



Designation: A 275/A 275M – 98

## Standard Test Method for Magnetic Particle Examination of Steel Forgings<sup>1</sup>

This standard is issued under the fixed designation A 275/A 275M; 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 ( $\epsilon$ ) 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 test method<sup>2</sup> provides a procedure for magnetic particle examination of steel forgings. The procedure will produce consistent results upon which acceptance standards can be based. This standard 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.

NOTE 1—Guide E 709E 709 may be utilized for magnetic particle examination in the field for machinery components originally manufactured from steel forgings.

1.3 The values stated in either inch-pound or SI units are to be regarded 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 must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.4 This specification 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 minimum requirements for magnetic particle examination shall conform to practice standards of Practice E 1444E 1444. If the requirements of this test method are in conflict with the requirements of Practice E 1444E 1444, the requirements of this test method shall prevail.

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

<sup>1</sup> 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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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Method SA-275/SA-275M in Section II of that Code.

### 2. Referenced Documents

2.1 *ASTM Standards:*

E 709 Guide for Magnetic Particle Examination<sup>3</sup>

E 1444 Practice for Magnetic Particle Examination<sup>3</sup>

2.2 *Other Document:*

Recommended Practice No. SNT-TC-1A, Supplement B-Magnetic Particle Method<sup>4</sup>

### 3. Terminology

3.1 *Definitions:*

3.1.1 *indication*—the visual magnetic particle buildup resulting from leakage fields in the magnetic field.

3.1.2 *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. [1.6 mm].

3.1.3 *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.

3.1.4 *magnetic particle method of examination*—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.

3.1.5 *nonrelevant indications*—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. Basis of Application

4.1 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:

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 03.03.

<sup>4</sup> Available from American Society for Nondestructive Testing, 4153 Arlington Plaza, Caller #28515, Columbus, OH 43228-0518.

4.1.1 The locations on the forgings 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 of magnetic particles, demagnetization requirements and magnetic field strengths.

4.2 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.

4.3 Acceptance standards.

## 5. Personnel Requirements

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

## 6. Stage of Inspection

6.1 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.

## 7. Magnetizing Apparatus

7.1 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.

7.2 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. Magnetic Particles

8.1 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.

8.2 The size and shape of the particles, and their magnetic properties, both individually and collectively, are important (see Section 11).

## 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 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- $\mu$ in. [6.35- $\mu$ m] finish.

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

9.3 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 14.1.1.2) may eliminate the problem.

## 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 or by coils.

10.1.1 *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  $\frac{1}{5}$  to  $\frac{1}{2}$ -s duration should be applied.

10.1.2 *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.

10.1.3 *Residual Method*—In the residual method the inspection medium is applied to the surface under inspection after the magnetizing current has ceased to flow. The effectiveness of this method depends upon the strength of the magnetizing force and the retentivity of the piece, which in turn depends upon such factors as chemical composition, heat treatment, etc. The residual method is not acceptable for forgings being inspected to comply with some regulatory bodies; it shall be used, therefore, only when approved by the purchaser.

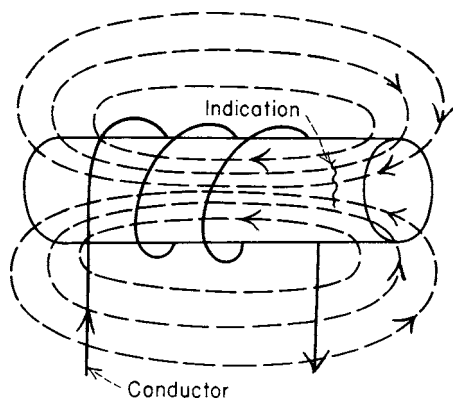
10.2 At least two separate examinations shall be carried out on each area. The second examination shall be with the lines of magnetic flux approximately perpendicular to those used for the first examination in that area. A different means of magnetizing may be used for the second examination. Magnetizing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

NOTE 2—An exception to the above rule is overall sequential multi-vector 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.

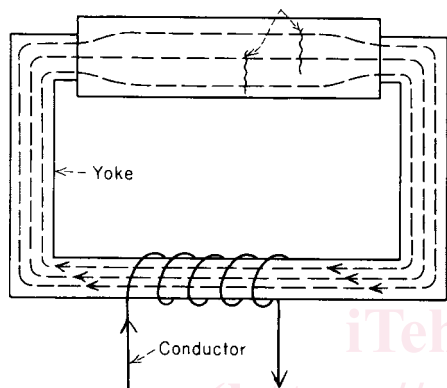
10.3 The two general types of magnetization with regard to direction are longitudinal and circular, as follows:

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, often formed by wrapping cable around the piece (Fig. 1). For special applications, magnetic yokes can be used (Fig. 2) when requirements of 7.2 are met.

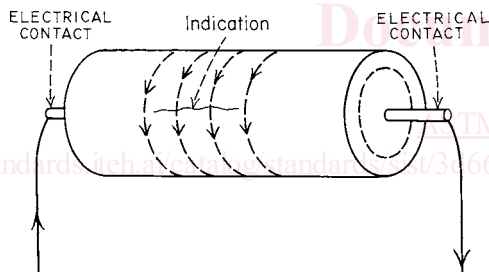
10.3.2 *Circular*—Circular magnetization is obtained by passing a current directly through the piece (Fig. 3), or induced through a conductor (Fig. 4), or conductors threaded (Fig. 5) through an opening in the piece. Localized circular magnetization may be obtained by passing current through the local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



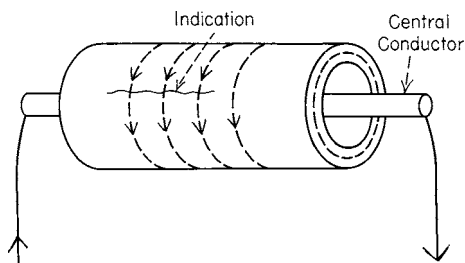
**FIG. 1 Longitudinal Magnetization**



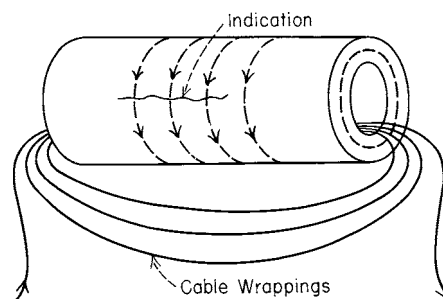
**FIG. 2 Longitudinal Magnetization, with Yoke**



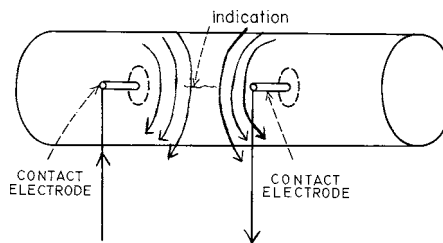
**FIG. 3 Circular Magnetization, Current Directly Through Forging**



**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**

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 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 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.

10.4 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