaction of ultrasonic waves with the tips of discontinuities. This interaction results in the emission of diffracted waves over a large angular range. Detection of the diffracted waves makes it possible to establish the presence of the imperfection. The time-of-flight of the recorded signals is a measure for the height of the imperfection, thus enabling sizing of the defect. The dimension of the imperfection is always determined from the time-of-flight of the diffracted signals. The signal amplitude is not used in size estimation.

The basic configuration for the TOFD technique consists of a separate ultrasonic transmitter and receiver (see Figure 2). Wide-angle beam compression wave probes are normally used since the diffraction of ultrasonic waves is only weakly dependent on the orientation of the imperfection tip. This enables the inspection of a certain volume in one scan. However, restrictions apply to the size of the volume that can be inspected during a single scan (see 7.2).

The first signal to arrive at the receiver after emission of an acoustic pulse is usually the lateral wave which travels just beneath the upper surface of the test specimen.

In the absence of discontinuities the second signal to arrive at the receiver is the backwall echo.

These two signals are normally used for reference purposes. If mode conversion is neglected, any signals generated by discontinuities in the material should arrive between the lateral wave and the backwall echo, since the latter two correspond, respectively, to the shortest and longest paths between transmitter and receiver. For similar reasons the diffracted signal generated at the upper tip of an imperfection will arrive before the signal generated at the lower tip of the imperfection. A typical pattern of indications (A-scan) is shown in Figure 3. The height of the imperfection can be deduced from the difference in time-of-flight of the two diffracted signals (see 8.1.5). Note the phase reversal between the lateral wave and the backwall echo, and between echoes of the upper and lower tip of the imperfection.

Where access to both surfaces of the specimen is possible and flaws are distributed throughout the specimen thickness, scanning from both surfaces will improve the overall precision, particularly in regard to flaws near the surfaces.

4.2 Requirements for surface condition and couplant

Care shall be taken that the surface condition meets at least the requirements stated in EN 583-1. Since the diffracted signals may be weak, the degradation of signal quality due to poor surface condition will have a severe impact on inspection reliability.