National Institute of Standards & Technology

Certificate

Standard Reference Material® 1450e

Thermal Conductivity - Fibrous Glass Board

Serial Number: SAMPLE

This Standard Reference Material (SRM) is intended primarily for use in the measurement of the thermal conductivity or thermal resistance of insulation materials. SRM 1450e is a high-density fibrous glass board certified for bulk density (ρ) and thermal conductivity (λ). The SRM can be used in conjunction with ASTM C177 [1] or ASTM C518 [2]. A unit of SRM 1450e consists of a square panel of fibrous glass and phenolic binder molded into a semi-rigid board. The nominal dimensions of a unit are 610 mm × 610 mm × 25 mm, and the bulk density of the material lot ranges from 110 kg•m^{-3} to 154 kg•m^{-3}.

Certified Values and Uncertainties: The certified values of ρ (kg•m^{-3}) and λ (W•m^{-1}•K^{-1}), and their associated relative expanded uncertainties ($k = 2$) for this unit are

$$\rho = \text{SAMPLE} \pm 1.5\ \%\ (k = 2)$$

$$\lambda = -1.97313\times10^{-3} + 1.99227\times10^{-5}\rho + 1.07923\times10^{-4}T \pm 1.0\ \%\ (k = 2)$$

where ρ is the specimen bulk density (kg•m^{-3}) valid from 110 kg•m^{-3} to 154 kg•m^{-3} and T is the mean specimen temperature (K) valid from 280 K to 360 K. Certified values of λ are valid for barometric pressures from 60 kPa to sea-level pressure (101.325 kPa). The measurands are shown above and are traceable to the SI derived unit of density expressed as kilogram per cubic meter and the SI derived unit of thermal conductivity expressed as watt per meter kelvin.

Expiration of Certification: The certification of **SRM 1450e** is valid indefinitely, within the uncertainty specified, provided the SRM is handled and stored in accordance with instructions given in this certificate (see "Instructions for Handling, Storage, and Use"). Accordingly, periodic recalibration or recertification of this SRM is not required. The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification, NIST will notify the purchaser. Registration (see attached sheet or register online) will facilitate notification.

Overall direction and coordination of the technical measurements leading to the certification of this SRM were performed by R.R. Zarr of the NIST Energy and Environment Division.

Statistical analysis was provided by N.A. Heckert of the NIST Statistical Engineering Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Office of Reference Materials.

Andrew K. Persily, Chief
Energy and Environment Division

Gaithersburg, MD 20899
Certificate Issue Date: 28 April 2020

Steven J. Choquette, Director
Office of Reference Materials

INSTRUCTIONS FOR HANDLING, STORAGE, AND USE

Stacking: Certified values of thermal conductivity are valid for a single unit, and are invalid for stacked units.

Slicing: Certified values of thermal conductivity are invalid for a unit where the thickness of the material has been modified by slicing.

Cutting: It is possible to cut the SRM unit into smaller pieces. It is imperative to verify that bulk density of each piece is within the certified range of bulk density (110 kg·m^{-3} to 154 kg·m^{-3}).

Upper Temperature Limit: The decomposition point of the binder is approximately 473 K (200 °C). As a precaution, this SRM should not be heated above 380 K (107 °C). It should be noted that oven drying, as opposed to desiccant drying, can remove other volatiles and potentially affect chemical or physical properties of the material.

Lower Temperature Limit: A lower temperature limit for SRM 1450e has not been established.

Use: The SRM unit should not be compressed more than 10 % of original thickness. The unit should be stored in the original packaging for identification purposes in a clean, dry environment at temperatures between 15 °C and 30 °C. Prior to the thermal conductivity measurement, the SRM should be maintained in laboratory conditions of 20 °C to 25 °C and from 40 % relative humidity (RH) to 65 % RH until the mass of the unit is stable (i.e., two successive measurements within 24 h differ by less than 1 %). Thermal conductivity measurements should be conducted in accordance with the appropriate ASTM Test Method C177 [1], C518 [2], or other similar international standard.

SOURCE, PREPARATION, AND ANALYSIS [(1)]

Source: SRM 1450e is a commercial insulation product supplied by Quiet Core, Incorporated.

Sample Selection: Test specimens for characterizing the steady-state thermal transmission properties of SRM 1450e were selected based on a randomized full factorial experimental design that required 30 test specimens (15 pairs) covering three nominal levels of density. The breakdown consisted of five pairs having a relatively low bulk density, five pairs near the mean bulk density, and five pairs having a relatively high bulk density.

Measurement Technique: Thermal conductivity measurements were made on the NIST 500 mm guarded-hot-plate apparatus [3] in accordance with ASTM Test Method C177 [1]. Under steady-state conditions, the operational definition [4] for the measured thermal conductivity (λ_{exp}) for a pair of specimens is defined by

$$\lambda_{exp} = \frac{Q L_{avg}}{2 A \Delta T_{avg}}$$

where Q is the time rate of heat flow through the meter area of both specimens; L_{avg} is the mean of the two specimen thicknesses; ΔT_{avg} is the average of temperature difference across the specimen thicknesses; and, the quantity $2A$ occurs because the metered power (Q) flows through two surfaces of the apparatus meter area. The basic quantities (Q, L_{avg}, A, and ΔT_{avg}) are metrologically traceable to fundamental metrology laboratories at NIST. Following a randomized full factorial design, λ_{exp} (W•m^{-1}•K^{-1}) was determined for three levels of bulk density ranging from 110 kg•m^{-3} to 154 kg•m^{-3} and five levels of mean temperature (280 K, 300 K, 320 K, 340 K, and 360 K). A temperature difference of 25 K was maintained across the thickness of the test specimens. A model, linear in bulk density (kg•m^{-3}) and mean temperature (K), was fit from the experimental data by least squares regression.

$$\lambda = -1.97313\times10^{-3} + 1.99227\times10^{-5}\rho + 1.07923\times10^{-4}T$$

The last digit of the coefficient is provided to reduce rounding errors. The residual standard deviation of the fit was 0.00016 W·m^{-1}·K^{-1}.

Measurement Uncertainty: Measurement uncertainties for SRM 1450e are discussed in reference [3]. The uncertainties in the certified values of thermal conductivity were calculated according to the ISO/JCGM Guide [5]. These uncertainties apply only to this lot of fibrous glass board and can be expressed as an expanded uncertainty $U = ku_c$ with U determined from a combined standard uncertainty u_c and a coverage factor of $k = 2$. The determination of u_c and the interpretation of the expanded uncertainties are discussed in reference 4. The expanded uncertainties of the certified thermal conductivity values are not expected to exceed 1 %. This estimate is based on the budget for the measurement uncertainties.

Supplemental Information: For unit conversions to non-SI units, the user should consult NIST Special Publication 811 [6].

[(1)] Certain commercial equipment, instruments or materials are identified in this certificate to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Notice to Users for SRM availability:
NIST strives to maintain the SRM inventory supply, but NIST cannot guarantee the continued or continuous supply of any specific SRM. Accordingly, NIST encourages the use of this SRM as a primary benchmark for the quality and accuracy of the user's in-house reference materials and working standards. As such, the SRM should be used to validate the more routinely used reference materials in a laboratory. Comparisons between the SRM and in-house reference materials or working measurement standards should take place at intervals appropriate to the conservation of the SRM and the stability of relevant in-house materials. For further guidance on how this approach can be implemented, contact NIST by email at srms@nist.gov.

REFERENCES

[1] ASTM C177-19; *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus*; Annual Book of ASTM Standards, Vol. 04.06, West Conshohocken, PA (2019).

[2] ASTM C518-17; *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus*; Annual Book of ASTM Standards, Vol. 04.06, West Conshohocken, PA (2019).

[3] Zarr, R.R.; Heckert, N.A.; *Certification of Standard Reference Material® 1450e, Fibrous-Glass Board*; NIST Special Publication 260-201 (2020); available at https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.260-201.pdf (accessed Apr 2020).

[4] ASTM C1045-19; *Standard Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions*; Annual Book of ASTM Standards, Vol. 04.06, West Conshohocken, PA (2019).

[5] JCGM 100:2008; *Evaluation of Measurement Data - Guide to the Expression of Uncertainty in Measurement*; (GUM 1995 with Minor Corrections), Joint Committee for Guides in Metrology (JCGM) (2008); available at https://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed Apr 2020); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297; U.S. Government Printing Office: Washington, DC (1994); available at https://www.nist.gov/pml/nist-technical-note-1297 (accessed Apr 2020).

[6] Thompson, A.; Taylor, B.N.; *Guide for the Use of the International System of Units (SI)*; NIST Special Publication 811; U.S. Government Printing Office: Washington, DC (2008); available at https://www.nist.gov/pml/special-publication-811 (accessed Apr 2020).

Users of this SRM should ensure that the Certificate in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax 301-948-3730; e-mail srminfo@nist.gov; or via the Internet at https://www.nist.gov/srm.