National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2853

Magnetic Moment Standard - Yttrium Iron Garnet Sphere

This Standard Reference Material (SRM) is intended for use in the calibration of magnetometers (such as vibrating sample magnetometers) used in the measurement of the magnetic properties of materials. SRM 2853 consists of a yttrium iron garnet (YIG) sphere with a nominal diameter of 1 mm and a nominal mass 2.8 mg. The SRM 2853 lot was produced by grinding pure (99.5 %), single-crystal YIG into spheres.

Certified Values and Uncertainty: The certified value for the specific magnetization, σ, at 298 K in an applied magnetic field of 398 kA/m (5000 Oe) is:

$$\sigma = 27.6\ \text{Am}^2/\text{kg} \pm 0.1\ \text{Am}^2/\text{kg} \quad (27.6\ \text{emu/g} \pm 0.1\ \text{emu/g}) \qquad (1)$$

The uncertainty in the certified value is calculated as $U = ku_c$, where $k = 2$ is the coverage factor for a 95 % level of confidence, and u_c is the combined standard uncertainty calculated and expressed in accordance with References 1, 2, and 3.

Corrections for temperature can be made using the equation:

$$\sigma = 27.6\ [1 - 0.0021\ (T - 298)] \qquad (2)$$

where σ is the specific magnetization in Am^2/kg and T is the temperature in kelvins. Using this correction, the stated uncertainty remains unchanged over the temperature range from 293 K to 303 K, providing the temperature is measured to an accuracy of ± 0.5 K. For temperatures between 250 K and 293 K, and between 303 K and 310 K, the uncertainties are approximately doubled. No correction for the applied field is necessary for fields between 100 kA/m (1250 Oe) and 800 kA/m (10 kOe). To determine the magnetic moment, *m,* in Am^2, multiply the specific magnetization in Am^2/kg determined from Equation 2 by the SRM mass in kg. The mass value of each SRM, at the time of its packaging, is provided with the unit (see note below).

Expiration of Certification: The certification of this SRM within the measurement uncertainties specified is valid indefinitely, provided the SRM is used in accordance with the instructions in this certificate. If damage or discoloration of the SRM is visible, discard the SRM.

Certification of this SRM was performed by R.D. Shull, R.D. McMichael, and L.J. Swartzendruber of the NIST Metallurgy Division.

Statistical analysis and measurement advice were provided by S.D. Leigh of the NIST Statistical Engineering Division.

The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the NIST Standard Reference Materials Program by J.M. Adams.

Carol A. Handwerker, Chief
Metallurgy Division

Gaithersburg, MD 20899
Certificate Issue Date: 20 May 2002

John Rumble, Jr., Acting Chief
Standard Reference Materials Program

Technical advice and assistance were provided by L.H. Bennett, D. Mathews, L.C. Smith, G.E. Hicho, F. Biancaniello, R.L. Park, J.G. Hodos, and R.V. Drew of the NIST Metallurgy Division, and H.E. Metger of the NIST Fabrication Technology Division.

The YIG spheres were prepared from pure, single-crystal YIG by Deltronic Crystal Industries, Inc., Dover, NJ.

Measurement Technique: The magnetic moment was determined by a sampling technique using an absolute magnetometer that was developed at NIST and is based on the Faraday method. The magnetometer was calibrated using three different methods to determine the value of the field gradient.

Storage and Handling: When not in use, store SRM 2853 in the packaging provided, or in a manner that provides equivalent or better protection against loss or damage. The sphere should be carefully handled to avoid scratching, chipping, or the attachment of magnetic dust or particles from the environment. The use of plastic or other nonmagnetic tweezers with smooth surfaces and a gentle grip is satisfactory. **DO NOT** expose the SRM to corrosive chemicals or temperatures above 373 K (100 °C).

NOTE ON MASS VALUES: NIST **DOES NOT** *certify* the mass of ferromagnetic materials. Mass values for this series of SRMs were determined in a magnetically shielded electrobalance calibrated using standards traceable to NIST. Because the YIG sphere is ferromagnetic, the presence of small magnetic fields can influence the measured mass value. The value given has an expanded uncertainty of ± 3 μg (with a coverage factor of 2).

NOTE ON UNITS: One oersted (Oe) corresponds to $1000/4\pi$ A/m. For additional discussion on units of measure, refer to References 4 and 5.

REFERENCES

[1] *Guide to the Expression of Uncertainty in Measurement*; 92-67-10188-9, 1st Ed, ISO, Geneva, Switzerland (1993); see also Taylor, B.N.; Kuyatt C.E.; *Guidelines for Evaluating and Expressing Uncertainty of NIST Measurement Results*; NIST Technical Note 1297, U.S. Government Printing Office, Washington, DC (1994); available at http://physics.nist.gov/Pubs/.

[2] *Guide to the Expression of Uncertainty in Measurement*; ANSI/NCSL Z540-2-1997, National Conference of Standards Laboratories Boulder, CO (1997/1998).

[3] Ruhkin, AL.; Vangel, M.G.; *Estimation of a Common Mean and Weighted Means Statistics*; Journal of the American Statistical Association, Vol. 93 No. 441, pp. 303-308 (1998).

[4] Bennett, L.H.; Page, C.H.; Swartzendruber, L.J.; *Comments on Units in Magnetism*; J. Res. Natl. Bur. Std., Vol. 83(1), p. 9 (1978).

[5] Taylor, B.N.; *Guide for the Use of the International System of Units (SI)*; NIST Special Publication 811.

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-6776; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet http://www.nist.gov/srm.