Use of Bartington Instruments' Mag-01H for Verification of Magnetic Shielding

Objectives

Measuring the effectiveness of magnetic shielding using magnetometer measurements, whether from a manufacturer's perspective, or for magnetic shield users trying to assess the residual field present.

Instrumentation

- Three-axis Magnetometer Mag-13 with Spectramag-6 Data Acquisition Unit.
- Mag-01H single axis magnetometer with Mag B or Mag F (cryogenic applications) Probe.

Background

Magnetic shielding can be made from a variety of ferromagnetic material. For cheaper installation, stainless steel may be used, but for higher degrees of attenuations, material with higher permeability (μ) such as mumetal are used. The shield concentrates any incident magnetic field within the shielding material and deflects the field around the shielded area. A typical shape used for shields is a cylinder. Using multiple layers with a gap between each layer further amplifies the shielding effect of each layer, effectively reducing the field experienced inside to a minimum. Alignment of the shield normal to the incident field maximises its effectiveness.

However, shields can over time become magnetised from field exposure or stress-induced magnetisation.

Method

Whether it is to check the effectiveness as part of quality control, or check that an installation is providing adequate attenuation, it may be necessary to check the residual field inside magnetic shielding.

The centre of the shield will be the area where the residual field is at minimum. It will therefore be best to position the sensor on a rail system in the centre of the shield. For room temperature measurements, the use of the Mag-13MS square section sensors will make the setup easier. Connected to a Spectramag-6, the data will be digitised and displayed. For cryogenic applications, the F probe and Mag-01H will provide the same measurements, though in a single axis.

With a rail system, measurements can be taken at different positions along the length of the shield. To characterize the sensor's offset, two measurements should be taken at any given point by flipping the X, Y and Z axes 180 degrees. The offset of the sensor is equal to the sum of the two values (e.g. +X and -X) divided by 2. The residual field inside the shield is therefore the field measured minus the sensor's offset.

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Shielding is less effective if the shields have become magnetised. When magnetised, the incident field lines do not concentrate within the material and are not deflected away from the target area as effectively. The expected level of shielding is calculated using the shape and dimensions of the shield, and is a proportion of the external field. If the field measured does not correlate to the expected value, then the shield may be magnetised.

If this occurs, the layers can be individually degaussed. The test described above can be used to test whether degaussing is required, and also the results of degaussing.

In practice it is found that there is a level of measured field which cannot be removed by degaussing; this is a small amount of magnetism which is present in the shield and is not removable.

Probes are sometimes mounted inside the shielded area during experiments and connected to a feedback system, which is used to cancel out any fluctuations actively during the experimental process.

Reference

[1] Tasson J D 2002 Magnetic Shielding for an Experiment to Measure the n - 4He Weak Interaction Northern Michigan University