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MAGNETIC PARTICLE

5.7.1 Introduction

The magnetic particle test (MT) is used for testing ferromagnetic materials (steel, wrought iron, cast iron, etc.). MT is used to confirm suspected cracks or test suspect-details. The primary advantage of MT is the high sensitivity in the detection of tight surface cracks and other small discontinuities. Typical detectable discontinuities include cracks, lack of fusion, and other weld related surface discontinuities. Base metal discontinuities such as seams, laps, and "stringers" are also easily detected.

As defined by American National Standards Institute (ANSI), the magnetic particle method utilizes the principle that magnetic lines of force, when present in a ferromagnetic material, will be distorted by a change in material continuity, such as a sharp dimensional change or a discontinuity. If the discontinuity is open to, or close to, the surface of a magnetized material, flux lines will be distorted at the surface; a condition termed flux leakage. When fine magnetic particles are distributed over the area of the discontinuity where the flux leakage exists, the particles will converge at the discontinuity and the accumulation of particles will be visible for the inspector.

The objective of magnetic particle testing is to cause a magnetic field of sufficient strength and predetermined direction to leak if discontinuities are present. The inspector detects these leaks by sprinkling the test area with particles, blowing away the excess, and then looking for areas where the particles have accumulated. These areas of accumulation indicate a surface or possibly a subsurface discontinuity.

MT methods and implementation procedures are fully described by the following terms:

1. **Dry method:** The dry method describes the type of indicating medium, the particles, as dry. Commercial powders are available in various colors including red, black, grey, or yellow. The color selection should be based on the maximum color contrast with the material to be tested. Refer to Figure 5.7.1-1 for a view of the test powder colors. Dry fluorescent particles are also available for use with a black light. Dry particles are finely divided ferromagnetic material with high permeability and low retentivity. The powder consists of a mixture of particle sizes, smaller ones being attracted by weak leakage fields, and larger ones for detecting larger discontinuities.

Figure 5.7.1-1: Sample Powder Colors.

2. **Wet Method:** If powders or particles are suspended in oil or water, the method is considered wet. Wet suspensions are also available in various colors and fluorescent. They can be sprayed onto the part, or the part can be bathed in a suspension. Wet fluorescent particles provide maximum sensitivity (superior visibility) if used with the proper current, lighting, and surface preparation. Wet particles are mixed with the suspension in predetermined concentrations and particle sizes. The concentration will affect the test sensitivity. Light concentrations will produce faint indications and heavy concentrations may provide too much coverage. They are generally smaller in size and lower in permeability than dry particles.

3. **Continuous Procedure:** This term is used when the magnetizing force is applied prior to the application of the particles and terminated only after excess particles have been lightly blown away.

4. **Residual Procedure:** This term residual is used where the particles are applied after the part has been magnetized, and the magnetizing current terminated.

Field-testing of bridges and related structures use portable units, which include the small portable prod or yoke units with alternating current (AC), half-wave direct current (HWDC) capability. Portable prod equipment is commonly available in amperages up to 1,500. However, it can also be powered from 115-volt single-phase AC. Prods directly induce the electrical current into the part. **The inspector should note that direct current (DC) prods may cause arc strikes and therefore, they should never be used on nonredundant steel tension members (NSTMs).** Refer to Figure 5.7.1.2 for a view of prod equipment. Prods are used with a separate power unit that generates the current for testing. Both prods can be attached to a single fixture, similar to a yoke.

Figure 5.7.1.2: Prods used for MT

Yokes are lightweight portable units easily carried to the job site. On some yokes the legs are fixed at a set distance. On others the legs are adjustable for various pole spacing. Yokes operate with 115 volt AC. The potential for electrical arc strikes is normally not an issue with a yoke, even when used with half-wave direct current (HWDC) current. Refer to Figure 5.7.1-3 for a view of a portable field kit.

This testing method is covered in American Society for Testing and Materials (ASTM) Test E709, “Standard Guide for Magnetic Particle Examination.”

Figure 5.7.1-3: Magnetic Particle Inspection Kit.

5.7.2 Applications

MT is a sensitive means of locating small and shallow surface cracks and can locate near surface discontinuities with direct current. Unlike with liquid penetrant, cracks filled with foreign material can be detected and no elaborate pre-cleaning is necessary. This test is also effective on painted surfaces.

This method is reasonably fast, inexpensive especially compared to some other nondestructive evaluation (NDE) methods, and the equipment is very portable. There is also little or no limitation due to size or shape of the part being inspected. Refer to Figures 5.7.2-1 and 5.7.2-2 for views of magnetic particle tests being performed in the field. Refer to Figure 5.7.2-3 for a view of a crack that was identified using magnetic particle testing.

Figure 5.7.2-1: Yoke MT on a Built-Up Plate Bridge Girder Butt-Weld.

Figure 5.7.2-2: Prod MT on a Sign Structure Base.

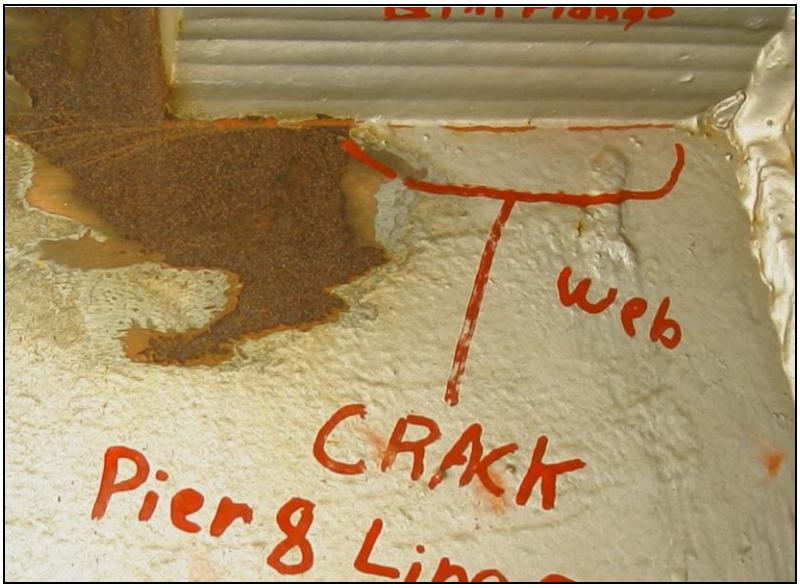

Figure 5.7.2-3: Crack Identified by MT.

5.7.3 Limitations

MT does have some limitations. This test will work only on ferromagnetic material and the magnetic field must be in a direction perpendicular to the principal plane of the discontinuity for best detection. MT will not disclose fine porosity. The deeper the discontinuity lies below the test surface, the larger the discontinuity must be to provide a readable indication.

As previously mentioned, DC prods (not the same as the Half Wave Direct Current (HWDC) yoke) should not be used on NSTM's. Test surfaces should be clean and paint removed for highest sensitivity. Also, residual magnetism may need to be removed. Although the method appears simple, the need for experienced and knowledgeable operators is required.

Permanent magnets can be used in certain applications where the access to 115V AC power is not available or not available for practical access. This method has many limitations. Permanent magnets are only properly used when these limitations preventing the formation of adequate leakage fields at the discontinuities is addressed and accounted for in the test procedure.