



Standard Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current¹

This standard is issued under the fixed designation A 966/A 966M; 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 test method 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 test method 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. The ability to detect subsurface discontinuities is very limited when using an alternating power source, and therefore the test surfaces should be in the final thermally treated and finish machined condition.

1.3 When subsurface indications are sought in forgings, then dc magnetization in accordance with Test Method A 275/A 275M 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 exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings²

2.2 Other Document:

Practice No. SNT-TC-1A, Supplement B—Magnetic Particle Method³

3. Terminology

3.1 Definitions:

3.1.1 *(ac) magnetic particle method of examination*—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*—the visual magnetic particle buildup resulting from leakage fields in the magnetic field.

3.1.3 *linear indication*—an indication in which the length is at least three times the width. The minimum length of indications to be considered linear shall be $\frac{1}{16}$ in. [1.5 mm].

3.1.4 *magnetic flux*—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.

3.1.5 *nonrelevant indications*—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. 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.

¹ This test method is under the jurisdiction of ASTM Committee A-1 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 *Annual Book of ASTM Standards*, Vol 01.05.

³ Available from American Society for NonDestructive Testing, 1711 Arlington Lane, P.O. Box 28518, Columbus, OH 43228-0518.

5. Personnel Requirements

5.1 Personnel performing the magnetic particle examination in this test method 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.

6. Stage of Examination

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

7. Magnetizing Apparatus

7.1 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.

7.2 Portable electromagnetic alternating current yokes may be used as a magnetizing apparatus.

8. Magnetic Particles

8.1 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.

9. Surface Preparation

9.1 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 1/8 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.

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

10. Methods of Magnetization

10.1 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.

10.1.1 *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 1/5 to 1/2 s duration should be applied.

10.1.2 The surge and residual methods are not applicable to this test method.

10.2 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.

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

10.3.1 *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).

10.3.2 *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 10.5.3) localized circular magnetization may be obtained by passing current through local areas by the use of prod-type contacts (Fig. 6).

10.4 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.

10.5 *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.

10.5.1 *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.

10.5.1.1 *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

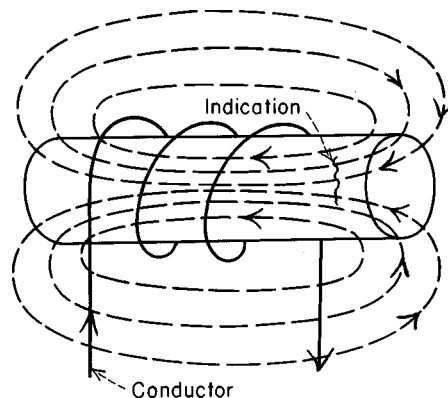


FIG. 1 Longitudinal Magnetization

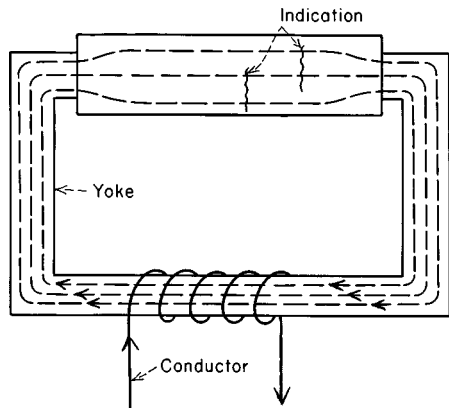


FIG. 2 Longitudinal Magnetization, with Yoke

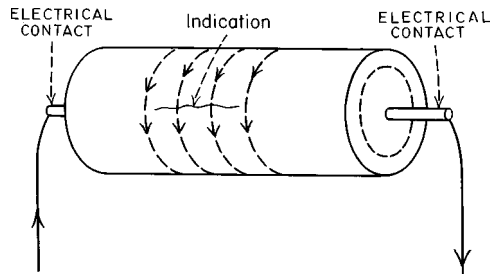


FIG. 3 Circular Magnetization, Current Directly Through Forging

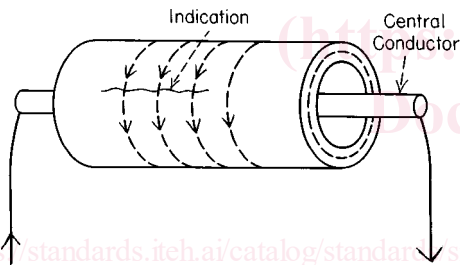


FIG. 4 Circular Magnetization, Current Through a Conductor

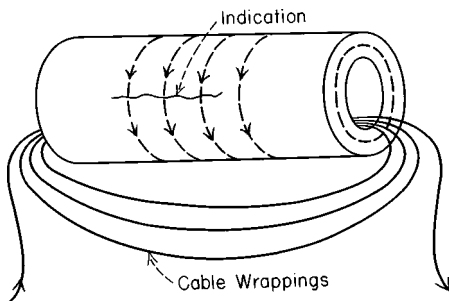


FIG. 5 Circular Magnetization, Current Through Conductors Threaded Through Forging

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 10.5.6).

(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

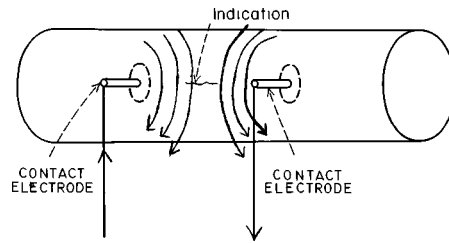


FIG. 6 Circular Magnetization with “Prod” Type Contact Electrodes

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 10.5.6). 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 to 4500 ampere-turns. A field indicator (see 10.5.6) shall be used to demonstrate the presence of an adequate field strength over the area to be inspected.

10.5.1.2 *Circular Magnetization* (Fig. 5)—For circular magnetization with through coils, use the current with amperage as specified in 10.5.2 divided by the number of turns in the coil.

10.5.2 *Direct Magnetization*—When current is passed directly through the part to be examined, the current shall be between 100 and 900 A [4 and 35 A per millimetre] per inch 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 to 900 A/inches [25 to 35 A per millimetre]; for diameters or sections between 5 and 10 in. [125 to 250 mm], 400 to 600 A/inches [15 to 25 A per millimetre]; and 100 to 400 A/inches [4 to 15 A per millimetre] for outside diameters or sections over 10 in. [250 mm]. If it is not practical to obtain

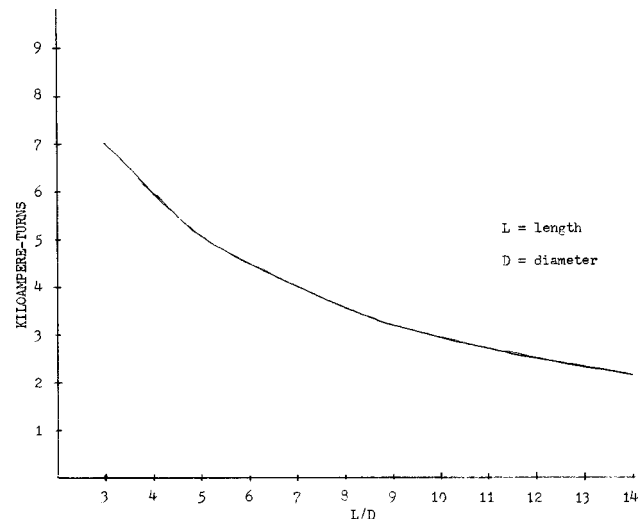


FIG. 7 Longitudinal Magnetization