

MAGNETIC PARTICLE INSPECTION

1. SCOPE:

1.1 Purpose: This specification covers procedures for wet and dry methods of magnetic particle inspection.

1.2 Application: Primarily for detecting the presence of small grinding or quenching cracks, seams, nonmetallic inclusions, and other imperfections on and immediately below the surface of magnetizable materials.

1.2.1 When AMS 2640 appears on the drawing or is required by written instructions, magnetic particle inspection shall be performed on parts which have been heat treated to the final condition and whose surfaces have been finished machined. If surface treatments are to be applied, an inspection may be performed before such treatments. If surface treatments are of the type which may cause cracks, then an inspection shall be performed after such treatments, using a magnetic substance with a suitable color. This paragraph shall not be interpreted as prohibiting additional magnetic particle inspections during manufacture of parts.

1.2.2 Either fluorescent or nonfluorescent magnetic particle inspection may be used unless one or the other is specifically called for on the drawing or in other inspection procedure instructions.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

AMS 3160 - Solvent, Petroleum

AMS 3161 - Oil, Inspection, Odorless, Heavy Solvent

SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade or their use by governmental agencies is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

AMS 2640J

- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D96 - Water and Sediment in Crude Oils

- 2.3 ASNT Publications: Available from American Society for Nondestructive Testing, 3200 Riverside Drive, P.O. Box 5642, Columbus, OH 43221.

ASNT-TC-1A - Recommended Practice, Personnel Qualification and Certification in Nondestructive Testing

3. TECHNICAL REQUIREMENTS:

- 3.1 Qualification of Personnel: Interpretation of the indications revealed by this inspection procedure and final disposition of parts shall be the responsibility of only qualified personnel having considerable experience with magnetic particle inspection and nonuniformity of its results. Unless otherwise specified, inspection personnel shall be certified in accordance with ASNT-TC-1A with a minimum classification level of II.

3.2 Process:

- 3.2.1 Wet Method: All materials and parts shall be inspected by the wet method unless the dry method (3.2.2) is specified. Wet method shall use either the continuous or the residual method as warranted by the particular material or part undergoing inspection.

3.2.1.1 Materials and Control:

- 3.2.1.1.1 Liquid Vehicle: Shall be a light petroleum distillate of approximately 3.0 centistokes (36 SUS) viscosity at 100°F (38°C) similar in properties to AMS 3160 or AMS 3161 or shall be water containing a suitable corrosion inhibitor, wetting agents, and defoaming agents.

- 3.2.1.1.2 Magnetic Substance: Shall be suitable for the purpose and in either paste or power form; it shall be capable of being satisfactorily dispersed in the liquid vehicle. The concentration of magnetic substance in the suspension shall conform to 3.2.1.1.3.1 or 3.2.1.1.3.2 as applicable.

- 3.2.1.1.3 Suspension: The viscosity of the petroleum distillate vehicle shall never exceed 5.0 centistokes (42.5 SUS) at operating temperature. Suitable means shall be provided for agitating the suspension. The suspension shall consist of magnetic substance of adequate concentration in the liquid vehicle to produce clear indications of imperfections with the magnetizing procedure, type of magnetic substance, and examining method used.

- 3.2.1.1.3.1 Nonfluorescent Suspension:

- 3.2.1.1.3.1.1 When petroleum distillate is used as the vehicle, a concentration of 1.0 - 1.5 oz by weight of solids per gallon of suspension (7.5 - 11.2 g/L) as applied is recommended for the residual method; a concentration of 1.5 - 2.0 oz by weight of solids per gallon of suspension (11.2 - 15.0 g/L) is recommended for the continuous method.
- 3.2.1.1.3.1.2 When water is used as the vehicle, a concentration of 2.0 - 3.0 oz by weight of solids per gallon of suspension (15.0 - 22.5 g/L) is recommended; a concentration of 0.8 - 1.2 oz by weight of solids per gallon of suspension (6.0 - 9.0 g/L) is recommended when the magnetic substance usually used with petroleum distillate is used with a wetting agent.
- 3.2.1.1.3.2 Fluorescent Suspension: When either petroleum distillate or water is used as the vehicle, a concentration of 0.10 - 0.20 oz by weight of solids per gallon of suspension (0.75 - 1.50 g/L) is recommended.
- 3.2.1.1.4 Test of Suspension: Suspension concentration shall be tested at a maximum of 8 hr intervals when in constant use in order to maintain proper control, determined as in 3.2.1.1.4.1 or by other method approved by purchaser.
- 3.2.1.1.4.1 After not less than 30 min. continuous pump circulation of the suspension, fill a 100 mL cone shaped graduated centrifuge tube, as specified in ASTM D96, to the 100 mL mark with the suspension. Demagnetize the suspension, if considered necessary, and let stand for 30 to 45 min. or until the solid matter has completely settled out. The volume of the settled solids in the tube shall be 1.0 to 2.4 mL for the nonfluorescent paste suspension and 0.1 to 0.5 mL for the fluorescent paste suspension.
- 3.2.1.1.4.1.1 Other methods of test which produce equivalent results may be substituted for the above method.
- 3.2.1.1.4.1.2 Water-base suspensions shall be tested at least weekly to ensure presence of wetting agent by "water break", and corrosion inhibitor by chemical analysis, or other suitable methods.
- 3.2.1.1.5 Renewal of Suspension: A suspension shall be discarded and replaced before the vehicle exceeds a viscosity of 5.0 centistokes (42.5 SUS) at operating temperature or when it becomes discolored by oil or contaminated with lint or other foreign substance to the extent that proper distribution and concentration of the suspension or the intensity, character, or definition of the deposit of the magnetic substance is affected.

AMS 2640J

3.2.1.2 Operation: The suspension shall be applied to the magnetized part by flowing from a hose, pouring, or immersion, either while the magnetizing current is flowing (continuous method) or after the part has been magnetized and the current turned off (residual method).

3.2.2 Dry Method: May be used when permitted by purchaser's Inspection and Engineering Departments for special applications where it might offer certain advantages (See 8.2).

3.2.2.1 Material: The magnetic substance shall be a dry powder providing suitable contrasts for the intended purpose.

3.2.2.2 Operation: The powder shall be sprayed or dusted directly on the part and the part lightly tapped or otherwise vibrated in order to obtain efficient distribution of the powder. Care shall be exercised to avoid excessive use of powder as such use will interfere with effective indication of defects. Care shall be used in removing excess powder to avoid disturbing indications present. The most effective magnetizing method shall be used.

3.3 Procedure:

3.3.1 Magnetic particle inspection shall be performed on a part in such a manner as to ensure satisfactory detection of all imperfections. A complete inspection test shall consist of one or more distinct magnetizing, inspection, and demagnetizing operations so conducted that the lines of force will be approximately at right angles to any discontinuity that may be in the part.

3.3.2 When fluorescent magnetic particle process is used, the parts shall be examined under black light in a darkened area with a maximum ambient white light level of approximately one foot candle. Black light irradiance shall be not less than $800 \mu\text{w}/\text{cm}^2$ at the part surface. It is preferable that equipment used to measure intensity be responsive only to black light in a wave length range of 3200 - 3900 Angstrom units (320 - 390 nm) (See 8.3).

3.3.3 The surfaces of all materials and parts shall be properly cleaned to remove oil, grease, dirt, and other contamination which might interfere with the proper distribution and concentration, or with the intensity, character, or definition of the deposit, of the magnetic substance.

3.3.4 Oil holes and other openings which lead to areas from which the magnetic substance cannot be easily removed should, before the part is magnetized, be plugged with grease or similar nonabrasive material readily soluble in engine oil.

3.3.5 Direct current, as produced by batteries, generators, or rectifiers, shall be used for magnetizing unless alternating current is proven to be satisfactory for specific application.

3.3.6 The magnetic field shall be induced in a part by one or more methods and in various directions. The two methods used to produce such magnetic fields are: (1) Bipolar or Longitudinal, (2) Circular. The longitudinal method is produced by placing a part between the poles of an electromagnet or within a solenoid coil. The circular method is produced by passing a high-amperage, low-voltage current either through the part or through a conductor which might be placed through an opening in the part. The magnetic field shall be of suitable intensity and direction to reveal all indications which might be cause for rejection.

3.3.6.1 Suitable magnetic field strength will normally be achieved with the circular method of magnetization by using a magnetizing current of 800 - 1200 amp per inch (25 mm) of outside diameter for cylindrically shaped parts, or per inch (25 mm) of cross-sectional diagonal perpendicular to the direction of current flow for other shapes.

3.3.6.2 When a solenoid coil is used to produce longitudinal magnetization, suitable field strength will normally be produced by currents calculated in the following manner if the ratio of part length to outside diameter is between 2 and 15. For parts with a cross-sectional area less than 1/10 the area of the coil opening, the part should be placed near the side (or bottom) of the coil and 3.3.6.2.1.1.1 equation should be used.

3.3.6.2.1 If the calculated value of L/D for the part is greater than 15, the value 15 is assigned to L/D for use in the equation.

3.3.6.2.1.1 Low-fill factor coils

3.3.6.2.1.1.1 For parts positioned toward the side of the coil:

$$I = \frac{45,000}{NL/D}$$

3.3.6.2.1.1.2 For parts positioned in the center of the coil:

$$I = \frac{43,000R}{6N (L/D) - 5N}$$

3.3.6.2.1.2 High-fill factor coils (coils formed with cable):

$$I = \frac{35,000}{N (L/D + 2)}$$

where: L = Part length in in. (millimetres). For parts longer than 18 in. (450 mm), L shall be assigned a value of 18 in. (450 mm).

D = Part diameter in in. (millimetres)

R = Coil radius in in. $\frac{\text{(millimetres)}}{25}$

N = Number of turns in the coil

I = Coil current to be used in amperes

- 3.3.7 The magnetic substance shall be applied to the magnetized part by the wet process, unless the dry process has been specifically approved for certain special conditions.
- 3.3.8 The current used for magnetizing should not be such that saturation results. Size and shape of parts under test shall be considered and satisfactory current selected to adequately magnetize various sections of the part. In some cases it may be necessary to magnetize a part by sections to produce the proper flux density and to prevent misinterpretation of the resulting indications. Saturation may be identified by excessive accumulations of magnetic substance at slight changes of section or by pronounced indication of grain flow.
- 3.3.9 It may be feasible to magnetize several parts simultaneously in the same magnetic field. This may be done by placing several parts in a coil in the same position or by means of a conductor placed through a hole in the parts. An example of this method would be placing a number of nuts, washers, etc on a bar conductor.
- 3.3.10 Parts shall be satisfactorily demagnetized after each magnetizing and inspection operation, unless subsequent magnetizations are of sufficient intensity to mask the effects of the preceding magnetizations. Parts shall be satisfactorily demagnetized after the final inspection.
- 3.3.11 The inspected parts shall be cleaned at this or some subsequent stage to remove the retained magnetic substance and any material used to plug oil holes.

4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Acceptance Criteria: Disposition of parts or product containing indications shall be in accordance with purchaser's specified inspection standards or, if no inspection standards have been submitted by purchaser, by purchaser's authorized personnel.