Designation: E1444/E1444M – 16$^{\varepsilon 1}$

Standard Practice for Magnetic Particle Testing[1]

This standard is issued under the fixed designation E1444/E1444M; 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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

ε[1] NOTE—Summary of Changes updated editorially in July 2016.

1. Scope*

1.1 This practice establishes minimum requirements for magnetic particle testing used for the detection of surface or slightly subsurface discontinuities in ferromagnetic material. Guide E709 can be used in conjunction with this practice as a tutorial.

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

1.2 The magnetic particle testing method is used to detect cracks, laps, seams, inclusions, and other discontinuities on or near the surface of ferromagnetic materials. Magnetic particle testing may be applied to raw material, billets, finished and semi-finished materials, welds, and in-service parts. Magnetic particle testing is not applicable to non-ferromagnetic metals and alloys such as austenitic stainless steels. See Appendix X1 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 is a combined standard, an ASTM standard in which rationalized SI units and inch-pound units are included in the same standard, with each system of units to be regarded separately as standard.

1.4.1 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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:*[2]

A275/A275M Practice for Magnetic Particle Examination of Steel Forgings

A456/A456M Specification for Magnetic Particle Examination of Large Crankshaft Forgings

E543 Specification for Agencies Performing Nondestructive Testing

E709 Guide for Magnetic Particle Testing

E1316 Terminology for Nondestructive Examinations

E2297 Guide for Use of UV-A and Visible Light Sources and Meters used in the Liquid Penetrant and Magnetic Particle Methods

E3022 Practice for Measurement of Emission Characteristics and Requirements for LED UV-A Lamps Used in Fluorescent Penetrant and Magnetic Particle Testing

2.3 *ASNT Documents:*[3]

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:*[4,5]

AMS 2641 Magnetic Particle Inspection Vehicle

[1] 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.

Current edition approved June 1, 2016. Published June 2016. Originally approved in 1991. Last previous edition approved in 2012 as E1444 - 12. DOI: 10.1520/E1444_E1444M-16ϵ1.

[2] 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.

[3] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

[4] 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.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

***A Summary of Changes section appears at the end of this standard**

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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[5]
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
AMS 2175 Castings, Classification and Inspection of
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:*[4,6]
FED-STD-313 Material Safety Data Sheets, Preparation and the Submission of
FED-STD-595 Colors

2.6 *Military Standards:*[4,6]
MIL-STD 45562A Calibration Systems Requirements
A-A-59230 Fluid, Magnetic Particle Inspection, Suspension

2.7 *OSHA Document:*[7]
29 CFR 1910.1200 Hazard Communication

2.8 *ANSI Document:*[4,8]
ANSI/NCSL Z 540-1 General Requirement for Calibration Laboratories and Measuring Test Equipment

2.9 *ISO Document:*
ISO 10012-1 Measurement Management Systems—Requirements for Measurement Processes and Measuring Equipment[9]

2.10 *AIA Document:*
NAS 410 NAS Certification and Qualification of Nondestructive Test Personnel[10]

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 testing, which appear in Terminology E1316, shall apply to the terms used in this practice.

4. Significance and Use

4.1 *Description of Process*—Magnetic particle testing 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 testing 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 examination personnel and, therefore, must be supplemented by a detailed written procedure that conforms to the requirements of this practice.

5. General Practice

5.1 *Personnel Qualification*—Personnel performing examinations in accordance with this practice shall be qualified and certified 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.

5.2 *Agency Qualification*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in E543. The applicable edition of E543 shall be specified in the contractual agreement.

5.3 *Written Procedure*—Magnetic particle testing 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 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 testing in accordance with the requirements of 5.1. Procedures shall be submitted to the Cognizant Engineering Organization for review, or approval, or both, when requested.

[6] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.
[7] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.
[8] Available from National Conference of Standards Laboratories, 1800 30th St. Suite 305b, Boulder, CO. 80301.
[9] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.
[10] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

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

5.3.1.1 Procedure identification number and the date it was written;

5.3.1.2 Identification of the part(s) to which the procedure applies; this shall include the material, or alloy, or both;

5.3.1.3 For new components, sequence of magnetic particle testing as related to manufacturing process operation (for example, post plating, after heat treat, etc.);

5.3.1.4 Identification of test parts used for system performance verification (see 7.1.1 and 7.1.2);

5.3.1.5 Process controls (see Table 1);

5.3.1.6 Areas of the part to be examined;

5.3.1.7 Part preparation required before examination;

5.3.1.8 Directions for positioning the item with respect to the magnetizing equipment;

5.3.1.9 The type of magnetizing current and the equipment to be used;

5.3.1.10 Method of establishing the magnetization (head, coil, prods, yoke, cable wrap, etc.);

5.3.1.11 Directions of magnetization to be used, the order in which they are applied, and any demagnetization procedures to be used between shots;

5.3.1.12 The current level, or the number of ampere turns, to be used and the duration of its application;

5.3.1.13 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;

5.3.1.14 Type of records and method of marking parts after examination;

5.3.1.15 Acceptance requirements, to be used for evaluating indications and disposition of parts after evaluation; and

5.3.1.16 Post-examination demagnetization and cleaning requirements.

5.4 *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.

5.4.1 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 5.4.3 through 5.4.3.5) or other coatings.

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

5.4.3 *Plating and Coatings*—Examine parts which will receive either a plating or coating as follows:

5.4.3.1 Examination is required prior to all non-electroplated coatings.

5.4.3.2 Electroplated surfaces with a final plating thickness of 0.0008 in. [0.02 mm] or less shall be examined either before or after electroplating, or grinding, or both, of electroplated surfaces.

5.4.3.3 Electroplated surfaces with a final plating thickness of between 0.0008 in. [0.02 mm] and 0.0050 in. [0.13 mm] shall be examined both before and after electroplating, or grinding, or both, of electroplated surfaces.

(1) Electroplated surfaces with a final plating thickness of 0.0050 in. [0.13 mm] or greater shall be examined before electroplating, or grinding, or both, of electroplated surfaces.

(2) Magnetic particle examination after electroplating is not required for steels with a tensile strength less than or equal to 160 ksi.

5.4.3.4 Use caution when examining parts with an electroplated nickel coating as indications may form from the resulting leakage fields within the nickel plating itself.

5.4.3.5 For in-service examination, plating or coatings do not require removal prior to examination unless they are damaged, or they interfere with the examination process.

5.5 *Materials:*

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

TABLE 1 Required Verification Intervals

Item	Maximum Time Between Verification[A]	Paragraph
Lighting:[B]		
Visible light intensity	Weekly	7.3.1.1
Ambient light intensity	Weekly	7.3.1.2
Black light intensity	Daily	7.3.2, 7.4.5
Battery powered black light intensity check	Before and after each use	7.4.5.2
Black light integrity	Weekly	7.3.2
System Performance:[B]	Daily	7.1, 7.1.1, 7.1.2
Wet particle concentration	8 hours, or every shift change	7.2.1.1
Wet particle contamination:[B]	1 week	7.2.1.2
Water break test	Daily	7.2.2
Equipment calibration check:[B]		
Ammeter accuracy	6 months	7.4.1
Timer control	6 months	7.4.2
Quick break	6 months	7.4.3
Yoke dead weight check	6 months	7.4.4
Black and white light meters	6 months	7.4.7
Gaussmeter or Field Indicator accuracy	6 months	7.4.6

[A] When the test system is in operation.
[B] The maximum time between verifications may be reduced or extended when substantiated by actual technical/reliability data.

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

5.5.3 *Suspension Vehicles*—The suspension vehicle for the wet method shall be a light petroleum distillate conforming to AMS 2641 (Type I) or A-A-59230, or a suitably conditioned water that conforms to the requirements of 5.5.4. 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.

5.5.4 *Conditioned Water Vehicle*—When water is used as a suspension vehicle for magnetic particles, the conditioning agents used shall comply with AS 4792. Proper wetting shall be determined by a water break test (see 7.2.2). Smoother surfaces generally require a greater percent of wetting agent than rough surfaces. Foaming of the bath must be minimized to the point that it does not interfere with the examination process.

5.5.4.1 *Water Vehicle Conditioning Agents*—Any agents added to the water vehicle for any purpose shall conform to the requirements of the particle manufacturer.

5.5.5 *Particle Concentration*—The concentration of particles in the suspension bath shall be as specified in the written procedure. Particle concentrations outside of the range of 0.1 to 0.4 mL in a 100-mL bath sample for fluorescent particles and 1.2 to 2.4 mL in a 100 mL sample for nonfluorescent particles shall not be used. Fluorescent particles and nonfluorescent particles shall not be used together.

5.6 *Safety*—The safe handling of magnetic particles (wet or dry), oil vehicles, water baths, and water conditioner concentrates are governed by the suppliers' Material Safety Data Sheets (MSDS). Material Safety Data Sheets, conforming to 29 CFR 1910.1200, or equivalent, must be provided by the supplier to any user and shall be prepared in accordance with FEDSTD-313.

5.6.1 *Flammability*—Flash point of oil vehicles shall be in accordance with AMS 2641, Type I carriers. The suppliers' MSDS shall certify the flash point.

5.6.2 *Personnel Hazards*—Precautions against inhalation, skin contact, and eye exposure are detailed in the suppliers' MSDS. These precautions shall be observed.

5.6.3 *Electrical Hazards*—Magnetizing equipment shall be maintained properly to prevent personnel hazards from electrical short circuits. Care must be taken to reduce arcing and the possible ignition of oil baths.

5.6.4 *Black Light*—Replace cracked or broken ultraviolet filters immediately. Broken filters can allow harmful shortwave ultraviolet energy to be emitted and must be replaced immediately. Spectacles designed to absorb ultraviolet wavelength radiation are suggested for close, high-intensity black light examination. LED UV-A lamps used for evaluation purposes shall comply with Practice E3022.

6. Specific Practice

6.1 *Preparation of Parts for Testing:*

6.1.1 *Pre-examination Demagnetization*—The part shall be demagnetized before testing if prior operations have produced a residual magnetic field that may interfere with the examination.

6.1.2 *Surface Cleanliness and Finish*—The surface of the part to be examined shall be essentially smooth, clean, dry, and free of oil, scale, machining marks, or other contaminants or conditions that might interfere with the efficiency of the examination.

6.1.3 *Plugging and Masking*—Plugging and masking is required when specified by the Cognizant Engineering Organization.

6.1.4 All areas on the part where electrical contact is made shall be sufficiently clean to prevent electrical arcing.

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

6.2 *Magnetization Methods:*

6.2.1 *Types of Magnetizing Current*—The types of currents used for magnetic particle testing are full-wave rectified current (1 or 3 phase), half-wave rectified current, and alternating current. The equipment used shall fulfill the magnetizing and demagnetizing requirements adequately, as outlined herein, without damage to the part under examination, and they shall include the necessary features required for safe operation.

6.2.2 *Permanent Magnets*—Permanent magnets are not to be used for magnetic particle testing unless specifically authorized by the Cognizant Engineering Organization. When permanent magnets are used, adequate magnetic field strength shall be established in accordance with 7.4.4.

6.2.3 *Yokes*—When using yokes (electromagnetic probes) for magnetic particle testing, they shall meet the requirements of 7.4.4.

6.2.4 *Magnetizing Current Application*—Alternating current is to be only used for the detection of discontinuities open to the surface. Full-wave direct current has the deepest possible penetration and must be used for examination of sub-surface discontinuities when using the wet magnetic particle method. Half-wave direct current can also be used for examination of sub-surface discontinuities and due to the pulsating nature of the waveform; it has the advantage of increased particle mobility.

6.2.5 *Magnetic Field Directions*—Discontinuities are difficult to detect by the magnetic particle method when they make an angle less than 45° to the direction of magnetization. To ensure the detection of discontinuities in any direction, each part must be magnetized in a minimum of two directions at approximately right angles to each other. Depending on part geometry, this may consist of circular magnetization in two or more directions, multiple circular and longitudinal magnetization, or of longitudinal magnetization in two or more directions. The pie gauge as illustrated in Fig. X5.1, the flexible laminated strips as described in Annex A3, or a properly prepared master part using notched shims may only be used as a tool to demonstrate the direction of the external magnetic

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field. The pie gauge or flexible laminated strips shall not be used to determine adequate field strength. Exceptions necessitated by part geometry, size, or other factors require specific approval of the Cognizant Engineering Organization.

6.2.6 *Multidirectional Magnetization*—Multidirectional magnetization may be used to fulfill the requirement for magnetization in two or more directions if it is demonstrated that it is effective in all areas, which require examination as practical. Test parts in accordance with 6.3.1.1 or shims manufactured to the requirements of AS 5371, or as otherwise approved by the Cognizant Engineering Organization, shall be used to verify field direction, strength, and balance in multidirectional magnetization. Balancing of the combined magnetic field is critical and an adequate balance must be visually demonstrated to be effective in all areas, which require examination. The particle application must be timed so that the magnetization levels reach full value in all directions while the particles are mobile on the surface under examination. The residual method shall only be used with the approval of the Cognizant Engineering Organization.

6.2.7 *Direct Magnetization*—Direct magnetization is accomplished by passing current directly through the part under examination. Electrical contact is made to the part using head and tail stock, prods, clamps, magnetic leeches, or by other means. Caution shall be taken to ensure that the electrical current is not flowing while contacts are being applied or removed and that excessive heating does not occur in any area of the part. Unless otherwise specified by the Cognizant Engineering Organization, prods shall not be used for the examination of aerospace components (flight hardware) or on finished surfaces.

6.2.8 *Indirect Magnetization*—Indirect part magnetization uses pre-formed coils, cable wraps, yokes, field (flux) flow fixtures, or a central conductor to induce a magnetic field in a part when no direct electrical contact is made.

6.2.9 *Induced Current Magnetization*—Induced current magnetization (toroidal or circumferential field) is accomplished by inductively coupling a part to an electrical coil in order to create a suitable current flow within the part as illustrated in Fig. X5.2. This method is often advantageous on ring-shaped parts with a central aperture and with an *L/D* ratio less than three, especially where the elimination of arcing or burning is of vital importance.

6.2.10 *Parallel Current Induced Magnetization*—This method of magnetization may occur when a ferromagnetic part is placed alongside and parallel to a current-carrying conductor. A magnetic field will be induced in the part that is more transverse than circular. This type of magnetization shall not be used for magnetic particle testing unless approved by the Cognizant Engineering Organization.

6.2.11 *Magnetization of Aerospace Lifting Hardware*—The use of permanent magnets, electromagnetic yokes, coil wraps or prods on aerospace lifting hardware must be approved by the Cognizant Engineering Organization.

6.3 *Magnetic Field Strength:*

6.3.1 *Magnetic Field Strength*—The applied magnetic field shall have sufficient strength to produce satisfactory indications, but it must not be so strong that it causes the masking of relevant indications by nonrelevant accumulations of magnetic particles. Adequate magnetic field strength may be determined by one or a combination of the following methods:

6.3.1.1 In unidirectional, or multidirectional magnetizing applications, by examining parts having known or artificial discontinuities of the type, size, and location specified in the acceptance requirements or by using the notched shims as defined in Annex A1;

6.3.1.2 In unidirectional magnetizing applications only, by using a Hall Effect probe gaussmeter capable of measuring the peak values of the tangential field as described in Annex A5. Tangential-field strengths shall have a minimum value of 30 Gauss (30×10^{-4} Tesla [T]) when measured at the part surface using a Hall Effect probe gaussmeter as described in Annex A5. The maximum Gauss value derived is limited by the restrictions of 6.3.1.

6.3.1.3 Using the current levels specified by the formulas given in Appendix X3 and Appendix X4. These current levels and formulas provide only a rough guide and shall only be used in conjunction with either 6.3.1.1, or 6.3.1.2, or Cognizant Engineering Organization approval, or a combination thereof. In some cases the formulas in Appendix X3 and Appendix X4 may lead to over magnetization of the work piece and care should be exercised when using them.

6.3.2 *Longitudinal Magnetization Using Coils*—Longitudinal magnetization is often accomplished by passing current through a coil encircling the part, or section of the part, to be examined (that is, by using a coil shot). This produces a magnetic field parallel to the axis of the coil. The actual effective distance must be demonstrated based on the particular part to be examined. For parts longer than these effective distances, the entire length shall be examined by repositioning the part within the coil, allowing for approximately 10 % effective magnetic field overlap. See 6.3.1 for field strength methods that can be used in coil magnetization.

6.4 *Particle Application:*

6.4.1 *Dry Magnetic Particle Application, Continuous Method*—When using dry particles, the flow of magnetizing current shall be initiated prior to application of the magnetic particles to the surface under examination and terminated after powder application has been completed and any excess blown off. Precautions shall be taken to prevent any damage to the part due to overheating.

6.4.1.1 Apply dry powder so that a light, uniform, dust-like coating settles on the surface of the part under examination while the part is being magnetized. Specially designed powder blowers or shakers using compressed air or hand power shall be used. The applicators shall introduce the particles into the air in a manner such that they reach the part surface in a uniform cloud with a minimum of force.

6.4.1.2 After the powder is applied, and before the magnetizing force is removed, excess powder shall be removed, by means of a dry air current with sufficient force to remove the excess particles if it interferes with interpretation and evaluation, but not strong enough to disturb particles held by a leakage field that is indicative of discontinuities. In order to recognize the broad, fuzzy, lightly held powder patterns formed by near-surface discontinuities, the formation of indications

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must be observed carefully during both powder application and removal of the excess powder. The dry particle method shall not be used to examine aerospace components (flight hardware). Dry magnetic particles shall not be reused.

6.4.2 *Wet Magnetic Particle Application, Continuous Method*—Fluorescent or nonfluorescent particles suspended in a liquid vehicle at the required concentration shall be applied by gently spraying or flowing the suspension over the area to be examined.

6.4.2.1 Proper sequencing and timing of part magnetization and application of particle suspension are required to obtain the proper formation and retention of indications. This requires that the stream of suspension be diverted from the part simultaneously with, or slightly before, energizing the magnetic circuit.

6.4.2.2 The magnetizing current shall be applied for a duration of at least 0.5 second for each application, with a minimum of two shots being used. The second shot shall follow the first while the particles are still mobile on the surface of the part.

6.4.2.3 Under special circumstances, such as the use of automated equipment or for critical parts, the 0.5–second duration and the two-shot requirement may be waived provided it is demonstrated that the procedure can detect known discontinuities in reference parts.

6.4.2.4 Care shall be exercised to prevent any damage to the part due to overheating or other causes. Weakly held indications on highly finished parts are readily washed away, and care must be exercised to prevent high-velocity flow over critical surfaces.

6.4.2.5 Particle application by continuous immersion shall be used only when specifically approved by the Cognizant Engineering Organization or when it has been documented that it can detect discontinuities or artificial discontinuities in parts under examination.

6.4.3 *Residual Magnetization Method*—In the residual magnetization method, the magnetic particles are applied to the part under examination after the magnetizing force has been discontinued. The residual method is not as sensitive as the continuous method. It can be useful on materials with high retentivity. It is also useful for the examination of parts or areas of parts, which because of geometric constraints, cannot be examined with the continuous method. The residual method shall be used only when specifically approved by the Cognizant Engineering Organization or when it has been documented that it can detect discontinuities or artificial discontinuities in parts under examination. The test parts shall have the same material and processing steps, and similar geometry, to the actual parts being examined.

6.4.4 *Magnetic Slurry/Paint Application*—Magnetic paints or slurries are applied to the part with a brush, squeeze bottle, or aerosol can before or during the magnetization operation. This method is for special applications, such as overhead or underwater examination. This method may be used only when specifically approved by the Cognizant Engineering Organization.

6.4.5 *Magnetic Polymer Application*—Polymerizable material containing magnetic particles shall be held in contact with the part under examination during the period of its cure. Before curing takes place, and while the magnetic particles are still mobile, the part shall be magnetized to the specified level. This requires prolonged or repeated periods of magnetization. This method is for special applications, such as bolt holes which cannot be examined readily by the wet or dry method, and shall be used only when specifically approved by the Cognizant Engineering Organization. AMS-I-83387 establishes the examination process for magnetic rubber.

6.4.6 *Particle Selection for Aerospace Lifting Hardware*—The use of dry powder or non-fluorescent wet particles on aerospace lifting hardware must be approved by the Cognizant Engineering Organization.

6.5 *Evaluation*—Following magnetization and particle application, the parts shall be examined for indications. All indications will be identified as relevant or nonrelevant. Relevant indications will be compared to the proper accept/reject criteria and the parts accepted or rejected accordingly.

6.5.1 *Eye Glasses*—When using fluorescent materials, personnel shall not wear eye glasses that are photochromic or that have permanently darkened lenses. This is not intended to prohibit the use of eyeglasses with lenses treated to absorb ultraviolet light.

6.5.2 *Dark Adaptation*—Personnel must wait at least one minute after entering a darkened area for their eyes to adjust to the low-level lighting before performing fluorescent magnetic particle testing.

6.5.3 *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 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 A456/A456M. Methods for establishing requirements for steel forgings are covered in Practice A275/A275M. Methods for classifying metal castings are given in AMS 2175 and AMS 5355.

6.6 *Recording of Indications*—When required by the written procedure, the location of all rejectable indications shall be marked on the part, and permanent records of the location, direction, and frequency of indications may be made by one or more of the following methods:

6.6.1 *Written Description*—By recording the location, length, direction, and number of indications in sketch or tabular form.

6.6.2 *Transparent Tape*—For dry particle indications, by applying transparent adhesive-backed tape to which the indications will adhere and placing it on an approved form along with information giving its location on the part.

6.6.3 *Strippable Film*—By covering the indication with a spray-on strippable film that fixes the indications in place and placing the resultant reproduction on an approved form along with information giving its location on the part.

6.6.4 *Photography*—By photographing or video recording the indications themselves, the tape, or the strippable film reproduction and placing the photograph in a tabular form along with information giving its location on the part.

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6.7 *Post Examination Demagnetization and Cleaning*—All parts shall be demagnetized and cleaned after final examination. Apply corrosion protection as required.

6.7.1 *Demagnetization:*

6.7.1.1 When using AC demagnetization, the part shall be subjected to a field with a peak value greater than, and in nearly the same direction as, the field used during examination. This AC field is then decreased gradually to zero. When using an AC demagnetizing coil, the part is passed through the coil while the current is flowing. For effective demagnetization, parts having complex configurations may require rotating or tumbling while passing through the field of the coil prior to the current being shut off. Repeat this process as necessary.

6.7.1.2 When using DC demagnetization, the initial field shall be higher than, and in nearly the same direction as, the field reached during examination. The field shall then be reversed, decreased in magnitude, and the process repeated (cycled) until an acceptably low value of residual field is reached.

6.7.1.3 Whenever possible, parts that have been magnetized circularly shall be magnetized in the longitudinal direction before being demagnetized. After demagnetization, a calibrated field indicator shall not detect magnetic flux fields with an absolute value above 3 G (3×10^{-4} T) anywhere on the part.

6.7.2 *Post-examination Cleaning*—Cleaning shall be done with a suitable solvent, air blower, or by other means.

6.7.2.1 Parts shall be examined to ensure that the cleaning procedure has removed magnetic particle residues from holes, crevices, passage ways, etc. Such residue could have an adverse effect on the intended use of the part.

6.7.2.2 Care shall be taken to remove all plugs, masking, or other processing aids that may affect the intended use of the part.

6.7.2.3 Parts shall be protected from corrosion or damage as required.

6.8 *Record of Examination*—Results of all final magnetic particle examinations shall be recorded. All recorded results shall be identified, filed, and made available to the cognizant engineering organization upon request. Records shall provide for traceability to the specific part or lot inspected. As a minimum, the records shall include: identification of the procedure used, disposition of the examination; identification of the inspector's examination stamp, electronic ID or signature; and the date of examination. Records shall be kept for a minimum of three years or as otherwise specified in the purchase order or contract.

6.9 *Marking of Accepted Parts*—Unless otherwise specified by the Cognizant Engineering Organization, parts that have been accepted using magnetic particle testing shall be marked in accordance with the applicable drawing, purchase order, contract, or as specified herein prior to leaving the testing facility.

6.9.1 Marking shall be applied in such a manner and location as to be harmless to the part. The identification shall not be obliterated or smeared by subsequent handling and, when practicable, placed in a location that will be visible after assembly.

6.9.1.1 When subsequent processing would remove the identification, the applicable marking shall be affixed to the record accompanying the finished parts or assembly.

6.9.1.2 Bolts and nuts and other fastener products may be identified as having met the requirements of magnetic particle testing by marking each package conspicuously.

6.9.2 *Impression Stamping, Ink Stamping, Laser Marking, Dyeing, Vibro Engraving or Etching*—Impression stamping, ink stamping, laser marking, dyeing, vibro engraving or etching may be used when permitted or required by the applicable written procedure, detail specification or drawing, or when the nature of the part is such as to provide for impression stamping of part numbers or other examination personnel markings. Impression stamping shall be located only in the area provided adjacent to the part number or examination personnel's stamp.

6.9.3 *Other Identification*—Other means of identification, such as tagging, may be used for parts that have a configuration or function precluding the use of stamping, vibro engraving, or etching, as in the case of completely ground or polished balls, rollers, pins, or bushings.

6.10 *Identifying Symbols and Color Markings:*

6.10.1 *One-Hundred Percent Examination*—When items are examined and accepted by 100 % examination, each item shall be marked as follows:

6.10.1.1 *Dyeing*—When dyeing is applicable, a dye of acceptable adherence which is predominantly blue (in accordance with FED-STD-595) shall be employed. However, if a color conflict is incurred with any other method, magnetic particle examination may be indicated by two adjacent blue dots or other suitable means.

6.10.1.2 *Stamping, Laser Marking, Vibro Engraving, or Etching*—When impression stamping or ink stamping, laser marking, vibro engraving, or etching is used to mark 100 % examined parts, the letter "M" with a circle around it shall be employed.

6.10.2 *Marking Accepted Lots*—When items are accepted by means of a sampling procedure, each item of an accepted lot shall be marked as follows:

6.10.2.1 *Dyeing*—When dyeing is applicable, a dye of acceptable adherence that is predominantly orange (in accordance with FED-STD-595) shall be employed.

6.10.2.2 *Stamping, Laser Marking Vibro Engraving, or Etching*—When impression stamping, vibro engraving or etching is used to mark lot examined parts, the letter "M", without a circle around it shall be employed.

7. Quality Control

7.1 *System Performance Verification*—The overall performance of the magnetic particle testing system, including the equipment, materials, and the lighting environment being used, shall be verified initially and at regular intervals thereafter. The required verification intervals are stated in Table 1. Records of the verification results shall be maintained and retained for the time period specified in the contract. Establish a system in accordance with ANSI Z540-1 or ISO 10012-1 for calibration and certification of all current and voltage measuring devices,

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