Designation: C767 – 93 (Reapproved 2013)

# Standard Test Method for Thermal Conductivity of Carbon Refractories[1]



## 1. Scope

1.1 This test method supplements Test Method C201, and shall be used in conjunction with that procedure to determine the thermal conductivity of carbon or carbon-bearing refractories. This test method is designed for refractories having a conductivity factor of not more than 200 Btu·in./h·ft $^2$·°F (28.8 W/m·K).

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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:*[2]

C155 Classification of Insulating Firebrick

C201 Test Method for Thermal Conductivity of Refractories

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

## 3. Significance and Use

3.1 The thermal conductivity of carbon refractories is a property required for selecting their thermal transmission characteristics. Users select carbon refractories to provide specified conditions of heat loss and cold face temperature, without exceeding the temperature limitation of the carbon refractory. This test method establishes placement of thermocouples and positioning of test specimens in the calorimeter.

3.2 This procedure must be used with Test Method C201 and requires a large thermal gradient and steady state conditions. The results are based upon a mean temperature.

3.3 The data from this test method is suitable for specification acceptance, estimating heat loss and surface temperature, and the design of multi-layer refractory construction.

3.4 The use of these data requires consideration of the actual application environment and conditions.

## 4. Apparatus

4.1 The apparatus shall be in accordance with Test Method C201 with the addition of thermocouples, back-up insulation, and refractory fiber paper as described in Section 5 of this test method.

## 5. Test Specimen and Preparation

5.1 Select the test specimen and prepare in accordance with Test Method C201.

5.2 *Thermocouples*—Embed calibrated thermocouples[3] in the test specimen at two points for measuring temperature. Thermocouples[4] sheathed with material having low reactivity with carbon must be used. Use the top thermocouple for one test only.

5.3 *Installation of Thermocouples*—Place the hot junction of the thermocouples in the center of each 9 by 4½-in. (228 by 114-mm) face and just below the surface of the test specimen. Cut grooves to receive the wire in each 9 by 4½-in. face of the brick to a depth necessary to embed the thermocouple just beneath the surface by means of an abrasive wheel. The layout for the grooves allows all of the cold-junction ends of the wires to extend from one end of the brick. Cut a groove in the center of each 9 by 4½-in. face along the 9-in. dimension and end ¼ in. (6 mm) beyond the center. Before cementing[5] the thermocouples in place, take measurements to obtain, within ±0.01 in. (±0.3 mm), the eventual distance between the center lines of the thermocouple junctions. Do this by measuring the 2½-in. (64-mm) dimension of the brick at the location for the

[1] This test method is under the jurisdiction of ASTM Committee C08 on Refractories and is the direct responsibility of Subcommittee C08.02 on Thermal Properties.

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[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.

[3] Method E220 specifies calibration procedures for thermocouples.

[4] Claud S. Gordon Co., 5710 Kenosha St., Richmond, IL 60071, 1⁄16 –in. (2–mm) sheathed Xactpak thermocouple, Cat. No. 401-2104 or equivalent.

[5] Alundum Cement RA 562 supplied by the Norton Co., One New Bond St., Worcester, MA 01606, is satisfactory for this purpose.

hot junctions and deducting the distance between the center line of each junction in its embedded position and the surface of the brick.

5.4 Cover the calorimeter and inner and outer guards with a 0.50-in. (12.7-mm) thick layer of Group 20 insulating firebrick (see Classification C155) for the purpose of obtaining a higher mean temperature in the test sample than would result by placing the sample directly over the calorimeter area. Cut and grind the back-up insulation so as to provide surfaces that are plane and do not vary from parallel by more than ±0.01 in. (0.3 mm). Grind the sides of the pieces that are to be placed in contact plane and at right angles to the horizontal faces. Make the joints between the pieces tight without the use of any mortar.

5.5 Place two strips of refractory fiber paper 13½ by ½ by 0.02 in. (342 by 13 by 0.5 mm) along the 13½-in. dimension of the inner guard at the outside edges. Place twelve strips of refractory fiber paper 2 by ½ by 0.02 in. (51 by 13 by 0.5 mm) on the outer guards at intervals in the pattern shown in Fig. 1. These strips serve as spaces to prevent contact between the back-up insulation or the test material and the calorimeter assembly. Then place the back-up insulation on the calorimeter assembly so as to provide a level and plane surface. Place additional strips of refractory fiber paper of the same dimensions in the same pattern upon the back-up insulation. These strips serve as spacers to prevent contact between the carbon brick and the back-up insulation. Place the test specimen centrally over the center of the calorimeter section on its 9 by 4½-in. (228 by 114-mm) face, place the guard brick at the sides of the test specimen so as to cover completely the calorimeter and inner guard area, and place the soap brick along the edges of the three brick so as to cover completely the calorimeter assembly. Fill the small space between the furnace walls and the test brick assembly with granulated insulating firebrick.

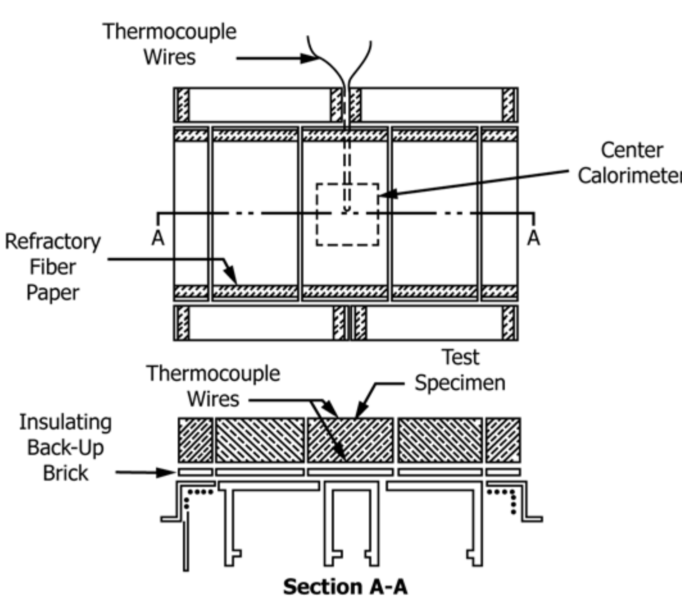


FIG. 1 Arrangement of Refractory-Fiber Paper Strips in Calorimeter Assemblage

5.6 Place the silicon carbide slab over the 9 by 13½-in. (228 by 342-mm) area of the three 9-in. (228-mm) brick specimen, and space it 1 in. nominal above the specimen by placing under each corner of the slab rectangular pieces of Group 28 insulating firebrick (see Classification C155) cut to measure ⅜-in. (10-mm) square and 1-in. nominal length.

## 6. Conditions of Test

6.1 Make a special effort to seal the furnace tightly so that the atmosphere can be maintained nonoxidizing through introduction of argon under slight positive pressure as measured by a draft gage. In addition, place several pieces of carbon refractory around the edges of the furnace on top of the outer guard brick to react with any oxygen that may enter the furnace chamber. The argon should not impinge on the test samples, but should impinge on these additional pieces of carbon. Maintain the atmosphere void of oxygen throughout the test.

## 7. Procedure

7.1 Place the heating chamber in position, start water flowing through the calorimeter assembly, and supply current to the heating unit. Maintain the rate of water flow through the calorimeter between 120 and 200 g/min. Determine the flow by weighing the quantity of water collected during a measured time period. The weight of water collected shall not be less than 200 g and shall be weighed to an accuracy of ±0.5 g. The rate of flow shall be constant within ±1 % during the test period.

7.2 Allow the furnace to reach a condition of steady state of heat flow at various mean temperatures successively increased. A steady state shall be that condition when the measured flow of heat into the calorimeter varies less than 2 % over a 2-h period, during which time the temperature difference between the calorimeter and the inner guard has not been more than 0.05°F (0.03°C), the hot face of the test specimen has not varied more than 5°F (3°C), and the temperature of the water entering the calorimeter has not varied at a rate of more than 1°F (0.5°C)/h (Note 1). Usually, 12 h or more are needed to obtain a balance with the apparatus after a definite change is made in the hot-face temperature.

NOTE 1—Significant errors will result if the tolerances specified are exceeded.

7.3 After the steady state of heat flow has been reached, measure the temperature of the test specimen, the rate of water flow through the calorimeter, and the temperature rise of the water flowing through the calorimeter. Take at least four sets of readings at approximately 30-min intervals during the 2-h holding period, and these shall be averaged for the final values for that particular heating chamber temperature.

NOTE 2—From these data a preliminary thermal conductivity calculation may be made, using estimated distances between thermocouple junctions in the test specimen.

7.4 At the conclusion of the test, examine the specimens for changes which may have taken place as a result of the heat treatment. Then remove the thermocouple wires, cut the brick in half through the 4½ by 2½-in. (114 by 64-mm) dimension, and examine for voids and cracks.

## 8. Calculation

8.1 Make the record of test data, the calculations, and the report in accordance with Test Method C201.

## 9. Precision and Bias

9.1 Refer to Test Method C201 for a statement of precision and bias.

## 10. Keywords

10.1 calorimeter; carbon refractories; refractories; thermal conductivity