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Non-destructive testing — Pulsed eddy current testing of ferromagnetic metallic components

Essais non destructifs — Contrôle par courants de Foucault pulsés de composants métalliques ferromagnétiques

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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 methods*.

Non-destructive testing — Pulsed eddy current testing of ferromagnetic metallic components

1 Scope

This document specifies the pulsed eddy current (PEC) testing technique used to perform thickness measurement on ferromagnetic metallic components with or without the presence of coating, insulation and weather sheeting.

This document applies to the testing of in-service components made of carbon steel and low-alloy steel in the temperature of −100 °C to 500 °C (temperature measured at metal surface). The range of wall thickness of components is from 3 mm to 65 mm and the range of thickness of coatings is from 0 mm to 200 mm. The tested components also include piping of diameter not less than 50 mm.

The technique described in this document is sensitive to the geometry of the component and applying the technique to components outside of its scope will result in unpredictable inaccuracy. This document does not apply to the testing of crack defects and local metal loss caused by pitting.

This document does not establish evaluation criteria. The evaluation criteria shall be specified by the contractual agreement between parties.

2 Normative references

The following documents are referred to in 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 15548-3, *Non-destructive testing — Equipment for eddy current examination — Part 3: System characteristics and verification*

ISO 16809, *Non-destructive testing — Ultrasonic thickness measurement*

3 Terms and definitions

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

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

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

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

3.1
coating
material which covers the surface of a tested component in the forms of adhesive, adsorbed layer, bundle, twine or inlay, etc. such as paint, plastic, asphalt, rock-wool, foam, metal mesh, cement, carbon (glass) fibre, marine organism, etc.

Note 1 to entry: For the purpose of this document, the word coating is used to describe any protective or insulative layer on the component to be tested.

3.2
cover
sheet metal protective layer on the outside of the coating

3.3
excitation pulse duration
time needed for the energy to travel through the actual thickness of the component

Note 1 to entry: It needs to be long enough to penetrate the full thickness

3.4
decay rate
rate of change in electromagnetic field measured by the receiver sensor after the transmitter has been switched off

Note 1 to entry: For example, the bending point of one of the typical measurement methods (see Figure 1).

3.5
bending point
point where the received signal decay rate changes from linear to exponential

3.6
characteristic time
time measured between the end of the excitation pulse and the bending point

Note 1 to entry: Its value is proportional to the magnetic permeability, electrical conductivity and the thickness squared.

3.7
pulse repetition frequency
prf
number of pulses generated per second, expressed in Hertz (Hz)

4 General principles

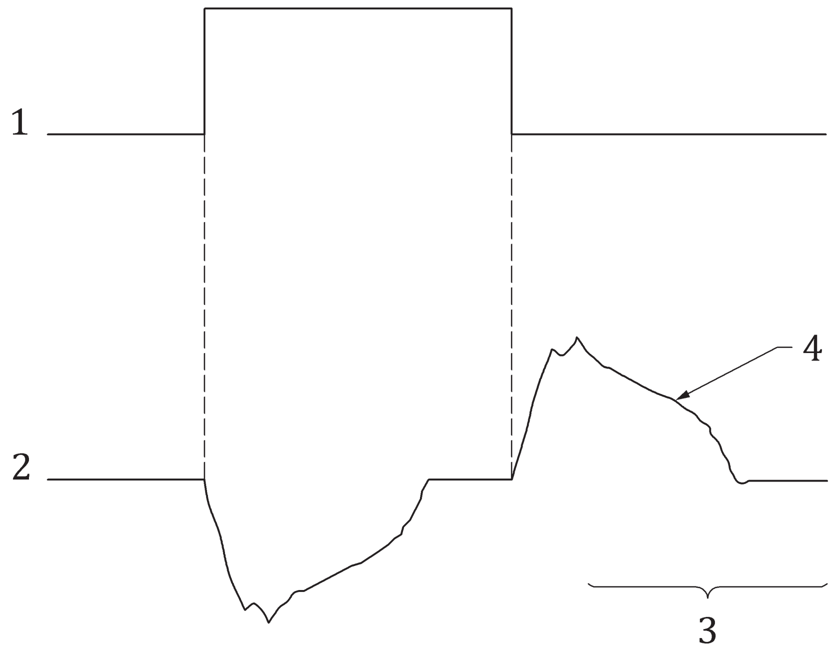
4.1 Principles of PEC testing

According to ISO 12718, pulsed eddy currents are eddy currents generated by a pulsed electromagnetic field.

Similar to sinusoidal eddy currents, induced pulsed eddy currents are modified by any local variation in the material properties.

The pulse is characterized by its duration (T), which enables to generate induced currents with a very high intensity.

The time interval between two measurements is linked to the material thickness.



Key

1 excitation signal waveform
2 detection signal waveform
3 decay curve
4 bending point

Figure 1 — Pulsed eddy current signal

The transmission signal from the probe shows a very broad spectrum of frequencies.

The received signal also has a frequency (or time) spectrum, the analysis of which provides information coming from different depths in the material.

The instrument is specific to the technique, as it must be capable of generating pulses.

Probes are of the separate transmit-receive type.

The measurement technique varies from one instrument to another, depending on the manufacturer.

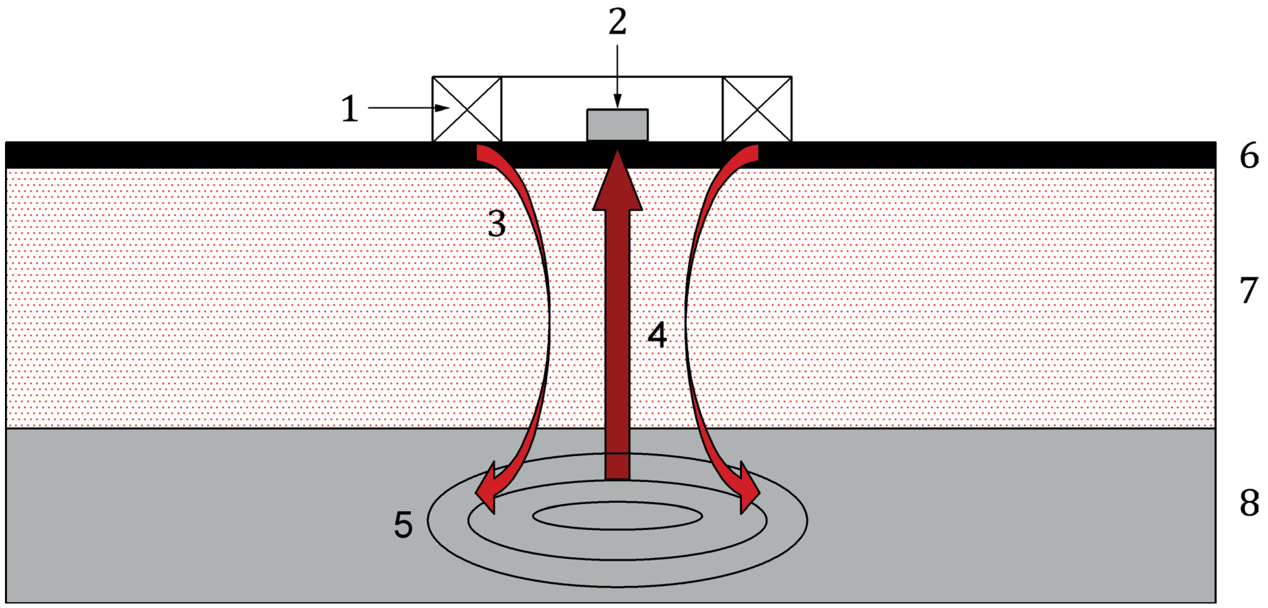
For example, the measurement techniques could be:

— use of characteristic time at the bending point;

— measurement of the time required for a specific decay;

— measurement of the decay curve slope, etc.

See Figure 2.



Key

1 sender coil
2 receiver devices
3 primary magnetic field
4 secondary magnetic field
5 eddy currents
6 cover/sheeting
7 insulation
8 tested component

NOTE Cladding and insulation form the coating.

Figure 2 — Basic principle of pulsed eddy current testing technique

4.2 Characteristics of PEC testing

4.2.1 Advantages

The following characteristics of the method represent the main advantages of PEC testing technique:

— the method does not require removing the insulation on the product tested;

— the test can be performed while the plant is in operation;

— no coupling medium, such as water, is needed.

4.2.2 Limitations

The component geometry shall be known to enable the instrument to be set up properly e.g. excitation pulse length and pulse repetition frequency.

There is a number of influencing factors that need to be controlled or taken into account when deploying the technique.

4.3 Influence factors

4.3.1 Coating

The nature of the coating can have an influence on the accuracy and sensitivity of the technique. Coating/insulation parameters such as electrical conductivity, magnetic permeability, and thickness should be taken into account.

For a coating with ferromagnetic material, extra magnetization may be needed to saturate it for more accurate testing results. It is also important to reduce the vibration, often occurring with such cover, to improve the reliability of the test. Indeed, signals corrupted by too high vibration shall not be recorded.

4.3.2 Tested component

The tested component may have an influence on the accuracy and sensitivity of the technique, parameters such as

— material properties of tested component,

— variation in material properties (from pipe to pipe for example), and

— variation in thickness

should be taken into account.

Vibration of the tested component during testing can also lead to the inaccuracy of testing results.

4.3.3 Temperature

The temperature variation inside a component can influence the electromagnetic characteristics of the tested component, and can therefore influence the testing results accuracy.

Temperature variation shall not exceed 20 °C.

4.3.4 Probe

The probe shall be selected to suit the component geometry.

Other factors influence the accuracy of the technique, including:

— probe active area;

— probe motion or probe speed (for dynamic scan);

— probe position with respect to the component;

— pulse length.

4.3.5 Reference zone

The reference zone is the zone on which the calibration is performed.

The differences between test zones and reference zone in physical characteristics such as magnetic permeability and conductivity can influence the testing results. If the differences are too significant, the reference zone shall be reselected.

4.3.6 Other factors

Care shall be taken to avoid the presence, modification or movement of conductive or magnetic pieces in the zone of influence of the probe, otherwise test results may be affected.