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19 March 2003

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Non-destructive testing — Eddy current testing — General principles and guidelines

The European Standard EN 12084:2001 has the status of a British Standard

ICS 19.100

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National foreword

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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;

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 12, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

© BSI 05-2001

ISBN 0 580 37174 3

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12084

March 2001

ICS 19.100

English version

Non destructive testing - Eddy current testing - General principles and guidelines

Essais non destructifs - Examen par courants de Foucault - Principes généraux et directives

Zerstörungsfreie Prüfung - Wirbelstromprüfung - Allgemeine Grundlagen und Richtlinien

This European Standard was approved by CEN on 4 February 2001.

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Ref. No. EN 12084:2001 E

Contents

Page

Foreword....3

1 Scope....4

2 Normative references....4

3 Terms and definitions....4

4 General principles....4

5 Qualification of personnel....5

6 Purpose of examination and products to be tested....5

7 Measurement techniques....5

8 Equipment....6
8.1 Examination system....6
8.2 Eddy current instrument....6
8.3 Probes....7
8.4 Reference pieces....7

9 Preparation of equipment....7
9.1 Instrument settings....7
9.2 Probe setting....7

10 Verification of equipment....7
10.1 Functional verification....7
10.2 Preventive verification....8

11 Preparation of product to be tested....8
11.1 Surface preparation....8
11.2 Identification....8

12 Examination....8
12.1 Safety precautions and environmental protection....8
12.2 Examination coverage....8
12.3 Signal characterization....9
12.4 Acceptance criteria....9

13 Documentation....9
13.1 Examination procedure....9
13.2 Examination report....11

Annex ZA (informative) Clauses of this European Standard addressing essential requirements or other provisions of EU Directives....12

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Foreword

This European Standard 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 September 2001, and conflicting national standards shall be withdrawn at the latest by September 2001.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

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

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1 Scope

This standard defines the general principles to be applied to the eddy current non-destructive examination of products and materials in order to provide a defined and repeatable performance.

It includes guidelines for the preparation of application documents, which describe the specific requirements for the application of the eddy current method to a product.

2 Normative references

This European Standard 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 Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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

EN 1330-5, Non-destructive testing - Terminology - Part 5 : Terms used in Eddy Current testing.

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions given in EN 1330-5 apply.

4 General principles

The eddy current examination is based upon the induction of an electric current in a conducting material. The quantity measured and analysed is related to the distribution of the induced currents. For alternating excitation it is represented by a vector in the complex plane.

The distribution of eddy current in material depth is governed by physical laws; the density of these currents decreases drastically with increasing depth. For high frequency excitation, this decrease is an exponential function of depth.

The basic parameters which influence the measured quantity are all of the following properties of the product to be tested, alone or in combination :

- the conductivity of the material ;
- the magnetic permeability of the material ;
- the size and geometry of the product to be tested ;
- the geometry between the eddy current probe and the product to be tested.

More detailed information is obtained when the measured quantity is displayed in the complex plane.

The following characteristics of the method can be used to advantage :

- it can be used without making physical contact with the product ;
- it does not need a coupling medium such as water ;
- it is capable of being used at high throughput speeds.

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5 Qualification of personnel

It is assumed that eddy current testing is performed by qualified and capable personnel. In order to prove this qualification, it is recommended to certify the personnel in accordance with EN 473 or equivalent.

NOTE For pressure equipment see directive 97/23/EC, annex I, 3.1.3 : "For pressure equipment in categories III and IV, the personnel must be approved by a third-party organization recognized by a Member State."

6 Purpose of examination and products to be tested

The purpose of the examination can be one or more of the following :

- to reveal discontinuities in the product which can affect its fitness for purpose ;
- to measure the thickness of coatings and layers ;
- to measure other geometric characteristics ;
- to measure metallurgical or mechanical properties of the product ;
- to measure the conductivity and/or permeability of the product ;
- to sort products based upon above mentioned properties.

Examples of products to be tested are conducting materials such as :

- tubes, profiles, bars, wire rods ;
- components of the automotive and machining industries ;
- forged or cast products ;
- multi-layer components in the aircraft industry.

Examples of the application of the method include :

- on line testing in rolling mills, finishing lines, drawing lines ;
- in-service inspection of heat exchanger tubing ;
- verification of the properties of mass produced articles and semi-finished products ;
- maintenance inspection of aircraft ;
- inspection of the surface of cylindrical holes formed in products.

7 Measurement techniques

Measurements can be static or dynamic, the latter requiring relative movement between the probe and the product to be tested.

The scanning of the product to be tested can be performed manually or by the use of mechanized equipment which precisely controls the scanning path.

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The commonly applied measurement techniques are :

a) Absolute measurement.

The measurement of the deviation from a fixed reference point. The reference point is defined by a calibration procedure and can be generated by a reference voltage or coil. This technique can be used for sorting the product into classes based on physical properties such as hardness, dimensions or chemical composition. It can also be used for the identification of continuous or gradually changing discontinuities.

b) Comparative measurement.

The subtraction of two measurements, one of which is taken as a reference. This technique is normally used to sort the product into classes.

c) Differential measurement.

The subtraction of two measurements made at a constant distance between the measurement locations and on the same scanning path. This measurement technique reduces the background noise due to slow variations in the product to be tested.

d) Double differential measurement.

The subtraction of two differential measurements. This measurement technique provides high-pass filtering of a differential measurement independent of the relative speed between the probe and the product to be tested.

e) Pseudo differential measurements

The subtraction of two measurements made at a constant distance between the measurement locations.

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8 Equipment

8.1 Examination system

The examination employs an eddy current instrument, a probe or probes, and interconnecting cable or cables. This combination, or together with any mechanized equipment and peripheral units for data storage etc., form an examination system.

All essential parts of the system shall be defined in the relevant application documents (13.1) or in a written procedure agreed at the time of enquiry and order.

Factors to be considered include :

the type and metallurgical condition of the material from which the product is manufactured ;

the shape, dimensions, and surface condition of the product ;

the purpose of the measurement e.g. detection of cracks or evaluation of thickness etc. ;

the type, position, and orientation of the discontinuities to be revealed ;

the environmental conditions in which the measurement is performed.

8.2 Eddy current instrument

The choice of an eddy current instrument depends on the purpose of the examination. Of particular importance are the adjustable parameters of the instrument, the range of such parameters and the form of the signal display.

The parameters of the instrument which are relevant to the examination shall be described in the application document and characterized in accordance with applicable standards.

8.3 Probes

The choice of probe depends on the purpose of the examination.

The parameters of the probe which are relevant to the examination shall be described in the application document and characterized in accordance with applicable standards.

8.4 Reference pieces

The application of an eddy current examination requires the use of reference pieces. They contain known features which can be used to set up the examination system, to make functional checks, to ensure the capability of the examination, and to provide calibration curves.

Normally the reference piece shall be of the same material and in the same finished state as the product to be tested.

The equivalence of any alternative procedure shall be demonstrated.

The features can take the form of :

holes or notches with specified dimensions ;

natural or induced defects of known characteristics ;

a range of known coating thicknesses ;

a range of known material properties.

The measurable characteristics of the features and the reference pieces shall not change significantly with time.

9 Preparation of equipment

9.1 Instrument settings

Instrument settings are derived from a knowledge of the purpose of the examination and the product to be tested.

Some settings e.g. filtering, phase, and sensitivity, can be derived from the use of the reference pieces.

9.2 Probe setting

The fixing and guiding of the probe influence the effectiveness of the examination.

Changes in the probe clearance influence the sensitivity of the examination.

A signal due to the lift off effect can be used to dynamically control the sensitivity.

Where the examination is mechanized, the speed of the probe over the surface being examined and the scanning path shall be maintained throughout the examination within a tolerance to be specified in the examination procedure.

10 Verification of equipment

The performance of the examination system shall be verified at specified intervals both on site and in the laboratory. The verification shall be in accordance with applicable standards.

10.1 Functional verification

Functional checks shall be carried out at specified intervals, at least at the beginning and the end of an examination, and/or when parts of the equipment are exchanged, and/or when personnel are changed.

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Once established, the operating conditions shall be maintained throughout the examination. An allowance for drift shall be made, in accordance with applicable standards or with the examination procedure agreed at the time of enquiry and order.

Failure of this verification shall be recorded and all of the product examined since the previously successful verification shall be considered not examined.

10.2 Preventive verification

The frequency of this verification is typically once a year.

Deviations and the corrective action taken shall be recorded.

11 Preparation of product to be tested

11.1 Surface preparation

The surface condition of the product to be tested can affect the effectiveness of the examination.

The effectiveness of the examination can be affected by :

- dirt ;
- scale ;
- non-conductive coatings, particularly if the thickness is variable ;
- other surface finishes which are conductive ;
- surface roughness ;
- weld spatter ;
- oil, grease, or water.

When such conditions cannot be changed, the effectiveness of the examination shall be demonstrated.

11.2 Identification

Products to be examined shall be uniquely identified, individually or by test batch.

Additionally a reference datum can be required to clearly locate the position of any reportable discontinuities.

12 Examination

The detailed steps of the examination shall be defined in the examination procedure (see 13.1).

12.1 Safety precautions and environmental protection

National and local accident prevention, electrical safety, handling of hazardous substances, and environmental protection regulations shall be observed at all times.

12.2 Examination coverage

The surface of the product shall be scanned in accordance with the requirements of the application document (see 13.1) or following a written procedure agreed at the time of enquiry and order.

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The following should be included :

area to be scanned or the untestable area ;

direction of scanning ;

size and type of probe ;

surface speed relative to the probe ;

width of coverage of the probe.

The degree of coverage of the surface is determined by the width of coverage of the probe, and can be influenced by the data acquisition rate of the instrument and the surface speed.

For complete coverage of the surface, that is with no under lap, the width of the scanning path shall not exceed the width of coverage of the probe.

12.3 Signal characterization

In order to make decision, examination results have to be correlated with features of the tested product such as cracks, wear, physical properties.

Application documents or a procedure, agreed at the time of enquiry and order, shall therefore include :

recording requirements ;

evaluation requirements ;

reporting requirements.

Signals are analysed with respect to characteristics, such as the amplitude, the phase, or the combination of both in defined ranges.

Classification of indications can then range from a simple mechanized sorting device to a classification using a multiparameter correlation technique based on more than one calibration curve.

12.4 Acceptance criteria

The acceptance criteria and the subsequent action for the product shall be defined in the application documents (see 13.1) or in a written procedure agreed at the time of enquiry and order.

13 Documentation

The documentation consists of the examination procedure and the examination report.

13.1 Examination procedure

The general requirements for the application and use of the eddy current method to a product are described in application documents such as :

product standard ;

specification ;

code of practice ;

contractual document.

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The examination procedure is derived from these documents and describes all the essential parameters and the precautions to be observed. The following shall be included :

purpose of the examination ;

description of the product to be examined ;

application documents ;

qualification and certification of personnel ;

area to be examined ;

scanning plan ;

surface preparation ;

environmental conditions ;

reference pieces ;

arrangement of the examination system ;

verification intervals for the instrument and the probe ;

requirements for signal evaluation ;

description of, and the sequence of the examination ;

content of the examination report.

Prior to the definition of an examination procedure some or all of the following information is necessary :

purpose of the examination ;

detail of the product to be tested ;

physical location of the area where the examination is to be conducted ;

requirement for surface preparation ;

degree of surface deformation due to the examination process that can be tolerated without reducing the fitness for purpose of the product to be examined ;

degree of coverage of the product to be tested ;

sensitivity of the examination ;

method of verifying the sensitivity ;

acceptance criteria if specified ;

requirements of the examination report ;

qualification of the personnel.

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13.2 Examination report

The examination report shall contain sufficient information to enable the examination to be repeated at a future date.

At least the following shall be included :

- identification of the manufacturer of the product ;
- identification of each examined object ;
- reference to the application documents and the examination procedure ;
- a technique sheet (or equivalent) in cases where the examination procedure allows for a variation in the method of examination, equipment, or equipment set-up ;
- identification of the examination system particularly the type and unique identification of the instrument and probes ;
- instrument settings ;
- identification of the reference pieces used ;
- results of the examination ;
- any deviation from the examination procedure ;
- organisation responsible for the examination ;
- name and qualification, of the examiner ;
- signature of the examiner or name and signature of other authorised person ;
- date and site of the examination.

The format of an examination report shall be agreed at the time of enquiry and order.

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Annex ZA
(informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements or provisions of EU Directive:

Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment

Compliance with the tests describe in this Standard provides, for the fabricant of pressure equipment, one means to demonstrate that the equipment is conforming to the following Essential Requirements or Provisions of the Directive concerned.

Table ZA.1 - Correspondence between this European Standard and Pressure Equipment Directive (PED)

Clause / Sub-clause of EN 12084	Essential requirements or provisions of Directive	Remarks
All clauses	Annex I subclause 3.2.1	

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