Designation: A275/A275M − 23

Standard Practice for Magnetic Particle Examination of Steel Forgings[1]

This standard is issued under the fixed designation A275/A275M; 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.

1. Scope*

1.1 This practice[2] covers a procedure for magnetic particle examination of steel forgings. The procedure will produce consistent results upon which acceptance standards can be based. This practice does not contain acceptance standards or recommended quality levels.

1.2 Only direct current or rectified alternating (full or half wave) current shall be used as the electric power source for any of the magnetizing methods. Alternating current is not permitted because its capability to detect subsurface discontinuities is very limited and therefore unsuitable.

1.2.1 Portable battery powered electromagnetic yokes are outside the scope of this practice.

NOTE 1—Guide E709 may be utilized for magnetic particle examination in the field for machinery components originally manufactured from steel forgings.

1.3 The minimum requirements for magnetic particle examination shall conform to practice standards of Practice E1444/E1444M. If the requirements of this practice are in conflict with the requirements of Practice E1444/E1444M, the requirements of this practice shall prevail.

1.4 This practice and the applicable material specifications are expressed in both inch-pound units and SI units. However, unless the order specifies the applicable "M" specification designation [SI units], the material shall be furnished to inch-pound units.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

A508/A508M Specification for Quenched and Tempered Vacuum-Treated Carbon and Alloy Steel Forgings for Pressure Vessels

A788/A788M Specification for Steel Forgings, General Requirements

E165/E165M Practice for Liquid Penetrant Testing for General Industry

E709 Guide for Magnetic Particle Testing

E1316 Terminology for Nondestructive Examinations

E1351 Practice for Production and Evaluation of Field Metallographic Replicas

E1444/E1444M Practice for Magnetic Particle Testing for Aerospace

2.2 *Other Document:*[4]

Recommended Practice No. SNT-TC-1A, Supplement B-Magnetic Particle Method

3. Terminology

3.1 *Definitions of Terms*—For definitions of terms used in this standard that are not included in 3.2, refer to Terminology E1316.

3.2 *Definitions:*

[1] This practice is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.06 on Steel Forgings and Billets.

Current edition approved Nov. 1, 2023. Published November 2023. Originally approved in 1944. Last previous edition approved in 2023 as A275/A275M – 18 (2023). DOI: 10.1520/A0275_A0275M-23.

[2] For *ASME Boiler and Pressure Vessel Code* applications see related Method SA-275/SA-275M in Section II of that Code.

[3] 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.

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

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

3.2.1 *indication, n*—the visual magnetic particle buildup resulting from leakage fields in the magnetic field.

3.2.2 *linear indication, n*—an indication in which the length is at least three times the width. The minimum length of indications to be considered linear shall be 1⁄16 in. [1.6 mm].

3.2.3 *magnetic flux, n*—the product of the magnetic induction and the area of a surface (or cross section) when the magnetic induction is uniformly distributed and normal to the plane of the surface. The concept that the magnetic field is flowing along the lines of force suggests that these lines are therefore "flux" lines, and they are called magnetic flux.

3.2.4 *magnetic particle method of examination, n*—a method for detecting discontinuities on or near the surface in suitably magnetized materials, which employs finely divided magnetic particles that tend to congregate in regions of leakage fields.

3.2.5 *nonrelevant indications, n*—indications produced by leakage fields; however, the conditions causing them are present by design or accident, or other features of the part having no relation to the damaging flaws being sought. The term signifies that such an indication has no relation to the discontinuities that might constitute defects.

4. Significance and Use

4.1 For ferromagnetic materials, magnetic particle examination is widely specified for the detection of surface and near surface discontinuities such as cracks, laps, seams, and linearly oriented nonmetallic inclusions. Such examinations are included as mandatory requirements in some forging standards such as Specification A508/A508M.

4.2 Use of direct current or rectified alternating (full or half wave) current as the power source for magnetic particle examination allows detection of subsurface discontinuities.

5. Basis of Application

5.1 When in accordance with the requirements of the inquiry, contract, order, or specifications, forgings are furnished subject to magnetic particle examination. The manufacturer and the purchaser shall be in agreement concerning the following:

5.1.1 The locations on the forgings that are to be subjected to magnetic particle examination.

5.1.2 The type, size, number, location, and orientation of indications that are to be considered injurious.

5.1.3 The method of application of magnetic particles, demagnetization requirements and magnetic field strengths.

5.2 In cases where large undercuts in the forgings are to be taken by the purchaser, the manufacturer shall be given the privilege (when the design permits) of machining slots or grooves in the rough-machined forging to explore the internal conditions prior to shipping.

5.3 Acceptance standards.

6. Personnel Requirements

6.1 Personnel performing the magnetic particle examination to this practice shall be qualified and certified in accordance with a written procedure conforming to Recommended Practice No. SNT-TC-1A or another national standard that is acceptable to both the purchaser and the supplier.

7. Stage of Inspection

7.1 Unless otherwise specified by the purchaser, acceptance inspection shall be performed on a forging in the final machined surface condition and final thermally treated condition (including stress relief) or within 0.030 in. [0.8 mm] of the final machined surface.

8. Magnetizing Apparatus

8.1 Rectified alternating (full or half wave) or direct-current electric power sources may be used. When current is passed through the part itself, the equipment shall consist of contacting or clamping elements with sufficient surface area and clamping pressure to allow the required current to flow without damaging (burning) the part being examined.

8.2 Portable electromagnetic (ac-dc) yokes may be used in the dc mode as a magnetizing apparatus, provided the sensitivity to detect crack-like defects is demonstrated to be at least equivalent to that of the direct-magnetization method.

8.2.1 Portable battery powered electromagnetic yokes are not included in the scope of this practice.

9. Magnetic Particles

9.1 The inspection medium shall consist of finely divided ferromagnetic particles, which may be suspended in a suitable liquid medium, or used in dry powder form.

9.2 The size and shape of the particles, and their magnetic properties, both individually and collectively, are important (see Section 12).

10. Surface Preparation

10.1 The sensitivity of the magnetic particle examination will depend to a considerable extent upon the condition of the surface being tested. Defects may be satisfactorily revealed on shot-blasted or otherwise cleaned forged surfaces, or on surfaces having small amounts of heat-treating scale without any special surface preparation; however, loose scale must be removed. To reveal fine defects, the surfaces to be inspected should be smooth machined to at least a 250 µin. [6.35 µm] finish where the definition for surface finish is in accordance with Specification A788/A788M.

10.2 The surfaces shall be free of grease, oils, or other substances to which the particles may adhere.

10.3 Rough surfaces hamper the mobility of magnetic powders due to mechanical trapping, which in turn produces false indications. Such areas should be surface ground. If grinding is impractical, a paper tape overlay (as described in 15.1.1.2) may eliminate the problem.

11. Methods of Magnetization

11.1 The forging may be magnetized either by passing current through the piece or by inducing a magnetic field by means of a central conductor or by coils.

11.1.1 *Continuous Method*—In the continuous method, the inspection medium is applied to the surface under inspection while the current is still flowing. The current source generates high amperage current in pulses of up to 1 s duration. The duration of this flow shall allow at least three pulses of current or in the case where machines supply continuous current flow a minimum shot of ⅕ s to ½ s duration should be applied.

11.1.2 *Surge Method*—In the surge method a high-magnetizing force is applied and then reduced to a lower continuous value, which is maintained during application of the inspection medium.

11.2 At least two separate examinations shall be carried out on each area. The second examination shall be with the lines of magnetic flux approximately perpendicular to those used for the first examination in that area. A different means of magnetizing may be used for the second examination. Magnetizing in more than one direction cannot be accomplished simultaneously.

NOTE 2—An exception to the above rule is overall sequential multivector magnetization whereby several magnetizing circuits are provided for sequentially magnetizing a part in multiple directions depending upon the locations of the current connectors. By this technique, flaws of any orientation can be detected with a single application of magnetic particles.

11.3 The two general types of magnetization with regard to direction are longitudinal and circular, as follows:

11.3.1 *Longitudinal*—When a forging is magnetized longitudinally, the magnetic flux lines are usually parallel to the axis of the piece. A longitudinally magnetized piece always has definite poles readily detectable by compass or magnetometer. Longitudinal magnetization is usually accomplished by placing the forging within a solenoid, often formed by wrapping cable around the piece (Fig. 1). For special applications, magnetic yokes can be used (Fig. 2) when requirements of 8.2 are met.

11.3.2 *Circular*—Circular magnetization is obtained by passing a current directly through the piece (Fig. 3), or induced through a conductor (Fig. 4), or conductors threaded (Fig. 5) through an opening in the piece. Localized circular magnetization may be obtained by passing current through the local areas by use of prod-type contacts (Fig. 6).

11.4 The magnetic field is confined almost entirely to the piece and there may be no external manifestation of the magnetized condition. Indications will appear strongest in the direction perpendicular to the direction of the magnetic field.

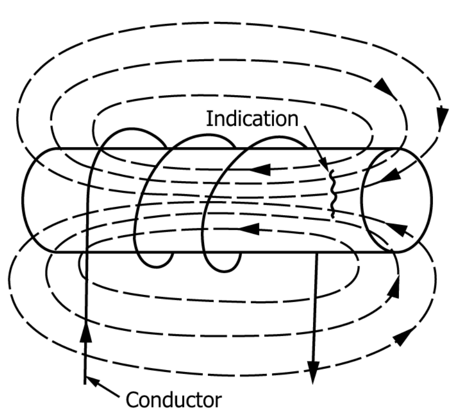

FIG. 1 Longitudinal Magnetization

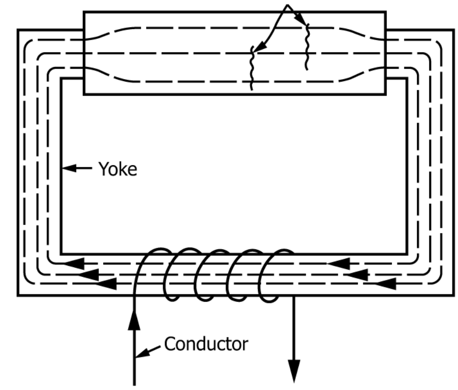

FIG. 2 Longitudinal Magnetization, with Yoke

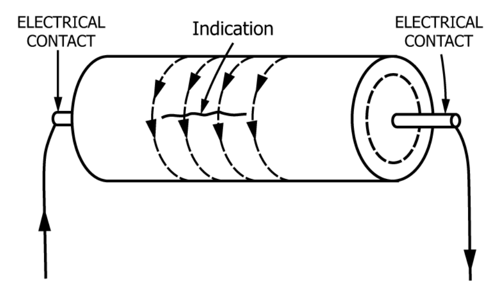

FIG. 3 Circular Magnetization, Current Directly Through Forging

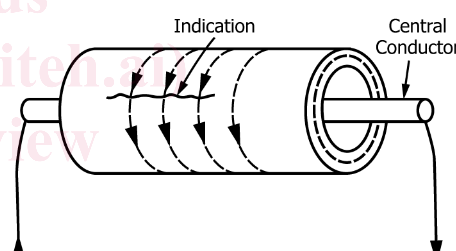

FIG. 4 Circular Magnetization, Current Through a Conductor

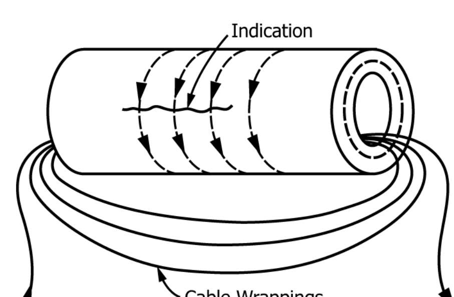

FIG. 5 Circular Magnetization, Current Through Conductors Threaded Through Forging

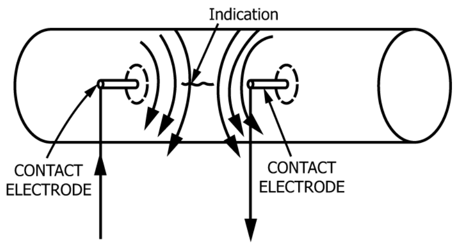

FIG. 6 Circular Magnetization with "Prod" Type Contact Electrodes

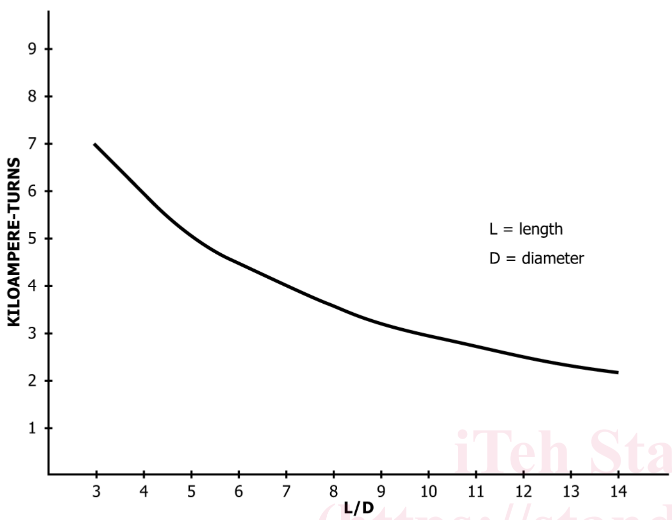

FIG. 7 Longitudinal Magnetization

11.5 *Field Strength*—The minimum field strength that will reveal and permit classification of all objectionable defects shall be used. The maximum field strengths practical are the ones just below the point at which excessive adherence of the particles begins to occur over the surface being inspected.

11.5.1 *Coil Magnetization*—When coil magnetization is used, the magnetic field strength is directly proportional to the current (ampere-turns if a coil or solenoid is used) and inversely proportional to the thickness of the section being inspected.

11.5.1.1 *Longitudinal Magnetization*—For encircling coils (Fig. 1), the turns of the coil shall be kept closely together. The field strength decreases as distance from the coil increases and long parts must be magnetized in sections. If the area to be inspected extends beyond 6 in. [150 mm] on either side of the coils, the adequacy of the field shall be demonstrated by the use of field indicators (see 11.5.6).

(1) Small Forgings—Magnetizing force shall be 35 000 ampere-turns divided by the sum of 2 plus the "length over diameter" ratio of the test part. For example, a part 10 in. [250 mm] long by 2 in. [50 mm] in outside diameter has an *L/D* ratio of 5. Therefore, 35 000⁄(2 + 5) = 5000 ampere-turns; if a 5 turn coil is used, the current required is 5000/5 or 1000 A. This formula provides an adequate field strength on small parts having an *L/D* ratio of 4 or greater. For parts having a smaller *L/D* ratio, adequate field strengths shall be demonstrated by the use of a field indicator (see 11.5.6). The graph in Fig. 7 may be used to determine the ampere-turns required for each *L/D* relationship.

(2) Large Forgings—For large forgings the magnetizing force shall be in the range from 1200 ampere-turns to 4500 ampere-turns. A field indicator (see 11.5.6) shall be used to demonstrate the presence of an adequate field strength over the area to be inspected.

11.5.1.2 *Circular Magnetization* (Fig. 5)—For circular magnetization with through coils, use the current with amperage as specified in 11.5.2 divided by the number of turns in the coil.

11.5.2 *Direct Magnetization*—When current is passed directly through the part to be examined, the current shall be between 100 A per inch and 900 A per inch [4 A per millimetre and 35 A per millimetre] of diameter or cross section (per inch or millimetre of greatest width in a plane at right angles to current flow). For hollow parts this would be wall thickness when cables are clamped to the wall. Suggested current for diameters or sections up to 5 in. [125 mm] are 600 A per inch to 900 A per inch [25 A per millimetre to 35 A per millimetre]; for diameters or sections between 5 in. and 10 in. [125 mm to 250 mm], 400 A per inch to 600 A per inch [15 A per millimetre to 25 A per millimetre]; and 100 A per inch to 400 A per inch [4 A per millimetre to 15 A per millimetre] for outside diameters or sections over 10 in. [250 mm]. If it is not practical to obtain these current levels for diameters over 10 in. [250 mm], the presence of an adequate field strength shall be demonstrated using a field indicator. In all other instances the adequacy of the magnetizing force shall be demonstrated by means of a field indicator (see 11.5.6). When large parts have been examined by clamping contacts to the wall thickness the adequacy of the field in the circumferential direction shall also be determined by the field indicator.

11.5.3 *Prod Magnetization*—When prods are used to circularly magnetize a local area, the field strength is directly proportional to the amperage used but also varies with the prod spacing and thickness of section being inspected.

11.5.3.1 A magnetizing force of 75 A per linear inch to 100 A per linear inch [3 A per millimetre to 4 A per millimetre] of prod spacing shall be used for material under ¾ in. [20 mm] thick, and 100 A per linear inch to 125 A per linear inch [4 A per millimetre to 5 A per millimetre] of prod spacing shall be used for material ¾ in. [20 mm] and over in thickness.

11.5.3.2 Prod spacing shall be a maximum of 8 in. [200 mm]. Prod spacing less than 3 in. [75 mm] usually is not feasible due to banding of the particles around the prods. Care shall be taken to prevent local overheating or burning of the surface being examined. Steel- or aluminum-tipped prods or copper-brush-type prods rather than solid copper-tipped prods are recommended where the magnetizing voltage is over 25 V open circuit (bad contact) in order to avoid copper penetration. Permanent magnetic leeches may be used as a pair or in conjunction with a prod. Leeches should not be used in excess of 1500 A because loss of magnetization occurs.