PREPRINT

U. S. Department of Commerce
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# National Bureau of Standards

# Certificate

## Standard Reference Materials

### Magnetic Gram Susceptibility

### 763-Aluminum
### 764-Platinum
### 765-Palladium
### 766-Manganese Fluoride

These Standard Reference Materials are issued primarily for the calibration of instruments used to measure magnetic susceptibility.

Magnetic gram susceptibility as a function of temperature[a/]

| Temperature | 763 (Al) | 764 (Pt) | 765 (Pd) | 766[b/] ($MnF_2$) |
|---|---|---|---|---|
| K | | $10^6 \chi_g$, $cm^3\ g^{-1}$ | | |
| 77.7 | .696 | -- | -- | -- |
| 295 | .605 | .993 | 5.28 | 124.0 |
| 296 | -- | .992 | 5.27 | 123.7 |
| 297 | .604 | .991 | 5.26 | 123.3 |
| 298 | -- | .991 | 5.25 | 123.0 |
| 299 | .603 | .990 | 5.24 | 122.6 |

[a/] Magnetic susceptibility values are estimated to have an uncertainty less than $\pm$ 0.5 percent.

[b/] Susceptibility values have not been corrected for demagnetization or anisotropic effects.

The overall direction and coordination of technical measurements at NBS leading to certification were performed by G. A. Candela and R. E. Mundy.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. E. Michaelis.

Washington, D. C. 20234
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J. Paul Cali, Chief
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(over)

Preparation and Handling:

The materials for these SRM's were all of the highest possible purity obtainable. Each SRM was thoroughly cleaned and etched prior to packing. The etchants used were the following:

| SRM | Etchant | |
|---|---|---|
| Al | $HF/H_2O$ | 1:1 |
| $MnF_2$ | $HF/H_2O$ | 1:10 |
| Pd and Pt | $HCl/HNO_3$ | 1:3, hot |

Finally, the materials were thoroughly rinsed with distilled $H_2O$.

Caution:

These SRM's should be handled only with non-ferrous instruments such as brass or plastic forceps and contact with any ferromagnetic materials must be avoided. Should any cutting or grinding of the samples be required or should any surface contamination be suspected, it is recommended that the samples be etched as described above.

Procedure:

An apparatus was constructed so that absolute measurements can be made by the Gouy method.[1/]

The expression, $f = 1/2k \text{ grad } B^2$, relates the measurable quantities, force-per-unit volume (f) and magnetic field (B), to the field independent isotropic magnetic susceptibility (k). The component of force in a given x direction on a piece of homogeneous matter of volume V is then given by:

$$F_x = \frac{(k - k_M)}{2\mu_o} \int_V \frac{dB^2}{dx} \, dV$$

[1/] G. A. Candela and R. E. Mundy, "Absolute magnetic susceptibilities by the Gouy and the Thorpe-Senftle methods," IRE Trans. Instr. I-2, 106 (1962).

$k_M$ is the susceptibility of the medium. In the Gouy method, a cylinder of matter of constant cross section (a), and uniform density is orientated with its axis in the x direction. The force in the x direction is given by:

$$F_x = \frac{a(k - k_M)}{2\mu_o} \int_{x_o}^{x_1} \frac{dB^2}{dx}\, dx = \frac{a(k - k_M)}{2\mu_o} (B_1^2 - B_0^2)$$

where $B_1$ and $B_0$ are the fields at $x_1$ and $x_0$, respectively.

When $k >> k_M$, the gram susceptibility is then equal to:

$$\chi_g = \frac{2 F_x \mu_o}{M_s/\ell (B_1^2 - B_0^2)}$$

where $\ell$ is the length of the cylindrical sample and $M_s$ is the mass of the sample.

The samples were all measured in an atmosphere of dry nitrogen gas. $B_1$ was measured by a proton resonance magnetometer and $B_0$ was measured by a calibrated Hall effect gaussmeter. The magnetic fields used were $1000 \leq B_1 \leq 7500$ gauss and in all the experiments $B_0^2 < 0.005\ B_1^2$. The sample lengths were measured by direct comparison to gage blocks. The temperature was measured by a calibrated copper constantan thermocouple.

## SUPPLEMENTARY INFORMATION

Although not certified, the volume susceptibilities of these SRM's are given at 297 K.

| SRM | Type | Volume Susceptibility $10^6$ k |
|---|---|---|
| 763 | Aluminum | 1.63[a] |
| 764 | Platinum | 21.2 |
| 765 | Palladium | 63.1 |
| 766 | Manganese Fluoride | 484 |

[a] 1.87 at 77.7 K.