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Small Rare Earth Magnet Flux Index Calculation – Standard Operating Procedure

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Laboratory Sciences Mechanical
Small Rare Earth Magnet Flux Index Calculation – Standard Operating Procedure

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1.0 Purpose

The purpose of this guide is to provide instructions for NPTEC LSM lab staff to calculate the flux index of small, rare-earth magnets having various shapes using calibrated equipment and tools. Staff developed the following test methodology with the objective of reducing variability in test results due to the difficulties in handling small magnets and determining the location of the magnetic poles. This test method can be used for any sized spherical, rectangular, or cube magnets. Please refer to 16 CFR 1262 for details on the actual test procedure.

2.0 Tools and Equipment

a. Direct current (DC) field gaussmeter with a resolution of 5 gauss (G) or higher, capable of determining the field with an accuracy of 1.5% or better. The gaussmeter having an axial type probe with: an active area diameter of 0.76 +/- 0.13mm and a distance between the active area and probe tip of 0.38 +/- 0.13mm (Figure 1).
   i. F71 Multi-Axis Teslameter provided and calibrated by Lake Shore Cryotronics Inc.
   ii. FP-2X-250-ZS15 3-Axis Probe provided and calibrated by Lake Shore Cryotronics, Inc.

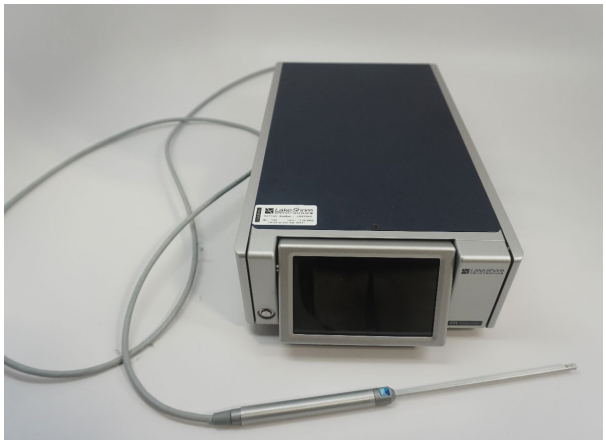

Figure 1: Teslameter and Probe

b. Test stand assembly (Figure 2) including:
   i. Vertical adjustable stand.
   ii. 40mm x 40mm Z-axis stage provided by Opto Sigma (Part# TADC-401SUU).
   iii. Clamp mount for probe.
   iv. 65mm x 65mm XY-axis stage provided by Opto Sigma (part# TSD-652CUU).
   v. Wooden block (2x4) mounted to the XY-axis stage using 4x brass or other non-ferrous screws.

vi. Double-sided tape placed on the wooden block.

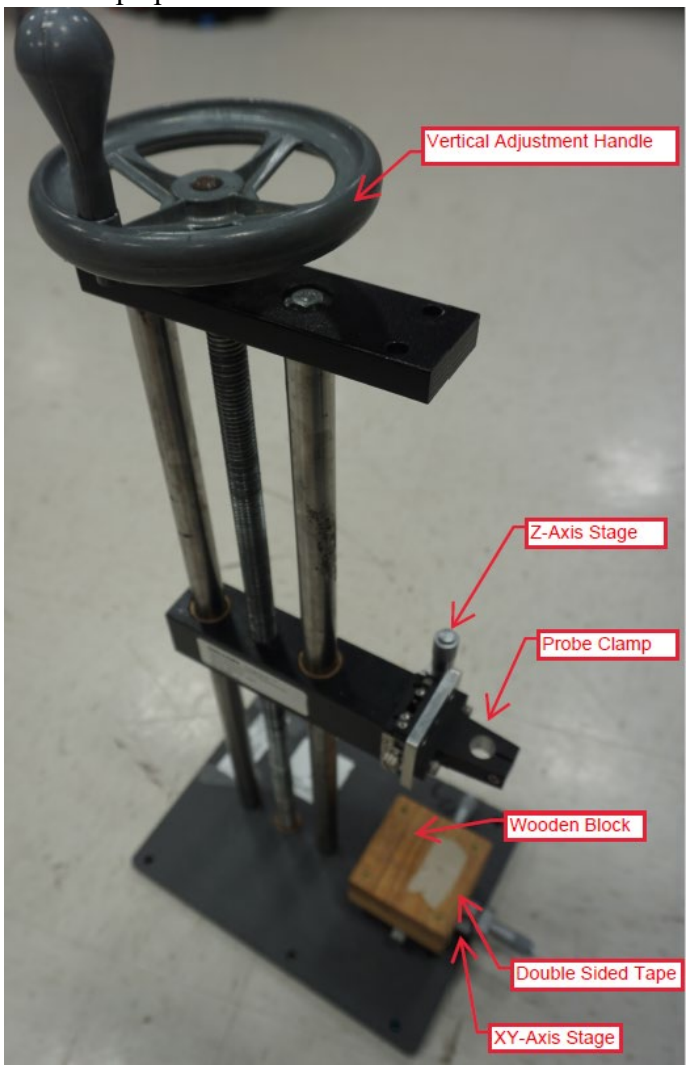

Figure 2: Test Stand Assembly

c. Magnetic field viewer card (Figure 3).

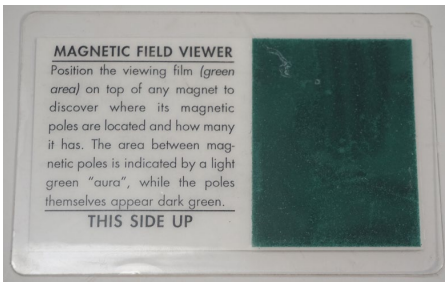

Figure 3: Magnetic Field Viewer Card

d. Calibrated magnets of 750 ± 2% G and 2.6 ± 2% kG (Figure 4).

Figure 4: Calibrated Magnets

e. 4060 zero-gauss chamber, provided by Lake Shore Cryotronics, Inc. (Figure 5).

Figure 5: Zero Gauss Chamber

f. Metal vernier calipers with resolution of 0.1 mm (Figure 6).

Figure 6: Metal Vernier Calipers

g. Stainless steel feeler gauge (0.254 mm) (Figure 7).

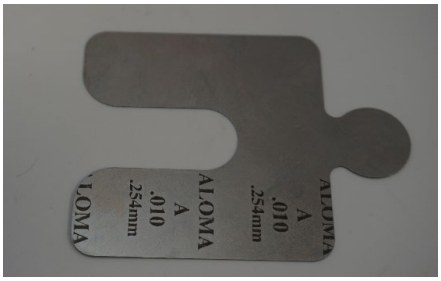

Figure 7: Stainless steel Feeler Gauge

3.0 Setup Procedure

a. Use the magnetic field viewer card to locate the magnet's pole. Below are examples of the card identifying the pole of round and rectangular magnets (Figure 8).

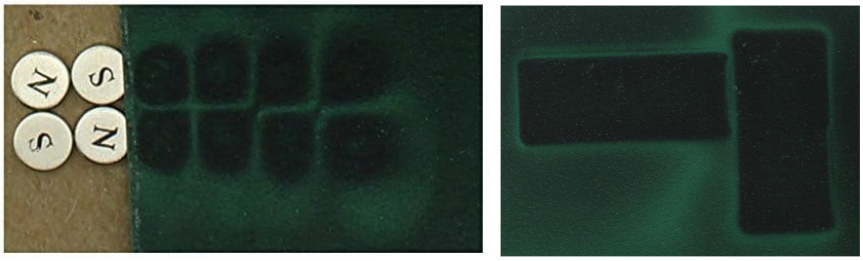

Figure 8: Magnets poles identified.

b. Use the metal calipers to measure and record diameter (d) (mm) of spherical magnet or length (l) and width (w) (mm) of rectangular/cube magnets. Take these measurements in the X, Y and Z planes of the magnet to verify size. Use these measurements to calculate the cross-sectional area of the magnetic pole (mm^2).
   i. Spherical magnetic pole area = $\frac{1}{4} \cdot \pi \cdot d^2$.
   ii. Rectangular/Cube magnetic pole area = $l \cdot w$.

c. Prepare test stand and a new piece of double-sided tape.

d. <u>For spherical magnets</u>: Place the magnet on the flat surface of the metal calipers through its attraction to the calipers (Figure 9). This establishes a vertical pole orientation of the magnet.

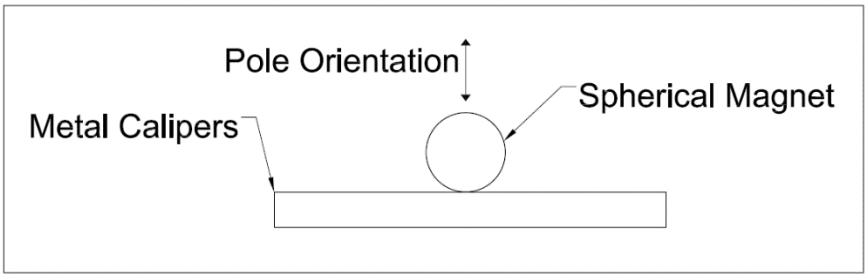

Figure 9: Magnet Placed on Flat Surface of Calipers

e. For spherical magnets: Holding the metal calipers parallel and the magnet facing towards the wooden block/double-sided tape, lower the calipers and press the magnet into the double-sided tape with force to maintain adhesion (Figure 10). Maintain the orientation of the magnet when transferring to the double-sided tape.

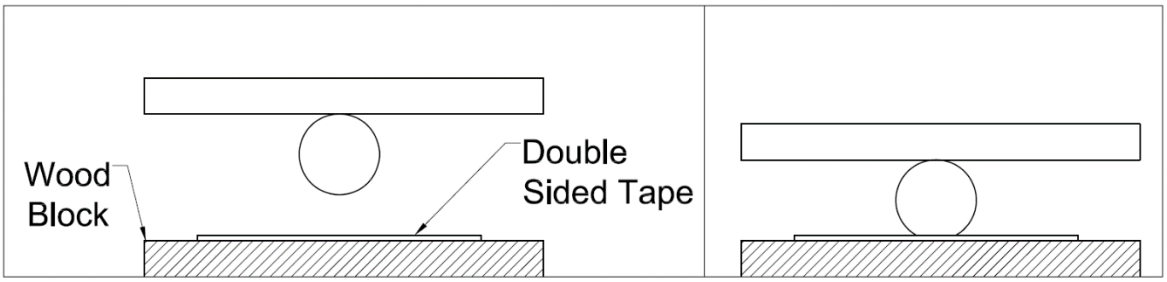

Figure 10: Magnet Pressed into Double-Sided Tape

f. For spherical magnets: Once the magnet is stabilized in the double-sided tape, remove the calipers. Monitor the magnet when lifting the calipers and confirm magnet has not rolled or shifted. The spherical magnet should now be held with the magnetic poles perpendicular to the wooden block surface (Figure 11).

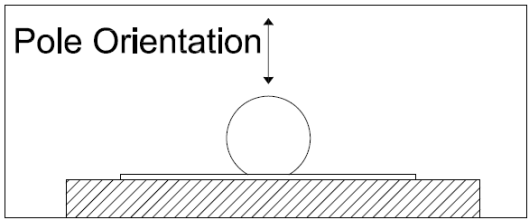

Figure 11: Magnet Transferred to Double-Sided Tape

g. For rectangular/cube magnets: Using the magnetic field viewer card, verify the magnet's pole is facing vertically.
h. For rectangular/cube magnets: Place the magnet onto the double-sided tape while maintaining the magnet's pole oriented vertically.

4.0 Test Procedure and Results

a. Verify calibration is up to date of the teslameter and probe.
b. Verify teslameter is set to direct current (DC).
c. Remove all magnetic sources from the test area.
d. Zero the probe by placing the probe tip within the zero-gauss chamber.
e. Using calibrated magnets, verify gauss readings are within ± 2%.
f. Place the probe within the clamp and arrange the probe tip above the magnet.
g. Record the maximum flux density (kG) in the Z-axis direction. *Note, the maximum flux density reading pulls values from the magnitude reading which is a vector sum of all three axes*.
    i. Adjust the vertical probe position to be 0.254 mm above the magnet using the vertical adjusting stand and feeler gauge.
    ii. Adjust the magnet position under the probe by turning the knobs of the XY-axis table to locate the highest flux density reading in the Z-axis direction.
    iii. Lower the vertical probe position to contact the magnet using the Z-axis stage to locate the maximum flux density in the Z-axis direction. This may take several seconds to allow the reading to reach its highest point.
h. Calculate the flux index (kG^2mm^2) by multiplying the square of the maximum flux density in the Z-axis direction (kG^2) by the area of the pole surface (mm^2).

5.0 Performance Requirement

a. If the magnet fits within the small part cylinder described in 16 CFR 1501.4, the flux index shall be less than 50 kG^2mm^2.