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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

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 15549 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 4, *Eddy current methods*.

Non-destructive testing — Eddy current testing — General principles

1 Scope

This International Standard 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 referenced documents are indispensable for the application 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 personnel*

ISO 12718, *Non-destructive testing — Eddy current testing — Terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12718 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 currents in a material according to depth is governed by physical laws, the density of the currents decreasing drastically with increasing depth. For high-frequency excitation, this decrease is an exponential function of depth.

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

— the conductivity of the material;

— the magnetic permeability of the material;

— 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 following characteristics of the method represent advantages:

— 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

It is assumed that the eddy current testing will be performed by qualified and capable personnel. In order to ensure that this is the case, it is recommended that personnel 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 purpose;

— to measure the thickness of coatings or 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 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 heat-exchanger tubing;

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

— maintenance inspection of aircraft;

— inspection of the surfaces 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.

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 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 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 form of the signal display.

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

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 applicable standards.

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 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;

— 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.

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

12 Examination

12.1 Steps in the examination

The detailed steps of the examination shall be defined in the examination procedure (see 13.2).

12.2 Safety precautions and environmental protection

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

