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ASTM C1363:05 Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus

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Description

This test method establishes the principles for the design of a hot box apparatus and the minimum requirements for the determination of a steady state thermal performance of building assemblies when exposed to controlled laboratory conditions.

Scope

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 C 739, C 764, C 1224 and Practice C 1373.

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1 This test method replaces Test Methods C 236, the Guarded Hot Box, and C 976, the Calibrated Hot Box which have been withdrawn. Test apparatus designed and operated previously under Test Methods C 236 and C 976 will require slight modifications to the calibration and operational procedures to meet the requirements of Test Method C 1363.

A properly designed and operated hot box apparatus is directly analogous to the Test Method C 177 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.

- 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.
- 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 C 177 Hot Plate, a Test Method C 518 Heat Meter or another Test Method C 1363 Hot Box will provide adequate specimens. Note that the use of Test Method C 518 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.

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 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.

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 85C and the normal inside residential temperatures is approximately 21C. Building materials used to construct the test specimens shall be pre-conditioned, if necessary, based upon the materials 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 C 870 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.

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. \

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.

Specific procedures for the thermal testing of fenestration systems (windows, doors, skylights, curtain walls, etc.) are described in Test Method C 1199 and Practice E 1423.

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.

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).

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.

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.

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.

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.

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.

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