Designation: E 1444 – 01

Standard Practice for Magnetic Particle Examination[1]

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 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 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 semifinished materials, welds, and in-service parts. Magnetic particle examination is not applicable to nonferromagnetic metals and alloys such as austenitic stainless steels. See Appendix X5 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:*

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings[2]

A 456 Specification for Magnetic Particle Inspection of Large Crankshaft Forgings[2]

D 1966 Test Methods for Foots in Raw Linseed Oil[3]

E 543 Practice for Evaluating Agencies that Perform Nondestructive Testing[4]

E 709 Guide for Magnetic Particle Examination[4]

E 1316 Terminology for Nondestructive Examinations[4]

2.3 *ASNT Documents:*

SNT-TC-1A Recommended Practice No. "Personnel Qualification and Certification in Nondestructive Testing[5]

ANSI/ASNT CP-189 Standard for Qualification and Certification of NDT Personnel[5]

2.4 *Society of Automotive Engineers (SAE)-AMS Documents:*[6]

AMS 2300 Premium Aircraft Quality Steel Cleanliness Magnetic Particle Inspection Procedure[7]

AMS 2301 Aircraft Quality Steel Cleanliness Magnetic Particle Inspection Procedure[7]

AMS 2303 Aircraft Quality Steel Cleanliness Martensitic Corrosion Resistant Steels Magnetic Particle Inspection Procedure[7]

AMS 2641 Magnetic Particle Inspection Vehicle[7]

AMS 3040 Magnetic Particles, Nonfluorescent, Dry Method[7]

AMS 3041 Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Ready-To-Use[7]

AMS 3042 Magnetic Particles, Nonfluorescent, Wet Method, Dry Powder[7]

AMS 3043 Magnetic Particles, Nonfluorescent, Wet Method, Oil Vehicle, Aerosol Packaged[7]

AMS 3044 Magnetic Particles, Fluorescent, Wet Method, Dry Powder[7]

AMS 3045 Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle, Ready-To-Use[7]

AMS 3046 Magnetic Particles, Fluorescent, Wet Method, Oil Vehicle, Aerosol Packaged[7]

AMS 5062 Steel, Low Carbon Bars, Forgings, Tubing,

[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.

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[2] *Annual Book of ASTM Standards*, Vol 01.05.

[3] *Annual Book of ASTM Standards*, Vol 05.01.

[4] *Annual Book of ASTM Standards*, Vol 03.03.

[5] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

[6] 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.

[7] Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

Sheet, Strip, and Plate 0.25 Carbon, Maximum[7]
AMS 5355 Investment Castings[7]
AMS I-83387 Inspection Process, Magnetic Rubber[7]
AS 4792 Water Conditioning Agents for Aqueous Magnetic Particle Inspection[7]
AS 5282 Tool Steel Ring Standard for Magnetic Particle Inspection[7]
AS 5371 Reference Standards Notched Shims for Magnetic Particle Inspection[7]

2.5 *Federal Standards:*[6]

FED-STD-313 Material Safety Data Sheets, Preparation and the Submission of[8]
FED-STD-595 Colors[8]

2.6 *Military Standards:*[6]

MIL-STD-1907 Inspection, Liquid Penetrant and Magnetic Particle Soundness Requirements for Materials, Parts, and Weldments[8]
MIL-STD-2175 Castings, Classification and Inspection of[8]
A-A-59230 Fluid, Magnetic Particle Inspection, Suspension[8]

2.7 *OSHA Document:*[9]

29 CFR 1910.1200 Hazard Communication

2.8 *ANSI Document:*[6]

ANSI/NCSL Z 540-1 General Requirement for Calibration Laboratories and Measuring Test Equipment[10]

2.9 *ISO Document:*

ISO 10012-1 Quality Assurance Requirements for Measuring Equipment[11]

2.10 *AIA Document:*

NAS 410 Certification and Qualification of Nondestructive Test Personnel[12]

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 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.

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 specified in AMS 2300, 2301, or 2303 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 submitted to the Cognizant Engineering Organization for review and/or approval 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:

[8] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[9] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
[10] Available from National Conference of Standards Laboratories, 1800 30th St. Suite 305b, Boulder, CO. 80301.
[11] Available from International Organization for Standardization, Case Postale 56, Geneva, Switzerland.
[12] Available from Aerospace Industries Association of America, Inc., 1250 Eye St. NW, Washington D.C. 20005.

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.

TABLE 1 Required Verification Intervals

Item	Maximum Time Between Verification[A]
Lighting:[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:[B] (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:[B] (7.2.1.2)	1 week
Water break test (7.2.2)	daily
Equipment calibration check:[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

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

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^2 (10 W/m^2) 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.

5.8.4 *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 7.4.2). 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 inspection process.

5.8.5 *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.

6. Specific Practice

6.1 *Preparation of Parts for Examination*:

6.1.1 *Preinspection Demagnetization*— The part shall be demagnetized before examination 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 *Plating and Coatings*—Examine parts which will receive either a plating or coating as follows:

6.1.4.1 Examination is required prior to all nonelectroplated coatings.

6.1.4.2 Examination is required prior to electroplating when the final plating thickness will exceed 0.0008 in (0.02 mm).

6.1.4.3 Examination is required after electroplating and or grinding of electroplated surfaces with the following exceptions: *1*) magnetic particle examination is not required for plating thickness' greater than 0.005 in (0.13 mm) and *2*) magnetic particle examination is not required for steels with a tensile strength less than or equal to 160 ksi.

6.1.4.4 Use caution when examining parts with an electroplated nickel coating as indications may form in the nickel plating itself.

6.1.4.5 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.

6.2 *Magnetization Methods*:

6.2.1 *Types of Magnetizing Current*—The types of currents used for magnetic particle examination are full-wave rectified alternating (FWDC) current (1 or 3 phase), half-wave rectified alternating (HWDC) current, and alternating (AC) 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 examination unless specifically authorized by the Cognizant Engineering Organization. When permanent magnets are used, adequate magnetic field strength shall be established in accordance with 7.3.4.

6.2.3 *Yokes*—When using yokes (electromagnetic probes) for magnetic particle examination, adequate magnetic field strength shall be established in accordance with 7.3.4.

6.2.4 *Magnetizing Current Application*— Alternating current is to be used only for the detection of defects open to the surface. Full-wave rectified alternating current has the deepest possible penetration and must be used for inspection for defects below the surface when using the wet magnetic particle method. Half-wave rectified alternating current is advantageous for the dry powder method because it creates a pulsating unidirectional field that gives increased mobility to the particles.

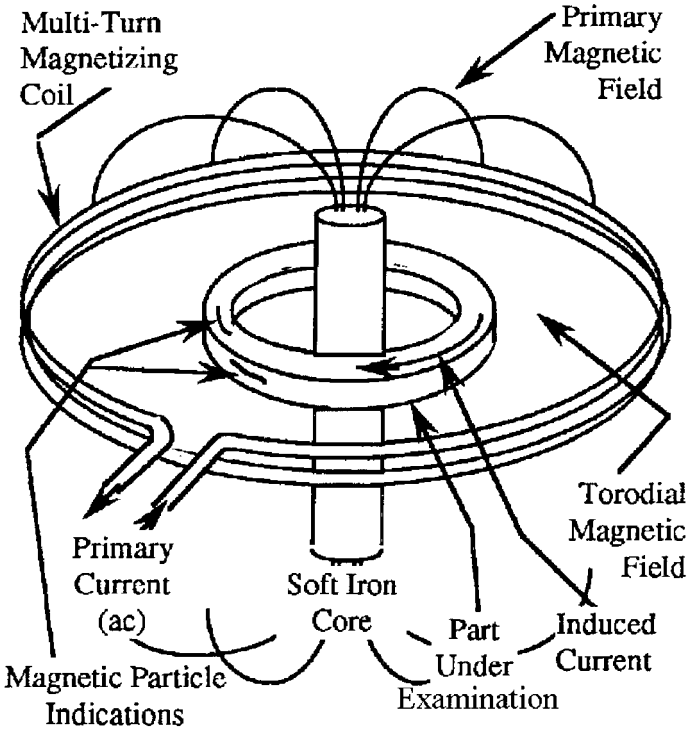
6.2.5 *Magnetic Field Directions*—Discontinuities are difficult to detect by the magnetic particle method when they make an angle less than 45° to the direction of magnetization. To ensure the detection of discontinuities in any direction, each part must be magnetized in a minimum of two directions at 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. 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 directions if it is demonstrated that it is effective in all areas. 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. Balance of the field intensity is critical. The field intensity shall be balanced in all directions. 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.

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 the contact area. 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 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 to create a suitable current flow in the part as illustrated in Fig. 1. This method is often advantageous on ring-shaped parts with a



The primary current sets up an oscillating field.
This primary magnetic field induces a current in the ring shaped part under examination

FIG. 1 Example of Induced Current Magnetization

central aperture and with an *L/D* ratio less than three, especially where the elimination of arcing or burning is of vital importance.

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 three methods:

6.3.1.1 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 Appendix X2;

6.3.1.2 By using a Hall effect probe gaussmeter capable of measuring the peak values of the tangent field; and

6.3.1.3 By using the current levels specified in sections 6.3.4 or 6.3.5 or the formulas given in Appendix X4. These current levels and formulas provide only a rough guide and shall be used in conjunction with another field strength monitoring method.

6.3.2 Tangential-field strengths in the range of 30 to 60 Gauss [G] (30 to 60 $\times$ 10^{-4} Tesla [T]) measured at the part surface are normally adequate magnetization levels for magnetic particle examination when using a Hall effect probe gaussmeter. Insure that field strengths in this range are present in all areas of the part to be examined. Current levels that provide a 30 to 60 G (30 to 60 $\times$ 10^{-4} T) field may be used instead of the current levels specified in paragraphs 6.3.4 and 6.3.5 or the current used in the formulas of Appendix X4.

6.3.3 *Magnetization Current Levels*—The current values given are average current values and are applied directly to full-wave rectified current. For other types of current, the operator's manual or the equipment manufacturer should be consulted.

6.3.4 *Prod Current Levels*—When using prods on material ¾ in. (19 mm) in thickness or less, 90 to 115 A/in. of prod spacing (3.5 to 4.5 A/mm) shall be used. For material greater than ¾ in. (19 mm) in thickness, 100 to 125 A/in. of prod spacing (4.0 to 5.0 A/mm) shall be used. Prod spacing shall not be less than 2 in. (50 mm) or greater than 8 in. (200 mm). The effective width of the magnetizing field when using prods is one fourth of the prod spacing on each side of a line through the prod centers.

6.3.5 *Direct Circular Magnetization*— When magnetizing by passing current directly through the part the nominal current shall be 300 to 800 A/in. of part diameter (12 to 32 A/mm). The diameter of the part shall be taken as the greatest distance between any two points on the outside circumference of the part. Currents will normally be 500 A/in. (20 A/mm) or lower, with the higher currents up to 800 A/in. (32 A/mm) being used to examine for inclusions or to examine low-permeability alloys such as precipitation-hardened steels. Amperages of less than 300 A/in. may be used when part configuration dictates and approval is obtained from the Level III and the Cognizant Engineering Organization.

6.3.6 *Central Conductor Circular Magnetization*—Circular magnetization may be provided by passing current through a conductor that is positioned inside the part. In this case, alternating current is to be used only when the sole purpose of the test is to examine for surface discontinuities on the inside surface of the part. If only the inside of the part is to be examined, the diameter shall be the greatest distance between two points, 180 degrees apart on the inside circumference. Otherwise, the diameter is determined as in 6.3.5.

6.3.6.1 *Centrally Located Conductor*—When the axis of the central conductor is located near the central axis of the part, the same current levels as given in 6.3.5 shall apply.

6.3.6.2 *Offset Central Conductor*—When the conductor that is positioned inside the part is placed against an inside wall of the part, the current levels as given in 6.3.5 shall apply, except that the total diameter shall be the sum of the diameter of the central conductor plus twice the wall thickness of the part. The distance along the part circumference (interior) that may be effectively examined shall be taken as approximately four times the diameter of the central conductor up to 360 degrees provided the presence of suitable fields is verified. The entire circumference shall be examined by rotating the part on the conductor, allowing for approximately a 10 % magnetic field overlap. See Fig. 2 for an illustration.

6.3.7 *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 effective field extends a distance on either side of the coil center approximately equal to the radius of the coil. The actual effective distance must be demonstrated based on the particular part to

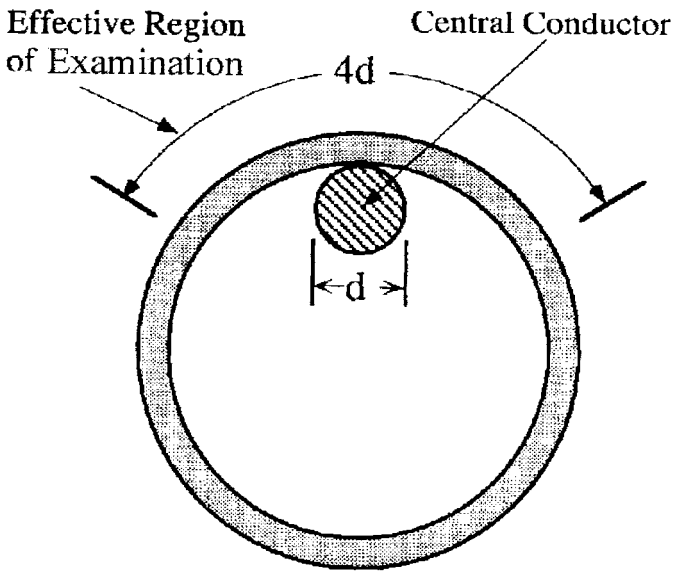


FIG. 2 The Effective Region of Examination When Using an Offset Central Conductor is Equal to Four Times the Diameter of the Conductor as Indicated

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 Appendix X4 for formulas 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, if it interferes with interpretation and evaluation, by means of a dry air current with sufficient force to remove the excess particles, 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 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).

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 or by immersion of the part in the suspension.

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 ½ s for each application, with a minimum of two shots being used. The second shot shall follow the first in rapid succession. It should come after the flow of suspension has been interrupted and before the part is examined for indications.

6.4.2.3 Under special circumstances, such as the use of automated equipment or for critical parts, the ½ s 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 hence care must be exercised to prevent high-velocity flow over critical surfaces.

6.4.3 *Residual Magnetization Method*— In the residual magnetization method, the magnetic particles are applied to the part under examination immediately after the magnetizing force has been discontinued. The residual method is not as sensitive as the continuous method. It can be useful, for example, in detecting service induced fatigue cracks on the surface of 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.