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Second edition
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Non-destructive testing — Equipment for eddy current examination —

Part 1: Instrument characteristics and verification

Essais non destructifs — Appareillage pour examen par courants de Foucault —
Partie 1: Caractéristiques de l'appareil et vérifications

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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. www.iso.org/directives

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 135, *Non-destructive Testing*, Subcommittee SC 4, *Eddy current methods*.

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This second edition cancels and replaces the first edition (ISO 15548-1:2008), of which it constitutes a minor revision. It also incorporates the Correction ISO 15548-1:2008/Cor 1:2010.

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

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— *Part 1: Instrument characteristics and verification*

— *Part 2: Probe characteristics and verification*

— *Part 3: System characteristics and verification*

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Non-destructive testing — Equipment for eddy current examination —

Part 1: Instrument characteristics and verification

1 Scope

This part of ISO 15548 identifies the functional characteristics of a general-purpose eddy current instrument 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 are characterised using the principles of this part of ISO 15548.

This part of ISO 15548 gives neither the extent of verification nor acceptance criteria for the characteristics. They are given in the application documents.

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2 Normative references

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The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 — Vocabulary*

ISO 15549, *Non-destructive testing — Eddy current testing — General principles*

3 Terms and definitions

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

4 Eddy current instrument characteristics

4.1 General characteristics

4.1.1 Type of instrument

a) An instrument has a general-purpose application when the relationship between the measured quantity and the display or output is established by the user. A range of probes can be connected to the instrument. The instrument manufacturer shall provide details of the internal electrical characteristics, in order that the user can design the examination system. The examination system shall be in accordance with ISO 15549. The user shall be able to vary the value of frequency, gain, balance (unless an automatic balance is used), phase, filters and gain and zero of the display.

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b) An instrument is of specific application when the relationship between the measured quantity and the display or output is explicitly defined in the range of application. The probe is specific to the instrument. For this type of instrument, this part of ISO 15548 may be partially applied.

4.1.2 Power supply

The instrument can be powered by batteries or by the local AC power supply. The nominal values of voltage, frequency and power consumption shall be stated, together with the tolerance for correct operation.

4.1.3 Safety

The instrument and its accessories shall meet the applicable safety regulations, for example, electrical hazard, surface temperature, explosion, etc.

4.1.4 Technology

The instrument can be wholly analogue or partly analogue and partly digital.

The excitation can be single frequency, multifrequency, swept frequency or pulsed.

The instrument can be single or multichannel.

The instrument settings can be manual, remote controlled, stored or preset.

The instrument shall have component outputs and can be with or without a self-contained display.

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4.1.5 Physical presentation

The instrument can be portable, cased or rack mounted, with the component parts integrated or modular.

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The weight and size shall be specified for the instrument and its accessories.

The plugs and sockets shall be specified regarding type and pin interconnections.

The instrument model number and the serial number shall be clearly readable and located in a readily accessible place.

4.1.6 Environmental effects

The warm-up time necessary for the instrument to reach stable operating conditions within specified limits shall be stated.

The temperature, humidity and vibration ranges for normal use, storage and transport shall be specified for the instrument and its accessories.

The instrument shall conform to relevant electromagnetic compatibility (EMC) regulations.

4.2 Electrical characteristics

4.2.1 General

The electrical characteristics of an instrument shall be evaluated after the warm-up time has elapsed.

The electrical characteristics are only valid for the stated operating conditions.

When relevant, the stability of the specified values with time, for specified environmental conditions, shall be stated.

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The electrical characteristics apply to various items of the functional block diagram of the instrument. Where applicable, they are provided by the manufacturer. Some of these characteristics can be verified according to the methodology described in Clause 6.

4.2.2 Functional block diagram

The functional block diagram of a typical general-purpose eddy current instrument is shown in Figure 1.

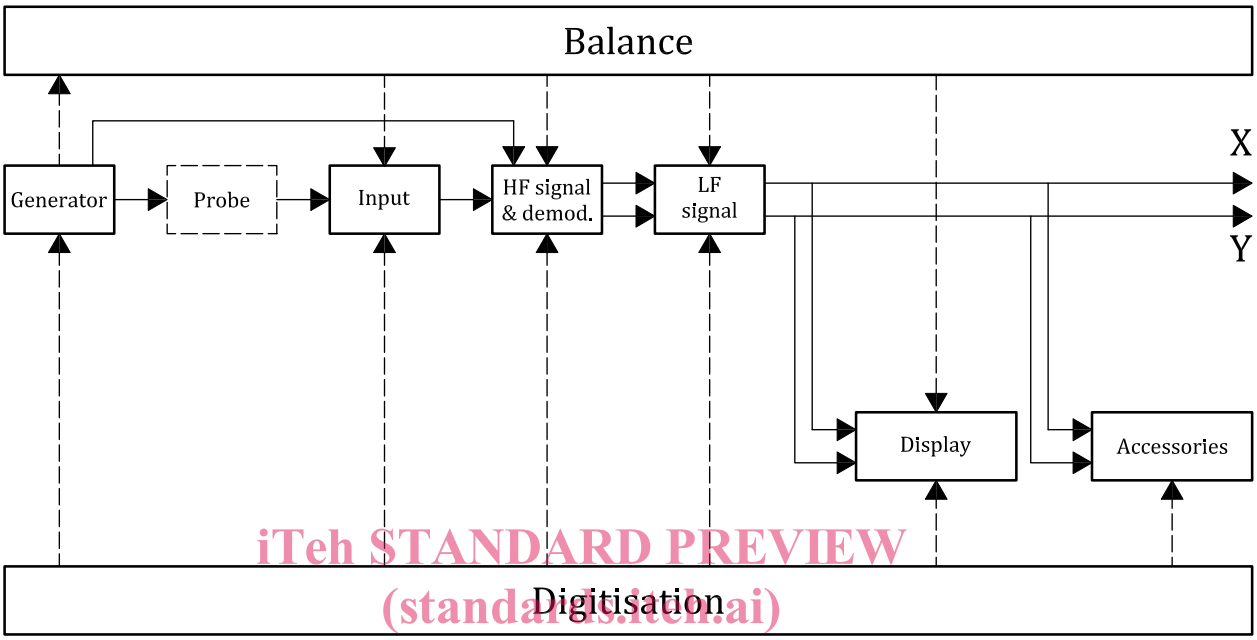

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Figure 1 — Functional block diagram of eddy current instrument

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4.2.3 Generator unit

The source of excitation is the generator unit.

In the case of alternating excitation (sinusoidal, triangular, rectangular, etc.), the characteristics to be defined are as follows:

— type of generator: current or voltage;

— type of excitation: single or multifrequency;

— frequency setting: range, step size, deviation from nominal value;

— harmonic distortion;

— amplitude setting: range, step size, deviation from nominal value, maximum output voltage or current;

— source impedance with frequency dependence.

In the case of multifrequency excitation, it shall be stated whether frequencies are injected simultaneously or multiplexed, independent or related, and the multiplexing sequence shall be specified, when relevant.

4.2.4 Input stage characteristics

The input stage interfaces the probe to the instrument. It provides impedance matching and amplification, as required.

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The characteristics to be defined are as follows:

— input impedance with frequency dependence;

— gain setting range, step size, deviation from nominal value;

— maximum input voltage;

— common-mode operating parameters, when relevant.

4.2.5 Balance

Balance is the compensation of the signal to achieve a predetermined operating point, e.g. zero. The compensation may be performed manually or automatically, at the input stage, or during HF signal processing, or during demodulated signal processing, or on the display.

The characteristics to be defined are as follows:

— maximum input range, which can be compensated;

— residual value at balance (expressed as a percentage of a specified range, e.g. full-scale output).

4.2.6 High-frequency signal processing

4.2.6.1 HF filtering

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Filters reduce the signal frequency content which can have an undesirable effect on the test result.

The filters used before demodulation are referred to as carrier frequency filters (HF filters). These are usually band-pass filters which suppress any signal frequencies which do not correspond to the excitation frequency.

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The characteristics to be defined are as follows:

— gain;

— bandwidth at 3 dB attenuation;

— rate of attenuation;

— transient response.

4.2.6.2 HF amplification

The characteristics to be defined are as follows:

— gain setting range, step size, deviation from nominal value;

— input signal range;

— bandwidth;

— output saturation level.

4.2.6.3 Demodulation

Synchronous demodulation extracts the vector components from the HF signal.

For positive polarity of demodulation, a delay in the signal will cause the signal vector to rotate clockwise. The polarity of demodulation shall be positive and shall be confirmed.

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The characteristics to be defined are as follows:

— wave shape of the reference signal, e.g. sine, square, pulse;

— bandwidth for each wave shape of the reference signal;

— phase-dependent amplitude deviations;

— phase-dependent phase deviations.

Amplitude demodulation extracts the low-frequency amplitude variations from the HF signal.

4.2.7 Demodulated signal processing

4.2.7.1 Vector amplification

Vector amplification generally consists of two transmission channels of identical design. These channels amplify the vector components produced by synchronous demodulation. In some instruments, these components can be amplified with different gains.

The characteristics to be defined are as follows:

— gain setting range, step size, deviation from nominal value;

— input signal ranges;

— bandwidth;

— output saturation level.

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4.2.7.2 LF filtering

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The filters used after demodulation are referred to as low-frequency filters (LF filters). The bandwidth of the filter is chosen to suit the application, e.g. wobble, surface speed, etc.

The characteristics to be defined are as follows:

— gain;

— bandwidth at 3 dB attenuation;

— rate of attenuation;

— transient response.

4.2.7.3 Phase setting

Phase setting permits rotation of the demodulated signal vector on the complex plane display.

The characteristics to be defined are as follows:

— range;

— step size;

— amplitude variation of the signal vector with phase setting;

— deviation of indicated phase rotation from actual phase rotation.

4.2.8 Output and signal display

The type of display can be an indicator display, or a hard-copy display, or a screen display.

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The type of presentation can be, for example, complex plane, ellipse, time-synchronous, frequency spectrum, imaging.

The related characteristics to be defined include:

— size;

— graticule divisions, major and minor;

— full-scale-display voltage range or time range;

— transfer factor e.g. volts/division;

— linearity;

— bandwidth.

The output can be analogue, digitised or logical.

The characteristics of analogue outputs to be defined are as follows:

— voltage or current range;

— output impedance;

— linearity;

— bandwidth.

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The characteristics of digitised outputs to be defined are as follows:

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— data protocol;

— serial or parallel;

— voltage and current levels;

— speed and format;

— sampling rate;

— analogue/digital A/D resolution, range and linearity.

The characteristics of logical outputs to be defined are as follows:

— voltage and current levels;

— settling delay;

— hysteresis;

— actively high or low.

4.2.9 Digitisation

4.2.9.1 General

Whenever digitisation is performed, the following characteristics shall be defined:

— stage of digitisation in the signal processing;

— digitisation technique;

— A/D resolution;

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— sampling rate.

The information supplied by the manufacturer shall therefore include data on the parameters in 4.2.9.2 to 4.2.9.5.

4.2.9.2 Stage of digitisation

Digitisation may be performed either before or after signal demodulation.

4.2.9.3 Digitisation technique

Digitisation can be performed using an internal clock or an external encoder.

4.2.9.4 A/D resolution

Resolution is the nominal value of the converter input voltage corresponding to one digitisation bit.

The number of digitisation bits is equally useful information, even though it can be directly accessed through the maximum input voltage and the resolution.

4.2.9.5 Sampling rate

The sampling rate is the frequency, in hertz, at which the A/D conversion is made.

5 Verification

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5.1 General

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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 pieces 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.

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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

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

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

Sufficient data on the characteristics featured in an instrument, probe and reference piece shall be provided, in order that verification can 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 the 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 characteristics of instrument

6.1 Measuring requirements

All measurements described in the following subclauses are made at the inputs and outputs of the instrument. These measurements do not require opening the instrument (black-box concept).

Keeping the black-box concept, any alternative method, the equivalence of which shall be demonstrated, may be used.

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