INTERNATIONAL STANDARD

ISO 9934-1

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Non-destructive testing — Magnetic particle testing —

Part 1: General principles

Essais non destructifs — Magnétoscopie —

Partie 1: Principes généraux du contrôle

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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 3.

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 part of ISO 9934 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9934-1 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 2, *Surface methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

ISO 9934 consists of the following parts, under the general title *Non-destructive testing — Magnetic particle testing*:

— *Part 1: General principles*

— *Part 2: Detection media*

— *Part 3: Equipment*

Annex A of this part of ISO 9934 is for information only.

Contents

Foreword

The text of EN ISO 9934-1:2001 has been prepared by Technical Committee CEN/TC 138 "Non-destructive testing", the secretariat of which is held by AFNOR, in collaboration with Technical Committee ISO/TC 135 "Non-destructive testing".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2002, and conflicting national standards shall be withdrawn at the latest by June 2002.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European standard specifies general principles for the magnetic particle testing of ferromagnetic materials. Magnetic particle testing is primarily applicable to the detection of surface-breaking discontinuities, particularly cracks. It can also detect discontinuities just below the surface but its sensitivity diminishes rapidly with depth.

The standard specifies the surface preparation of the part to be tested, magnetization techniques, requirements and application of the detection media and the recording and interpretation of results. Acceptance criteria are not defined. Additional requirements for the magnetic particle testing of particular items are defined in product standards (see the relevant EN Standard).

This standard does not apply to the residual magnetization method.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 473, *Non-destructive testing - Qualification and certification of NDT personnel - General principles*.

EN 1330-1, *Non-destructive testing - Terminology - Part 1 : General terms*.

EN 1330-2, *Non-destructive testing - Terminology - Part 2 : Terms common to non-destructive testing methods*.

EN ISO 3059, *Non-destructive testing - Penetrant testing and magnetic particle testing - Viewing conditions (ISO 3059:2001)*.

prEN ISO 9934-2, *Non-destructive testing - Magnetic particle testing - Part 2 : Characterisation of products (ISO/DIS 9934-2:1999)*.

prEN ISO 9934-3, *Non-destructive testing - Magnetic particle testing - Part 3 : Equipment (ISO/DIS 9934-3:1998)*.

prEN ISO 12707, *Non-destructive testing - Terminology - Terms used in magnetic particle testing*.

3 Terms and definitions

For the purposes of this standard, the terms and definitions given in EN 1330-1, EN 1330-2 and prEN ISO 12707 apply.

4 Qualification and certification of personnel

It is assumed that magnetic particle testing is performed by qualified and capable personnel. In order to provide this qualification, it is recommended to certify the personnel in accordance with EN 473 or equivalent.

5 Safety and environmental requirements

Magnetic particle testing may require the use of toxic, flammable and/or volatile materials. In such cases, working areas shall therefore be adequately ventilated and far from sources of heat or flames. Extended or repeated contact of detecting media and contrast paints with the skin or mucous membranes shall be avoided.

Testing materials shall be used in accordance with the manufacturer's instructions. National accident prevention, electrical safety, handling of dangerous substances and personal and environmental protection regulations shall be observed at all times.

When using UV-A sources, care shall be taken to ensure that unfiltered radiation from the UV-A source does not directly reach the eyes of the operator. UV-A filters, whether forming an integral part of the lamp or a separate component, shall always be maintained in a safe condition.

NOTE Magnetic particle testing often creates high magnetic fields close to the object under test and the magnetizing equipment. Items sensitive to these fields should be excluded from such areas.

6 Testing procedure

When required at the time of enquiry and order, magnetic particle testing shall be performed in accordance with a written procedure.

NOTE The procedure may take the form of a brief technique sheet, containing a reference to this and other appropriate standards. The procedure should specify testing parameters in sufficient detail for the test to be repeatable.

7 Surface preparation

Areas to be tested shall be free from dirt, scale, loose rust, weld spatter, grease, oil and any other foreign matter that may affect the test sensitivity.

The surface quality requirements are dependent upon the size and orientation of the discontinuity to be detected. The surface shall be prepared so that relevant indications can be clearly distinguished from false indications.

Non-ferromagnetic coatings up to approximately 50 µm thick, such as unbroken tightly adherent paint layers, do not normally impair detection sensitivity. Thicker coatings reduce sensitivity. Under these conditions, the sensitivity shall be verified.

There shall be a sufficient visual contrast between the indications and the test surface. For the non-fluorescent technique, it may be necessary to apply a uniform, thin, adherent layer of an approved contrast aid paint.

8 Magnetization

8.1 General requirements

The minimum flux density in the component surface shall be 1 T. This flux density is achieved in low alloy and low carbon steels with high relative permeability with a tangential field strength of 2 kA/m.

NOTE 1 For other steels, with lower permeability, a higher tangential field strength may be necessary. If magnetization is too high, spurious background indications may appear, which could mask relevant indications.

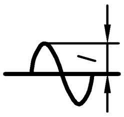
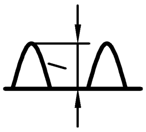
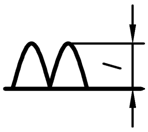
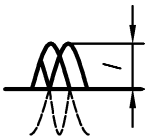
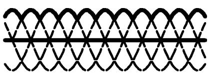
When magnetization is generated from time-varying currents, the rms. value is the required quantity. If the current meter on the magnetizing equipment records the mean current, the corresponding rms. value is given in Table 1, for various common waveforms. The use of pulsed or phase-cut currents requires specific measurements.

If cracks or other linear discontinuities are likely to be aligned in a particular direction, the magnetic flux shall be aligned perpendicular to this direction where possible.

NOTE 2 The flux may be regarded as effective in detecting discontinuities aligned up to 60º from the optimum direction. Full coverage may then be achieved by magnetizing the surface in two perpendicular directions.

When there is need to find sub-surface discontinuities, d.c. or rectified waveforms shall be used.

Table 1 - Relationship between peak mean and rms values for various sinusoidal waveforms

Wave form	Peak	Mean	rms	rms/means
Alternating current 	I	0	0.707 I $(=\frac{I}{\sqrt{2}})$	-
Alternating current half-wave rectified 	I	0.318 I $(=\frac{I}{\pi})$	0.5 I	1.57
Alternating full-wave rectified 	I	0.637 I $(=\frac{2}{\pi}I)$	0.707 I $(=\frac{I}{\sqrt{2}})$	1.11
Three phase half-wave rectified 	I	0.826 I	0.840 I	1.02
Three phase sinusoidal full wave rectified 	I	0.955 I $(=\frac{3}{\pi}I)$		

8.2 Verification of magnetization

The adequacy of the surface flux density shall be established by one or more of the following methods :

a) by testing a component containing fine natural or artificial discontinuities in the least favourable locations ;

b) by measuring the tangential field strength as close as possible to the surface Information on this is given in prEN ISO 9934-3 ;

c) by calculating the tangential field strength for current flow methods. Simple calculations are possible in many cases, and they form the basis for current values specified in the informative annex ;

d) by the use of other methods based on established principles.

NOTE Flux indicators (e.g. shim-type), placed in contact with the surface under test, provide a guide to the magnitude and direction of the tangential field strength, but should not be used to verify that the tangential field strength is acceptable.

8.3 Magnetizing techniques

This section describes a range of magnetization techniques. Multi-directional magnetization can be used to find discontinuities in any direction. In the case of simple-shaped objects, formulae are given in the annex for achieving approximate tangential field strengths. Magnetizing equipment shall meet the requirements of and be used in accordance with prEN 9934-3.

Magnetizing techniques are described in the following Clauses.

NOTE More than one technique may be necessary to find discontinuities on all test surfaces and in all orientations. Demagnetization may be required where the residual field from the first magnetization cannot be overcome. Techniques other than those listed may be used provided they give adequate magnetization, in accordance with 8.1.

8.3.1 Current flow techniques

8.3.1.1 Axial current flow

Current flow offers high sensitivity for detection of discontinuities parallel to the direction of the current.

Current passes through the component, which shall be in good electrical contact with the pads. A typical arrangement is shown in Figure 1. The current is assumed to be distributed evenly over the surface and shall be derived from the peripheral dimensions. An example of approximate formula for the current required to achieve a specified tangential field strength is given in annex A.

Care shall be taken to avoid damage to the component at the point of electrical contacts. Possible hazards include excessive heat, burning and arcing.

NOTE Certain contact materials such as copper or zinc may cause metallurgical damage to the component if arcing occurs. Lead contact pads may be used, but only in well ventilated conditions, because they may generate harmful vapours. Contact areas should be as clean and as large as practicable and of a material compatible with the component under test.

8.3.1.2 Prods; Current flow

Current is passed between hand-held or clamped contact prods as shown in Figure 2, providing an inspection of a small area of a larger surface. The prods are then moved in a prescribed pattern to cover the required total area. Examples of testing patterns are shown in Figure 2 and Figure 3. Approximate formulae for the current required to achieve a specified tangential field strength are given in annex A.

This technique offers the highest sensitivity for discontinuities elongated parallel to the direction of the current.

Particular care shall be taken to avoid surface damage due to burning or contamination of the component by the prods, as for 8.3.1.1. The warning in this subclause concerning the use of lead prods should also be noted. Zinc plated or galvanised prods shall not be used. Arcing or excessive heating shall be regarded as a defect requiring a verdict on acceptability. If further testing is required on such affected areas, it shall be carried out using a different technique.

8.3.1.3 Induced current flow

Current is induced in a ring shaped component by making it, in effect, the secondary of a transformer, as shown in Figure 4. An example of an approximate formula for the induced current required to achieve a specified tangential field strength is given in annex A.

8.3.2 Magnetic flow techniques

8.3.2.1 Threading conductor

Current is passed through an insulated bar or flexible cable, placed within the bore of a component or through an aperture, as shown in Figure 5.

This method offers the highest sensitivity for discontinuities parallel to the direction of current flow. The example of approximate formula given in annex A for a central conductor is also applicable in this case. For a non-central conductor, the tangential field strength shall be verified by measurement.

8.3.2.2 Adjacent conductor(s)

One or more insulated current-carrying cables or bars are laid parallel to the surface of the component, adjacent to the area to be tested and supported a distance d above it, as shown in Figure 6 and Figure 7.

The adjacent conductor technique of magnetization requires the material being tested to be in close proximity to a current flowing in one direction. The return cable for the electric current shall be arranged to be as far removed from the testing zone as possible and, in all cases, this distance shall be greater than 10 d, where 2 d is the width of the tested area

The cable shall be moved over the component at intervals of less than 2 d to ensure that the inspection areas overlap. An example of an approximate formula for the current required to achieve a specified tangential field strength in the test zone is given in annex A.

8.3.2.3 Fixed installation

The component, or a portion of it, is placed in contact with the poles of an electromagnet, as shown in Figure 8.

8.3.2.4 Portable electromagnet (Yoke)

The poles of an a.c. electromagnet (yoke) are placed in contact with the component surface as shown in Figure 9. The testing area shall not be greater than that defined by a circle inscribed between the pole pieces and shall exclude the zone immediately adjacent to the poles. An example of a suitable testing area is shown in Figure 9.

NOTE The magnetization requirements defined in 8.1, can only be met with a.c. electromagnets. D.c. electromagnets and permanent magnets may only be used by agreement at the time of enquiry and order.

8.3.2.5 Rigid coil

The component is placed within a current-carrying coil so that it is magnetized in the direction parallel to the axis of the coil, as shown in Figure 10. Highest sensitivity is achieved for discontinuities elongated perpendicular to the coil axis.

When using rigid coils of a helical form, the pitch of the helix shall be less than 25 % of the coil diameter.

NOTE For short components, where the length to diameter ratio is less than 5, it is recommended that magnetic extenders be used. The current required to achieve the necessary magnetization is thus reduced.

An example of an approximate formula is given in annex A for the current required to achieve a specified tangential field strength.

8.3.2.6 Flexible coil

A coil is formed by winding a current-carrying cable tightly around the component. The area to be tested shall lie between the turns of the coil, as shown in Figure 11.

The annex A gives approximate formulae for the current required to achieve a specified tangential field strength.

9 Detection media

9.1 Properties and selection of media

The characterisation of detection media shall be in accordance with prEN ISO 9934-2.