



Designation: C 1484 – 07

Standard Specification for Vacuum Insulation Panels¹

This standard is issued under the fixed designation C 1484; 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 specification covers the general requirements for Vacuum Insulation Panels (VIP). These panels have been used wherever high thermal resistance is desired in confined space applications, such as transportation, equipment, and appliances.

1.2 Vacuum panels typically exhibit an edge effect due to differences between panel core and panel barrier thermal properties. This specification applies to composite panels whose center-of-panel apparent thermal resistivities (sec. 3.2.3) typically range from 87 to 870 m·K/W (12.5 to 125 hr·ft²·°F/Btu·in) at 24°C (75°F) mean, and whose intended service temperature boundaries range from –70 to 480°C (–94 to 900°F).

1.3 The specification applies to panels encompassing evacuated space with: some means of preventing panel collapse due to atmospheric pressure, some means of reducing radiation heat transfer, and some means of reducing the mean free path of the remaining gas molecules.

1.4 Limitations

1.4.1 The specification is intended for evacuated planar composites; it does not apply to non-planar evacuated self-supporting structures, such as containers or bottles with evacuated walls.

1.4.2 The specification describes the thermal performance considerations in the use of these insulations. Because this market is still developing, discrete classes of products have not yet been defined and standard performance values are not yet available.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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 specifications and determine the applicability of regulatory limitations prior to use.* For specific safety considerations see [Annex A1](#).

2. Referenced Documents

2.1 ASTM Standards:²

- C 165 Test Method for Measuring Compressive Properties of Thermal Insulations
- C 168 Terminology Relating to Thermal Insulation
- C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- C 203 Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation
- C 480 Test Method for Flexure Creep of Sandwich Constructions
- C 518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- C 740 Practice for Evacuated Reflective Insulation In Cryogenic Service
- C 1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions
- C 1055 Guide for Heated System Surface Conditions that Produce Contact Burn Injuries
- C 1058 Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation
- C 1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus
- C 1136 Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
- C 1363 Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus
- C 1667 Standard Test Method for Using Heat Flow Meter Apparatus to Measure the Center-of-Panel Thermal Resistivity of Vacuum Panels
- D 999 Test Methods for Vibration Testing of Shipping Containers
- D 1434 Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheet
- D 2221 Test Method for Creep Properties of Package Cushioning Materials
- D 2126 Test Method for Response of Rigid Cellular Plastics

¹ This specification is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.22 on Organic and Nonhomogeneous Inorganic Thermal Insulations.

Current edition approved Sept. 1, 2007. Published September 2007. Originally approved in 2000. Last previous edition approved in 2001 as C 1484-01.

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.

to Thermal and Humid Aging

D 3103 Test Method for Thermal Insulation Performance of Distribution Packages

D 3763 Test Method for High Speed Puncture Properties of Plastics Using Load and Displacement Sensors

D 4169 Practice for Performance Testing of Shipping Containers and Systems

E 493 Test Methods for Leaks Using the Mass Spectrometer Leak Detector in the Inside-Out Testing Mode

F 88 Test Method for Seal Strength of Flexible Barrier Materials

2.2 Other Standards:

ISO 8318 Packaging - Complete, Filled Transport Packages - Vibration Tests Using a Sinusoidal Variable Frequency³

IEC68-2-6, Part 2, Test F, Vibration, Basic Environmental Testing Procedures⁴

TAPPI T803 Puncture Test of Containerboard⁵

3. Terminology

3.1 *Definitions*—Terminology **C 168** applies to terms used in this specification.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *adsorbent*—a component of some VIP designs, comprising a chemical or physical scavenger for gas molecules.

3.2.2 *center-of-panel*—a small area located at the center of the largest planar surface of the panel, equidistant from each pair of opposite edges of that surface.

3.2.3 *center-of-panel apparent thermal resistivity*—the thermal performance of vacuum panels includes an edge effect due to some heat flow through the panel barrier and this shunting of heat around the panel becomes more prevalent with greater panel barrier thermal conductivity, as shown in **Fig. 1**. For panels larger than a minimum size (as described in **11.4.1**), the center-of-panel apparent thermal resistivity is the intrinsic core thermal resistivity of the VIP. This center-of-panel measurement is used for quality control, compliance verification, and to calculate the effective thermal performance of a panel. The effective thermal performance of a panel will vary with the size and shape of the panel.

3.2.3.1 *Discussion*—Apparent thermal resistivity, the inverse of apparent thermal conductivity, is used when discussing the center-of-panel thermal behavior and this value is independent of the panel thickness.

3.2.4 *edge seal*—any joint between two pieces of panel barrier material.

3.2.5 *effective thermal resistance (Effective R-value)*—this value reflects the total panel resistance to heat flow, considering heat flow through the evacuated region and through the panel barrier.

3.2.5.1 *Discussion*—Depending on the thermal conductivity and thickness of the panel barrier and the size of the panel, the effective thermal resistance of the panel over the edge to edge area may be significantly less than the thermal resistance measured or calculated at the center of the panel. The effective thermal resistance will also depend on the temperatures imposed on the two faces of the panel.

3.2.5.2 *Discussion*—Thermal resistance, the inverse of thermal conductance, is used when discussing the effective thermal performance of the panel. This value includes the effect of the actual panel dimensions, including the panel thickness.

³ International Organization for Standardization, Case Postale 56, Geneva CH-1211, Switzerland.

⁴ International Electrotechnical Commission, 3 Rue De Varembe; PO Box 131, Geneva CH-1211, Switzerland.

⁵ TAPPI, 15 Technology Parkway S., Norcross, GA 30092.

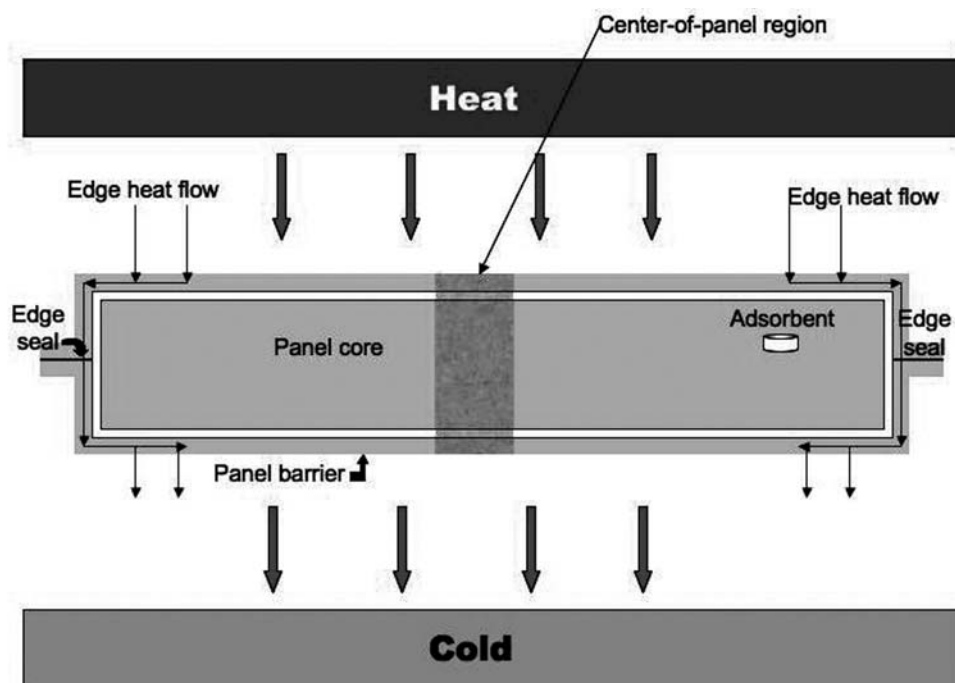


FIG. 1 Side View of a Vacuum Insulation Panel Showing Edge Heat Flow and the Center-of-Panel Region

3.2.6 *effective thermal resistance after puncture*—this value represents the effective thermal resistance of the panel in the event of a total panel barrier failure (complete loss of vacuum). The edge effect is still present after a puncture.

3.2.7 *evacuated or vacuum insulations*—insulation systems whose gas phase thermal conductivity portion of the overall apparent thermal conductivity has been significantly reduced by reduction of the internal gas pressure. The level of vacuum will depend on properties of the composite panel materials, and the desired effective thermal conductivity.⁶

3.2.8 *panel barrier*—the material that envelops the evacuated volume and is used to separate the evacuated volume from the environment and to provide a long term barrier to gas and vapor diffusion.

3.2.9 *panel core*—the material placed within the evacuated volume in order to perform one or more of the following functions: prevent panel collapse due to atmospheric pressure, reduce radiation heat transfer, and establish interstitial spaces that are smaller in dimension than (or near to), the mean free path length of the remaining gas molecules. The thermal conductivity of the panel core, or λ_{core} , is defined as the thermal conductivity of the core material under the same vacuum that would occur within a panel, but without the panel barrier material. This is the thermal conductivity that would be measured in the center of an infinitely large panel.

3.2.10 *service life*—The period of time over which the center-of-panel thermal conductivity meets the definition of a superinsulation. A standard-condition service life is defined as that period of time over which the center-of-panel thermal conductivity meets the definition of a superinsulation under standard conditions of 24°C (75°F) and 50 % relative humidity.

3.2.10.1 *Discussion*—The thermal resistance of a VIP degrades with time due to residual outgassing of VIP materials and gas diffusion through the panel barrier and edge seals. Both of these processes are affected by the service environment, most importantly by the service temperature and humidity in the surrounding air. The service life in hotter or more humid conditions may be shorter; conversely drier or colder environmental conditions can extend the life of the panel.

3.2.11 *superinsulation*—insulation systems whose center-of-panel thermal resistivity exceeds 87 m · K/W (12.5 h·ft²·°F/BTU · in.) measured at 24°C (75°F) mean.

3.3 *Symbols and Units*—The symbols used in this test method have the following significance:

- 3.3.1 A = area, m².
- 3.3.2 B = outgassing coefficient of panel barrier, Pa·l/(h^(1-β)).
- 3.3.3 C = outgassing coefficient of panel filler, Pa·l/(h^(1-α)).
- 3.3.4 d_o = density of the gas at standard temperature and pressure, kg/m³.
- 3.3.5 g = outgassing rate, Pa·l/h.
- 3.3.6 G = adsorbent capacity, Pa·m³.
- 3.3.7 k = gas permeation rate, m³/h.
- 3.3.8 M = molecular weight, kg/mole.
- 3.3.9 P = pressure, Pa.

- 3.3.10 p = gas permeance, m/h·Pa.
- 3.3.11 R = ideal gas constant, 8.315 J/g·mole · K.
- 3.3.12 T = temperature, K.
- 3.3.13 V = internal VIP free volume, m³.
- 3.3.14 α = outgassing exponent of filler.
- 3.3.15 β = outgassing exponent of panel barrier.
- 3.3.16 τ = time, h.
- 3.3.17 *Subscripts*:
 - 3.3.17.1 e = environmental.
 - 3.3.17.2 f = flange.
 - 3.3.17.3 i = refers to a specific gas, that is, P_i is the partial pressure of the i^{th} gas.
 - 3.3.17.4 $init$ = initial.
 - 3.3.17.5 s = surface.

4. Ordering Information

4.1 Orders shall include the following information:

- 4.1.1 Title, designation, and year of issue of this specification,
- 4.1.2 Product name,
- 4.1.3 Panel size and effective R-value required,
- 4.1.4 Service environmental parameters: maximum temperature, average temperature, maximum relative humidity, average relative humidity,
- 4.1.5 Required service life,
- 4.1.6 Tolerance if other than specified,
- 4.1.7 Quantity of material,
- 4.1.8 Special requirements for inspection or testing, or both,
- 4.1.9 If packaging is other than specified,
- 4.1.10 If marking is other than specified,
- 4.1.11 Special installation instructions if applicable,
- 4.1.12 Required compressive resistance,
- 4.1.13 Required effective thermal resistance after puncture,
- 4.1.14 Any required fire characteristics,
- 4.1.15 Required creep characteristics,
- 4.1.16 Required edge seal strength, and
- 4.1.17 Required dimensional stability at service environmental conditions.

5. Materials and Manufacture

5.1 *Panel Composite Design*—The panel shall consist of a gas barrier layer(s), as described in 5.2, and an evacuated core material or system as described in 5.3. See Fig. 1. An engineered quantity of gas adsorbent is optional. It is not necessary that the panel design be symmetrical, depending upon end-use requirements.

5.2 *Panel Barrier Composition*—The panel barrier consists of one or more layers of materials whose primary functions are to control gas diffusion to the core, and to provide mechanical protection. Candidate panel barrier materials include metallic, organic, inorganic or a combination thereof depending on the level of vacuum required, the desired service life, and the intended service temperature regimes. Panel barrier materials are selected to prevent outgassing, or at least to give off only those gases or vapors which can be conveniently adsorbed.

5.3 *Panel Core Composition*—The core shall comprise a system of cells, microspheres, powders, fibers, aerogels, or laminates, whose chemical composition is as follows:

⁶ For further discussion on heat flow mechanisms in evacuated insulations, see Practice C 740.