INTERNATIONAL STANDARD

ISO 15548-2

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Non-destructive testing — Equipment for eddy current examination —

Part 2: Probe characteristics and verification

Essais non destructifs — Appareillage pour examen par courants de Foucault —

Partie 2: Caractéristiques des capteurs et vérifications

Reference number
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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 15548-2 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 138, *Non-destructive Testing*, in collaboration with ISO Technical Committee TC 135, *Non-destructive Testing*, Subcommittee SC 4, *Eddy current methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 15548 consists of the following parts, under the general title *Non-destructive testing — Equipment for eddy current examination*:

- *Part 1: Instrument characteristics and verification*
- *Part 2: Probe characteristics and verification*
- *Part 3: System characteristics and verification*

Non-destructive testing — Equipment for eddy current examination —

Part 2:
Probe characteristics and verification

1 Scope

This part of ISO 15548 identifies the functional characteristics of a probe and its interconnecting elements and provides methods for their measurement and verification.

The evaluation of these characteristics permits a well-defined description and comparability of eddy current equipment.

By careful choice of the characteristics, a consistent and effective eddy current examination system can be designed for a specific application.

Where accessories are used, these should be characterised using the principles of this part of ISO 15548.

This part of ISO 15548 does not give the extent of verification nor acceptance criteria for the characteristics. These are given in the application documents.

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 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 Characteristics of probe and interconnecting elements

4.1 General characteristics

4.1.1 Application

Probes and interconnecting elements are selected to satisfy the requirements of the intended application.

The design is influenced by the instrument with which they are used.

4.1.2 Probe types

The probe is described by the following:

— type of material to be examined, i.e. ferromagnetic, non-ferromagnetic with high or low conductivity;

— function, e.g. separate or combined transmit/receive probe;

— family, e.g. coaxial probe, surface probe;

— measurement mode, e.g. absolute, differential;

— purpose of the examination, e.g. detection of discontinuities, sorting or thickness measurement, etc.;

— specific features, e.g. focused, shielded, etc.

4.1.3 Interconnecting elements

They may include the following:

— cables and/or extensions;

— connectors;

— slip rings;

— rotating heads;

— transformers;

— active devices, e.g. multiplexer, amplifier, etc.

4.1.4 Physical characteristics

The following shall be stated among others:

— external size and shape;

— weight;

— information about mechanical mounting;

— model number and serial number;

— material of manufacture of probe housing;

— composition and thickness of facing material;

— presence and purpose of core or shield;

— type of interconnecting elements (see 4.1.3);

— orientation mark (direction for maximum sensitivity, see 6.2.3.3);

— position mark (electrical centre, see 6.2.3.4).

4.1.5 Safety

The probe and its interconnecting elements shall meet the applicable safety regulations regarding electrical hazard, surface temperature, or explosion.

Normal use of the probe should not create a hazard.

4.1.6 Environmental conditions

The temperature and humidity for normal use, storage and transport should be specified for the probe and its interconnecting elements.

The tolerance of the probe and its interconnecting elements to the effects of interference noise and electromagnetic radiation shall conform to electromagnetic compatibility (EMC) regulations.

Materials used in the manufacture of the probe should be resistant to contaminants.

4.2 Electrical characteristics

The external electrical connections to the probe shall be clearly identified or declared in writing.

The electrical characteristics of a probe connected to a specified length and type of cable are as follows:

- recommended range of excitation current and voltage for safe operation;
- recommended range of excitation frequencies;
- impedance of the excitation element in air;
- resonant frequency of the excitation element in air;
- impedance of the receiving element(s) in air.

The electrical characteristics of an extension cable shall also be clearly identified.

4.3 Functional characteristics

The functional characteristics of a probe shall be determined for a defined system.

The measurement of the functional characteristics of a probe requires the use of calibration blocks. The material used for the reference block is determined by the application.

The functional characteristics of a probe are as follows:

- directionality;
- response to elementary discontinuities (hole, slot);
- length and width of coverage;
- area of coverage;
- minimum dimensions of discontinuities for constant response;
- penetration characteristics;
- geometric effects;
- normalised impedance locus (when the frequency is varied) of the exciting element with minimum probe clearance from a homogeneous block of a specified material.

These characteristics cannot be used alone to establish the performance (e.g. resolution, smallest detectable discontinuity, etc.) of the probe in a given test system, for a given application.

When relevant, the influence of interconnecting elements on the functional characteristics of the probe shall be measured.

5 Verification

5.1 General

For a consistent and effective eddy current examination, it is necessary to verify that the performance of the component parts of the eddy current test system is maintained within acceptable limits.

The physical condition of the reference blocks shall be verified to be within acceptable limits, before being used to verify the system or probes.

The measuring equipment used for verification shall be in a known state of calibration.

For a better understanding, the verification procedure is described identically in all three parts of ISO 15548.

5.2 Levels of verification

There are three levels of verification. Each level defines the time intervals between verification and the complexity of the verification.

It is understood that initial type testing has already been carried out by the manufacturer or under his control.

a) Level 1: Global functional check

A verification is performed at regular intervals of time on the eddy current test system, using reference blocks to verify that the performance is within specified limits.

The verification is usually performed at the examination location.

The time interval and the reference blocks are defined in the verification procedure.

b) Level 2: Detailed functional check and calibration

A verification on an extended time scale is performed to ensure the stability of selected characteristics of the eddy current instrument, probe, accessories and reference blocks.

c) Level 3: Characterisation

A verification is performed on the eddy current instrument, probe accessories and reference blocks to ensure conformity with the characteristics supplied by the manufacturer.

The organization requiring the verification shall specify the characteristics to be verified.

The main features of verification are shown in Table 1.

Table 1 — Verification levels

Level	Object	Typical time period	Instruments	Responsible entity
1 Global functional check	Stability of system performance.	Frequently, e.g. hourly, daily.	Reference blocks.	User
2 Detailed functional check and calibration	Stability of selected characteristics of the instrument, probes and accessories.	Less frequently but at least annually and after repair.	Calibrated measuring instruments, reference blocks.	User
3 Characterisation	All characteristics of the instrument, probes and accessories.	Once (on release) and when required.	Calibrated laboratory measuring instruments and reference blocks.	Manufacturer, user

5.3 Verification procedure

The characteristics to be verified are dependent on the application. The essential characteristics and the level of verification shall be specified in a verification procedure.

The examination procedure for the application shall refer to the verification procedure. This can restrict the number of characteristics of a general-purpose instrument to be verified for a defined application.

Sufficient data on the characteristics featured in an instrument, probe and reference block shall be provided, in order that verification may be performed within the scope of this part of ISO 15548.

5.4 Corrective actions

Level 1: When the performance is not within the specified limits, a decision shall be made concerning the product examined since the previous successful verification. Corrective actions shall be made to bring the performance within acceptable limits.

Level 2: When the deviation of the characteristic is greater than the acceptable limits specified by the manufacturer or in the application document, a decision shall be made concerning the instrument, the probe or the accessory being verified.

Level 3: When the characteristic is out of the acceptable range specified by the manufacturer or by the application document, a decision shall be made concerning the instrument, the probe or the accessory being verified.

6 Measurement of electrical and functional characteristics of a probe

6.1 Electrical characteristics

6.1.1 General

The electrical characteristics alone do not define the characteristics of the probe in its application.

The methods and measuring instruments given in 6.1.2 to 6.1.5 are for guidance; other equivalent methods and instrumentation can be used.

6.1.2 Measurement conditions

The measurements are made at the probe connector without the use of interconnecting elements of the inspection system. The probe is placed in air and away from any conductive or magnetic material.

The measurements are made for each element of the probe accessible at the probe connector. The other elements are left in open circuit.

When the probe is designed for use under particular conditions, for example, temperature or pressure, any additional measurements that are required shall be specified in the application document.

6.1.3 Resonant frequency of the excitation element

6.1.3.1 Excitation element with a single coil

Using an impedance meter, measure the resonant frequency f_{res} of the excitation element.

6.1.3.2 Excitation elements with multiple coils

An excitation element containing multiple coils will give multiple resonance frequencies. The lowest frequency shall be reported/measured.

6.1.4 Impedance of the excitation element

Measure the resistance R_0 using a multimeter, and the inductance L_0 using an impedance meter. The inductance is measured at the lowest frequency of the recommended operating range for the probe.

If the capacitance C_0 is too small to be measured directly, calculation should provide a more accurate result:

$$C_0 = \frac{1}{4\pi^2 f_{res}^2 L_0}$$

The model of the excitation-element impedance is given in Figure 1.

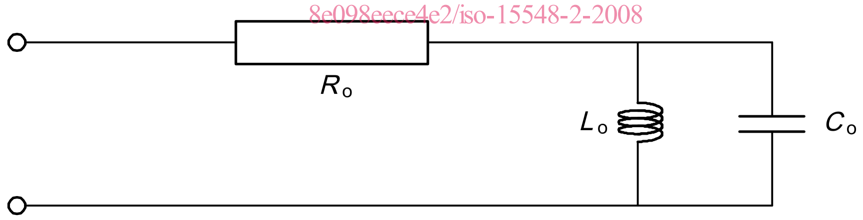


Figure 1 — Excitation-element impedance

6.1.5 Impedance of the receiving element(s)

Measure the resistance using a multimeter, and the inductance and the capacitance using an impedance meter. The measured values of impedance can be given as a curve against frequency.

6.2 Functional characteristics

6.2.1 General

This part of ISO 15548 characterises commonly used probe types. Probes which are designed for special (unusual) applications shall be characterised in accordance with an application document which follows the methodology of this part of ISO 15548. The characteristics described in this part of ISO 15548 can give useful information about such probes.

The functional characteristics are defined for two classes of probes: surface probes and co-axial probes.

6.2.2 Measurement conditions

6.2.2.1 General

A general-purpose eddy current instrument, characterised in accordance with ISO 15548-1, can be used, provided that it has the required accuracy.

Alternatively, sufficient instrumentation comprising a voltage/current generator, synchronous detection amplifier and a voltmeter or oscilloscope can be used.

When the probe does not feature a connecting cable, the characteristics of the cable used for the measurements shall be documented.

The probe characteristics are measured within the frequency range specified by the probe manufacturer using reference blocks containing known features, such as slots and holes.

The reference blocks shall be made using the specifications in the application document for the material, metallurgical properties and surface finish. Its geometry shall comply with the requirements included in the following subclauses. Blocks made from ferromagnetic material shall be demagnetized before use. The reference block can be replaced by any other device, the equivalence of which shall be demonstrated for the measured characteristic (alternative blocks, electric circuit, coil, ball, etc.).

The functional characteristics can be affected by the presence of any perturbing electromagnetic field or ferromagnetic material in the zone of influence of the probe. Care shall be taken to avoid these effects when making the measurements described in 6.2.2.2 and 6.2.2.3.

The measurement conditions for each characteristic shall be recorded, for example, excitation frequency and voltage/current, details of the reference block, etc.

The measured values are the amplitude of the signal and, when applicable, the phase of the signal.

6.2.2.2 Measurement of the amplitude of the signal

a) Absolute measurements

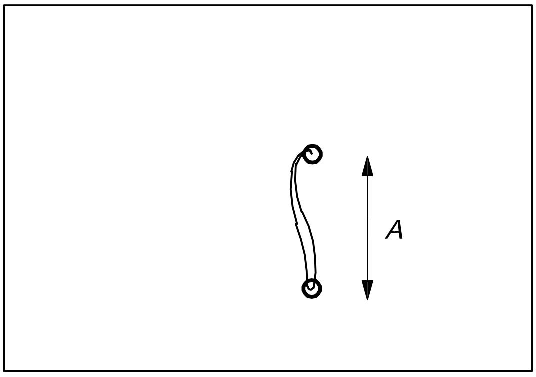
The amplitude of the signal is the length of the vector joining the balance point to the point corresponding to the maximum excursion of the signal from the balance point, unless otherwise specified in an application document, see Figure 2 a).

b) Differential measurements

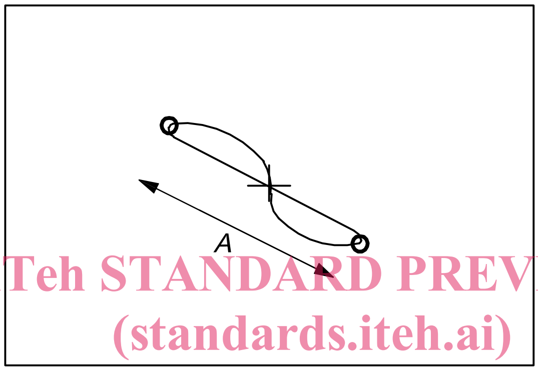
The amplitude of the signal is the length of the line joining the two extreme points of the signature i.e. peak to peak value, unless otherwise specified in an application document, see Figure 2 b).

c) Other measurements

The method shall be specified in an application document.



a) Amplitude measurement for an absolute signal



b) Amplitude measurement for a differential signal

Figure 2 — Amplitude measurements for signals

6.2.2.3 Measurement of the phase angle of the signal

The reference for the measurement of phase angle shall be the positive X axis.

The span shall be 360°, either as 0° to 360° or 0° to ± 180°.

The polarity of measurement shall be specified as follows:

— P360: 0° to 360°, positive is counterclockwise (mathematical convention);

— N360: 0° to 360°, positive is clockwise;

— P180: 0 to ± 180°, positive is counterclockwise;

— N180: 0 to ± 180°, positive is clockwise.

The phase angle is the angle between the reference line and the line representing the signal amplitude determined in 6.2.2.2.

6.2.3 Surface probes

Unless otherwise specified, the measurements shall be conducted with constant probe clearance, which will be specified in the application document.