Designation: E 970 – ~~98~~00

An American National Standard

Standard Test Method for Critical Radiant Flux of Exposed Attic Floor Insulation Using a Radiant Heat Energy Source[1]

This standard is issued under the fixed designation E 970; 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 fire-test-response standard describes a procedure for measuring the critical radiant flux of exposed attic floor insulation subjected to a flaming ignition source in a graded radiant heat energy environment in a test chamber. The specimen is any attic floor insulation. This test method is not applicable to those insulations that melt or shrink away when exposed to the radiant heat energy environment or the pilot burner.

1.2 This fire-test-response standard measures the critical radiant flux at the point at which the flame advances the farthest. It provides a basis for estimating one aspect of fire exposure behavior for exposed attic floor insulation. The imposed radiant flux simulates the thermal radiation levels likely to impinge on the floors of attics whose upper surfaces are heated by the sun through the roof or by flames from an incidental fire in the attic. This fire-test-response standard was developed to simulate an important fire exposure component of fires that develop in attics, but is not intended for use in estimating flame spread behavior of insulation installed other than on the attic floor.

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

1.4 The text of this standard references notes and footnotes that provide explanatory information. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this standard.

1.5 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*

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 practices and determine the applicability of regulatory limitations prior to use.*

1.7 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

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[1] This test method is under the jurisdiction of ASTM Committee ~~E-5~~ E05 on Fire Standards and is the direct responsibility of Subcommittee E05.22 on Surface Burning.
Current edition approved ~~April~~ July 10, ~~1998.~~ 2000. Published ~~July 1998.~~ August 2000. Originally published as E 970 – 83. Last previous edition E 970 – 9~~6~~8.

C 665 Specification for Mineral Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing[2]
C 764 Specification for Mineral Fiber Loose-Fill Thermal Insulation[2]
E 84 Test Method for Surface Burning Characteristics of Building Materials[3]
E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality of a Lot or Process[4]
E 176 Terminology Relating to Fire Standards[3]
E 631 Terminology of Building Constructions[3]
E 648 Test Method for Critical Radiant Flux of FloorCovering Systems Using a Radiant Heat Energy Source[3]
2.2 *Federal Specifications:*
HH-I-515 Insulation Thermal (Loose Fill for Pneumatic or Poured Application), Cellulosic or Wood Fiber[5]
HH-I-521, Insulation Blankets, Thermal (Mineral Fiber, for Ambient Temperature)[5]
HH-I-1030 Insulation, Thermal (Mineral Fiber, for Pneumatic or Poured Application)[5]

3. Terminology

3.1 For definitions of terms used in this test method and associated with fire issues refer to the terminology contained in Terminology E 176.

3.2 *Definition:*

3.2.1 *attic*, *n*—an accessible enclosed space in a building immediately below the roof and wholly or partly within the roof framing.

3.2.2 See Terminology E 631 for additional definitions of terms used in this test method.

3.3 Definitions of Terms Specific to This Standard:

3.3.1 *critical radiant flux*, *n*—the level of incident radiant heat energy on the attic floor insulation system at the most distant flame-out point. It is reported as W/cm^2(or $Btu/ft^2·s$).

3.3.2 *radiant flux profile*, *n*—the graph relating incident radiant heat energy on the specimen plane to distance from the point of initiation of flaming ignition, that is, 0 mm.

3.3.3 *total flux metre*, *n*—the instrument used to measure the level of radiant heat energy incident on the specimen plane at any point.

4. Summary of Test Method

4.1 A horizontally mounted insulation specimen is exposed to the heat from an air-gas radiant heat energy panel located above and inclined at 30 ± 5° to the specimen. After a short preheat, the hottest end of the specimen is ignited with a small calibrated flame. The distance to the farthest advance of flaming is measured, converted to kilowatts per square meter from a previously prepared radiant flux profile graph, and reported as the critical radiant flux.

5. Significance and Use

5.1 This fire-test-response standard is designed to provide a basis for estimating one aspect of the fire exposure behavior to exposed insulation installed on the floors of building attics. The test environment is intended to simulate conditions that have been observed and defined in full-scale attic experiments.

5.2 The test is intended to be suitable for regulatory statutes, specification acceptance, design purposes, or development and research.

5.3 The fundamental assumption inherent in the test is that critical radiant flux is one measure of the surface burning characteristics of exposed insulation on floors or between joists of attics.

5.4 The test is applicable to attic floor insulation specimens that follow or simulate accepted installation practice.

5.5 In this procedure, the specimens are subjected to one or more specific sets of laboratory fire test exposure conditions. If different test conditions are substituted or the anticipated end-use conditions are changed, caution should be used to predict changes in the performance characteristics measured by or from this test. Therefore, the results are strictly valid only for the fire test exposure conditions described in this procedure.

5.5.1 If the test results obtained by this test method are to be considered in the total assessment of fire hazard in a building structure, then all pertinent established criteria for fire hazard assessment developed by Committee E-5 must be included in the consideration.

6. Apparatus

6.1 *Radiant Panel Test Chamber* (Fig. 1), located in a draft-protected laboratory that maintains a temperature from 10.0 to 26.7°C (50 to 80°F) and a relative humidity from 30 to 70 %.

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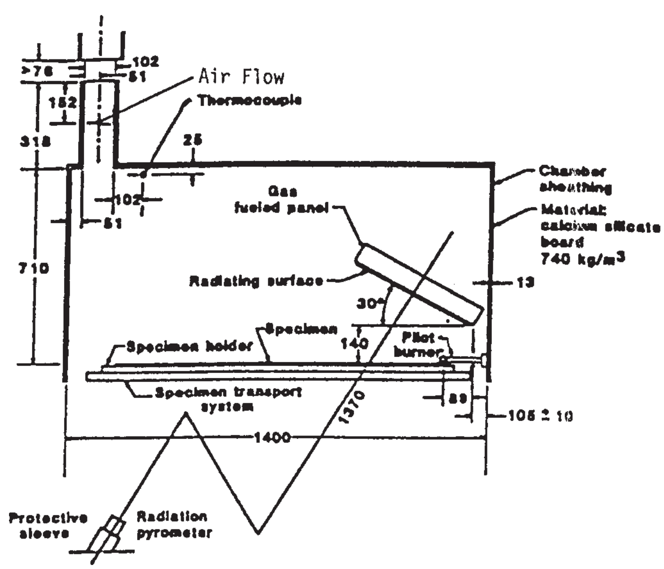
[2] *Annual Book of ASTM Standards*, Vol 04.06.
[3] *Annual Book of ASTM Standards*, Vol 04.07.
[4] *Annual Book of ASTM Standards*, Vol 14.02.
[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

FIG. 1 Radiant Test Panel Chamber

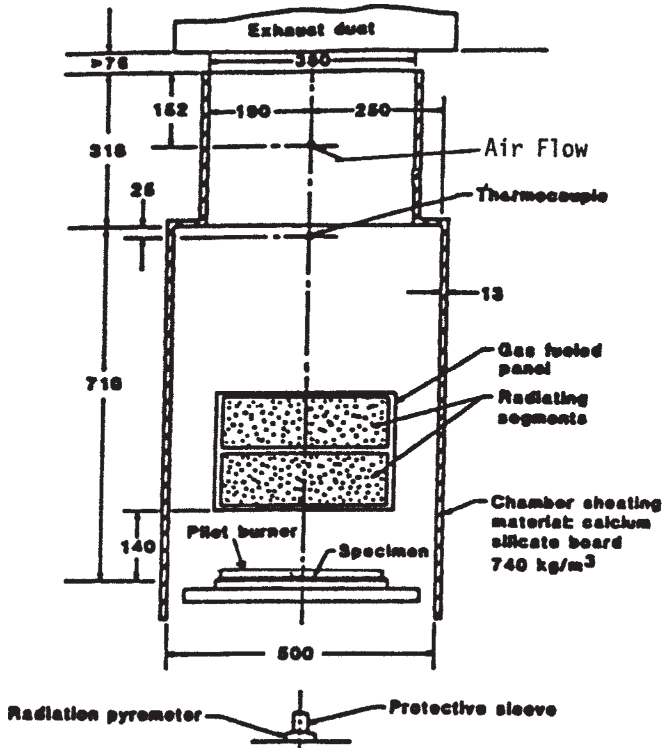
6.1.1 The radiant panel test chamber (Fig. 2 and Fig. 3) shall consist of an enclosure 1400 mm (55 in.) long by 500 mm (19½ in.) deep by 710 mm (28 in.) above the test specimen. The sides, ends, and top shall be of 13-mm (½-in.) calcium silicate, 740-kg/m^3(46-lb/ft^3) nominal density, insulating material[6] with a thermal conductivity at 177°C (350°F) of 0.128 W/(m·K) (0.89 Btu · in./(h·ft^2·°F)). One side shall be provided with an approximately 100 by 1100 mm (4 by 44 in.) draft-tight fire-resistant glass window so that the entire length of the test specimen is visible from outside the fire test chamber. On the same side and below the observation window is a door which, when open, allows the specimen platform to be moved out for mounting or removal of test specimens. At the low flux end of the chamber on the 500 mm side, a draft-tight fire-resistant window is permitted for additional observations.

[6] Marinite I, manufactured by Manville Specialty Products Group, P.O. Box 5108, Denver, CO 80217, available through the local Manville distributor, has been found satisfactory.



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.

FIG. 2 Flooring Radiant Tester Schematic, Side Elevation



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.

FIG. 3 Flooring Radiant Panel Tester Schematic Low Flux End, Elevation

6.1.2 The bottom of the test chamber shall consist of a sliding steel platform which has provisions for rigidly securing the test specimen holder in fixed and level position. The free, or air access, area around the platform shall be in the range from 0.2580 to 0.3225 m^2 (400 to 500 $in.^2$).

6.1.3 When the flame front advance is to be measured, a metal scale marked with 10 mm intervals shall be installed on the back of the platform or on the back wall of the chamber.

6.1.4 The top of the chamber shall have an exhaust stack with interior dimensions of 102 $\pm$ 3 mm (4 $\pm$ 0.13 in.) wide by 380 $\pm$ 3 mm (15.00 $\pm$ 0.13 in.) deep by 318 $\pm$ 3 mm (12.50$\pm$ 0.13 in.) high at the opposite end of the chamber from the radiant energy source.

6.2 *Radiant Heat Energy Source* , a panel of porous ~~refractory~~ material mounted in a cast iron or steel frame, with a radiation surface of 305 by 457 mm (12 by 18 in.). It shall be capable of operating at temperatures up to 816°C (1500°F). The panel fuel system shall consist of a venturi-type aspirator for mixing gas[7] and air at approximately atmospheric pressure, a clean dry air supply capable of providing 28.3 m^3/h (1000 f^3t/h) at standard temperature and pressure at 76 mm (3.0 in.) of water, and suitable instrumentation for monitoring and controlling the flow of fuel to the panel.

6.2.1 The radiant heat energy panel is mounted in the chamber at 30 $\pm$ 5° to the horizontal specimen plane. The radiant energy panel angle shall be adjusted to obtain the flux profile within the limits specified in accordance with 10.6. The horizontal distance from the 0 mark on the specimen fixture to the bottom edge (projected) of the radiating surface of the panel is 89 $\pm$ 3 mm (3.5 $\pm$ 0.13 in.). The panel-to-specimen vertical distance is 140 $\pm$ 3 mm (5.5 $\pm$ 0.13 in.) (Fig. 2).

6.2.2 *Radiation Pyrometer* for standardizing the thermal output of the panel, suitable for viewing a circular area 254 mm (10 in.) in diameter at a range of about 1.37 m (54 in.). It shall be calibrated over the 460 to 510°C (860 to 950°F) operating blackbody temperature range in accordance with the procedure described in Annex A1.

6.2.3 *Voltmeter*, high-impedance or potentiometric, with a suitable millivolt range shall be used to monitor the output of the radiation pyrometer described in 6.2.2.

6.3 *Dummy Specimen Holder* (Fig. 4 and Fig. 5), constructed from heat-resistant stainless steel (UNS N08330 (AISI Type 330) or equivalent) having a thickness of 1.98 mm (0.078 in.) and an overall dimension of 1140 by 320 mm (45 by 12¾ in.) with a specimen opening of 200 by 1000 mm (7.9 by 39.4 in.). Six slots shall be cut in the flange on either side of the holder to reduce warping. The holder shall be fastened to the platform with two stud bolts at each end.

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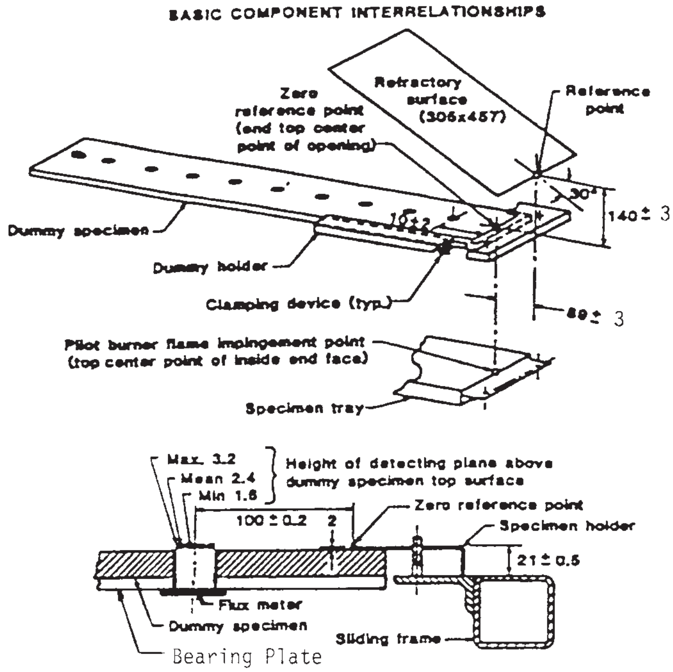
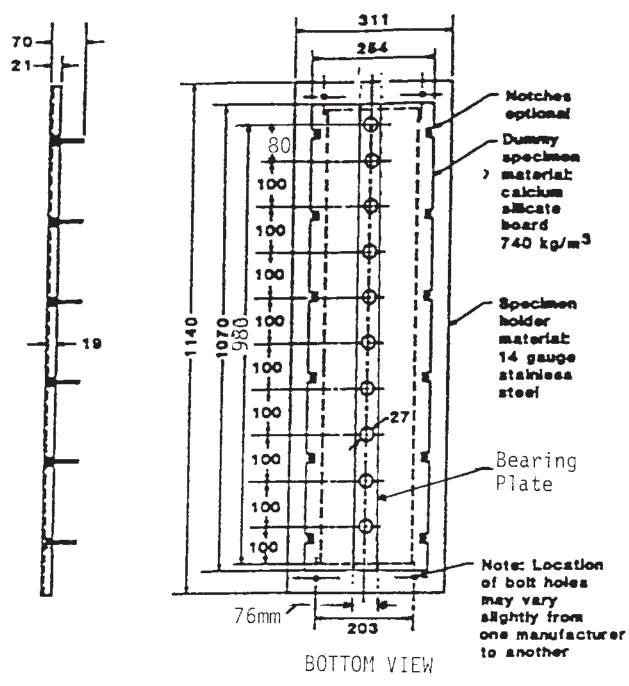
[7] Gas used in this test method shall be either commercial grade propane having a heating value of approximately 83.1 MJ/m^3 (2500 Btu/ft^3), or natural gas, or commercial grade methane having a minimum purity of 96 %.



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.

FIG. 4 Zero Reference Point Related to Detecting Plane



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.

FIG. 5 Dummy Specimen in Specimen Holder

6.4 *Dummy Specimen*, used in the flux profile determination, made of 19-mm (¾-in.) inorganic 740-kg/m^3 (46-lb/ft^3) nominal density calcium silicate board (Fig. 4 and Fig. 5). It is 250 mm (10 in.) wide by 1070 mm (42 in.) long with 27-mm (1¹⁄₁₆-in.) diameter holes centered on and along the centerline at the 100, 200, 300, . . . , 900, and 980-mm locations measured from the maximum flux end of the specimen.

6.4.1 To provide proper and consistent seating of the flux meter in the hole openings, a stainless steel or galvanized steel bearing plate (Fig. 4 and Fig. 5) shall be mounted and firmly secured to the underside of the calcium silicate board with holes corresponding to those specified above. The bearing plate shall run the length of the dummy specimen board and have a width of 76 mm (3.0 in.). The thickness of the bearing plate shall be set in order to maintain the flux meter height specified in 10.5. The maximum thickness of the bearing plate shall not exceed 3 mm (⅛ in.).

6.5 *Total Heat Flux Transducer* , to determine the flux profile of the chamber in conjunction with the dummy specimen (Fig. 4), shall be of the Schmidt-Boelter[8] type, have a range from 0 to 15 kW/m^2 (0 to 1.32 Btu/ft^2·s) and shall be calibrated over the operating flux level range from 0.10 to 15 kW/m^2 in accordance with the procedure outlined in Annex A1. A source of 15 to 25°C cooling water shall be provided for this instrument.

6.5.1 *Voltmeter*, high-impedance or potentiometric, with a range from 0 to 10 mV and reading to 0.01 mV shall be used to measure the output of the total heat flux transducer during the flux profile determination.

6.6 *Specimen Tray* (Fig. 6), constructed from 14-gage heat-resistant stainless steel (UNS-N08330 (AISI Type 330) or equivalent), thickness 1.98 mm (0.078 in.). The depth of the tray is 50 mm (2 in.). The flanges of the specimen tray are drilled to accommodate two stud bolts at each end; the bottom surface of the flange is 21 mm (0.83 in.) below the top edge of the specimen tray. The overall dimensions of the tray and the width of the flanges shall be such that the tray fills the open space in the sliding platform. The tray must be adequate to contain a specimen at least 1000 mm (40 in.) long and 250 mm (10 in.) wide. The zero reference point on the dummy specimen shall coincide with the pilot burner flame impingement point (Fig. 4).

6.7 *Pilot Burner*, used to ignite the specimen, is a nominal 6 mm (¼ in.) inside diameter, 10 mm (⅜ in.) outside diameter stainless steel tube line burner having 19 evenly spaced 0.7 mm (0.028 in.) diameter (No. 70 drill) holes drilled radially along the centerline and 16 evenly spaced 0.7 mm (0.028 in.) diameter (No. 70 drill) holes drilled radially 60 below the centerline (Fig. 7).

6.7.1 In operation, the gas[7] flow is adjusted to 0.85 to 0.115 m^2/h (3.0 to 4.0 SCFH) (air scale) flow rate. With the gas flow properly adjusted and the pilot burner in the test position, the pilot flame will extend from approximately 63.5 mm (2.5 in.) at the ends to approximately 127 mm (5 in.) at the center.

6.7.2 The holes in the pilot burner shall be kept clean. One means for opening the holes in the pilot burner is to use nickel-chromium or stainless steel wire that has a diameter of 0.5 mm (0.020 in.). Surface contaminants shall be removed from the burner. One means for removing contaminants is the use of a soft wire brush.

6.7.3 The pilot burner is positioned no more than 5° from the horizontal so that the flame generated will impinge on, and reach out over the specimen from the zero distance point (see Fig. 2 and Fig. 3). The burner must have the capability of being moved at least 50 mm (2 in.) away from the specimen when not in use.

6.8 *Thermocouples*—A 3.2-mm (⅛-in.) stainless steel sheathed grounded junction Chromel-Alumel thermocouple (6.8.1) shall be located in the radiant panel test chamber (Fig. 2 and Fig. 3). The chamber thermocouple is located in the longitudinal central vertical plane of the chamber 25 mm (1 in.) down from the top and 102 mm (4 in.) back from the inside of the exhaust stack.

6.8.1 The thermocouple shall be kept clean to ensure accuracy of readout.

6.8.2 An indicating potentiometer with a range from 100 to 500°C (212 to 932°F) shall be used to determine the chamber temperature prior to a test.

6.9 *Exhaust Duct*, with a capacity of 28.3 to 85 m^3/min (1000 to 3000 ft^3/min) at standard temperature and pressure decoupled from the chamber stack by at least 76 mm (3 in.) on all sides and with an effective area of the canopy slightly larger than plane area of the chamber with the specimen platform in the OUT position, is used to remove combustion products from the chamber. With the panel turned on and the dummy specimen in place, the air flow through the stack shall be 76.2 ± 15.2 m/min. (250 ± 50 ft/min.) when measured with a calibrated hot-wire anemometer.[9] The reading is taken about 30 s after insertion of the probe into the center of the stack opening at a distance of 152 mm (6 in.) down from the top of the stack opening (Fig. 2 and Fig. 3).

6.10 A timing device with a minimum resolution of 0.10 min shall be used to measure preheat, pilot contact, time of maximum flame travel, and when all flaming goes out.

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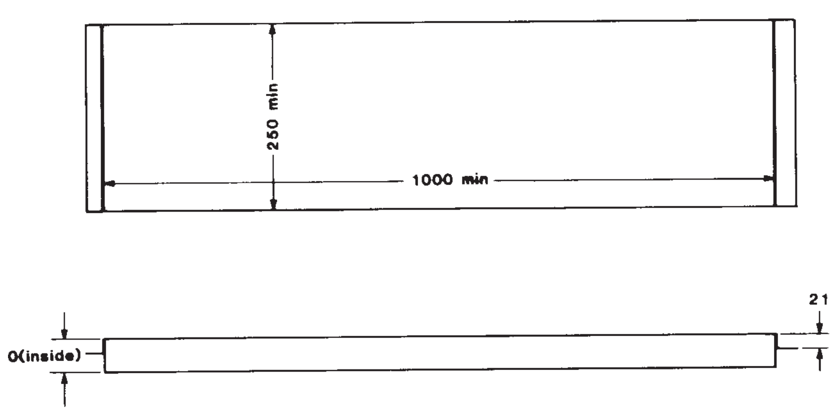
[8] Medtherm 64-2-20, manufactured by Medtherm Corp., P.O. Box 412, Huntsville, AL 35804, has been found satisfactory for this purpose.

[9] Omega HH-615 HT manufactured by Omega Engineering, Inc., Box 4047, Stamford, CT 06907, has been found satisfactory.



NOTE 1—All dimensions in millimetres. 1 in. = 25.4 mm.

FIG. 6 Specimen Tray

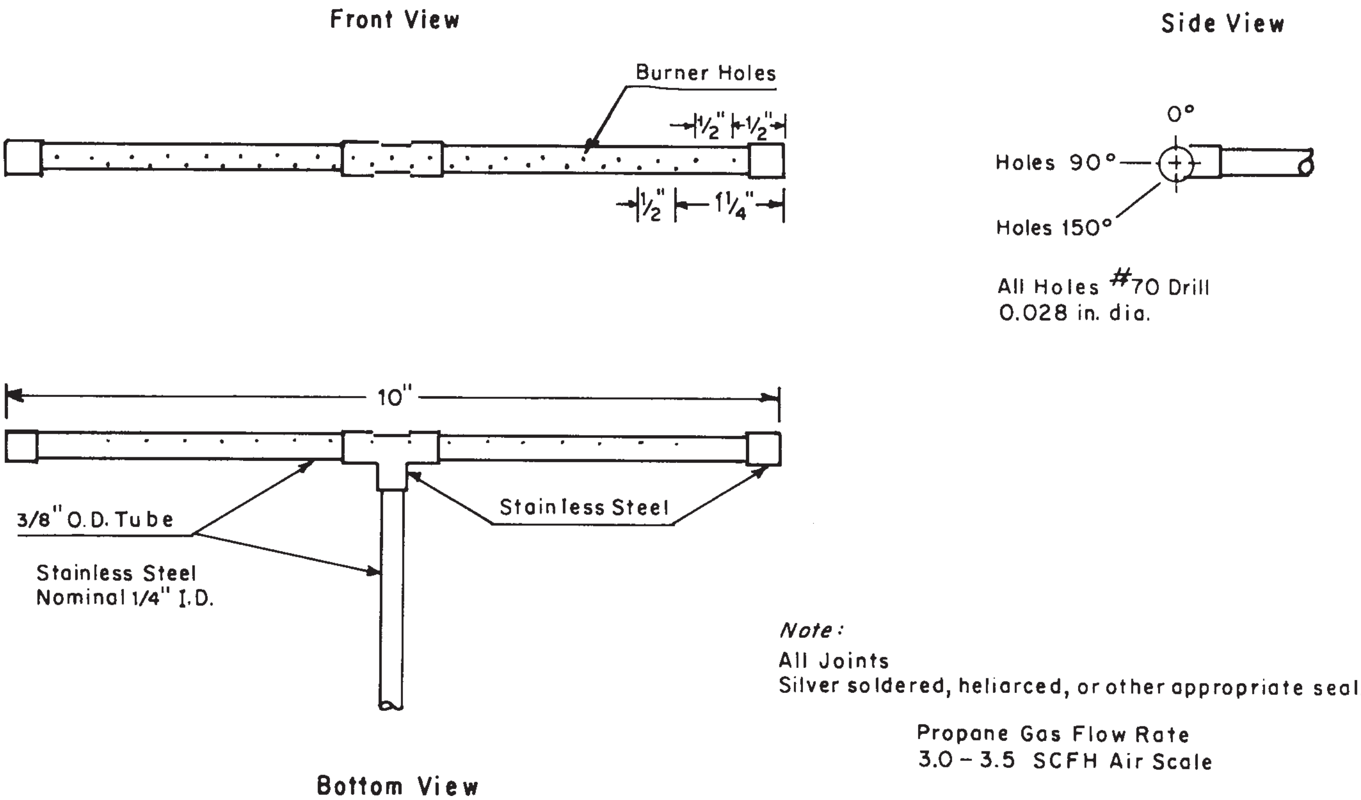


FIG. 7 Pilot Burner

7. Hazards

7.1 Suitable safeguards following sound engineering practices shall be installed in the panel fuel supply to guard against a gas-air explosion in the test chamber. Consideration shall be given, but not limited to the following : (*1*) a gas feed cutoff activated when the air supply fails, (*2*) a fire sensor directed at the panel surface that stops fuel flow when the panel flame goes out, and (*3*) a commercial gas water heater or gas-fired furnace pilot burner control thermostatic shut-off that is activated when the gas supply fails or other suitable and approved device. Manual reset is a requirement of any safeguard system used.

7.2 In view of the potential hazard from products of combustion, the exhaust system must be so designed and operated that the laboratory environment is protected from smoke and gas. The operator shall be instructed to mini mize his exposure to combustion products by following sound safety practice; for example, ensure that the exhaust system is working properly, wear appropriate clothing including gloves, etc.

8. Sampling

8.1 The samples selected for testing shall be representative of the product.

8.2 Standard ASTM sampling practice shall be followed where applicable; see Practice E 122 for choice of sample size to estimate the average quality of a lot or process.

9. Test Specimens

9.1 The test specimen shall be attic floor insulation sized to provide for adequate filling of the specimen tray (see Fig. 6).

9.2 The insulation specimen to be used for the test shall simulate actual installation practice. Typical examples are:

9.2.1 Loose-fill insulation intended for pneumatic application blown and conditioned prior to filling the specimen tray, and then gently screeded so that the insulation is level across the top of the tray.

9.2.2 Loose-fill insulation intended for pouring applications poured into the specimen tray and then gently screeded so that the insulation is level across the top of the tray.

9.2.3 Insulation batts or boards sliced to a depth of 50 mm (2 in.) and cut to fit into the specimen tray.

9.3 A minimum of three specimens per sample shall be tested.

9.4 The density of the specimen tested shall be deter-mined by weighing the specimen tray just prior to testing. Density shall be representative of field application.

10. Radiant Heat Energy Flux Profile Standardization

10.1 In a continuing program of tests, the flux profile shall be determined not less than once a week. Where the time interval between tests is greater than one week, the flux profile shall be determined at the start of the test series.

10.2 Mount the dummy specimen in the mounting frame, and attach the assembly to the sliding platform.

10.3 With the sliding platform out of the chamber, turn on the exhaust, and ignite the radiant panel. Allow the unit to heat for 1.5 h. The pilot burner is off during this determination. Adjust the fuel mixture to give an air-rich flame. Make fuel flow settings to bring the panel blackbody temperature to 485 ± 25°C (839 ± 45°F) and record the chamber temperature. After the panel blackbody temperature has stabilized, move the specimen platform into the chamber and close the door.

10.4 Allow 0.5 h for the closed chamber to equilibrate.

10.5 Measure the radiant heat energy flux level at the 400-mm point with the total flux meter instrumentation. This is done by inserting the flux meter in the opening so that its detecting plane is 1.6 to 3.2 mm (1⁄16 to 1⁄8 in.) above and parallel to the plane of the dummy specimen and reading its output after 30 ± 10 s. If the level is within the limits specified in 10.6, start the flux profile determination. If it is not, adjust the panel fuel flow as required to bring the level within the limits specified in 10.6. A suggested flux profile data log format is shown in Fig. 8.

10.6 Run the test under chamber operating conditions that give a flux profile as shown in Fig. 9. The radiant heat energy incident on the dummy specimen shall be between 8.7 and 9.5 kW/m^2 (0.77 and 0.83 $Btu/ft^2·s$) at the 200-mm point, between 4.8 and 5.2 kW/m^2 (0.42 and 0.46 $Btu/ft^2·s$) at the 400-mm point, and between 2.2 and 2.6 kW/m^2 (0.19 and 0.23 $Btu/ft^2·s$) at the 600-mm point.

10.7 Insert the flux meter in the 100-mm opening following the procedure given in 10.5. Read the millivolt output at 30± 10 s and proceed to the 200-mm point. Repeat the 100-mm procedure. Determine the 300 to 980-mm flux levels in the same manner. Following the 980-mm measurement, make a check reading at 400-mm. If this is within the limits set forth in 10.6, the test chamber is in calibration, and the profile determination is completed. If not, adjust fuel flow, allow 0.5 h for equilibrium, and repeat the procedure.

10.8 Plot the radiant heat energy flux data as a function of distance along the specimen plane on rectangular coordinate graph paper. Draw a smooth curve through the data points. This curve will hereafter be referred to as the flux profile curve.

10.9 Determine the open chamber temperature and radiant panel blackbody temperature identified with the standard flux profile by opening the door and moving the specimen platform out. Allow 0.5 h for the chamber to equilibrate. Read and record, in degrees Celsius, the chamber temperature and the optical pyrometer output that gives the panel blackbody temperature. These temperature settings shall be used in subsequent test work instead of measuring the dummy specimen radiant flux at 200, 400, and 600 mm.

11. Conditioning

11.1 Condition test specimens to equilibrium or a minimum of 48 h, whichever is greater, at 21 ± 3°C (69.8 ± 5.4°F) and a relative humidity of 50 ± 5 % immediately prior to testing. A less than 1 % change in net weight of the specimen in two consecutive weighings with 2 h between each weighing constitutes equilibrium. The maximum cumulative time between removing a sample from the conditioning environment (21 ± 3°C, 50 ± 5 % relative humidity) and inserting it into the radiant chamber shall not exceed 10 min.

12. Procedure

12.1 With the sliding platform out of the chamber, turn on the exhaust fan, and ignite the radiant panel. Allow the unit to heat for 1.5 h (Note 1). Read the panel blackbody temperature and the chamber temperature. If these temperatures are in agreement to within ± 5°C (41°F) with those determined in accordance with 10.9, the chamber is ready for use.

NOTE 1—It is recommended that a sheet of calcium silicate board,[6] be used to cover the opening when the hinged portion of the front panel is open and the specimen platform is moved out of the chamber. The mill-board is used to prevent heating of the specimen and to protect the operator.

12.2 Mount the specimen tray containing the specimen on the sliding platform.

Radiant Flux Profile

Date ______
Blackbody Temperature ______ mV. ______ °C (°F)
Gas Flow ______ NTP m^3/h (SCFH) Air Flow ______ NTP m^3/h (SCFH)
Room Temperature ______ °C (°F)
Air Pressure ______ Gas ______ mm (in.) of H_2O
Flux Meter Conversion Factor ______
Radiometer No. ______ from Calibration on ______

Distance, mm	mV	W/cm^2
100	______	______
200	______	______
300	______	______
400	______	______
500	______	______
600	______	______
700	______	______
800	______	______
900	______	______
980	______	______

Signed ____________

FIG. 8 Flux Profile Data Log Format

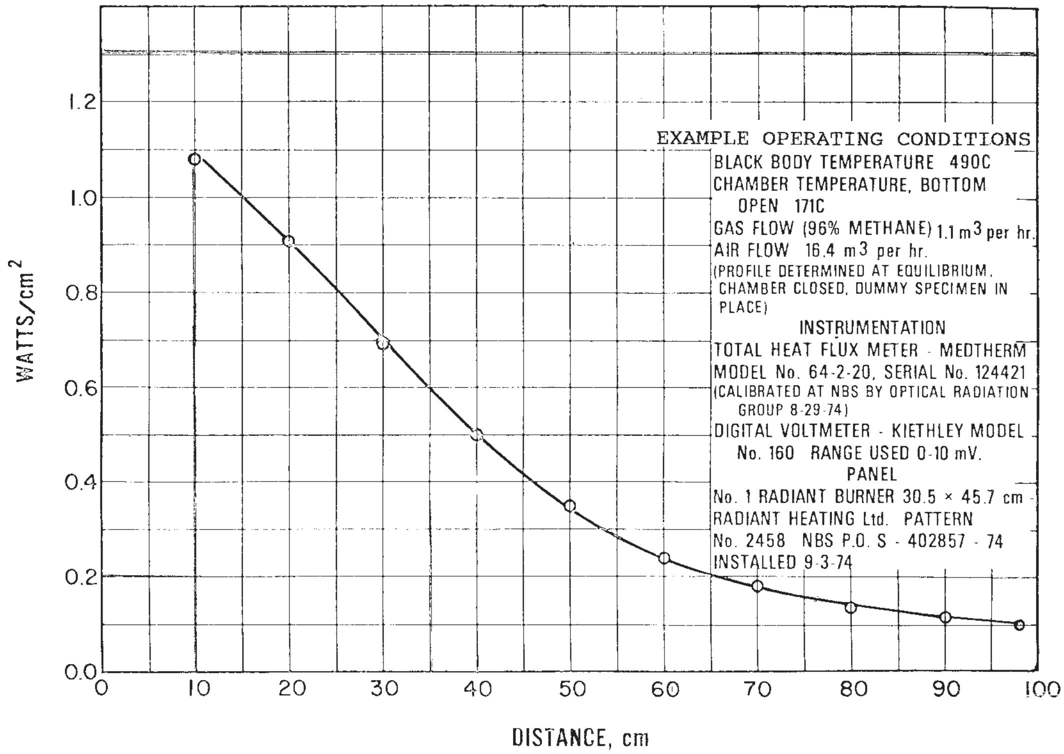


FIG. 9 Standard Radiant Heat Energy Flux Profile

12.3 Ignite the pilot burner, move the specimen into the chamber, and close the door. Start the timer. After 2 min ± 5 s preheat, with the pilot burner on and set so that the flame is horizontal and 50 mm (2 in.) above the specimen, bring the pilot burner flame into contact with the specimen at the 0-mm mark. Leave the pilot burner flame in contact with the specimen for 2 min, then remove to a position 50 mm above the specimen, and turn the pilot burner off.

12.4 If the specimen does not ignite within 2 min following pilot burner flame application, terminate the test. For specimens that do ignite, continue the test until all specimen flaming goes out.

12.5 When the test is completed, open the door and pull out the specimen platform.

12.6 Measure the distance burned, that is, the point of farthest advance of the flame front, to the nearest 1 mm. From the flux profile curve, convert the distance to kilowatts per square metre critical radiant heat flux. Read to two significant figures. A suggested data log format is shown in Fig. 10.

12.7 Remove the specimen and its mounting frame from the movable platform.

Test Number ______ Date ______ Time ______
Laboratory __________
Specimen Identification/Code No. ______________________________

Test Assembly: ______________________________

Panel Angle ______° Temperature __________ °C (°F)
Flow: Gas ______ NTP m³/h (SCFH) Air ______ NTP m³/h (SCFH)
Pressure, mm (in.) H_2O: Initial, Air,__________ Gas ______ ;
Chamber: Temperature Initial __________ Maximum __________ °C (°F)
Room: Temperature __________ °C (°F) Hood Draft __________ mm (in.) water

Flame Front Advance

Distance, mm (in.)	Time, min						
___	______	___	______	___	______	___	______
___	______	___	______	___	______	___	______
___	______	___	______	___	______	___	______
___	______	___	______	___	______	___	______
___	______	___	______	___	______	___	______
___	______	___	______	___	______	___	______

Total Burn Length __________ mm (in.) Critical Radiant Flux, W/cm² __________
Flame Front Out __________ min Flux Profile Reference __________
All Flame Out __________ min

Signed ______________________________

FIG. 10 Radiant Panel Test Data Log Format

12.8 Before each test, verify that the blackbody temperature and chamber temperature meet the requirements of Section 12.1.

13. Calculation

13.1 Calculate the mean, standard deviation, and coefficient of variation of the critical radiant flux test data on the three specimens in accordance with standard practice **(1).** [10]

$$s = \sqrt{(\Sigma X^2 - n\bar{X}^2)/n - 1} \text{ and } v = s/X \times 100 \quad (1)$$

where:
s = estimated standard deviation,
X = value of single observation,
n = number of observations,
$\bar{X}$ = arithmetic mean of the set of observations, and
v = coefficient of variation.

14. Report

14.1 Report the following information:
14.1.1 Description of the attic floor insulation tested,
14.1.2 Description of the procedure used to prepare the insulation specimen,
14.1.3 Density and critical radiant flux of each of the specimens tested, and
14.1.4 Average critical radiant flux, standard deviation, and coefficient of variation.

15. Precision and Bias

15.1 Based on changes that have been made in this test method, Task Group E5.22.06 is developing data regarding a precision and bias statement.

16. Keywords

16.1 attic floor insulation; cellulosic fiber insulation; critical radiant flux; fire; loose fill insulation; mineral fiber insulation; radiant panel

[10] The boldface numbers in parentheses refer to the list of references at the end of this standard.

ANNEX

(Mandatory Information)

A1. PROCEDURE FOR CALIBRATION OF RADIATION INSTRUMENTATION

A1.1 Radiation Pyrometer

A1.1.1 Calibrate the radiation pyrometer by means of a conventional blackbody enclosure placed within a furnace and maintained at uniform temperatures of 460, 470, 480, 490, 500, and 510°C (860, 878, 896, 914, 932, and 950°F). The blackbody enclosure may consist of a closed Chromel metal cylinder with a small sight hole in one end. Sight the radiation pyrometer upon the opposite end of the cylinder where a thermocouple indicates the blackbody temperature. Place the thermocouple within a drilled hole and in good thermal contact with the blackbody. When the blackbody enclosure has reached the appropriate temperature equilibrium, read the output of the radiation pyrometer. Repeat for each temperature.

A1.1.2 An acceptable alternative to the procedure described in A1.1.1 is the use of an outside agency to provide calibration traceable to the National Institute of Standards and Technology (NIST).

A1.2 Total Heat Flux Meter

A1.2.1 The total flux meter calibration shall be developed by transfer calibration methods with an NIST-calibrated flux meter. This latter calibration shall make use of the radiant panel tester as the heat source. Measurements shall be made at each of the ten dummy specimen positions, and the mean value of these results shall constitute the final calibration.

A1.2.2 Each laboratory shall maintain a dedicated calibrated reference flux meter against which one or more working flux meters shall be compared as needed. The working flux meters shall be calibrated at least once per year.

APPENDIX

(Nonmandatory Information)

X1. COMMENTARY OF CRITICAL RADIANT FLUX TEST FOR EXPOSED ATTIC FLOOR INSULATION

X1.1 When consideration was being given in 1977 to revision of General Services Administration (GSA) Fed. Specs. HH-I-515C, for cellulose loose-fill insulation, HH-I-521E, for insulation blankets, and HH-I-1030A, for mineral fiber loose-fill insulation, three questions were asked about the flammability requirements: (*1*) Were the existing test methods representative of configurations and exposures likely to be found in actual use?; (*2*) If not, what test methods should be introduced in their place?; and (*3*) What would be reasonable levels of acceptance in terms of fire safety of occupants? The basic premise assumed was that the addition of insulation should not increase the normal and expected level of fire risk to the occupants of typical single family dwellings. It is important to remember that the concern here is whether the insulation is the first item to ignite or is it the cause for flame spread, and not whether it becomes involved in the later stages of a fire.

X1.2 In the insulation market, in particular for residential occupancies, insulation has two major applications: (*1*) on the floors of attics in an exposed condition and (*2*) in exterior side walls. It was believed that the attic floor application was more critical because it presented an extended exposed surface and this problem should be addressed first. Past examination of the fire test methods in the Federal specifications at first suggested that Test Method E 84 may be inappropriate for testing insulation installed on the floor of an attic. Loose-fill insulation is not normally installed over a metal screen nor is it likely to be exposed to flames from below.

X1.3 Attic floor insulation (loose-fill or batting) is typically applied between and over floor joist in an attic where the air is relatively still and where the temperature and humidity vary depending upon the season, the geographical location, the geometrical arrangements, the extent of free or forced attic ventilation, etc. The most severe exposure is likely to develop during periods of elevated outdoor temperatures and high solar radiation. Typical small ignition sources would be an electrical failure causing an arc or a carelessly applied propane torch.

X1.4 This scenario, insulation on the floor of an attic in still air exposed to radiation from the roof and subjected to a small ignition source, is modeled by the conditions of Test Method E 648. This standard originally was developed for evaluating floor covering systems in corridors exposed to radiation from fully developed fires in rooms. The test method involves a graded radiant exposure varying from 0.1 to 1.1 W/cm^2, which corresponds approximately to differences between direct summer solar radiation and the irradiance on the floor from a preflashover fire on the ceiling. The Flooring Radiant Panel Test was adapted to accommodate insulation specimens and introduced into the GSA HH-I-515D standard as the Attic Floor Radiant Panel Test. The material under evaluation in the test is exposed to a graded irradiance and ignited with a pilot burner at the high flux end of the specimen. The flux at the farthest point where the flame extinguishes is defined as the critical radiant flux.

X1.5 Measurements were made in the attic of a private home in the Washington, DC, area during July of 1977 to define approximate attic temperatures. Daytime temperatures of 60°C were measured. A temperature of 71°C is used as a design value for attic fans by the American Ventilation Association **(2).** This temperature would correspond to the underside of the roof acting as a black body radiator imposing a flux level of 0.08 W/cm^2 onto the insulation. A50 % safety factor would bring the flux level to 0.12 W/cm^2. For comparison purposes, the solar radiation reaching the surface normal to the sun's rays on a clear summer day in Florida is 0.11 W/cm^2.

X1.6 The selected radiant flux exposure covers the range of anticipated thermal radiation levels in conventional attic spaces. The lower level (0.1 W/cm^2) corresponds approximately to that resulting from direct solar radiation. The upper level (1.1 W/cm^2) includes that which may be anticipated from an incidental fire or an overheated appliance or device. The critical radiant flux measurement is an indication of the level of external radiant heat below which surface flame propagation, in the presence of a pilot flame, would not be expected.

X1.7 In a report by Gross **(3)** there is a description of large-scale attic mock-up experiments in which several cellulosic and glass fiber products were exposed to temperatures of 71 and 82°C. These experiments supported the use of the attic floor radiant panel test and the criterion chosen for recommendation to GSA. A second series of large-scale attic fire experiments was subsequently conducted at the National Bureau of Standards **(4).** These experiments showed that materials with critical radiant flux values greater than the surface heat flux generated in the simulated summer attic conditions did not propagate flame away from a small torch ignition source. Ignition sources larger than the torch flames could raise the air temperature in the attic and the heat flux to the floor of the attic to values above those found in these experiments. Attic fire experiments carried out at Underwriters Laboratories **(5,6)**also demonstrated that, for materials having critical radiant flux values greater than 0.12 W/cm^2, flames did not propagate more than 133 mm (5.25 in.) when exposed to an open flame. On the other hand, for materials having values below 0.12 W/cm^2, flame propagation of greater than 762 mm (30 in.) was observed in at least 50 % of the experiments—on the conservative or safe side. Other attic construction methods would also influence test conditions. Flame spread over the exposed insulation surface would only be expected in cases where the incident surface heat flux exceeds the critical radiant flux of the insulation material as measured in the attic floor radiant panel test.

X1.8 As part of the development of the flammability test methods for HH-I-515D, an interlaboratory program was conducted to evaluate the repeatability and reproducibility of the methods for cellulose insulation. Details of this study are described by Lawson **(7).** The results for the critical radiant flux determination showed that the pooled coefficient of variation for repeatability (within laboratory) was 12 % and the average coefficient of variation for reproducibility (between laboratory) was 25 %. These values were not significantly greater for loose-fill cellulose insulation than for other materials and compare favorably with precision estimates available from other standard fire tests. Until the adoption of the line burner in 1994, this study was the basis for the precision and bias statement. The following sections (X1.8.1 to X1.8.4) represent the precision and bias statement at that time using the small torch tip ignition burner.

X1.8.1 Defining test results as the average of three replicate determinations, the repeatability (within laboratory variability) is about 12 % of the measured value and the reproducibility (between laboratory variability) is of the order of 21 % of measured value.

X1.8.2 This statement is based on the results of one, nine-laboratory factorially designed experiment in which a total of seven cellulosic loose-fill insulations were tested.

X1.8.3 *Repeatability* is a quantity that will be exceeded only about 5 % of the time by the difference, taken in absolute value, of two randomly selected results obtained in the same laboratory on a given material **(8)**.

X1.8.4 *Reproducibility* is a quantity that will be exceeded only about 5 % of the time by the difference, taken in absolute value, of two single test results made on the same material in two different randomly selected laboratories **(8)**.

X1.9 The test procedure has been shown to be applicable to all insulation used on attic floors. However, certain limitations of this test are:

X1.9.1 The test does not provide an indication of the tendency of the insulation to smolder.

X1.9.2 The test does not provide information on the rate of the surface flame spread under constant heat flux exposure conditions.

X1.9.3 The test is not applicable to those insulations which melt or shrink away when exposed to the radiant heat environment or the pilot burner.

X1.9.4 The test results may not be applicable where appreciable air movement due to forced ventilation or wind is present.

X1.9.5 Current ASTM specifications that list Test Method E 970 are Specifications C 665 and C 764.

REFERENCES

(**1**) *Manual on Quality Control of Materials, ASTM STP ISC*, ASTM, 1951.

(**2**) *The Handbook of Moving Air*, American Ventilation Association, Houston, TX, 1977.

(**3**) Gross, D., "A Preliminary Study of the Fire Safety of Thermal Insulation for Use in Attics or Enclosed Spaces in Residential Housing," *NBSIR 78-1497*, National Bureau of Standards, June 1978.

(**4**) Evans, D. D., and Davis, S., "Technical Support for the Consumer Product Safety Commission 1979 Interim Standards for Cellulose Insulation, *NBSIR 81-2213*, National Bureau of Standards," March 1981.

(**5**) Kleinfelder, W. A., "Investigation of the Fire Performance of Building Insulation in Full-Scale and Laboratory Fire Test," *ORNL/SUB/79-7863/1*, Oak Ridge National Laboratory, April 1984.

(**6**) Metes, W. S., and Kleinfelder, W. A., "Flammability of Thermal Insulation Materials in Laboratory Tests and a Simulated Attic," *Subject 861*, Underwriters Laboratories, Inc., March 1979.

(**7**) Lawson, J. R., "Interlaboratory Evaluation of the Attic Floor Radiant Panel Test and Smoldering Combustion Test for Cellulose Thermal Insulation," *NBSIR 79-1588*, National Bureau of Standards, February 1979.

(**8**) Mandel, J., "Repeatability and Reproducibility," *Materials Research and Standards*, Vol 11, No. 8, p. 8.