NFPA 265

Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Coverings on Full Height Panels and Walls

2002 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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This edition of NFPA 265, *Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Coverings on Full Height Panels and Walls*, was prepared by the Technical Committee on Fire Tests, and acted on by NFPA at its May Association Technical Meeting held May 19–23, 2002, in Minneapolis, MN. It was issued by the Standards Council on July 19, 2002, with an effective date of August 8, 2002, and supersedes all previous editions.

This edition of NFPA 265 was approved as an American National Standard on July 19, 2002.

Origin and Development of NFPA 265

The danger of using carpet-like textile coverings on walls and ceilings is well known, and these coverings have been recognized as a major contributing factor in many fires. Research conducted by the Fire Research Laboratory of the University of California at Berkeley and the American Textile Manufacturers Institute produced a report, "Room Fire Experience of Textile Wall Coverings," that indicated that consideration of only the flame spread rating as measured by NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, might not reliably predict the fire behavior of textile wall coverings. Concerns were raised regarding the findings that low flame spread textile wall coverings, when placed in a room/corner test procedure, produced a large, rapidly growing fire.

The proposed standard was intended to fill a void and complement the series of interior finish fire tests that were being referenced in NFPA *101*®, *Life Safety Code*®, and other codes. The standard created a testing method that addressed the recognized hazards of using textile materials for wall coverings by supplying a means to evaluate the performance characteristics under specified fire exposure conditions and providing a valid repeatable and reproducible fire test method.

The 1998 edition was revised to recognize and incorporate into the standard the current practices being performed in testing laboratories, and requirement for the measurement of smoke obscuration was added. These changes were directly associated with the revisions to the 1997 edition of NFPA *101*, *Life Safety Code*, on interior finishes.

The 2002 edition has been revised to comply with NFPA's *Manual of Style* regarding standardization of format.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet between the paragraphs that remain.

Information on referenced publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard describes a test method for determining the contribution of textile wall coverings to room fire growth during specified fire exposure conditions.

1.1.2* This test method shall be used to evaluate the flammability characteristics of textile wall coverings where such materials constitute the exposed interior surfaces of buildings and demountable, relocatable, full-height partitions used in open building interiors.

1.1.3 This test method shall not be used to evaluate the fire endurance of assemblies, nor shall it be used to evaluate the effect of fires originating within a wall assembly.

1.1.4 The test method shall not be used for the evaluation of floor or ceiling finishes.

1.1.5* This test method shall not apply to fabric-covered, lower-than-ceiling-height, freestanding, prefabricated panel furniture systems.

1.2 Purpose.

1.2.1 This test method shall measure certain fire performance characteristics of textile wall covering materials in an enclosure under specified fire exposure conditions.

1.2.2 This test method shall determine the potential extent to which the textile wall covering materials contribute to fire growth in a room and the potential for fire spread beyond the room under the particular conditions simulated.

1.3 Application.

1.3.1 This test method shall provide all of the following:

(1) Extent of fire growth in the test room
(2) Rate of heat release by the specimen
(3) Total heat released by the specimen
(4) Time to flashover in the test room, if it occurs
(5) Time to flame extension beyond the doorway of the test room, if it occurs
(6) Total heat flux incident to the floor of the test room
(7) Upper level gas temperature in the test room
(8) Smoke obscuration, as determined in the exhaust duct
(9) Production of carbon monoxide, as determined in the exhaust duct
(10) Emissions of other combustion gases, as determined in the exhaust duct

1.3.2 This test method shall not provide data that can be generalized to apply to rooms or spaces of different shapes, sizes, and ventilation. However, this test method shall provide a general ranking of wall covering materials for use in making judgments, provided it is understood that the conditions observed in the test might or might not be repeated in actual exposures of the tested wall coverings to fire.

1.3.3 This test method shall not provide either of the following:

(1) The full information concerning toxicity of combustion gases
(2) Fire resistance of wall–ceiling systems

1.4 Summary of Method.

1.4.1 The sample shall be tested by either of the following protocols:

(1) Method A protocol shall use a corner test exposure with the specimens mounted on two walls of the test compartment.
(2) Method B protocol shall use the same test in a compartment having three fully lined walls.

1.4.1.1 These test methods shall use a gas burner to produce a diffusion flame to expose the walls in the corner of a room 2.4 m × 3.7 m × 2.4 m (8 ft × 12 ft × 8 ft).

1.4.1.2 The burner shall produce a prescribed rate of heat output of 40 kW for 5 minutes followed by 150 kW for 10 minutes, for a total exposure period of 15 minutes.

1.4.1.3 The contribution of the textile wall covering to fire growth shall be measured by constant monitoring of the incident heat flux on the center of the floor, the temperature of the gases in the upper part of the room, the rate of heat release, the smoke release, and the time to flashover.

1.4.1.4 The test shall be conducted while providing natural ventilation to the room, through a single doorway of 0.8 m × 2.0 m (30 in. × 80 in.).

1.4.1.5 The combustion products shall be collected in a hood feeding into a chamber that is connected to an exhaust duct in which measurements of the gas velocity, temperature, and concentrations of selected gases are made.

1.4.2 Flashover shall be considered to have occurred when any two of the following conditions have been attained:

(1) The heat release rate exceeds 1 MW.
(2) The heat flux at floor exceeds 20 kW/m^2.
(3) The average upper layer temperature exceeds 600°C (1112°F).
(4) Flames exit the doorway.
(5) Autoignition of paper target on floor occurs.

Chapter 2 Referenced Publications (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1 Shall. Indicates a mandatory requirement.

3.2.2 Should. Indicates a recommendation or that which is advised but not required.

3.2.3 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Average Upper Gas Layer Temperature. Temperature based on the average of the four ceiling quadrant thermocouples and the center of the room ceiling thermocouple.

3.3.2* Textile. Originally a woven fabric, now generally applied to (1) staple fibers and filaments suitable for conversion to or use as yarns or for the preparation of nonwoven fabrics, (2) yarns made from natural or manufactured fibers, and (3) fabrics made from fibers as defined in (1) and (2) and from yarns.

Chapter 4 Test Equipment

4.1 Ignition Source.

4.1.1 The ignition source for the test shall be a gas burner with a nominal 305 mm × 305 mm (12 in. × 12 in.) porous top surface of refractory material as shown in Figure 4.1.1.

4.1.2 The refractory material, through which the gas is supplied, shall be permitted to be either of the following:

(1) A 25.4 mm (1 in.) thick porous ceramic fiberboard over a 152 mm (6 in.) chamber
(2) A layer of white Ottawa silica sand not less than 102 mm (4 in.) for providing the horizontal surface through which the gas is supplied

4.1.3 The top surface of the burner, through which the gas is applied, shall be located horizontally 305 mm (12 in.) above the floor.

4.1.4 The burner enclosure shall be located such that the edge of the diffusion surface is located 51 mm (2 in.) from both walls, in a corner of the room, opposite the door.

4.1.5 The gas supply to the burner shall be of C.P. grade propane (99 percent purity or better).

4.1.5.1 The burner shall be capable of producing a net heat output of 40 kW ± 1 kW for 5 minutes followed by a net heat output of 150 kW ± 5 kW for 10 minutes.

4.1.5.2* Flow rates shall be calculated using the net heat of combustion of propane or 85 MJ/m^3 (2280 Btu/ft^3) at standard conditions of 20°C (68°F) temperature and 100 kPa (14.70 psi) absolute pressure.

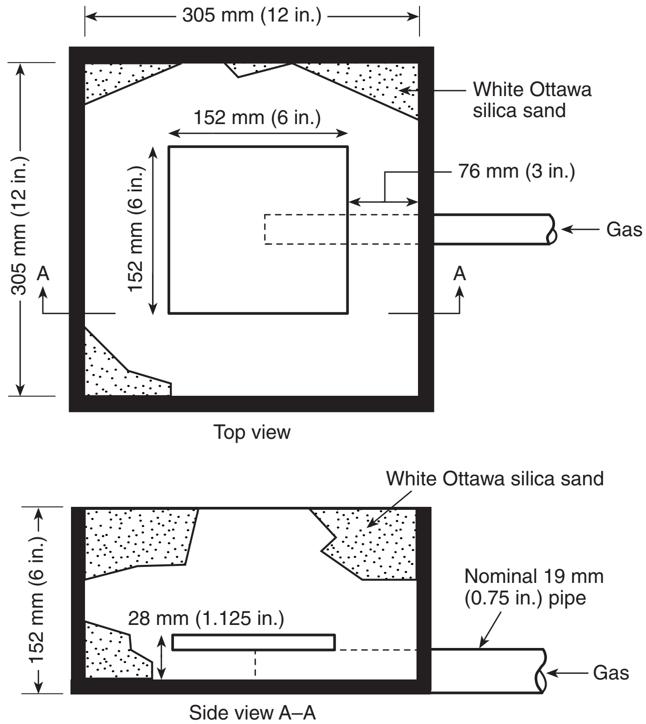

FIGURE 4.1.1 Gas Burner.

4.1.5.3 The gas flow rate shall be metered throughout the test with an accuracy of ±3 percent.

4.1.6* The heat output from the burner shall be controlled to ±5 percent.

4.1.7 The burner design shall allow switching from 40 kW to 150 kW within 10 seconds.

4.1.8 The burner shall be ignited by a pilot burner or a remotely controlled spark igniter.

4.1.9 Burner controls shall be provided for automatic gas supply shutoff if flameout occurs.

4.2 Compartment Geometry and Construction. Compartment geometry and construction shall be as shown in Figure 4.2.

4.2.1* The interior dimensions of the fire room floor, when the specimens are in place shall measure 2.44 m ± 0.1 m × 3.66 m ± 0.1 m (8 ft ± 3.9 in. × 12 ft ± 3.9 in.).

4.2.2 The finished ceiling shall be 2.44 m ± 0.1 m (8 ft ± 3.9 in.) above the floor.

4.2.3 There shall be four walls at right angles defining the compartment, as shown in Figure 4.2.

4.2.4* The room shall be placed indoors in an essentially draft-free, heated space large enough to ensure that there is no influence of the surroundings on the test fire.

4.2.5 There shall be a doorway measuring 0.76 m ± 6.4 mm × 2.03 m ± 6.4 mm (30 in. ± 0.25 in. × 80 in. ± 0.25 in.) in the center of one of the 2.44 m × 2.44 m (8 ft × 8 ft) walls, and no other wall, floor, or ceiling openings that allow ventilation.

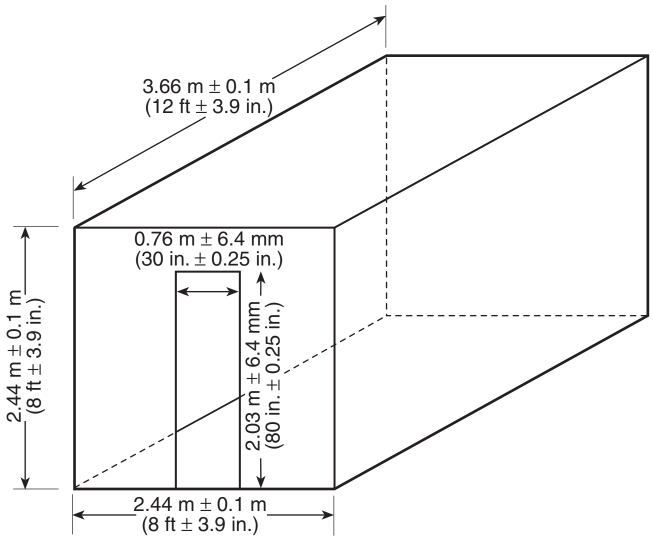

FIGURE 4.2 Interior Room Dimensions and Interior Doorway Dimensions.

4.2.6* The test compartment shall be a framed (with wood or metal studs) or a concrete block structure.

4.2.6.1 The inside surface of the walls, ceiling, and floor shall be of Type X gypsum wallboard or of calcium silicate board of 736 kg/m^3 (46 lb/ft^3) density.

4.2.6.2 The nominal thickness of the inside surface shall be at least 12 mm (0.5 in.).

4.2.7 The door frame shall be constructed to remain unchanged during the test period to a tolerance of ±1 percent in height and width.

Chapter 5 Specimen Mounting and Installation

5.1 Specimen Mounting.

5.1.1 Test specimens shall be mounted on a substrate that is appropriate to the intended application.

5.1.2* Where a manufacturer specifies use of an adhesive, specimens shall be mounted in a manner that uses the adhesive and application rate specified by the manufacturer and that is comparable to actual field installations.

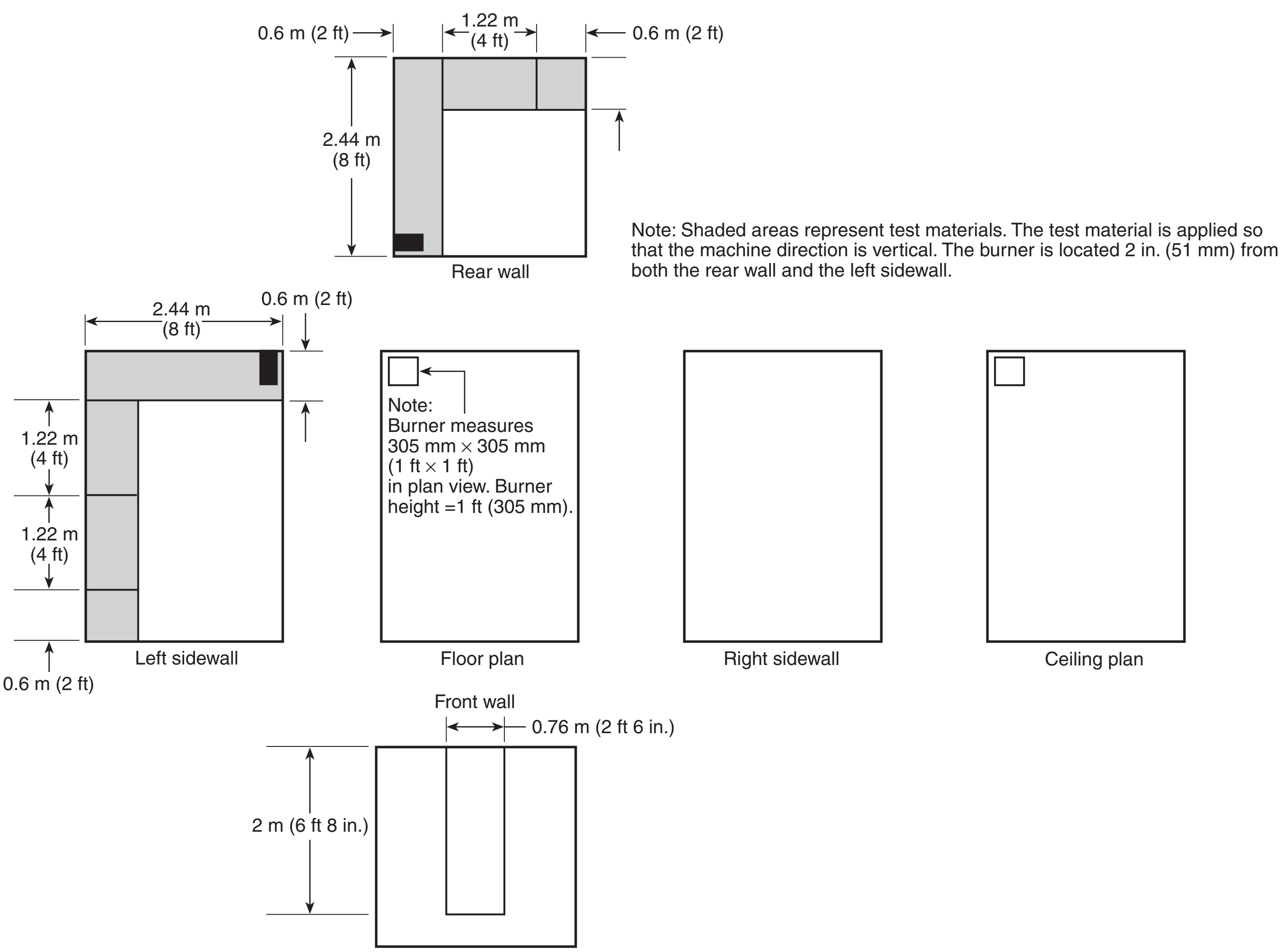

FIGURE 5.2.1.1 Specimen Mounting for Method A Test Protocol.

5.1.3 Where a specimen exhibits a distinct direction, the sample shall be mounted such that the machine direction is vertical, unless the manufacturer indicates that a different method of mounting is to be used in actual installations.

5.2 Specimen Installation. The specimen assembly shall be installed on the interior wall surfaces of the test room as described in 5.2.1 or 5.2.2.

5.2.1 Method A Test Protocol.

5.2.1.1 The specimen assembly shall be installed on the left sidewall and the rear wall (as viewed from the room door) and as illustrated in Figure 5.2.1.1.

5.2.1.2 Vertically installed portions of specimen assemblies shall extend 0.6 m (2 ft) from the ceiling and shall be installed for the full 2.44 m (8 ft) width of the rear wall and the full 3.66 m (12 ft) length of the left sidewall.

5.2.2 Method B Test Protocol. For the Method B test protocol, specimen assemblies shall be installed to cover fully both 2.44 m × 3.66 m (8 ft × 12 ft) walls and the 2.44 m × 2.44 m (8 ft × 8 ft) wall not having the door.

5.3 Conditioning of Specimen.

5.3.1* Prior to testing, the mounted specimen shall be conditioned to equilibrium, as defined in 5.3.2, in an atmosphere at a temperature of 21°C ± 3°C (70°F ± 5°F) and a relative humidity of 50 percent ± 5 percent.

5.3.2 Equilibrium shall be considered to have been reached when a representative piece of the specimen has achieved constant mass, which is reached when two successive weighing operations, carried out at an interval of 24 hours, do not differ by more than 0.1 percent of the mass of the test piece, or 0.1 g (0.0035 oz), whichever is greater.

5.3.3 The specimens shall be tested as soon as possible after removal from such conditions, if test room conditions differ from those in 5.3.1 and 5.3.2.

5.3.4 The time between removal from conditioning room and start of testing shall be recorded as part of the test documentation.

Chapter 6 Environmental Conditions

6.1 Fire Room Environment.

6.1.1 The test building in which the fire room is located shall have vents for the discharge of combustion products and shall have provisions for fresh air intake, so that no oxygen-deficient air is introduced into the fire room during the test.

6.1.2 Prior to the start of the test, the ambient air at the mid-height entrance to the compartment shall have a velocity of less than 0.5 m/s (100 ft/min) in any direction, as measured at a horizontal distance of 0.91 m (3 ft) from the center of the doorway.

6.1.3 The following two ambient conditions shall be maintained:

(1) The ambient temperature in the fire room, measured by one of the thermocouples in 7.1.2, shall be in the range of 18°C to 24°C (64°F to 75°F).
(2) The ambient relative humidity in the fire room shall be 50 percent ± 5 percent.

6.2 Building Environment.

6.2.1 The building shall be sized so that there is no smoke accumulation in the building below the level of the top of the fire compartment.

6.2.2 The ambient temperature in the test building at locations around the fire compartment shall be above 4°C (40°F).

6.2.3 The relative humidity shall be less than 75 percent for the duration of the test.

Chapter 7 Instrumentation

7.1 Room Instrumentation. The instrumentation specified in 7.1.1 through 7.1.2 shall be provided for this test.

7.1.1* Heat Flux. A total heat flux gauge (calorimeter) shall be mounted at a height of 26 mm ± 25 mm (1.1 in. ± 0.9 in.) above the floor surface, facing upward, in the geometric center of the test room as shown in Figure 7.1.1.

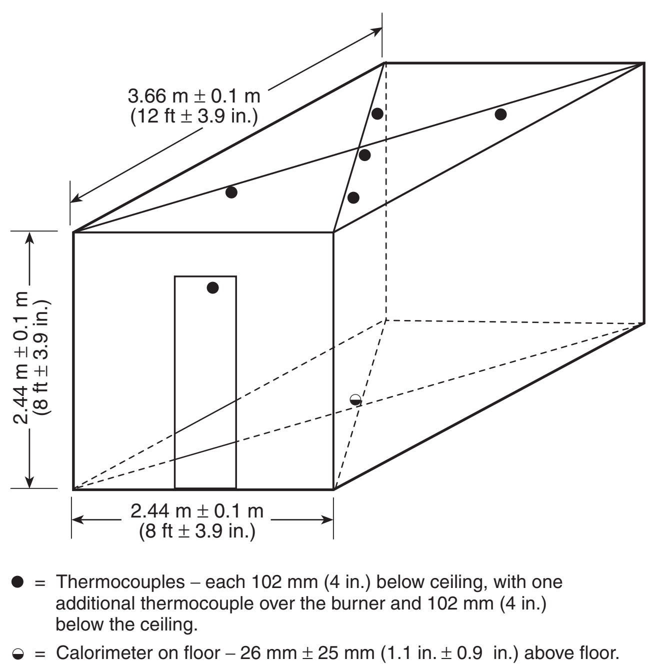

FIGURE 7.1.1 Thermocouple and Calorimeter Placement.

7.1.1.1* The gauge shall be of the Gardon (foil) or Schmidt–Boelter (thermopile) type with a full-scale design range of 50 kW/m^2.

7.1.1.1.1 The target receiving radiation shall be a circular, flat surface not more than 15 mm (0.4 in) in diameter and coated with a matte black finish, having a view angle of 180 degrees.

7.1.1.1.2 The target shall be contained within a water-cooled body whose front face shall be of polished metal that is flat, coinciding with the plane of the target, and circular, with a diameter of not more than 50 mm (2 in.).

7.1.1.2 The heat flux gauge shall have an accuracy of ±3 percent and a repeatability of 0.5 percent.

7.1.1.3 During operation, the heat flux gauge shall be maintained at a constant temperature [±3°C (±5°F)] above the dew point by water supplied at a temperature of 50°C to 65°C (122°F to 149°F).

7.1.1.4 The calibration of the heat flux gauge shall be checked, whenever required, by comparing the calibration with two similar instruments held as, and used exclusively as, reference standards, one of which is to be fully calibrated at yearly intervals.

7.1.2 Thermocouples. Bare Type K Chromel Alumel® thermocouples, 0.5 mm (20 mil) in diameter, shall be used at each required location as shown in Figure 7.1.1.

7.1.2.1 The thermocouple wire within 13 mm (0.5 in.) of the bead shall be run along expected isotherms to minimize conduction errors.

7.1.2.2* The insulation between the Chromel and Alumel wires shall be stable to a temperature not less than 1100°C (2000°F), or the wires shall be separated.

7.1.2.3 A thermocouple shall be located in the interior plane of the door opening on the door centerline, 102 mm (4 in.) from the top.

7.1.2.4 Thermocouples shall be located at six positions, 102 mm (4 in.) below the ceiling.

7.1.2.4.1 These thermocouples shall be located at the center of the ceiling, at the center of each of the four ceiling quadrants, and directly over the center of the ignition burner.

7.1.2.4.2 The thermocouples shall be mounted on supports or shall penetrate through the ceiling with their junctions 102 mm (4 in.) away from a solid surface.

7.1.2.4.3 There shall be no attachments to the test specimens.

7.1.2.4.4 Any ceiling penetration shall be just large enough to permit passage of the thermocouples.

7.1.2.4.5 Spackling compound or ceramic fiber insulation shall be used to backfill the holes around the thermocouple wire.

7.1.3 Paper Targets. Two paper target flashover indicators consisting of a single piece of newsprint crumpled into an approximate 152 mm (6 in.) diameter ball shall be placed on the floor of the test room as shown in Figure 7.1.3.

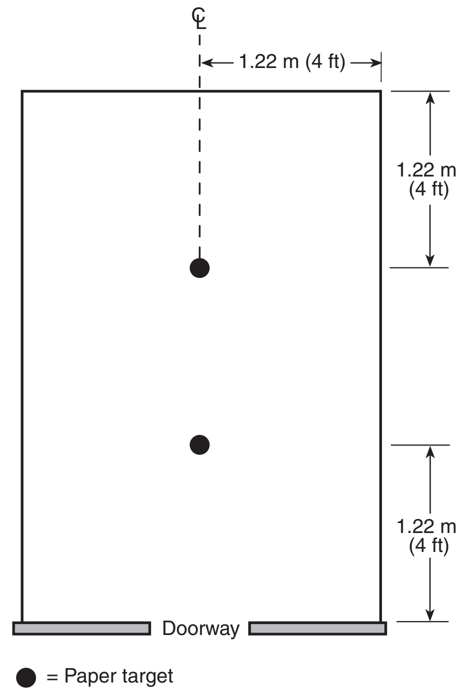

FIGURE 7.1.3 Plan View of Paper Target Arrangement.

7.1.4* Photographic and Video Records. Photographic and video equipment shall be used to record the spread of fire in the room and the fire projection from the door of the room.

7.1.4.1 The location of the camera shall avoid interference with airflow.

7.1.4.2 The interior wall surfaces of the test room adjacent to the corner in which the burner is located shall be marked with a 0.3 m (12 in.) grid.

7.1.4.3 A clock shall appear in all photographic and video records showing the time to no less than the nearest 1 second from the start of the test and shall comply with the following paragraphs:

(1) The clock shall be synchronized with all other measurements.
(2) The clock shall be made to correlate the photographic and video records with time.

7.1.4.4 Color slides or photographs shall be taken at intervals not greater than 15 seconds for the first 3 minutes of the test and at intervals not greater than 2 minutes thereafter for the duration of the test.

7.1.4.5 A continuous video recording shall also be made.

7.2 Canopy Hood and Exhaust Duct.

7.2.1 A hood shall be installed immediately adjacent to the door of the fire room.

7.2.1.1 The bottom of the hood shall be level with the top surface of the room.

7.2.1.2 The face dimensions of the hood shall be at least 2.44 m × 2.44 m (8 ft × 8 ft), and the depth shall be 1.1 m (3.5 ft).

7.2.1.3 The hood shall feed into a chamber having a 0.91 m × 0.91 m (3 ft × 3 ft) cross section.

7.2.1.3.1 The chamber shall be a minimum height of 0.91 m (3 ft).

7.2.1.3.2 The chamber height shall be permitted to be increased to a maximum of 1.8 m (6 ft) to satisfy building constraints.

7.2.1.3.3 The exhaust duct connected to a chamber shall comply with all of the following:

(1) It shall be at least 406 mm (16 in.) in diameter.
(2) It shall be horizontal.
(3) It shall be permitted to have a circular aperture of at least 305 mm (12 in.) at its entrance or mixing vanes in the duct as shown in Figure 7.2.1.3.3(a) and Figure 7.2.1.3.3(b).

7.2.2 The hood shall have sufficient exhaust draft to collect all of the combustion products leaving the room.

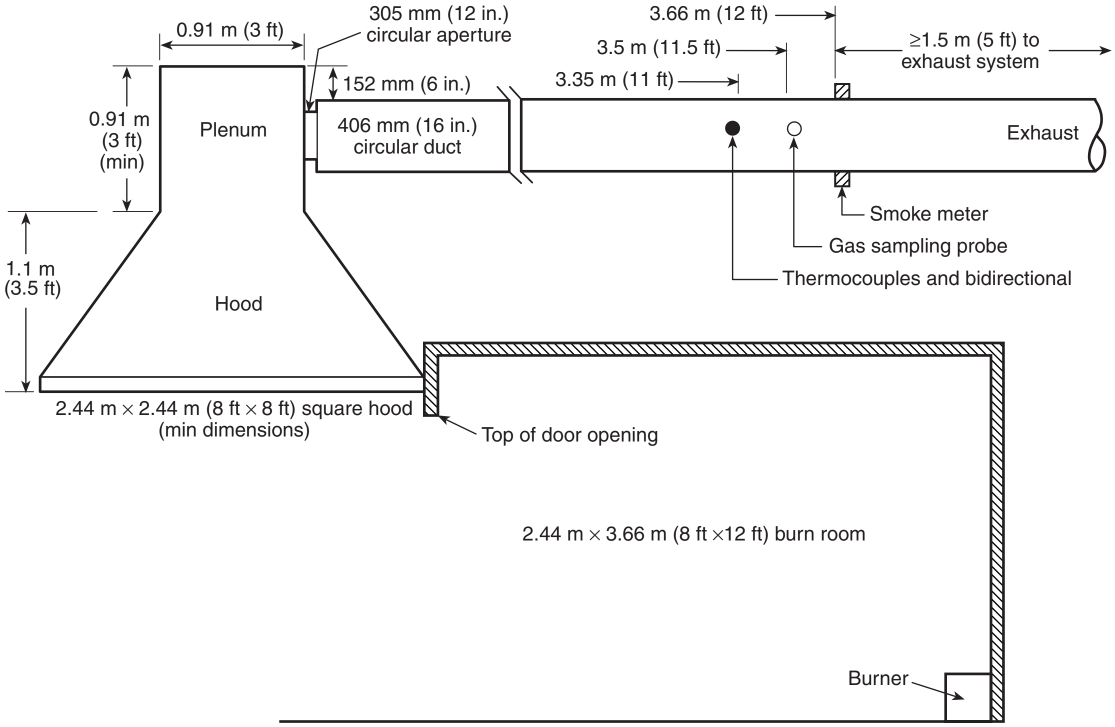

FIGURE 7.2.1.3.3(a) Canopy Hood and Exhaust Duct.

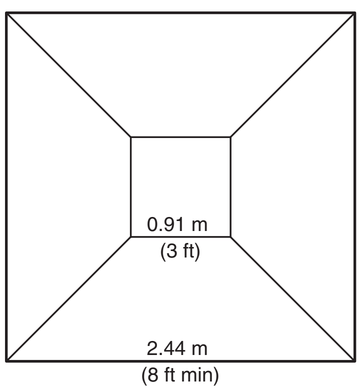

FIGURE 7.2.1.3.3(b) Plan View of Canopy Head.

7.2.2.1 During the test, the exhaust draft shall be capable of moving up to 3.4 m^3/s (7000 standard ft^3/min), equivalent to 7.6 m^3/s (16,100 ft^3/min) at 399°C (750°F).

7.2.2.2 Provision shall be made so that the exhaust draft can operate at 0.47 m^3/s to 3.4 m^3/s (1000 to 7000 standard ft^3/min).

7.2.2.3 Mixing vanes shall be required in the duct if concentration gradients are found to exist.

7.2.3 An alternative exhaust system design shall be permitted to be used if the design meets the requirements outlined in Chapter 8 and the performance requirements in 7.2.2.

7.3 Instrumentation in Exhaust Duct.

7.3.1 The exhaust collection system shall be constructed with all of the following requirements:

(1) A blower
(2) A steel hood
(3) A duct
(4) A bidirectional probe
(5) A thermocouple(s)
(6) An oxygen measurement system
(7) A smoke obscuration measurement system (white light photocell lamp/detector or laser)
(8) A combustion gas sampling and analysis system

7.3.2* A bidirectional probe or an equivalent measuring system shall be used to measure gas velocity in the duct.

7.3.2.1 A typical probe, shown in Figure 7.3.2.1, shall consist of a short stainless steel cylinder that is 44 mm (1.75 in.) long and has a 22 mm (0.875 in.) inside diameter with a solid diaphragm in the center.

7.3.2.2 The pressure taps on either side of the diaphragm shall support the probe.

7.3.2.3 The axis of the probe shall run along the centerline of the duct, 3.35 m (11 ft) downstream from the entrance.

7.3.2.4 The taps shall be connected to a pressure transducer that shall be able to resolve pressure differences of 0.25 Pa (0.001 psi) in H_2O.

7.3.3 One pair of thermocouples shall be placed 3.35 m (11 ft) downstream of the entrance to the horizontal duct. The pair of thermocouples shall straddle the center of the duct and shall be separated 50 mm (2 in.) from each other as shown in Figure 7.2.1.3.3(a).

7.3.4 Sampling Line.

7.3.4.1* The sampling line tubes shall be constructed of a material that will not affect the concentration of the combustion gas species to be analyzed.

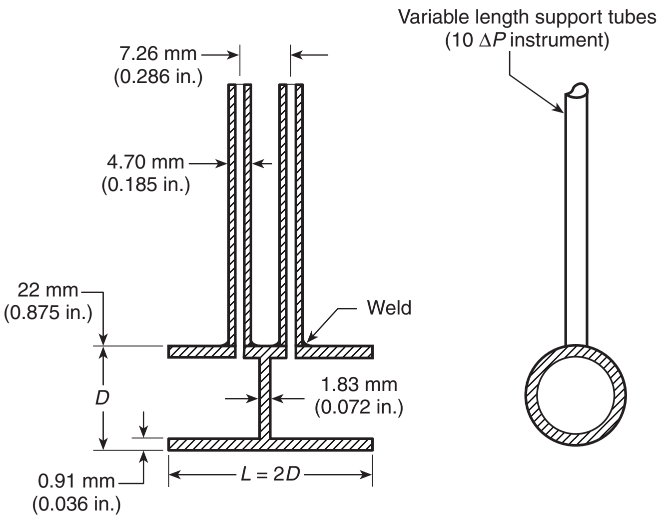

FIGURE 7.3.2.1 Bidirectional Probe.

7.3.4.2 The following sequence of the gas train, shown in Figure 7.3.4.2, shall be used:

(1) Sampling probe
(2) Soot filter
(3) Cold trap
(4) Gas path pump
(5) Vent valve
(6) Drying column
(7) Flow controller
(8) Oxygen analyzer

7.3.4.3 The gas train shall also include spanning and zeroing facilities.

7.3.4.4* For each gas analyzer used, the system delay time shall be determined for the analyzer to reach a 90 percent response to a step change in the gas concentration.

7.3.5* Oxygen Concentration. A gas sampling tube shall be located 3.5 m (11.5 ft) downstream from the entrance to the duct at the geometric center of the duct [to within 12.7 mm (½ in.) of the center], to obtain a continuously flowing sample for determining the oxygen concentration of the exhaust gas as a function of time.

7.3.5.1 A filter and cold trap shall be placed in the line ahead of the analyzer to remove particulates and water.

7.3.5.2 The oxygen analyzer shall be of the paramagnetic or polarographic type.

7.3.5.3 The oxygen analyzer shall be capable of measuring oxygen concentration in a range of 21 percent to 15 percent, with a relative accuracy of 50 ppm in this concentration range.

7.3.5.4 The signal from the oxygen analyzer shall be within 5 percent of its final value and shall occur within 30 seconds of introducing a step change in composition of the gas stream flowing past the inlet to the sampling tube.

7.3.5.5 The oxygen analyzer shall include an absolute-pressure transducer for gas pressure variations.

7.3.5.6 A rotameter shall be located on the outlet of the oxygen analyzer.

7.3.6 Carbon Dioxide Concentration.

7.3.6.1 The gas sampling tube described in 7.3.5, or an alternative gas sampling tube at the same location, shall be used to provide a continuous sample for the measurement of the carbon dioxide concentration, by means of an analyzer with a range of 0 to 20 percent, with a maximum relative error of 2 percent of full scale.

7.3.6.2 The total system-response time between the sampling inlet and the meter shall be no longer than 30 seconds to reach a value within 5 percent of the final value, after the introduction of a step change in composition of the gas stream flowing past the inlet to the sampling tube.

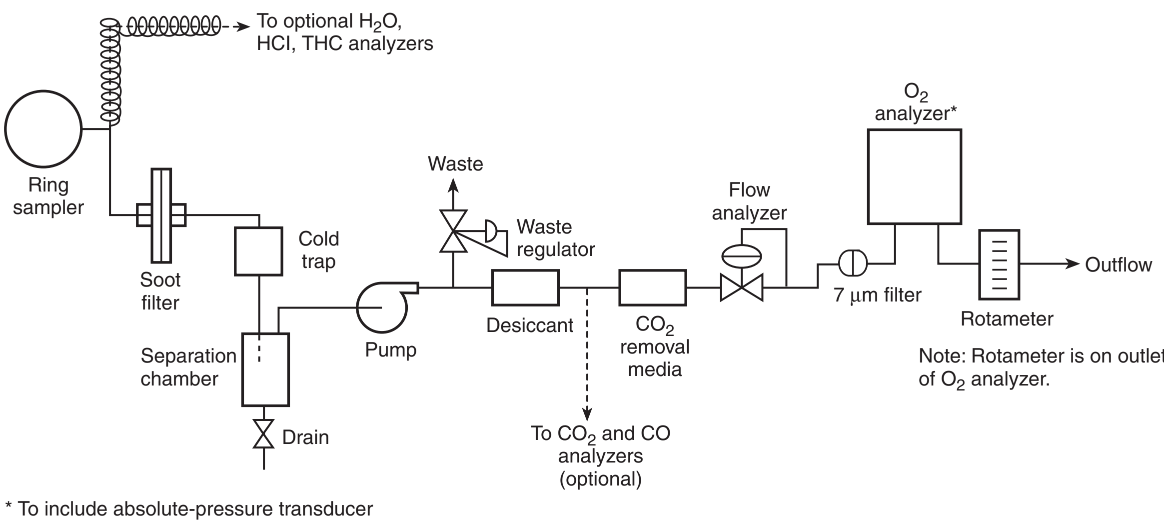

FIGURE 7.3.4.2 Schematic of Gas Train and Mass Train.

7.3.7 Carbon Monoxide Concentration.

7.3.7.1 The gas sampling tube described in 7.3.5, or an alternative gas sampling tube at the same location, shall be used to provide a continuous sample for the measurement of the carbon monoxide concentration, by means of an analyzer with a range of 0 to 10 percent, with a maximum relative error of 2 percent of full scale.

7.3.7.2 The total system-response time between the sampling inlet and the meter shall be no longer than 30 seconds to reach a value within 5 percent of the final value, after the introduction of a step change in composition of the gas stream flowing past the inlet to the sampling tube.

7.3.8 Smoke Obscuration Measurement.

7.3.8.1 An optical system shall be installed for measurement of light obscuration across the centerline of the exhaust duct.

7.3.8.2 The optical density of the smoke shall be determined by measuring the light transmitted with a photometer system consisting of a white light source and a photocell/detector or a laser system for measurement of light obscuration across the centerline of the exhaust duct.

7.3.8.2.1* A white light photometer system shall consist of a lamp, lenses, an aperture, and a photocell as shown in Figure 7.3.8.2.1.

7.3.8.2.2 The system shall be constructed so that soot deposits on the optics during a test do not reduce the light transmission by more than 5 percent.

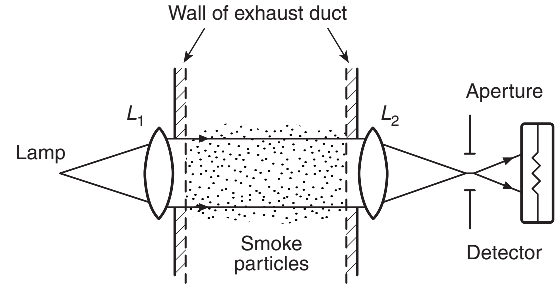

FIGURE 7.3.8.2.1 Optical System Using a White Light.

7.3.8.3* A helium–neon laser system shall consist of silicon photodiodes as main beam and reference detectors, and of electronics to derive an extinction and to set a zero reading.

7.3.8.3.1 A helium–neon laser system shall be designed for split-yoke mounting in two pieces that are rigidly coupled together but resiliently attached to the exhaust duct by means of refractory gasketing.

7.3.8.3.2 A 0.5 mW to 2 mW helium–neon laser beam shall be projected horizontally across the exhaust duct as shown in Figure 7.3.8.3.2(a) and Figure 7.3.8.3.2(b).

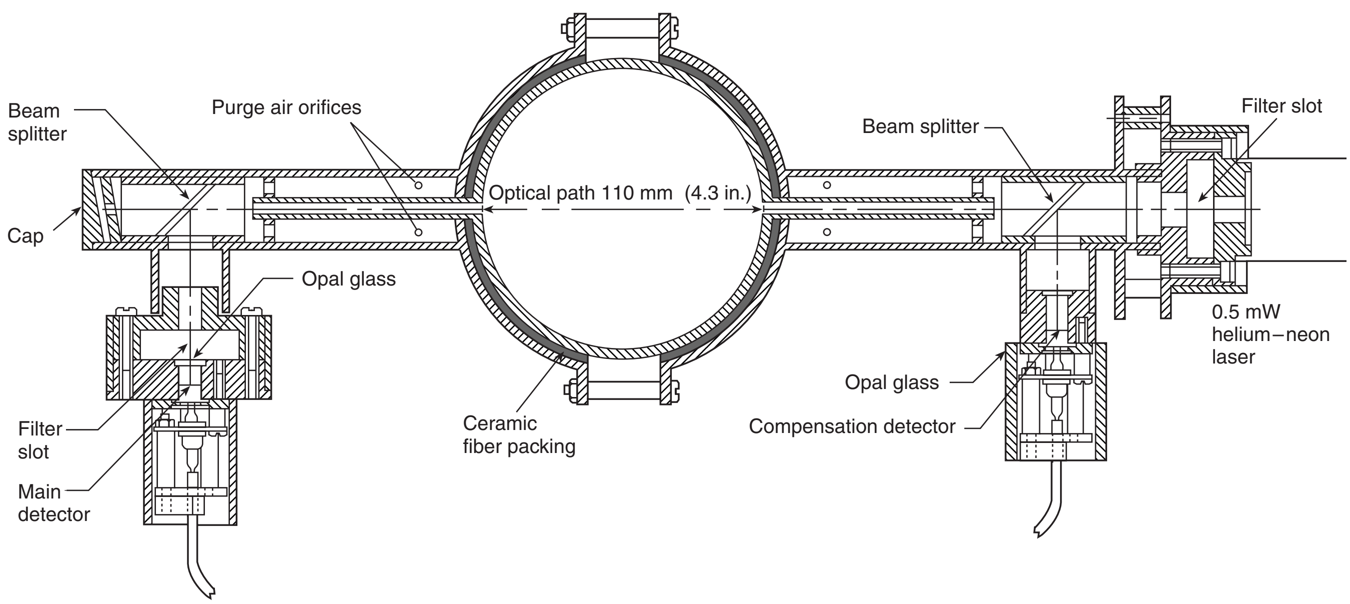

FIGURE 7.3.8.3.2(a) Laser Extinction Beam.

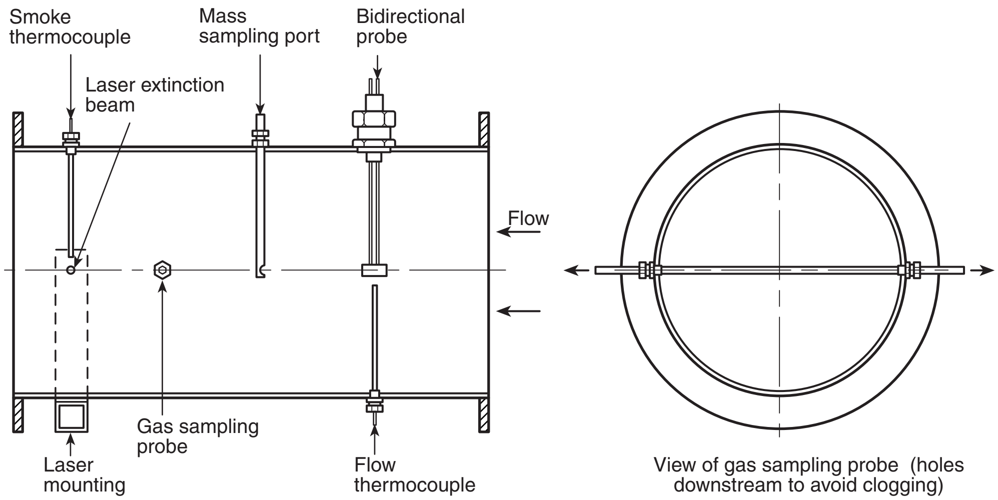

FIGURE 7.3.8.3.2(b) Recommendations for Mounting the Laser Beam and Other Instrumentation in Exhaust Duct.

Chapter 8 Calibration

8.1 Calibration and Documentation of Ignition Source and Test Equipment.

8.1.1 The following three instruments shall be calibrated with standard sources after initial installation:

(1) Smoke meters
(2) Flow or velocity transducers
(3) Gas analyzers

8.1.2 A calibration test shall have been performed prior to and within 30 days of any fire test, using the standard ignition source under the exhaust hood.

8.1.3 The data resulting from a calibration test shall provide all of the following:

(1) The output as a function of time, after the burner is activated, of all instruments normally used for the standard fire test
(2) The maximum extension of the burner flame, as recorded by still photographs taken at 30-second intervals or continuous video recording
(3) The temperature and velocity profiles across the duct cross section at the location of the bidirectional probe
(4) The differential pressure across the bidirectional probe

8.1.4 The results obtained in 8.1.3(3) and 8.1.3(4) shall be used to determine the calibration factor, *C*, in the equation in 10.1.3.

8.2* Calibration. The calibration procedure for heat release measurements shall be as follows:

(1) Estimate an approximate value of the calibration factor *C* (C_{est}) as the product of the cross section of the duct (in square meters) multiplied by 22.1.
(2) Burn propane, as described in 4.1.5, for not less than 15 minutes at a heat release rate of 150 kW ± 5 kW.
    (a) Take measurements at intervals not greater than 6 seconds.
    (b) The response of the system to a stepwise change of the heat output from the burner shall be a maximum of 12 seconds to 90 percent of final value.
    (c) Use a value of combustion expansion factor (α) *(see Section 10.4)*, of energy (E), and of heat of combustion (Ht_{comb}) as follows:

$$\alpha = 1.084$$
$$E = 12.8 \text{ MJ/kg}$$
$$Ht_{comb} = 46.5 \text{ MJ/kg}$$

(3) Calculate the total heat released and the corrected calibration factor C_{est} so that the total heat released, as determined by the oxygen consumption calculation shown in Chapter 10, agrees with the theoretical value obtained from measurement of the volumetric flow rate and weight loss of the fuel, to within ±5 percent, by using the following equation:

$$C_{corr} = \frac{Ht_{comb}(\text{MJ/kg}) \times \text{mass fuel burnt (kg)}}{\int \dot{q}(\text{MW})\,dt} = C_{est}$$

(4) Use the corrected value of calibration factor for all tests.
(5) If the calibration factor does not agree, within ±5 percent, with the value determined during the previous calibration, check the system for leaks or other problems before proceeding with the test.
(6) Correct any problem found during the system check and perform a new calibration in accordance with this chapter.

8.3 Smoke Measurement Calibration. The smoke measuring system shall be calibrated initially using two neutral density filters of significantly different values and also at 100 percent transmission.

8.3.1 Once this calibration is set, no less than the zero value of extinction coefficient (100 percent transmission) shall be verified each day, prior to testing.

8.3.2 If departure from the zero line is found at the end of a calibration test, the problem shall be corrected and a new calibration shall be performed in accordance with this chapter.

8.4* Gas Analyzers Calibration. Gas analyzers shall be calibrated daily, prior to testing, using manufacturers' instructions.

Chapter 9 Test Procedure

9.1 Methods.

9.1.1 Method A protocol and Method B protocol specified in 1.4.1 shall follow the same test procedure, except for specimen mounting.

9.1.2 Either test method shall be used.

9.2 Procedure. The test procedure shall be as follows:

(1) Establish an initial volumetric flow rate of at least 0.47 m^3/s (1000 standard ft^3/min) through the duct, and increase the volume flow rate to 3.4 m^3/s (7000 standard ft^3/min) as required to keep the oxygen content above 14 percent and to capture all effluents from the burn room.
(2) Turn on all sampling and recording devices, and establish steady-state baseline readings for at least 3 minutes.
(3) Ignite the gas burner and simultaneously start the clock, and increase the flow rate to provide a rate of heat release of 40 kW ± 1 kW by the burner.
   (a) Continue the exposure at the 40 kW ± 1 kW level for 5 minutes.
   (b) Within 10 seconds following the 5-minute exposure, increase the gas flow to provide a rate of heat release by the burner of 150 kW ± 5 kW exposure for 10 minutes.
(4) Take 35 mm color photographs at 30-second intervals, or provide a continuous video recording to document the growth of the fire.
(5) Provide a voice or written record of the fire, which will provide the times of all significant events, such as times of ignition, escape of flames through the doorway, and flashover.
(6) Shut off the ignition burner 15 minutes after start of the test, and terminate the test at that time unless safety considerations dictate an earlier termination.
(7) Document damage after the test, using words, pictures, and drawings.

Chapter 10 Calculations

10.1* Flow Rate Equations. The calculation methods described in this chapter shall be used to determine the rate of heat release.

10.1.1 The mass flow rate through the duct shall be obtained from the velocity measured with a bidirectional probe *(see 7.3.2)*.

10.1.2* The mass flow rate shall be calculated using a measured velocity profile in the duct.

10.1.3 The mass flow rate shall be calculated by using the following equation:

$$\dot{m}_e = C\sqrt{\frac{\Delta\rho}{T_e}}$$

10.1.4* The oxygen depletion factor shall be calculated according to the following equation:

$$\phi = \frac{X^0_{O_2}\left(1 - X_{CO_2} - X_{CO}\right) - X_{O_2}\left(1 - X^0_{CO_2}\right)}{X^0_{O_2}\left(1 - X_{O_2} - X_{CO_2} - X_{CO}\right)}$$

10.1.5 The rate of heat release shall be calculated according to the following equation:

$$\dot{q} = \left[E\phi - \left(E_{CO} - E\right)\frac{1-\phi}{X_{O_2}}\left(\frac{X_{CO}}{X_{O_2}}\right)\right]\frac{M_{O_2}}{M_e}\left(\frac{\dot{m}}{1+\phi(\alpha-1)}\right)\left(X^0_{O_2}\right)$$

10.1.6* The total heat released shall be calculated according to the following equation:

$$\text{THR} = \int \dot{q}\, dt$$

10.2 Smoke Measurement Equations.

10.2.1 The extinction coefficient, *k*, shall be calculated from the following equation:

$$k = \frac{1}{L_p}\ln\left(\frac{I_0}{I}\right)$$

10.2.2 The optical density per unit light path length shall be calculated according to the following equation:

$$\text{OD} = \frac{1}{D}\log\left(\frac{I_0}{I}\right)$$

10.2.3 The volumetric flow rate at the smoke meter shall be calculated as the product of the mass flow rate and the temperature at the measurement point (bidirectional probe), corrected by the density of air at the standard temperature (273.15 K) and by the temperature, in K, as shown in the following equation:

$$\dot{V}_s = \dot{m}_e\left(\frac{T_e}{\rho_o 273.15}\right) = \frac{\dot{m}_e T_e}{353}$$

10.2.4 The rate of smoke release shall be defined by the following equation:

$$\text{RSR} = \dot{V}_s k$$

10.2.5 The total smoke released shall be defined by the following equation:

$$\text{TSR} = \int \text{RSR}\, dt$$

10.3 Release Rate of Combustion Gases.

10.3.1 Carbon Monoxide. The release rate of carbon monoxide shall be calculated from the following equation:

$$\dot{m}_{CO} = \frac{X_{CO}\left(1 - X^0_{O_2} - X^0_{CO_2}\right)}{1 - X_{O_2} - X_{CO_2} - X_{CO}}\left(\frac{M_{CO}}{M_a}\right)\frac{\dot{m}_e}{1+\phi(\alpha-1)}$$

10.3.2 Other Combustion Gases.

10.3.2.1 When other combustion gases are measured, their release rate shall be calculated from the following equation:

$$\dot{m}_x = \frac{\sum\left(X_{xi}\dot{m}_{ei}\Delta t_i\right)\frac{\dot{m}_e}{M_a}}{\text{test period}}$$

10.3.2.2 The release rate of other combustion gases shall be a function of the summation of the concentrations of that gas at each scan in the exhaust (the products of the mole fraction of the combustion gas, the overall mass flow rate for that scan, and the scan period), its molecular weight, and the total test period.

10.4 Symbols.

C	=	calibration factor for orifice plate or bi-directional probe ($kg^{1/2}$, $m^{1/2}$, or $K^{1/2}$)
E	=	net heat released per unit mass of oxygen consumed: 13.1 MJ/kg
E_{CO}	=	net heat released per unit mass of oxygen consumed, for carbon monoxide: 17.6 MJ/kg
Ht_{comb}	=	heat of combustion of the fuel used: 46.5 MJ/kg for propane
I_o	=	light intensity for a beam of parallel light rays, measured in a smoke-free environment, with a detector having the same spectral sensitivity as the human eye and reaching the photodetector
I	=	light intensity for a parallel light beam having traversed a certain length of smoky environment and reaching the photodetector
k	=	extinction coefficient (L/m)
L_p	=	light path length of beam through smoky environment, which is equal to the duct diameter (m)
$\dot{m}_e$	=	mass flow rate in exhaust duct (kg/s)
$\dot{m}_{CO}$	=	release rate of carbon monoxide (kg/s)
$\dot{m}_x$	=	release rate of combustion product x (kg/s)
M_a	=	molecular weight of incoming and exhaust air: 29 kg/kmol
M_{CO}	=	molecular weight of carbon monoxide: 28 kg/kmol
M_{O_2}	=	molecular weight of oxygen: 32 kg/kmol
M_x	=	molecular weight of specimen X
OD	=	optical density per unit light path length (L/m)
$\Delta\rho$	=	pressure drop across the orifice plate or bi-directional probe (Pa)
$\dot{q}$	=	rate of heat release (kW)
RSR	=	rate of smoke release (m^2/s)
Δt	=	scan period (sec)
T_e	=	gas temperature at the orifice plate or bi-directional probe (K)
test period	=	duration of test (sec)
THR	=	total heat released (MJ)
TSR	=	total smoke released (m^2)
$\dot{V}_s$	=	volumetric flow rate at location of smoke meter (value adjusted for smoke measurement calculations) (m^3/s)
X_{CO}	=	measured mole fraction of CO in exhaust flow (nondimensional)
X_{CO_2}	=	measured mole fraction of CO_2 in exhaust flow (nondimensional)
$X^0_{CO_2}$	=	measured mole fraction of CO_2 in incoming air (nondimensional)
X_{O_2}	=	measured mole fraction of O_2 in exhaust flow (nondimensional)
$X^0_{O_2}$	=	measured mole fraction of O_2 in incoming air (nondimensional)
X_x	=	measured mole fraction of combustion gas x in exhaust flow (nondimensional)
α	=	combustion expansion factor (nondimensional) (Use a value of 1.105, unless the value for the test specimen, not the ignition gas, is known)
ϕ	=	oxygen depletion factor (nondimensional)
ρ_o	=	density of air at 273.15 K: 1.293 (kg/m^3)

Chapter 11 Documentation

11.1 Report. The report shall include the data and information specified in 11.2 through 11.8.

11.2 Materials. Materials shall include all of the following:

(1) Name, thickness, density, and size of the test material, along with other identifying characteristics or labels
(2) Mounting, installation (including attachment method), and conditioning of materials (including all relevant time periods involved)
(3) Layout of specimens in test room (including appropriate drawings)
(4) Relative humidity and temperature of the room and the test building prior to and during the test

11.3 Burner Gas Flow. The burner gas flow shall be the fuel gas flow to the ignition burner and its calculated rate of heat output.

11.4 Time History of the Total Heat Flux to Floor. The time history of the total heat flux to floor shall be the total incident heat flux at the center of the floor for the heat flux gauge as a function of time starting 3 minutes prior to the test.

11.5 Time History of the Gas Temperature. The time history of the gas temperature shall be the temperature of gases in the room, in the doorway, and in the exhaust duct for each thermocouple as a function of time starting 3 minutes prior to the test.

11.6 Time History of the Rate of Heat Release of the Fire.

11.6.1 The rate of heat release shall be calculated from the measured oxygen, carbon monoxide, and carbon dioxide concentrations and the temperature and volumetric flow rate of the gas in the duct.

11.6.2 The rate of heat release time history shall be reported, as well as the maximum and average values.

11.6.3 The total heat released time history shall be reported, as well as the final value and the values of both the rate of heat release and the total heat released, every 1 minute.

11.7 Time History of the Fire Growth. The time history of the fire growth shall be a transcription of the visual, photographic, audio, and written records of the fire test.

11.7.1 The records shall indicate all of the following:

(1) Time of ignition of the wall finish
(2) Approximate location of the flame front most distant from the ignition source at intervals not exceeding 15 seconds during the fire test
(3) Time of flashover
(4) Time at which flames extend outside the doorway

11.7.2 In addition, the still photographs and continuous video recording specified in 7.1.4 shall be supplied.

11.7.3 Drawings, photographs, and video recordings showing the extent of the damage to the materials after the test shall be supplied.

11.8 Time History of Smoke Obscuration. The smoke obscuration shall be described by means of the optical density, rate of smoke release, and total smoke released, measured with the instrumentation in the exhaust duct.

11.8.1 The rate of smoke release and optical density time history shall be reported, as well as the maximum and average values.

11.8.2 The total smoke released time history shall be reported, as well as the final value and the rate of smoke release and total smoke released values every 1 minute.

11.9 Discussion of Performance. A complete discussion of sample performances shall be conducted and shall include all of the following:

(1) Flame spread to ceiling during 40 kW exposure
(2) Burning to outer extremities of 0.6 m (2 ft) wide samples mounted vertically in the corner of the room with testing under Method A protocol
(3) Presence of burning droplets on the floor that persist in burning 30 seconds or more
(4) Visibility conditions in the fire test room
(5) Other pertinent details with respect to fire growth

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.2 Demountable, relocatable, full-height partitions include demountable, relocatable, full-height partitions that fill the space between the finished floor and the finished ceiling.

A.1.1.5 Freestanding panel furniture systems include all freestanding panels that provide visual separation, acoustical separation, or both and that are intended to be used to divide space or to support components to form complete work stations.

A.3.3.2 Textile. The definition of textile is intended to include carpets or textile floor coverings.

A.4.1.5.2 This net heat of combustion corresponds to a propane gas flow rate of approximately 26.9 L/min for 40 kW and 100.8 L/min at 150 kW, for propane with a net heat of combustion of 46.5 MJ/kg, under standard conditions of 101 kPa (15 psi) absolute pressure and 20°C (68°F) temperature.

A.4.1.6 Two typical arrangements for a gas supply are illustrated in Figure A.4.1.6.

A.4.2.1 A study by R. D. Peacock and J. N. Breese (NBSIR 82-2516, *Computer Fire Modeling for the Prediction of Flashover*) examined the effect of geometric room changes on the minimum energy required to cause flashover. It showed that increased room height beyond 2.4 m (approximately 8 ft) changed the minimum needed flashover energy (expressed as a percentage) as follows: percent $100 + 5.3\ \Delta H$.

Here ΔH is the increase in room height (expressed in meters). Thus, for instance, if the height were changed by 0.2 m (7.8 in.), the energy scaling would be changed by 1.06 percent.

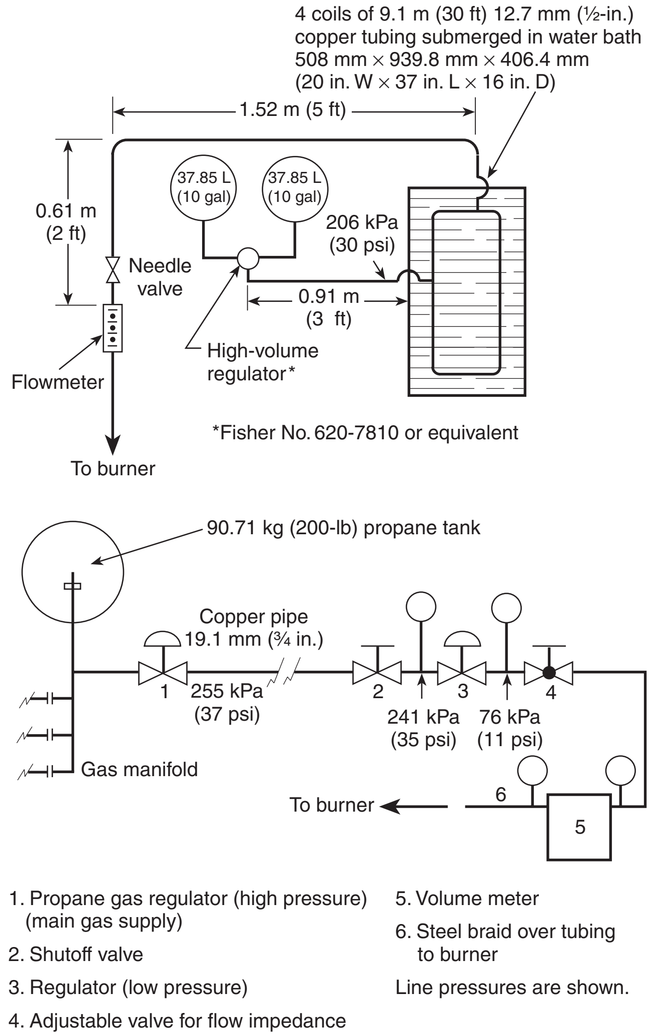

FIGURE A.4.1.6 Two Typical Gas Flow Regulation Systems.

This is completely insignificant, since few fire measurements can be made to a repeatability or reproducibility of better than 10 percent. The effects of changing floor areas were similarly modest. Room dimensions having a tolerance of ±0.1 m (±3.9 in.) should be entirely adequate for reproducibility.

A.4.2.4 To facilitate the mounting of the instruments and the ignition source, it is convenient to place the test room so that the floor can be reached from underneath.

A.4.2.6 If self-supporting panels are tested, a separate exterior frame or block compartment is not required.

A.5.1.2 It has been shown that the specific adhesive used to secure a specimen can significantly affect the fire performance of a wall covering system, and therefore the adhesive utilized should be the same as that intended for actual use.

A.5.3.1 For products where vaporization of solvents occurs (such as those using adhesives) or products containing wood, a conditioning time of 4 weeks is not uncommon.

A.7.1.1 It is preferable to mount the total heat flux gauge at a height between 5 mm and 30 mm (0.2 in. and 1.2 in.) above the floor surface.