Standard Reference Materials:

Glass Fiberblanket SRM for Thermal Resistance

J.G. Hust
The National Bureau of Standards was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, the Institute for Computer Sciences and Technology, and the Institute for Materials Science and Engineering.

### The National Measurement Laboratory

Provides the national system of physical and chemical measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; provides advisory and research services to other Government agencies; conducts physical and chemical research; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

| Basic Standards |
| Radiation Research |
| Chemical Physics |
| Analytical Chemistry |

### The National Engineering Laboratory

Provides technology and technical services to the public and private sectors to address national needs and to solve national problems; conducts research in engineering and applied science in support of these efforts; builds and maintains competence in the necessary disciplines required to carry out this research and technical service; develops engineering data and measurement capabilities; provides engineering measurement traceability services; develops test methods and proposes engineering standards and code changes; develops and proposes new engineering practices; and develops and improves mechanisms to transfer results of its research to the ultimate user. The Laboratory consists of the following centers:

| Applied Mathematics |
| Electronics and Electrical Engineering |
| Manufacturing Engineering |
| Building Technology |
| Fire Research |
| Chemical Engineering |

### The Institute for Computer Sciences and Technology

Conducts research and provides scientific and technical services to aid Federal agencies in the selection, acquisition, application, and use of computer technology to improve effectiveness and economy in Government operations in accordance with Public Law 89-306 (40 U.S.C. 759), relevant Executive Orders, and other directives; carries out this mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards guidelines, and managing Federal participation in ADP voluntary standardization activities; provides scientific and technological advisory services and assistance to Federal agencies; and provides the technical foundation for computer-related policies of the Federal Government. The Institute consists of the following centers:

| Programming Science and Technology |
| Computer Systems Engineering |

### The Institute for Materials Science and Engineering

Conducts research and provides measurements, data, standards, reference materials, quantitative understanding and other technical information fundamental to the processing, structure, properties and performance of materials; addresses the scientific basis for new advanced materials technologies; plans research around cross-country scientific themes such as nondestructive evaluation and phase diagram development; oversees Bureau-wide technical programs in nuclear reactor radiation research and nondestructive evaluation; and broadly disseminates generic technical information resulting from its programs. The Institute consists of the following Divisions:

| Inorganic Materials |
| Fracture and Deformation |
| Polymers |
| Metallurgy |
| Reactor Radiation |

---

1 Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Gaithersburg, MD 20899.
2 Some divisions within the center are located at Boulder, CO 80303.
3 Located at Boulder, CO, with some elements at Gaithersburg, MD.
Standard Reference Materials:

Glass Fiberblanket SRM for Thermal Resistance

J.G. Hust

Center for Chemical Engineering
National Engineering Laboratory
National Bureau of Standards
Boulder, CO 80303

Sponsored by:
Office of Standard Reference Materials
National Measurement Laboratory
National Bureau of Standards
Gaithersburg, MD 20899
Standard Reference Materials (SRM's) as defined by the National Bureau of Standards (NBS) are well-characterized materials, produced in quantity and certified for one or more physical or chemical properties. They are used to assure the accuracy and compatibility of measurements throughout the Nation. SRM's are widely used as primary standards in many diverse fields in science, industry, and technology, both within the United States and throughout the world. They are also used extensively in the fields of environmental and clinical analysis. In many applications, traceability of quality control and measurement processes to the national measurement system is carried out through the mechanism and use of SRM's. For many of the Nation's scientists and technologists it is therefore of more than passing interest to know the details of the measurements made at NBS in arriving at the certified values of the SRM's produced. An NBS series of papers, of which this publication is a member, called the NBS Special Publication – 260 Series, is reserved for this purpose.

The 260 Series is dedicated to the dissemination of information on different phases of the preparation, measurement, certification and use of NBS SRM's. In general, much more detail will be found in these papers than is generally allowed, or desirable, in scientific journal articles. This enables the user to assess the validity and accuracy of the measurement processes employed, to judge the statistical analysis, and to learn details of techniques and methods utilized for work entailing the greatest care and accuracy. These papers also should provide sufficient additional information not found on the certificate so that new applications in diverse fields not foreseen at the time the SRM was originally issued will be sought and found.

Inquiries concerning the technical content of this paper should be directed to the author(s). Other questions concerned with the availability, delivery, price, and so forth, will receive prompt attention from:

Office of Standard Reference Materials
National Bureau of Standards
Gaithersburg, MD 20899

Stanley D. Rasberry, Chief
Office of Standard Reference Materials
OTHER NBS PUBLICATIONS IN THIS SERIES


* Send order with remittance to Superintendent of Documents, US Government Printing Office Washington, DC 20402. Remittance from foreign countries should include an additional one-fourth of the purchase price for postage.

** May be ordered from: National Technical Information Services (NTIS). Springfield Virginia 22161.
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>iii</td>
</tr>
<tr>
<td>Abstract</td>
<td>1</td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2. Material Characterization</td>
<td>1</td>
</tr>
<tr>
<td>3. Measurements</td>
<td>2</td>
</tr>
<tr>
<td>4. Data Analysis</td>
<td>2</td>
</tr>
<tr>
<td>5. Comparisons</td>
<td>6</td>
</tr>
<tr>
<td>6. Certified Values</td>
<td>13</td>
</tr>
<tr>
<td>7. Summary</td>
<td>15</td>
</tr>
<tr>
<td>8. Acknowledgments</td>
<td>15</td>
</tr>
<tr>
<td>9. References</td>
<td>15</td>
</tr>
</tbody>
</table>
Standard Reference Materials: Glass Fiberblanket SRM for Thermal Resistance

J. G. Hust

Chemical Engineering Science Division
Center for Chemical Engineering
National Bureau of Standards
Boulder, Colorado 80303

The apparent thermal conductivity data that provide the basis for the certification of glass fiberblanket as an SRM of thermal resistance are reported and analyzed. Detailed analysis and intercomparisons of NBS and other published data are given. These data are represented by an equation describing the dependencies of the data on temperature and density. Certified values of thermal resistance are given for temperatures from 100 to 330 K and densities from 10 to 16 kg/m³.

Key words: apparent thermal conductivity; density; glass fiberblanket; Standard Reference Material; temperature; thermal resistance

1. Introduction

The National Bureau of Standards (NBS) has an on-going program to establish physical property Standard Reference Materials (SRM's) as needed to improve measurement reliability. The Center for Chemical Engineering (CCE) has been active in a portion of this effort for about 20 years in establishing SRM's for thermal conductivity over a broad range of conductivities and temperatures. The status of this effort was recently summarized by Hust [1]. The Center for Building Technology (CBT) has supplied calibrated transfer specimens (CTS's) for thermal resistance of insulations for over 50 years.

During the mid 1970's, the American Society for Testing and Materials recognized the strong need for thermal insulation SRM's. As a consequence, a task group was established under the auspices of ASTM subcommittee C16.30 on thermal measurements. The recommendations for establishing thermal insulation SRM's was published in 1978 [2].

The purpose of the present publication is to describe the combined effort of CCE and CBT of NBS to establish the second of a series of insulation SRM's as recommended by the ASTM subcommittee. The first insulation SRM is a glass fiberboard material. It was established as an SRM of thermal resistance by Siu and Hust [3] for the temperature range 255 to 330 K in 1982, and was extended to 100 K in 1985 by Hust [4].

2. Material Characterization

In October 1979 two lots of 2.54 cm thick, glass fiberblanket insulation were purchased by the National Voluntary Laboratory Accreditation Program (NVLAP) and the Office of Standard Reference Materials (OSRM) both of NBS. The NVLAP lot was used for proficiency testing. Its density ranged from 8 to 19 kg/m³. The OSRM lot, supplied as 61 x 61 cm square specimens, was to be used as SRM stock and the specimen densities ranged from 12 to 15 kg/m³. The specimens were selected individually from a much larger lot on a criterion of uniformity of
density over the center 36 x 36 cm square portions. The material consists of fibrous glass made into a low-density blanket bonded with phenolic resin. The fibers average about 5 \( \mu \text{m} \) in diameter and are oriented with their lengths extending primarily parallel to the face of the blanket. The binder content is reported to be about 6\% by weight. The selection of this lot is described in detail in reference [14].

3. Measurements

The data used for certification of this material were obtained from two NBS apparatus:

a) The CBT 100 cm line source guarded hot plate with a 40 cm diameter meter area. It is described by Powell and Rennex [5]. A smaller version is described by Hahn [6].

b) The CCE 20 cm circular guarded hot plate with a 10 cm diameter meter area. It is described by Smith, Hust, and Van Poolen [7].

During 1980 and 1981 measurements were conducted at CCE on five pairs of specimens from the OSRM material at temperatures ranging from 100 K to 350 K. The test specimens were selected as follows: First, four 61 cm (24 in) squares were selected from the OSRM lot. These four pieces were chosen so their densities spanned the density range of the lot approximately uniformly. The specimen identification numbers were 81614, 81356, 80156, and 85715. The densities of these specimens were 12.16 (0.759), 13.01 (0.812), 14.24 (0.891), and 14.91 \( \text{kg/m}^3 \) (0.931 \text{lb/ft}^3), respectively. These four pieces were cut into 11.7 cm (4.6 in) squares and the area density of each piece was determined. Five sets of matched pairs of specimens were selected from the 11.7 cm squares. This size was chosen so that the specimens spanned the gap between the meter and guard portions of the guarded hot plate. Guard frames were prepared from the same material to fill the remaining space between the hot and cold plates. These specimens ranged in density from 10.5 to 16 \( \text{kg/m}^3 \). The CCE measurements were conducted with various fill gases (air, nitrogen, argon, and helium) and over a range of fill-gas pressure from atmospheric pressure to high vacuum. The CCE measurements also involved a range of temperature differences between the hot cold plates from as small as 10 K to as large as 100 K. These variations in test conditions were helpful in separating the heat transfer mechanisms in this material. These data by CCE have been reported [8, 9, and 10]. The atmospheric pressure data with air as the fill-gas are listed in Tables 1 and 2.

More recently, CBT measured twenty-eight pairs of specimens from the OSRM lot using the 100 cm GHP [5]. These specimens included densities from 12 to 15 \( \text{kg/m}^3 \). All of the CBT measurements, listed in Table 3, were performed at 297 K with air as the fill-gas. The specimens were selected to span the entire density range of the lot. The densities given in Table 3 are for the entire 61 cm square specimens.

4. Data Analysis

This report serves as the basis of the certification of this SRM over the temperature range 100 to 330 K with air as the fill-gas at atmospheric pressure and a plate emittance of 0.8.
Table 1. CCE thermal conductivity data for glass fiberblanket (Set 1).

<table>
<thead>
<tr>
<th>$T_{\text{mean}}$ (K)</th>
<th>$T_{\text{hot}}$ (K)</th>
<th>$T_{\text{cold}}$ (K)</th>
<th>Density (kg/m$^3$)</th>
<th>Thickness (cm)</th>
<th>$\lambda_{\text{obs}}$ (m$^2$K/m$^{-1}$)</th>
<th>Percent Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>299 311.448 286.362 14.75</td>
<td>2.5892 39.970</td>
<td>-1.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>299 311.453 286.427 14.75</td>
<td>2.5892 40.355</td>
<td>-0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>299 311.368 286.439 14.75</td>
<td>2.5892 40.848</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>249 260.599 238.257 14.76</td>
<td>2.5874 31.205</td>
<td>1.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 108.943 91.068 14.79</td>
<td>2.5824 10.250</td>
<td>-4.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>97 108.753 84.785 14.79</td>
<td>2.5823 10.255</td>
<td>-0.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>97 108.866 84.326 14.79</td>
<td>2.5823 10.370</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>111 123.376 98.174 14.79</td>
<td>2.5828 11.753</td>
<td>-0.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>111 123.287 96.269 14.79</td>
<td>2.5828 11.931</td>
<td>0.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>124 136.242 111.392 14.79</td>
<td>2.5832 13.386</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>136 148.977 123.504 14.79</td>
<td>2.5835 14.940</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>149 161.313 135.979 14.78</td>
<td>2.5839 16.588</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>162 174.164 149.286 14.78</td>
<td>2.5844 18.106</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>174 186.811 161.806 14.78</td>
<td>2.5848 19.696</td>
<td>-0.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>187 199.531 174.611 14.78</td>
<td>2.5852 21.366</td>
<td>-0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>187 199.399 174.010 14.78</td>
<td>2.5852 21.275</td>
<td>-0.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 212.040 187.211 14.77</td>
<td>2.5856 23.012</td>
<td>-0.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>212 224.628 199.894 14.77</td>
<td>2.5861 24.853</td>
<td>-0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>225 237.777 212.043 14.77</td>
<td>2.5865 26.869</td>
<td>-0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>237 249.758 225.170 14.77</td>
<td>2.5870 28.793</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250 262.310 237.589 14.76</td>
<td>2.5874 30.910</td>
<td>0.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>251 261.442 239.802 14.76</td>
<td>2.5874 31.068</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>262 274.855 249.807 14.76</td>
<td>2.5879 33.145</td>
<td>0.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>275 287.504 262.484 14.76</td>
<td>2.5883 35.618</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>288 300.073 275.064 14.76</td>
<td>2.5888 38.048</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 312.537 287.671 14.75</td>
<td>2.5893 40.858</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>313 325.127 300.282 14.75</td>
<td>2.5898 43.680</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>325 337.512 312.764 14.75</td>
<td>2.5903 47.052</td>
<td>0.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>336 350.056 322.678 14.75</td>
<td>2.5907 49.957</td>
<td>0.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350 362.512 333.764 14.74</td>
<td>2.5913 54.043</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>351 335.306 294.375 14.75</td>
<td>2.5915 44.380</td>
<td>0.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>330 362.339 297.060 14.75</td>
<td>2.5904 48.243</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>357 362.637 350.773 14.74</td>
<td>2.5915 56.191</td>
<td>1.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350 356.040 344.026 14.74</td>
<td>2.5913 53.903</td>
<td>0.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>338 349.850 325.269 14.74</td>
<td>2.5908 49.172</td>
<td>-1.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>337 349.523 325.165 14.74</td>
<td>2.5907 51.708</td>
<td>3.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>313 325.093 300.323 13.67</td>
<td>2.7938 44.868</td>
<td>-0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>325 337.730 312.757 13.67</td>
<td>2.7944 48.037</td>
<td>-0.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>338 350.061 325.083 13.67</td>
<td>2.7949 51.555</td>
<td>-0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350 362.525 337.771 13.67</td>
<td>2.7954 55.430</td>
<td>-0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 309.293 290.863 13.68</td>
<td>2.7933 41.650</td>
<td>-0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350 362.489 338.093 13.81</td>
<td>2.7954 55.705</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>325 337.504 313.172 13.81</td>
<td>2.7944 48.261</td>
<td>0.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 312.496 288.474 13.82</td>
<td>2.7933 41.956</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>149 161.174 136.068 13.85</td>
<td>2.7875 16.208</td>
<td>-1.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>149 161.936 136.427 13.85</td>
<td>2.7876 16.938</td>
<td>2.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>162 174.180 149.132 13.85</td>
<td>2.7880 18.289</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>174 199.768 149.231 13.84</td>
<td>2.7885 19.900</td>
<td>0.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>187 224.455 149.024 13.84</td>
<td>2.7889 21.533</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>195 241.527 149.199 13.84</td>
<td>2.7892 22.763</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199 249.525 149.056 13.84</td>
<td>2.7894 23.312</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>212 274.651 149.271 13.84</td>
<td>2.7898 25.314</td>
<td>0.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>244 299.737 187.458 13.83</td>
<td>2.7910 30.361</td>
<td>-0.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>262 324.765 199.559 13.83</td>
<td>2.7918 33.962</td>
<td>-1.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>275 349.719 199.809 13.82</td>
<td>2.7923 36.605</td>
<td>-1.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percent Deviation = \( \frac{(\lambda_{\text{obs}} - \lambda_{\text{calc}})}{\lambda_{\text{calc}}} \) \times 100
Table 2. CCE thermal conductivity data for glass fiberblanket (Set 2).

<table>
<thead>
<tr>
<th>(T_{\text{mean}}) (K)</th>
<th>(T_{\text{hot}}) (K)</th>
<th>(T_{\text{cold}}) (K)</th>
<th>Density (kg/m(^3))</th>
<th>Thickness (cm)</th>
<th>(\lambda_{\text{obs}}) (mW-m(^{-1})-K(^{-1}))</th>
<th>Percent Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>112</td>
<td>124.141</td>
<td>99.248</td>
<td>10.65</td>
<td>2.5828</td>
<td>11.976</td>
<td>2.95</td>
</tr>
<tr>
<td>149</td>
<td>161.282</td>
<td>136.046</td>
<td>10.64</td>
<td>2.5839</td>
<td>16.843</td>
<td>1.94</td>
</tr>
<tr>
<td>199</td>
<td>212.049</td>
<td>186.900</td>
<td>10.64</td>
<td>2.5856</td>
<td>24.175</td>
<td>-0.37</td>
</tr>
<tr>
<td>250</td>
<td>262.297</td>
<td>237.813</td>
<td>10.63</td>
<td>2.5874</td>
<td>33.316</td>
<td>-0.95</td>
</tr>
<tr>
<td>300</td>
<td>312.381</td>
<td>287.707</td>
<td>10.62</td>
<td>2.5893</td>
<td>45.406</td>
<td>-1.64</td>
</tr>
<tr>
<td>111</td>
<td>123.999</td>
<td>98.585</td>
<td>11.65</td>
<td>2.5828</td>
<td>11.777</td>
<td>1.39</td>
</tr>
<tr>
<td>149</td>
<td>161.547</td>
<td>137.084</td>
<td>11.65</td>
<td>2.5840</td>
<td>17.043</td>
<td>2.98</td>
</tr>
<tr>
<td>200</td>
<td>212.028</td>
<td>187.237</td>
<td>11.64</td>
<td>2.5856</td>
<td>24.100</td>
<td>0.84</td>
</tr>
<tr>
<td>250</td>
<td>262.157</td>
<td>237.405</td>
<td>11.63</td>
<td>2.5874</td>
<td>33.079</td>
<td>1.30</td>
</tr>
<tr>
<td>300</td>
<td>312.516</td>
<td>287.932</td>
<td>11.62</td>
<td>2.5893</td>
<td>44.767</td>
<td>0.65</td>
</tr>
<tr>
<td>111</td>
<td>123.154</td>
<td>96.367</td>
<td>15.95</td>
<td>2.5828</td>
<td>11.881</td>
<td>-0.84</td>
</tr>
<tr>
<td>149</td>
<td>161.604</td>
<td>136.697</td>
<td>15.94</td>
<td>2.5840</td>
<td>16.785</td>
<td>1.53</td>
</tr>
<tr>
<td>200</td>
<td>212.063</td>
<td>187.456</td>
<td>15.93</td>
<td>2.5856</td>
<td>23.020</td>
<td>0.05</td>
</tr>
<tr>
<td>250</td>
<td>262.271</td>
<td>237.740</td>
<td>15.92</td>
<td>2.5874</td>
<td>30.738</td>
<td>1.55</td>
</tr>
<tr>
<td>300</td>
<td>312.432</td>
<td>287.704</td>
<td>15.91</td>
<td>2.5893</td>
<td>40.290</td>
<td>1.39</td>
</tr>
<tr>
<td>112</td>
<td>123.844</td>
<td>100.088</td>
<td>13.67</td>
<td>2.5828</td>
<td>11.659</td>
<td>-1.89</td>
</tr>
<tr>
<td>149</td>
<td>161.690</td>
<td>136.757</td>
<td>13.66</td>
<td>2.5840</td>
<td>16.427</td>
<td>-0.31</td>
</tr>
<tr>
<td>200</td>
<td>212.038</td>
<td>187.418</td>
<td>13.65</td>
<td>2.5856</td>
<td>23.238</td>
<td>-0.53</td>
</tr>
<tr>
<td>250</td>
<td>262.292</td>
<td>238.163</td>
<td>13.64</td>
<td>2.5874</td>
<td>31.600</td>
<td>0.79</td>
</tr>
<tr>
<td>301</td>
<td>312.705</td>
<td>289.380</td>
<td>13.63</td>
<td>2.5893</td>
<td>41.740</td>
<td>-0.72</td>
</tr>
<tr>
<td>325</td>
<td>337.474</td>
<td>312.600</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.794</td>
<td>1.15</td>
</tr>
<tr>
<td>325</td>
<td>337.396</td>
<td>312.691</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.603</td>
<td>0.75</td>
</tr>
<tr>
<td>325</td>
<td>337.363</td>
<td>312.854</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.256</td>
<td>0.06</td>
</tr>
<tr>
<td>325</td>
<td>337.394</td>
<td>312.857</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.288</td>
<td>0.07</td>
</tr>
<tr>
<td>325</td>
<td>337.351</td>
<td>312.858</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.288</td>
<td>0.08</td>
</tr>
<tr>
<td>325</td>
<td>337.349</td>
<td>312.856</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.288</td>
<td>0.08</td>
</tr>
<tr>
<td>325</td>
<td>337.357</td>
<td>312.848</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.256</td>
<td>0.01</td>
</tr>
<tr>
<td>325</td>
<td>337.343</td>
<td>312.850</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.287</td>
<td>0.08</td>
</tr>
<tr>
<td>200</td>
<td>212.220</td>
<td>188.514</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.334</td>
<td>-0.51</td>
</tr>
<tr>
<td>200</td>
<td>212.263</td>
<td>188.482</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.200</td>
<td>-1.10</td>
</tr>
<tr>
<td>200</td>
<td>212.272</td>
<td>188.540</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.247</td>
<td>-0.91</td>
</tr>
<tr>
<td>200</td>
<td>212.253</td>
<td>188.592</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.317</td>
<td>-0.62</td>
</tr>
<tr>
<td>200</td>
<td>212.274</td>
<td>188.583</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.228</td>
<td>-1.01</td>
</tr>
<tr>
<td>200</td>
<td>212.303</td>
<td>188.594</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.209</td>
<td>-1.11</td>
</tr>
<tr>
<td>200</td>
<td>212.249</td>
<td>188.551</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.220</td>
<td>-1.05</td>
</tr>
<tr>
<td>200</td>
<td>212.272</td>
<td>188.544</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.192</td>
<td>-1.15</td>
</tr>
<tr>
<td>200</td>
<td>212.268</td>
<td>188.545</td>
<td>13.65</td>
<td>2.5857</td>
<td>23.196</td>
<td>-1.14</td>
</tr>
<tr>
<td>325</td>
<td>336.894</td>
<td>313.263</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.103</td>
<td>-0.29</td>
</tr>
<tr>
<td>325</td>
<td>336.831</td>
<td>312.958</td>
<td>13.63</td>
<td>2.5903</td>
<td>47.966</td>
<td>-0.47</td>
</tr>
<tr>
<td>325</td>
<td>336.939</td>
<td>313.594</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.233</td>
<td>-0.12</td>
</tr>
<tr>
<td>325</td>
<td>337.035</td>
<td>313.292</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.136</td>
<td>-0.27</td>
</tr>
<tr>
<td>325</td>
<td>337.398</td>
<td>313.676</td>
<td>13.63</td>
<td>2.5903</td>
<td>48.472</td>
<td>0.21</td>
</tr>
<tr>
<td>151</td>
<td>163.891</td>
<td>137.402</td>
<td>13.66</td>
<td>2.5840</td>
<td>16.623</td>
<td>-0.24</td>
</tr>
<tr>
<td>351</td>
<td>362.502</td>
<td>338.916</td>
<td>13.62</td>
<td>2.5913</td>
<td>56.480</td>
<td>1.36</td>
</tr>
<tr>
<td>325</td>
<td>336.865</td>
<td>314.109</td>
<td>13.63</td>
<td>2.5903</td>
<td>47.087</td>
<td>-2.69</td>
</tr>
</tbody>
</table>

Percent Deviation = \((\lambda_{\text{obs}} - \lambda_{\text{calc}})100/\lambda_{\text{calc}}\)
Table 3. CBT thermal conductivity data for glass fiberblanket.

<table>
<thead>
<tr>
<th>T_{mean} (K)</th>
<th>T_{hot} (K)</th>
<th>T_{cold} (K)</th>
<th>Density (kg/m^3)</th>
<th>Thickness (cm)</th>
<th>\lambda_{obs} (mW·m^{-1}·K^{-1})</th>
<th>Percent Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>14.90</td>
<td>2.540</td>
<td>39.06</td>
<td>-1.86</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.20</td>
<td>2.540</td>
<td>42.24</td>
<td>-1.06</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>13.80</td>
<td>2.540</td>
<td>40.13</td>
<td>-1.70</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>13.30</td>
<td>2.540</td>
<td>40.83</td>
<td>-1.26</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>14.90</td>
<td>2.540</td>
<td>39.70</td>
<td>-0.21</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>13.90</td>
<td>2.540</td>
<td>40.94</td>
<td>0.56</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.90</td>
<td>2.540</td>
<td>41.76</td>
<td>-0.10</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.80</td>
<td>2.540</td>
<td>42.24</td>
<td>0.75</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.30</td>
<td>2.540</td>
<td>42.60</td>
<td>0.11</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>13.20</td>
<td>2.540</td>
<td>41.43</td>
<td>-0.06</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.60</td>
<td>2.540</td>
<td>42.25</td>
<td>0.19</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.80</td>
<td>2.540</td>
<td>41.86</td>
<td>-0.15</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.70</td>
<td>2.540</td>
<td>42.52</td>
<td>1.12</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>13.20</td>
<td>2.540</td>
<td>41.71</td>
<td>0.61</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>14.30</td>
<td>2.540</td>
<td>40.68</td>
<td>0.88</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>13.10</td>
<td>2.540</td>
<td>42.24</td>
<td>1.59</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.80</td>
<td>2.540</td>
<td>41.57</td>
<td>-0.85</td>
</tr>
<tr>
<td>297</td>
<td>311.00</td>
<td>283.20</td>
<td>12.70</td>
<td>2.540</td>
<td>41.97</td>
<td>-0.18</td>
</tr>
<tr>
<td>311</td>
<td>321.03</td>
<td>301.03</td>
<td>13.18</td>
<td>2.528</td>
<td>43.86</td>
<td>-2.81</td>
</tr>
<tr>
<td>297</td>
<td>307.03</td>
<td>287.03</td>
<td>13.18</td>
<td>2.539</td>
<td>41.35</td>
<td>-0.51</td>
</tr>
<tr>
<td>273</td>
<td>283.15</td>
<td>263.15</td>
<td>13.18</td>
<td>2.535</td>
<td>35.30</td>
<td>-2.36</td>
</tr>
<tr>
<td>273</td>
<td>283.15</td>
<td>263.15</td>
<td>13.18</td>
<td>2.558</td>
<td>35.60</td>
<td>-1.50</td>
</tr>
<tr>
<td>311</td>
<td>320.96</td>
<td>300.96</td>
<td>12.15</td>
<td>2.543</td>
<td>46.81</td>
<td>0.51</td>
</tr>
<tr>
<td>297</td>
<td>307.04</td>
<td>287.04</td>
<td>12.15</td>
<td>2.541</td>
<td>42.65</td>
<td>-0.46</td>
</tr>
<tr>
<td>273</td>
<td>283.21</td>
<td>263.21</td>
<td>12.15</td>
<td>2.570</td>
<td>36.38</td>
<td>-2.01</td>
</tr>
<tr>
<td>311</td>
<td>321.02</td>
<td>301.02</td>
<td>14.86</td>
<td>2.532</td>
<td>43.82</td>
<td>1.55</td>
</tr>
<tr>
<td>297</td>
<td>307.06</td>
<td>287.06</td>
<td>14.86</td>
<td>2.551</td>
<td>40.19</td>
<td>0.72</td>
</tr>
<tr>
<td>273</td>
<td>283.12</td>
<td>263.12</td>
<td>14.86</td>
<td>2.580</td>
<td>34.73</td>
<td>-0.47</td>
</tr>
</tbody>
</table>

Percent Deviation = \( \frac{(\lambda_{obs} - \lambda_{calc})100}{\lambda_{calc}} \)
To facilitate comparison of the data and to provide a basis for the certification, a model was selected and optimized to represent the data. A variety of models from the literature were examined for this purpose. None of them proved adequate for the entire temperature range of this certification. As a consequence, modification of the form presented for the certification of the glass fiberboard SRM [4] was used. This model described the 128 GHP data points from CCE and CBT with no systematic deviations either as a function of temperature (from 100 to 350 K) or a function of density (from 10.5 to 16 kg/m$^3$). The model is given by equation (1).

$$\lambda(T,\rho) = a_1 + a_2\rho + a_3 T + a_4 T^3/\rho + a_5 \exp -[(T-180)/75]^2$$  \hspace{1cm} (1)$$

where the values of the parameters, $a_i$, are $a_1 = -0.1059$, $a_2 = 0.1378$, $a_3 = 0.07714$, $a_4 = 8472.10^{-9}$, and $a_5 = 1.339$, $\rho$ is the bulk density in kg/m$^3$, $T$ is temperature in K, and $\lambda(T,\rho)$ is the apparent thermal conductivity in mW m$^{-1}$ K$^{-1}$.

The deviations of the data from this model are shown in figure 1 as a function of temperature, and in figure 2 as a function of bulk density. The two standard deviation values computed from the residuals of the fit is 2.1%. For illustration, values of $\lambda(T,\rho)$ are calculated and plotted in figure 3 as a function of temperature at a density of 13 kg/m$^3$, and in figure 4 as a function of density at a temperature of 300 K.

Although the deviations shown in figures 1 and 2 appear random, systematic differences between the CCE and CBT data as a function of temperature are noted. A similar difference in the slope as a function of temperature was noted in the data for the glass fiberboard SRM 1450b [4]. The source of this systematic difference is unknown, but it is less than the overall scatter of the data sets.

5. Comparisons

It is desirable to compare equation (1) to the results from other measurements on similar materials. It is most convenient to make these comparisons of $\lambda(T,\rho)$ through the use of the models. The baseline for these comparisons will be the values as calculated from equation (1).

The most direct comparison that can be made is with respect to the recently completed round robin on low-density glass fiberblanket materials as reported by Hust and Pelanne [11]. Part of these measurements were performed on the NVLAP material obtained from the same supplier as was the OSRM material. The data used to develop the model reported by Hust and Pelanne [11] included temperatures from 255 to 330 K, and densities from 11 to 35 kg/m$^3$. The comparison of the two models as a function of temperature for a density of 13 kg/m$^3$ is shown in figure 5. The comparison as a function of density at a temperature of 300 K is shown in figure 6.

Systematic differences between the two equations of as much as 2% are noted at the lower densities. The agreement is excellent at the higher densities. Since part of the material used in the round robin was similar to the material
Figure 1. Deviations of measured apparent thermal conductivities from values calculated with equation (1) versus the mean temperature of the measurements at densities from 10.5 to 16 kg/m$^3$.

- CCE Spec. 1
- CCE Spec. 2
- CCE Spec. 3
- CCE Spec. 4
- CCE Spec. 5
- CBT
Figure 2 Deviations of measured apparent thermal conductivities from values calculated with equation (1) versus the bulk density of the specimens at temperatures from 100 to 360 K.

- CCE Spec. 1
- CCE Spec. 2
- CCE Spec. 3
- CCE Spec. 4
- CCE Spec. 5
+ CBT

\[ 2s = 2.1\% \]
Figure 3  Thermal conductivity as a function of temperature at a density of 13 kg/m³ as calculated from equation (1).
Figure 4  Thermal conductivity as a function of bulk density at a temperature of 300 K as calculated from equation (1).
Figure 5 Comparison of equation (1) to previously published equations as a function of temperature at a density of 14.75 kg/m$^3$. Percent Difference = $(\lambda_i - \lambda_{\text{eq.1}})100/\lambda_{\text{eq.1}}$.

- $\bigcirc$ Round Robin Model [11]
- $\triangle$ Smith and Hust [9,10]
Figure 6  Comparison of equation (1) to previously published equations as a function of density at a temperature of 297 K. Percent Difference = \( \frac{(\lambda_i - \lambda_{\text{eq},i})}{\lambda_{\text{eq},i}} \times 100\% \).  

▼ - GHP [12]  
◇ - HFM [12]  
+ - HFM [14]
used for this SRM, the difference as a function of density is probably an indication of measurement uncertainty.

The supplier of this material performed numerous characterization measurements at a temperature of 297 K using heat flow meter apparatuses of various sizes. They reported that the following equation described their apparent thermal conductivity values as a function of density, \( \rho \), within the imprecision of the data: 

\[ \lambda = 28.57 + 179.6/\rho \]

where \( \lambda \) is in mW m\(^{-1}\) K\(^{-1}\) and \( \rho \) is in kg/m\(^3\). Calculated values from this equation are compared to equation (1) in figure 6. This curve is nearly parallel to the curve for the round robin equation [11]. Since the round robin equation is based on NBS data, a systematic difference between the supplier's measurements and NBS measurements is noted.

Another comparison that is useful for SRM utilization is with respect to the equation presented by Rennex [12], \( \lambda = 25.3 + 212/\rho \), for the CBT GHP data at a temperature of 297 K. Figure 6 shows that the equation presented by Rennex differs by less than 1% from equation (1).

The NBS-HFM apparatus with plate dimensions of 61 x 61 cm (24 x 24 in) and meter dimensions of 25 x 25 cm (10 x 10 in) was used to measure 75 specimens from this lot at 297 K. Rennex [12] reported these data and an equation describing the data to within about ±2%. This equation, \( \lambda = 24 + 229/\rho \), is compared to equation (1) in figure 6. The deviations of the two equations are well within 1% at the low density end, but exceed 1% at the higher densities.

6. Certified Values

For certification purposes, values of thermal resistance, \( R \), are desirable. Values of \( R \) at a thickness of 2.54 cm (1 in), \( R_0 \), calculated from equation (2) are listed in Table 4 in units of m\(^2\) K W\(^{-1}\).

\[ R_0 = 0.0254/\lambda(T,\rho) \]  

(2)

The as-tested thickness will most likely be slightly different from 2.54 cm. The \( R \) values at different thicknesses, \( L \), are calculated from

\[ R = R_0 L/0.0254 \]  

(3)

where \( R \) is the thermal resistance at the tested thickness, and \( R_0 \) is the certified value interpolated from the table or calculated from equation (2).

It should be noted that this material is certified only for thicknesses within the range of the tests reported, nominally 2.54 cm (1 in). The specimens should be in good contact with the apparatus plates, but compression to a thickness less than 2.4 cm should be avoided. Reference 13 may aid the user in connection with the compression properties and homogeneity of this material.

Values of thermal resistance of this SRM are expected to be within 3% of the computed values at temperatures from 250 to 330 K, and increasing to 5% at 100 K. These estimates are based on the experimental data and include both material variability and measurement uncertainty.
Table 4. Certified Values of Thermal Resistance of a 2.54 cm Thick Specimen, $R_0$, as a Function of Density and Temperature. (These values have been corrected for the thermal expansion of the measurement plates.)

<table>
<thead>
<tr>
<th>Temperature (K)</th>
<th>Density (kg·m$^{-3}$)</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2.475*</td>
<td>2.443</td>
<td>2.403</td>
<td>2.358</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>2.219</td>
<td>2.202</td>
<td>2.176</td>
<td>2.144</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>2.000</td>
<td>1.995</td>
<td>1.979</td>
<td>1.957</td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>1.812</td>
<td>1.816</td>
<td>1.809</td>
<td>1.795</td>
<td></td>
</tr>
<tr>
<td>140</td>
<td>1.649</td>
<td>1.661</td>
<td>1.661</td>
<td>1.654</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>1.508</td>
<td>1.526</td>
<td>1.532</td>
<td>1.530</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>1.386</td>
<td>1.409</td>
<td>1.420</td>
<td>1.422</td>
<td></td>
</tr>
<tr>
<td>170</td>
<td>1.279</td>
<td>1.306</td>
<td>1.321</td>
<td>1.328</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>1.185</td>
<td>1.216</td>
<td>1.234</td>
<td>1.244</td>
<td></td>
</tr>
<tr>
<td>190</td>
<td>1.102</td>
<td>1.136</td>
<td>1.157</td>
<td>1.170</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>1.027</td>
<td>1.064</td>
<td>1.088</td>
<td>1.104</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>0.960</td>
<td>0.999</td>
<td>1.026</td>
<td>1.043</td>
<td></td>
</tr>
<tr>
<td>220</td>
<td>0.898</td>
<td>0.939</td>
<td>0.968</td>
<td>0.988</td>
<td></td>
</tr>
<tr>
<td>230</td>
<td>0.842</td>
<td>0.884</td>
<td>0.914</td>
<td>0.936</td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>0.789</td>
<td>0.832</td>
<td>0.864</td>
<td>0.887</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>0.739</td>
<td>0.783</td>
<td>0.816</td>
<td>0.841</td>
<td></td>
</tr>
<tr>
<td>260</td>
<td>0.693</td>
<td>0.737</td>
<td>0.77</td>
<td>0.796</td>
<td></td>
</tr>
<tr>
<td>270</td>
<td>0.650</td>
<td>0.694</td>
<td>0.728</td>
<td>0.754</td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>0.609</td>
<td>0.653</td>
<td>0.688</td>
<td>0.715</td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>0.571</td>
<td>0.615</td>
<td>0.649</td>
<td>0.677</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>0.536</td>
<td>0.579</td>
<td>0.613</td>
<td>0.641</td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>0.503</td>
<td>0.546</td>
<td>0.580</td>
<td>0.607</td>
<td></td>
</tr>
<tr>
<td>320</td>
<td>0.472</td>
<td>0.514</td>
<td>0.548</td>
<td>0.575</td>
<td></td>
</tr>
<tr>
<td>330</td>
<td>0.444</td>
<td>0.485</td>
<td>0.518</td>
<td>0.545</td>
<td></td>
</tr>
</tbody>
</table>

*R_0* values are in units of m$^2$·K·W$^{-1}$
7. Summary

Measurements and data analysis are presented to establish a lot of glass fiberblanket as an SRM of thermal resistance for temperatures from 100 to 330 K and densities from 10 to 16 kg/m³. A model is presented that describes the data over the above temperature and density range to within the imprecision of the data. Comparisons to previously published values for similar material are presented.

8. Acknowledgments

This project has extended over a period of several years. During this time numerous people have contributed to this effort. B. Rennex performed the measurements attributed to CBT in this report. D. R. Smith and L. Van Poolen conducted some of the measurements attributed to CCE. Keith Kirby and Lee Kieffer provided support through the Office of Standard Reference Materials, OSRM. In addition, funding was supplied by the Department of Energy (DoE, ORNL) with the guidance of Ted Lundy and Dave McElroy.

9. References


**4. TITLE AND SUBTITLE**
Standard Reference Materials:
Glass Fiberblanket SRM for Thermal Resistance

**5. AUTHOR(S)**
J. G. Hust

**9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)**
NATIONAL BUREAU OF STANDARDS
U.S. DEPARTMENT OF COMMERCE
GAIJTHERSBURG, MD 20899

**10. SUPPLEMENTARY NOTES**
Library of Congress Catalog Card Number: 85:600582

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

**11. ABSTRACT**
(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

The apparent thermal conductivity data that provide the basis for the certification of glass fiberblanket as an SRM of thermal resistance are reported and analyzed. Detailed analysis and intercomparisons of NBS and other published data are given. These data are represented by an equation describing the dependencies of the data on temperature and density. Certified values of thermal resistance are given for temperatures from 100 to 330 K and densities from 10 to 16 kg/m³.

**12. KEY WORDS**
Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons
apparent thermal conductivity; density; glass fiberblanket; Standard Reference Material; temperature; thermal resistance

**13. AVAILABILITY**
☐ Unlimited
☐ For Official Distribution. Do Not Release to NTIS
☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

**14. NO. OF PRINTED PAGES**
27

**15. Price**
USCOMM-DC 6043-P80
Technical Publications

Periodicals

Journal of Research—The Journal of Research of the National Bureau of Standards reports NBS research and development in those disciplines of the physical and engineering sciences in which the Bureau is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Bureau’s technical and scientific programs. Issued six times a year.

Nonperiodicals

Monographs—Major contributions to the technical literature on various subjects related to the Bureau’s scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Applied Mathematics Series—Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world’s literature and critically evaluated. Developed under a worldwide program coordinated by NBS under the authority of the National Standard Data Act (Public Law 90-396). NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20036.

Building Science Series—Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NBS administers this program as a supplement to the activities of the private sector standardizing organizations.

Consumer Information Series—Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today’s technological marketplace.


Order the following NBS publications—FIPS and NBSIR’s—from the National Technical Information Service, Springfield, VA 22161.


NBS Interagency Reports (NBSIR)—A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche form.