INTERNATIONAL STANDARD

ISO 9934-3

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Non-destructive testing — Magnetic particle testing —

Part 3: Equipment

Essais non destructifs — Magnétoscopie —

Partie 3: Équipement

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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 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 ZZ provides a list of corresponding International and European Standards for which equivalents are not given in the test.

Contents

Foreword

This document (ISO 9934-3:2002) has been prepared by Technical Committee ISO/TC 135 "Non-destructive testing" in collaboration with Technical Committee CEN/TC 138, "Non-destructive testing", the secretariat of which is held by AFNOR.

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 December 2002, and conflicting national standards shall be withdrawn at the latest by December 2002.

This Standard consists of the following parts :

EN ISO 9934-1	Non destructive testing - Magnetic particle testing - Part 1 : General rules
prEN ISO 9934-2	Non destructive testing - Magnetic particle testing - Part 2 : Detection media
EN ISO 9934-3	Non destructive testing - Magnetic particle testing - Part 3 : Equipment

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, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard describes three types of equipment for magnetic particle testing :

— portable or transportable equipment ;

— fixed installations ;

— specialized testing systems for testing components on a continuous basis, comprising a series of processing stations placed in sequence to form a process line.

Equipment for magnetizing, demagnetizing, illumination, metering and monitoring are also described.

This standard specifies the properties to be provided by the equipment supplier, minimum requirements for application and the method of measuring certain parameters. Where appropriate, measuring and calibration requirements and in-service checks are also specified.

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 10084 *Case hardening steels - Technical delivery conditions*

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

EN ISO 9934-1:2001 *Non-destructive testing - Magnetic particle testing - Part 1 : General rules (ISO 9934-1:2001)*

EN 60529 *Degrees of protection provides by enclosures (IP Code) (IEC 60529:1989)*

3 Safety requirements

The equipment design shall take into account of all European, national and local regulations which include health, safety, electrical and environmental requirements.

4 Types of devices

4.1 Portable electromagnets (AC[1])

4.1.1 General

Hand-held portable electromagnets (yokes) produce a magnetic field between the two poles. (When testing according to EN ISO 9934-1, DC electromagnets should only be used if agreed at enquiry and order stages).

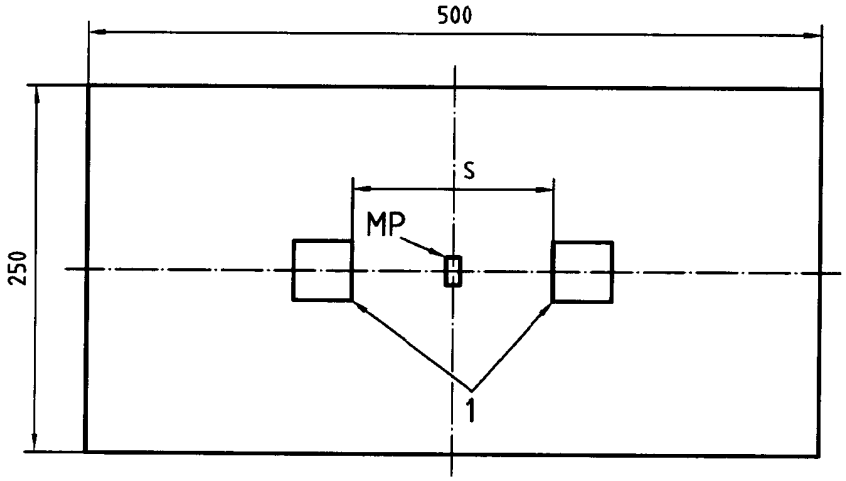
Magnetization shall be determined by measuring the tangential field strength H_t at the centre of a line joining the centres of the pole faces of the electromagnet with pole extenders where used. The electromagnet with a pole spacing s is placed on a steel plate as shown in Figure 1. The plate shall have the dimensions (500 ± 25) mm x (250 ± 13) mm x (10 ± 0.5) mm and shall be of steel conforming to C 22 (EN 10084)..

1) AC = alternative current, and DC = rectified current

Periodic functional checks may be carried out either by the method described above or by a lift test. The electromagnet shall be capable of supporting a steel plate or rectangular bar conforming to C 22 (EN 10084) and having a minimum mass of 4,5 kg, with the magnet poles set at their recommended spacing. The major dimension of the plate or bar shall be greater than the pole spacing *s* of the electromagnet

NOTE : To lift a steel plate with a mass of 4,5 kg requires a lifting force of 44 N.

Dimensions in millimetres



Key

MP Measuring point for the tangential field strength
s Pole spacing
1 Poles

Figure 1 — Determination of the characteristics of portable electromagnets

4.1.2 Technical data

The following data shall be provided by the equipment supplier:

— recommended pole spacing (maximum and minimum pole spacing) (s_{max}, s_{min});

— cross sectional dimensions of the poles;

— electrical supply (voltage, current and frequency);

— current wave forms available;

— method of current control and effect on waveform (e.g. : thyristor);

— duty cycle at maximum output (ratio of current 'ON' to 'Total' time expressed as a percentage);

— maximum current 'ON' time;

— tangential field strength H_t at s_{max} and s_{min} (following 4.1);

— overall dimensions of the equipment;

— equipment mass, in kilograms;

— specified electrical protection degree (IP) see EN 60529.

4.1.3 Minimum requirements

The following requirements shall be satisfied at an ambient temperature of 30 °C and at maximum output :

— duty cycle	≥ 10 %
— current 'ON' time	≥ 5 s
— surface temperature of handle	≤ 40 °C
— tangential field strength at s_{max} (see 4.1)	≥ 2 kA/m (RMS)
— lifting force	≥ 44 N

4.1.4 Additional requirements

The electromagnet shall be supplied with a power ON/OFF switch preferably mounted on the handle.

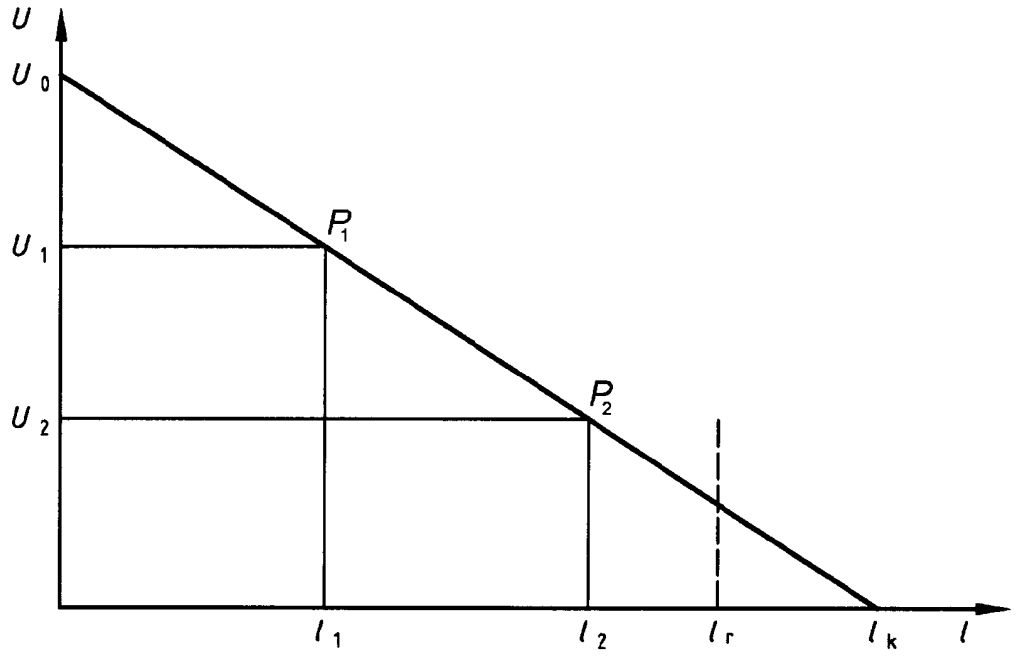
Generally electromagnets should be usable with one hand.

4.2 Current generators

Current generators are used to supply current for magnetizing equipment. A current generator is characterized by the open circuit voltage U_0, the short circuit current I_k and the rated current I_r (RMS-values).

The rated current I_r is defined as the maximum current for which the generator is rated at the duty cycle of 10 % and for a current 'ON' time of 5 s if not otherwise specified.

The open circuit voltage U_0 and the short circuit current I_k are derived from the load-characteristic of the generator at maximum power (with any feed back controls disconnected). The load line of the generator may be derived by connecting two widely different loads, such as different lengths of cable, in turn to the generator. For the first cable, the current I_1 through the cable and voltage U_1 across the output terminals are measured and plotted, to give point P_1 on Figure 2. The process is repeated with a second load to give point P_2. The load line is constructed by drawing a straight line between P_1 and P_2. The open circuit voltage U_0 and short circuit current I_k are then given by the intercepts on the axes, as shown in Figure 2.



Key

P_1, P_2 Measuring points for determination of the load characteristics

Figure 2 — Load characteristics of the current generator

4.2.1 Technical data

The following data shall be provided by the equipment supplier:

— open circuit voltage U_0 (RMS);

— short circuit current I_k (RMS);

— rated current I_r (RMS);

— duty cycle at maximum output (if other than as specified in 4.2);

— maximum current 'ON' time (if other than specified in 4.2);

— current wave forms available;

— method of current regulation and effect on waveform;

— working range and incremental setting steps;

— method of constant current control if available;

— type of meter (digital, analog);

— resolution and accuracy of current output meter;

— electrical supply requirements at maximum current output (voltage, phases, frequency and current);

— specified electrical protection degree (IP) see EN 60529;

— overall dimensions of equipment;

— equipment mass, in kilograms;

— type of demagnetization if available (see clause 8) .

4.2.2 Minimum requirements

The following minimum requirements shall be satisfied at an ambient temperature of 30°C and at the rated current I_r :

— duty cycle: ≥ 10 %

— current 'ON' time: ≥ 5 s

NOTE : High testing rates will require a higher duty cycle.

4.3 Magnetic benches

4.3.1 General

Fixed installation benches may include facilities for current flow and magnetic flow techniques. Magnetic flow may be achieved either by an electromagnetic yoke or a fixed coil (see EN ISO 9934-1). The characteristics of the current generator are defined in 4.2.

When facilities for multidirectional magnetization are included, each circuit shall be independently controlled. Magnetization shall be sufficient to achieve the required detection capability in all directions.

The characteristic of the electromagnetic yoke is the tangential field strength H_t measured, in kiloamperes per metre, at the midpoint of the length of a cylindrical bar conforming to C22 (EN 10084) of specified dimensions (length and diameter) appropriate to the acceptance range of the equipment.

If the bench is to be used for magnetic flow testing of components longer than 1 m, or segments of the length are magnetized individually, the supplier shall define how magnetizing capability is determined. This shall include a specification of the tangential field strength for a bar of suitable length and diameter.

4.3.2 Technical data

The following data shall be provided by the equipment supplier:

— types of magnetization available;

— current wave forms available;

— method of current control and effect on waveform;

— working range and incremental setting steps;

— method of constant current control if available;

— monitoring of magnetizing current(s);

— magnetizing duration range;

— automated features;

— duty cycle at maximum output;

— maximum current 'ON' time (if other than specified in 4.2);

- tangential field strength H_t (see 4.3);
- open circuit voltage U_0 (RMS);
- short circuit current I_k (RMS);
- rated current I_r (RMS);
- cross sectional dimensions of poles;
- maximum clamping length;
- method of clamping;
- compressed air pressure;
- maximum dimension between headstocks and bed;
- maximum test piece diameter;
- maximum mass of test piece (supported and unsupported);
- type of usable detection media (water-/ oil-based);
- schematic lay out of the equipment (current generator, control panel, location of the detection medium reservoir);
- type of meter (digital, analog);
- accuracy and resolution of meter;
- electrical supply requirements at maximum current output (voltage, phases, frequency and current);
- overall dimensions of equipment;
- equipment mass, in kilograms.
- characteristics of coils:
  - number of turns;
  - maximum achievable ampere turns;
  - length of the coil;
  - internal diameter of the coil or length of sides if the coil is rectangular;
  - field strength in the centre of the coil.

4.3.3 Minimum requirements

The following minimum requirements shall be satisfied at a temperature of 30 °C:

- duty cycle at maximum output ≥ 10 %
- current 'ON' time ≥ 5 s
- tangential field strength (see 4.3) ≥ 2 kA/m

— detection capability if required.

4.3.4 Additional requirements

The equipment supplier shall verify the detection capability for a specified component.

4.4 Specialized testing systems

These systems are usually automated and designed for a special task. Complex components may require the use of multidirectional magnetization. The number of circuits and the magnetizing values depend on the location and the directions of the discontinuities to be detected. Therefore in many cases the detection capability can be verified only with test pieces having natural or artificial discontinuities in the relevant zones and directions.

4.4.1 Technical data

The following data shall be provided by the equipment supplier:

a) number and types of magnetizing circuits;

b) characteristics of the magnetizing circuits;

c) current wave forms available;

d) method of current control and effect on waveform;

e) working range and incremental setting steps;

f) method of constant current control if available;

g) monitoring of the magnetizing current(s);

h) system cycle time;

i) prewetting and wetting time;

j) magnetizing time;

k) postmagnetizing time;

l) type of meter (digital, analog);

m) accuracy and resolution of meter;

n) duty cycle at maximum output;

o) maximum current 'ON' time (if other than specified in 4.2);

p) electrical supply requirements at maximum current output (voltage, phases, frequency and current) ;

q) type of demagnetization;

r) type of usable detection media (water-/oil-based);

s) schematic lay out of the equipment (current generator, control panel, location of the detection medium reservoir);

t) compressed air pressure;

u) overall dimensions of equipment;

v) equipment mass, in kilograms.

4.4.2 Minimum requirements

The following minimum requirements shall be satisfied at a temperature of 30 °C:

— to meet the agreed detection capability;

— to meet the agreed cycle time;

— independent control of each circuit.

5 UV-A sources

5.1 General

UV-A sources shall be designed and used in accordance with EN ISO 3059.

5.2 Technical data

The following data shall be provided by the equipment supplier:

a) surface temperature of the UV-A housing after 1 hour;

b) type of cooling (e.g. heat exchanger);

c) electrical supply requirements (voltage, phases, frequency and current);

d) overall dimensions of equipment;

e) equipment mass, in kilograms.

At a distance of 400 mm from the UV-A source at the stated voltage:

f) irradiated area (diameter or length x width measured at half of the maximum surface irradiance);

g) irradiance after 15 minutes operation;

h) irradiance after 200 hours continuous operation (typical value);

i) illuminance after 15 minutes operation (see 9.3);

j) illuminance after 200 hours continuous operation (typical value).

5.3 Minimum requirements

The following minimum requirements shall be satisfied at a temperature of 30 °C :

— filter resistant against detection media splashes;

— hazard protection of handheld units when in parked position;

— UV-A irradiance at 400 mm from the source ≥ 10 W/m2;

— illuminance at 400 mm from the source ≤ 20 lx;

— surface temperature of handle ≤ 40 °C.

6 Detection media system

6.1 General

Usually in magnetic benches and specialised testing systems the detection media circulates through the reservoir, wetting units and the drain tray.

6.2 Technical data

The following data shall be provided by the equipment supplier :

a) agitation method;

b) material of the reservoir, wetting unit and drain tray;

c) protection against corrosion;

d) type of usable detection media (water-/oil-based);

e) delivery rate of the system;

f) volume of the reservoir;

g) electrical supply requirements of the pump, if separate from the equipment;

h) manual/automated wetting;

i) fixed/movable wetting unit;

j) hand hose.

6.3 Minimum requirements

The following minimum requirements shall be satisfied :

— corrosion resistant material for the detection media circuit;

— regulation of the delivery rate.

7 Inspection booth

7.1 General

When using fluorescent detection media, inspection shall be carried out in low ambient visible light to ensure good contrast between discontinuity indications and background (see EN ISO 3059).

For this purpose an inspection booth is required which may be integral with the magnetizing equipment (bench) or it may be a separate free standing enclosure.

7.2 Technical data

The following data shall be provided by the equipment supplier :

a) visible light in absence of UV-A radiation;

b) class of flammability;

c) construction materials;

d) type of ventilation;

e) dimensions and access(es).

7.3 Minimum requirements

The following minimum requirements shall be satisfied :

— visible light < 20 lx;

— flame retardant material;

— no glare from visible and/or UV-A radiation within operators field of vision.

8 Demagnetization

8.1 General

Facilities for demagnetization may be included in the magnetizing equipment or, demagnetizing may be carried out using a separate equipment.

If viewing for indications is carried out after demagnetization, indications shall be preserved by a suitable method.

8.2 Technical data

The following data shall be provided by the equipment supplier :

a) method(s) of demagnetization;

b) type of current regulation;

c) field strength (at the centre of the empty demagnetizing coil if applicable);

d) residual field for a specified component;

e) electrical supply requirements at maximum current output (voltage, phases, frequency and current) if separate from the general equipment;

f) overall dimensions of equipment if separate from the general equipment;

g) equipment mass, in kilograms, if separate from the general equipment.

8.3 Minimum requirements

The equipment shall be capable of demagnetizing to a specified level (typically 0.4 to 1.0 kA/m) unless otherwise agreed

9 Measurements

9.1 General

In connection with this standard, measurements are required for :

— determination of the equipment characteristics;

— checking inspection parameters.

All electric and magnetic values should be specified and measured in RMS values (true). For unidirectional waveforms the RMS-measurement shall take into account the DC-component. If a RMS-measurement is not possible, the measurement method of values shall be declared.

9.2 Current measurement

AC (sinusoidal wave form) can be measured with clamp meters (measuring error < 10 %) or with a shunt and general multipurpose voltage meters (measuring error < 10 %). For measuring phased currents, a meter with a crest factor > 6 (ratio peak value to RMS-value) shall be used.

9.3 Magnetic field measurement

Magnetization may be determined by measuring the tangential field strength using a Hall probe. To obtain the required field strength, three factors should be considered, depending on the method of magnetization and the location of the measurement

a) Orientation of the field-sensitive element

The plane of the field sensitive element should be kept normal to the surface. If a normal field component exists, a tilt may introduce a substantial error.

b) Surface proximity of the field-sensitive element

If the field varies strongly with height above the surface, it may be necessary to make two measurements at different heights to deduce the value at the surface.

c) Direction of the magnetic field

To determine the direction and magnitude of the field, the probe shall be rotated to give the maximum reading.

9.3.1 Technical data

The following data shall be provided by the supplier :

a) measured value;

b) type and dimensions of the probe;

c) distance of the sensor from the probe surface;

d) geometry of the sensing element;

e) type of instrument;

f) dimensions of the instrument;

g) electrical supply (battery, mains).

9.3.2 Minimum requirements

The following minimum requirement shall be satisfied:

— measurement accuracy better than 10 %.

9.4 Visible light measurement

See EN ISO 3059:2001.

When measuring the visible light from UV sources, the luxmeter shall be insensitive to UV and infrared radiation. Appropriate filters shall be incorporated.

9.5 UV-A irradiance measurement

See EN ISO 3059:2001.

9.6 Verification and calibration of instruments

The verification and calibration procedures for instruments shall be carried out so that during the calibration interval the measuring error remains within limits given in this standard. This shall be done, following the recommendations of the manufacturer of the instrument and in accordance with the quality assurance system of the user.

Bibliography

EN 473 *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 methods*

prEN ISO 9934-2:2001 *Non-destructive testing - Magnetic particle testing - Part 2 : Detection media*

prEN ISO 12707:2000 *Non destructive testing - Terminology - Terms used in magnetic particle testing*

Annex ZZ
(normative)

Corresponding International and European Standards for which equivalents are not given in the text

At the time of publication of this part of ISO 9934, the following ISO documents were equivalent to the normative European Standards referenced in the text. Members of ISO and IEC maintain registers of currently valid International Standards.

EN 10084 ISO 683-11, *Heat-treatable steels, aloy steels and free-cutting steels — Part 11: Wrought case-hardening steels.*

ICS 19.100

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