Designation: C 447 – 03

Standard Practice for Estimating the Maximum Use Temperature of Thermal Insulations[1]

This standard is issued under the fixed designation C 447; 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 covers estimation of the maximum use temperature of thermal insulation including loose fill, blanket, block, board, and preformed pipe insulation. It is based upon selected performance criteria, and characterization of product properties during and after use conditions.

1.2 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 165 Test Method for Measuring Compressive Properties of Thermal Insulations[2]

C 167 Test Methods for Thickness and Density of Blanket or Batt Thermal Insulations[2]

C 168 Terminology Relating to Thermal Insulation[2]

C 177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus[2]

C 203 Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation[2]

C 302 Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation[2]

C 303 Test Method for Density of Preformed Block-Type Thermal Insulation[2]

C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation[2]

C 411 Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation[2]

C 421 Test Method for Tumbling Friability of Preformed Block-Type Thermal Insulation[2]

C 446 Test Method for Breaking Load and Calculated Modulus of Rupture of Preformed Insulation for Pipes[2]

C 518 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus[2]

D 1621 Test Method for Compressive Properties of Rigid Cellular Plastics[3]

D 1622 Test Method for Apparent Density of Rigid Cellular Plastics[3]

3. Terminology

3.1 Definitions C 168 shall apply to the terms used in this practice.

4. Summary of Practice

4.1 Dimensions, weight and other pertinent properties of the insulation are measured before, during, and after exposure to a hot surface.

4.2 Properties during and after exposure, and, in some cases, the degree of change in properties are reported for use in establishing the maximum service temperature of the insulation material.

5. Significance and Use

5.1 This practice is intended for use as a guide in evaluating the behavior of insulations at elevated temperatures, and in judging suitability for use under the conditions of an intended application. It is not intended for acceptance or certification testing on a lot basis.

5.2 No single test for estimating maximum use temperature can be used that will apply to all types of insulations, nor can any single maximum use temperature be applied to any insulation that will be applicable under all possible conditions of use. Maximum use temperature may depend on thickness, temperature gradient, heating rate, and other factors. When the various test methods listed herein are employed, the test results serve as guides and, as such, must be applied with good engineering judgment in arriving at an acceptable temperature limit for the products and applications being considered.

[1] This practice is under the jurisdiction of ASTM Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.31 on Chemical and Physical Properties.

Current edition approved April 10, 2003. Published May 2003. Originally approved in 1959 . Last previous edition approved in 2001 as C447 – 85 (2001)ε1.

[2] *Annual Book of ASTM Standards*, Vol 04.06.

[3] *Annual Book of ASTM Standards*, Vol 08.01.

5.3 The criteria used to establish acceptable performance is provided in the material specification or as agreed upon between the purchaser and seller.

5.4 In most cases, the properties covered by the applicable material standards (for example, thermal transmission, strength, etc.) are the properties important to the end use of the product. Major changes in those properties resulting from in-service conditions can cause failure or substandard performance of the installed system.

5.5 Unless removal and reuse of the insulation is an important consideration, properties that relate primarily to handling and installation shall be eliminated from the evaluation.

NOTE 1—Installation assemblies: some systems create conditions that will affect the performance from the data obtained in the test procedures of this practice.

5.6 The listing of a test procedure in this practice does not imply that the performance of that particular procedure is required. Only those tests which are relevant to the requirements of the application involved, or which are agreed upon between the purchaser and the seller are preformed.

5.7 Most of the changes that occur in the functionally important characteristics of all types of thermal insulation during service result from changes in the matrix or binder system first, followed by changes in the bulk filler materials where such fillers have been used.

5.7.1 In general, these changes are temperature-dependent and the major portion of the change takes place fairly quickly once the critical temperature has been reached.

5.7.2 Typically, organic thermoplastic materials or binders will change in the 140 to 240°F (60 to 116°C) temperature range. Thermosetting organic materials or binders will start to deteriorate above 350°F (177°C). Hydrated inorganic binders such as clays, portland and lumnite cements, gypsum, sodium silicates, oxysulfates, and oxychlorides will lose varying amounts of water of crystallization at temperatures from 250 to 900°F (121 to 482°C) dependent on the compound involved. Glass fibers and glass foams may start to sinter around 1000°F (538°C). Rock or slag wools, perlites and refractory fibers may show change at temperatures in excess of 1300°F (704°C) dependent on specific composition.

5.8 If, after testing samples exposed to the maximum service temperature, additional tests are made of samples exposed to intermediate temperatures (third or quarter points in the full service temperature range), the results of such tests, when plotted with proper curve fit techniques, may give some indication of changes in product characteristics throughout the service range. These results may also be used to bracket the temperature range within which a change has occurred (significant change in slope of curve).

5.9 Some properties of thermal insulations containing trapped gases other than air change with time, and at different rates, depending upon the age, thickness, facing and boundary conditions. Elevated temperature exposure accelerates these changes. Changes in properties of these materials may continue over a very long period of time, however, and it is beyond the scope of this recommended practice to establish a minimum time period for evaluation of these long-term changes.

6. Test Conditions

6.1 If required, testing shall begin at the hot face temperature of the desired application or that claimed as the maximum use temperature. When there has been significant deterioration of the properties tested during or after exposure at the maximum hot face temperature, additional specimens will be exposed at lower temperatures (third or quarter points of the temperature range from ambient to maximum) to establish the critical temperature. Additional tests shall be made until enough data have been obtained to establish acceptable performance.

6.2 The criteria necessary to establish acceptable performance by any of the methods described shall be as provided in the material specification or as agreed upon between the purchaser and seller. For example, a minimum value of compressive strength or a maximum percent dimensional change might be specified as the criterion for estimating the maximum use temperature.

6.3 With anisotropic materials that are produced initially in large cross-sections and mechanically fabricated in subsequent operations to produce boards or preformed pipe insulation, it is advisable to examine properties of interest in all three axes.

6.4 Since soaking heat exposure seldom occurs under “as installed” conditions, and such exposure will produce results that may be misleading, samples shall be conditioned using hot-face-/cold-face methods rather than soaking heat. Soaking heat exposure should be limited to preliminary evaluation and quality control testing.

6.5 The elevated temperature exposure time required to effect major change will vary with the generic type of product being tested. Preliminary trials shall be made to establish the minimum hot surface exposure time required for a particular insulation material. The minimum exposure time has been reached when the property of interest shows no more than expected random variations in three consecutive readings taken at three hour intervals.

7. Test Specimens

7.1 The test specimens shall be selected to be representative of the material under evaluation. Original surfaces shall be retained at least on the hot face of the specimens.

7.2 Other specimen dimensions shall conform to the requirements of Test Method C 411. Where further fabrication of the specimen after exposure is not practical, additional specimens, precut to the required size, shall be exposed separately.

8. Procedure

8.1 *Hot Surface Performance*—Test and report the hot surface performance of the insulation in accordance with Test Method C 411 with the following exceptions and additions.

8.1.1 The thickness of the test specimens shall be the intended thickness of the application or the manufacturer’s recommended minimum and maximum thickness for the test temperature. The number of layers of insulation exposed and tested shall be representative of the intended application or the manufacturer’s recommendation at the test thickness.

8.1.2 Unless a specific heat-up period is dictated by the intended application, included in the material specification or

recommended by the manufacturer, the apparatus shall be preheated to the test temperature using a blank specimen of similar thermal transmission properties. Once the test temperature has been reached, the blank specimen shall be removed and the test specimen(s) quickly applied to the hot surface.

8.1.3 The hot face temperature shall be the service temperature being evaluated; − 0, + 5 %.

8.1.4 Where specific fastening methods are dictated by the material specification, the insulation shall be held against the hot surface by means representing these fastening methods, for example, screws, exterior frames, etc. The attachment method shall be included in the report.

8.1.5 Measure and report the dimensions and weight of the specimens before and after exposure. Suitable measuring instruments and procedures can be found in Test Methods C 167, C 303 or D 1622, and C 302 for blankets or felt, block or board, and preformed pipe insulation respectively. Dimensions, and changes in dimensions, of the hot and cold faces shall be measured and reported separately.

8.1.6 Record the temperature rise during heat-up at 1-in. (25-mm) increments through the thickness of the specimen as an indication of endothermic or exothermic reactions within the insulation. Temperature shall be recorded continuously, or at a maximum interval of 5 min, until equilibrium is reached. Suitable temperature sensors with a maximum response time of 1 min and an accuracy of + /− 1 % shall be used. The sensors shall be located at the top center of the specimen for preformed pipe covering.

8.2 *Thermal Transmission Properties*—Test and report the thermal transmission properties of the insulation in accordance with Test Methods C 177 and C 518 for blanket, felt, block or board insulation or Test Method C 335 for preformed pipe insulation.

8.2.1 The test thickness shall be 1½ ± ½in. (38 ± 13 mm) for Test Methods C 177 and C 518. For Test Method C 335 the test thickness is adjusted as required to achieve the proper cold face temperature.

8.2.2 The hot face temperature shall be the service temperature being evaluated; − 0, + 5 %.

8.2.3 The cold face temperature shall be representative of the intended application or a maximum of 200°F (93°C).

8.2.4 Prior to measurement the specimens shall be exposed on the test apparatus at the test temperature for the minimum period determined in 6.5. Separate hot surface exposure is not required.

NOTE 2—Where cyclic operating conditions are anticipated, it is prudent to confirm thermal transmission properties at lower temperatures following exposure to the maximum hot face temperature.

8.3 *Other Properties*—Test and report the other pertinent properties of the insulation following hot surface exposure.

8.3.1 Specimens shall be obtained from material exposed in accordance with 7.1. Where further fabrication after exposure is not possible, additional specimens precut to the required size are exposed separately maintaining the thickness and other exposure parameters of 7.1.

8.3.2 The full thickness of the exposed specimen shall be tested. Where it is impractical to test the specimens at full thickness, they may be carefully slit to two or more layers. The results of tests on each layer shall be reported separately and identified as to the original location through the thickness from hot to cold face.

8.3.3 Where it is useful to compare the properties of the insulation material before and after exposure, the specimens used for“ before exposure” tests shall be of the same size and selected from similar material as those used for the “after exposure” test.

8.3.4 Depending on the application, the following properties are useful in estimating the suitability of the insulation following exposure to the test service temperature. Additional pertinent properties are found in the applicable material specification and the manufacturer’s literature. The provisions of Section 5 shall be considered in selecting properties for testing.

8.3.4.1 *Compression Properties*—Test Method C 165 or Test Method D 1621.

8.3.4.2 *Flexural Strength*—Test Methods C 203, Test Method C 446.

8.3.4.3 *Water/Moisture Absorption/Repellency/Wicking Ability*—Refer to the appropriate material specification.

8.3.4.4 *Tumbling Friability*—Test Method C 421.

9. Keywords

9.1 hot surface performance; maximum use temperature; thermal insulation