National Institute of Standards & Technology

Certificate

Standard Reference Material 1853

Magnetic Particle Test Ring (Individually Calibrated)

Serial No.

This Standard Reference Material (SRM), Magnetic Particle Test Ring, provides a means for obtaining a leakage field of known value. Such a leakage field is useful for verifying the magnetic properties of particles used in Magnetic Particle Inspection (MPI).

The test ring has a series of holes machined at various depths below the surface (see Figure 1). These holes serve as artificial defects which produce leakage fields when the ring is magnetized. The ring is magnetized by a direct current flowing in a conductor placed through the center of the ring (see Figure 2). The current may be adjusted to give a leakage field of a predetermined magnitude.

With a predetermined current flowing through the central conductor, magnetic particles are then applied to determine if they will form an indication. Particles with improper magnetic properties, and/or shape distributions, will require very high currents (i.e. strong leakage fields) to give clear indications on the ring.

The leakage field gradient produced by each defect in the ring for a direct current of 1500 amperes is certified. When testing magnetic particles with this ring, essentially equivalent results will be obtained for either direct current or unfiltered full wave rectified alternating current.

The ring was machined from vacuum arc remelted 52100 steel meeting the requirements of Aerospace Materials Specification AMS 6444G. The lot of material used for this ring had a coercive force of 610 ± 15 A/m (7.7 ± 0.2 Oe), and a hardness of HRB 86 (Rockwell B scale). The microstructure consists essentially of spherodized cementite in a ferrite matrix.

Certification

To certify the ring, the perpendicular component of the leakage field was measured using a Hall probe with a width of 1.5 mm, a length of 2.75 mm and a thickness of 0.1 mm. The probe was centered on the ring with the narrow dimension parallel to the ring axis and with a liftoff of 0.1 mm. The central conductor current was cycled from 0 to 2300 A to 0 and then to 1500 ± 10 A. With 1500 A flowing, the ring was moved in steps of 0.15 mm with a field measurement taken at each step. Following this measurement, the current was reset to 0 and the residual leakage field from the first three holes was measured.

Gaithersburg, MD 20899
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Using the leakage field measurement data, the field gradient derivative, H', at each step was calculated by dividing the difference in field values by the step length. The resulting data was least squares fitted to 3 parameters; A, x_o, and d, for each defect using the formula

$$H' = A[1-3(x-x_o)^2/d^2] / [1+(x-x_o)^2/d^2]^3.$$

H' is the derivative of the perpendicular component of the leakage field in kA/m^2, x is the distance along the ring circumference in cm, A is the peak amplitude of the leakage field gradient, x_o is the location of the defect, and d is a width parameter. Table I, attached, gives the values of A obtained by the above procedure. (The rings are individually calibrated. Check that the serial number listed on Table I and the serial number of the ring agree.)

The overall direction and coordination of the preparation and technical measurements leading to the certification of this SRM were performed by L.J. Swartzendruber and D.E. Mathews of the NIST Metallurgy Division.

The technical and support aspects involved in the certification and issuance of this Standard Reference Material were coordinated through the Standard Reference Materials Program by T.E. Gills.

Instructions for Use

In using the ring to test magnetic particles, the following procedure is recommended:

1. Place a straight piece of conductor with a length of 40 cm (16 inches) or longer (and capable of carrying a current of at least 2300 A for the duration of the test) through the center of the ring with the axis of the conductor parallel to the axis of the ring.

2. Saturate the ring magnetically by applying a central conductor direct current shot of 2300 A or greater. Return the current to zero.

3. Select a test level, A_t, for the leakage field gradient. Using a central conductor current between 1000 and 2000 A, determine the hole number and test current required to obtain A_t. The required test current, I_t, to obtain the leakage field gradient A_t using hole n is given by

   $$I_t = 1500 \cdot A_t/A_n,$$

   where A_n is the certified value of A at 1500 A given in Table I for the n^{th} hole. If the required current is less than 1000 A use a larger n, if it is greater than 2000 A, use a smaller n. The direction of current flow must be in the same direction as that used in step 2 above. This procedure results in a value for A_t accurate to within approximately ±10% plus the uncertainty in the current used.

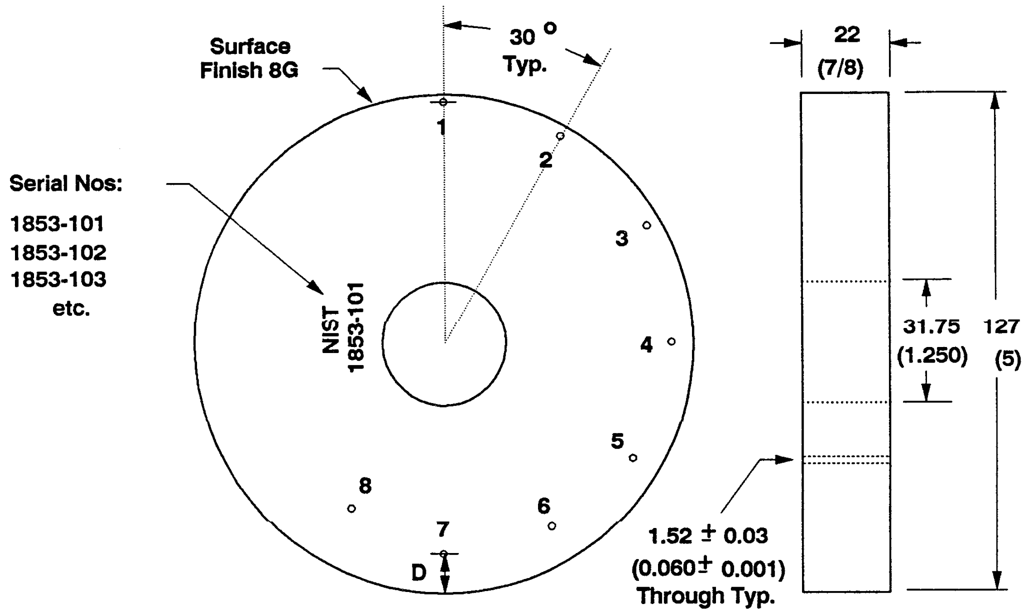
4. Place the hole selected in step 3 above at a specified angle from the vertical. Magnetize the ring by passing the current determined in step 3. Using a suitable applicator, apply the particles or particle suspension to the ring. Examine the ring under suitable lighting conditions for a magnetic particle indication.

Notes:

When using the above procedure, it is not necessary to demagnetize the ring before use, or to perform step 2 more than once as long as the direction of current flow is not changed. The leakage field values obtained when applying current from the demagnetized state will be less than the values given in Table I , which apply to the previously saturated state. If the current is increased to a value greater than 1500 A, then lowered directly to 1500 A, the leakage fields will be greater than those given in Table I. With the test hole at an angle of about 60° from the vertical, both wet and dry particles generally give a clear indication when A_t is greater than about 1200 kA/m^2. This value is best obtained using hole no. 5.

This ring test is sensitive only to magnetic properties and particle shape. It is not sensitive to particle size. Therefore, independent tests are required to determine if the particle size distribution is suitable for the indication of fine defects. Size requirements for magnetic particles are given in Aerospace Materials Specifications AMS 3040 through AMS 3046.

The leakage field value is one of the most important parameters in determining the strength of a magnetic particle indication. However, many other factors are important, including the location of the hole from the vertical, method and intensity of illumination, the technique used in applying the particles, and the timing of the current flow with respect to particle application. These and other factors and requirements are discussed in ASTM E 1444 and ASTM E 709.



Material: Vacuum Melted 52100 (per AMS 6444G), Normalized, and Annealed
All dimensions in mm (in)

Hole No.	1	2	3	4	5	6	7	8
D, mm ± 0.03 D, in ± 0.001	1.78 (0.070)	3.05 (0.120)	4.57 (0.180)	6.35 (0.250)	8.38 (0.330)	10.67 (0.420)	13.21 (0.520)	16.00 (0.630)

Figure 1. Ring construction.

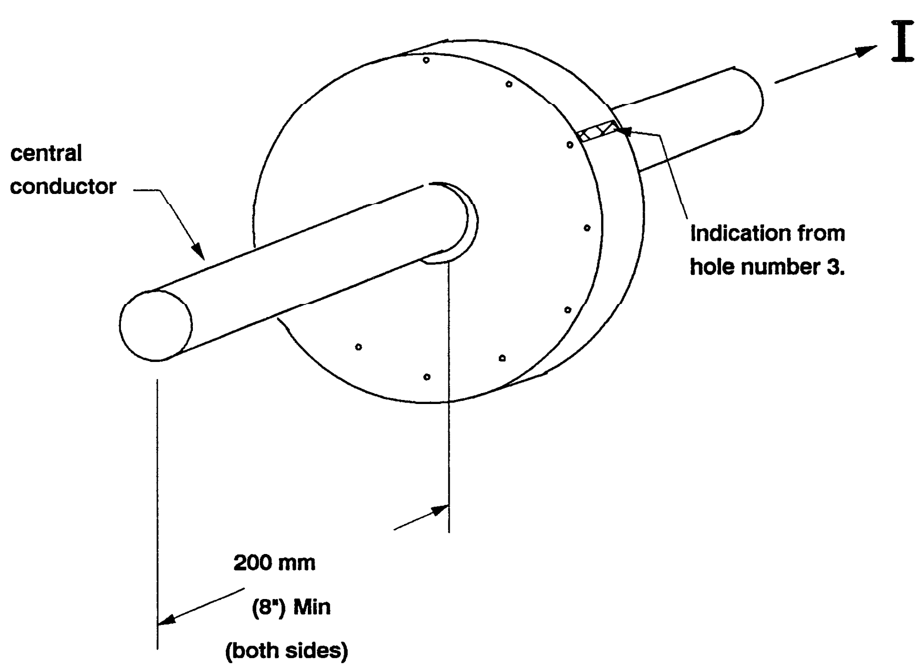


Figure 2. Placement of central conductor.