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Standard Reference Material 1450a

Thermal Resistance - Fibrous Glass Board

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Thermal Resistance *(R) of a Nominal 2.54 cm Thick Specimen as a Function of Density (ρ) and Temperature (T) (The thickness of each specimen must be measured by the user in order to correctly determine its density, see section on Measurement Procedure.)

Temperature	Density				
	60 $kg \cdot m^{-3}$	80 $kg \cdot m^{-3}$	100 $kg \cdot m^{-3}$	120 $kg \cdot m^{-3}$	140 $kg \cdot m^{-3}$
255 K	0.931 $m^2 \cdot K \cdot W^{-1}$	0.921 $m^2 \cdot K \cdot W^{-1}$	0.911 $m^2 \cdot K \cdot W^{-1}$	0.901 $m^2 \cdot K \cdot W^{-1}$	0.891 $m^2 \cdot K \cdot W^{-1}$
260	.917	.907	.897	.887	.878
265	.903	.893	.883	.874	.865
270	.888	.879	.870	.860	.852
275	.874	.865	.856	.847	.838
280	.859	.850	.842	.833	.825
285	.845	.836	.828	.820	.812
290	.830	.822	.814	.806	.798
295	.816	.808	.800	.792	.785
300	.801	.793	.786	.778	.771
305	.786	.779	.772	.765	.758
310	.772	.765	.758	.751	.744
315	.758	.751	.744	.737	.731
320	.743	.737	.730	.724	.718
325	.729	.723	.717	.710	.704
330	.715	.709	.703	.697	.691

*The last digit is provided for accurate interpolation.

The tabulated values of thermal resistance were computed using an empirical equation obtained from a least squares analysis of 70 thermal resistance measurements made on 33 pairs of specimens taken from this particular lot of material. These certified values apply only to this lot of fibrous glass board. Values of thermal resistance of this SRM are expected to be within 2 percent of the computed values. This estimate is based on the experimental data and is believed to include both material variability and measurement uncertainty.

The technical measurements and statistical analysis were performed under the direction of Frank J. Powell and H. H. Ku, respectively.

The technical support aspects involved in the preparation, certification, and issuance of Standard Reference Material 1450a were coordinated through the Office of Standard Reference Materials by R. K. Kirby.

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Introduction - Background

SRM 1450a is a nominally 2.54 cm thick semi-rigid board formed from fine-glass fibers in a phenolic binder. The bulk density of the material ranges from about 60 to 140 $kg \cdot m^{-3}$ (4 to 9 $lb \cdot ft^{-3}$). The material was donated by Owens-Corning Fiberglas Corporation.

With proper handling this material appears to be stable for a period of at least 20 years, see section on Measurement Procedure.

Base Measurements

Thermal resistance measurements of SRM 1450a were made on the NBS 20-cm square guarded hot-plate apparatus (conforming to ASTM C-177**). Specimens were air dried in an oven at 373 K for 24 hours before placement into the apparatus. Measurements were made at mean specimen temperatures from 255 to 330 K with temperature gradients from 9 to 12 $K \cdot cm^{-1}$.

Data were fitted to an equation of the form

$$\lambda(\rho,T) = \frac{L}{R} = a_0 + a_1\rho + a_2T^3 \qquad \text{(Eq. 1)}$$

$\lambda(\rho,T)$ = thermal conductivity, $W \cdot m^{-1} \cdot K^{-1}$

R = thermal resistance, $m^2 \cdot K \cdot W^{-1}$

L = thickness, m

ρ = bulk density, $kg \cdot m^{-3}$

T = mean specimen temperature, K

by the method of least squares using the Omnitab Fit routine. The values of the coefficients obtained are

$a_0 = 1.930 \times 10^{-2}\ W \cdot m^{-1} \cdot K^{-1}$

$a_1 = 1.534 \times 10^{-5}\ W \cdot m^2 \cdot K^{-1} \cdot kg^{-1}$

$a_2 = 4.256 \times 10^{-10}\ W \cdot m^{-1} \cdot K^{-4}$

The standard deviation computed from residuals of the fit is 2.6×10^{-4} (~1 percent). All of the measured values were within 3 standard deviations of the computed values and examination of the residuals did not reveal any systematic trends.

****Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate,** Annual Book of ASTM Standards, Part 18, pp. 19-52, American Society for Testing and Materials, Philadelphia, Pa., 1977.

Measurement Procedure

Speciments must be air dried in an oven at 373 K for 24 hours before any measurements are made.

Caution: This SRM should not be heated above 375 K (215 °F) at any time.

The density is determined by weighing the dried specimen to an accuracy of at least 10 g, measuring the two long dimensions to at least 5 mm, and determining the average thickness (measure at several places) to at least 0.2 mm by placing thin metal plates (about 2 mm thick and 25 mm square) of known thickness on either surface, applying a slight pressure not to exceed 2.5 kPa (6 $oz \cdot in^{-2}$), and measuring across the sandwich with a micrometer. It may be possible to directly measure the thickness in a guarded hot-plate apparatus according to the procedure specified in ASTM C-177.

It is recommended that the thermal resistance measurements be made at a thickness as close to, but not exceeding, the measured thickness. The pressure from the clamping force should not exceed 2.5 kPa. The mean specimen temperature must be measured with an accuracy of at least 1 K.

Calculation of the Certified Thermal Resistance

If the measured thickness is 0.0254 m then the R-values can be interpolated directly from the tabulated values. If the measured thickness is different from 0.0254 m then the R-values must be calculated by substitution in Eq. 1. For example, the thermal resistance of SRM 1450a of thickness 0.0258 m, density 93 $kg \cdot m^{-3}$ and temperature 283 K is:

$$R = \frac{0.0258}{1.93 \times 10^{-2} + 1.534 \times 10^{-5} \times 93 + 4.256 \times 10^{-10} \times 283^3}$$

$$R = 0.849\ m^2 \cdot K \cdot W^{-1}$$

Conversions

Parameters	SI Units	Factors to Convert (Multiply SI Units)	Conventional Units
Density, ρ	$kg \cdot m^{-3}$	0.06243	$lb \cdot ft^{-3}$
Thermal conductivity, λ	$W \cdot m^{-1} \cdot K^{-1}$	6.9335	$Btu \cdot in \cdot h^{-1} \cdot ft^{-2} \cdot (°F)^{-1}$
Thermal resistance, R	$m^2 \cdot K \cdot W^{-1}$	5.6783	$h \cdot ft^2 \cdot °F \cdot Btu^{-1}$
Temperature, T	K	1.8(T-273.15)+32	°F