



Standard Practice for Calibration of the Heat Flow Meter Apparatus¹

This standard is issued under the fixed designation C 1132; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers a means for calibration of the heat flow meter apparatus in conjunction with Test Method C 518. The apparatus shall be calibrated as a unit, with the heat flux transducer(s) installed in the apparatus using either standard reference materials (SRM), calibrated transfer specimens (CTS), or other appropriate reference standards.

1.2 This practice applies to the calibration of a heat flow meter apparatus over a wide range of heat flow rates and temperatures that permits the testing of a wide variety of insulation materials over an extended temperature range. It is applicable to materials with the same requirements and temperature ranges allowed in Test Method C 518.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- C 168 Terminology Relating to Thermal Insulating Materials²
- C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus²
- C 518 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus²
- E 178 Practice for Dealing with Outlying Observations³

3. Terminology

3.1 Definitions:

3.1.1 *calibrated transfer specimen (CTS)*—a thermal calibration specimen that has been measured by a national standards laboratory (1).⁴

¹ This practice is under the jurisdiction of ASTM Committee C-16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.30 on Thermal Measurement.

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² Annual Book of ASTM Standards, Vol 04.06.

³ Annual Book of ASTM Standards, Vol 14.02.

⁴ The boldface numbers in parentheses refer to the references at the end of this practice.

3.1.2 *standard reference material (SRM)*—a lot of material that has been characterized by a national standards laboratory (1).

3.1.3 For definitions of other terms used in this practice, refer to Terminology C 168 and Test Method C 518.

3.2 Symbols: Symbols:

C = thermal conductance, $W/m^2 \cdot K$ (Btu/hr·ft²·F)

E = heat flux transducer output, V

S = calibration factor of heat flow meter apparatus, $(W/m^2)/V$ ((Btu/hr·ft²)/V)

T = temperature, K (F)

3.2.1 Subscripts:

a, b = first, second specimen

c = cold

h = hot

4. Significance and Use

4.1 This practice is used to compute the calibration factor, S , for a heat flow meter apparatus in conjunction with Test Method C 518.

4.2 This practice shall be used to produce meaningful heat flux measurements from a heat flow meter apparatus (Test Method C 518).

4.3 The heat flow meter apparatus is a secondary (relative) apparatus requiring calibration to a primary (absolute) apparatus, which is usually a guarded hot plate (Test Method C 177). Therefore, the accuracy of the heat flow meter is no better than the accuracy of the primary apparatus used to measure the calibration standards.

4.4 The heat flow meter apparatus is widely used because it is fast, inexpensive to operate, and is applicable to a wide range of test specimens. The precision and bias of the heat flow meter apparatus can be excellent if calibration is carried out within the range of heat flows expected. This means calibration shall be carried out with similar types of materials, of similar thermal conductances, at similar thicknesses, mean temperatures, and temperature gradients, as expected for the test specimens. Errors can be significant for measurements outside the range of the calibration parameters. At the present time there is no definitive method of determining similarity of standards to test specimens, so engineering judgment shall be used. As additional standards become available, the user should

review them for similarity to the test specimens.

5. Calibration Standards

5.1 Calibration standards may be good for many years if handled carefully. To confirm their stability, they shall be checked periodically by either comparing to other standards using Test Method C 518 or verifying independently using Test Method C 177.

5.2 It is recommended that the standards obtained from a national standards laboratory should not be used on a daily basis, but secondary or working standards should be produced. Create a record on the secondary standards with the following information:

- 5.2.1 Name of national standards laboratory to which the secondary standard is traceable,
- 5.2.2 Date the secondary standard was produced,
- 5.2.3 Date the secondary standard was last tested,
- 5.2.4 Thermal value of the secondary standard,
- 5.2.5 Range of parameters for which it is valid, and
- 5.2.6 Estimate of bias of the primary and secondary standard.

6. Procedure

6.1 Calibrate the heat flow meter apparatus under the same conditions of plate temperatures, specimen thickness, heat flow direction, and apparatus orientation as those for which calibration data are available.

6.2 The heat flow meter apparatus should be used under the same conditions as those for which it was calibrated.

6.3 An assessment of the sensitivity of the calibration standard to test conditions should be supplied by the source of the transfer standard to determine its limitation of use.

6.4 *One or Two Temperature Points*—If the calibration standard was tested at one or two mean temperatures, conduct the calibration and subsequent tests at the same mean temperatures.

6.5 *Multiple Temperature Points*—If the calibration standard is tested at three or more mean temperatures, calibrate the heat flow meter apparatus at the same mean temperatures using the same temperature gradients (2). A smooth curve can be fitted to the points such that a calibration factor can be interpolated for any given mean temperature. It is not permissible to extrapolate above or below the mean temperature range of the calibration standard measurements. Changing the plate temperatures of a heat flow meter apparatus has the potential of changing apparatus calibration. When changing temperatures, take steps to determine if the heat flux transducer sensitivity has changed.

6.6 *One or Two Thickness Points*—If calibration standards are available at one or two thicknesses, the heat flow meter apparatus can be calibrated for those thicknesses without an exhaustive thickness study. If tests are to be conducted at thicknesses other than the calibrated thicknesses, make a thorough study of the error of the heat flow meter apparatus at other thicknesses. Several references on this subject are given at the end of this practice (2-6).

6.7 *Multiple Thickness Points*—If calibration standards are available at three or more thicknesses, the heat flow meter apparatus can be calibrated over the same thickness range. A

smooth curve can be fitted to the points such that a calibration factor can be interpolated for any given thickness. If tests are to be conducted at thicknesses above or below the calibrated thicknesses, make a thorough study of the error of the heat flow meter apparatus at these thicknesses.

7. Calibration Calculation

7.1 This section contains the equations for calculating the calibration factor of the apparatus design configurations allowed in Test Method C 518. The calibration and testing configurations should be identical. The calibration factor of a heat flow meter is determined by running the same standard specimen a number of times, not consecutively, but over a period of time.

7.1.1 *One Calibration Standard*—Apparatus with one heat flux transducer and one specimen (see Fig. 1).

$$S = \frac{C}{E(T_h - T_c)} \quad (1)$$

7.1.2 *Two Calibration Standards*—Apparatus with one heat flux transducer and one specimen configuration (apparatus is the same as in 7.1).

7.1.2.1 The two calibration standards need to be the same thickness and of similar material, but they need not be identical. With this equation, it is not necessary to know the thermal conductance of each calibration standard, but it is necessary to know the average thermal conductance of the two specimens (such as would be known if the standards were a Test Method C 177 pair).

$$S = \frac{C_a + C_b}{E\left(\frac{1}{(T_{ha} - T_{ca})} + \frac{1}{(T_{hb} - T_{cb})}\right)} \quad (2)$$

7.1.3 *Two Calibration Standards*—Apparatus with one heat flux transducer and two specimens (see Fig. 2).

7.1.3.1 Again, the specimens need to be the same thickness and of similar material but not necessarily identical.

$$S = \frac{C_a + C_b}{E\left(\frac{1}{(T_{ha} - T_{ca})} + \frac{1}{(T_{hb} - T_{cb})}\right)} \quad (3)$$

7.1.4 *One Calibration Standard*—Apparatus with two heat flux transducers and one specimen (see Fig. 3).

$$S = \frac{C}{E\left(\frac{E_1 + E_2}{T_h - T_c}\right)} \quad (4)$$

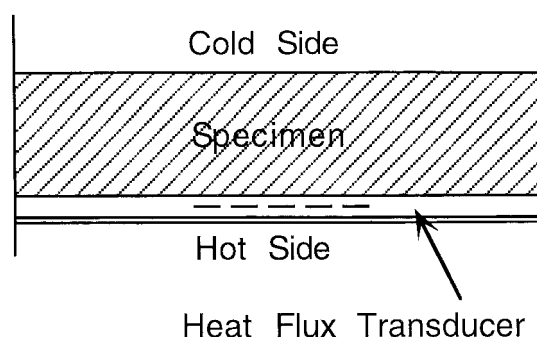


FIG. 1 Apparatus with One Heat Flux Transducer and One Specimen Configuration