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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2308

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Submitted for recognition as an American National Standard

MAGNETIC RUBBER INSPECTION

1. SCOPE:

1.1 Purpose:

This specification covers the procedural requirements necessary for the performance of magnetic rubber inspection.

1.2 Application:

This procedure has been used typically for detecting the presence of cracks and other imperfections on and immediately below the surface of ferromagnetic material. Magnetic rubber inspection may be applied to raw material, billets, finished and semi-finished materials, welds, and in-service parts. Magnetic rubber inspection is not applicable to non-ferromagnetic metals and alloys.

1.2.1 Magnetic rubber inspection involves the use of a special formulation of magnetic powder in room-temperature curing liquid rubber. The material is poured onto the test part and a magnetic field is applied. This causes the magnetic particles to migrate through the liquid rubber and concentrate at the location of cracks or other discontinuities in the test metal. The rubber is then allowed to cure and the solid cast impression (replica) is removed from the part. An examination at low magnification reveals the location of cracks as dark lines of concentrated powder. Since the rubber has conformed to the exact contour of the test area, the casting also displays surface conditions such as roughness and machining quality.

1.3 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2309 Magnetic Rubber Inspection Material

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification

3. TECHNICAL REQUIREMENTS:

3.1 Material, Equipment, and Supplies:

3.1.1 Material: The magnetic rubber inspection material used in this process shall meet the requirements of AMS 2309.

3.1.2 Equipment:

3.1.2.1 Magnetizing Equipment: All magnetizing apparatus shall be capable of reliably providing uniform, controlled magnetic field strengths as required in the testing of each part. Each magnetizing apparatus shall be capable of inducing in the piece under inspection a magnetic flux of suitable intensity in the desired direction.

3.1.2.1.1 A variable output DC electromagnetic yoke is preferred.

3.1.2.1.2 Stationary or portable prods or coils may be used if such equipment is capable of providing continuous magnetization for not less than 30 seconds.

3.1.2.2 Gauss Meter: A portable gauss meter capable of measuring accurately values up to 100 gauss (0.01T) shall be used to determine proper field strength on surfaces to be inspected. The device shall be equipped with both transverse and axial probes. Dial or similar type meters of suitable range may be used if capable of providing transverse and axial measurements.

3.1.2.3 Microscope: A microscope with 7 to 10X magnification and a high intensity illuminator shall be used to examine the magnetic rubber replica castings for detection of discontinuities as small as 0.13 mm (0.005 inch) in length. Lower power magnifications may be used to detect larger discontinuities if approved by purchaser's specified inspection standards, or if inspection standards have not been submitted, by purchaser's authorized personnel.

3.1.3 Supplies:

3.1.3.1 Measuring and Mixing: Supplies for measuring quantities of magnetic rubber inspection materials and for mixing curing agents include disposable graduated syringes (5 to 100 mL capacities), paper cups, and wooden stirrers (tongue depressors).

3.1.3.2 Damming Materials: Materials to form reservoirs to hold the liquid rubber over the surface to be inspected include sealing putty, nonmagnetic foil or tubing, and mylar or cellophane tape.

3.2 Preparation of Parts for Inspection:

3.2.1 Cleaning: The area to be inspected shall be free from grease, dirt, or other foreign materials which might interfere with the proper distribution of the magnetic particles in the rubber or with the subsequent examination of the replica casting. Cleaning should be performed using a stiff brush, cloth, and a solvent or degreasing agent as applicable which does not damage the material under test. An air jet may be used to remove loose lint.

3.2.2 Coatings: Removal of paint or electroplated coatings is usually unnecessary; however, such coatings should be removed when maximum defect sensitivity is required.

3.2.3 Taping and Damming: It is necessary to form reservoirs to hold the liquid rubber in or on the area to be inspected. Although procedures cannot be provided for all surface geometries, procedures for the most commonly encountered are provided. Other more complicated areas may require the ingenuity of the inspector to design and construct a reservoir.

3.2.3.1 Vertical Holes: Mylar or cellophane tape shall be placed beneath the hole and an aluminum cylinder and a ring of sealing putty is placed above the hole to contain the liquid rubber.

3.2.3.2 Horizontal Holes: Mylar or cellophane tape shall be placed on one side of the hole and an aluminum cup dam sealed on the other side. A small vent hole shall be punched in the tape at the uppermost edge of the hole to release trapped air during the pouring step.

3.2.3.3 Flat Surfaces Facing Upward: Putty or aluminum-sided dams may be used to hold the liquid rubber.

3.2.3.4 Flat Surfaces Facing Downward: "Upside-down" surfaces may be inspected by forming a putty reservoir beneath the test area and pressure filling with the liquid rubber. Entrapped air shall be allowed to escape by placing a small vent hole in the putty next to the inspection area.

3.3 Preparation for Magnetizing:

3.3.1 Selection of Magnetizing Methods: Magnetic fields may be applied 6y using DC current or permanent magnets.

3.3.1.1 Electromagnetic Yokes: These consist of a coil wound around a U-shaped core of soft iron. The legs of the yoke can be either fixed or adjustable. Adjustable legs permit changing the contact spacing and the relative angle of contact to accommodate irregular-shaped parts. In areas of limited accessibility, iron extension pole pieces may be used to direct magnetic fields into the part. The field strength of the yoke is adjustable with a variac with an AC input current and an AC or DC output current. Direct current shall be used unless alternating current is proven to be satisfactory for specific applications.

3.3.1.2 Coils: Single-loop and multiple-loop conductor coils may be wrapped around the inspection area and induce magnetic fields in the part upon flow of DC current. The field strength is adjusted by varying the number of turns of coils or the amperage of the electric current.

3.3.1.3 Central Conductors: Magnetic fields may be induced in a part by passing a wire or cable carrying an electric current through a hole in the part. Direct current, as produced by generators or rectifiers, shall be used unless alternating current is proven to be satisfactory for a specific application.

3.3.1.4 Permanent Magnets: Permanent magnets are useful in certain applications such as bolts, gears, or other parts whose shape make magnetization difficult with an electromagnetic yoke. It is important that the test area be demagnetized prior to using permanent magnets because any residual field in the part may reduce the magnet's effectiveness.

3.3.2 Adjusting Field Strength:

3.3.2.1 Direction of the Magnetic Field: Magnetic fields must be applied so that the magnetic lines of force run approximately perpendicular to the anticipated direction of defects. When the direction of defects is not known, the part must be magnetized in two directions, 90 degrees apart. Both directions of magnetization can be applied sequentially to the same casting of magnetic rubber provided the field strength for each direction is measured and adjusted as in 3.3.2.2. The particles accumulated by the first direction of magnetization will not be disturbed by the second direction of magnetization.

3.3.2.2 Measuring Magnetic Field Strengths: The magnetic field strength should be measured with a gauss meter as described in 3.1.2.2. The field strength should be set to the desired level by adjusting:

a. The variac of the magnet power supply, or
b. The position of the permanent magnet, or
c. The power through magnetizing coils or central conductors.

3.3.2.3 Magnetic Field Strength Requirements: Field strength requirements for various applications are shown in Table 1. These are guidelines only and may be adjusted as necessary to obtain optimum results. Test parts with known cracks are particularly useful for establishing magnetizing methods.

TABLE I - Magnetic Field Strength Requirements

Inspection Area	Field Strength MT	Field Strength Gauss	Duration Seconds
Bare holes	0.3 to 0.7	30 to 70	30
Bare surfaces	0.8 to 1.0	80 to 100	60
Coated surfaces	1.0	100	1 to 10 minutes depending on coating thickness

3.3.2.3.1 The foregoing section relates to setting up and adjusting for magnetizing only. Actual magnetization will be performed following addition of the magnetic rubber inspection material.

3.4 Preparation of Magnetic Rubber Inspection Material:

The material shall be prepared for the inspection, including mixing, measuring, and addition of curing agents in accordance with manufacturer's instructions.

3.5 Pouring Onto Test Area:

The prepared mixture shall be carefully poured into the previously prepared reservoir. A plastic syringe and plastic or rubber tubing may be used to transfer the rubber to difficult to reach areas.

3.6 Magnetizing:

The test area shall be magnetized following procedures selected in 3.3.

3.7 Pot Life:

The pot life is the time from addition of curing agents to the point when the rubber becomes too thick for the magnetic particles to migrate. Thus, magnetization must be completed within that time. The pot life of the magnetic rubber formulation shall be included in the manufacturer's instructions.

3.8 Curing:

The replica castings shall be allowed to cure to a firm, tack-free condition. Approximate cure times shall be provided by the manufacturer.

3.9 Removal of Cured Replicas:

The tape, dams, and putty shall be removed and the cured rubber gently lifted out of the inspection area. When removing from holes, wooden push rods facilitate extraction. If the rubber sticks to the part, additional cure time should be allowed. If the rubber continues to stick, it must be removed (scraped off if necessary) and the inspection repeated after application of teflon-based release agent.

3.9.1 Silicone release agent should not be used.

3.10 Examination of Magnetic Rubber Castings:

3.10.1 Microscopic Examination: A 7 to 10X stereo microscope and a strong illuminator should be used. The casting shall be held in the hands and focusing accomplished by lowering or raising the casting beneath the microscope lens. This allows the inspector to view the casting at various angles and to scan the entire area of interest.

3.10.2 Evaluation of Magnetic Field Strength: The reliability of magnetic rubber inspection is dependent on the application of the proper magnetic field strength. If the magnetic field strength is too low, faint defect indications may not be detected. If the magnetic field strength is too high, defect indications may be hidden in a dark background.

3.10.2.1 Evaluation of Magnetic Field Strength Applied to Holes: The strength of magnetic fields applied to holes are displayed on the casting by a "halo" at the edge of the hole. This halo should be detectable but not excessively dark.

3.10.2.2 Evaluation of Magnetic Field Strength Applied to Gears and Threads: Magnetic field strength is indicated by "halos" at the teeth of the gears or threads. Note that the replica casting is a negative image, the teeth appearing in the casting as valleys and the roots appearing as elevated regions.

3.10.2.3 Evaluation of Magnetic Field Strength Applied to Flat Surfaces: When surfaces are inspected, magnetic field strength is indicated by a darkening in scratches, tool marks, or other areas of roughness.

3.10.3 Defect Indications: Defect indications appear in the magnetic rubber castings as dark lines against the gray or colored background. Indications caused by cracks are distinguished from those caused by scratches or gouges by observing them at different angles of light so that the topography of the surface can be seen. Where scratches or gouges are present, the rubber flows into the depressed area. Crack openings are too narrow for the rubber to enter. Therefore concentrations of magnetic powder where there is no surface depression indicates the presence of cracks.

3.11 Post Inspection Procedures:

3.11.1 Cleaning: After inspection, the test part should be cleaned with a solvent or degreasing agent to remove residual silicones. Where the part is to be replated, repainted, or coated with a sealant or adhesive, cleaning may be important to restore the original adhesive properties of the surface.

3.11.2 Demagnetization: Residual magnetic fields shall be removed with the AC circuit of the electromagnet. Slowly cycling the power output from maximum to minimum several times will remove residual magnetic fields in the test part to an acceptable level.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Qualification of Inspection Personnel:

All personnel performing magnetic rubber inspection shall be qualified and certified in accordance with MIL-STD-410. Personnel initially establishing procedures or training other personnel shall be qualified to a Level III. Personnel examining magnetic rubber replicas for defect indications and making accept/reject decisions shall be qualified to at least a Level II. Personnel performing the processing steps described in this specification shall be qualified to at least a Level I.

4.2 Acceptance Criteria:

Disposition of parts, or of product containing indications, shall be in accordance with purchaser's specified inspection standards or, if inspection standards have not been submitted by purchaser, by purchaser's authorized personnel.

4.2.1 Parts or product having defects detrimental to their strength and serviceability shall be rejected.