AS ISO 9934.3:2020
ISO 9934-3:2015

Australian STANDARD®

Non-destructive testing — Magnetic particle testing

Part 3: Equipment

STANDARDS Australia

AS ISO 9934.3:2020

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- Australasian Thermographers Association
- Australian Institute for Non-Destructive Testing
- Australian Nuclear Science and Technology Organisation
- Austroads
- Engineers Australia
- Institute of Electrical Inspectors
- National Aerospace Non-Destructive Testing Board of Australia
- Weld Australia

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Non-destructive testing — Magnetic particle testing

Part 3: Equipment

Originated as part of AS B260.4A—1968.
Revised and redesignated as AS 1171—1976.
Previous edition 1998.
Revised and redesignated as AS ISO 9934.3:2020.

Preface

This Standard was prepared by the Australian members of Joint Standards Australia/Standards New Zealand Committee MT-007, Non-Destructive Testing of Metals and Materials, to supersede AS 1171—1998, *Non-destructive testing — Magnetic particle testing of ferromagnetic products, components and structures.*

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to describe the following three types of equipment for magnetic particle testing:

(a) Portable or transportable equipment.

(b) Fixed installations.

(c) 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, measurement, 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.

This Standard is identical with, and has been reproduced from, ISO 9934-3:2015, *Non-destructive testing — Magnetic particle testing — Part 3: Equipment.*

As this document has been reproduced from an International Standard, the following applies:

(i) In the source text "this part of ISO 9934" should read "this Australian Standard".

(ii) A full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms "normative" and "informative" are used in Standards to define the application of the appendices or annexes to which they apply. A "normative" appendix or annex is an integral part of a Standard, whereas an "informative" appendix or annex is only for information and guidance.

Contents

1) AC = alternating current, and DC = rectified current.

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.

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 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

ISO 9934-3 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 138, *Non-destructive testing*, in collaboration with 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).

This second edition cancels and replaces the first edition (ISO 9934-3:2002), which has been technically revised.

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*

NOTES

Australian Standard®

Non-destructive testing — Magnetic particle testing

Part 3: Equipment

1 Scope

This part of ISO 9934 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, measurement, and monitoring are also described.

This part of ISO 9934 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

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 3059, *Non-destructive testing — Penetrant testing and magnetic particle testing — Viewing conditions*

ISO 9934-1, *Non-destructive testing — Magnetic particle testing — Part 1: General rules*

EN 10250-2, *Open steel die forgings for general engineering purposes — Non-alloy quality and special steels*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

3 Safety requirements

The equipment design shall take into account all international, 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 ISO 9934-1, DC[1)] electromagnets should only be used if agreed at enquiry and order stages.

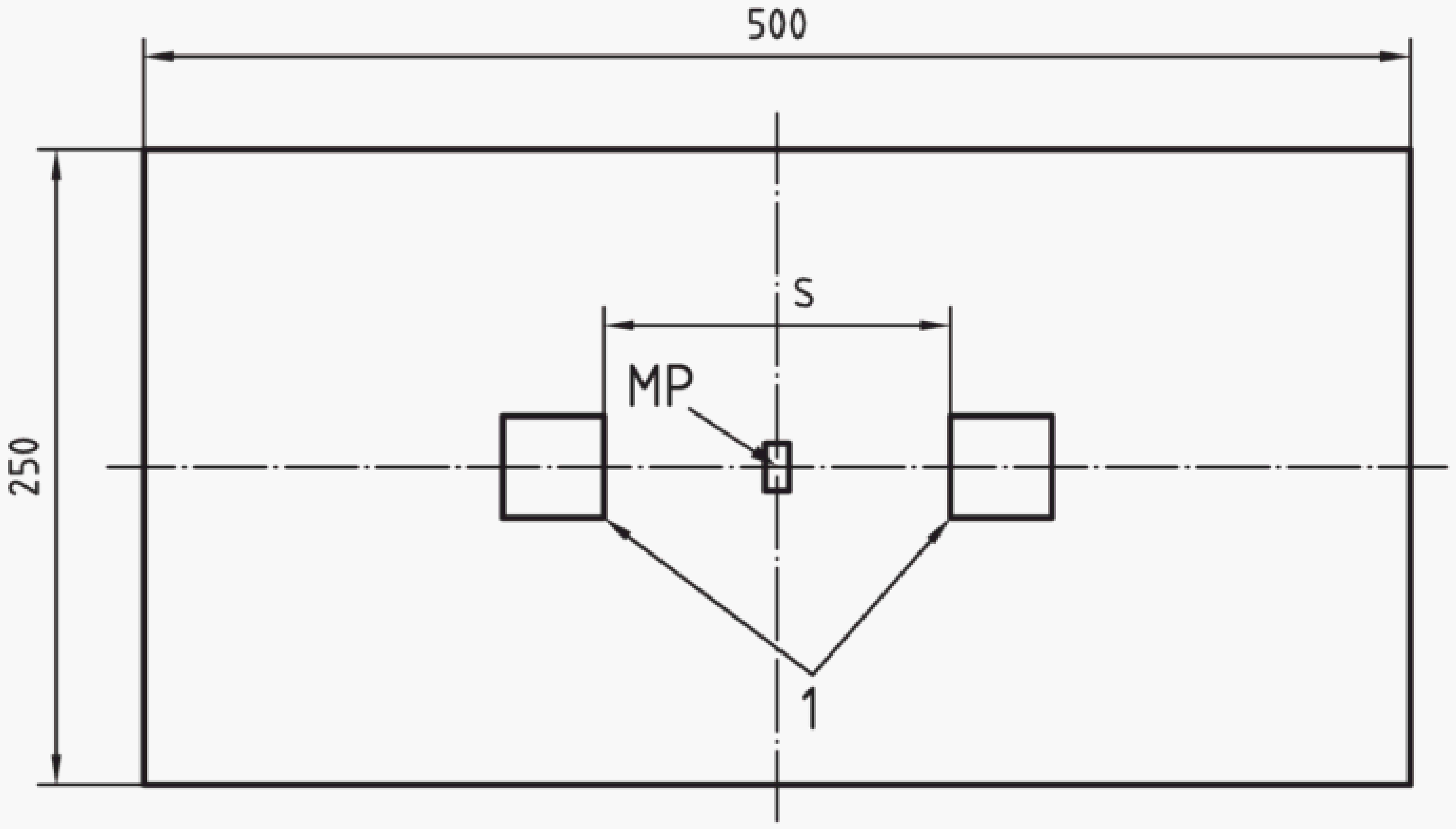
Magnetization shall be determined by measuring the tangential field strength, H_t, at the centre of a line joining the centres of the pole faces of the electromagnet with pole extenders where used. The electromagnet with a pole spacing, *s*, is placed on a steel plate as shown in Figure 1. The plate shall

1) AC = alternating current, and DC = rectified current.

have the dimensions (500 ± 25) mm × (250 ± 13) mm × (10 ± 0,5) mm and shall be of steel conforming to C22 (1.0402) of EN 10250-2. Periodic functional checks can 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 C22 (1.0402) of EN 10250-2 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

1 poles

s pole spacing

MP measuring point for the tangential field strength

Figure 1 — Determination of the characteristics of portable electromagnets

4.1.2 Technical data

The following data shall be provided:

— 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) according to IEC 60529.

4.1.3 Technical 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

4.2.1 General

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 feedback controls disconnected). The load line of the generator can 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.

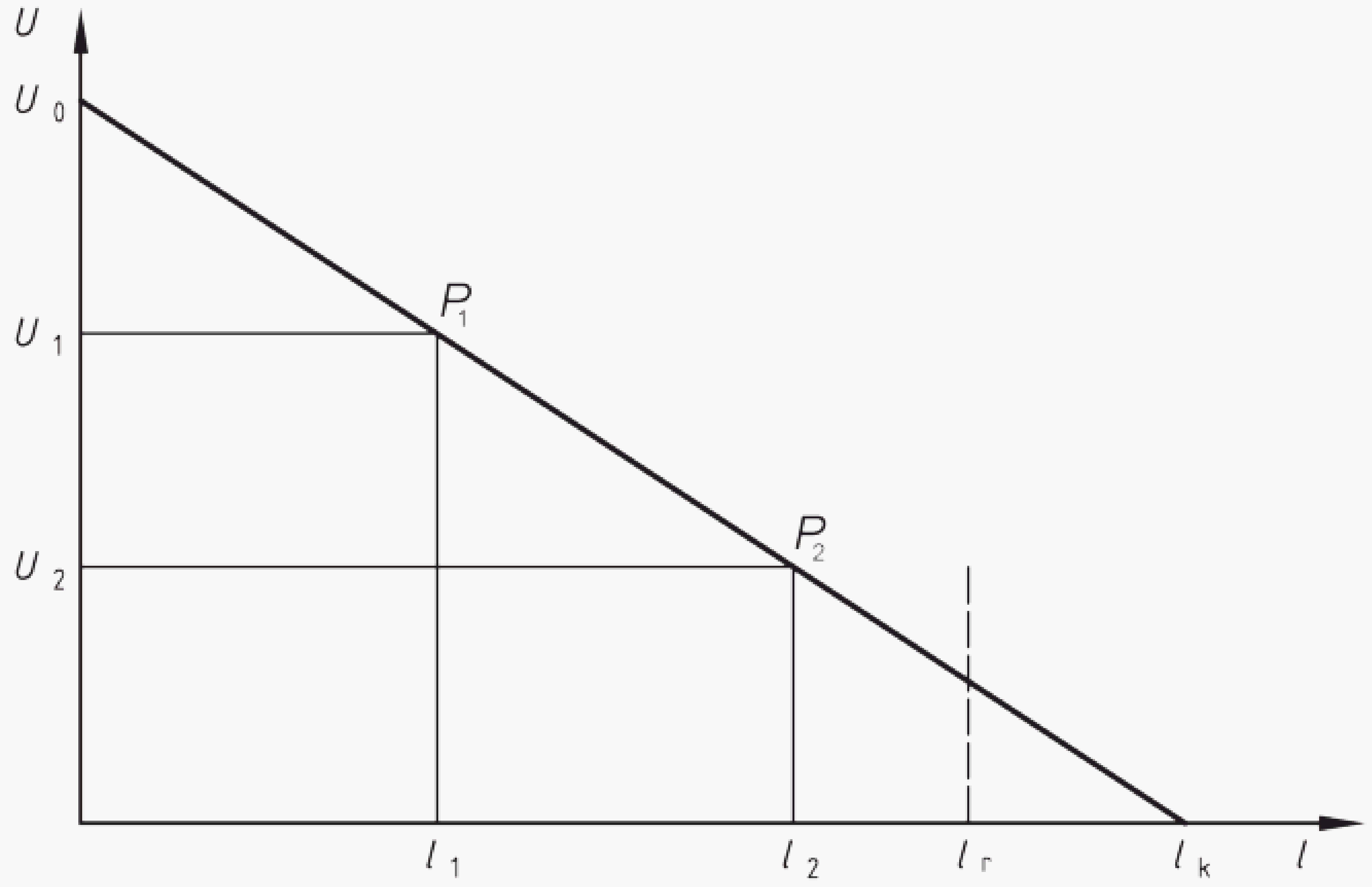


Figure 2 — Load characteristics of the current generator

4.2.2 Technical data

The following data shall be provided:

- 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 4.2.1);
- maximum current "ON" time (if other than specified in 4.2.1);
- 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) according to IEC 60529;
- overall dimensions of equipment;
- equipment mass, in kilograms;
- type of demagnetization, if available (see Clause 8).

4.2.3 Technical requirements

The following 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 can include facilities for current flow and magnetic flow techniques. Magnetic flow can be achieved either by an electromagnetic yoke or a fixed coil. 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 (1.0402) of EN 10250-2, 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:

— 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 Technical requirements

The following 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 4.3.1) ≥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 might 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:

— number and types of magnetizing circuits;

— characteristics of the magnetizing circuits;

— 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 the magnetizing current(s);

— system cycle time;

— prewetting and wetting time;

— magnetizing time;

— postmagnetizing time;

— type of meter (digital, analog);

— accuracy and resolution of meter;

— duty cycle at maximum output;

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

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

— type of demagnetization;

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

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

— compressed air pressure;

— overall dimensions of equipment;

— equipment mass, in kilograms.

4.4.2 Technical requirements

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

— meet the agreed detection capability;

— 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 ISO 3059.

5.2 Technical data

The following data shall be provided:

— surface temperature of the UV-A housing after 1 h;

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

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

— overall dimensions of equipment;

— equipment mass, in kilograms;

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

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

  — irradiance after 15 min operation;

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

  — illuminance after 15 min operation (see 5.3);

  — illuminance after 200 h continuous operation (typical value).

5.3 Technical requirements

The following requirements shall be satisfied under working conditions:

— anti-splashing screen at a maximal ambient temperature;

— hazard protection of hand-held units when in parked position;

— UV-A irradiance at 400 mm from the source ≥10 W/m^2;

— 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 specialized 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:

— agitation method;

— material of the reservoir, wetting unit, and drain tray;

— protection against corrosion;

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

— delivery rate of the system;

— volume of the reservoir;

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

— manual/automated wetting;

— fixed/movable wetting unit;

— hand hose.

6.3 Technical requirements

The following 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 ISO 3059).

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

7.2 Technical data

The following data shall be provided:

— visible light in absence of UV-A radiation;

— class of flammability;

— construction materials;

— type of ventilation;

— dimensions and access(es).

7.3 Technical requirements

The following 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 can be included in the magnetizing equipment, or demagnetizing can 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:

— method(s) of demagnetization;

— type of current regulation;

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

— residual field for a specified component;

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

— overall dimensions of equipment if separate from the general equipment;

— equipment mass, in kilograms, if separate from the general equipment.

8.3 Technical requirements

The equipment shall be capable of demagnetizing to a specified level (typically 0,4 kA/m to 1,0 kA/m) unless otherwise agreed.

9 Measurements

9.1 General

In connection with this part of ISO 9934, measurements are required for the following:

— determination of the equipment characteristics;

— checking inspection parameters.

For all current and magnetic field measurements, only instruments that respond directly to the waveform shall be used. Instruments that calculate peak or RMS values based on calculation derived from other values shall not be used. Where True RMS meters are used to measure RMS values the specified crest factor of the instrument shall be greater than the crest factor of the waveform being measured and generally not less than 5.

9.2 Current measurement

Pure AC sinusoidal waveforms can be accurately measured using clamp meters or other conventional instruments. Measurements of phase controlled currents can be more complex and it shall be verified that the instrument used has the correct response before use on these waveforms. Measurement systems using shunts with suitable voltage measurement instruments shall be regarded as current meters and conform with the requirements for such instruments.

9.3 Magnetic field measurement

9.3.1 General

Magnetization can 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.

— 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 can introduce a substantial error.

— Surface proximity of the field-sensitive element

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

— Direction of the magnetic field

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

9.3.2 Technical data

The following data shall be provided:

— measured value;

— type and dimensions of the probe;

— distance of the sensor from the probe surface;

— geometry of the sensing element;

— type of instrument;

— dimensions of the instrument;

— electrical supply (battery, mains).

9.3.3 Technical requirements

The following requirement shall be satisfied:

— measurement accuracy better than 10 %.

9.4 Viewing conditions

Equipment requirements shall be according to ISO 3059.

9.5 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 International 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

[1] ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

[2] EN 1330-1, *Non-destructive testing — Terminology — Part 1: General terms*

[3] EN 1330-2, *Non-destructive testing — Terminology — Part 2: Terms common to non-destructive methods*

[4] ISO 9934-2, *Non-destructive testing — Magnetic particle testing — Part 2: Detection media*

[5] ISO 12707, *Non-destructive testing — Terminology — Terms used in magnetic particle testing*

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