NBS COLLABORATIVE REFERENCE PROGRAM
FOR
THERMAL INSULATION MATERIALS

THERMAL CONDUCTIVITY
REPORT NO. 1

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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NBS COLLABORATIVE REFERENCE PROGRAM FOR THERMAL INSULATION MATERIALS

THERMAL CONDUCTIVITY REPORT NO. 1

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FORWARD

On January 18, 1979, the U.S. Department of Commerce under its National Voluntary Laboratory Accreditation Program (NVLAP), published final criteria for accrediting laboratories that test thermal insulation materials. A portion of the accreditation requirement involves proficiency sample testing. An NBS Collaborative Reference Program (CRP) has been established to fulfill a part of the proficiency testing requirements of NVLAP.

> Detailed information about the NVLAP for Thermal Insulation was published in the Federal Register, vol. 44, No. 13, Thursday, January 18, 1979, pages 3886-3906. Copies are available from NVLAP, Room B06 Bldg 225, National Bureau of Standards, Washington, DC 20234.

THE PROGRAM

Although independent of the National Voluntary Laboratory Accreditation Program, this CRP provides a vehicle for laboratories to fulfill the NVLAP proficiency testing requirement. Laboratories interested in comparing test results independently of NVLAP and those laboratories wishing to determine their readiness to seek accreditation before formally applying to NVLAP are encouraged to participate in this CRP. For those laboratories seeking NVLAP accreditation, data and laboratory identity will be provided by the CRP program directly to NVLAP. For those laboratories who are solely in the CRP, identity will remain anonymous.

SPONSORS

The Collaborative Reference Program for Thermal Insulation is cosponsored by the National Bureau of Standards and by Collaborative Testing Services, Inc (CTS). CTS is a non-profit organization of associations that offers CRPs to a wide range of industries.

WHAT EXACTLY IS A COLLABORATIVE REFERENCE PROGRAM?

A Collaborative Reference Program is a periodic interlaboratory testing program that provides each participant with checks on its testing performance. It is conducted on a periodic schedule and involves the distribution of specially prepared samples to participating laboratories. The samples are tested by the participants in accordance with designated standard test methods and the results are reported to NBS for statistical evaluation. This program provides each participating laboratory with a critical evaluation, in report form, of its testing performance in terms of accuracy and precision, and permits a comparison of its performance with that of other participating laboratories.

BOARD AND BLOCK

The test for thermal conductivity of board-type material was conducted using a single specimen of polystyrene beadboard for each participating laboratory. Participants were asked to test the material using either one of two test methods, ASTM C177-76 or ASTM C518-76, at a mean test temperature of approximately 75 degrees F.

A total of 28 laboratory results were reported (see Table 1 and Key To Tables). Results from laboratories A921A and A921B were received too late for inclusion in the group statistics. Among the data reported on time, the results for laboratory A915 were determined to be outside the statistical limits for inclusion in the group statistics. Data excluded from the group statistics are flagged with an "X".

For the 25 results included, the average k value (GRAND MEAN) is 0.2641 BTU·inch / hour·ft^2·degree F. The standard deviation among laboratory results (SD MEAN) is 0.0078, or approximately 3% of the GRAND MEAN. The GRAND MEAN expressed in SI units is 0.0381 watt / meter·degree K.

TABLE 1

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BOARD AND BLOCK CRP NO. 1

LAB CODE	ASTM TEST METHOD	k VALUE	NORMAL DEVIATE
A901A	C518-76	.267	0.37
A901B	C518-76	.275	1.40
A901C	C518-76	.265	0.12
A901D	C177-76	.267	0.37
A901E	C177-76	.272	1.01
A901F	C177-76	.271	0.88
A903	C518-76	.260	-0.53
A904	C177-76	.257	-0.91
A906A	C518-76	.257	-0.91
A906B	C518-76	.272	1.01
A907	C518-76	.261	-0.40
A908A	C518-76	.274	1.27
A908B	C518-76	.275	1.40
A909	C518-76	.253	-1.42
A910	C518-76	.275	1.40
A911	C518-76	.260	-0.53
A912	C518-76	.272	1.01
A914	C518-76	.256	-1.03
A915	C177-76	.314 X	6.40
A916	C518-76	.263	-0.14
A919	C177-76	.259	-0.65
A920	C518-76	.257	-0.91
A921A	C518-76	.252 X	-1.55
A921B	C518-76	.253 X	-1.42
A922	C518-76	.271	0.88
A924A	C177-76	.273	1.14
A924B	C177-76	.272	1.01
A925	C518-76	.259	-0.65
GRAND MEAN		.2641	
SD MEAN		.0078	

LOOSE FILL

The test for thermal conductivity of loose fill-type insulation was conducted using two specimens of shredded cellulosic material for each participating laboratory. This material, which was not an insulation product, is similar to cellulosic insulation in its thermal properties. Participants were asked to test the material using either one of two test methods, ASTM C177-76 or ASTM C518-76, at a mean test temperature of approximately 75 degrees F.

A total of 15 laboratory results were reported (see Table 2 and Key To Tables). Each laboratory made two test determinations, one on each of two test specimens from the same lot of material. The table gives the average for the two determinations (k VALUE) for each laboratory and the average over all laboratories (GRAND MEAN). The GRAND MEAN is 0.2767 BTU·inch / hour·ft^2·degree F. The standard deviation among laboratory results (SD Mean) is 0.0062 or approximately 2.2% of the GRAND MEAN. The GRAND MEAN expressed in SI units is 0.0399 watt / meter·degree K.

Also shown in the table are the within laboratory standard deviations (WITHIN LAB STD DEV) and the ratios of these to the average of the within laboratory standard deviations (RELATIVE STD DEV). Considering that only two replicate determinations were made by each laboratory, none of the WITHIN LAB STD DEV values is extreme.

TABLE 2

NBS COLLABORATIVE REFERENCE PROGRAM
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LOOSE FILL CRP NO. 1

LAB CODE	ASTM TEST METHOD	k VALUE (average k)	NORMAL DEVIATE	WITHIN LAB STD DEV	RELATIVE STD DEV
A901A	C518-76	.2670	-1.57	0.0042	1.89
A901B	C518-76	.2675	-1.49	0.0007	0.32
A901C	C177-76	.2715	-0.84	0.0021	0.95
A902	C177-76	.2790	0.37	0.0028	1.26
A903A	C518-76	.2750	-0.28	0.0014	0.63
A903B	C177-76	.2890	1.98	0.0028	1.26
A904A	C177-76	.2740	-0.44	0.0014	0.63
A904B	C518-76	.2785	0.29	0.0007	0.32
A906	C518-76	.2770	0.04	0.0014	0.63
A911	C518-76	.2800	0.53	0.0014	0.63
A913	C518-76	.2785	0.29	0.0049	2.21
A914	C518-76	.2720	-0.76	0.0028	1.26
A923	C177-71	.2850	1.33	0.0042	1.89
A925	C518-76	.2735	-0.52	0.0007	0.32
A926	C518-76	.2835	1.09	0.0021	0.95
GRAND MEAN		.2767	AVERAGE	.0022	
SD MEAN		.0062			

BATT AND BLANKET

The test for thermal conductivity of batt type material was conducted using specimens of fiberglass from a reference collection of pre-characterized one-inch thick batts. Participants were asked to test the material using either one of two test methods, ASTM C177-76 or ASTM C518-76, at a mean test temperature of approximately 75 degrees F. Each batt in the reference collection has a different k value which has been determined by prior testing. Because the k value for each batt must remain confidential, this report does not show the laboratory test values nor does it show the actual percent deviations. Instead it shows the magnitudes of the percent deviations from the actual k values (see Table 3).

Each laboratory was sent batts in two different ranges, .31 to .33 and .26 to .29 BTU·inch / hour·ft^2·degree F. Results of tests on batts in the higher range are shown in Column A and the lower range in Column B.

The data shown for each laboratory is based on the percent deviation of the laboratory results from the predetermined actual value.

$$\text{percent deviation} = \left\{\frac{\text{Lab value - actual value}}{\text{actual value}}\right\} \cdot 100$$

In order not to divulge the actual values for the batts, the table only shows how close the laboratory came to the actual value within four ranges expressed as percent deviations from actual; -2% to +2%, -4% to +4%, -6% to +6%, and beyond -6% or +6%. A deviation beyond 6% (>6%) may mean that the laboratory is not following the standard procedure or that the laboratory has a calibration problem.

TABLE 3

NBS COLLABORATIVE REFERENCE PROGRAM
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BATT AND BLANKET CRP NO. 1

LAB CODE	ASTM TEST METHOD	MAGNITUDE OF PERCENT DEVIATION FROM ACTUAL k VALUE COLUMN A	COLUMN B
A901A	C177-76	2%	2%
A901B	C518-76	4%	2%
A902	C177-76	2%	4%
A903A	C518-76	2%	2%
A903B	C518-76	2%	4%
A904	C177-76	>6%	4%
A905	C518-76	4%	4%
A906A	C518-76	4%	2%
A906B	C518-76	6%	2%
A907	C518-76	4%	4%
A908A	C518-76	2%	2%
A908B	C518-76	2%	2%
A909	C518-76	6%	>6%
A910	C518-76	2%	4%
A911	C518-76	4%	4%
A912	C518-76	2%	2%
A913	C518-76	2%	2%
A914	C518-76	2%	2%
A915	C177-76	>6%	>6%
A916	C518-76	2%	2%
A917	C518-76	2%	2%
A918	C518-76	4%	4%
A919	C177-76	>6%	>6%
A920	C518-76	2%	2%
A921	C518-76	2%	2%
A922	C518-76	2%	2%
A923	C177-71	6%	6%
A924	C518-76	2%	4%
A925	C518-76	2%	2%
A926	C518-76	4%	2%

KEY TO TABLES

Column Heading

LAB CODE — A confidential laboratory indentification number known only by the participant and the Collaborative Reference Program staff.

ASTM TEST METHOD — ASTM test method used by the laboratory.

TABLE 1 - BOARD AND BLOCK

k VALUE — Thermal conductivity value for the single test measurement made by each laboratory.

GRAND MEAN (of k VALUE) — The average of the k values reported by the laboratories, excluding those flagged with an "X". This number is used as the "best estimate" of the k value for the sample material.

SD MEAN — The standard deviation of the k values about the GRAND MEAN. This number is an indication of the spread of results among the laboratories.

NORMAL DEVIATE — The normal deviate (normalized deviation of laboratory result from GRAND MEAN) is an indication of how far the laboratory results are from the GRAND MEAN. The sign shows whether the laboratory is high (+) or low(−). The magnitude shows how many standard deviations the laboratory is from the GRAND MEAN. A normal deviate of greater than ±2 may mean that the laboratory is not following the standard procedure or that the laboratory has a calibration problem.

$$\text{Normal Deviate} = \frac{\text{k VALUE} - \text{GRAND MEAN}}{\text{SD MEAN}}$$

X — The data marked with an X are not included in the GRAND MEAN nor in the SD MEAN because that data were reported late or the data were determined to be outside the statistical limits for inclusion.

TABLE 2 - LOOSE FILL

k VALUE — This is the calculated average of the two test determinations reported by each laboratory.

GRAND MEAN (of k VALUE) — The average of the k VALUES. This number is used as the "best estimate" of the k value for the sample material.

KEY TO TABLES continued

SD MEAN	The standard deviation of the k VALUEs about the GRAND MEAN. This number is an indication of the spread of results among the laboratories.
NORMAL DEVIATE	see under Table 1
WITHIN LAB STD DEV	The standard deviation of the two test determinations reported by each laboratory. This number is an indication of the spread of results within each laboratory.
AVERAGE (within lab std dev)	The average of the within laboratory standard deviations. This number is an indication of the within laboratory precision of repeated measurements.
RELATIVE STD DEV	The ratio of the within laboratory standard deviations to the AVERAGE for all laboratories. This number is an indication of the ability of the laboratory to repeat its measurements relative to the average ability. A relative standard deviation of less than 0.01 or greater than 3.37 indicates that the laboratory may not be following the procedure considered standard for this analysis.

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15. SUPPLEMENTARY NOTES

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

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

Collaborative Reference Programs provide participating laboratories with the means for checking periodically the level and uniformity of their testing in comparison with that of other participating laboratories. An important by-product of the programs is the provision of realistic pictures of the state of the testing art. This is one of the periodic reports showing averages for each participant, within and between laboratory variability, and other information for participants and standards committees.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Collaborative reference program; Laboratory evaluation; Thermal insulation; Reference samples

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