Designation: E 2257 – 03

An American National Standard

Standard Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies[1]

This standard is issued under the fixed designation E 2257; 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 is a fire-test-response standard.

1.2 This test method is intended to evaluate, under specified fire-exposure conditions, the contribution to room fire growth provided by wall or ceiling materials and assemblies, or both. The method is not intended to evaluate the fire endurance of assemblies or fires originating in the wall assembly. The method provides a means to evaluate the effectiveness of thermal barriers in restricting the contribution of combustible materials in the wall assembly to fire growth in a room fire.

1.3 This test method, simulating a fire in the corner of a 2420 by 3630 mm (8 by 12 ft) room containing a single open doorway, provides a means to evaluate the relative performance of specified wall and ceiling materials or assemblies when they are used together in the same relationship within an enclosure, and simulating the manner in which they will be used.

1.4 This test method is intended to evaluate the contribution to fire growth provided by a surface product using a specified ignition source. It shall, however, be noted that the type, position and heat output of the ignition source will considerably influence fire growth. The thermal exposure conditions from the ignition source specified in this method will result in flashover during the 20 min duration for many common finish materials, in particular if specimens are mounted on the walls and the ceiling (standard configuration).

1.5 This test method provides a means for evaluating wall and ceiling finish materials and assemblies, including panels, tiles, boards, sprayed or brushed coatings, etc. This test method is not intended to evaluate flooring materials or furnishings.

1.6 This method shall be used in conjunction with Guide E 603, which covers instrumentation and the general effect of various parameters, and Guide E 2067, which deals with full-scale oxygen consumption calorimetry.

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

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

1.9 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.

1.10 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 84 Test Method for Surface Burning Characteristics of Building Materials[2]

E 136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C[2]

E 603 Guide for Room Fire Experiments[2]

E 2067 Practice for Full-Scale Oxygen Consumption Calorimetry Fire Tests[2]

2.2 *ISO Standards:*

ISO 9705 Fire Tests—Reaction to Fire—Room Fire Test[3]

ISO 13943 Fire Safety—Vocabulary[3]

2.3 *NFPA Standards:*

NFPA 265 Standard Method of Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings[4]

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[1] This test method is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.13 on Large Scale Fire Tests.

Current edition approved May 10, 2003. Published July 2003.

[2] *Annual Book of ASTM Standards*, Vol 04.07.

[3] Available from International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland.

[4] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269-9101.

NFPA 286 Standard Method of Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, see Terminology E 176 and ISO 13943. In case of conflict, the definitions given in Terminology E 176 shall prevail.

3.1.1 *assembly*, *n*—a unit or structure composed of a combination of materials or products, or both. **E 176**

3.1.2 *flashover*, *n*—the rapid transitionto a state of total surface involvement in a fire of combustible materials within an enclosure. **E 176**

3.1.3 *heat flux*, *n*—heat transfer to a surface per unit area, per unit time. **E 176**

3.1.4 *heat release rate*, *n*—the heat evolved from the specimen per unit time. **E 176**

3.1.5 *optical density of smoke*, *n*—a measure of the attenuation of a light beam through smoke, expressed as the common logarithm of the ratio of the incident flux, I_0, to the transmitted flux, I. **E 176**

3.1.6 *oxygen consumption principle*, *n*—the expression of the relationship between the mass of oxygen consumed during combustion and the heat released. **E 176**

3.1.7 *smoke*, *n*—the airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion. **E 176**

3.1.8 *smoke obscuration*, *n*—reduction of light transmission by smoke as measured by light attenuation. **E 176**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *specimen*, *n*—representative piece of the product, which is to be tested together with any substrate or treatment.

4. Summary of Test Method

4.1 This method uses a gas burner to produce a diffusion flame in contact with the walls and ceiling in the corner of a 2420 by 3630 by 2420 mm (8 by 12 by 8 ft) high room. The burner produces a prescribed net rate of heat output of 100 kW (5690 Btu/min) during the first 10 min, followed by 300 kW (17 060 Btu/min) during the next 10 min. The contribution of the wall and ceiling materials or assemblies to fire growth is measured in terms of the time history of the incident heat flux on the center of the floor, the time history of the temperature of the gases in the upper part of the room, the time to flashover, and the rate of heat release. The test is conducted with natural ventilation to the room provided through a single doorway 780 by 2015 mm (30 by 80 in.) in width and height. The combustion products are collected in a hood feeding into a plenum connected to an exhaust duct in which measurements are made of the gas velocity, temperature, light obscuration, and concentrations of oxygen, carbon dioxide, and carbon monoxide.

5. Significance and Use

5.1 This fire test is applicable to a description of certain fire performance characteristics in appraising wall and ceiling materials, products, or systems under specified fire-exposure conditions in an enclosure. The test indicates the maximum extent of fire growth in a room, the rate of heat release, and if they occur, the time to flashover, and the time to flame extension beyond the doorway following flashover. It determines the extent to which the wall and ceiling materials or assemblies contribute to fire growth in a room and the potential for fire spread beyond the room, under the particular conditions simulated. It does not measure the contribution of the room contents. (See Appendix X1, Commentary.)

NOTE 1—Time to flashover is defined herein as either the time when the radiant flux onto the floor exceeds 20 kW/m^2 or the average temperature of the upper hot gas layer reaches 600°C (1100°F) or flames exit the doorway or spontaneous ignition of a paper target on the floor occurs. The spontaneous ignition of a crumpled single sheet of newspaper placed on the floor 0.9 m (3 ft) out from the center of the rear wall provides a visual indication of flashover.

5.1.1 The potential for the spread of fire to other objects in the room, remote from the ignition source, is evaluated by measurements of: (*a*) the total heat flux incident on the center of the floor, and (*b*) a characteristic upper level gas temperature in the room.

5.1.2 The potential for the spread of fire to objects outside the room of origin is evaluated by the measurement of the rate of heat release of the fire.

5.1.3 Measurements of the rate of production of carbon monoxide, carbon dioxide, and visible smoke are taken.

5.1.4 The overall performance of the test specimen is visually documented by full-color photographic records. Video taping of the complete fire test is an acceptable alternative to the photographic record. Such records show when each area of the test specimen becomes involved in the fire.

5.2 In this procedure, the specimens are subjected to a specific set of laboratory fire test exposure conditions. If different test conditions are substituted or the anticipated end-use conditions are changed, it is not known whether it is possible by use of this test to predict changes in the performance characteristics measured. Therefore, the results are strictly valid only for the fire test exposure conditions described in this procedure.

6. Ignition Source

6.1 The ignition source for the test shall be a gas burner with a nominal 170 by 170 mm (6.7 by 6.7 in.) porous top surface of a refractory material, as shown in Fig. 1.

6.2 The top surface of the burner through which the gas is supplied shall be located horizontally, 170 mm (6.7 in.) off the floor, and the burner enclosure shall be in contact with both walls in a corner of the room opposite from the door, and the edge of the diffusion surface shall be flush with the wall.

6.3 The burner shall be supplied with C.P. grade propane (99 % purity), with a net heat of combustion of 46.5 ± 0.5 MJ/kg (20 000 ± 200 Btu/lb.) The gas flow to the burner shall be measured with an accuracy of at least ±3 %. The flow measuring equipment shall be calibrated per the manufacturer's instructions at least once per year. The heat output to the burner shall be controlled within ±5 % of the prescribed value.

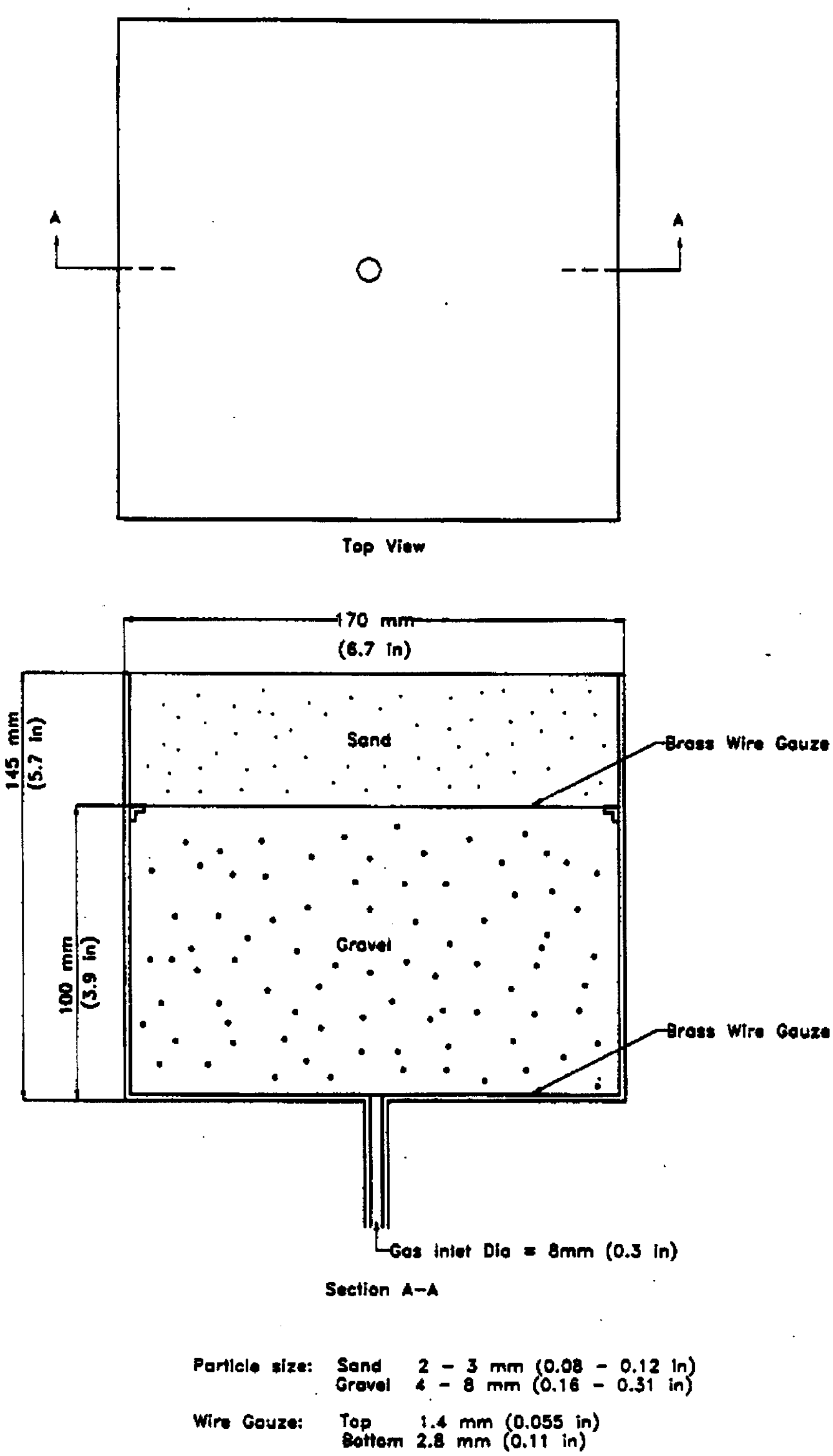

FIG. 1 Gas Burner Ignition Source

6.4 The gas supply to the burner shall produce a net heat output of 100 ± 3 kW (5690 ± 170 Btu/min) for the first 10 min, followed by 300 ± 10 kW (17060 ± 570 Btu/min) for the next 10 min.

NOTE 2—This corresponds to a flow of approximately 67.3 L/min at 100 kW, and 202.0 L/min at 300 kW for propane with a net heat of combustion of 46.5 MJ/kg, under standard conditions of 101 kPa pressure and 20°C temperature.

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

6.6 Burner controls shall be provided for automatic gas supply shut-off if flameout occurs.

7. Compartment Geometry and Construction

NOTE 3—The choices for the size of compartment fire experiments are discussed in Guide E 603. The compartment dimensions and tolerances defined in this section have been chosen to make it convenient to utilize both standard U.S. size 1.22 by 2.44 m (4 by 8 ft) building materials or panels and standard 1.2 by 2.4 m panel sizes common outside the U.S.

7.1 The room shall consist of four walls at right angles, floor, and ceiling and shall have the following inner dimensions: 3630 ± 30 mm (12 ft) in length, 2420 ± 20 mm (8 ft) in width, and 2420 ± 20 mm (8 ft) in height (see Fig. 2). The room shall be placed indoors in an essentially draft free, conditioned space, large enough to ensure that there is no influence on the test fire. In order to facilitate the mounting of the instruments and of the ignition source, it is convenient to place the test room so that the floor is accessible from beneath.

7.2 There shall be a doorway in the center of one of the 2420 by 2420 mm (8 by 8 ft) walls, and no other wall, floor or ceiling openings that allow ventilation. The doorway shall have the following dimensions: 780 ± 20 mm (30 in.) in width, and 2015 ± 15 mm (80 in.) in height.

7.3 The test compartment shall be a framed or a concrete-block structure. If the former type of structure is used, the interior walls and ceiling of the frame shall be lined with gypsum wallboard or calcium silicate board with a density of 500 to 800 kg/m^3 (31 to 50 lb/ft^3). The minimum thickness of the lining material shall be 20 mm (¾ in.).

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

8. Instrumentation in the Fire Room

8.1 The following are minimum requirements for instrumentation for this test. Added instrumentation is desirable for further information.

8.2 *Heat Flux*:

8.2.1 *Specification*—The total heat flux meters shall be of the Gardon (foil) or the Schmidt-Boelter (thermopile) type with a design range of approximately 50 kW/m^2 (4.4 Btu/ft^{2}s). The target receiving radiation, and possibly to a small extent convection, shall be flat, circular, not more than 15 mm (⅝ in.) in diameter and coated with a durable matt black finish. The target shall be contained within a water-cooled body whose front face shall be of highly polished metal, flat, coinciding with the plane of the target and circular, with a diameter of not more than 50 mm (2 in.) The heat flux meter shall have an accuracy of at least ± 3 % and a repeatability within ± 0.5 %. In operation, the meter shall be maintained at a constant temperature, at least 5°C above the dew point.

8.2.2 *Location*—The heat flux meter shall be mounted at the geometric center of the floor (see Fig. 2). The target area shall be between 5 and 30 mm (¼ and 1¼ in.) above the floor surface.

8.2.3 *Calibration*—The heat flux meters shall be calibrated at yearly intervals.

8.3 *Gas Temperatures*:

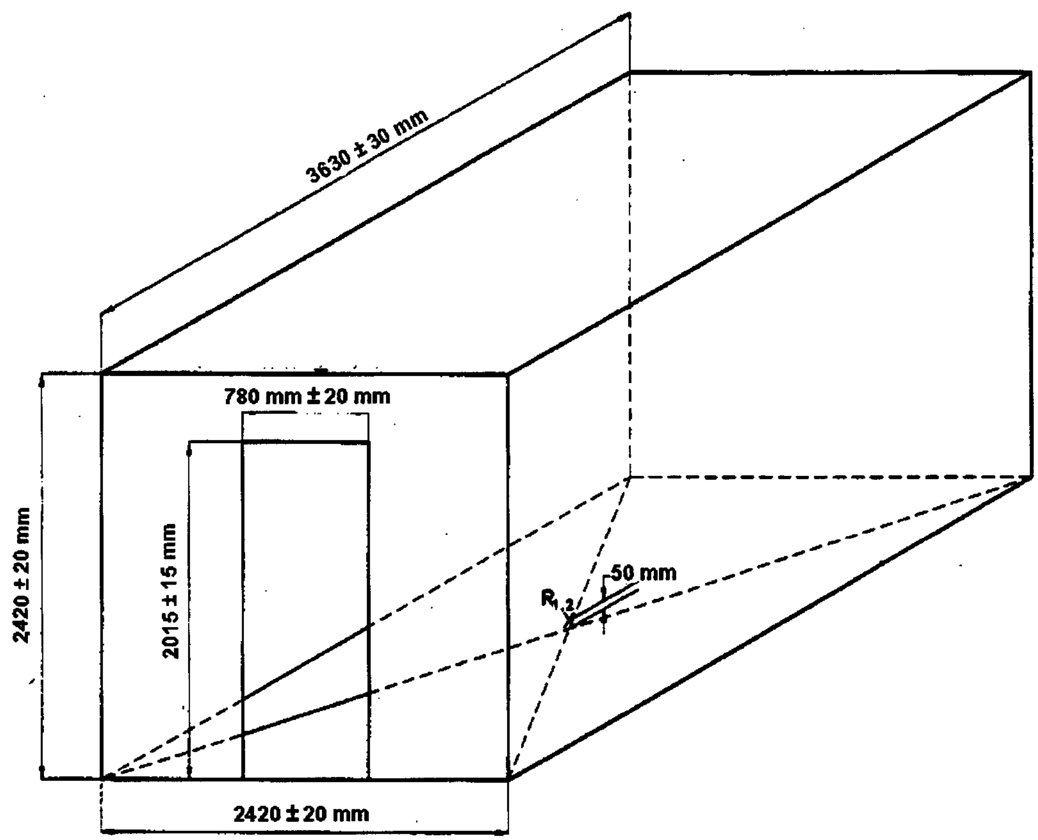

FIG. 2 Room Geometry and Placement of Heat Flux Meter

8.3.1 *Specification*—Bare Type K Chromel-Alumel thermocouples 0.5 mm (20 mil) in diameter shall be used at each required location. The thermocouple wire, within 13 mm (½ in.) of the bead, shall be run along expected isotherms (horizontally) to minimize conduction errors. The insulation between the Chromel and Alumel wires shall be stable to at least 1100°C (2000°F), or the wires shall be separated.

NOTE 4—1.6 mm OD Inconel sheathed thermocouples with an ungrounded junction and high purity (99.4 %) magnesium oxide insulation will work satisfactorily. The commonly used silicone-impregnated glass insulation breaks down above 800°C (1500°F.)

8.3.2 *Location in Doorway*—A thermocouple shall be located in the interior plane of the door opening on the door centerline, 100 mm (4 in.) down from the top (see Fig. 3).

8.3.3 *Locations for Room*—Thermocouples shall be located 100 mm (4 in.) down from the center of the ceiling and from the center of each of the four ceiling quadrants, and one shall be directly over the center of the ignition burner, 100 mm (4 in.) below the ceiling. The thermocouples shall be mounted on supports or penetrate through the ceiling with their junctions at least 100 mm (4 in.) away from a solid surface. There shall be no attachments to the test specimens. Any ceiling penetration shall be just large enough to permit passage of the thermocouples with back filling using spackling compound or ceramic fiber insulation.

8.4 *Photographic Records*:

8.4.1 *Specification*—Photographic or video equipment shall be used to record continuously the fire spread in the room and the fire projection from the door of the room. The location of the camera shall avoid interference with the air inflow. When wall linings are tested, the interior wall surfaces of the test room, adjacent to the corner in which the burner is located, shall be clearly marked with a 0.3 m (12 in.) grid. A clock shall appear in all photographic records, giving time to the nearest l s or 0.01 min from the start of the test. This clock shall be accurately synchronized with all other measurements, or other provisions shall be made to correlate the photo record with time. If 35 mm color photographs are used, they shall be taken at 15 s intervals for the first 3 min of the test and at least at 60 s intervals thereafter for the duration of the test.

8.4.2 *Location and Level of Lighting*—A 300-Watt flood-type quartz halogen lamp shall be positioned diametrically opposite the ignition source near floor level. The lamp shall be aimed at the wall corner/ceiling intersection above the ignition source.

8.4.3 *Type and Location of Video Camera*—A video camera with a mechanically adjustable iris, adjusted to prevent automatic closing of the iris opening due to brightness of the fire (at least 50 % open), shall be used. A video monitor shall be used to determine when adjustments and compensation for the brightness of the flames are needed.

NOTE 5—A window, cut 600 mm (2 ft) above the floor in the front wall

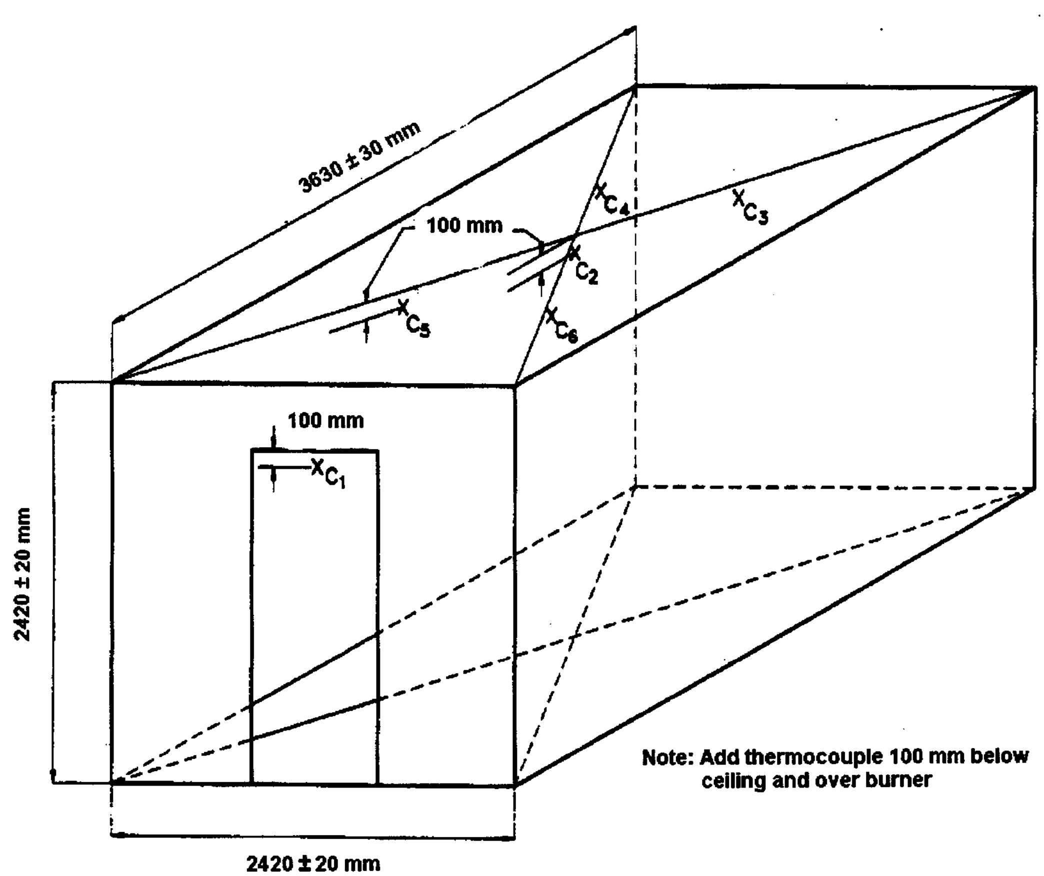

FIG. 3 Room Geometry and Thermocouple Placement

facing the gas burner, fitted with heat-resistant, impact-resistant glazing, provides useful photographic access. Flood lights shall not raise the ambient temperature in the room above that specified in Section 12.

9. Canopy Hood and Exhaust Duct

9.1 *Location and Design*—A hood shall be installed immediately adjacent to the door of the fire room. The bottom of the hood shall be level with the top surface of the room. The face dimensions of the hood shall be at least 2440 by 2440 mm (8 by 8 ft), and the depth shall be 1050 mm (3.5 ft) The hood shall feed into a plenum having a 914 by 914 mm (3 by 3 ft) cross section (see Fig. 4). The plenum shall have a minimum height of 914 mm (3 ft) The maximum height is 1830 mm (6 ft). The exhaust duct connected to the plenum shall be 406 mm (16 in.) in diameter, horizontal, and shall have a circular aperture of 305 mm (12 in.) or guide vanes at its entrance (see Fig. 4).

9.2 The hood shall have a draft sufficient to collect all of the combustion products leaving the room by moving at least a standard 2.5 m^3/s (5000 ft^3/min) Provisions shall be made to vary the draft to change the flow from 1 to 2.5 standard m^3/s (2000 to 5000 ft^3/min) Mixing vanes shall be required in the duct if concentration gradients are found to exist.

9.3 An alternative exhaust system design is permitted, provided it has been shown to produce equivalent results. (Equivalency is shown by meeting the requirements of 9.2.)

10. Instrumentation in the Exhaust Duct

10.1 *Duct Gas Velocity*:

10.1.1 *Specification*—A bi-directional probe or an equivalent measuring system shall be used to measure gas velocity in the duct **(1)**.[5] The probe shown in Fig. 5 consists of a short stainless steel cylinder 44 mm (1¾ in.) long and 22 mm (⅞ in.) inside diameter with a solid diaphragm in the center. The pressure taps on either side of the diaphragm support the probe. The axis of the probe shall be along the centerline of the duct 3350 mm (11 ft) downstream from the entrance. The taps shall be connected to a pressure transducer that shall be able to resolve pressure differences of 0.25 Pa (0.001 in. H_2O). Differential pressure measurements shall be smoothed by filtering the transducer output signal through an RC circuit with a time constant of 5 s. Alternatively, digital filtering of the pressure transducer output signal to simulate the effect of this RC circuit shall be permitted. One pair of thermocouples as specified in 8.3.1 shall be placed 3350 mm (11 ft) downstream of the entrance to the horizontal duct. The pair of thermocouples shall straddle the center of the duct and be separated 50 mm (2 in.) from each other.

NOTE 6—The bi-directional probe was chosen for measuring velocity in the exhaust duct, rather than the Pitot-static tube in order to avoid problems of clogging with soot.

NOTE 7—Capacitance pressure transducers have been found to be most

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

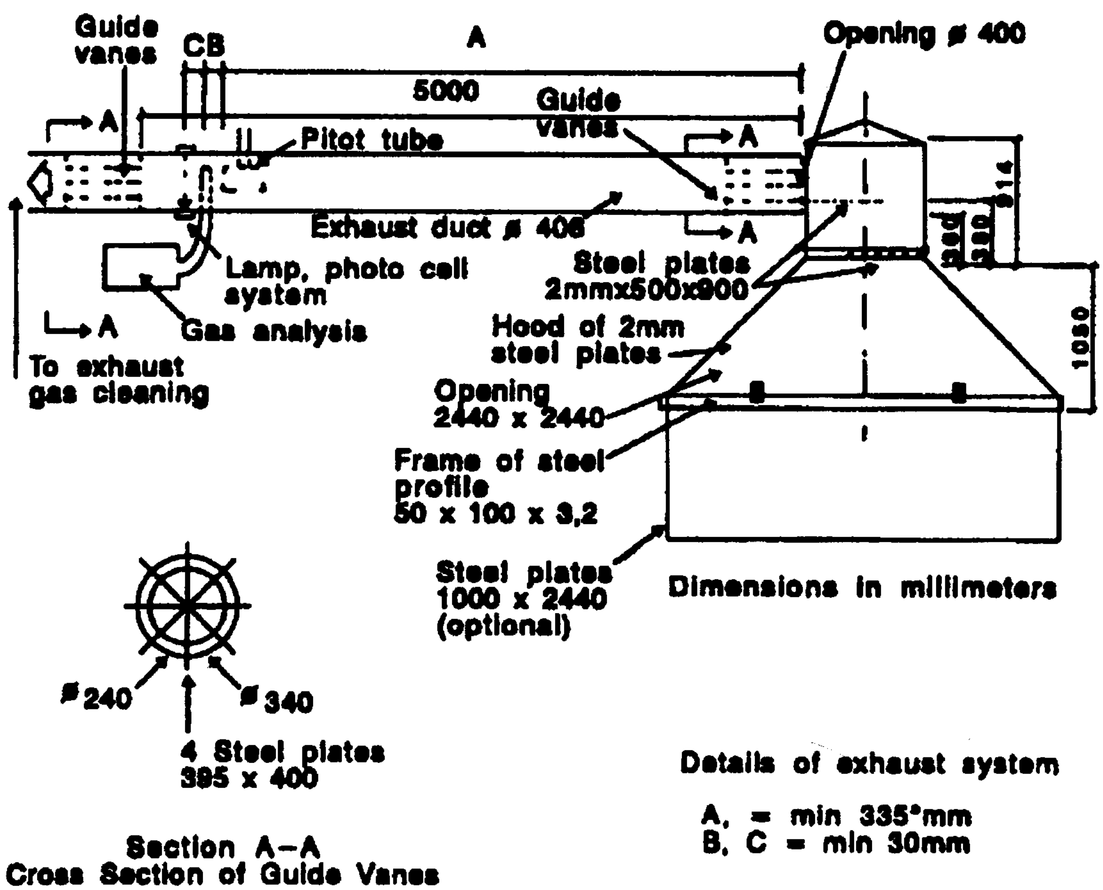

FIG. 4 Hood Geometry and Placement of Duct Instrumentation

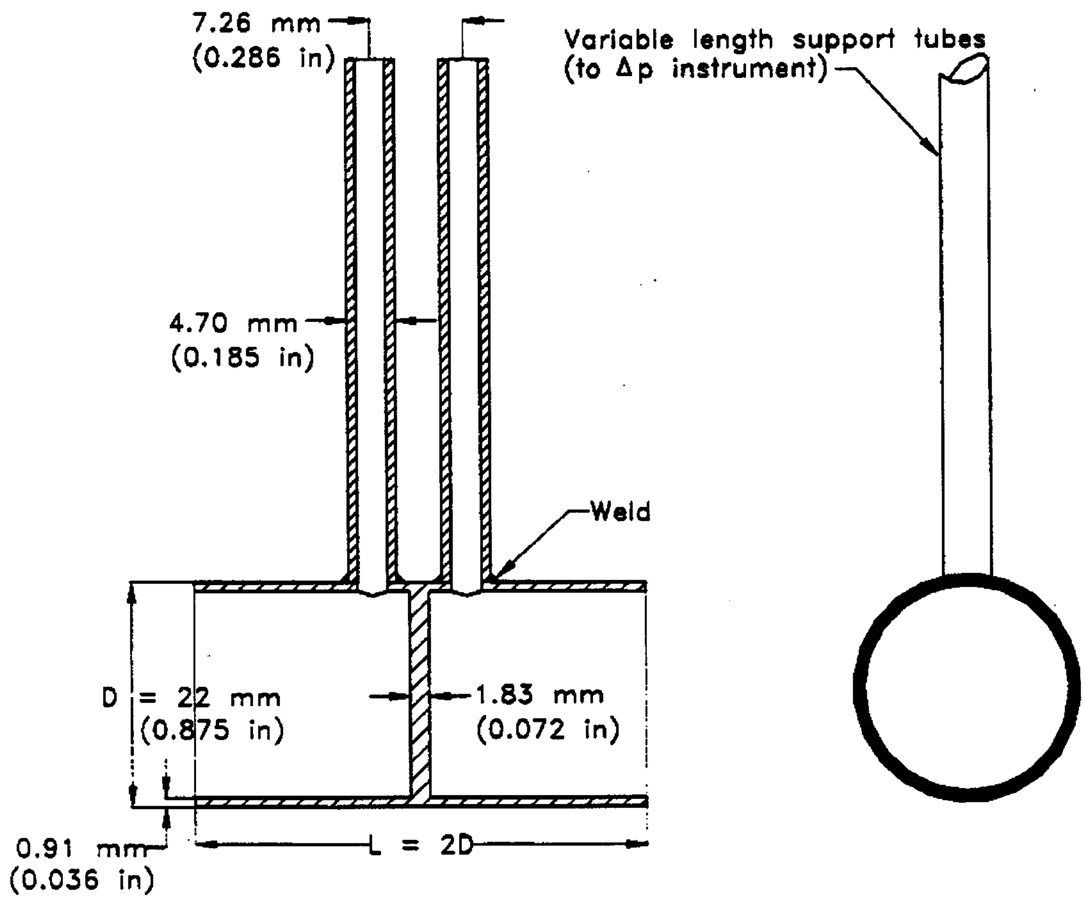

FIG. 5 Bi-directional Probe

suitable for this application.

10.2 *Duct Oxygen Concentration*:

10.2.1 *Specification*—A stainless steel gas sampling tube shall be located 3660 mm (12 ft) downstream from the entrance to the duct, to obtain a continuously flowing sample for determining the oxygen concentration of the exhaust gas as a function of time. A suitable filter and cold trap or permeable membrane drier shall be placed in the line ahead of the analyzer, to remove particulates and water. The oxygen analyzer shall be of the paramagnetic type and shall be capable of measuring the oxygen concentration in the range from 21 % down to 15 % with an accuracy of ± 0.01 % in this concentration range. The signal from the oxygen analyzer shall be within 5 % of its final value in 60 s after introducing a step change in composition of the gas stream flowing past the inlet to the sampling tube.

10.3 *Duct Carbon Dioxide Concentration*:

10.3.1 *Specification*—The gas sampling tube described in 10.2.1, or an alternative tube in the same location, shall provide a continuous sample for the measurement of the carbon dioxide concentration using an analyzer with a range of 0 to 5 %, with a maximum error of 0.1 % of full scale. The signal from the analyzer shall be within 5 % of its final value in 60 s after introducing a step change in composition of the gas stream flowing past the inlet to the sampling tube.

10.4 *Duct Carbon Monoxide Concentration*:

10.4.1 *Specification*—The gas sampling tube defined in 10.2.1, or an alternative tube in the same location, shall provide a continuous sample for the measurement of the carbon monoxide concentration using an analyzer with a range from 0 to 1 % with a maximum error of ± 0.02 %. The signal from the analyzer shall be within 5 % of its final value in 60 s after introducing a step change in composition of the gas stream flowing past the inlet to the sampling tube.

10.5 *Optical Density of Smoke in Duct*:

10.5.1 A meter shall be installed to measure the optical density of the exhaust gases in a vertical path across the width of a horizontal duct, 600 mm (2 ft) downstream of the duct velocity probe. The optical density shall be continuously recorded over the duration of the test.

10.5.2 One photometer system found suitable consists of a lamp, lenses, an aperture, and a photocell (see Fig. 6). Construct the system so that soot deposit on the optics during a test do not reduce the light transmission by more than 5 %.

10.5.3 Alternatively, instrumentation constructed using a 0.5 to 2.0 mW helium-neon laser, instead of a white-light system, is also acceptable (see Fig. 7).

NOTE 8—It has been shown that white light and laser systems will provide similar results **(2)**.

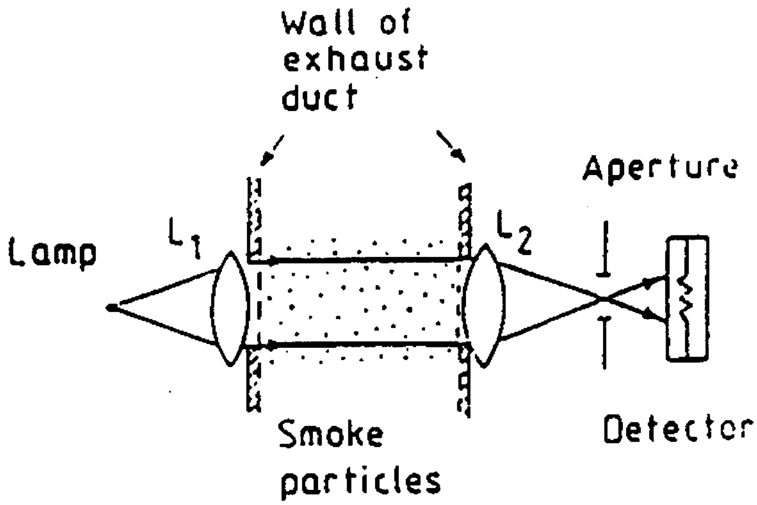

FIG. 6 White-Light Smoke Photometer

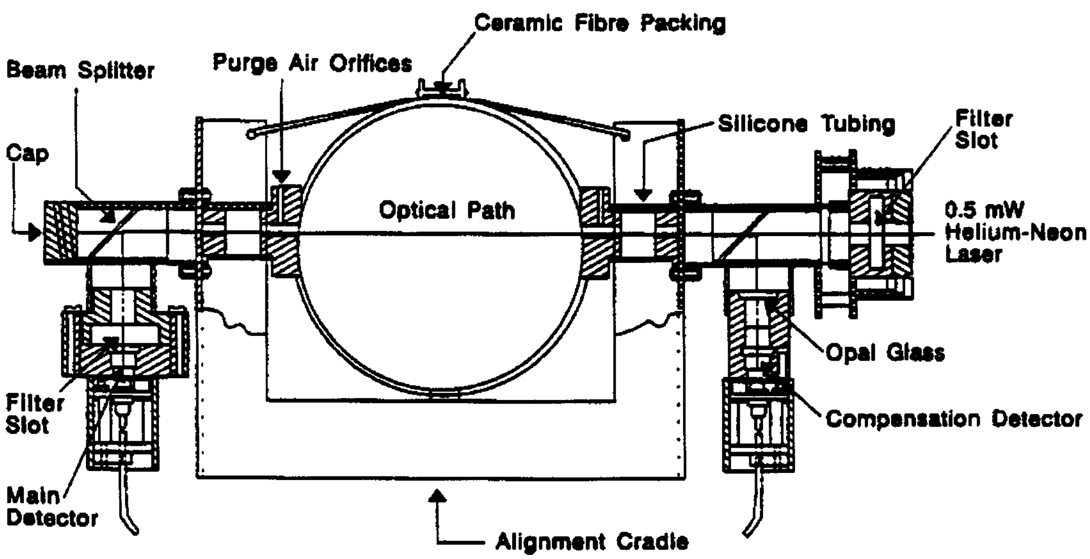

FIG. 7 Laser Smoke Photometer

10.6 *Data Acquisition*—The data collection system used shall have facilities for the recording of the output from the bi-directional probe, the gas analyzers, the heat flux meter, the thermocouples, and the smoke measuring system. The data acquisition system shall have an accuracy corresponding to at least 50 ppm oxygen for the oygen channel, 0.5°C for the temperature measuring channels, and 0.01 % of full-scale instrument output for all other instrument channels. The system shall be capable of recording data for at least 22 min, at intervals not exceeding 6 s. The system shall be calibrated at least once per year.

11. Specimen Mounting

11.1 Specimen mounting shall be according to one of three configurations (see Appendix X1).

11.1.1 *Standard Configuration*—Specimens shall be mounted to cover the entire ceiling, the two side walls, and the back wall.

11.1.2 *Wall Configuration*—Specimens shall be mounted to completely cover the walls, except the front wall containing the door. The entire ceiling shall be covered with gypsum board with a density of 725 ± 50 kg/m^3 (45 ± 5 lb/ft^3) and a minimum thickness of 13 mm (½ in.).

11.1.3 *Ceiling Configuration*—Specimens shall be mounted to cover the entire ceiling. The two side walls and the back wall shall be covered entirely with gypsum board with a density of 725 ± 50 kg/m^3 (45 ± 5 lb/ft^3) and a minimum thickness of 13 mm (½ in.).

11.2 The specimens, for example, the ceiling and wall materials whose contribution is being tested, shall be mounted on a framing or support system comparable to that intended for their field use, using backing materials, insulation, or air gaps, as appropriate to the intended application and representing a typical value of thermal resistance for the wall system. (See Appendix X2.)

11.3 In cases where the product to be tested is in panel form, the standard dimensions (width, length and thickness) of the panels shall be used, if possible.

11.4 Thin surface materials, thermoplastic products that melt, paints and varnishes shall, depending on their end use, be applied to one of the following substrates; (*a*) Non-combustible fiber reinforced silicate board with a dry density of 680 ± 50 kg/m^3 (42 ± 3 lb/ft^3), suitable thickness is between 9 and 13 mm (and ½ in.); (*b*) Non-combustible board with a dry density of 1650 ± 150 kg/m^3 (103 ± 9 lb/ft^3), suitable thickness is between 9 and 13 mm (and ½ in.); (*c*) Ordinary particleboard with a density of 680 ± 50 kg/m^3 (42 ± 3 lb/ft^3) at normal conditioning atmosphere, that is, 50 ± 5 % of relative humidity and 23 ± 2°C (73 ± 4°F) of temperature, suitable thickness is between 9 and 13 mm (and ½ in.); and (*d*) Gypsum board with a density of 725 ± 50 kg/m^3 (45 ± 5 lb/ft^3) at normal conditioning atmosphere, suitable thickness is between 9 and 13 mm (⅜ and ½ in.) Other substrates are acceptable depending on the end use of the product, for example steel and mineral wool.

11.5 Paints and varnishes shall be applied to the appropriate substrate with the application rate specified by the sponsor.

11.6 A detailed description of the mounting method used shall be given in the test report. If a special mounting technique is used in order to improve the physical behavior of the specimen during the test, this shall be clearly stated in the report.

12. Fire Room Environment

12.1 The temperature in the fire test room and the surroundings shall be 20 ± 10°C.

12.2 The horizontal wind draft measured at a horizontal distance of 1000 mm (40 in.) from the center of the doorway shall not exceed 0.5 m/s (1.6 ft/s).

12.3 When necessary, the specimens shall be conditioned to approximate equilibrium in an atmosphere of 50 ± 5 % relative humidity at a temperature of 23 ± 2°C (73 ± 4°F). Equilibrium is considered to be reached when a representative piece of the specimen has achieved constant mass. Constant mass is considered to be reached when two successive weighing operations, carried out at an interval of 24 h, do not differ by more than 0.1 % of the mass of the test piece or 0.1 g, whichever is greater. For wood based products and products where vaporization of solvents occurs, a conditioning time of at least four weeks is not uncommon.

13. Heat Release Rate Calibration

13.1 A heat release rate calibration test shall be performed prior to and within 30 days of any fire test according to the procedure described in Section 14. The calibration test shall use the standard gas burner described in Section 6. The burner shall be placed directly under the center of the hood so that its top surface is 2 m (80 in.) below the bottom of the hood. The propane gas supply to the burner shall produce a net heat output of 300 ± 10 kW (17 060 ± 570 Btu/min) for 10 min. A new value for the calibration constant *C* shall be obtained as follows:

13.1.1 Determine the rate of heat release according to the equations in Annex A1, using the theoretical value for the calibration constant, C_{th} (see A1.2.2). Determine the average heat release rate over the 10-min calibration test duration, $q_{avg,1}$.

13.1.2 Determine the average rate of heat release over the 10-min test duration, $q_{avg,2}$, from the mass loss of the fuel and its heat of combustion. The net heat of combustion of 99 % purity propane is 46.5 kJ/g (20000 ± 200 Btu/lb).

13.1.3 Calculate a new value for the calibration constant from:

$$C_{new} = C_{th}\frac{\dot{q}_{avg,\,2}}{\dot{q}_{avg,\,1}} \tag{1}$$

13.1.4 The difference between C_{new} and C_{th} shall not exceed 20 % of the theoretical value The difference between C_{new} and the value obtained from the previous calibration, C_{old}, shall not exceed 5 % of the theoretical value. If any of the two differences exceed the limit, the gas sampling system shall be checked for leaks, and the gas analysis and flow measuring instrumentation shall be examined for proper operation. No tests shall be performed until the cause of the discrepancy is found and corrective action is taken.

14. Procedure

14.1 Zero the pressure transducer signal after connecting the two ports of the transducer.

14.2 Establish an initial volumetric flow of 1 m^3/s (2000 ft^3/min) through the duct. During the test, increase the volume flow through the duct to 2.5 m^3/s (5000 ft^3/min) as necessary to collect all combustion products emerging from the room.

14.3 Calibrate the smoke meter by blocking the light beam (zero) and using a neutral density filter (span). Calibrate the gas analyzers with zero (nitrogen) and span gases (dry air for oxygen and certified mixtures for carbon monoxide and carbon dioxide).

14.4 Turn on all sampling and recording devices, and establish steady-state baseline readings for at least 2 min. Data collection between the end of the baseline period and ignition of the burner shall not be suspended for more than 1 min.

14.5 Simultaneously ignite the gas burner and start the clock. Increase gas flow in steps as indicated in 6.4.

14.6 If 35 mm color photographs are used, they shall be taken at 15 s intervals during the first 3 min, and at 60 s intervals thereafter to document the growth of the fire.

14.7 Provide a continuous voice or written record of the fire, which will give times of all significant events, such as flame attachment to the wall, flames out of the doorway, flashover, etc.

14.8 The ignition burner shall be shut off at 20 min after the start of the test, and the test shall be terminated at that time unless safety considerations dictate an earlier termination.

14.9 Describe damage after the test, using both words and pictures.

15. Report

15.1 The report shall include the following:

15.1.1 *Materials*:

15.1.1.1 *Material Description*—The name, thickness, density, and size of the material shall be listed, along with other identifying characteristics or labels.

15.1.1.2 Materials mounting and conditioning.

15.1.1.3 Layout of specimens and attachments in test room (include appropriate drawings).

15.1.1.4 Relative humidity, temperature, and barometric pressure of the room and the test building at the start of the test.

15.1.2 *Burner Gas Flow*—The fuel gas flow to the ignition burner and its calculated rate of heat output.

15.1.3 *Time History of the Total Heat Flux to Floor*—The total incident heat flux at the center of the floor for each heat flux gage as a function of time starting 1 min prior to the test.

15.1.4 *Time History of the Gas Temperature*—The temperature of gases in the room, the doorway, and in the exhaust duct for each thermocouple as a function of time starting 1 min prior to the test. The temperatures recorded by the thermocouples in the duct will be used in the calculations below.

15.1.5 *Mass Flow in the Duct Gas*—The mass flow of the gas in the duct shall be calculated from Annex A1 and reported as a function of time starting 1 min prior to the test.

15.1.6 *Oxygen Concentration*—The oxygen concentration measured by the analyzer as a function of time starting 1 min prior to the test.

15.1.7 *Carbon Dioxide Concentration*—The carbon dioxide concentration measured by the analyzer as a function of time starting 1 min prior to the test. (Separate reporting of the mass flow, temperature, oxygen and carbon dioxide concentrations provide diagnostic information on the performance of the exhaust gas collection system and also provide a check on the heat production calculations).

15.1.8 *Time History of the Total Rate of Heat Production of the Fire*—The total rate of heat production shall be calculated from the measured oxygen and carbon dioxide concentrations and the temperature and mass flow of the gas in the duct. The calculation is based on Annex A1.

15.1.9 *Time History of the Rate of Carbon Monoxide Production*—The rate of carbon monoxide production shall be calculated from the measured carbon monoxide concentrations and mass flow of the gas in the duct. The calculation is based on Annex A1.

15.1.10 *Time History of the Rate of Smoke Particulate Production*—The rate of smoke release (product of the volumetric flow of the gas in the duct at the duct gas temperature and the extinction coefficient at the specified smoke meter location in the duct) as a function of time after the start of the test. The calculation is based on Annex A1.

15.1.11 *Time History of the Fire Growth*—A transcription of the visual, photographic, audio, and written records of the fire test. The records shall indicate the time of ignition of the wall and ceiling finishes, the approximate location of the flame front most distant from the ignition source, at intervals not exceeding 15 s during the fire test, the time of flashover, and the time at which flames extend outside the doorway. In addition, still photographs taken at intervals not exceeding 15 s for the first 3 min, beginning at the start of the test and every 30 s for the remainder of the test shall be supplied. Photographs showing the extent of the damage of the materials after the test shall also be supplied. The camera settings, film speed, and lighting used shall be described.

15.1.12 *Flaming Droplets and Debris*—Report whether flaming droplets or debris reach the floor at a distance of more than 1.2 m (4 ft) from the corner.

15.1.13 *Calibration Test*—A report on the pre-test calibration conducted in Section 13.

16. Precision and Bias

16.1 Between May 1989 and June 1990 a room/corner test round robin was conducted in Europe using the test protocol described in this standard. Four different lining materials were attached to walls and ceiling, and were tested at five laboratories in Denmark, Finland, Norway, Sweden, and the United Kingdom. The four materials were birch plywood (density 650 kg/m^3, thickness 12 mm), melamine faced particleboard (density 700 kg/m^3, thickness 12 mm), fire retarded plywood (density 620 kg/m^3, thickness 9 mm), and fire retarded polystyrene foam (density 30 kg/m^3, thickness 25 mm.) The time to flashover, defined as 1 MW heat release rate, was 137 $\pm$ 37 s and 199 $\pm$ 18 s for the birch plywood and melamine faced particleboard respectively. The specified range corresponds to the 95 % confidence interval. Heat release rate reached the 1 MW level in only one laboratory for the fire retarded plywood. The time to 700 kW heat release rate for this material was 634 $\pm$ 15 s. Similar relative ranges were found for the rates of smoke and CO production for the three materials. The results for the fire retarded polystyrene foam varied considerably. This variance was attributed to the fact that the participating laboratories used different adhesives and mounting techniques, which appear to be critical for the performance of this material. Full details are found in the report that was published as ISO/TC92/SC1 document N 233 in January 1991.

17. Keywords

17.1 carbon dioxide; carbon monoxide; corner; fire; fire-test response; flame; heat release; heat release rate; ignition; optical density; oxygen consumption calorimetry; room; smoke obscuration; toxic gases

ANNEX

(Mandatory Information)

A1. CALCULATION OF THE RATE OF HEAT, SMOKE, AND CO-PRODUCTION

A1.1 Prior to performing any calculations, all measurements in the exhaust duct shall be shifted over the appropriate time interval to account for the travel time of the products of combustion between the fire and the instrumentation in the duct. New values for the delay times shall be determined during each calibration test (see Section 13). Delay times shall be rounded to nearest multiple of the data collection interval. The delay times for the thermocouples, pressure transducer, and smoke photometer are determined as the time difference between ignition of the burner flame and the moment when the output from the thermocouples at the bi-directional probes reach the mid-point between initial (at time 0) and final (at 600 s) values. The delays time for each gas analyzer is determined as the time difference between ignition of the burner flame and the moment when the output from that analyzer reaches the mid-point between initial (at time 0) and final (at 600 s) value.

A1.2 *Mass Flow through the Duct*:

A1.2.1 The mass flow through the duct is obtained from the velocity measured with a bi-directional probe (see 10.1.1) along the center line. The equation to calculate mass flow is (symbols are defined in A1.7):

$$\dot{m}_e = C \sqrt{\frac{\Delta p}{T_e}} \quad \text{(A1.1)}$$

A1.2.2 The theoretical value of C is approximately constant for the range of operating conditions specified in this standard, and is estimated as follows. According to Ref **(1)**, the centerline velocity measured with the bi-directional probe is given by:

$$V_c = \frac{\sqrt{2\,\Delta p\,\rho_e}}{f\,(Re)} \quad \text{(A1.2)}$$

where the Reynolds number correction, $f\,(Re)$, for $40 < Re < 3800$ is calculated from:

$$f(Re) = 1.533 - 1.366\;10^{-3}\,Re + 1.688\;10^{-6}\,Re^2 - 9.706\;10^{-10}\,Re^3 + 2.555\;10^{-13}\,Re^4 - 2.484\;10^{-17}\,Re^5 \quad \text{(A1.3)}$$

A1.2.3 If $Re > 3800$, $f\,(Re)$ is equal to an asymptotic value of 1.08. The average velocity over the cross-section of the duct, V_e, is slightly smaller than V_c. Defining the ratio of V_e to V_c as k_c, and assuming that the gases flowing through the exhaust duct are at atmospheric pressure and have the same properties as air, the mass flow can be estimated from:

$$\dot{m}_e = \rho_e V_e A \approx \frac{353}{T_e} k_c V_c A \quad \text{(A1.4)}$$

A1.2.4 Combination of Eq A1.1, Eq A1.2, and Eq A1.4 then results in:

$$C_{th} \approx 26.54 \frac{k_c A}{f(Re)} \quad \text{(A1.5)}$$

A1.2.5 Using a typical value of 0.9 for k_c (methods to determine k_c are described in Ref **(3)**), and the asymptotic value of 1.08 for $f\,(Re)$, leads to the following simple estimate:

$$C_{th} \approx 22A \quad \text{(A1.6)}$$

A1.3 *Rate of Heat Release* **(4)**:

A1.3.1 Calculate the mass flow according to Eq A1.1, and the oxygen depletion factor according to Eq A1.7:

$$\phi = \frac{X_{O_2}^{A^\circ}(1 - X_{CO_2}^A - X_{CO}^A) - X_{O_2}^A(1 - X_{CO_2}^{A^\circ})}{X_{O_2}^{A^\circ}(1 - X_{O_2}^A - X_{CO_2}^A - X_{CO}^A)} \quad \text{(A1.7)}$$

A1.3.2 Then calculate the rate of heat release according to Eq A1.8:

$$\dot{q} = \left(E\phi - (E_{CO}{}^{-E}) \frac{1 - \phi}{2} \frac{X_{CO}^A}{X_{O_2}^A} \right) \frac{M_{O_2}}{M_a} \frac{\dot{m}_e}{1 + \phi\,(\alpha - 1)} X_{O_2}^{A^\circ} \quad \text{(A1.8)}$$

A1.4 *Smoke Release Rate*:

A1.4.1 Calculate the extinction coefficient, k, from Eq A1.9:

$$k = \frac{1}{D} \ln\left(\frac{I_0}{I}\right) \quad \text{(A1.9)}$$

A1.4.2 The volumetric flow at the smoke meter $\dot{V}_s$ in m^3/s is calculated from the mass flow at the bi-directional probe $\dot{m}_e$ in kg/s (see A1.3), and the density based on temperature at the smoke meter T_s in K, as shown in Eq A1.10:

$$\dot{V} = \frac{\dot{m}_e T_s}{353} \quad \text{(A1.10)}$$

A1.4.3 Rate of smoke release ($\dot{s}$) is then defined by Eq A1.11:

$$\dot{s} = k\dot{V}_s \quad \text{(A1.11)}$$

A1.5 *Release Rate of Carbon Monoxide*:

A1.5.1 The release rate of carbon monoxide is calculated from Eq A1.12:

$$\dot{m}_{CO} = \frac{X_{CO}^A(1 - X_{O_2}^{A^\circ} - X_{CO_2}^{A^\circ})}{1 - X_{O_2}^A - X_{CO_2}^A - X_{CO}^A} \frac{M_{CO}}{M_a} \frac{\dot{m}_e}{1 + \phi(\alpha - 1)} \quad \text{(A1.12)}$$

A1.6 The following numerical values are recommended for use in the equations:

A1.6.1 Energies: E = 13.1 MJ/kg of O_2 for tests and E = 12.76 MJ/kg of O_2 for gas burner calibartions, E_{CO} = 17.6 MJ/kg of O_2; Molecular mass: M_a = 29 kg/kmol, M_{CO} = 28 kg/kmol, M_{O_2} = 32 kg/kmol; Expansion factor: α = 1.084.

A1.7 *Symbols*:

A	=	cross-sectional area of the duct at the location of the probe (in m^2)
C	=	orifice plate coefficient ($kg^{1/2} \times m^{1/2} \times K^{1/2}$)
D	=	duct diameter (m)

E	=	net heat released per unit mass of O_2 consumed (13.1 MJ/kg)
E_{CO}	=	net heat released per unit mass of O_2 consumed, for CO (17.6 MJ/kg)
$f(Re)$	=	Reynolds number correction
I_0	=	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 (cd)
I	=	light intensity for a parallel light beam having traversed a certain length of smoky environment and reaching the photodetector (cd)
k	=	extinction coefficient (1/m)
k_c	=	velocity profile shape factor (non dimensional)
$\dot{m}_e$	=	mass flow in exhaust duct (kg/s)
$\dot{m}_{CO}$	=	release rate of carbon monoxide (kg/s)
M_a	=	molecular mass of incoming air (29 kg/kmol)
M_{CO}	=	molecular mass of carbon monoxide (28 kg/kmol)
M_{O_2}	=	molecular mass of oxygen (32 kg/kmol)
Δp	=	differential pressure measured across the bi-directional probe (Pa)
$\dot{q}$	=	rate of heat release (kW)
$\dot{s}$	=	rate of smoke release (m^2/s)
T_e	=	gas temperature at the bidirectional probe (K)
T_s	=	gas temperature at the smoke meter (K)
$\dot{V}_S$	=	volumetric flow at the smoke meter (m^3/s)
X_{CO}^A	=	measured mole fraction of CO in exhaust flow
$X_{CO_2}^A$	=	measured mole fraction of CO_2 in exhaust flow
$X_{CO_2}^{A°}$	=	measured mole fraction of CO_2 in incoming air
$X_{O_2}^A$	=	measured mole fraction of O_2 in exhaust flow
$X_{O_2}^{A°}$	=	measured mole fraction of O_2 in incoming air
α	=	combustion expansion factor (normally a value of 1.084)

APPENDIXES

(Nonmandatory Information)

X1. COMMENTARY

X1.1 Over the years the regulatory community has used Test Method E 84 for the control of interior wall and ceiling linings. Test Method E 84 evaluates the relative surface burning characteristics of interior finish materials exposed to a developing fire of sufficient size to produce progressive involvement. When examining conditions beyond the initial stages of fire growth, experiments in room configurations have shown that there is increasing influence of the enclosure environment (that is, compartment size, configuration, degree and location of ventilation, ignition source severity, and other factors) on the surface burning characteristics of interior finish materials. During the 1970's several of the regulatory groups incorporated into their codes requirement for "diversified tests" for certain materials. As a result, different room and corner tests were devised to provide additional information on the fire properties of the materials. The work in ASTM on developing a standard room test is the outgrowth of this earlier work. Guide E 603 provides the background for this method. The room fire test configuration has been developed to provide relevant fire performance information indicative of the involvement of materials in building fires.

X1.2 This method is intended to evaluate the probability of full room involvement, or the time at which it occurs, when the wall or ceiling materials are exposed to an incidental fire, that is, a fire that is not of sufficient size to produce full room involvement by itself. The ignition source is the standard ignition source in ISO 9705, and was developed in the 1980's in Finland and Sweden.

X1.3 In addition, this standard room fire test is a useful element in the evaluation of systems that depend on a barrier to reduce the potential for fire involvement of these materials.

X1.4 In those cases where the burning of the furnishings alone produces heat at a sufficient rate to cause full room involvement, this method will evaluate the potential of the interior finish materials to provide additional flames outside of the room, which could contribute to fire spread from the fire room.

X1.5 This method specifies three different specimens configurations. The standard configuration in this method with the same material on walls and ceiling is the standard configuration specified in ISO 9705. A large amount of data is available for this configuration, which is the most severe of the three configurations. Research at the Forest Products Laboratory in Madison, WI demonstrated that room test performance in the wall configuration is more consistent with the Test Method E 84 flame spread index classification **(5)**. The 100 kW ignition burner flame intermittently hits the ceiling, which makes it possible to evaluate ceiling materials without lining the walls (ceiling configuration). However, if the ceiling material in this configuration does not stay in place during the test, the results shall not be valid.

X1.6 This method evaluates the potential contribution of combinations of wall and ceiling materials and assemblies to both the rate and extent of room fire growth and fire spread from the fire room, using as one measure the total rate of heat production of the materials when exposed to a specified ignition source in a room of given geometry and size. While the results of the test strictly apply only to the particular combination tested, engineering judgment shall be exercised as to the fire performance of other combinations. For example; (*a*) if a particular combination tested is found acceptable according to some set of criteria; and (*b*) if one of the materials is replaced by a material definitely known to produce a lower rate of heat release, and it does not have a substantially lower thermal inertia (square root of the product of the thermal conductivity, density, and heat capacity), the new combination is generally acceptable.

X1.7 Several factors were considered in choosing the layout and dimensions of the hood, plenum, exhaust duct, and sampling or measuring locations. Based on experiments with an earlier version of this method, it was deduced that a volume flow of 2.4 m^3/s (5000ft^3/min) would be needed to collect all the combustion products from a test room under post flashover conditions, while a reduction of this flow to 0.47 m^3/s (1000 ft^3/min) would be required to provide adequate sensitivity of the oxygen consumption measurement during the early stages of the fire, or for materials with inherently low heat release rates **(6)**. The 406 mm (16 in.) diameter pipe was chosen to provide a velocity of 4 m/s at 0.47 m^3/s (12 ft/s at 1000 ft^3/min) which yields a Froude number of $Fr = v^2/gD = 1.8$, which should be sufficient to avoid stratification in the exhaust duct and to provide a Reynolds number of $Re = vD/\nu = 25\,000$, which assures turbulence. The 305 mm (12 in.) diameter aperture at the entrance to the duct provides an area ratio for expansion of 1.765 which is expected to provide adequate mixing over a length of 6 diameters from the orifice **(7)**. The gas sampling probe is located at 6.75 diameters.

X1.8 Due to considerable soot production in many fires, pitot tubes are generally not useful for measuring velocity of combustion products because of clogging of the holes. In order to deal with this problem, a more robust bidirectional probe was designed by McCaffrey and Heskestad **(1)**. This type of probe was chosen to measure velocity in the exhaust duct.

X1.9 The 8500 mm (17 ft) overall horizontal length should be amenable to any test building capable of accommodating a 2420 by 3630 mm (8 by 12 ft) room with a 2400 by 2400 m (8 by 8 ft) hood located in front of it. A blower that will provide a negative pressure of 1.25 kPa (5 in. H_2O) under a maximum flow of 2.4 m^3/s (5000 ft^3/min) is adequate when the flow is measured with a bi-directional probe. These specifications are based on a pressure drop of 1.5 Pa/m (0.006 in. H_2O/ft) of duct, and a 0.88 kPa (3.5 in. H_2O) drop at the entrance taking the 0.305 m (12 in.) orifice and the jet contraction into account.

$$\Delta P = 4.4\,\rho\,\frac{\bar{\mu}^{2}}{2}\ (\mathrm{Pa}) \quad \text{(X1.1)}$$

X1.10 Since the hood, plenum, exhaust duct, and associated equipment serve essentially as a measuring instrument to record the rates of heat release, smoke production, and carbon monoxide production, and do not affect the growth of the fire, some flexibility is allowed in the design so long as the departures from the above specifications do not affect the calculated rates. In order to accomplish this, the following four requirements shall be met; (*a*) all of the combustion products shall be collected; (*b*) these products shall be well mixed at the sampling point; (*c*) there shall not be a significant difference in the deposition and coagulation of the smoke prior to the smoke meter; and (*d*) the flow conditions shall be uniform enough to accurately determine the volume flow in the duct.

X1.11 The stipulated test conditions are such that if a combination of materials is found acceptable in terms of the results of this test, it is expected that the materials will be acceptable for many other room fire conditions in which the interior finish is a critical element of fire growth. For example, a substantial increase in the size of the ignition source or a reduction in room size, both changes from the standard test conditions, would lead to full involvement without any contribution from the interior finish. Therefore, for these variations, the interior finish is no longer the critical element producing flashover. On the other hand, a reduction in ignition source size or an increase in room size generally results in a less severe fire, and the standard test results are probably be conservative.

X1.12 This method is not intended to measure the contribution of room furnishings to fire growth and spread. These would have to be measured by an alternative test method.

X2. GUIDE TO MOUNTING TECHNIQUES FOR WALL AND CEILING INTERIOR FINISH MATERIALS

X2.1 *Introduction*:

X2.1.1 This guide is intended as an aid in determining the method of mounting various building materials in the standard fire test room. These mountings are described for test method uniformity and for good laboratory practice. They are not meant to imply restriction in the specific details of field installation. They are intended to be used for general material testing where the specific details of the field installation either have not been established or are so broad that any single installation method is not representative of the full range of installation possibilities.

X2.1.2 Mounting methods are grouped according to materials to be tested, which are broadly described either by usage or by form of the material.

X2.1.3 For some building materials, none of the methods described are applicable. In such cases, other means of attachment have to be devised. Wherever possible these specimens shall be mounted using the same method of attachment as that contemplated in the field installation.

X2.1.4 All backing materials, when used, shall be supported on a framed support system. A typical supporting framework is shown in Fig. X2.1.

X2.1.5 Whenever calcium silicate board or gypsum wallboard is specified as a backing substrate in subsequent paragraphs, the material shall be as described in 11.5. Where metal screws in combination with washers and wing nuts are specified for fastening, they shall be standard 6.4 mm (¼ in.) by 0.8 threads per mm (20 threads per inch (TPI)) round-head steel

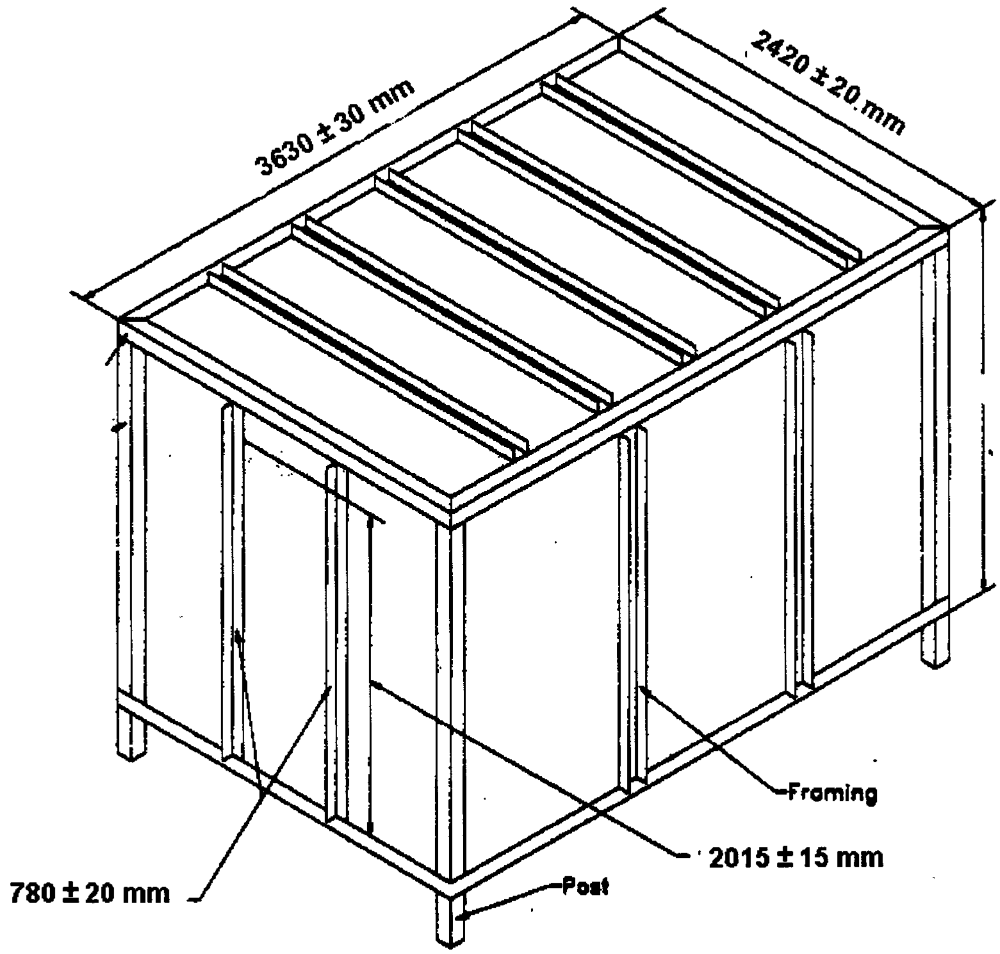

FIG. X2.1 Typical Steel Frame Support System

machine screws, 6.4 mm (1⁄4 in.) by 0.8 threads per mm (20 TPI) steel wing nuts and a 50.8 mm (2 in.) outside diameter by 1.1 mm (0.044 in.) thick flat steel washers with a 7.1 mm (9⁄32 in.) inside diameter hole. Fastening screws shall be installed as shown in Fig. X2.2. The fastening pattern is shown in Fig. X2.3 for rigid wall materials and in Fig. X2.4 for flexible wall materials. The fastening pattern for all ceiling materials is shown in Fig. X2.5.

X2.2 *Acoustical Materials and Other Board Materials*:

X2.2.1 Depending on the type of field mounting required by the acoustical product, either wood furring strips or metal runners shall be used to support acoustical material.

X2.2.2 Metal runners for mounting shall be attached to the substrate to approximate the field suspension systems application.

X2.2.3 Wood furring strips for mounting acoustical materials and other board materials shall be nominal 25 by 50 mm (1 by 2 in.) wood furring strips and attached to a substrate to approximate the field installation.

X2.3 *Batt- or Blanket-Type Insulating and Other Flexible Materials*:

X2.3.1 Batt- or blanket-type and other flexible materials that do not have sufficient rigidity or strength to support themselves shall be supported by round-head machine screws in combination with wing nuts and flat washers, as specified in X2.1.5, which are inserted through the material in such a way as to fasten the material to a substrate board.

X2.4 *Building Units*:

X2.4.1 Materials falling within this category include organic or inorganic materials, or both, formed or laminated into blocks, boards, planks, slabs, or sheets of various sizes, thicknesses, or shapes. If building units have sufficient structural integrity to support themselves, no additional mounting to a substrate board support is required. If the building units are of such construction that require individual components that are not selfsupporting, the component shall be fastened to the substrate board as specified in X2.1.5.

X2.5 *Coatings or Spray Applied Materials*:

X2.5.1 Coating materials, such as cementitious mixtures, mastic coatings, sprayed fibers, etc., shall be mixed and applied to the substrate board as specified in the manufacturer's instructions at the thickness, coverage rate, or density recommended by the manufacturer.

X2.5.2 Materials intended for application to a wood surface shall be applied to a substrate as specified in 11.4(*c*).

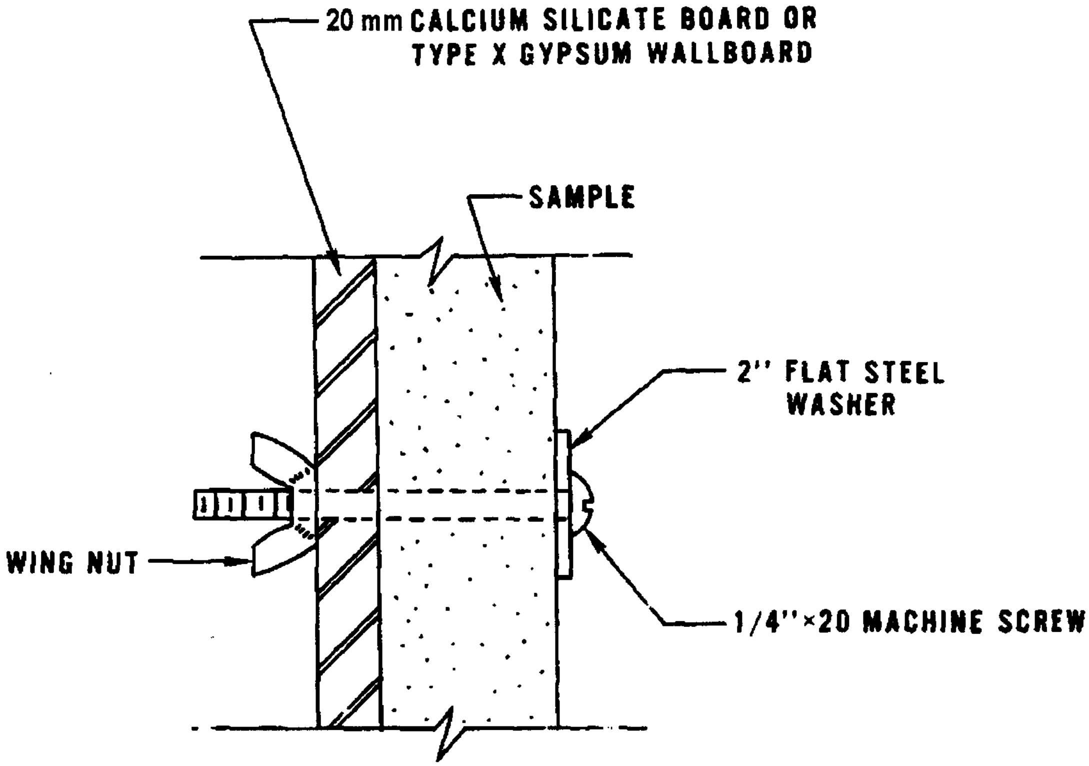

FIG. X2.2 Material Fastening Technique

X2.5.3 Coating materials intended for application to particular combustible surfaces, but not wood, shall be applied to the specific surface for which they are intended. The coating material and combustible material shall be attached to the substrate board as specified in X2.1.5.

X2.5.4 Coating materials intended only for field application to non-combustible surfaces shall be applied to a substrate as specified in 11.4(*a*) or (*b*).

X2.6 *Wall Covering Materials*:

X2.6.1 Wall coverings such as vinyl coatings, wallpaper, and textile wall coverings of various types shall be mounted on gypsum wallboard as specified in 11.4(*d*), or on the actual substrate to which they shall be applied, using the adhesive and application technique specified by the manufacturer. Where a wall covering has a distinct directionality, the sample shall be mounted such that the machine direction is vertical, unless the manufacturer indicates a different method of mounting will be used in actual installations.

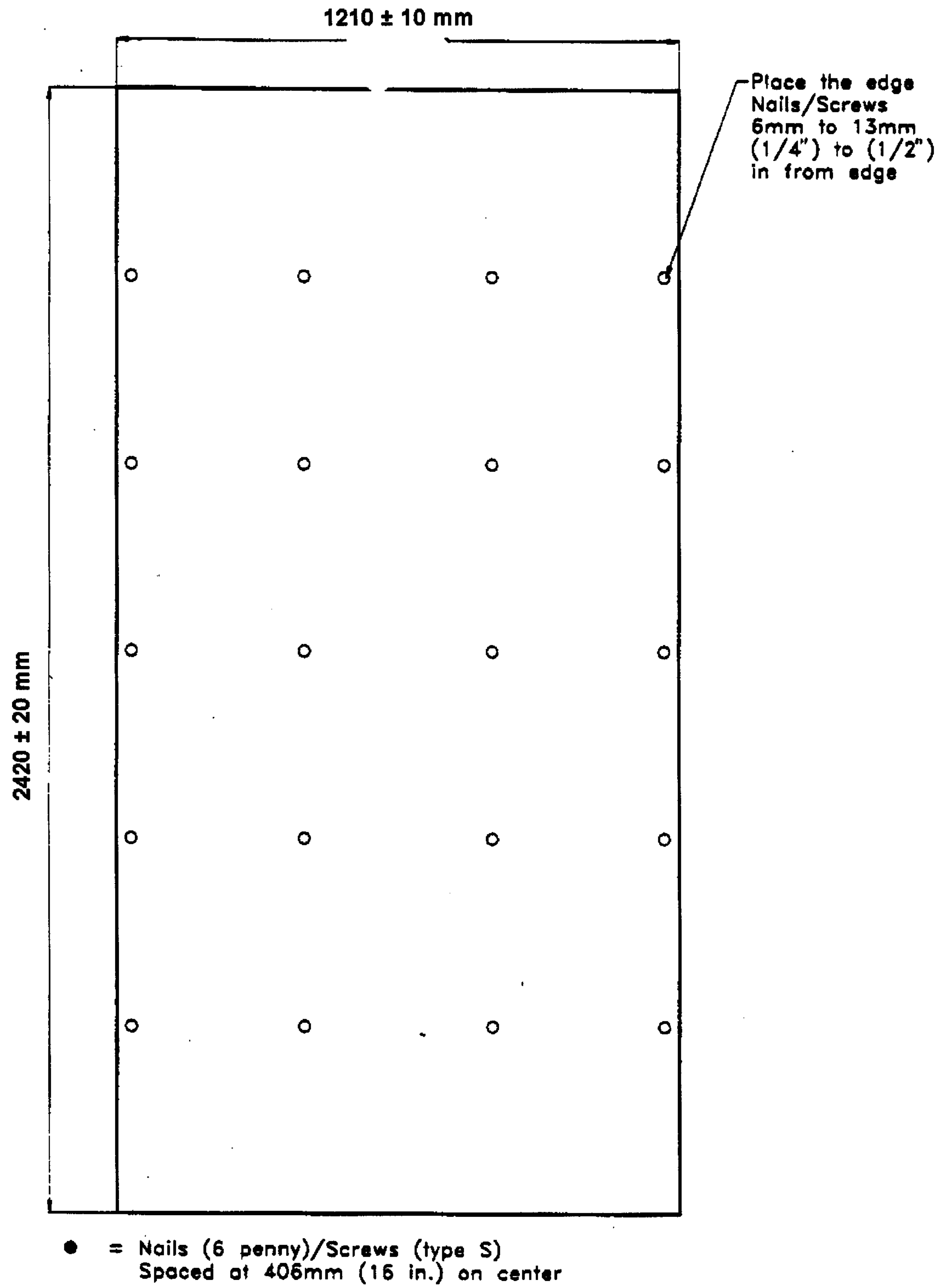

FIG. X2.3 Attachment Details for Rigid Wall Materials

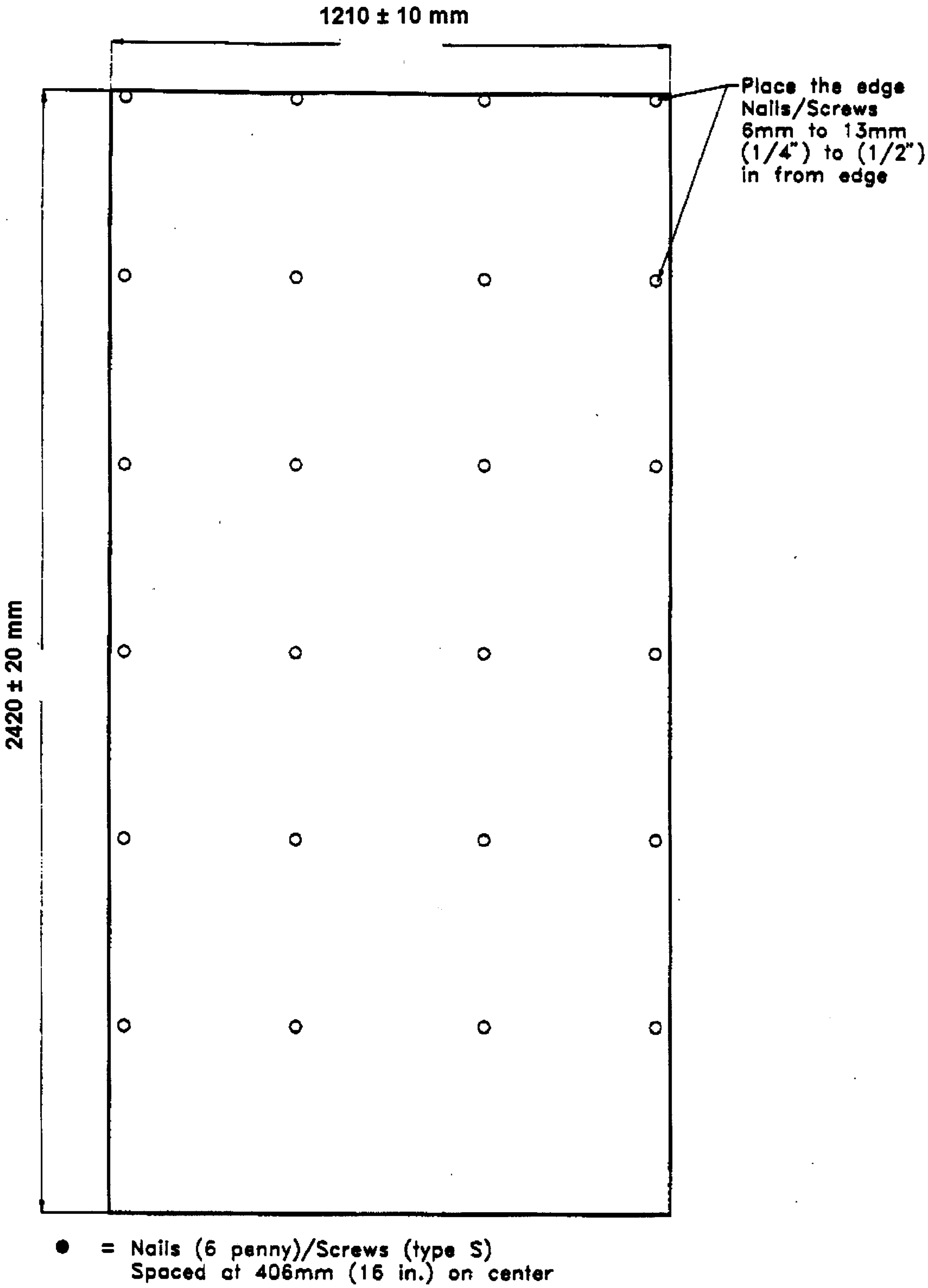

FIG. X2.4 Attachment Details for Thermoplastic Wall Materials

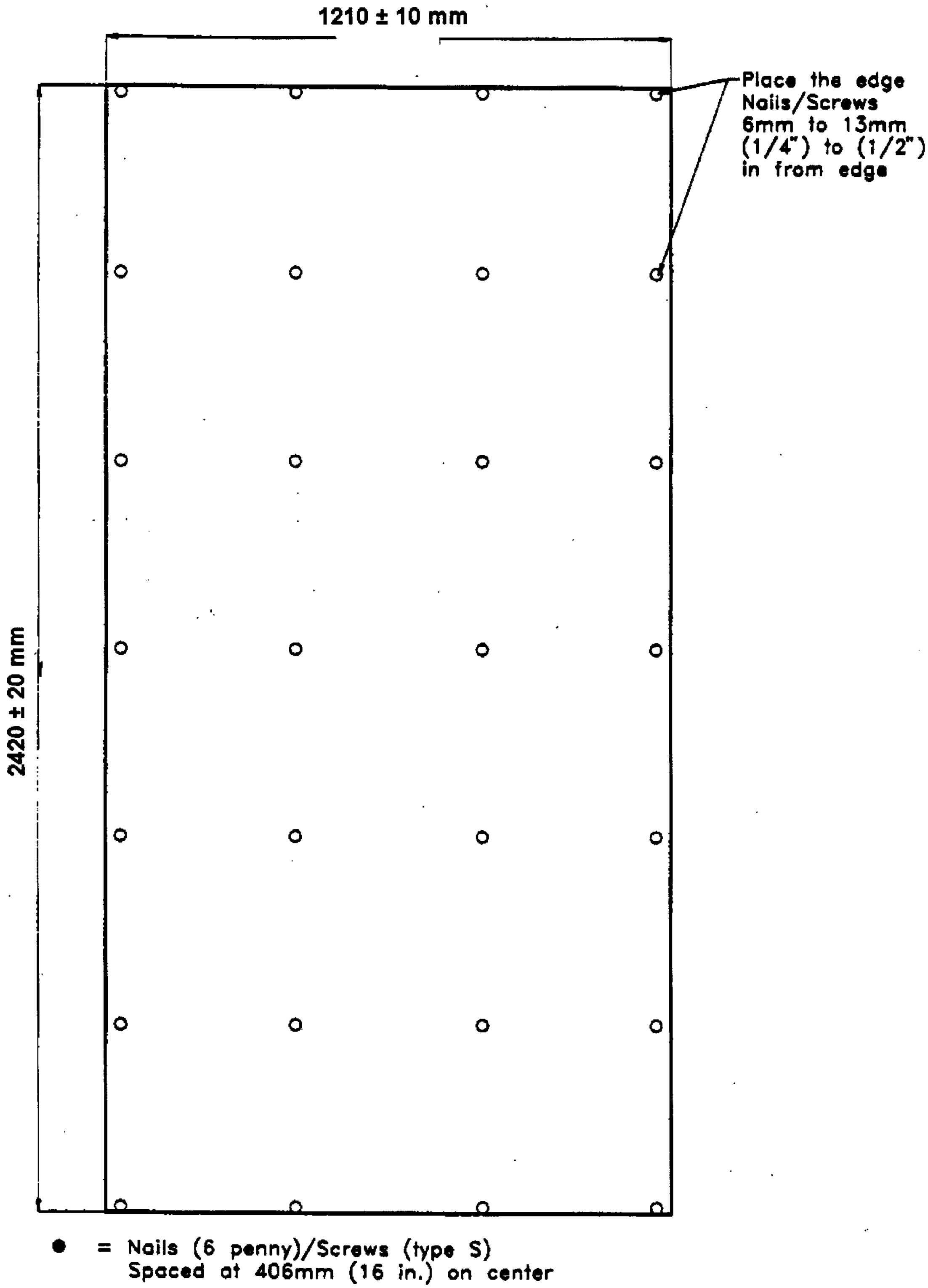

FIG. X2.5 Attachment Details for Ceiling Materials

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