U. S. Department of Commerce
Malcolm Baldrige
Secretary
National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards

Certificate

Standard Reference Material 769

Electrical Residual Resistivity Ratio

J. G. Hust and D. R. Smith

This Standard Reference Material (SRM) is a set of five aluminum rods that are intended for use in checking four-terminal dc and eddy current decay techniques for determining the impurity level in high purity metals.

Residual resistivity ratio (RRR) is defined as the ratio of the electrical resistivity at the ice-point (273.15 K) to the electrical resistivity at a sufficiently low temperature where it is independent of temperature. Liquid helium temperature (4 K) is generally used for this residual value. The RRR values and the identification markings of each rod in the set are given below.

Rod Number (Hole Number)	Identification Mark	$\rho_{273.15}/\rho_4$
1		
2		
3		
4		
5		

Each of the values tabulated has an uncertainty of ± 4 percent due to the combined effects of material variability and measurement uncertainty. The principal component in the measurement uncertainty is that due to the determination of the decay time-constant.

The residual resistivity of a "pure" metal is dependent on the concentration of the chemical impurity and the physical imperfection (i.e., physical imperfection can be caused by rapid quenching or work hardening). These rods have been annealed at 400 °C for 1 hour and, therefore, should be relatively free of physical imperfections. Care should be taken in their handling (especially those of highest RRR) to prevent mechanical damage, such as bending, which will decrease the indicated RRR value. In the event such abuse occurs, the original RRR value can be restored by reannealing. The specimen must, however, be carefully cleaned prior to annealing to avoid diffusion of surface impurities into the bulk of the metal.

It should also be noted that the resistivity of the highest RRR rod may not be at the lowest value at 4 K. Therefore, the certified value of RRR is valid only for the temperatures 4 and 273.15 K. In addition, the purest rods undoubtedly exhibit a size-effect due to boundary scattering. Thus, no attempt should be made to reduce the size of these rods as it would decrease the RRR according to the magnitude of the size-effect. Finally, electrical resistivity is increased in the presence of magnetic fields. This is, again, most important for the purest rods.

The coordination of the preparation of these specimens, the measurements, and the evaluation of the data was performed by J.G. Hust of the Thermophysical Properties Division (Boulder, Colorado).

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

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George A. Uriano, Chief
Office of Standard Reference Materials

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This SRM was fabricated from commercially supplied aluminum rods. The nominally 10,000 RRR rod represents the purest commercially available material. The nominally 100 RRR material represents a grade of aluminum wire typical of common electrical conductors. The measurement of residual resistivities and the associated RRR in this range requires special low signal-level techniques. The conventional four terminal dc technique can be applied with sub-microvolt sensitivity for the 100 RRR rod. However, the 10,000 RRR rod requires sub-nanovolt sensitivity or alternate techniques such as the eddy current decay technique used[1] to certify these rods. In this technique, values of the decay time-constants were obtained at 4 and 76 K. From the decay time-constant at 4 K, RRR values were calculated using the intrinsic electrical resistivity at 273.15 K (24.8 nΩ·m). In addition, the values of decay time-constant at 76 K were used to confirm the intrinsic resistivity at 76 K and to make adjustments for deviations from Matthiessen's Rule. These redundant values of RRR were averaged and plotted versus position of each specimen within the original rod. From these plots, the certified values of RRR were obtained.

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[1]A.F. Clark, V.A. Deason, J.G. Hust, and R.L. Powell, The Eddy Current Decay Method for Resistivity Characterization of High Purity Metals, NBS Special Publication 260-39 (1972) 43 pp.