INTERNATIONAL

Designation: C1130 – 24

Standard Practice for Calibration of Thin Heat Flux Transducers[1]

This standard is issued under the fixed designation C1130; 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, in conjunction with either Test Method C177, C518, C1114, or C1363, establishes procedures for the calibration of heat flux transducers that are dimensionally thin in comparison to their planar dimensions.

1.1.1 The thickness of the heat flux transducer shall be less than 30 % of the narrowest planar dimension of the heat flux transducer.

1.2 This practice describes techniques for determining the sensitivity, *S*, of a heat flux transducer when subjected to one dimensional heat flow normal to the planar surface or when installed in a building application.

1.3 This practice shall be used in conjunction with Practice C1046 and Practice C1155 when performing in-situ measurements of heat flux on opaque building envelope components. This practice is comparable, but not identical, to the calibration techniques described in ISO 9869-1.

1.4 This practice is not intended to determine the sensitivity of heat flux transducers used as components of heat flow meter apparatus, as in Test Method C518, or used for in-situ industrial applications, as covered in Practice C1041.

1.5 This practice does not preclude the laboratory calibration of heat flux transducers for large-scale insulation systems operated at temperatures lower or higher than that for building envelope components. For these applications, the heat flux transducers shall be calibrated at the temperatures that the transducer will be used.

1.5.1 For cryogenic applications, the test apparatuses described in Guide C1774 are acceptable methods for calibration.

1.6 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.7 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses are provided for information only and are not considered standard.

1.8 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation
C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
C1041 Practice for In-Situ Measurements of Heat Flux in Industrial Thermal Insulation Using Heat Flux Transducers (Withdrawn 2019)[3]
C1044 Practice for Using a Guarded-Hot-Plate Apparatus or Thin-Heater Apparatus in the Single-Sided Mode
C1046 Practice for In-Situ Measurement of Heat Flux and Temperature on Building Envelope Components
C1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus
C1155 Practice for Determining Thermal Resistance of Building Envelope Components from the In-Situ Data
C1363 Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
C1774 Guide for Thermal Performance Testing of Cryogenic Insulation Systems

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

Current edition approved March 15, 2024. Published March 2024. Originally approved in 1989. Last previous edition approved in 2021 as C1130 – 21. DOI: 10.1520/C1130-24.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

2.2 *ISO Standards:*[4]

ISO 9869-1 Thermal insulation – Building elements – In-situ measurement of thermal resistance and thermal transmittance – Part 1: Heat flow meter method

3. Terminology

3.1 *Definitions*—For definitions of terms relating to thermal insulating materials, see Terminology C168.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *mask*—material (or materials) having the same, or nearly the same, thermal properties and thickness surrounding the heat flux transducer thereby promoting one-dimensional heat flow through the heat flux transducer.

3.2.2 *R-squared* (R^2)—coefficient of determination (also known as "goodness of fit") is a statistical measure of how close the data are to the fitted line.

3.2.3 *sensitivity*—the ratio of the electrical output of the heat flux transducer to the heat flux passing through the device when measured under steady-state heat flow.

3.2.4 *test stack*—a layer or a series of layers of material put together to comprise a test sample (for example, a roof system containing a membrane, an insulation, and a roof deck).

3.3 *Symbols:*

3.3.1 E—measured HFT output voltage, V.

3.3.2 q—steady-state heat flux, W/m^2 (Btu/h·ft^2).

3.3.3 S—sensitivity, V/(W/m^2) (V/(Btu/h·ft^2)).

3.3.4 u_c—combined standard uncertainty, V.

3.3.5 u_1—standard uncertainty of the regression coefficients, V.

3.3.6 u_2—standard uncertainty for replicate measurements, V.

3.3.7 u_3—standard uncertainty for the measurement, V.

4. Summary of Practice

4.1 This practice presents three techniques for the laboratory calibration of heat flux transducers (**1**)[5]: *(1)* ideally guarded; *(2)* embedded; and, *(3)* surface mounted. These techniques establish a hierarchy defined by the extent that the assumption of one-dimensional heat flow is satisfied (**1**).

4.1.1 The ideally-guarded technique places the heat flux transducer (HFT) in a test stack consisting of homogeneous, thermally characterized materials that promotes one-dimensional heat flow normal to the planar dimensions of the HFT. The results of this technique provide a baseline calibration for the HFT.

4.1.2 The embedded technique places the HFT within a test stack consisting of material layers identical, or comparable to, the building construction to be studied under application.

4.1.3 The surface mounted calibration, which is the most complex, places the HFT on the external surface of a test stack and incorporates environmental effects that cause lateral heat flow in the locality of the HFT.

4.2 The calibration results are intended for use with Practice C1046 to measure in-situ the heat flux through opaque building envelope components and with Practice C1155 for the subsequent analysis of the measurement data. The intended application of the HFT is used to determine the appropriate calibration technique (**2**).

4.2.1 If the HFT is to be embedded in the building envelope, the HFT shall be calibrated in a test stack of materials that simulate the surrounding construction materials.

4.2.2 If the HFT is to be surface mounted on the building envelope construction, the HFT shall be calibrated using a hot box that is oriented similarly (horizontal, vertical, or inclined) as the measurement site.

5. Significance and Use

5.1 The application of HFTs and temperature sensors to building envelopes provide in-situ data for evaluating the thermal performance of an opaque building envelope component under actual environmental conditions, as described in Practices C1046 and C1155. These applications require calibration of the HFTs at levels of heat flux and temperature consistent with end-use conditions.

5.2 This practice provides calibration procedures for the determination of the heat flux transducer sensitivity, S, that relates the HFT voltage output, E, to a known input value of heat flux, q.

5.2.1 The applied heat flux, q, shall be obtained from steady-state tests conducted in accordance with either Test Method C177, C518, C1114, C1363, or, for cryogenic applications, Guide C1774.

5.2.2 The resulting voltage output, E, of the heat flux transducer is measured directly using (auxiliary) readout instrumentation connected to the electrical output leads of the sensor.

NOTE 1—A heat flux transducer (see also Terminology C168) is a thin stable substrate having a low mass in which a temperature difference across the thickness of the device is measured with thermocouples connected electrically in series (that is, a thermopile). Commercial HFTs typically have a central sensing region, a surrounding guard, and an integral temperature sensor that are contained in a thin durable enclosure. Practice C1046, Appendix X2 includes detailed descriptions of the internal constructions of two types of HFTs.

5.3 The HFT sensitivity depends on several factors including, but not limited to, size, thickness, construction, temperature, applied heat flux, and application conditions including adjacent material characteristics and environmental effects.

5.4 The subsequent conversion of the HFT voltage output to heat flux under application conditions requires *(1)* a standardized technique for determining the HFT sensitivity for the application of interest; and, *(2)* a comprehensive understanding of the factors affecting its output as described in Practice C1046.

5.5 The installation of a HFT potentially changes the local thermal resistance of the test artifact and the resulting heat flow

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[5] The boldface numbers in parentheses refer to the references at the end of this standard.