



Standard Test Method for Heat Flux Through Evacuated Insulations Using a Guarded Flat Plate Boiloff Calorimeter¹

This standard is issued under the fixed designation C 745; 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 covers the determination, from cryogenic to near room temperatures, of heat flux through evacuated insulations (Note 1) within the approximate range from 0.3 to 30 W/m². Heat flux values obtained using this method apply strictly only to the particular specimens as tested.

NOTE 1—This test method is primarily intended for use to assess heat flux through evacuated *multilayer* insulations which are highly anisotropic by nature. Characteristically, multilayer insulations exhibit apparent thermal conductivity values one or two orders of magnitude lower than the best available powder, fiber, or foam insulations. Although this test method is also technically applicable to these latter insulations, other ASTM methods with less stringent requirements are equally applicable and much more economical and practical for such materials.

1.2 This shall be a primary test method for measuring heat flux through evacuated insulations (Note 2), since calibration of the apparatus depends on measurement standards traceable to the National Institute of Standards and Technology (NIST) for length, force, temperature, time, etc. Traceable standards are not yet available for heat flux through standard evacuated reference specimens or transfer standards.

NOTE 2—Values of heat flux for the same materials and environments specified in this method may also be obtained by measuring electrical energy dissipation using a guarded hot plate (Test Method C 177) (**1**, **2**)² or a guarded cylindrical apparatus (**3**, **4**), or by measuring transient thermal response (**5**).

1.3 Specimens to be tested using this method shall be flat and may be either a circular or a rectangular configuration, as appropriate for the particular apparatus being used (Note 3). Contoured specimens or those of other shapes must be tested by other methods which are outside the scope of this standard. Specimen sizes and thicknesses shall conform to the limitations specified in Section 7.

NOTE 3—Existing guarded flat plate boil-off calorimeters require circular specimens. For highly anisotropic multilayer insulations, this configuration somewhat simplifies heat transfer calculations, since the resulting heat flow is two-dimensional rather than three-dimensional as it would

be for a rectangular specimen.

1.4 Environmental and other parameters that can be varied in the application of this method are (1) the hot and cold boundary temperatures, (2) the boundary temperature at the exposed edge of the specimen, (3) the mechanical compressive pressure to be imposed on the specimen, and (4) the species and partial pressure of the gas occupying the interlayer cavities of the specimen and the test chamber (Note 4). Hot boundary temperature can be varied within the approximate range from 250 to 670 K, while cold boundary temperature can be varied from approximately 20 to 300 K (Note 5). Selection of boundary temperatures to be imposed at the hot and cold surfaces and at the edge of the specimen shall be subject to the limitations specified in Section 5. Mechanical compressive pressure values to be imposed using this method can vary in the approximate range from 5 to 10 kPa (Note 6).

NOTE 4—Although this test method is primarily intended for use to measure heat flux through evacuated insulations, it is also applicable for measurements where the specimen contains air or other gases at pressures ranging from fully evacuated to atmospheric. However, where measurements are to be made on a specimen that is not evacuated to a pressure of 1 mPa or less, the apparatus shall be provided with a low-conductivity pressure diaphragm to maintain high-vacuum conditions in the annular space between the measuring and guard vessels.

Heat transfer through evacuated multilayer insulations can vary significantly from specimen to specimen or from test to test due to the presence of minute but unknown quantities of outgas components (primarily water vapor) within the interstitial cavities. This effect can be minimized with preconditioning of the specimen by extended evacuation at room temperature or by a combination of heat and evacuation over a much shorter time span (see 9.2).

NOTE 5—Cold boundary temperatures down to that of liquid hydrogen (20 K) can be achieved using existing apparatus. Temperatures to approximately 4 K could be achieved with development of an apparatus suitable for use with liquid helium.

NOTE 6—The lower limit of mechanical compressive pressure that can be achieved for any particular specimen is the *self-compression* value due to the weight of the specimen within the earth's gravitational field.

1.5 Stating that test results were obtained using this specific method requires that all of the variables must be controlled, measured, and recorded as specified herein.

1.6 Details of construction of the calorimeter cannot be covered entirely by this specification since some technical knowledge is required regarding the compatibility of materials with the fluids used, temperature extremes that will be encountered, practical limitations in achieving and controlling the

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² The boldface numbers in parentheses refer to the list of references at the end of this test method.