

acid slowly with continuous stirring. The solution shall be at room temperature. Dip the coupons in the solution for 1 to 3 minutes.

(iii) Technique #3—Steel. This technique or technique #1 can be used for post-cleaning the tested steel coupons only.

Description: Use one of the following two solutions:

Solution #1. Add 100 ml of sulfuric acid (specific gravity 1.84), 1.5 ml organic inhibitor, and water to make a 1 liter solution. The solution shall be 50 °C (120 °F). Dip the coupons in this solution.

Solution #2 (also referred to as Clarke's solution). Add 20 g of antimony trioxide and 50 g of stannous chloride to 1 liter of hydrochloric acid (specific gravity 1.19). The solution shall be stirred and be used at room temperature. Dip the coupons in this solution stirring the solution at a rate such that deformation of the coupons does not occur. This dipping shall last for up to 25 minutes.

(iv) Technique #4—Aluminum. This technique or technique #1 can be used for post-cleaning the tested aluminum coupons only.

Description: Make a 1 liter solution by adding 20g of chromic acid, and 50 ml of phosphoric acid (specific gravity 1.69), to water. The solution shall be 80 °C (176 °F). Dip the coupons in this solution for 5–10 minutes. If a film remains, dip the coupons in nitric acid (specific gravity 1.42) for 1 minute. Repeat the chromic acid dip. Nitric acid alone may be used if there are no deposits.

(7) After cleaning, examine the metal coupons over a 40-W appliance light bulb for perforation.

(c) *Noncorrosiveness*. Noncorrosiveness shall be determined by the absence of any perforations (excluding notches which extend into the coupon 3 mm or less from any edge) on each of the six test coupons when the coupons are observed over a 40-W appliance light bulb.

#### § 1209.6 Test procedures for critical radiant flux.

This section provides the test procedure for determining the critical radiant flux of exposed attic floor insulation using a radiant heat energy source.

(a) *Apparatus and description of test procedure*. Test chamber (Figures 3 and 4 paragraph (b) of this section). An air-gas fueled radiant heat energy panel or equivalent panel inclined at 30° above and directed at a horizontally-mounted attic floor insulation specimen. The radiant panel generates a radiant energy flux distribution ranging along the approximately 100-cm length of the test specimen from a nominal maximum of 1.0 W/cm<sup>2</sup> to a minimum of 0.1 W/cm<sup>2</sup>. The test is initiated by open flame ignition from a pilot burner. The distance burned to flame-out is converted to W/cm<sup>2</sup> from the flux profile graph (Figure 8) and reported as critical radiant flux, W/cm<sup>2</sup>. Section 1209.8 provides a procedure for calibrating the radiation pyrometer used to standardize the thermal output of the panel.

(b) *Construction and instrumentation of the radiant panel test chamber*. The radiant panel test chamber shall be constructed and instrumented as follows:

(1) The radiant panel test chamber employed for this test shall be located in a draft protected area maintained at 21±3 °C (69.8±9 °F) and relative humidity of 50±20%. The radiant panel test chamber, (Figures 3 and 4) shall consist of an enclosure 140 cm (55 in) long by 50 cm (19½ in) deep by 71 cm (28 in) above the test specimen. The sides, ends, and top shall be of 1.3 cm nominal (½ in) calcium silicate board, such as Marinite I, 0.74 g/cm<sup>3</sup> (46 lb/ft<sup>3</sup>) nominal density, with a thermal conductivity at 177 °C (350 °F) of 1.11 cal (g)/hr cm<sup>2</sup> °C/cm [0.89 Btu/(hr) (ft<sup>2</sup>) (°F/in)]. One side shall be provided with an approximately 10 cm × 110 cm (4 × 44 inches) draft tight fire resistant glass window so that the entire length of the test specimen may be observed 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. A draft tight, fire resistant observation window may be installed at the low flux end of the chamber.

(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 a fixed and level position. The free, or air access, area around the platform shall be

in the range of 1935–3225 cm<sup>2</sup> (300–500 square in). The top of the chamber shall have an exhaust stack with interior dimensions of 10.2 cm (4 in) wide by 38 cm (15 in) deep by 31.8 cm (12.5 in) high at the opposite end of the chamber from the radiant energy source. The radiant heat energy source shall be a panel of porous refractory material mounted in a cast iron frame, with a radiation surface of 30.5×45.7 cm nominal (12 by 18 in). The panel fuel system shall consist of a venturi-type aspirator or equivalent system for mixing gas and air at approximately atmospheric pressure, a clean dry air supply capable of providing 28.3 NTP (Normal Temperature and Pressure m<sup>3</sup> per hr (1000 standard cubic feet per hour) at 7.6 cm (3.0 in) of water, and suitable instrumentation for monitoring and controlling the flow of fuel to the panel.

(3) The radiant heat energy panel shall be mounted in the chamber  $30 \pm 0.5^\circ$  to the horizontal specimen plane. The horizontal distance from the 0 mark on the specimen fixture to the bottom edge (projected) of the radiating surface of the panel is  $8.9 \text{ cm} \pm 0.1$  ( $3\frac{1}{2} \pm \frac{1}{32}$  in). The panel to specimen vertical distance is  $14.0 \text{ cm} \pm 0.1$  ( $5\frac{1}{2} \pm \frac{1}{32}$  in) (see Figure 5). The angle and dimensions given above are critical in order to obtain the required radiant flux. The radiation pyrometer for standardizing the thermal output of the panel shall be suitable for viewing a circular area 25.0 cm (10 in) in diameter at a range of about 1.37 m (54 in). It shall be calibrated over the black body temperature range of 490–510 °C (914–950 °F) in accordance with the procedure described in §1209.8. A high impedance voltmeter with a suitable millivolt range shall be used to monitor the output of the radiation pyrometer described. The dummy holder (see Figure 6), shall be constructed from 14 gauge heat-resistant stainless steel (AISI Type 300 (UNA-N08330)) or equivalent thickness 0.198 cm (0.078 in), having overall dimension of 114 cm (45 in) by 32 cm ( $12\frac{3}{4}$  in) with a specimen opening of 20 cm (7.9 inches) by 100 cm (39.4 in). Six slots are cut in the flange on either side of the holder to reduce warping. The holder is fastened to the platform with two stud bolts at each end.

(4) The specimen tray (see Figure 7) shall be constructed from 14 gauge heat-resistant stainless steel (AISI Type 300 (UNA-N08330)) or equivalent, thickness 0.198 cm (0.078 in). The depth of the tray is  $5.0 \pm 0.2$  cm ( $2 \pm \frac{5}{64}$  in). The flanges of the specimen tray are drilled to accommodate two stud bolts at each end; the bottom surface of the flange is  $2.1 \pm 0.1$  cm ( $0.83 \pm 0.04$  in) below the top edge of the specimen tray. The overall dimensions of the tray and the width of the flanges are not critical and should be chosen so that the tray essentially fills the open space in the sliding platform. Tray must be adequate to contain a specimen at least 100 cm long and 25 cm wide. It is important to note that the zero reference point on the dummy specimen coincides with the pilot burner flame impingement point (see Figure 5).

(5) The pilot burner used to ignite the specimen shall be a propane venturi torch with an axially symmetric burner tip having a propane supply tube with an orifice diameter of  $0.0076 \pm 0.0013$  cm ( $0.003 \pm 0.0005$  in). In operation, the propane flow is adjusted to give a pencil flame blue inner cone length of 1.3 cm ( $\frac{1}{2}$  in). The pilot burner is positioned so that the flame generated will impinge on the centerline of the specimen at the zero reference point and at right angles to the specimen length (see Figures 3 and 4). The burner shall be capable of being swung out of the ignition position so that the flame is horizontal and at least 5 cm (2 in) above the specimen plane.

(6) Two 3.2 mm nominal ( $\frac{1}{8}$  in) diameter stainless steel sheathed, grounded junction chromel alumel thermocouples are located in the flooring radiant panel test chamber (see Figures 3 and 4). Thermocouples shall be kept clean to ensure accuracy of readout. The chamber thermocouple is located in the longitudinal central vertical plane of the chamber  $2.5 \text{ cm} \pm 0.1$  ( $1 \pm \frac{1}{32}$  in) down from the top and  $10.2 \text{ cm} \pm 0.1$  ( $4 \text{ in} \pm \frac{1}{32}$ ) back from the inside of the exhaust stack. The exhaust stack thermocouple is centrally located  $15.2 \pm 0.1$  cm ( $6 \pm \frac{1}{32}$  in) from the top. A temperature indicating device with a range of 100–500 °C (212–932 °F) may be used to determine the chamber temperatures prior to a test.

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(7) An exhaust duct with a capacity of 28.3–85 NTP m<sup>3</sup> per minute (1000–3000 standard cubic feet per minute) decoupled from the chamber stack by at least 7.6 cm (3 in) on all sides and with an effective area of the canopy slightly larger than the plane area of the chamber with the specimen platform in the out position shall be used to remove combustion products from the chamber. With the panel turned on and dummy specimen in place, there shall be no measurable difference in air flow through the chamber stack with the exhaust on or off.

(8) The dummy specimen which is used in the flux profile determination shall be made of 1.9±0.1 cm ( $\frac{3}{4}\pm\frac{1}{32}$  in) 0.74 g/cm<sup>3</sup> (46 lb/ft<sup>3</sup>) nominal density calcium silicate board, such as Marinite I (see Figure 6). It is 25 cm (10 in) wide by 107 cm (42 in) long with 2.7±0.1 cm ( $1\frac{1}{16}\pm\frac{1}{32}$  in) diameter holes centered on and along the centerline at the 10, 20, 30, 40, 50, 60, 70, 80, 90 cm locations (within ±0.1 cm), measured from the zero reference point at the maximum flux end of the specimen. The total heat flux transducer used to determine the flux profile of the chamber in conjunction with the dummy specimen should be of the Schmidt-Boelter type, having a range of 0–1.5 W/cm<sup>2</sup> (0–1.32 Btu/ft<sup>2</sup> s), and shall be calibrated over the operating flux level range of .10 to 1.5 W/cm<sup>2</sup> in accordance with the procedure outlined in §1209.8. The incoming cooling water flowing through the instrument shall be 15–25 °C (59–77 °F). A high impedance voltmeter with a resolution of at least 0.01 mV shall be used to measure the output of the total heat flux transducer during the flux profile determination. A timer shall be used for measuring preheat and pilot contact time.

(c) *Safety procedures.* The possibility of a gas-air fuel explosion in the test chamber should be recognized. Suitable safeguards consistent with sound engineering practice should be installed in the panel fuel supply system. These may include one or more of the following:

(1) A gas feed cut-off 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,

(3) A commercial gas water heater or gas-fired furnace pilot burner control thermostatic shut-off, which is activated when the gas supply fails, or other suitable and approved device.

Manual reset is considered a desirable feature of any safeguard system used. 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 should be instructed to minimize exposure to combustion products by following sound safety practices, such as ensuring that the exhaust system is working properly and wearing appropriate clothing, including gloves.

(d) *Test specimens*—(1) *Specimens of insulation intended for pneumatic applications.* (i) Insulation shall be installed into the specimen tray using the blower/cyclone apparatus described in §1209.4(a).

(ii) Insulation shall be conditioned as described in §1209.4(b).

(iii) Apparatus #4, 6, 7, 8, 9 and 10 shall be used as described in §1209.4(d)(1)(i) with the following additional requirements.

(iv) The fill chamber (apparatus #6) shall be equipped with openings in the front and back so that a radiant panel specimen tray can be slid through the fill chamber.

(v) Adjust the blower control(s) (apparatus #9) such that the supply and overflow blowers will operate at a no load voltage of 40 volts RMS.

(vi) Turn on the blowers simultaneously and proceed to fill the fill chamber by picking up material from the box using the supply source hose. Large clumps of insulation shall be broken by hand before feeding them into the hose. Continue filling the chamber until large amounts of insulation are being drawn into the overflow hose.

(vii) Slowly slide the specimen tray through the fill chamber so that the low flux end of the tray is parallel with the back of the fill chamber filling the tray by sliding the tray forward to allow an excess of insulation to build up in the tray.

(viii) Shut off the blowers and remove the specimen tray and gently screed the insulation so that the insulation is level across the top of the tray. Take care not to compact the insulation or to leave large voids in the material. The tray may now be inserted into the radiant panel.

(2) *Specimens of insulation intended for pouring applications.* Insulation intended for pouring applications shall be poured into the tray until the tray is overfilled and then carefully screeded to the top of the tray taking care not to compact the insulation or leave large voids in the surface of the material.

(3) *Specimens of insulation intended for pouring and pneumatic applications.* If the insulation is intended for both pouring and pneumatic applications, or if it is uncertain whether the insulation will be poured or blown, the insulation shall be tested using the test procedures at paragraphs (d) (1) and (2) of this section for each of the applications. Three specimens shall be tested under the test procedure for each application. All of the specimens shall meet the criteria at § 1209.3(b) for passing the attic floor radiant panel test.

(e) *Radiant heat energy flux profile standardization.* In a continuing program of tests, determine the flux profile at least once a week. Where the time interval between tests is greater than one week, determine the flux profile at the start of the test series.

(1) Mount the dummy specimen in the mounting frame and attach the assembly to the sliding platform. With the sliding platform out of the chamber, ignite the radiant panel. Allow the unit to heat for 1 hour. 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 to an apparent black body temperature as measured by the radiation pyrometer, of approximately 500 °C (932 °F), and bring the chamber to a temperature of approximately 180 °C (356 °F). When equilibrium has been established, move the specimen platform into the chamber. Allow 0.5 hour for the closed chamber to reach equilibrium.

(2) Measure the radiant heat energy flux level at the 40 cm point with the

total flux meter instrumentation. This is done by inserting the flux meter in the opening so that its detecting plane is 0.16–0.32 cm ( $\frac{1}{16}$ – $\frac{1}{8}$  inch) above and parallel to the plane of the dummy specimen and reading its output after  $30 \pm 10$  seconds. If the level is within the limits specified, the flux profile determination is started. If it is not, make the necessary adjustments in the panel fuel flow. A suggested flux profile data log format is shown in Figure 9.

(3) The test shall be run under chamber operating conditions which give a flux profile as shown in Figure 8. The radiant heat energy incident on the dummy specimen shall be between 0.87 and .95 W/cm<sup>2</sup> (0.77 and .83 Btu/ft<sup>2</sup> sec) at the 20 cm point, between 0.48 and 0.52 W/cm<sup>2</sup> (0.42 and 0.46 Btu/ft<sup>2</sup> sec) at the 40 cm point, and between 0.22 and 0.26 W/cm<sup>2</sup> (0.19 and 0.23 Btu/ft<sup>2</sup> sec) at the 60 cm point. Insert the flux meter in the 10 cm opening, following the procedure given above. Read the millivolt output at  $30 \pm 10$  seconds and proceed to the 20 cm point. Repeat the 10 cm procedure. The 30 to 90 cm flux levels are determined in the same manner. Following the 90 cm measurement, make a check reading at 40 cm. If this is within the limits set forth, the test chamber is in calibration, and the profile determination is completed. If not, carefully adjust fuel flow, allow 0.5 hour for equilibrium and repeat the procedure. Plot the radiant heat energy flux data as a function of distance along the specimen plane on rectangular coordinate graph paper. Carefully draw the best smooth curve through the data points. This curve will hereafter be referred to as the flux profile curve.

(4) Determine the open chamber apparent black body and chamber temperatures that are identified with the standard flux profile by opening the door and moving the specimen platform out. Allow 0.5 hour for the chamber to reach equilibrium. Read the radiation pyrometer output and record the apparent black body temperature. This is the temperature setting that can be used in subsequent test work in lieu of measuring the radiant flux at 20 cm, 40 cm, and 60 cm using the dummy specimen. The chamber temperature also shall be determined again after 0.5

hour and is an added check on operating conditions.

(f) *Conditioning.* Test specimens shall be conditioned to equilibrium at  $21 \pm 3$  °C ( $69.8 \pm 5.4$  °F) and a relative humidity of  $50 \pm 5$  percent immediately prior to testing. A less than 1% change in net weight of the specimen in two consecutive weighings with two hours between each weighing constitutes equilibrium. The maximum cumulative time a conditioned sample may be exposed to conditions different from  $21 \pm 3$  °C ( $69.8 \pm 5.4$  °F) and relative humidity of  $50 \pm 5$ % before insertion in to the radiant panel chamber for testing is 10 minutes.

(g) *Test Procedure.* (1) With the sliding platform out of the chamber, ignite the radiant panel. Allow the unit to heat for 1 hour. It is recommended that a sheet of inorganic millboard 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 millboard is used to prevent heating of the specimen and to protect the operator. Read the panel apparent black body temperature and the chamber temperature. When these temperatures are in agreement to within  $\pm 5$  °C ( $\pm 9$  °F) with those determined previously, during the flux profile standardization procedure, the chamber is ready for use.

(2) Mount the specimen tray with insulation on the sliding platform and position with stud bolts (see Figure 9). Ignite the pilot burner, move the specimen into the chamber, and close the door. Start the timer. After 2 minutes  $\pm 5$  seconds preheat, with the pilot burner on and set so that the flame is horizontal and about 5 cm above the specimen, bring the pilot burner flame into contact with the center of the specimen at the 0 mark. Leave the pilot burner flame in contact with the specimen for 2 minutes  $\pm 5$  seconds, or until all flaming other than in the area of the pilot burner has ceased, then remove to a position of at least 5 cm above the specimen and leave burning until the test is terminated.

(3) If the specimen does not ignite within 2 minutes following pilot burner flame application, the test is terminated by extinguishing the pilot burner flame. For specimens that do ignite, the test is continued until the flame

goes out. When the test is completed, the door is opened, and the specimen platform is pulled out.

(4) Measure the distance burned, (the point of farthest advance of the flame front) to the nearest 0.1 cm (.03 in). From the flux profile curve, convert the distance to  $W/cm^2$  (Btu/ft<sup>2</sup>sec) critical radiant heat flux at flame out. Read to two significant figures. A suggested data log format is shown in Figure 10.

(5) Remove the specimen tray from the moveable platform. The succeeding test can begin as soon as the panel apparent black body temperature and chamber temperature are verified. The specimen tray should be at room temperature before the next specimen is inserted.

#### § 1209.7 Test procedures for smoldering combustion.

This section provides the test method for determining smoldering combustion characteristics of materials used for thermal insulation. This test shall be conducted on materials at the measured settled density as provided in § 1209.4.

(a) *Apparatus.* (1) The specimen holder shall be an open-top  $20 \pm 0.2$  cm ( $7.87 \pm 0.08$  in) square box,  $10 \pm 0.2$  cm ( $3.94 \pm 0.08$  in) in height, fabricated from a single piece of  $0.61 \pm 0.08$  mm thick (24 U.S. Standard gauge) stainless steel sheet with the vertical edges of the box overlapped, not to exceed 7 mm (.28 in) in seam width, and soldered so as to be watertight. A removable extension top extending  $8 \pm 5$  cm. above the top of the smolder box shall also be provided. The specimen holder during test use shall rest upon a pad of unfaced glass fiberboard or equivalent having dimensions equal to or greater than those of the bottom of the specimen holder. The unfaced glass fiberboard shall be approximately 2.5 cm (1 in) thick with a thermal conductivity of  $0.30 \pm 0.05$  cal(g)/hr cm<sup>2</sup> °C/cm ( $0.24 \pm 0.04$  Btu/hr ft<sup>2</sup> °F/in) at 23.9 °C (75 °F).

(2) Ignition source. The ignition source shall be a cigarette without filter tip made from natural tobacco,  $85 \pm 2$  mm ( $3.35 \pm 0.08$  in) long with a tobacco packing density of  $0.270 \pm 0.020$  g/cm<sup>3</sup> ( $16.9 \pm 1.25$  lb/ft<sup>3</sup>) and a total weight of  $1.1 \pm 0.1$  gm ( $0.039 \pm 0.004$  oz).