CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
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Project Number
S1522

Project Title
Magnetization of Materials Used in the Construction of Cryostats

Abstract

Objectives/Goals
The two main purposes of this research is to determine the relative magnetic susceptibility of cryostat materials at low temperatures and analyze the magnetic behavior of these materials in relation to the temperature and applied magnetic field. The results can help determine the possible contributions to error in low-temperature experiments dealing with weak magnetic signals.

Methods/Materials
An S.H.E. variable temperature susceptometer was used to measure the magnetization of the materials at temperatures of 2K, 3K, 4K, 5.5K, 7K, 10K, and 12K and at magnetic field strengths of .25 Tesla, .5T, 1T, 1.5T, 2T, 3T, 4T. The materials analyzed include 6061 aluminum alloy, 304 stainless steel, 304 annealed stainless steel, 316 stainless steel, beryllium copper, copper nickel 7030, Evanohm wire, fused silica, Grafoil, Manganin wire, Stycast 2850, Teflon, Vespel, yellow brass. All the samples were cleaned with acetone and metals were etched with nitric or hydrochloric acid. Most were cut into 6mm x 6mm cylinders, though some had irregular shapes, and are suspended with cotton or polyester thread.

Results
At an applied magnetic field of 1 Tesla and a temperature of 2 Kevin, the materials with the greatest relative magnetization to the ones with the lowest are listed as follows: copper nickel 7030, Manganin wire, 316 stainless steel, 304 stainless steel, Evanohm wire, Grafoil, stycast 2850, beryllium copper, 6061 aluminum, Vespel, yellow brass, Teflon, and silicon dioxide. The results are fit to a function with 3 parameters, one for a fixed contribution to magnetization, a linear contribution with respect to the magnetic field, and a hyperbolic tangential contribution with respect to the temperature and magnetic field; a data table is thus generated.

Conclusions/Discussion
Stainless steel, silicon dioxide, 6061 aluminum, and Manganin behave linearly with respect to the applied magnetic field, while most other materials display a hyperbolic tangential behavior. However, the fit parameters can be used to extrapolate the magnetization of the materials at different temperature and magnetic fields with good accuracy. Because many of the metallic materials are relatively very magnetic (though some are surprisingly very weakly magnetic), they should be seriously taken into consideration when using or construction cryostats.

Summary Statement
Analyzing the magnetic susceptibility and behavior of materials at low temperatures and high magnetic fields for error correction or prevention purposes.

Help Received
Used lab equipment at the University of Southern California under the supervision of Prof. Hans Bozler and Prof. Chris Gould; obtained advice, criticism, and various aid from USC students Barry Fink, Fuyuko Bray-Ali, Jinshan Zhang, and Kevin White. Participant in the Southern California Junior Academy of