International Standard

ISO 15548-1

# 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*

Third edition
2026-04



Reference number
ISO 15548-1:2026(en)



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Published in Switzerland

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# Foreword

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



This third edition cancels and replaces the second edition (ISO 15548-1:2013), which has been technically revised.

The main changes are as follows:

— inclusion of digital instrument;

— revision of the measurement procedures;

— introduction of acceptance criteria.

A list of all parts in the ISO 15548 series can be found on the ISO website.

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.

# Introduction

The evaluation of the characteristics of general-purpose eddy current instruments permits a well-defined description and comparability of eddy current instruments.

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

# Non-destructive testing — Equipment for eddy current examination —

# Part 1: Instrument characteristics and verification

## 1 Scope

This document specifies the characteristics of general-purpose eddy current instruments and provides methods for their evaluation and verification.

This document can be completed by an application document specifying acceptance criteria for the characteristics of the eddy current instrument.

Where accessories are used, these are characterized using the principles of this document (e.g. additional external amplifiers).

## 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, *Non-destructive testing — Eddy current testing — Vocabulary*

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

ISO 18173, *Non-destructive testing — General terms and definitions*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12718, ISO 18173 and ISO/IEC Guide 99 apply.

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

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

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

# 4 Eddy current instrument characteristics

## 4.1 General characteristics

### 4.1.1 Type of instrument

a) An instrument has a general-purpose application (e.g. crack detection) when the relationship between the measured quantity and the output of the instrument is established by the user. A range of probes can be connected to the instrument. The instrument may have a display that should be configurable by the user. The instrument manufacturer shall provide a list of adjustable parameters, 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 excitation frequency, gain, balance, phase and filters (unless an automatically setting is used).

b) An instrument is of specific application (such as coating thickness measurement, magnetic permeability, or electrical conductivity measurement) when the relationship between the measured quantity and the output is explicitly specified in the range of application. The probe is specific to the instrument. For this type of instrument, the ISO 15548 series can be partially applied.

### 4.1.2 Power supply

The instrument can be powered by internal batteries or by an external AC or DC 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

Applicable safety regulations for the instrument and its accessories can exist, e.g. electrical hazard, surface temperature, explosion protection.



### 4.1.4 Technology



The instrument can be completely analogue or mainly digital or partly digital and analogue.

The excitation can be single frequency, multi-frequency, 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 provide the eddy current signal at an analogue or digital interface.

The instrument can be with or without a built-in display.

### 4.1.5 Physical presentation

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

The weight and size shall be specified for the instrument .

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

The instrument manufacturer, manufacturer's address, model number, serial number, year of manufacturing, relevant technical data (power requirements, IP class), used standards (if any) and markings (e.g. CE) 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.

Applicable electromagnetic compatibility (EMC) regulations can exist.

## 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.

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.

Each part of the eddy current instrument may be analogue or digital.

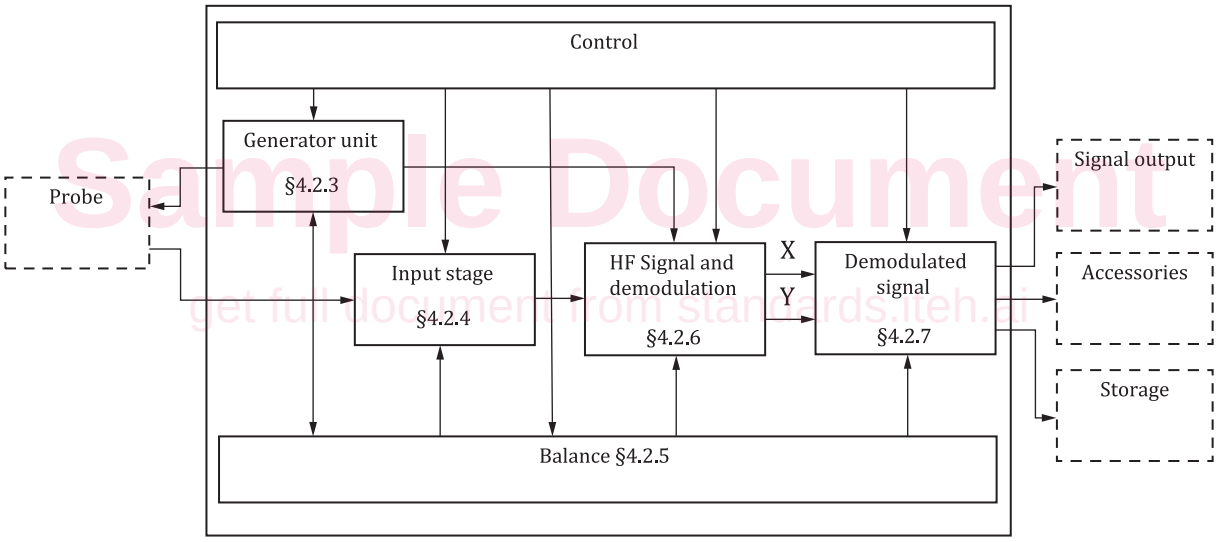


**Figure 1 — Functional block diagram of eddy current instrument**

### 4.2.3 Generator unit

The source of excitation is the generator unit.

The characteristics to be specified are as follows;

— type of generator: current or voltage;

— wave shape of the excitation signal;

— type of excitation: single or multi-frequency;

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

— differential source resistance;

— maximum output voltage and current;

— amplitude setting, if available: range, step size, deviation from nominal value.

In the case of sinusoidal alternating excitation, the additional characteristic to be specified is:

— harmonic distortion.

In the case of non-sinusoidal alternating excitation (triangular, rectangular, etc.), additional characteristics to be specified are:

— duty cycle;

— rise and fall time;

— linearity;

— overshoot.

In the case of multi-frequency 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.

The characteristics to be specified are as follows:

— the maximum allowable input voltage related to saturation and non-linearity;

— input impedance;

— input configuration (single ended, differential);

— number of inputs (parallel, multiplexed).



In the case of multi-channel instruments, additional characteristic to be specified is:

— cross-talk.

#### 4.2.5 Balance

Balance is the compensation of an offset of the signal to achieve a predetermined operating point. The compensation may be performed manually or automatically. If the compensation is available, it shall include both the imbalance of the sensor and provide sufficient residual dynamic for the acquisition of the desired signals.

Conversely, the instrument with a maximum dynamic range should be balanced accordingly through the following characteristics:

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

— maximum compensable input voltage.

#### 4.2.6 HF signal and demodulation

##### 4.2.6.1 High Frequency (HF) input filter

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

When applicable, 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.

The characteristics to be specified are as follows:

— Type of filter;

— Bandwidth at -3 dB;

— Attenuation rate.

#### 4.2.6.2 HF amplification

The characteristics to be specified are as follows:

— gain-setting range;

— step-size.

#### 4.2.6.3 Demodulation

Demodulation shall be a synchronous demodulation that extracts the low-frequency amplitude and phase variations 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.

The characteristic to be specified is:

— orthogonality of signal components (X and Y).

### 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 specified are as follows:

— common gain setting range, step size, deviation from nominal value for both vector components;

— individual gain setting range, step size, deviation from nominal value for both vector components.

#### 4.2.7.2 Phase setting

Phase setting permits rotation of the demodulated signal vector on the complex plane. If a phase setting is available for the instrument, the characteristics to be specified are as follows:

— phase rotation setting range, step size, deviation from nominal value;

— amplitude variation of the signal vector with phase setting.

#### 4.2.7.3 Low Frequency (LF) filtering

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.

The characteristics to be specified for each filter are as follows:

— cut-off frequency setting at 3 dB attenuation: range, step size, deviation from nominal value;

— rate of attenuation;

— ripple, if present (e.g. Chebyshev filter).

LF filters may have a variable cut-off frequency synchronized with the testing speed by an external encoder. In this case, the additional characteristics to be specified are as follows:

— type of the encoder signal;

— frequency range of encoder signal;

— relation between cut-off frequency of the filter and frequency of the encoder signal.

NOTE Devices displaying spatial dimension filters can also be stated in spatial frequency.

#### 4.2.7.4 Crosstalk

Crosstalk is related to multi-channel instruments only. It is the variation of the output of a channel in relation to the variation of the input of another channel.

The characteristics to be specified are as follows:

— variation of the output of a channel versus input variation of any other channel.

#### 4.2.7.5 Instrument noise

Instrument noise is the stochastic variation of the output at constant input. The maximum noise occurs usually at maximum amplification and is influenced by the filter settings.

The characteristic to be specified is:

— maximum peak-to-peak amplitude of the output at constant input.



### 4.2.8 Signal output

The type of output can be a display, a hard-copy device, analogue outputs or digital interface.

The type of presentation can be, for example, complex plane, strip chart, imaging or threshold signal.

The characteristics of a display shall include at least the following:

— type of presentation;

— size and resolution (number of pixels) for digital displays;

— grid divisions if present;

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

— linearity;

— bandwidth for analogue display or sampling rate for digital displays.

If the analogue output is generated by a digital to analogue converter (DAC), additional characteristics shall include at least the following:

— sampling rate per output;

— D/A resolution: number of bits and voltage per digit.

If a threshold output is available, it should be characterized by:

— type (x-, y- amplitude, box, circle, etc.);

— adjustment range;