

Australian Standard™

**Non-destructive testing—
Magnetic particle testing
of ferromagnetic products,
components and structures**

This Australian Standard was prepared by Committee MT/7, Non-destructive Testing of Metals and Materials. It was approved on behalf of the Council of Standards Australia on 29 May 1998 and published on 5 September 1998.

The following interests are represented on Committee MT/7:

Australasian Railway Association
Australian Aerospace Non-destructive Testing Committee
Australian Institute for Non-Destructive Testing
Australian Nuclear Science and Technology Organisation
Australian Pipeline Industry Association
Bureau of Steel Manufacturers of Australia
Electricity Supply Association of Australia
Industrial Research Limited New Zealand
Institution of Engineers Australia
Metal Trades Industry Association of Australia
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components and structures**

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee MT/7, Non-destructive Testing of Metals and Materials, to supersede AS 1171—1976, *Methods for magnetic particle testing of ferromagnetic products and components*.

This Standard is the result of a consensus among Australian and New Zealand representatives on the Joint Committee to produce it as an Australian Standard.

The objective of this revision is to upgrade the requirements for the magnetic particle testing of ferromagnetic materials for the detection of surface and near-surface discontinuities.

In preparing this Standard, the Committee took cognizance of BS 6072:1981, *Method for magnetic particle flaw detection*, and ASTM E 1444—94a, *Practice for magnetic particle examination*. This Standard now refers to ASTM E 1444 for the requirements for magnetic particle testing media instead of AS 2085—1977, *Magnetic particle testing media*.

Currently there are no International (ISO) Standards that cover the general practice of magnetic particle testing.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard

**Non-destructive testing—Magnetic particle testing
of ferromagnetic products, components and structures**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard specifies requirements for magnetic particle testing for the detection of surface and near-surface discontinuities in all types of ferromagnetic products, components and structures. It also specifies requirements for magnetic particle testing process control. Requirements for materials (media) are specified in ASTM E 1444.

NOTES:

- 1 Advice and recommendations on information to be supplied by the purchaser at the time of enquiry and order are given in Appendix A.
- 2 This Standard does not indicate the method to be used for the testing of any particular product. The method and the appropriate acceptance/rejection criteria should be specified in the relevant product Standard or application code.
- 3 The unit symbols used in this Standard are defined in AS 1000.

1.2 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS

- | | |
|------|---|
| 1000 | The International System of Units (SI) and its application |
| 1239 | Steel—Schedule of tool steel compositions |
| 1442 | Carbon steels and carbon-manganese steels—Hot-rolled bars and semifinished products |
| 1929 | Non-destructive testing—Glossary of terms |
| 2536 | Surface texture |
| 3000 | Electrical installations—Buildings, structures and premises (known as the SAA Wiring Rules) |
| 3669 | Non-destructive testing—Qualification and registration of personnel—Aerospace |
| 3998 | Non-destructive testing—Qualification and certification of personnel—General engineering |

AS/NZS

- | | |
|------|---|
| 3100 | Approval and test specification—General requirements for electrical equipment |
|------|---|

ASTM

- | | |
|--------|--|
| E 1444 | Practice for magnetic particle examination |
|--------|--|

BS

- | | |
|------|--|
| 5044 | Specification for contrast aid paints used in magnetic particle flaw detection |
|------|--|

1.3 DEFINITIONS For the purpose of this Standard, the definitions given in AS 1929 apply.

NOTE: The term 'product' in this Standard is taken to include component, test piece, work piece or structure.

1.4 PRINCIPLE OF TEST METHOD Ferromagnetic materials are magnetized, using electrical currents or permanent magnets, to a level where the magnetic field becomes distorted by surface and near-surface discontinuities, causing local flux leakage fields. Finely divided particles of ferro- or ferri-magnetic materials, applied as a powder or in a carrier fluid, are attracted to these flux leakage fields and accumulate to indicate the presence of discontinuities.

1.5 WRITTEN PROCEDURE REQUIREMENTS All magnetic particle inspections shall be performed to a specific written procedure that implements the requirements of this Standard for the components under test. A master written procedure may be utilized to cover the requirements common to a variety of similar components. As a minimum, the following information, where relevant, shall be included in individual procedures, a master procedure, or a combination thereof:

- (a) Company name and address.
- (b) Description and identity of the component.
- (c) Written procedure identification number and date of issue.
- (d) Material specification or type.
- (e) A sketch of the component showing its main dimensions and the area to be tested.
- (f) Surface condition at the time of testing, including the thickness and uniformity of any coating present.
- (g) Purpose of the test.
- (h) The manufacturing or overhaul stage at which the component is to be tested.
- (i) Magnetizing technique to be used, including waveform and current value.
- (j) The method of application of the indicating medium.
- (k) Technique, i.e. whether continuous or residual.
- (l) Equipment to be used.
- (m) Distance between contact areas, or coil dimensions.
- (n) Detecting media to be used.
- (o) Contrast aids to be used.
- (p) Viewing conditions.
- (q) Demagnetization procedure.
- (r) Method of reporting results.
- (s) Acceptance/rejection criteria, if applicable.
- (t) Minimum qualification of test operator.
- (u) Identity of person responsible for the procedure.
- (v) Reporting requirements.

1.6 SAFETY

1.6.1 General As magnetic particle testing methods may require the use of toxic, flammable and volatile materials, safety precautions shall be observed and testing shall be carried out in well-ventilated areas remote from heat and naked flame.

NOTE: Safety data sheets are available on request from suppliers of consumable materials and should be consulted to determine the hazards to personnel.

1.6.2 Fire hazards As the current flow methods described in this Standard require the use of high levels of current, it is important to ensure that any occurrence of overheating and arcing will not ignite flammable vapours that may be present when a carrier fluid containing magnetic particles is used.

CAUTION: ENSURE THAT ALL ELECTRICAL EQUIPMENT IS PROPERLY MAINTAINED AND THAT FIRE SAFETY PRECAUTIONS ARE OBSERVED. KEEP MATERIALS AND AUXILIARY EQUIPMENT AWAY FROM HEAT AND NAKED FLAMES.

THE USE OF HIGH INTENSITY LAMPS OF BOTH BLACK AND WHITE LIGHT CAN IGNITE EXPLOSIVE GAS MIXTURES. ENSURE HAZARDOUS AREAS ARE WELL VENTILATED.

1.6.3 Electrical safety Electrical equipment used shall comply with the requirements of AS/NZS 3100 and shall be wired to comply with the requirements of AS 3000.

NOTE: Magnetic fields resulting from the use of high current may affect the functioning of heart pacemakers.

1.6.4 Toxic materials Magnetic particle testing media shall be used with caution and always in accordance with the manufacturer's printed instructions.

WARNING: PROVIDE ADEQUATE VENTILATION TO ENSURE THE REMOVAL OF VAPOURS AND AIRBORNE PARTICLES GENERATED WHERE TOXIC MATERIALS ARE USED IN CONFINED SPACES.

Testing personnel shall use appropriate protective equipment to prevent skin contact and eye exposure to toxic liquids and the inhalation of fumes.

1.6.5 The use of black lights A black light should never be used when a filter glass is cracked or broken, as ultraviolet radiation harmful to the eyes may be emitted.

1.7 TESTING PERSONNEL The effectiveness of magnetic particle testing depends on the technical competence of the personnel performing the tests and on their ability to interpret indications. The responsibility for the nomination of acceptance/rejection criteria does not lie with the testing authority.

Personnel who perform testing to this Standard shall have appropriate qualifications in the specific area of test and shall meet the visual acuity requirements of a relevant national Standard.

NOTES:

- 1 The Australian Standards for qualification of personnel who perform non-destructive testing are AS 3669 and AS 3998. Organizations responsible for personnel certification are the Australian Institute for Non-Destructive Testing (AINDT) and the Certification Board for Inspection Personnel (CBIP), New Zealand.
- 2 The accreditation of testing laboratories is carried out in Australia by the National Association of Testing Authorities (NATA), and in New Zealand, by International Accreditation New Zealand (IANZ).

SECTION 2 EQUIPMENT AND MATERIALS

2.1 GENERAL The test equipment shall be capable of inducing magnetic flux in the product under test, in accordance with the requirements of the applicable test procedure. The magnetic field employed for this purpose may be generated from any source that is capable of producing the required flux density at the surface under test.

2.2 REQUIREMENTS FOR MAGNETIZING, DEMAGNETIZING AND AUXILIARY EQUIPMENT

2.2.1 Bench-type magnetizing equipment (incorporating a reservoir containing magnetic ink) Bench-type current flow, magnetizing, demagnetizing and associated equipment shall—

- (a) when designed either for continuous or stepped current adjustment, be capable of producing current values that are within $\pm 10\%$ of the current setting or within ± 50 A, whichever is the greater, over the range from zero to the maximum current value;
- (b) include a calibrated ammeter to indicate the current output;
- (c) be capable of meeting the expected current demand;
- (d) have, indicated on or near the ammeter, the nominal waveform of the magnetizing current together with the current parameter, e.g. peak, r.m.s., mean, or mean of the conducting half cycle; and
- (e) have a means to ensure that current-carrying contacts make firm electrical contact with the test part to prevent arcing or mechanical damage.

2.2.2 Permanent magnets and d.c. electromagnets Unless otherwise specified, permanent magnets and d.c. electromagnets (d.c. yokes) shall be capable of lifting not less than 18 kg of mild steel at a pole spacing of between 75 mm and 300 mm.

2.2.3 a.c. electromagnets Unless otherwise specified, a.c. electromagnets (a.c. yokes) shall be capable of lifting not less than 4.5 kg of mild steel at a pole spacing of between 75 mm and 300 mm.

NOTES:

- 1 As the strength of magnetization resulting from the use of d.c. electromagnets and especially permanent magnets is relatively low, this type of equipment should only be used where other methods of magnetization are not available or are unsuitable.
- 2 The lifting test pieces applicable to Clauses 2.2.2 and 2.2.3 are manufactured from a rectangular bar with one face at least 30 mm wide. The steel should be similar in chemical composition to grade 1020 of AS 1442 and be in the annealed condition.

2.2.4 Auxiliary equipment

2.2.4.1 Light sources for viewing The following light sources are required for the inspection of work pieces during testing:

- (a) *For white light viewing when using non-fluorescent magnetic particles*—unless suitable natural light is available, an artificial light source capable of illuminating a test area to a level of not less than 1000 lx.
- (b) *For black light viewing when using fluorescent magnetic particles*—a black light source capable of giving an irradiance of not less than 10 W/m^2 at a distance of 380 mm.

NOTE: For black light viewing it may be necessary to provide an inspection booth to restrict the ambient white light illuminance (see Clause 3.5.3).

2.2.4.2 Standard test pieces Test pieces that are used for checking test equipment, or that contain known discontinuities, shall be prepared in accordance with Appendix B.

2.2.4.3 Magnetic field strength meters and field indicators Magnetic field strength meters and field indicators are required to measure the flux density near a magnetized component and to prove the efficacy of demagnetizing procedures.

2.3 REQUIREMENTS FOR MAGNETIC POWDERS AND INKS

2.3.1 Composition The composition and properties of magnetic powders and inks shall be in accordance with the requirements of ASTM E 1444.

2.3.2 Concentration of inks The percentage volume of magnetic particles in wet suspension shall be in the following ranges:

- (a) Fluorescent particles 0.1% to 0.5% (preferred range 0.15% to 0.25%).
- (b) Non-fluorescent particles 1.0% to 3.0%.

2.3.3 Labelling The following information shall be legibly and durably marked on each container of magnetic powder or ink, or on a label fixed securely to each container:

- (a) The name of the manufacturer.
- (b) A description of the contents.
- (c) The contents by mass or by volume.
- (d) The batch number.
- (e) Information for the user.

NOTE: Manufacturers making a statement of compliance with this Australian Standard on a product, packaging or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

SECTION 3 METHODS OF TEST

3.1 SCOPE This Section gives details of magnetizing methods that are designed to ensure that discontinuities oriented in any direction in the test component can be revealed.

3.2 PREPARATION OF TEST SURFACE All areas to be tested shall be free from any foreign matter which could interfere with the interpretation of the test results, e.g. scale, dirt, grease, loose or flaking paint. The processes of surface preparation and cleaning shall not be detrimental to the product, its dimensional tolerances and surface finish, or to the testing media.

To improve contrast when using methods employing dry powder or magnetic inks, the product prior to test may be painted with a strippable lacquer, a titanium-based white paint or some other suitable material, provided that the coating chosen is compatible with the test medium. Care shall be taken to ensure that the thickness of the contrast aid does not adversely affect the sensitivity of the test.

Where a current flow method (see Clause 3.4.3 and 3.4.4) is being used, any paint or other non-conductive coatings present on the contact areas of the test component shall be removed to prevent arcing.

Where magnetic particle testing is to be carried out on surfaces that have a non-magnetic coating, pre-qualification testing shall be undertaken to ensure the efficacy of the method. If the surface being tested has a non-magnetic coating that cannot be removed, the thickness and uniformity of the coating and its likely effect on the test results shall be reported. Paint shall be removed from the area under test unless a degree of cracking in the test object is permitted by the specification. Requirements and advice on conducting magnetic particle inspections on painted surfaces are given in Appendix C.

NOTE: Information on contrast aid paints is given in BS 5044.

3.3 MAGNETIZATION

3.3.1 General During magnetization, the flux density and flux direction within the test part shall be such that the leakage flux from all discontinuities that require detection is capable of attracting and holding enough magnetic particles from the indicating medium to ensure that the discontinuities are detectable.

NOTES:

- 1 Whereas a.c. magnetization should be used for the detection of surface discontinuities, d.c. magnetization is the preferred method for the detection of sub-surface discontinuities.
- 2 Information on test methods for determining flux density and magnetizing current levels is contained in Appendix D.

3.3.2 Magnetic field directions Discontinuities are difficult to detect by the magnetic particle method when they make an angle of less than 45° to the direction of magnetization. To ensure their detection, regardless of their orientation, each part shall be magnetized in at least two directions at right angles to each other. Depending on part geometry, this may consist of—

- (a) circular magnetization in two or more directions;
- (b) both circular and longitudinal magnetization; or
- (c) longitudinal magnetization in two or more directions.

Exceptions, necessitated by part geometry, size, or other factors, require specific approval of the contracting agency.

3.3.3 Peak current The effective current value used in magnetic particle testing is the peak current. Appendix E gives wave forms and correction factors for sinusoidal-based waves to be applied should a test meter be calibrated in a convention other than peak value.

NOTE: Most magnetic particle machines using solid state controls employ non-sinusoidal wave forms in their magnetizing current circuits.

3.3.4 Application of indicating media To achieve the greatest test sensitivity, magnetic powder or ink should be applied immediately prior to magnetization, or during the magnetization of the product under test. Application should cease before the source of magnetization is removed.

The time of magnetization shall comply with the requirements of the product Standard or the written procedure, and shall be long enough to allow indications produced by the test to resolve, but shall be not less than 0.5 s.

NOTE: A good practice is to apply two successive magnetizing pulses of at least 0.5 s duration, such that the second follows the first in rapid succession.

3.4 MAGNETIZING METHODS

3.4.1 General The methods commonly employed to magnetize the work piece are tabulated in Figure 3.1 and listed as follows:

- (a) *Magnetic flow methods* These methods employ magnetic flow through the work piece, and require the use of either of the following equipment:
 - (i) Permanent magnets of various suitable configurations.
 - (ii) Electromagnetic yokes (either a.c. or d.c.).
- (b) *Current flow methods* These methods employ the passage of current through the work piece and require the use of either of the following equipment:
 - (i) Contact heads.
 - (ii) Prods or clamps.
- (c) *Coil methods* Coil methods employ magnetizing current flowing around the work piece by means of insulated coils, and comprise the following techniques:
 - (i) Low fill factor techniques.
 - (ii) High fill factor techniques.
 - (iii) Flat, spiral, astride and adjacent coil techniques.
- (d) *Threading bar and threading cable methods* These methods employ current flow through bars or flexible cables that are threaded through the work piece, for testing hollow products and holes.
- (e) *Induced current methods* These methods employ induced current and are used for magnetizing ring-shaped components.

Examples of these magnetizing methods are shown in Figures 3.2 to 3.7.

3.4.2 Magnetic flow methods

3.4.2.1 Application Magnetic flow methods are suitable for the general location of discontinuities in work pieces and employ an electromagnet or a permanent magnet. They are suitable for detecting discontinuities oriented transverse to a line joining the poles of the magnet (see Figures 3.2 (a) and (b)).