Designation: A966/A966M – 15 (Reapproved 2020)

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

This standard is issued under the fixed designation A966/A966M; 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.

1. Scope*

1.1 This practice covers a procedure for the magnetic particle examination of steel forgings using alternating current as the power source. The procedure will produce consistent results upon which acceptance standards can be based. This practice does not contain acceptance limits or recommended quality levels.

1.2 Only alternating 50–60 cycle current shall be used as the electric power source for any of the magnetizing methods.

1.3 When subsurface indications are sought in forgings, then dc magnetization in accordance with Practice A275/A275M should be used.

1.4 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. 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. Unless the order specifies the applicable "M" specification designation [SI units], the inch-pound units shall be used.

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

1.6 *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:*[2]

A275/A275M Practice for Magnetic Particle Examination of Steel Forgings

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

A963/A963M Specification for Deep Drawing Steel (DDS), Sheet, Carbon, Cold-Rolled (Withdrawn 2000)[3]

2.2 *Other Document:*[4]

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

3. Terminology

3.1 *Definitions:*

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

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

3.1.3 *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. [1.5 mm].

3.1.4 *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.

3.1.4.1 *Discussion*—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.

[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.

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[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] The last approved version of this historical standard is referenced on www.astm.org.

[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

3.1.5 *nonrelevant indications, n*—indications produced by leakage fields where the conditions causing them are present by accident or part design, or other features of the part having no relation to the damaging flaws being sought.

3.1.5.1 *Discussion*—This term signifies that such an indication has no relation to the discontinuities that might constitute defects.

4. Basis of Application

4.1 When in accordance with the requirements of the inquiry, contract, order, or specifications, forgings are to be examined by the magnetic particle method using alternating current; the manufacturer and the supplier shall be in agreement concerning the following:

4.1.1 The locations on the forging that are to be subjected to magnetic particle examination.

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

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

4.1.4 Acceptance standards.

5. Significance and Use

5.1 For ferromagnetic materials, magnetic particle examination is widely specified for the detection of surface and near-surface flaws such as cracks, laps, seams, and linearly oriented nonmetallic inclusions. Such examinations are included as mandatory requirements in some forging standards such as Specifications A508/A508M and A963/A963M.

5.2 Use of alternating current as the power source for magnetic particle examination imposes a significant restriction on the detection of subsurface indications, so that the procedure is essentially limited to the finding of flaws that are open to the surface. Attention therefore is drawn to the need to have the component in the finish-machined condition before conducting the magnetic particle examination.

5.3 The presence of residual magnetic fields in a component may be undesirable, and an advantage of the use of an ac power source for magnetic particle examination is that an acceptable level of demagnetization can be readily achieved.

6. Personnel Requirements

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

7. Stage of Examination

7.1 Unless otherwise specified by the purchaser, acceptance examination shall be performed on a forging in the final machined surface condition.

8. Magnetizing Apparatus

8.1 A 50 or 60 cycle alternating current shall be used. When current is passed through the forging 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 alternating current yokes may be used as a magnetizing apparatus.

9. Magnetic Particles

9.1 The inspection medium shall consist of finely divided ferromagnetic particles (which may be coated with a fluorescent material) suspended in a suitable liquid medium or used in dry powder form.

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 examined. While defects may be satisfactorily revealed on shot-blasted or otherwise cleaned forged surfaces, without any further surface treatment, all heat treatment or forging scale must be removed. However, to reveal fine defects of ⅛ in. [3 mm] or less in length, the surfaces to be examined shall be smooth machined to at least a 250 µin. [6.35 µm] finish where the definition for surface finish is as per Specification A788/A788M.

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

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, by coils, or by yoke.

11.1.1 *Continuous Method*—In the continuous method the inspection medium is applied to the surface under examination while the current is still flowing. The alternating 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 to ½ s duration should be applied.

11.1.2 The surge and residual methods are not applicable to this practice.

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 magnetization may be used for the second examination. Magnetizing in more than one direction cannot normally be accomplished simultaneously. 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 on the locations of the current connectors. By this technique, indications 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, frequently formed by wrapping cable around the piece (Fig. 1). For special applications, magnetic yokes can be used (Fig. 2).

11.3.2 *Circular*—Circular magnetization is obtained by passing a current through the piece (Fig. 3) or by induced by passing current through a conductor or conductors threaded through an opening in the piece (Fig. 4 or Fig. 5). By agreement with the purchaser (see 11.5.3) localized circular magnetization may be obtained by passing current through local areas by the 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.

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.

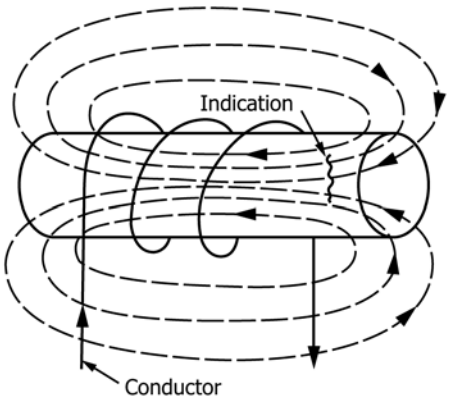

FIG. 1 Longitudinal Magnetization

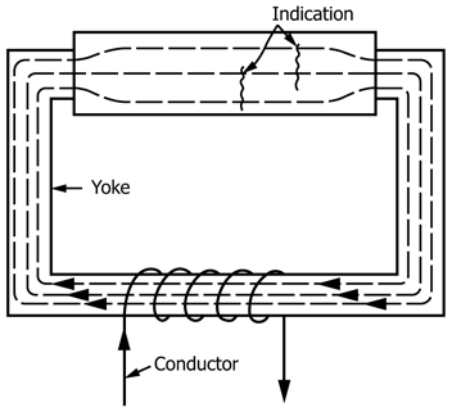

FIG. 2 Longitudinal Magnetization, with Yoke

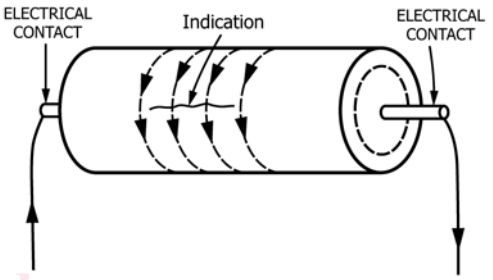

FIG. 3 Circular Magnetization, Current Directly Through Forging

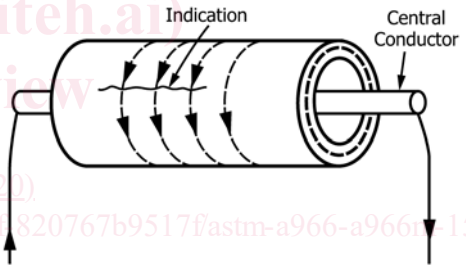

FIG. 4 Circular Magnetization, Current Through a Conductor

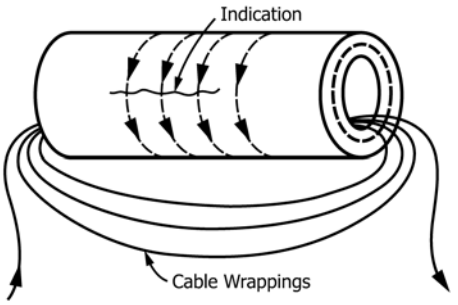

FIG. 5 Circular Magnetization, Current Through Conductors Threaded Through Forging

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.