Designation: C1363 − 24

Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus[1]

This standard is issued under the fixed designation C1363; 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 test method establishes the principles for the design of a hot box apparatus and the minimum requirements for the determination of the steady state thermal performance of building assemblies when exposed to controlled laboratory conditions. This method is also used to measure the thermal performance of a building material at standardized test conditions such as those required in material Specifications C739, C764, C1224 and Practice C1373.

1.2 This test method is used for large homogeneous or non-homogeneous specimens. This test method applies to building structures or composite assemblies of building materials for which it is possible to build a representative specimen that fits the test apparatus. The dimensions of specimen projections or recesses are controlled by the design of the hot box apparatus. Some hot boxes are limited to planar or nearly planar specimens. However, larger hot boxes have been used to characterize projecting skylights and attic sections. See 3.2 for a definition of the test specimen and other terms specific to this method.

NOTE 1—This test method replaces Test Methods C236, the Guarded Hot Box, and C976, the Calibrated Hot Box which have been withdrawn. Test apparatus designed and operated previously under Test Methods C236 and C976 will require slight modifications to the calibration and operational procedures to meet the requirements of Test Method C1363.[2]

1.3 A properly designed and operated hot box apparatus is directly analogous to the Test Method C177 guarded hot plate for testing large specimens exposed to air induced temperature differences. The operation of a hot box apparatus requires a significant number of fundamental measurements of temperatures, areas and power. The equipment performing these measurements requires calibration to ensure that the data are accurate. During initial setup and periodic verification testing, each measurement system and sensor is calibrated against a standard traceable to a national standards laboratory. If the hot box apparatus has been designed, constructed and operated in the ideal manner, no further calibration or adjustment would be necessary. As such, the hot box is considered a primary method and the uncertainty of the result is analyzed by direct evaluation of the component measurement uncertainties of the instrumentation used in making the measurements.

1.3.1 In an ideal hotbox test of a homogenous material there is no temperature difference on either the warm or cold specimen faces to drive a flanking heat flow. In addition, there would be no temperature differences that would drive heat across the boundary of the metering chamber walls. However, experience has demonstrated that maintaining a perfect guard/metering chamber balance is not possible and small corrections are needed to accurately characterize all the heat flow paths from the metering chamber. To gain this final confidence in the test result, it is necessary to benchmark the overall result of the hot box apparatus by performing measurements on specimens having known heat transfer values and comparing those results to the expected values.

1.3.2 The benchmarking specimens are homogeneous panels whose thermal properties are uniform and predictable. These panels, or representative sections of the panels, have had their thermal performance measured on other devices that are directly traceable or have been favorably compared to a national standards laboratory. For example, a Test Method C177 Hot Plate, a Test Method C518 Heat Meter or another Test Method C1363 Hot Box will provide adequate specimens. Note that the use of Test Method C518 or similar apparatus creates additional uncertainty since those devices are calibrated using transfer standards or standard reference materials. By performing this benchmarking process, the hot box operator is able to develop the additional equations that predict the magnitude of the corrections to the net heat flow through the specimen that account for any hot box wall loss and flanking loss. This benchmarking provides substantial confidence that any extraneous heat flows can be eliminated or quantified with sufficient accuracy to be a minor factor of the overall uncertainty.

1.4 In order to ensure an acceptable level of result uncertainty, persons applying this test method must possess a knowledge of the requirements of thermal measurements and

[1] This test method 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 1, 2024. Published March 2024. Originally approved in 1997. Last previous edition approved in 2019 as C1363 – 19. DOI: 10.1520/C1363-24.

[2] Footnotes in the text are supplied to clarify the discussion only, and as such, are not mandatory.

testing practice and of the practical application of heat transfer theory relating to thermal insulation materials and systems. Detailed operating procedures, including design schematics and electrical drawings, shall be available for each apparatus to ensure that tests are in accordance with this test method.

1.5 This test method is intended for use at conditions typical of normal building applications. The naturally occurring outside conditions in temperate zones range from approximately −48 to 85°C and the normal inside residential temperatures is approximately 21°C. Building materials used to construct the test specimens shall be pre-conditioned, if necessary, based upon the material's properties and their potential variability. The preconditioning parameters shall be chosen to accurately reflect the test samples intended use and shall be documented in the report. Practice C870 may be used as a guide for test specimen conditioning. The general principles of the hot box method can be used to construct an apparatus to measure the heat flow through industrial systems at elevated temperatures. Detailed design of that type of apparatus is beyond the scope of this method.

1.6 This test method permits operation under natural or forced convective conditions at the specimen surfaces. The direction of airflow motion under forced convective conditions shall be either perpendicular or parallel to the surface.

1.7 The hot box apparatus also is used for measurements of individual building assemblies that are smaller than the metering area. Special characterization procedures are required for these tests. The general testing procedures for these cases are described in Annex A11.

1.8 Specific procedures for the thermal testing of fenestration systems (windows, doors, skylights, curtain walls, etc.) are described in Test Method C1199 and Practice E1423.

1.9 The hot box has been used to investigate the thermal behavior of non-homogeneous building assemblies such as structural members, piping, electrical outlets, or construction defects such as insulation voids.

1.10 This test method sets forth the general design requirements necessary to construct and operate a satisfactory hot box apparatus, and covers a wide variety of apparatus constructions, test conditions, and operating conditions. Detailed designs conforming to this standard are not given but must be developed within the constraints of the general requirements. Examples of analysis tools, concepts and procedures used in the design, construction, characterization, and operation of a hot box apparatus is given in Refs (**1-34**).[3]

1.11 The hot box apparatus, when constructed to measure heat transfer in the horizontal direction, is used for testing walls and other vertical structures. When constructed to measure heat transfer in the vertical direction, the hot box is used for testing roof, ceiling, floor, and other horizontal structures. Other orientations are also permitted. The same apparatus may be used in several orientations but may require special design capability to permit repositioning to each orientation. Whatever the test orientation, the apparatus performance shall first be verified at that orientation with a specimen of known thermal resistance in place.

1.12 This test method does not specify all details necessary for the operation of the apparatus. Decisions on material sampling, specimen selection, preconditioning, specimen mounting and positioning, the choice of test conditions, and the evaluation of test data shall follow applicable ASTM test methods, guides, practices or product specifications or governmental regulations. If no applicable standard exists, sound engineering judgment that reflects accepted heat transfer principles must be used and documented.

1.13 This test method applies to steady-state testing and does not establish procedures or criteria for conducting dynamic tests or for analysis of dynamic test data. However, several hot box apparatuses have been operated under dynamic (non-steady-state) conditions after additional characterization (**1**). Additional characterization is required to insure that all aspects of the heat flow and storage are accounted for during the test. Dynamic control strategies have included both periodic or non-periodic temperature cycles, for example, to follow a diurnal cycle.

1.14 This test method does not permit intentional mass transfer of air or moisture through the specimen during measurements. Air infiltration or moisture migration can alter the net heat transfer. Complicated interactions and dependence upon many variables, coupled with only a limited experience in testing under such conditions, have made it inadvisable to include this type testing in this standard. Further considerations for such testing are given in Appendix X1.

1.15 *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.*

1.16 *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:*[4]

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

C236 Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box (Withdrawn 2001)[5]

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

[4] 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.

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

C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
C739 Specification for Cellulosic Fiber Loose-Fill Thermal Insulation
C764 Specification for Mineral Fiber Loose-Fill Thermal Insulation
C870 Practice for Conditioning of Thermal Insulating Materials
C976 Test Method for Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box (Withdrawn 2002)[5]
C1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions
C1058 Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation
C1130 Practice for Calibration of Thin Heat Flux Transducers
C1199 Test Method for Measuring the Steady-State Thermal Transmittance of Fenestration Systems Using Hot Box Methods
C1224 Specification for Reflective Insulation for Building Applications
C1371 Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers
C1373 Practice for Determination of Thermal Resistance of Attic Insulation Systems Under Simulated Winter Conditions
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E230 Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres
E1423 Practice for Determining Steady State Thermal Transmittance of Fenestration Systems
E1424 Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure and Temperature Differences Across the Specimen

2.2 *Other Documents:*

ASHRAE Handbook of Fundamentals, Latest Edition, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.[6]
ISO Standard 8990 Thermal Insulation Determination of Steady State Thermal Properties—Calibrated and Guarded Hot Box, ISO 8990-1994(E)[7]
ISO Standard 12567 Thermal Performance of Windows and Doors—Determination of Thermal Transmittance by Hot Box Method, ISO 12567-2000[7]

3. Terminology

3.1 *Definitions*—The definitions of terms relating to insulating materials and testing are governed by Terminology C168, unless defined below. All terms discussed in this test method are those associated with thermal properties of the tested specimen, unless otherwise noted.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *building element*—a portion of a building assembly, selected for test, in the expectation that it will exhibit the same thermal behavior as the larger building assembly that it represents. Guidance for the selection process is given in Section 7. For purposes of this method, a single material whose properties are being evaluated is also defined as a building element.

3.2.2 *metered specimen*—the element that fills the boundary of the metering chamber opening. The metered specimen can be: *(1)* the entire building element when it is the same size as the metering chamber opening dimensions; *(2)* the building element and the surround panel in the case when the building element is smaller than the opening; *(3)* a portion of the building element when the building element is larger than the opening.

3.2.3 *test specimen*—that portion of the metered specimen for which the thermal properties are to be determined. The test specimen can be: *(1)* the entire building element when it is the same size as the metering chamber dimensions; *(2)* the building element only in the case when the building element is smaller than the opening; *(3)* that portion of the building element that is within the metered area when the building element is larger than the opening.

3.2.4 *surround panel*—the surround panel, often called the mask, is a uniform structure having stable thermal properties that supports the building element within the metering area. The material shall be homogeneous and low thermal conductivity that both supports the test specimen and provides a uniform, reproducible heat flow pattern at the edges of the metering chamber perimeter.

3.2.5 *self-masking*—a hot box configuration which occurs when the metering chamber opening is less than the building element dimensions. This configuration may be used when the thermal behavior of the building element is such that it is "self-masking." This means that the lateral heat flow at the edges of the metering chamber can be minimized. With proper design and control of the metering chamber, this condition is easily obtained for test specimens that are homogeneous, or while not homogeneous, do not contain highly conductive elements that extend beyond the boundary of the metering chamber. This configuration was previously known as a "guarded hot box."

3.2.6 *masked*—a hot box configuration which occurs when the metering chamber opening is the same or greater than the test specimen dimensions. This configuration must be used when the test specimen cannot be "self-masking." Here, the perimeter of the test specimen requires a separate mask, called a surround panel, constructed to eliminate lateral heat flow. Note that the hot box wall acts as a mask when the test

[6] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329.

[7] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.