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Non-destructive testing — Eddy current testing — General principles

Essais non destructifs — Contrôle par courants de Foucault — Principes généraux

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 4, *Eddy current testing*.

This second edition cancels and replaces the first edition (ISO 15549:2008), which has been technically revised.

The main change compared to the previous edition is as follows:

— rewriting of Clause 5 "Qualification of personnel".

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Non-destructive testing — Eddy current testing — General principles

1 Scope

This document defines the general principles to be applied to non-destructive eddy current examination of products and materials in order to ensure 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 particular type of product.

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.

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 12718[1)], *Non-destructive testing — Eddy current testing — Vocabulary*

ISO 15548-1, *Non-destructive testing — Equipment for eddy current examination — Part 1: Instrument characteristics and verification*

ISO 15548-2, *Non-destructive testing — Equipment for eddy current examination — Part 2: Probe characteristics and verification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12718 apply.

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

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

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

4 General principles

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

The distribution of eddy currents in the depth of a material is governed by physical laws, the density of the currents decreasing drastically with the increasing depth. For a given frequency, this decrease is an exponential function of the depth.

The following properties, alone or in combination, of the product to be tested influence the measured quantity:

— the electrical conductivity of the material;

— the magnetic permeability of the material;

1) Under preparation.

— the size and geometry of the product to be tested;

— the geometrical relationship 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 method can be applied using the following characteristics:

— the method does not involve any physical contact with the product;

— it does not need a coupling medium such as water;

— high throughput speeds can be used.

5 Qualification of personnel

Personnel who perform eddy current testing shall be certified in accordance with ISO 9712 or equivalent.

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 could affect its fitness for the purpose;

— to assess the thickness of coatings or layers;

— to assess other geometric characteristics;

— to assess metallurgical or mechanical properties of the product;

— to assess the electrical conductivity and/or permeability of the product;

— to sort products on the basis of any of the above-mentioned properties.

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

— tubes, profiles, bars or wire rods;

— components in 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 or drawing lines;

— in-service inspection of the heat-exchanger tubing;

— verification of the properties of mass-produced articles and semi-finished products;

— maintenance inspection of an aircraft;

— inspection of the surfaces of cylindrical holes formed in products.

7 Examination techniques

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

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

Commonly used measurement modes 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 a 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 a product into classes.

c) Differential measurement.

The subtraction of two measurements made at a constant distance between the measurement locations and on the same scan 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.

8 Equipment

8.1 Examination system

The examination employs an eddy current instrument, one or more probes and interconnecting cabling. This combination, together with any mechanical equipment and peripheral units for data storage, etc., forms the examination system.

All essential parts of the system shall be defined in the relevant application document (see 13.2) or in a written procedure agreed at the time of enquiry and order.

Factors to be considered include:

— the type of material from which the product was manufactured and its metallurgical condition;

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

— the purpose of the measurement, e.g. detection of cracks or determination of thickness;

— the types of discontinuity to be revealed and their position and orientation;

— the environmental conditions under which the examination is to be performed.

8.2 Eddy current instrument

The choice of 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 type of signal representation.

The instrument parameters which are relevant to the examination shall be described in the application document and characterized in accordance with ISO 15548-1.

8.3 Probe

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

The probe parameters which are relevant to the examination shall be described in the application document and characterized in accordance with ISO 15548-2.

8.4 Reference test pieces

An eddy current examination requires the use of reference test pieces. Such test pieces contain known features which can be used to set up the examination system, to make functional checks, to verify the capability of the examination system and to provide calibration curves.

Normally, the reference test 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 with known characteristics, e.g. cracks induced by fatigue cycling;

— a range of known coating thicknesses;

— a range of known material properties.

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

9 Preparation of equipment

9.1 Instrument settings

Instrument settings are derived from 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 test pieces.

9.2 Probe settings

The way in which the probe is mounted, centred and guided influence the effectiveness of the examination.

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

A signal dependent on changes in the probe clearance can be used for dynamic control of the sensitivity.

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

10 Verification of equipment

10.1 Verification intervals

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.

10.2 Functional verification

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

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 products examined since the previous successful verification shall be considered as not having been examined.

10.3 Preventive verification

The frequency of this verification is typically once a year.

Deviations and the corrective action taken shall be recorded.

11 Preparation of the 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;

— conductive and/or ferromagnetic residue;

— scale;

— non-conductive coatings, particularly if the thickness is variable;

— other surface finishes which are conductive;

— the 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.