PREFERRED RELIABILITY PRACTICES

# MAGNETIC PARTICLE TESTING OF AEROSPACE MATERIALS

**Practice:**

Magnetic Particle Testing can be used on all ferromagnetic materials to locate surface and subsurface discontinuities such as cracks, laps, seams, and inclusions.

**Benefit:**

Magnetic particle testing is a cost effective and expedient nondestructive Testing (NDT) method for determining discontinuities in ferromagnetic material. This NDT method can be performed in both the longitudinal and transverse directions.

**Programs That Certified Usage:**

Saturn I, IB, V, Apollo, Skylab, Space Shuttle Solid Rocket Booster (SRB), Space Shuttle Main Engine (SSME), and other MSFC projects.

**Center to Contact for More Information:**

Marshall Space Flight Center (MSFC)

**Implementation:**

Magnetic particle testing (MPT) is a nondestructive method for locating cracks, laps, seams, inclusions and other discontinuities on or near the surface of ferromagnetic materials. MPT is based on the principle that the magnetic flux near the surface of a magnetized material is distorted locally by the presence of discontinuities. This distortion of the field pattern, or "flux leakage," as illustrated in Figure 1, is capable of attracting and holding an inspection medium of finely divided magnetic particles. Depending upon the type particles used, they will be visible under the proper lighting condition.

Direct current (DC) and alternating current are both suitable for magnetizing parts for MPT. The primary difference between the two currents is: the fields generated by DC penetrate the cross section of the part, and the field generated by the AC are confined to the metal at or near the surface of the part. Therefore, AC should not be used for subsurface discontinuities.

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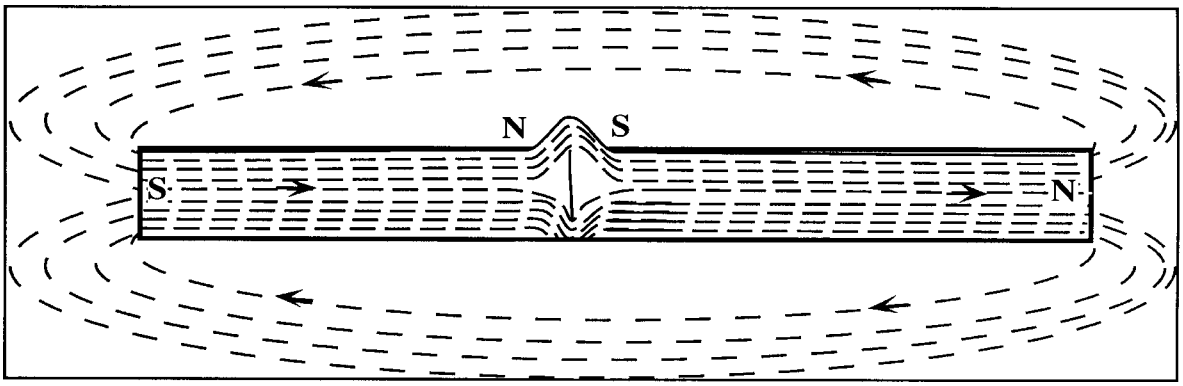


**Figure 1. Leakage Field at a Crack in a Bar Magnet**

The most common magnetization processes are circular and longitudinal. Circular magnetization is when electric current is passed through a straight conductor creating a circular magnetic field around the conductor (see Figure 2a). Longitudinal magnetization is when electric current is passed through a coil of one or more turns a magnetic field is established within the coil (see Figure 2b). To form an indication, the magnetic field must approach a discontinuity at an angle great enough to cause the magnetic field to leave the part and return after bridging the discontinuity. Best results occur when the intersection is 45 degrees to 90 degrees to the magnetic field lines.

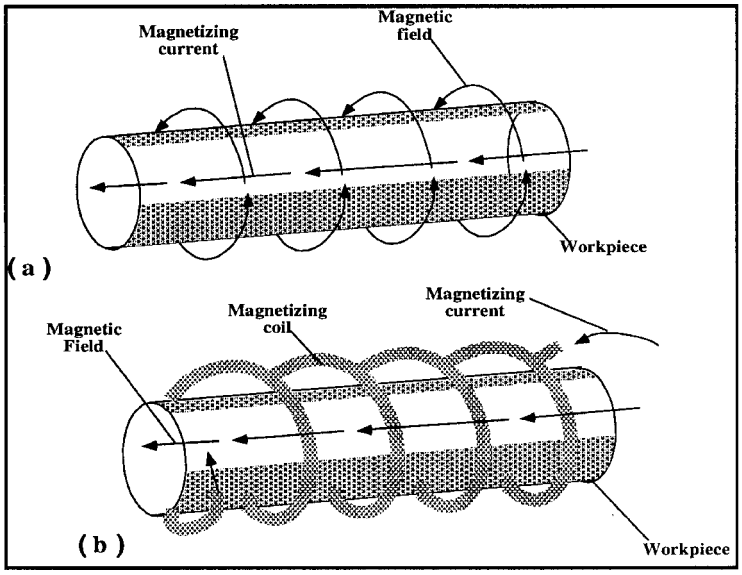


**Figure 2. Magnetized bars showing directions of magnetic field: (a) circular and (b) longitudinal**

Magnetic particles may be applied to surfaces in a dry form or they may be suspended in a water or oil carriers. The particles are usually coated with a fluorescent material for easy visualization using a black light.

When using MPT make sure the induced current is strong enough to produce the magnetic field required to show the flaws being tested for. One fast method to insure adequate current is the use of a “field indicator.” The field indicator consist of a metal disk with cross hatch lines with a thin metal cover attached over the cross hatch disk

mounted on a yoke handle. This field indicator is placed in the magnetic field and the current increased while adding magnetic particles until the magnetic particles form a well-distinguished cross on the metal cover. There are also formulas in the references that can be used to determine the starting current. The current can be adjusted as necessary to obtain the desired magnetic field.

The advantages of using Magnetic Particle Testing are:

1. Complex shapes can be tested.
2. Cracks filled with paint or other foreign material can be detected.
3. Large numbers of similar parts can be rapidly tested/automated.
4. Small fine cracks can be detected.
5. Subsurface discontinuities can be located.
6. Cracks can be located through thin nonmetallic coatings.
7. Estimate crack depth.
8. Easily learned.
9. Relatively low cost.

The disadvantages of magnetic particle testing are:

1. Only ferromagnetic materials can be tested.
2. High electric current required to magnetize.
3. Demagnetization required in some instances.
4. Extreme care to avoid burn spots.
5. Difficult to detect small defects below the surface.
6. Cleaning required after test.
7. Complex shapes may require more than two magnetizations.

All personnel performing MPT should be qualified and certified in accordance with MIL-STD-410E. Detecting discontinuities is relatively simple, but adequate interpretation of the indication requires experience and judgement.

The safe handling of the magnetic particles are governed by the suppliers Material Safety Data Sheet (MSDS). The suppliers MSDS should certify that the flash point of the oil carriers meet the requirements of DOD-F-87935. The MSDS should also detail personnel hazards such as inhalation, skin contact and eye exposure. Magnetizing equipment should be properly maintained to avoid personnel hazards from electrical shorts. Care should also be taken to avoid electrical arcing and possible ignition of the oil carriers. Any broken ultraviolet filters or bulbs should be replaced immediately. Personnel entering a darkened area to perform fluorescent testing should wait at least one minute for their eyes to adjust to the darkened area.

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**Technical Rational:**

MPT is a fast and cost-effective method for determining surface and subsurface defects in ferromagnetic materials. The MPT techniques may be used for in-process inspection and control, final inspection, receiving inspection, and periodic maintenance of machines, structures and handling equipment.

**Impact of Nonpractice:**

Failure to detect defects in surface and subsurface areas of components could result in failure of the components, failure of mission and in extreme cases loss of life.

**References:**

1. Bray, Don E. and Don McBride: "Nondestructive Testing Techniques," John Wiley & Sons, Inc., 1992.

2. McMaster, Robert C.: "Nondestructive Testing Handbook," Volume II, The Ronald Press Company, New York 1963.

3. Metals Handbook, Volume 17: "Nondestructive Inspection and Quality Control," pp. 89-128, ASM International, Metals Park, OH, 1989.

4. MIL-STD-1949A: "Military standard, Magnetic Particle Inspection," May 1989.

5. MIL-STD-1907: "Military Standard, Inspection, Liquid Penetrant and Magnetic Particle, Soundness Requirements for Materials, Parts and Weldments," March 1990.

6. MIL-I-83387: "Military Specification, Magnetic Rubber Inspection Process," July 1987.

7. ASTM E 1444-93: "Standard Practice for Magnetic Particle Examination," American Society for Testing and Materials, 1916 Race St. Philadelphia, PA 18103.

8. MSFC-STD-1249: "Standard NDE Guidelines and Requirements for Fracture Control Programs," Marshall Space Flight Center, AL 35812, September 1985.

9. CT-6-3: "Nondestructive Testing Magnetic Particles," Class Room Training Handbook, Second Edition, Convair Division of General Dynamics, San Diego, CA 1977.

10. P1-4-3: "Nondestructive Testing, Magnetic Particle," Programmed Instruction Handbook, Fourth Edition, Convair Division of General Dynamics, 1977.

11. MIL-STD-410E: "Military Standard, Nondestructive Testing Personnel Qualification and Certification," January 1991.