



# Standard Practice for Magnetic Particle Testing<sup>1</sup>

This standard is issued under the fixed designation E 1444; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 This practice establishes minimum requirements for magnetic particle examination used for the detection of surface or slightly subsurface discontinuities in ferromagnetic material. Guide E 709 can be used in conjunction with this practice as a tutorial.

NOTE 1—This Practice replaces MIL-STD-1949.

1.2 The magnetic particle examination method is used to detect cracks, laps, seams, inclusions, and other discontinuities on or near the surface of ferromagnetic materials. Magnetic particle examination may be applied to raw material, billets, finished and semi-finished materials, welds, and in-service parts. Magnetic particle examination is not applicable to non-ferromagnetic metals and alloys such as austenitic stainless steels. See Appendix X6 for additional information.

1.3 All areas of this Practice may be open to agreement between the Cognizant Engineering Organization and the supplier, or specific direction from the Cognizant Engineering Organization.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 The following documents form a part of this standard practice to the extent specified herein.

2.2 *ASTM Standards:*<sup>2</sup>

**A 275/A 275M** Test Method for Magnetic Particle Examination of Steel Forgings

**A 456** Specification for Magnetic Particle Inspection of Large Crankshaft Forgings

**D 1966** Test Methods for Foots in Raw Linseed Oil

**E 543** Practice for Evaluating Agencies that Perform Non-destructive Testing

**E 709** Guide for Magnetic Particle Examination

**E 1316** Terminology for Nondestructive Examinations

2.3 *ASNT Documents:*<sup>3</sup>

**SNT-TC-1A** Recommended Practice No. "Personnel Qualification and Certification in Nondestructive Testing

**ANSI/ASNT CP-189** Standard for Qualification and Certification of NDT Personnel

2.4 *Society of Automotive Engineers (SAE)-AMS Documents:*<sup>4,5</sup>

**AMS 2641** Magnetic Particle Inspection Vehicle

**AMS 3040** Magnetic Particles, Nonfluorescent, Dry Method

**AMS 3041** Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Ready-To-Use

**AMS 3042** Magnetic Particles, Nonfluorescent, Wet Method, Dry Powder

**AMS 3043** Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Aerosol Packaged

**AMS 3044** Magnetic Particles, Fluorescent, Wet Method, Dry Powder

**AMS 3045** Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle, Ready-To-Use

**AMS 3046** Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle, Aerosol Packaged<sup>5</sup>

**AMS 5062** Steel, Low Carbon Bars, Forgings, Tubing, Sheet, Strip, and Plate 0.25 Carbon, Maximum

**AMS 5355** Investment Castings

**AMS I-83387** Inspection Process, Magnetic Rubber

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.03 on Liquid Penetrant and Magnetic Particle Methods.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American Society for Nondestructive Testing, 1711 Arlington Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

<sup>4</sup> Copies of standards, specifications, drawings, and publications required by manufacturers in connection with specification acquisition should be obtained from the contracting activity or as directed by the contracting officer.

<sup>5</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

**AS 4792** Water Conditioning Agents for Aqueous Magnetic Particle Inspection

**AS 5282** Tool Steel Ring Standard for Magnetic Particle Inspection

**AS 5371** Reference Standards Notched Shims for Magnetic Particle Inspection

2.5 *Federal Standards:*<sup>4,6</sup>

**FED-STD-313** Material Safety Data Sheets, Preparation and the Submission of

**FED-STD-595** Colors

2.6 *Military Standards:*<sup>4,6</sup>

**MIL-STD-1907** Inspection, Liquid Penetrant and Magnetic Particle Soundness Requirements for Materials, Parts, and Weldments

**MIL-STD-2175** Castings, Classification and Inspection of

**A-A-59230** Fluid, Magnetic Particle Inspection, Suspension

2.7 *OSHA Document:*<sup>7</sup>

**29 CFR** 1910.1200 Hazard Communication

2.8 *ANSI Document:*<sup>4,8</sup>

**ANSI/NCSL Z 540-1** General Requirement for Calibration Laboratories and Measuring Test Equipment

2.9 *ISO Document:*

**ISO 10012-1** Quality Assurance Requirements for Measuring Equipment<sup>9</sup>

2.10 *AIA Document:*

**NAS 410** Certification and Qualification of Nondestructive Test Personnel<sup>10</sup>

2.11 *DoD Contracts*—Unless otherwise specified, the editions of the documents that are DoD adopted are those listed in the issue of the DoDISS (Department of Defense Index of Specifications and Standards) cited in the solicitation.

2.12 *Order of Precedence*—In the event of conflict between the text of this practice and the referenced documents cited herein, the text of this practice takes precedence.

### 3. Terminology

3.1 *Definitions*—The definitions relating to magnetic particle examination, which appear in Terminology **E 1316**, shall apply to the terms used in this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *Cognizant Engineering Organization*—The company, agency, or other authority responsible for the system or component for which magnetic particle examination is required. This, in addition to design personnel, may include personnel from material and process engineering, stress analysis, NDT or quality groups and others as appropriate.

### 4. Significance and Use

4.1 *Description of Process*—Magnetic particle examination consists of magnetizing the area to be examined, applying suitably prepared magnetic particles while the area is magnetized, and subsequently interpreting and evaluating any resulting particle accumulations. Maximum detectability occurs when the discontinuity is positioned on the surface and perpendicular to the magnetic flux.

4.2 This practice establishes the basic parameters for controlling the application of the magnetic particle method. This practice is written so that it can be specified on the engineering drawing, specification, or contract. It is not a detailed how-to procedure to be used by the inspector and, therefore, must be supplemented by a detailed written procedure that conforms to the requirements of this practice.

### 5. General Practice

5.1 *Acceptance Requirements*—The acceptance requirements applicable to the part or group of parts shall be incorporated as part of the written procedure either specifically or by reference to other applicable documents, such as **MIL-STD-1907**, containing the necessary information. When parts are zoned, the acceptance criteria for each zone shall be specified. Methods for establishing acceptance requirements for large crankshaft forgings are covered in Specification **A 456**. Methods for establishing requirements for steel forgings are covered in Test Method **A 275/A 275M**. Methods for classifying metal castings are given in **MIL-STD-2175** and **AMS 5355**.

5.1.1 *Aircraft-Quality Steel Cleanliness*—The examination of aircraft-quality steel for cleanliness using magnetic particle examination shall be as appropriate to the type of steel being inspected. However, inspection of parts fabricated from this material shall be in accordance with the requirements of this practice.

5.2 *Personnel Qualification*—Personnel performing examinations in accordance with this practice shall be qualified in accordance with ASNT Recommended Practice No. **SNT-TC-1A**, ANSI/ASNT Standard CP-189, **NAS 410**, or as specified in the contract or purchase order.

5.3 *Agency Qualification*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in **E 543**. The applicable edition of **E 543** shall be specified in the contractual agreement.

5.4 *Written Procedure*—Magnetic particle examination shall be performed in accordance with a written procedure applicable to the part or group of parts under examination. The procedure shall be in accordance with the requirements of this Practice. The process, when conducted in accordance with the written procedure, shall be capable of detecting the rejectable discontinuities specified in the acceptance criteria. The written procedure may be general if it clearly applies to all of the specified parts being examined and meets the requirements of this practice. All written procedures, including technique sheets for specific parts, shall be approved by an individual qualified and certified at Level III for magnetic particle examination in accordance with the requirements of **5.2**. Procedures shall be

<sup>6</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

<sup>7</sup> Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

<sup>8</sup> Available from National Conference of Standards Laboratories, 1800 30th St. Suite 305b, Boulder, CO. 80301.

<sup>9</sup> Available from International Organization for Standardization, Case Postale 56, Geneva, Switzerland.

<sup>10</sup> Available from Aerospace Industries Association of America, Inc. (AIA), 1250 Eye St., NW, Washington, DC 20005.

submitted to the Cognizant Engineering Organization for review, or approval, or both, when requested.

5.4.1 *Elements of the Written Procedure*— The written procedure shall include at least the following elements, either directly or by reference to the applicable documents:

- 5.4.1.1 Procedure identification number and the date it was written;
- 5.4.1.2 Identification of the part(s) to which the procedure applies; this shall include the material and alloy;
- 5.4.1.3 Sequence of magnetic particle examination as related to manufacturing process operation, if applicable;
- 5.4.1.4 Identification of test parts used for system performance verification (see 7.1.1 and 7.1.2);
- 5.4.1.5 Areas of the part to be examined (include an illustration, either a drawing or photo);
- 5.4.1.6 Part preparation required before examination;
- 5.4.1.7 Directions for positioning the item with respect to the magnetizing equipment;
- 5.4.1.8 The type of magnetizing current and the equipment to be used;
- 5.4.1.9 Method of establishing the magnetization (head, coil, prods, yoke, cable wrap, etc.);
- 5.4.1.10 Directions of magnetization to be used, the order in which they are applied, and any demagnetization procedures to be used between shots;
- 5.4.1.11 The current level, or the number of ampere turns, to be used and the duration of its application;
- 5.4.1.12 Type of magnetic particle material (dry or wet, visible or fluorescent, etc.) to be used and the method and equipment to be used for its application and, for the case of wet particles, the particle concentration limits;
- 5.4.1.13 Type of records and method of marking parts after examination;
- 5.4.1.14 Acceptance requirements, to be used for evaluating indications and disposition of parts after evaluation; and
- 5.4.1.15 Post-examination demagnetization and cleaning requirements.

5.5 *Examination Sequence*—Perform magnetic particle examination after all operations which might cause or reveal discontinuities. Such operations include, but are not limited to, forging, heat treating, electroplating, forming, welding, grinding, straightening, machining, and proof loading.

5.5.1 Perform magnetic particle examination prior to shot peening (to provide a beneficial compressive layer) and prior to applying protective finishes such as priming, painting, plating (see 6.1.2 through 6.1.4.5) or other coatings.

5.5.2 In-process examinations may not be substituted for final examination.

5.6 *Record of Examination*—The results of all magnetic particle examinations shall be recorded. Records shall provide for traceability to the specific part or lot examined, serial number if serialized, and they shall identify the NDE contractor or facility and the procedures used in the examination, the lot size, and the number of parts accepted. All recorded results shall be identified, filed, and made available for review by the contracting agency upon request.

5.7 *Lighting*:

5.7.1 *Visible Light*—Conduct visible light intensity measurements upon initial light installation or when changes occur that would cause the light intensity to change and at the intervals specified in Table 1.

5.7.1.1 Visible light shall be used when examining with nonfluorescent magnetic particles and for interpretation of indications found with fluorescent magnetic particles. A minimum light intensity of 100 fc (1000 lx) shall be available at the surface of the part undergoing examination or evaluation.

5.7.1.2 *Ambient Visible Light*—Fluorescent magnetic particle examinations shall be performed in a darkened area with a maximum ambient visible light level of 2 fc (20 lx) measured at the part surface.

5.7.2 *Black Lights*—Inspection black lights shall meet the requirements of 7.3.5. The minimum acceptable intensity is 1000 μW/cm<sup>2</sup> (10 W/m<sup>2</sup>) at the surface being examined. Black lights shall be checked periodically for cleanliness and integrity and shall be cleaned, repaired or replaced as appropriate. Periodic checks of cleanliness/integrity need not be recorded.

5.7.3 *Restricted Area Examination*—Where lamps are physically too large to directly illuminate the examination surface, special lighting, such as UV pencil lights or UV light guides or borescopes shall be used. The image viewed must have sufficient resolution to effectively evaluate the required discontinuities. Light intensity shall be measured at the expected working distance and shall meet the requirements of 5.7.1.1 and 5.7.2 as appropriate.

5.8 *Materials*:

5.8.1 *Dry Particle Requirements*—Dry particles shall meet the requirements of AMS 3040.

5.8.2 *Wet Particle Requirements*—Wet particles shall meet the requirements of AMS 3041, 3042, 3043, 3044, 3045, or 3046, as applicable.

5.8.3 *Suspension Vehicles*—The suspension vehicle for the wet method shall be a light petroleum distillate conforming to AMS 2641 (Type I) or DoD-F-87935, or a suitably conditioned water that conforms to the requirements of 5.8.4. When approved by the contracting agency, AMS 2641 (Type II) may be used. When specified, the oil suspension vehicle shall meet the salient characteristics specified in A-A-59230.

TABLE 1 Required Verification Intervals

Item	Maximum Time Between Verification <sup>A</sup>
<b>Lighting:<sup>B</sup></b>	
Visible light intensity (5.7.1.1)	weekly
Ambient light intensity (5.7.1.2)	weekly
Black light intensity (5.7.2, 7.3.5)	daily
System Performance: <sup>B</sup> (7.1, 7.1.1, 7.1.2)	daily
Wet particle concentration (7.2.1.1)	8 hours, or every shift change
Wet particle contamination: <sup>B</sup> (7.2.1.2)	1 week
Water break test (7.2.2)	daily
<b>Equipment calibration check:<sup>B</sup></b>	
Ammeter accuracy (7.3.1)	6 months
Timer control (7.3.2)	6 months
Quick break (7.3.3)	6 months
Yoke dead weight check (7.3.4)	6 months
Black and white light meters	6 months
Gaussmeter accuracy	6 months

<sup>A</sup> When the inspection system is in operation.

<sup>B</sup> The maximum time between verifications may be reduced or extended when substantiated by actual technical/reliability data.