Standard Practice for Ignition Sources[1]

1. Scope

1.1 This practice describes a series of ignition sources that have been used and that are potentially applicable to assessing fire-test-response characteristics resulting from the ignition of materials, products, or assemblies.

1.2 This practice does not identify which of the ignition sources described is applicable to any specific use since that is a function of the associated fire hazard (see also 5.2).

1.3 This practice is not necessarily comprehensive and it is possible that other applicable ignition sources exist (see also 5.3).

1.4 This practice describes both flaming and non-flaming ignition sources, since the outcome of a non-flaming ignition can be the eventual flaming ignition of these materials or products (see also 4.2).

1.5 This practice does not provide pass/fail criteria that can be used as a regulatory tool.

1.6 This fire standard cannot be used to provide quantitative measures.

1.7 Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

1.8 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.

1.9 This practice contains notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered requirements of the standard.

1.10 The values stated in SI units are to be regarded as standard in referee decisions. No other units of measurement are included in this standard. See IEEE/ASTM SI 10 for further details.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D635 Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
D1929 Test Method for Determining Ignition Temperature of Plastics
D3675 Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source
D3874 Test Method for Ignition of Materials by Hot Wire Sources
D5025 Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials
D5207 Practice for Confirmation of 20–mm (50–W) and 125–mm (500–W) Test Flames for Small-Scale Burning Tests on Plastic Materials
D5424 Test Method for Smoke Obscuration of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration
D5537 Test Method for Heat Release, Flame Spread, Smoke Obscuration, and Mass Loss Testing of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration
D6194 Test Method for Glow-Wire Ignition of Materials
E84 Test Method for Surface Burning Characteristics of Building Materials
E108 Test Methods for Fire Tests of Roof Coverings
E136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
E162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
E176 Terminology of Fire Standards
E648 Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source

[1] This practice is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.33 on Fire Safety Engineering.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials
E906/E906M Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using a Thermopile Method
E1321 Test Method for Determining Material Ignition and Flame Spread Properties
E1352 Test Method for Cigarette Ignition Resistance of Mock-Up Upholstered Furniture Assemblies
E1353 Test Methods for Cigarette Ignition Resistance of Components of Upholstered Furniture
E1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter
E1537 Test Method for Fire Testing of Upholstered Furniture
E1590 Test Method for Fire Testing of Mattresses
E1623 Test Method for Determination of Fire and Thermal Parameters of Materials, Products, and Systems Using an Intermediate Scale Calorimeter (ICAL)
E1822 Test Method for Fire Testing of Stacked Chairs
E1995 Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber, With the Test Specimen Oriented Horizontally
E2058 Test Methods for Measurement of Material Flammability Using a Fire Propagation Apparatus (FPA)
E2187 Test Method for Measuring the Ignition Strength of Cigarettes
E2574/E2574M Test Method for Fire Testing of School Bus Seat Assemblies
IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System

2.2 *Institute of Electrical and Electronic Engineers (IEEE) Standards:*[3]

IEEE 383 IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations
IEEE 1202 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies

2.3 *International Organization for Standardization (ISO) Standards:*[4]

ISO 871 Plastics—Determination of Ignition Temperature Using a Hot-Air Furnace
ISO 5657 Reaction to Fire Tests—Ignitability of Building Products Using a Radiant Heat Source
ISO 5659-2 Plastics—Smoke Generation Part 2: Determination of Optical Density by a Single-Chamber Test
ISO 5660-1 Reaction to Fire Tests—Heat Release, Smoke Production and Mass Loss Rate—Part 1: Heat Release (Cone Calorimeter Method)
ISO 8191-1 Furniture—Assessment of the Ignitability of Upholstered Furniture—Part 1: Ignition Source: Smouldering Cigarette
ISO 8191-2 Furniture—Assessment of the Ignitability of Upholstered Furniture—Part 2: Ignition Source: Match Flame Equivalent
ISO 9705 Reaction to Fire Tests—Full-Scale Room Test for Surface Products
ISO 12863 Standard Test Method for Assessing the Ignition Propensity of Cigarettes
ISO 12949 Standard Test Method for Measuring the Heat Release Rate of Low Flammability Mattresses and Mattress Sets
ISO 13943 Fire Safety—Vocabulary

2.4 *International Electrotechnical Commission (IEC) Standards:*[5]

IEC 60332-1-2 Tests on Electric and Optical Fibre Cables Under Fire Conditions—Part 1-2: Test for Vertical Flame Propagation for a Single Insulated Wire or Cable—Procedure for 1 kW Pre-mixed Flame
IEC 60332-2-1 Tests on Electric and Optical Fibre Cables Under Fire Conditions—Part 2-1: Test for Vertical Flame Propagation for a Single Small Insulated Wire or Cable – Apparatus
IEC 60332-3-10 Tests on Electric and Optical Fibre Cables Under Fire Conditions—Part 3-10: Test for Vertical Flame Spread of Vertically-mounted Bunched Wires or Cables—Apparatus
IEC 60695-2-10 Fire Hazard Testing—Part 2-10: Glowing/Hot-Wire Based Test Methods—Glow-Wire Apparatus and Common Test Procedure
IEC 60695-2-11 Fire Hazard Testing—Part 2-11: Glowing/Hot-Wire Based Test Methods—Glow-Wire Flammability Test Method for End-Products
IEC/TS 60695-2-20 Fire Hazard Testing—Part 2-20: Glowing/Hot-Wire Based Test Methods—Hot Wire Ignition Test—Apparatus, Confirmatory Test Arrangement and Guidance
IEC TS 60695-11-2 Fire Hazard Testing—Part 11-2: Test Flames—1 kW Nominal Pre-Mixed Flame—Apparatus, Confirmatory Test Arrangement and Guidance
IEC TS 60695-11-3 Fire Hazard Testing—Part 11-3: Test Flames—50 W Flame—Apparatus and Confirmational Test Methods
IEC TS 60695-11-4 Fire Hazard Testing—Part 11-4: Test Flames—50 W Flame—Apparatus and Confirmational Test Methods

2.5 *National Fire Protection Association (NFPA) Standards:*[6]

NFPA 260 Methods of Tests and Classification System for Cigarette Ignition Resistance of Components of Upholstered Furniture
NFPA 261 Method of Test for Determining Resistance of Mock-Up Upholstered Furniture Material Assemblies to Ignition by Smoldering Cigarettes

[3] Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854-4141, http://www.ieee.org.
[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.
[5] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland, http://www.iec.ch.
[6] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

NFPA 262 Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
NFPA 265 Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile or Expanded Vinyl Wall Coverings on Full Height Panels and Walls
NFPA 270 Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber
NFPA 286 Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth
NFPA 287 Test Methods for Measurement of Flammability of Materials in Cleanrooms Using a Fire Propagation Apparatus (FPA)
NFPA 289 Method of Fire Test for Individual Fuel Packages
NFPA 701 Methods of Fire Tests for Flame Propagation of Textiles and Films

2.6 *Underwriters Laboratories (UL) Standards:*[7]
UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 1040 Fire Test of Insulated Wall Construction
UL 1666 Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1685 Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
UL 1715 Standard for Fire Test of Interior Finish Material

2.7 *Federal Aviation Administration Standard:*[8]
Aircraft Material Fire Test Handbook DOT/FAA/AR-00/12, FAA Technical Center, April 2000

2.8 *FM Global Standard:*[9]
FM 4880 Approval Standard for Class 1 Fire Rating of Insulated Wall or Wall and Roof/Ceiling Panels—Interior Finish Materials or Coatings and Exterior Wall Systems

2.9 *U.S. Department of Commerce Standard:*[10]
16 CFR 1633 Standard for the Flammability (Open-Flame) of Mattresses and Mattress and Foundation Sets

2.10 *British Standards Institution Standard:*[11]
BS 5852 Methods of test for assessment of the ignitability of upholstered seating by smouldering and flaming ignition sources

2.11 *California Technical Bulletins:*
CAL TB 121 Flammability Test Procedure for Mattresses for Use in High Risk Occupancies (1980)
CAL TB 133 Flammability Test Procedure for Seating Furniture for Use in Public Occupancies (1991)

3. Terminology

3.1 Use Terminology E176 or ISO 13943 for definitions of terms used in this test method and associated with fire issues. Where differences exist in definitions, those contained in Terminology E176 shall be used.

3.2 *Definitions:*

3.2.1 *ignition, n*—the initiation of combustion.

3.2.1.1 *Discussion*—The combustion may be evidenced by glow, flame, detonation, or explosion. The combustion may be sustained or transient. **E176**

3.2.2 *piloted ignition, n*—ignition of combustible gases or vapors by a pilot source of ignition (compare spontaneous ignition, unpiloted ignition). **E176**

3.2.3 *pilot source of ignition, n*—a discrete source of energy, such as, for example, a flame, spark, electrical arc, or glowing wire (compare piloted ignition, unpiloted ignition). **E176**

3.2.4 *smoldering, n*—combustion of a solid without flame, often evidenced by visible smoke.

3.2.4.1 *Discussion*—Smoldering can be initiated by small sources of ignition, especially in dusts or fibrous or porous materials, and may persist for an extended period of time after which a flame may be produced. **E176**

3.2.5 *spontaneous ignition, n*—unpiloted ignition caused by an internal exothermic reaction (compare piloted ignition). **E176**

3.2.6 *sustained flaming, n*—flame on or over the surface of a test specimen that lasts longer than a defined period of time (contrast transitory flaming).

3.2.6.1 *Discussion*—Typically, the same defined period is used to define "transitory flaming." See the specific standard test method for applicable defined period of time. **E176**

3.2.7 *transitory flaming, n*—flame on or over the surface of a test specimen that does not last longer than a defined period of time (contrast sustained flaming).

3.2.7.1 *Discussion*—Typically, the same defined period of time is used to define "sustained flaming." See the specific standard test method for applicable defined period of time. **E176**

3.2.8 *unpiloted ignition, n*—ignition caused by one or more sources of energy without the presence of a pilot source of ignition (compare piloted ignition, spontaneous ignition). **E176**

4. Summary of Practice

4.1 This practice describes a series of standard ignition sources used in test methods, specifications, or regulations to assess fire-test-response characteristics of materials, products, or assemblies.

4.2 These ignition sources include those that assess the response to non-flaming ignition sources, including smoldering cigarettes, glow wires, hot wires, and radiant heat sources.

4.3 These ignition sources include those that assess the response to flaming ignition sources, including both premixed flames and diffusion flames.

4.4 This practice does not offer pass/fail criteria.

4.5 The information included in this practice is representative of the ignition sources in the various standards at the time this practice was written. Users of this practice are encouraged

[7] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.
[8] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.
[9] Available from FM Global, Norwood, MA, www.fmglobal.com.
[10] Available from U.S. Consumer Product Safety Commission, Washington, DC, 20207.
[11] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.

to consult the latest edition of any standard at the time of proposed use of an ignition source.

5. Significance and Use

5.1 A variety of standard test methods, specifications, and regulations have been issued by a number of different standards developing organizations and regulatory authorities that contain ignition sources used to assess fire-test-response characteristics associated with flaming and non-flaming ignition. This practice describes such ignition sources and provides information on the standard method in which they are described.

5.2 The ignition source to be chosen for any specific use needs to be relevant to the fire hazard associated with the intended application. Neither the scope of the standard containing the ignition source nor any other aspect of the standard has any bearing on the use of the ignition source for another application.

5.3 This practice is not expected to be a fully comprehensive list of ignition sources. If additional ignition sources are identified they can be added to the practice.

5.4 This practice does not describe test specimen preparation or detailed testing procedures for the materials or products.

5.5 This practice does not address limitations associated with the ignition sources described in this practice.

5.6 This practice does not necessarily address the latest edition of any standard referenced.

6. Classification of Ignition Sources

6.1 Ignition sources can be classified into the following two major categories: *(a)* flaming, which can be based on diffusion flames or premixed flames (typically gas burners) and *(b)* non-flaming, which can be based on smoldering ignition, glow wires, hot wires, and radiant heat sources. Radiant heat sources are often accompanied by a supplementary igniter, which can be a pilot flame.

6.2 *General Principles:*

6.2.1 When materials, products, or assemblies are exposed to thermal energy, once thermal decomposition has occurred, vapors and gases, potentially including flammable and combustible vapors, are generated. If the concentration of combustible or flammable vapors, or both, in the atmosphere falls between the lower and upper flammability limits, ignition will potentially result. Flammability limits are normally expressed as the percentage of fuel, by volume, in the fuel/air mixture.

6.2.2 If there is no external ignition source, other than radiant heat, this ignition represents spontaneous ignition.

6.2.3 If an external flame is present as the ignition energy source, even as a supplementary source, the ignition is known as piloted ignition.

6.2.4 After ignition has occurred, some burning materials have the potential to generate additional issues by forming flaming debris or molten drops. If this flaming debris spreads flame so as to ignite alternate combustible materials, this will accelerate flame spread.

6.2.5 The localized application of a heat source to some materials, products, or assemblies will result in glowing combustion. This can be evidenced by the formation of a carbonaceous char.

6.3 Overall characteristics of ignition sources follow.

6.3.1 The intensity of the ignition source. This is a measure of the thermal insult onto the test specimen resulting from the combined conduction, convection, and radiation effects caused by the ignition source.

6.3.2 The location of the impingement of the ignition source on the test specimen.

6.3.3 The duration of exposure of the test specimen and whether it is continuous or intermittent.

6.3.4 The orientation of the test specimen in relation to the ignition source.

6.3.5 The ventilation conditions in the vicinity of the ignition source and exposed surface of the test specimen.

6.4 *Diffusion Flame Ignition Sources*—In these ignition sources, a diffusion flame source, normally gas (typically propane, methane, or butane) flows through tubing without ingress of air prior to the base of the flame. These flames simulate natural flames and are particularly suitable for low intensity ignition sources and for horizontal or vertical exposures.

6.5 *Premixed Flame Ignition Sources*—In these ignition sources, a premixed flame source, normally gas (typically propane, methane, or butane) flows through a gas burner fitted with air inlet ports or an air intake manifold. Premixed flame sources are more directional than diffusion flame sources and can be used at higher intensities than diffusion flame sources.

7. Smoldering Cigarettes

7.1 Such ignition sources are included here because they are important. There are multiple regional and national differences between the various kinds of cigarettes used as ignition sources, including their mass and smoldering rates, and many of such differences have the potential to affect results. Two basic types of cigarettes are described here.

7.2 *Reduced Ignition Propensity Cigarettes*—Test Method E2187 (and ISO 12863) is a test used by regulators as a means of assessing whether any cigarette can be classified as a "reduced ignition propensity cigarette." In a number of countries, including the United States, Canada, and several European countries, commercial cigarettes need to comply with the regulatory requirements based on testing with one of these test methods. These cigarettes are being used as ignition sources in some testing.

7.2.1 Test Methods E1352 and E1353 are performed with commercial cigarettes (which are reduced ignition propensity cigarettes) as ignition sources. In these test methods the cigarettes are described as cigarettes without filter tips, made from natural tobacco 85 ± 2 mm long with a tobacco packing density of 0.270 ± 0.020 g/cm^3 and a total weight of 1.1 ± 0.1 g. The smoldering rate of this cigarette is 0.10 ± 0.01 mm/s when the cigarette is allowed to burn downward in a draft-protected area. With the cigarette supported at the bottom in a vertical position, the burning rate is determined in the region from 10 to 50 mm, measured from the top.

7.2.2 ISO 8191-1 is another test method that is performed using reduced ignition propensity cigarettes as ignition sources. In this test method, the cigarettes are described as cigarettes without filter tips, made from natural tobacco 70 ± 4 mm long with a diameter of 8.0 ± 0.5 mm and a total weight of 1.0 ± 0.1 g. The smoldering rate of these cigarettes is 0.07 ± 0.02 mm/s when the cigarette is allowed to burn downward in a draft-protected area. With the cigarette supported at the bottom in a vertical position, the burning rate is determined in the region from 5 to 55 mm, measured from the top.

7.3 *Standard Reference Material Cigarettes (SRM 1196)*—These cigarettes were designed to simulate the ignition strength of those cigarettes that were in commercial use in the United States before the development of Test Method E2187 and that had been identified as having the strongest ignition strength. Thus, these cigarettes do not comply with the requirements of "reduced ignition propensity cigarettes" as tested in accordance with Test Method E2187 or ISO 12863.

7.3.1 The cigarettes, described as NIST SRM 1196[12] cigarettes, are cigarettes without filter tips, made from natural tobacco, 83 ± 2 mm long with a tobacco packing density of 0.270 ± 0.020 g/cm^3 and a total weight of 1.1 ± 0.1 g. These cigarettes are used in NFPA 260 and NFPA 261.

[12] Available from National Institute of Standards & Technology (NIST), http://www.nist.gov/srm/index.cfm.

8. Non-Flaming Ignition Sources

8.1 *Glow Wires:*

8.1.1 This ignition source simulates overheating of materials by heating the glow-wire to an elevated temperature, normally a temperature in the range of 550 to 960 °C.

8.1.2 The glow-wire apparatus and ignition source are shown in Fig. 1 (Test Method D6194).

8.1.3 The glow-wire itself consists of a loop of Nichrome (nickel/chromium) (80% nickel and 20% chromium, iron-free) wire, 4 mm in nominal diameter.

8.1.4 The temperature of the glow-wire is measured by the use of a Type K sheathed fine-wire thermocouple having a maximum nominal overall diameter of 1.0 mm. and wires suitable for continuous operation at temperatures up to 960 °C, with the welded point located inside the sheath, for measuring the temperature of the glow-wire. Examples of suitable wire compositions are Nickel-Chromium (NiCr) and Nickel-Aluminum (NiAl). The thermocouple sheath is constructed of a metal that will allow the thermocouple to perform its function in air at sheath temperatures of at least 1050 °C. The thermocouple is arranged in a pocket hole, drilled in the tip of the glow-wire, as shown in Fig. 1. The thermal contact between the walls of the bored hole in the glow-wire is maintained by pinning the sheathed thermocouple in place. The thermocouple follows the movement of the tip of the glow-wire resulting from elongation caused by thermal heating. A temperature indicator for Type K thermocouples capable of reading up to 1000 °C is used. The supply circuit needs to be capable of

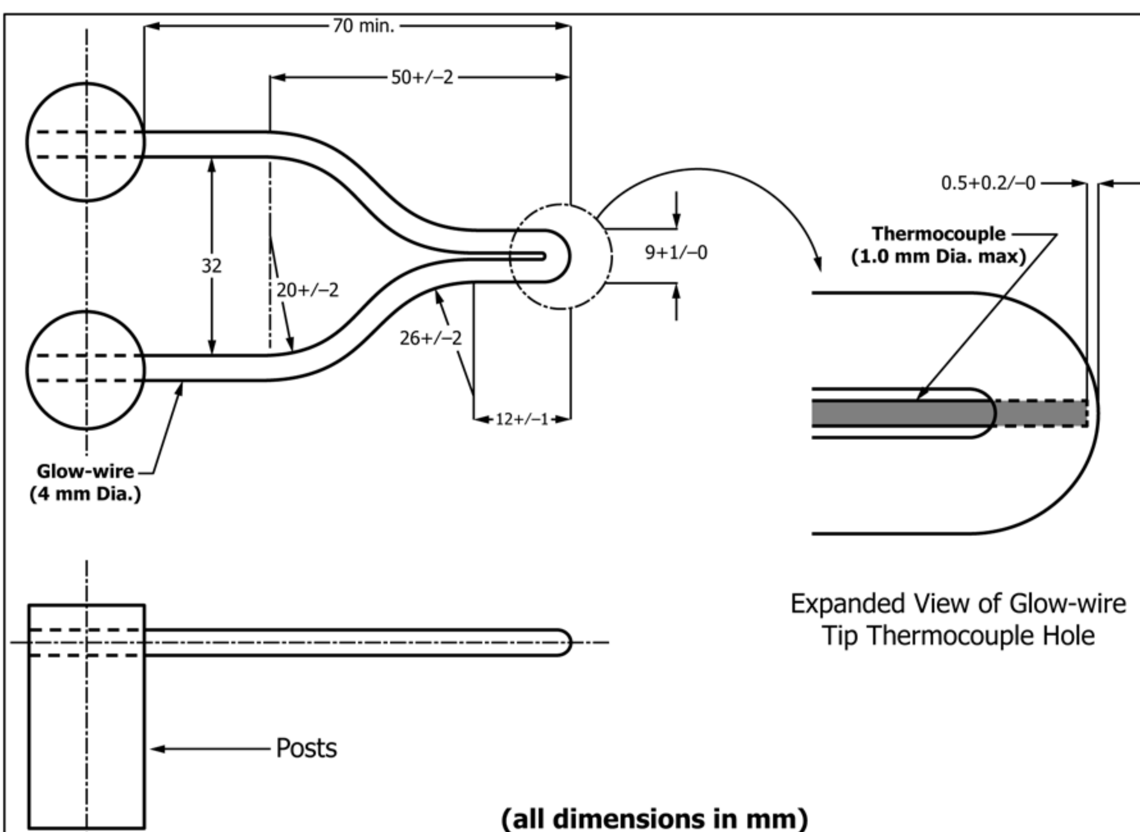


FIG. 1 Glow Wire Apparatus from Test Method D6194, Including Positioning of the Thermocouple

supplying up to 150 A at 2.1V, with smooth continuous adjustment of voltage to provide the required current as needed to maintain the desired glow-wire tip temperature.

8.1.5 The test apparatus holds the glow-wire in a horizontal plane and moves it against the vertical test specimen, maintaining a force of 1.0 ± 0.2 N over a distance of at least 7 mm (see Fig. 2). Similar equipment is described in IEC 60695-2-10 and IEC 60695-2-11.

8.2 *Hot Wires:*

8.2.1 This ignition source is an electrically heated hot wire that simulates the overloading of an electrically live material in direct contact with a test specimen. A schematic of the apparatus is shown in Fig. 3 (Test Method D3874).

8.2.2 The heater wire itself consists of a loop of Nichrome (nickel/chromium) (80% nickel and 20% chromium, iron-free) wire, 0.05 mm in nominal diameter. The wire has a nominal cold resistance of 5.28 Ω/m and has a length-to-mass ratio of 580 m/kg.

8.2.3 The supply circuit, used as a means for electrically energizing the heater wire, needs to have the following capabilities.

8.2.3.1 The circuit has sufficient capacity to maintain a continuous linear 50 to 60 Hz power density of at least 0.31 W/mm over the length of the heater wire at or near unity power factor. With the supply circuit operating at a current of 60 A with a voltage of 1.5 V, the approximate power density is 0.3 W/mm.

8.2.3.2 There needs to be a means for adjustment of voltage to achieve the desired current and to provide a smooth and continuous adjustment of the power level.

8.2.3.3 There needs to be a means of measuring the power to within ±2 %.

8.2.3.4 The test circuit is provided with an easily actuated on-off switch for the test power, and timers to record the duration of the application of test power.

8.2.4 Each test uses a length of previously calibrated wire measuring approximately 250 mm. Before testing, each straight length of wire is annealed by energizing the wire to dissipate 0.26 W/mm of length for 8 to 12 s to relieve the internal stresses within the wire. Similar equipment is described in IEC/TS 60695-2-20.

8.3 *Conical Radiant Ignition Sources:*

8.3.1 *Cone Calorimeter*—This ignition source is described in Test Method E1354 and in ISO 5660-1. The ignition source consists essentially of the following components: a conical radiant electric heater, capable of horizontal or vertical orientation, a temperature controller, a radiation shield, test specimen holders (different for the two orientations), and an electric ignition spark plug. The test specimen is 100 × 100 mm and the heat flux ranges up to 100 kW/m^2, with a spark igniter and no pilot flame. A cross section through the heater is shown in Fig. 4, and exploded views of horizontal and vertical orientations are shown in Fig. 5 and Fig. 6.

8.3.1.1 *Conical Heater:*

(1) The active element of the heater consists of an electrical heater rod, rated at 5000 W at 240 V, tightly wound into the shape of a truncated cone (Fig. 5 and Fig. 6). The heater is encased on the outside with a double-wall stainless steel cone, packed with a refractory fiber material of approximately 100 kg/m^3 density.

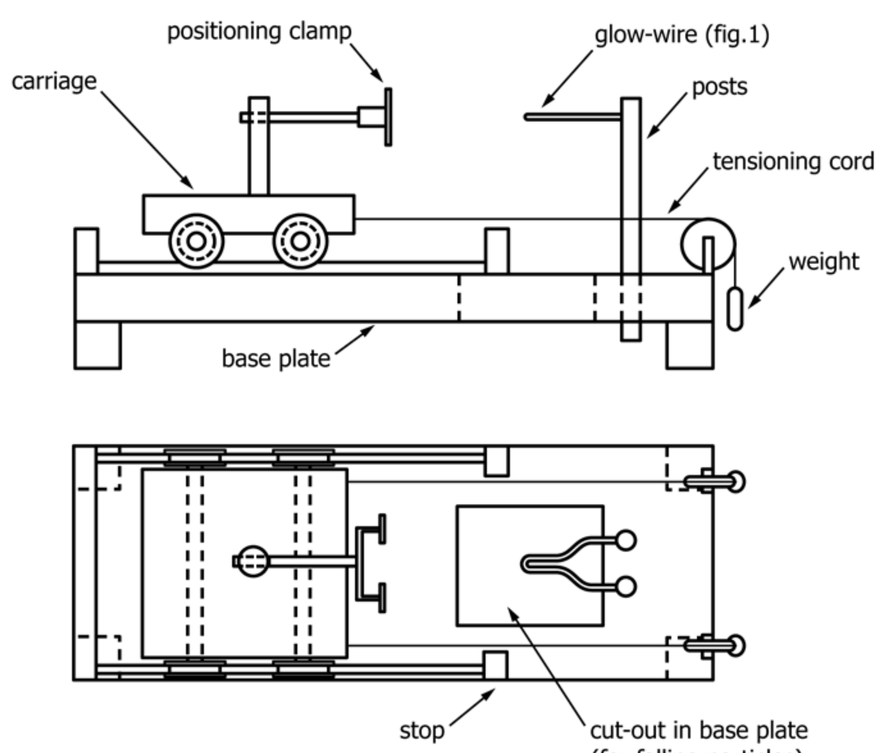


FIG. 2 Example of Glow Wire Apparatus from Test Method D6194

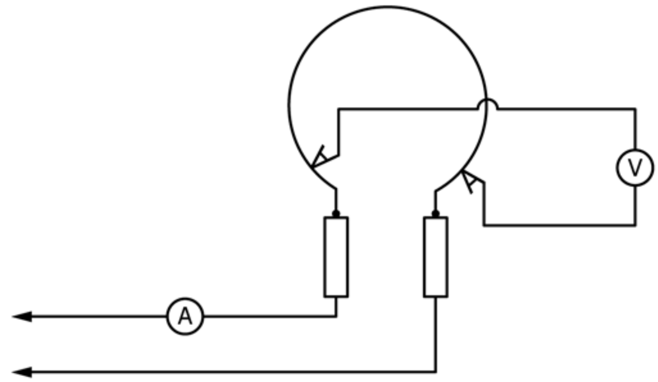
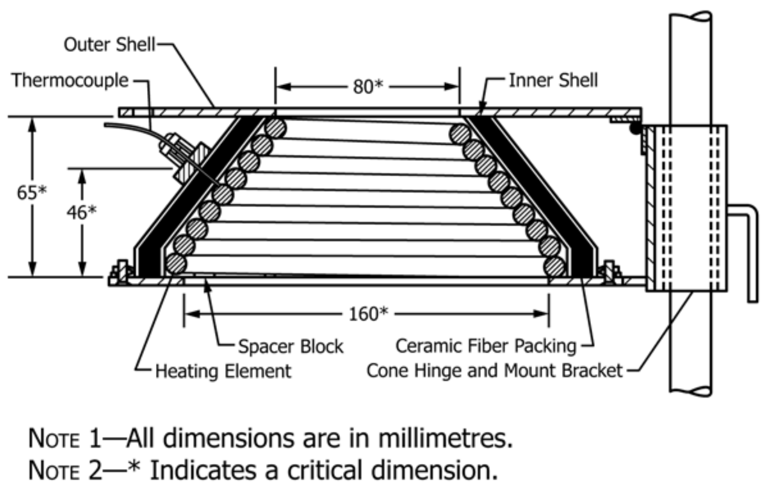


FIG. 3 Schematic of Hot Wire Apparatus from Test Method D3874



NOTE 1—All dimensions are in millmetres.

NOTE 2—* indicates a critical dimension.

FIG. 4 Cross-Section View of Cone Calorimeter Cone through the Heater (Test Method E1354)

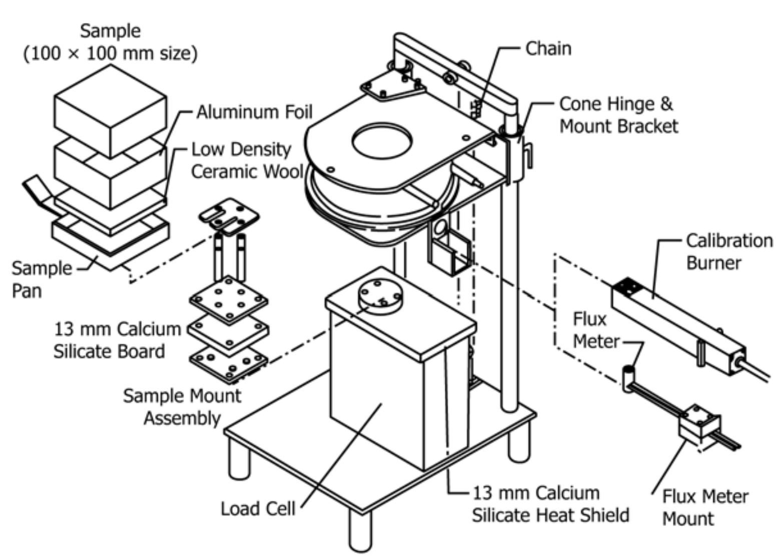


FIG. 5 Exploded View of Cone Calorimeter Ignition System, Horizontal Orientation (Test Method E1354)

(2) The heater is hinged so it can be swung into either a horizontal or a vertical orientation. The heater needs to be capable of producing irradiances on the surface of the test specimen of up to 100 kW/m^2. The irradiance needs to be uniform within the central 50 by 50-mm area of the test specimen to within ±2 % in the horizontal orientation and to

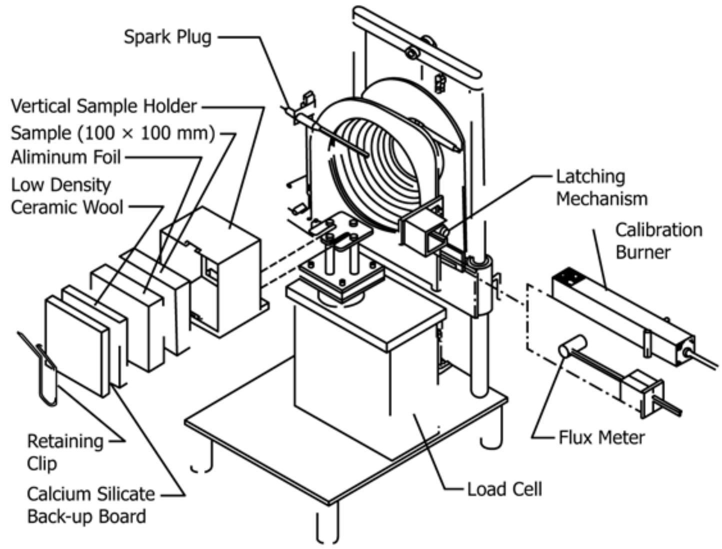


FIG. 6 Exploded View of Cone Calorimeter Ignition System, Vertical Orientation (Test Method E1354)

within ±10 % in the vertical orientation. The geometry of the heater is critical and so are the dimensions on Fig. 4.

(3) The irradiance from the heater needs to be capable of being held at a preset level by means of a temperature controller and three type K stainless steel sheathed thermocouples, symmetrically disposed and in contact with, but not welded to, the heater element (see Fig. 4). The thermocouples are of equal length and wired in parallel to the temperature controller.

8.3.1.2 *Temperature Controller:*

(1) The temperature controller for the heater needs to be capable of holding the element temperature steady to within ±2°C. A suitable system is a 3-term controller (proportional, integral, and derivative) and a thyristor unit capable of switching currents up to 25 A at 240 V.

(2) The controller needs to have a temperature input range of 0 to 1000°C; a set scale capable of being read to 2°C or better; and automatic cold junction compensation. The controller is equipped with a safety feature such that in the event of an open circuit in the thermocouple line, it will cause the temperature to fall to near the bottom of its range.

(3) The thyristor unit is of the zero crossing and not of the phase angle type.

(4) The heater temperature is monitored by a meter capable of being read to ±2°C, or better. It is permitted to be incorporated into the temperature controller.

8.3.1.3 *Test Specimen Holder:*

(1) Horizontal Test Specimen Holder—The bottom of the horizontal test specimen holder is lined with a layer of low density (nominal density 65 kg/m^3) refractory fiber blanket with a thickness of at least 13 mm. The distance between the bottom surface of the cone heater and the top of the test specimen is adjusted to be 25 mm.

(2) Vertical Test Specimen Holder—The vertical test specimen holder includes a small drip tray to contain a limited amount of molten material. A test specimen is installed in the vertical test specimen holder by backing it with a layer of refractory fiber blanket (nominal density 65 kg/m^3), the thickness of which depends on test specimen thickness, but needs to be at least 13 mm thick. A layer of rigid, ceramic fiber millboard is placed behind the fiber blanket layer. The millboard thickness is such that the entire assembly is rigidly bound together once the retaining spring clip is inserted behind the millboard. In the vertical orientation, the cone heater height is set so the center lines up with the test specimen center.

8.3.1.4 *Radiation Shield*—The cone heater is provided with a removable radiation shield to protect the test specimen from the heat flux prior to the start of a test. The shield is made of noncombustible material with a total thickness not to exceed 12 mm. The shield is one of the following:

(a) A water-cooled shield coated with a durable matte black finish of surface emissivity, e = 0.95 ± 0.05.

(b) A shield that is not water-cooled but is provided with a metallic reflective top surface to minimize radiation transfer.

(c) A shield that is not water-cooled but is provided with a ceramic, non-metallic, surface that minimizes radiation transfer to the test specimen surface. The shield is equipped with a handle or other suitable means for quick insertion and removal. The cone heater base plate is equipped with the means for holding the shield in position and allowing its easy and quick removal.

8.3.1.5 *Ignition Circuit*—External ignition is accomplished by a 10-kV discharge across a 3-mm spark gap located 13 mm above the center of the test specimen in the horizontal location; in the vertical orientation, the gap is located in the test specimen face plane and 5 mm above the top of the holder. A suitable power source is a transformer designed for spark-ignition use or a spark generator. The high voltage connections to the spark electrodes are not grounded to the chassis in order to minimize interference with the data-transmission lines. For testing with electric spark ignition, spark discharge needs to be continuously operating at 50 to 60 Hz until sustained flaming is achieved. The ignitor needs to be removed when sustained flaming is achieved.

8.3.1.6 *Ignition Timer*—The timing device for measuring time to sustained flaming needs to be capable of recording elapsed time to the nearest second and needs to be accurate to within 1 s in 1 h.

8.3.2 *Conical Smoke Chamber Heater*—This ignition source is described in Test Method E1995, in NFPA 270 and in ISO 5659-2. The ignition source consists essentially of the following components: a conical radiant electric heater, a test specimen holder, a radiation shield, and a pilot burner. The test specimen is 75 mm × 75 mm and the heat flux range is 25 or 50 kW/m^2, either with or without an external pilot flame. A cross-section through the heater is shown in Fig. 7.

NOTE 1—This ignition source is different from the one in the traditional smoke chamber described in Test Method E662.

8.3.2.1 *Conical Heater:*

(1) The active element of the heater consists of an electrical heater rod, rated at 450 W at 240 V, tightly wound into the shape of a truncated cone. The heater needs to be encased on the outside with a double-wall stainless steel cone, packed with a refractory fiber material of approximately 100 kg/m^3 density.

(2) The heater needs to be capable of producing irradiances on the surface of the test specimen of 10 to 50 kW/m^2, at the center of the surface of the test specimen. The irradiance needs to also be determined at a position of 25 ± 2 mm to each side of the test specimen center, and the irradiance at these two positions needs to be not less than 85 %, and not more than 115 %, of the irradiance at the center of the test specimen.

(3) The irradiance from the heater needs to be capable of being held at a preset level (25 and 50 kW/m^2) by means of a temperature controller and three type K stainless steel sheathed thermocouples, symmetrically disposed and in contact with, but not welded to, the heater element. The thermocouples need to be of equal length and wired in parallel to the temperature controller.

8.3.2.2 *Temperature Controller:*

(1) The temperature controller for the heater needs to be capable of holding the element temperature steady to within ±2°C. A suitable system is a 3-term controller (proportional, integral, and derivative) and a thyristor unit capable of switching currents up to 25 A at 240 V.

(2) The controller needs to have a temperature input range of 0 to 1000°C; a set scale capable of being read to 2°C or better; and automatic cold junction compensation. The controller needs to be equipped with a safety feature such that in the event of an open circuit in the thermocouple line, it will cause the temperature to fall to near the bottom of its range.

(3) The thyristor unit needs to be of the zero crossing and not of the phase angle type.

(4) The cone heater temperature needs to be monitored by a meter capable of being read to ±2°C, or better. It is typically incorporated into the temperature controller.

8.3.2.3 The cone heater needs to be secured from the vertical rods of the support framework and located so that the lower rim of the cone heater is 25 ± 1 mm above the upper surface of the test specimen.

8.3.2.4 *Radiation Shield*—The cone heater needs to be provided with a removable radiation shield to protect the test specimen from the irradiance prior to the start of the test. The radiation shield needs to be made of a noncombustible material with a total thickness not to exceed 12 mm. The radiation shield needs to comply with either 8.3.2.4*(1)* or 8.3.2.4*(2)* and needs to be kept in place for a maximum period of 10 s.

(1) A water-cooled radiation shield coated with a durable matte black finish of surface emissivity e = 0.95 ± 0.05.

(2) A radiation shield with a reflective top surface in order to minimize radiation transfer but not water-cooled.

(3) The radiation shield needs to be equipped with a handle or other suitable means for quick insertion and removal. The cone heater base plate needs to be equipped with the means for holding the radiation shield in position and allowing its easy and quick removal.

8.3.2.5 *Pilot Burner*—The flame from the associated required single-flame burner needs to have a length of 30 ± 5 mm and needs to be positioned horizontally 10 ± 1 mm above the top face of the test specimen. The color of the flame

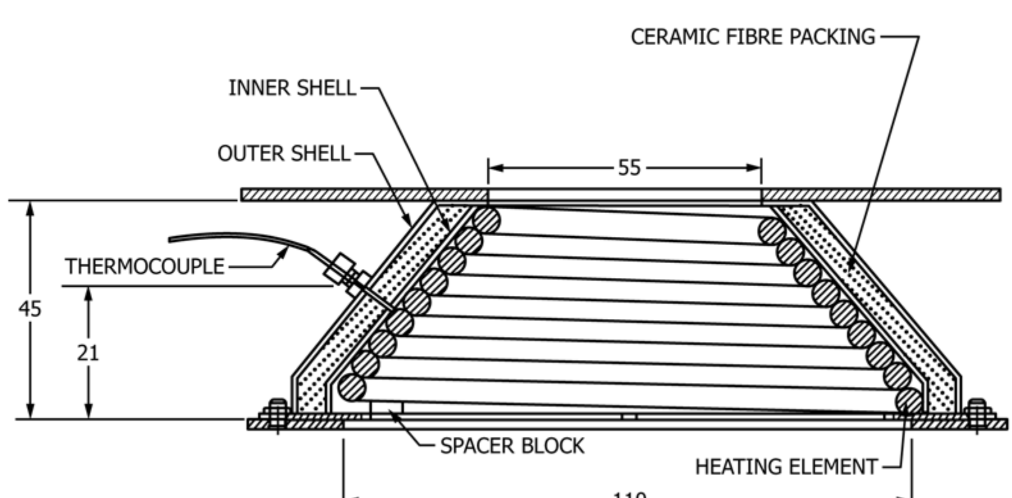


FIG. 7 Cross-Section View of Smoke Chamber Cone Heater (dimensions in mm) (Test Method E1995)

needs to be blue, with a yellow tip. Ensure that the tip of the burner is aligned with the edge of the test specimen, as shown in Fig. 8.

8.3.2.6 *Spark Igniter*—A small spark ignition device is placed next to the outlet tube of the burner, for the operator to cause reignition of the flame without opening the door of the chamber. A suitable system is a spark plug with a 3 mm gap, powered from a 10-kV transformer. A suitable transformer is of a type specifically designed for spark-ignition use, with an isolated (ungrounded) secondary to minimize interference with the data-transmission lines. An acceptable electrode length and spark plug location is such that the spark gap is located 13 mm above the test specimen, close to the pilot burner.

8.3.3 *Periodic Flaming Ignition Test:*

8.3.3.1 This ignition source is described in ISO 5657. The ignition source is a conical radiant heater similar to those described in 8.3.1 and in 8.3.2 but with somewhat different characteristics, both with respect to the heater itself and with respect to the test specimen. The test specimen is 165 mm × 165 mm and the heat flux range is 10 to 50 kW/m^2. Details are shown in Fig. 9.

8.3.3.2 The active element of the heater consists of an electrical heater rod, rated at 3000 W at 240 V, tightly wound into the shape of a truncated cone. The heater is encased on the outside with a double-wall stainless steel cone, packed with a refractory fiber material of approximately 100 kg/m^3 density.

(1) The heater needs to be capable of producing irradiances on the surface of the test specimen of 10 to 50 kW/m^2, at the aperture of a masking plate and in a reference plane coinciding with the underside of the masking plate. The distribution of the irradiance provided by the heater at the reference plane needs to be such that: *(a)* the variation of the irradiance within a circle of 50 mm diameter, drawn from the center of the masking plate aperture, needs to be not more than ± 3% of that at the center and that *(b)* the variation of the irradiance within a circle of 100 mm diameter, drawn from the center of the masking plate aperture, needs to be not more than ± 5% of that at the center.

(2) The irradiance from the heater needs to be capable of being held at a preset level by means of a temperature controller and three type K stainless steel sheathed thermocouples, symmetrically disposed and in contact with, but not welded to, the heater element. The thermocouples need to be of equal length and wired in parallel to the temperature controller.

8.3.3.3 *Pilot Flame*—The apparatus needs to be provided with a pilot flame and a secondary ignition source.

(1) The pilot flame stainless steel nozzle tube needs to be fed with a mixture of propane and air that is achieved by regulating the propane flow rate to 19 – 20 mL/min and the air flow rate to 160 – 180 mL/min. The flow rates are fed directly into the pilot flame from the flow meters.

(2) The apparatus needs to have a mechanism capable of bringing the pilot flame from its "off" position outside and above the cone heater (at a height of 10 ± 1 mm above the underside of the masking plate) to its "test" position within the cone (at a distance of 10 mm above the test specimen), through the cone and through the aperture in the masking plate. When the flame is in the "off" position, it issues horizontally over the center point of the aperture in the masking plate and perpendicular to the plane of the movement of the pilot arm, with the center of the orifice in the nozzle positioned at the indicated height. The mechanism needs to have the pilot flame move every 4 s (+ 0.4 – 0 s) from the "off" position to the test position in no more than 0.5 s, stay there for 1 s (+ 0.1 – 0 s) and return in a time of no more than 0.5 s.

(3) The secondary ignition source needs to be one of the following: a propane gas flame 15 mm long, from a nozzle with an internal diameter of 1 – 2 mm (50 W in heat output); a hot wire; or a spark igniter.

(4) The dipping of the pilot flame needs to be continuous until ignition of the test specimen.

8.4 *Other Radiant Ignition Sources:*

8.4.1 *OSU (Ohio State University Rate of Heat Release Apparatus) Radiant Heater*—This ignition source is described in Test Method E906/E906M, Configuration B.

8.4.1.1 *Radiation Source*—A radiant heat source for generating a heat flux of up to 100 kW/m^2, uses four silicon carbide elements, Type LL, 508 ± 3 mm by 16 ± 1 mm, with a nominal resistance of 1.6 V, as shown in Figs. 10-12. The silicon carbide elements are mounted in the stainless steel panel box by inserting them through 15.9 mm holes in 0.8 mm thick ceramic fiber. Locations of the holes in the pads and stainless steel cover plates are shown in Fig. 11. The diamond-shaped mask of 24-gage stainless steel is added to provide uniform heat flux over the area occupied by the 150 by 150 mm vertical sample. A power supply of 16.5 kVA, adjustable from

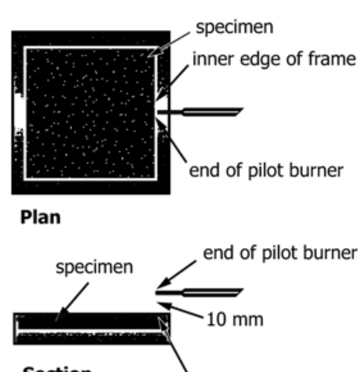


FIG. 8 Location of Pilot Burner for Smoke Chamber Cone Heater (Test Method E1995)

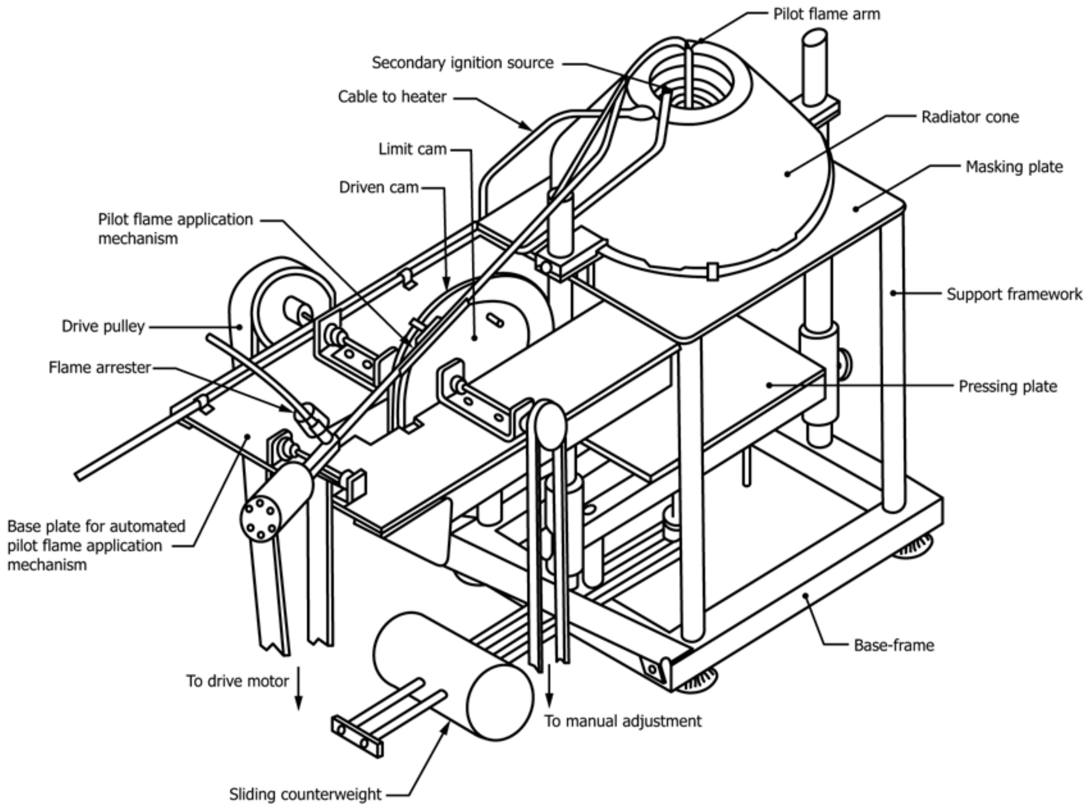


FIG. 9 Conical Heater of ISO 5657 Ignitability Apparatus

0 to 270 V is required. The normal orientation of the test specimen is vertical and this is the sole orientation described in 8.4.1.

8.4.1.2 *Piloted Ignition*—The radiant source has a lower pilot burner. The pilot flame tubing has a nominally 11.3 mm outside diameter, a nominally 0.8 mm wall, and stainless steel tubing. The fuel is methane or natural gas having 90% or more methane. A methane-air mixture, 120 cm^3/min gas, and 850 cm^3/min air needs to be the fuel mixture fed to the lower pilot flame burner. For the pilot flame described in 8.4.1.3*(2)*, no air is used.

8.4.1.3 *Pilot-Flame Positions*—In addition to piloted and non-piloted mode of operation, it is possible to accomplish pilot ignition of a test specimen by locating the pilot flame at different positions relative to the sample surface so that the flame will or will not impinge on the test specimen surface (see Fig. 11 and Fig. 12). The location chosen depends on the nature of ignition to be simulated by the test. In all piloted ignitions, the lower pilot flame size needs to be in accordance with 8.4.1.3*(1)*. Pilot positions are described in 8.4.1.3*(1)* and 8.4.1.3*(2)*. Pilot ignition by an impinging flame is required when information is wanted at a heat flux below which the pyrolysis rate of the test specimen can maintain a combustible gas phase. At heat fluxes above that producing a combustible gas mixture over the surface of the sample, use piloted ignition.

(1) Piloted Ignition—Vertical Test Specimen Without Impinging Flame—The pilot burner is a straight length of nominally 6.3 mm outside diameter, nominally 0.8 mm wall, and stainless steel tubing nominally 360 mm long. One end of the tubing needs to be closed, and three 2.5 ± 0.1 mm diameter drill holes (ANSI No. 40 drill holes), 60 mm apart, drilled into the tubing for gas ports, all radiating in the same direction. The first hole needs to be 5 mm from the closed end of the tubing. The tube is inserted into the environmental chamber through a 6.6 mm hole drilled 10 mm above the upper edge of the window frame. The tube is supported and positioned by an adjustable Z-shaped support mounted outside the environmental chamber above the viewing window. The tube is positioned above and 20 mm behind the exposed upper edge of the test specimen. The middle hole needs to be in the vertical plane perpendicular to the exposed surface of the test specimen that passes through its vertical centerline and needs to be pointed toward the radiation source. Fuel gas to the burner needs to be methane or natural gas with at least 90 % methane. Flow of fuel gas needs to be adjusted to produce flame lengths of 25 mm. An air-gas mixture cannot be used for this pilot burner.

(2) Pilot Ignition—Vertical Test Specimen With Impinging Flame—Normal position of the end of the pilot burner tubing is 10 mm from and perpendicular to the exposed vertical surface of the test specimen. The centerline at the outlet of the burner tubing needs to intersect the vertical centerline of the sample, 5 mm above the lower edge of the test specimen. An upper, non-impinging pilot burner is also used. The burner and its location are described in 8.4.1.3*(1)*.

8.4.1.4 An ignition source with only small differences from those described in Figs. 10-12 is used at a fixed incident heat flux of 35 kW/m^2 and described in Test Method E906/E906M Configuration A and in the FAA Aircraft Material Fire Test Handbook.

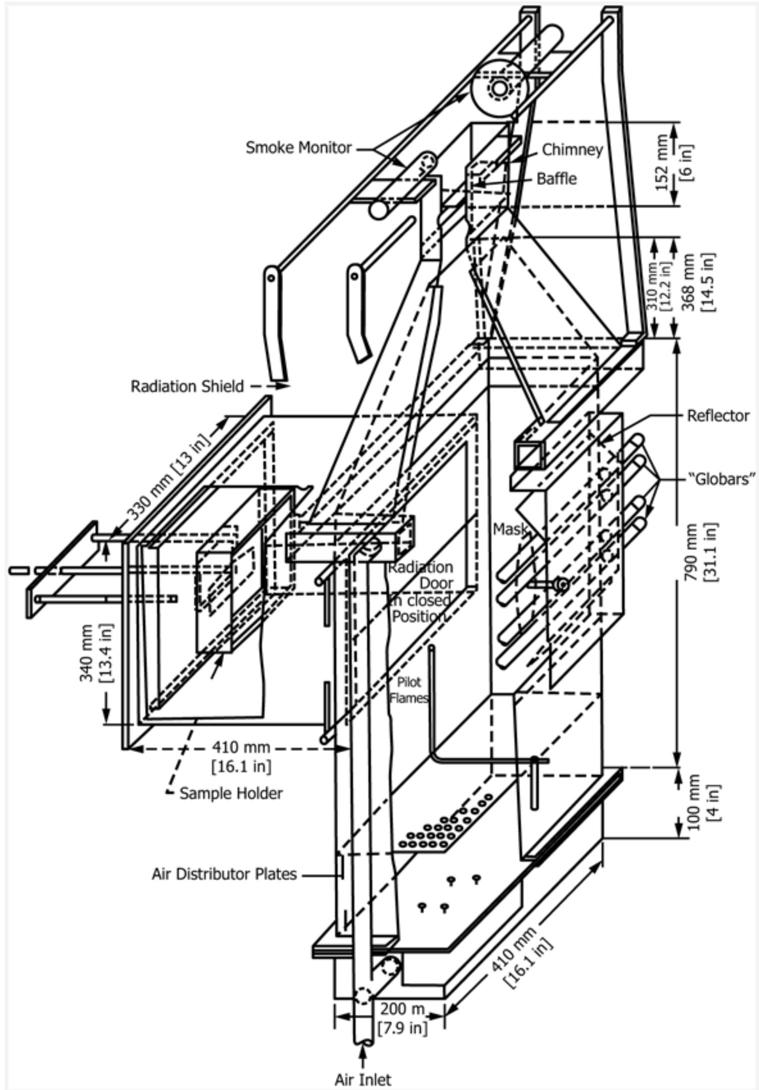


FIG. 10 Ohio State University Heat Release Rate Apparatus, per Test Method E906/E906M, Configuration B

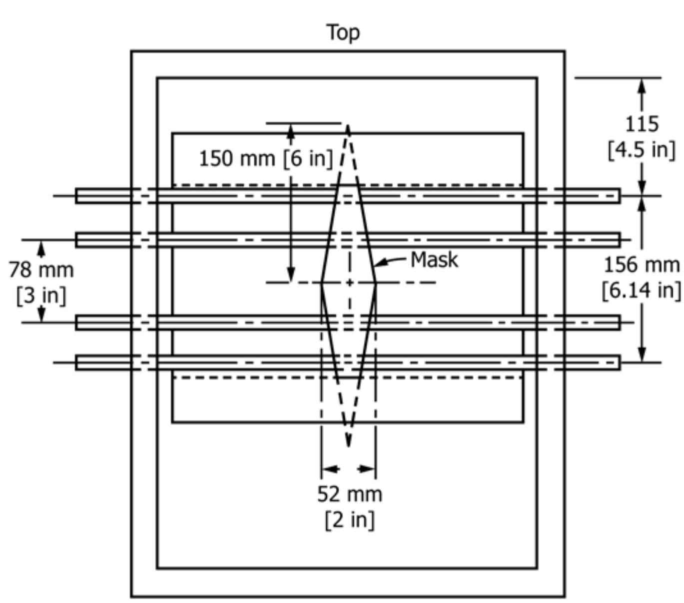


FIG. 11 Ohio State University Heat Release Rate Apparatus Configuration B (Test Method E906/E906M): Globar Radiant Panel

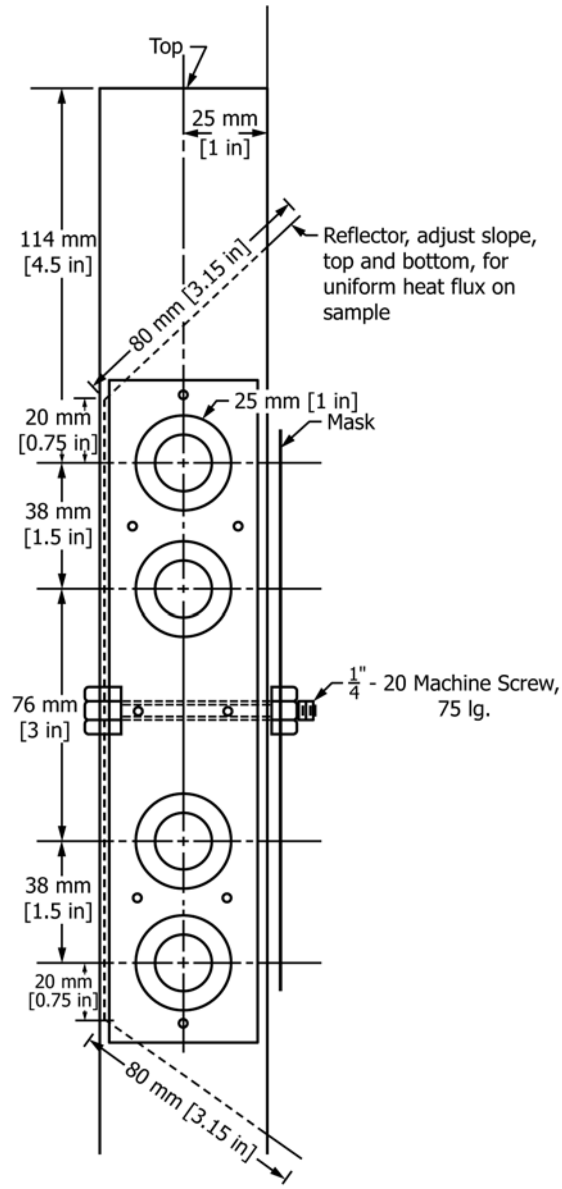


FIG. 12 Ohio State University Heat Release Rate Apparatus Configuration B (Test Method E906/E906M): Location of Holes in Globar Radiant Panel

8.4.2 *Lateral Ignition and Flame Spread Test (LIFT) Radiant Panel Heater*—This ignition source is described in Test Method E1321.

8.4.2.1 The ignition source consists of a main frame, test specimen holders, a stack, a radiant panel, and a pilot igniter (Figs. 13-15). A series of test specimens (of 155 mm by 155 mm dimensions) (see Fig. 16) are exposed to a nearly uniform heat flux and the time to flame attachment, using piloted ignition (see Fig. 16), is determined.

8.4.2.2 The main frame consists of two separate sections, the radiant-panel support frame and the test specimen support frame. The two frame sections are joined in a manner that allows adjustments in the relative position of the radiant panel to the test specimen to be made easily.

8.4.2.3 The radiant panel consists of a radiation surface of porous refractory tiles mounted at the front of a stainless steel plenum chamber to provide a flat radiating surface of approximately 280 by 483 mm. The plenum chamber includes baffle plates and diffusers to distribute the gas/air mixture evenly over the radiation surface. The gas/air mixture enters the plenum chamber at one of the short sides to facilitate easy connection when the panel is mounted from the frame. A reverberatory screen (see Fig. 15) is provided immediately in front of the radiating surface to enhance the combustion efficiency and increase the radiant output.

8.4.2.4 The appropriate air and fuel flow-metering devices, gas control valves, pressure reducer, and safety controls to support combustion at the radiant panel are all mounted on the panel support frame. A regulated air supply of about 8.33×10^{-3} m^3/s at a pressure sufficient to overcome the friction loss through the line, metering device, and radiant panel is required. The radiant-panel pressure drop amounts to approximately 20

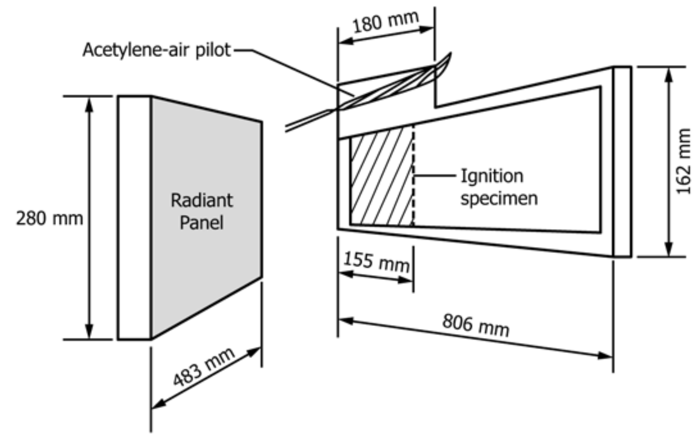


FIG. 13 Schematic of LIFT Radiant Panel Apparatus (Test Method E1321)

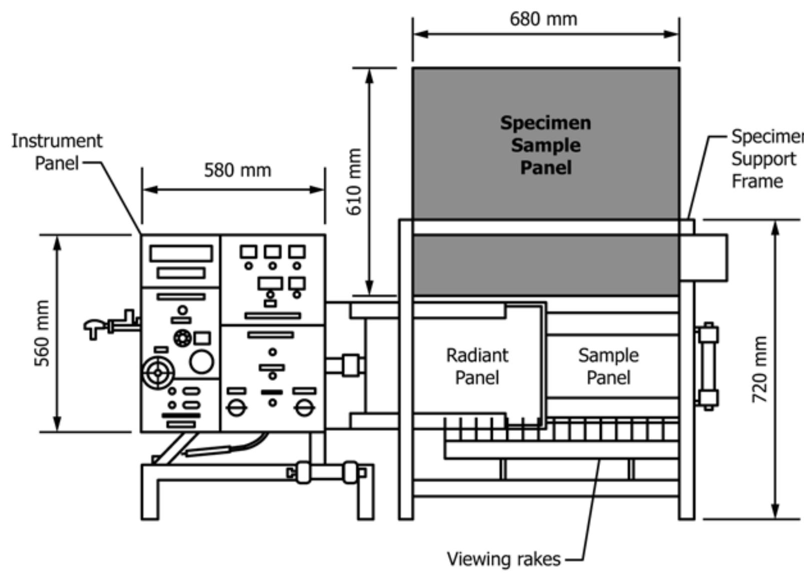


FIG. 14 LIFT Radiant Panel Apparatus Main Frame, Front View (Test Method E1321)

to 30 Pa. A flowmeter suitable for indicating air flow over the range of 2 to 15 × 10^{-3} m^3/s and a flowmeter suitable for indicating methane flow rates over the range of 0.1 to 1.1 × 10^{-3} m^3/s needs to be provided. The fuel gas used is either natural gas or methane. A pressure regulator needs to be provided to maintain a constant supply pressure. Gas needs to be controlled by either a manually adjusted needle valve or a Venturi mixer. The Venturi mixer will allow one to control the flux level of the panel by adjusting only the air valve. The fuel gas-flow requirements are roughly 0.26 to 1.03 × 10^{-3} m^3/s at a pressure sufficient to overcome line pressure losses.

8.4.3 *Radiant Ignition Source from the Traditional Radiant Panel Test (Test Method E162):*

8.4.3.1 The radiant panel consists of a porous refractory material vertically mounted in a cast-iron frame, exposing a radiating surface of 305 by 457 mm, capable of operating at temperatures up to 815°C. The panel is equipped with a Venturi-type aspirator for mixing gas and air at approximately atmospheric pressure; a centrifugal blower, or equivalent, capable of providing 9.4 L/s of air at a pressure of 700 Pa, an air filter to prevent dust from obstructing the panel pores, a pressure regulator, and a control and shut-off valve for the gas supply.

8.4.3.2 The specimen holder is a frame constructed from heat-resistant chromium steel and contains observation filed on its surface, to correspond with 76 mm interval lines on the specimen. The test specimens are 152 by 457 mm by the sheet thickness. The framework for support of the specimen holder has two transverse rods of stainless steel, each 12.7 ± 3.3 mm in diameter, with a stop to center the specimen holder directly in front of the radiant panel. The support and bracing members are constructed from metal stock.

8.4.3.3 There is a pilot burner, which consists of a length of stainless steel tubing approximately 203 to 229 mm long with nominally 3.2 mm inside diameter by nominally 4.8 mm outside diameter. As an option, the service life of the pilot burner is prolonged if the part of the burner that is exposed to radiant energy is protected with a porcelain tube nominally 5.2 mm inside diameter by nominally 7.14 mm outside diameter. The burner is mounted horizontally and at a slight angle to the

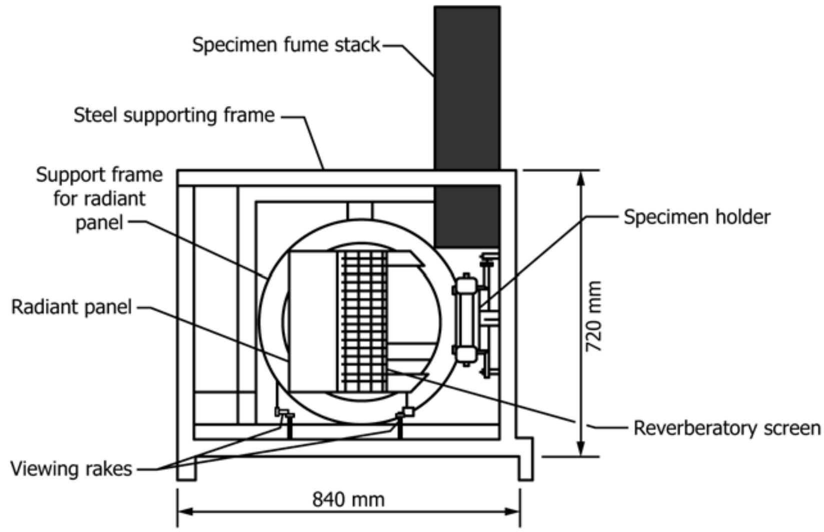


FIG. 15 LIFT Radiant Panel Apparatus Main Frame, Side View (Test Method E1321)

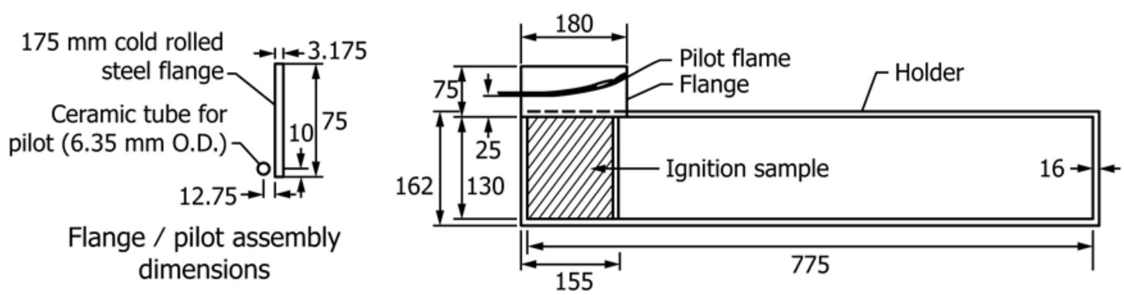


FIG. 16 Pilot Configuration for Ignition Test in Test Method E1321

intersection of the horizontal plane of the burner with the plane of the specimen. The burner needs to be capable of being moved out of position when not in use. The pilot provides a 51 to 76 mm flame of acetylene gas premixed with air in an aspirating type fitting. The position of the burner tip is such that the pilot flame is in contact or within 12.7 mm of contacting the upper central surface of the test specimen.

8.4.3.4 An alternate pilot burner is used in Test Method D3675, with the same radiant panel, when investigating fire test response characteristics of flexible cellular materials. The pilot burner is a porcelain tube 203 – 230 mm in length, nominally 6.3 mm in diameter, with two holes 1.5 ± 0.1 mm in diameter equally spaced in the tube. The burner is mounted horizontally and at an angle of 15 to 20° to the intersection of the horizontal plane of the burner with the plane of the spcimen with the outlet end of the burner spaced 32 ± 2 mm from the specimen. The pilot provides a 150 to 180-mm flame of acetylene gas premixed with air in an aspirating type fitting. Properly adjusted, the pilot flame has 25-mm inner blue cones and impinges on the upper central surface of the specimen within 13 mm of the edge of the specimen support frame. Flow rates of 0.015 dm^3/s of acetylene and 0.075 dm^3/s of air have been found to provide the desired flame.

8.4.4 *Radiant Ignition Source from the Flooring Radiant Panel Test (Test Method E648):*

8.4.4.1 The radiant panel consists of a porous refractory material vertically mounted in a cast iron or steel frame, exposing a radiating surface of 305 to 457 mm, capable of operating at temperatures up to 815°C. The panel is equipped with a Venturi-type aspirator for mixing gas and air at approximately atmospheric pressure: a centrifugal blower, or equivalent, capable of providing 9.4 L/s of air at a pressure of 700 Pa, an air filter to prevent dust from obstructing the panel pores, a pressure regulator and a control and shut-off valve for the gas supply.

8.4.4.2 The specimen holder is constructed from heat-resistant stainless steel (AISI Type 300 (UN ANO8330) or equivalent) having a thickness of 1.98 mm and an overall dimension of 1140 by 320 mm with a specimen opening of 200 ± 3 mm by 1000 + 15 mm – 0 mm. Six slots are cut in the flange on either side of the holder to reduce warping. The holder is fastened to the platform with two stud bolts at each end.

8.4.4.3 There is a pilot burner, used to ignite the specimen, which is a nominal 6 mm inside diameter, 10 mm outside diameter stainless steel tube line burner having 19 evenly spaced 0.7 mm diameter (#70 drill) holes drilled radially along the centerline, and 16 evenly spaced 0.7 mm diameter (#70 drill) holes drilled radially 60° below the centerline (Fig. 17). In operation, the gas flow is adjusted to 0.085 to 0.100 m^3/h (air

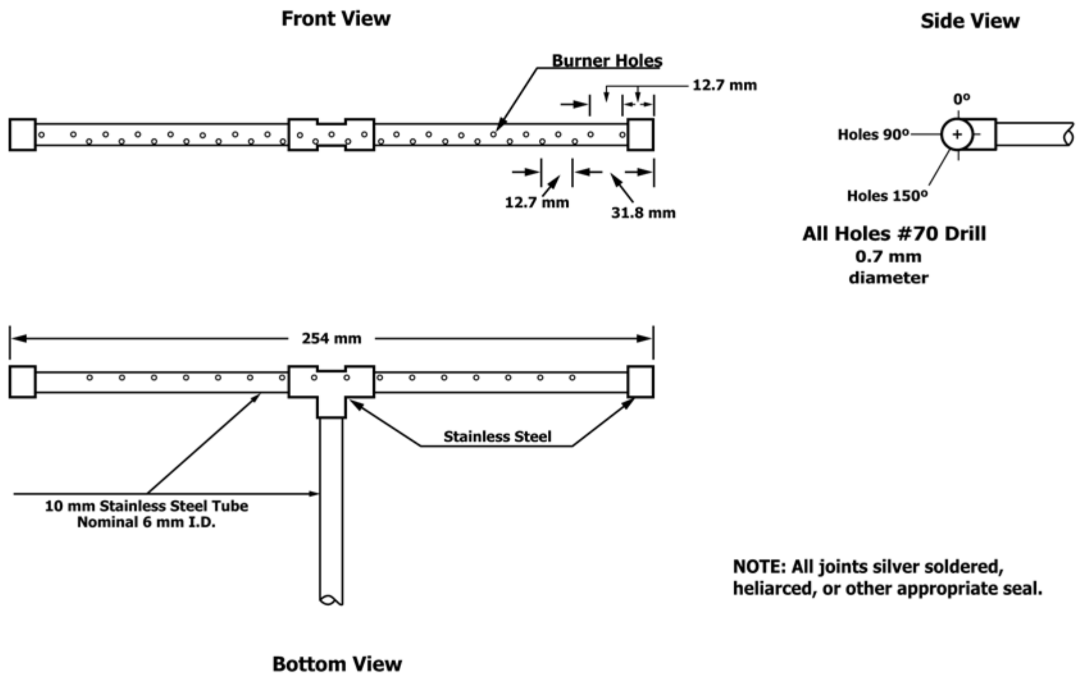


FIG. 17 Pilot Burner for Test Method E648

scale) flow rate. The pilot burner is positioned no more than 5° from the horizontal so the flame generated will impinge on the specimen at the 0 distance burned point (Fig. 18 and Fig. 19). When the burner is not being applied to the specimen, it is

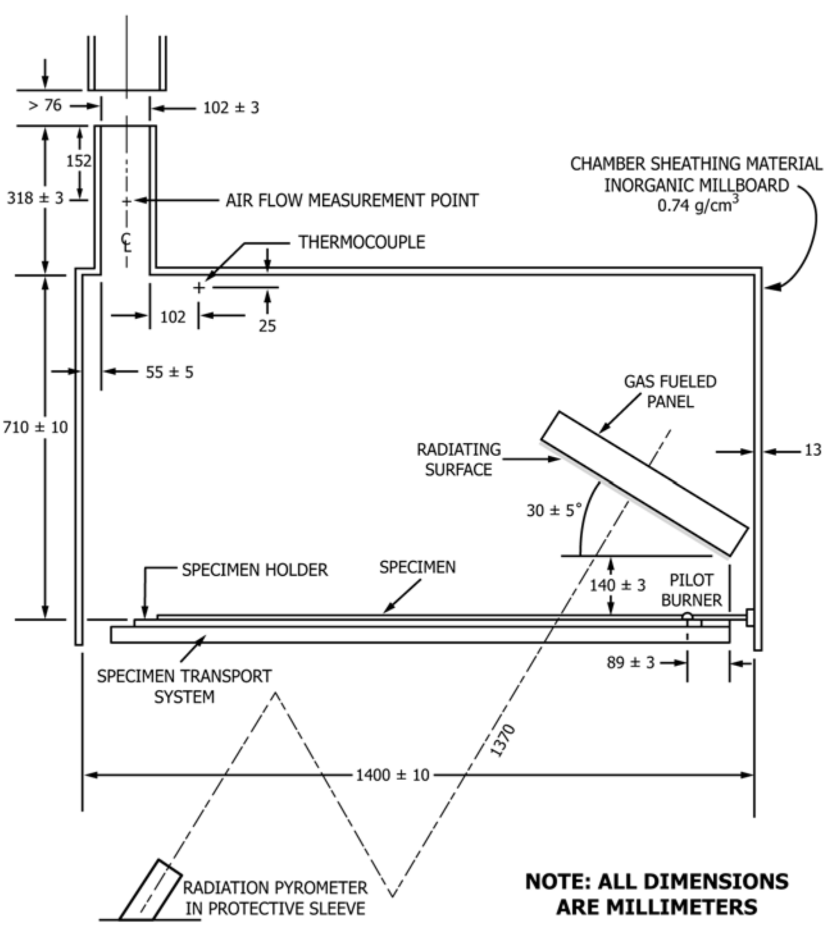


FIG. 18 Flooring Radiant Panel Tester Schematic Side Elevation

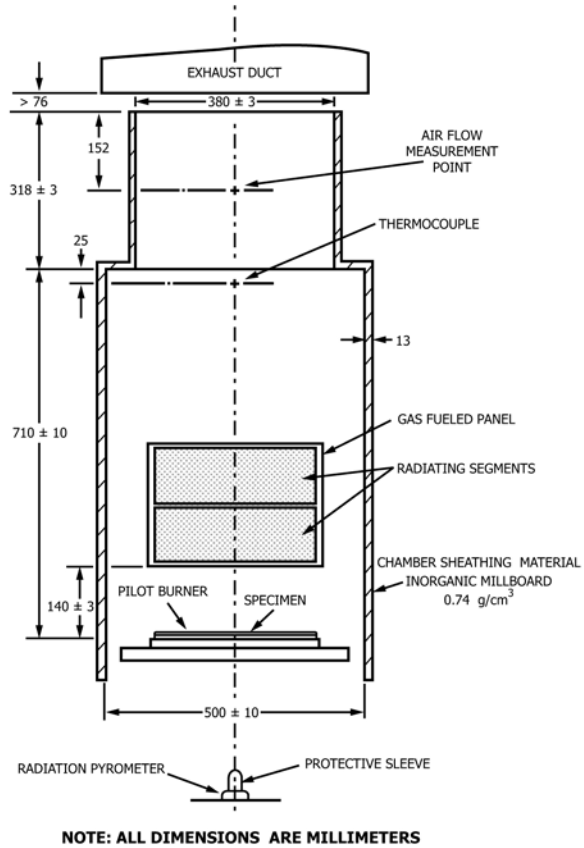


FIG. 19 Flooring Radiant Panel Tester Schematic Low Flux End, Elevation

moved away from the ignition position so it is at least 50 mm away from the specimen.

8.4.5 *Radiant Ignition Source from the Intermediate Scale Calorimeter Radiant Panel (Test Method E1623):*

8.4.5.1 A generic version of the radiant panel of Test Method E1623 consists of steel framing that supports an array of adjustable, ceramic-faced, natural or propane gas burners. The radiant panel dimensions are a minimum of 1542 mm wide by 1330 mm high. The framing is braced or water-cooled such that the radiant panel does not deflect more than 25 mm due to heat warping, and meets the heat flux calibration in 8.4.5.8.

8.4.5.2 The radiant panel array has enough adjustable burners to meet the calibration requirements in 8.4.5.8. Each burner is comprised of a plenum space in which the natural or propane gas is injected at a controlled rate by the burner's control system. Combustion air is aspirated into the plenum space through the gas and air injection port.

(1) The gas flow is controlled by the automated fuel control system. Metering and on/off valves are connected to each burner, or to a sub-array of burners to control the surface burning temperature of each burner or sub-array of burners. These control valves are used to adjust the temperature profile of the array in order to meet the heat flux calibration in 8.4.5.8.

8.4.5.3 The face of each burner is covered with a stainless steel floating screen for higher surface temperature and safety. The screens are installed to allow for elongation of screens and supporting rods, so as to allow the distance between the burners and screens to remain constant when heated. The optimum distance between the surface of the burners and the outer surface of the screen was found to be 5 mm. The rows of gas burners are attached to the support framing.

8.4.5.4 Natural gas of net heating value at least 790 kJ/mol, or propane gas with a heat combustion of 46.5 MJ/kg is supplied to the unit through a fuel control system. All gas pipe connections to the burners are sealed with a gas pipe compound resistant to liquefied petroleum gases. A drip leg is installed in the gas supply line going to each heater to minimize the possibility of any loose scale or dirt within the gas supply line from entering the burner's control system.

8.4.5.5 Ignition of the burners shall be accomplished by spark igniters or pilot flames.

8.4.5.6 The irradiance from the radiant panel assembly needs to be capable of being held at a preset level by means of regulating the flow of gas to the burners. The flow of the gas is regulated using an automatic flow controller, motorized valve, and a thermocouple located on the surface of a ceramic burner. The irradiance is directly proportional to the temperature on the surface of the ceramic burners. Gas flow is continuously measured to calculate the heat released from the radiant panel assembly.

8.4.5.7 Ignition of the burners is accomplished by individual, automatic spark igniters and pilot flames. The spark igniters are used to ignite the pilot flames, which in turn are used to ignite the burners after pilot flame temperature sensors have reached a required value. The pilot remains on until the burners are extinguished.

8.4.5.8 After the calibration panel has come to equilibrium, heat flux measurements are made with the target face of the flux meter at the following distances away from the radiant panel: 300, 400, 600, 800, 1000, and 2000 mm. It is essential that no individual heat flux measurement deviates from the average at each of the distances by more than 6.6 %. The average heat flux measurements in the bottom row of the calibration panel cannot deviate from that in any of the heat flux values used by more than 65 %.

8.5 *Hot Air Ignition:*

8.5.1 *Setchkin Apparatus Furnace (Test Method D1929 or ISO 871)*—The furnace is shown in Fig. 20 and consists primarily of an electrical heating unit and a test specimen holder. The furnace needs to have a furnace tube and an inner ceramic tube. The furnace tube needs to be a vertical tube with an inside diameter of 100 ± 5 mm and a length of 230 ± 20 mm, made of a ceramic that will withstand at least 750°C. The vertical tube stands on the furnace floor, fitted with a plug for the removal of accumulated residue. The ceramic tube needs to withstand at least 750°C, with an inside diameter of 75 ± 5 mm, a length of 230 ± 20 mm, and a thickness of approximately 3 mm. It is placed inside the furnace tube and positioned 20 ± 2 mm above the furnace floor on three small spacer blocks. The top needs to be covered by a disk of heat-resistant material with a 25 ± 2 mm diameter opening in the center that is used for observation and passage of smoke and gases. The pilot flame needs to be located immediately above the opening. An electrical heating unit, contained within a mineral fiber sleeve and constructed of 50 turns of 1.3 ± 0.1 mm Nichrome V alloy wire, shall be wound around the furnace tube and embedded in heat-resistant cement. Thermal insulation (see Fig. 20) consists of a layer of mineral fiber, approximately 60 mm thick, and covered by a metal jacket.

NOTE 2—This apparatus (without the igniter) is also used to assess the behavior of materials at 750°C in Test Method E136.

8.5.1.1 Ignition is either with or without using a pilot igniter.

8.5.2 *Air Source*—An outside air source shall be used to supply clean air near the top of the annular space between the ceramic tubes, through a copper tube at a steady and controllable rate. Air is heated and circulated in the space between the

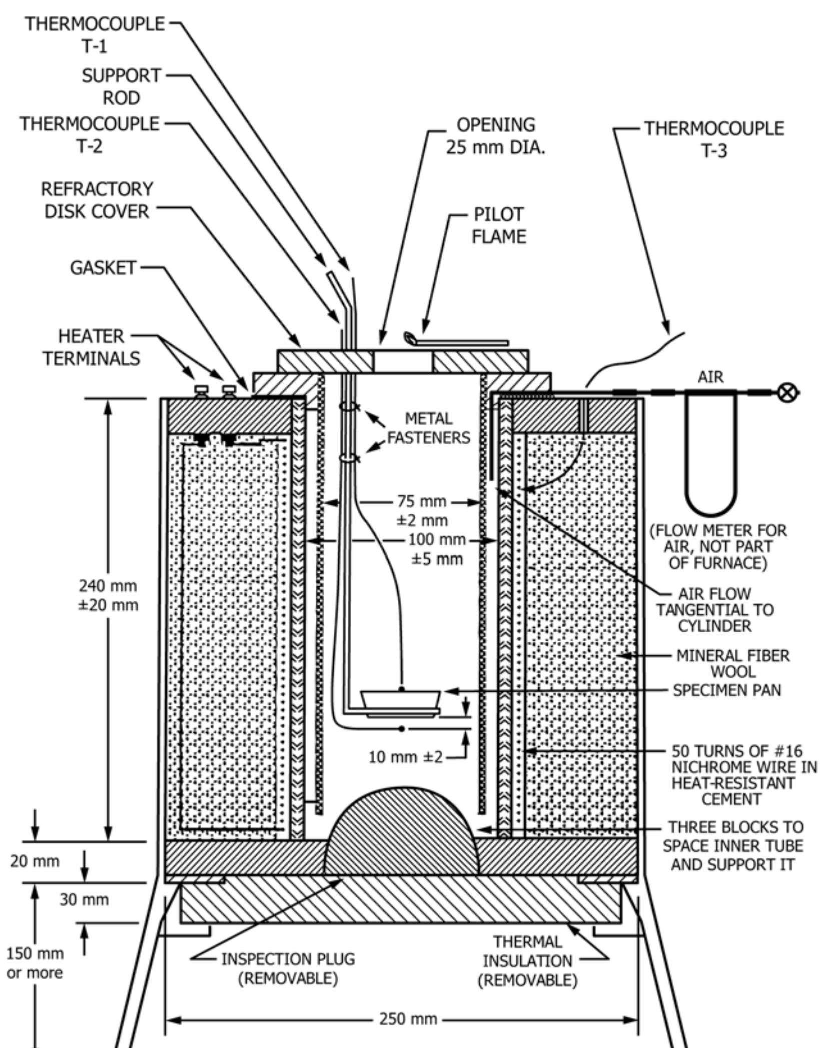


FIG. 20 Setchkin Apparatus Furnace (Test Method D1929)

two tubes and enters the inner furnace tube at the bottom. Air is metered by a rotameter or other suitable device.

8.5.3 *Pilot Igniter*—It consists of a nominal 1.8 ± 0.3 mm inside diameter (ID) copper tubing attached to a gas supply of 94 % minimum purity propane and placed horizontally 5 ± 1 mm above the top surface of the disk cover. The pilot flame needs to be adjusted to 20 ± 2 mm in length and centered above the opening in the disk cover.

8.5.4 *Test Specimen Support and Holder*—The test specimen pan consists of a metal container of approximately 0.5 mm thick steel measuring 40 ± 2 mm in diameter by 15 ± 2 mm in depth. It is held in a ring of approximately 2.0 mm diameter stainless steel welding rod. The ring is welded to a length of the same type of rod extending through the cover of the furnace, as shown in Fig. 20. The bottom of the test specimen pan is located 185 ± 5 mm down from the top of the inner furnace tube.

8.5.5 *Thermocouples*—There are three thermocouples, 0.5 mm diameter, Chromel-Alumel (Type K), or Iron-Constantan (Type J), for temperature measurement. They are connected to a calibrated recording instrument with a tolerance not exceeding ±2°C.

8.5.5.1 Thermocouple TC_1 is used to measure the temperature of the test specimen and is located as close as possible to the center of the upper surface of the test specimen when the test specimen is in place within the furnace. The thermocouple wire is attached to the test specimen support rod.

8.5.5.2 Thermocouple TC_2 is used to indicate the temperature, T_2, of the air traveling past the test specimen. It is located 10 ± 2 mm below the center of the test specimen pan. The thermocouple wire is attached to the test specimen support rod.

8.5.5.3 Thermocouple TC_3 is used to measure the temperature, T_3, of the heating coil. It is located adjacent to the furnace heating coil and used as a reference for temperature adjustment purposes because of its faster response.

8.5.6 Heating control is conducted by means of a variable transformer or an automatic controller connected in series with the heating coils.

8.6 *Infrared Heating System:*

8.6.1 *Fire Propagation Apparatus Test*—This ignition source is described in Test Method E2058 and in NFPA 287. The ignition source consists of the following components: an infrared heating system, a power controller, an ignition pilot flame, and an ignition timer.

8.6.2 *Infrared Heating System*—Each of four 241 mm long infrared heaters contains six tungsten-filament tubular quartz lamps in a compact reflector body that, for a 120 V input produces 190 kW/m^2 of radiant flux in front of the quartz window that covers the lamps. The emitter of each lamp is a 127 mm-long tungsten filament in an argon atmosphere enclosed in a 9.5 mm outer-diameter clear quartz tube. The emitter operates at a minimum of 2475 K for a 120 V input, to produce a spectral energy peak at 1.15 µm.

8.6.3 *Power Controller*—The power controller maintains the output voltage required by the heater array despite variations in the line voltage and load impedance, through the use of phase angle power control to match the hot/cold resistance characteristics of the tungsten-quartz lamps. The controller also incorporates average voltage feedback to linearize the relationship between the voltage set by the operator and the output voltage to the lamps.

8.6.4 *Ignition Pilot Flame*—The ignition pilot consists of an ethylene-air (60–40 by volume) flame adjusted for a 10 mm length and anchored at the horizontal end of a 50 mm long, 6.35 mm outer diameter, 4.70 mm inner diameter, stainless steel tube. The horizontal section of the tube contains a four-hole ceramic insert to produce a stable flame and prevent flashback. The pilot flame tube needs to be able to be rotated and elevated to position the horizontal flame at specified locations near the specimen.

8.6.5 *Ignition Timer*—The ignition timer for measuring time to sustained flaming needs to be capable of recording elapsed time to the nearest 0.1 s and have an accuracy of better than 1 s in 1 h.

9. Diffusion Flame Flaming Ignition Sources

9.1 *Needle Flame Test*—This ignition source is described in IEC 60695-11-5. It is a needle flame which provides a low-intensity, low-area diffusion flame. This source is intended to simulate the effect of small flames resulting from fault conditions within electrical equipment. The needle burner consists of a piece of stainless-steel hypodermic tubing with the end tapered off. The burner has a minimum length of 35 mm with a bore of 0.5 mm ± 0.1 mm and an outer diameter not exceeding 0.9 mm. The burner is connected with flexible tubing to a cylinder containing butane or propane. The gas needs to have a purity of at least 95%. Butane gas is the standard reference gas, but propane gas is occasionally also used. With the axis of the needle burner in the vertical position, the gas supply is adjusted so that the length of the flame is 12 mm ± 1 mm.

9.2 *Tubular Burners:*

9.2.1 This ignition source, which is equivalent to a burning match, is described in ISO 8191-2. It is a diffusion flame with a calorific output approximating that of a burning match, at a flame exposure time of 15 ± 2.0 s. The burner barrel consists of a stainless-steel tube of the following dimensions: 8.0 ± 0.1 mm outside diameter, 6.5 ± 0.1 mm inside diameter, 200 ± 5 mm length. The burner tube is connected with flexible tubing to a cylinder containing propane and the flexible tubing between the flowmeter and the burner tube has an internal diameter of 8 mm and a length of 2.0 ± 0.2 m. The flowmeter is calibrated to supply a propane gas flow rate at 25°C of 45 ± 2 mL/min. Under these conditions, the flame height is approximately 40 mm, the area of impingement on the exposed surface of a test specimen is 7.5 ± 0.2 cm^2, and the heat flux is 40 ± 2 kW/m^2.

9.2.2 A very similar ignition source, using butane gas, is described in BS 5852, and is used for three ignition sources, as described below. It consists of a tubular burner consisting of a length of stainless steel tube, with 8.0 ± 0.1 mm outside diameter and 6.5 ± 0.1 mm internal diameter and 200 ± 5 mm, connected by a flexible tube via a flow meter, fine control valve, an optional on-off valve, and a cylinder regulator providing a nominal outlet pressure of 2.8 kPa containing butane. The flow meter is calibrated to supply the required butane gas flow rates. The flexible tube connecting the output of the flow meter to the burner tube is 2.5 – 3.0 m in length with an internal diameter of 7.0 ± 1.0 mm. The butane gas used has a known net heat of combustion of 49.6 ± 0.5 MJ/kg. The gas flow rate of butane is measured at a pressure of 101 ± 5 kPa and a temperature of 20 ± 5°C.

9.2.2.1 *Ignition Source 1*—This uses butane at a flow rate of 45 mL/min at 25°C, corresponding to a flame height of 35 mm, measured from the top of the burner tube, when held vertically upwards and when the flames are burning freely in air. The gas flow is maintained for 20 s. This ignition source is also equivalent to a match.

9.2.2.2 *Ignition Source 2*—This uses butane at a flow rate of 160 mL/min at 25°C, corresponding to a flame height of 145 mm, measured from the top of the burner tube, when held vertically upwards and when the flames are burning freely in air. The gas flow is maintained for 40 s.

9.2.2.3 *Ignition Source 3*—This uses butane at a flow rate of 350 mL/min at 25°C, corresponding to a flame height of 240 mm, measured from the top of the burner tube, when held vertically upwards and when the flames are burning freely in air. The gas flow is maintained for 70 s.

9.2.2.4 These ignition sources are used in BS 5852 to assess the ignitability of upholstered furniture composites or of complete items of seating furniture. The test specimens consist of either (a) upholstered furniture mock-ups (with both a vertical and a horizontal cushion), representative of an upholstery material and a filling material (or foam), with or without an interliner, or (b) of actual upholstered furniture items. The burner tube is placed axially along the junction between the vertical and horizontal portions of the test specimen so that the flame is not less than 100 mm from the nearest side or edge.

9.3 *Burner Generating a 50 W and a 500 W Flame:*

9.3.1 This ignition source, described in specification D5025 (as well as in IEC TS60695-11-3 for a 50 W flame and in IEC TS60695-11-4 for a 500 W flame), is a laboratory burner. The burner consists of a barrel threading onto a one-piece base and gas inlet, as shown in Fig. 21. The components need to be constructed of metal, typically of brass or aluminum.

9.3.2 The burner barrel consists of a mixing tube and threaded air-inlet adapter. The mixing tube needs to be of seamless construction, with an inside diameter of 9.5 ± 0.3 mm. The length of the barrel from the top of the air-inlet openings to the top of the mixing tube is 100 ± 10 mm. The top of the mixing tube is not equipped with end attachments, such as stabilizers. The air-inlet adapter, located at the bottom of the mixing tube, is approximately 25 mm high and 20 mm in overall diameter. The minimum area of the air-inlet openings is

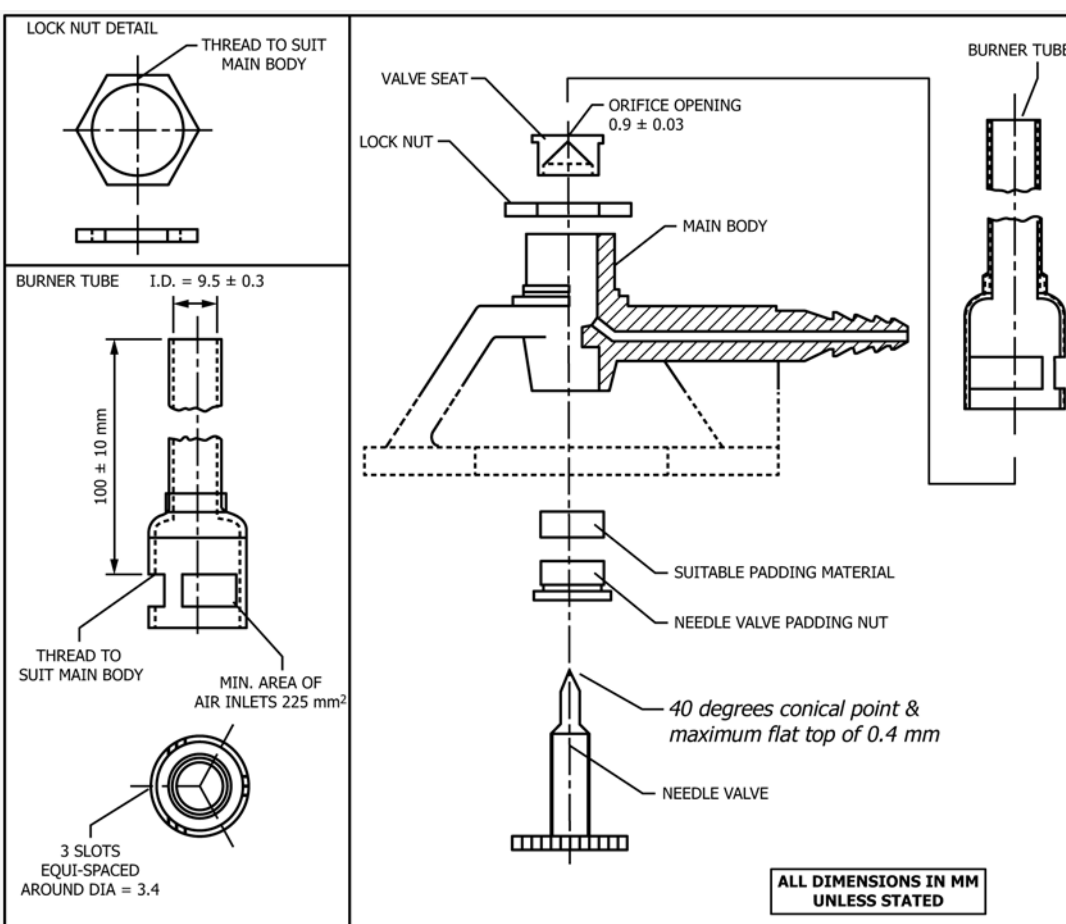


FIG. 21 Diffusion Burner for 50 W or 500 W Flames (Specification D5025)

225 mm^2 distributed equidistant around the adapter. With the barrel fully screwed into the base and the lock nut in place, the air-inlet openings need to be completely closed.

9.3.2.1 The requirement for the minimum area of the air-inlet openings has commonly been obtained with three openings, approximately 6.5 by 12.5 mm.

9.3.3 *Burner Orifice*—The base of the burner is equipped with an orifice of 0.90 ± 0.03 mm in diameter and 1.60 ± 0.05 mm in length.

9.3.4 *Needle Valve*—The base of the burner is equipped with a machined needle valve to restrict the orifice opening and regulate gas velocity through the burner. A knurled knob needs to be provided for adjustment of the valve. The needle valve needs to be machined with a conical point using an angle of 40° with a maximum flat top of 0.4 mm. The needle needs to align with the orifice in the valve seat. Alignment can be confirmed by removing the barrel and igniting the fuel gas directly at the orifice. The flame needs to remain vertical.

9.3.4.1 If the flame slants, possible reasons include, but are not limited to: the orifice is off-center, or the needle is worn. It is important to periodically confirm the alignment and to take appropriate actions to ensure the flame remains vertical.

9.3.5 *Gas Inlet*—The base of the burner needs to be provided with a serrated fitting for connection to the gas supply.

9.3.6 *Lock Nut (Optional)*—The burner is provided with a lock nut that threads onto the base. This allows the barrel to be tightened securely against the lock nut when test flames require positioning of the barrel with air-inlet openings partially or fully open.

9.3.7 Guidance on the dimensions associated with a 50 W and a 500 W flame are shown in Table 1.

9.3.8 This burner is to be calibrated with Practice D5207.

9.3.9 This burner is also suitable for use in the horizontal orientation, for example as shown in Fig. 22 (Test Method D635 or UL 94), or for testing at an angle of 60°, as described in the FAA Aircraft Material Fire Test Handbook.

9.4 *Diffusion Flame Burner for Vertical Fabrics:*

9.4.1 This burner, described in NFPA 701, test method 2, and intended for vertical test specimens, consists of a diffusion flame laboratory burner that conforms to Specification D5025. The burner has an inside diameter of 9.5 ± 1.5, – 0 mm and a length of 100 ± 0 mm, and meets the calibration or confirmation practice of Practice D5207.

9.4.1.1 If the burner is equipped with a gas flow controlling valve, the valve is fully open in order to prevent restriction of gas flow.

TABLE 1 Characteristics of 50 W and 500 W Flame Burners

Gas Composition	Gas Flow Rate (mL/min)	Area of Impingement (cm^2)	Minimum Gas Purity (%)
50 W – 20 mm high flame			
Methane	105	1.8	98
Propane	42	1.8	98
Butane	33	1.8	95
500 W – 125 mm high flame with 40 mm inner blue cone			
Methane	965	18	98
Propane	380	18	98
Butane	300	18	95

9.4.1.2 The burner is fixed in a position so that the barrel is at a 25-degree angle with the vertical, with the upper tip of the burner located 100 mm below the bottom edge of the vertical test specimen.

9.4.1.3 The gas supply to the burner is at least 97 % pure methane or manufactured or natural gas having a heat value of 25×10^6 J/m^3 to 31×10^6 J/m^3.

9.4.1.4 A needle valve for gas flow control is used followed by a rotameter in the gas line leading to the burner.

9.4.1.5 The upper limit of the rotameter is 150 to 300 L/h.

9.4.1.6 A pressure gauge is located between the gas supply and the needle valve used for controlling the gas flow.

9.4.1.7 The gas lines from the needle valve to the rotameter and from the rotameter to the burner have a bore of at least 6 mm (0.24 in.) and a total length that does not exceed 1.5 m.

9.4.2 The gas pressure supplied to the burner is 17.5 ± 2.0 kPa with a flow rate of 113 ± 3 L/h.

9.4.3 The burner air inlets are sealed with electrical adhesive tape to prevent the entrance of air, and the gas is adjusted to produce a 280 ± 12 mm flame.

9.4.4 The position of the test specimen relative to the test flame is maintained by using clips attached to the edges of the test specimen. The clips are attached to the edges of the test specimen at the midpoint of the specimen's length.

9.4.5 The test flame is applied at an angle of 25 degrees from the vertical with the burner opening 100 mm below the edge of the test specimen and within 20 mm of the middle of the width of the lower edge of the test specimen in a single sheet, or at the middle segment of folded test specimens.

9.4.6 The test flame is applied to the test specimen for 2 min and then withdrawn.

10. Premixed Flame Flaming Ignition Sources

10.1 *General*—Gas burners are always set up to conform to precise gas flow rates or flame heights, or both. Secondary checks of flame temperature or heat flux need to be performed periodically, but criteria on these parameters are not necessarily an essential part of the laboratory procedure. After setting up the burner for a particular test it is desirable to leave the burner in this orientation throughout a series of experiments. This objective is conveniently satisfied if the operator only has to maintain the gas flow constant to the burner. Gas burners are normally connected to the gas supply by flexible tubing via a cylinder regulator providing an outlet pressure, on-off valve, fine-control valve, and flowmeter. The use of a sufficient length of tubing inside the controlled environment helps to ensure that the gas equilibrates to the required temperature before flow measurement. It is essential to check direct-reading flowmeters, even those obtained with a direct calibration for the gas used initially, and at regular intervals during testing, with a method capable of measuring accurately the absolute gas flow at the burner tube.

10.2 *Premixed Burner for 1 kW Flame:*

10.2.1 This ignition source, described in IEC 60695-11-2, provides a high-intensity premixed flame of uniform flux. It is intended to simulate the effect on materials of a secondary

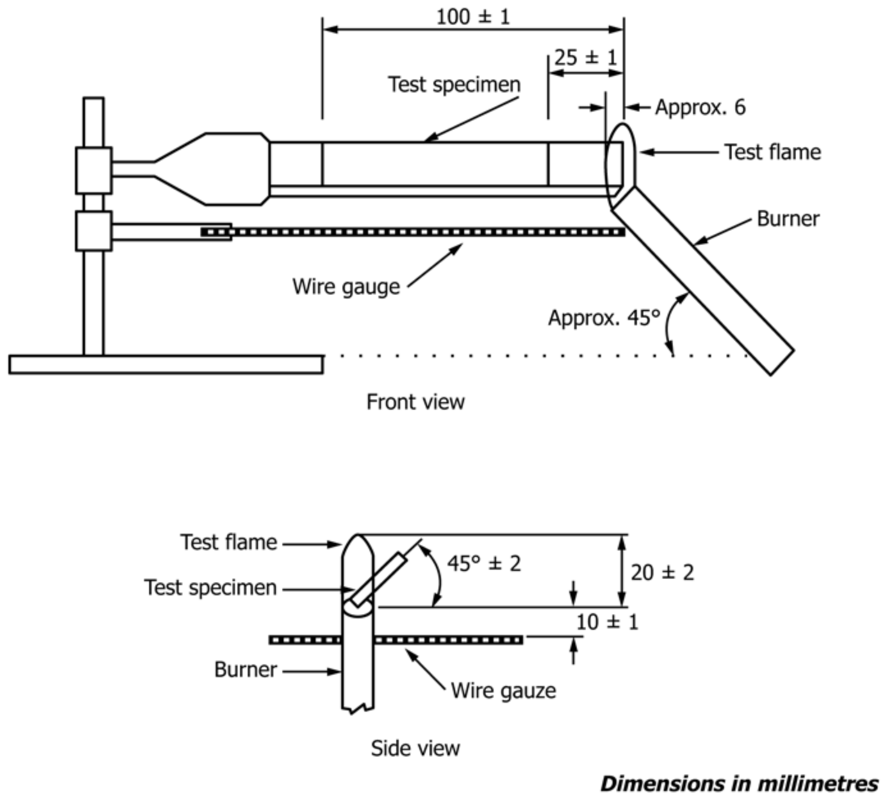


FIG. 22 Diffusion Burner Used for Horizontal Exposures (Test Method D635)

source arising from other flaming items in the vicinity, or from a fire in its early stages. It is also used in IEC 60332-1 and IEC 60332-2.

10.2.2 The burner (see Fig. 23) consists of a brass barrel tube of the following dimensions: 17.0 mm outside diameter, 12.0 mm internal diameter, and 110 mm length. The burner barrel is fitted with a gas injector and flame stabilizer that are removable for cleaning purposes. Both air (oil-free laboratory

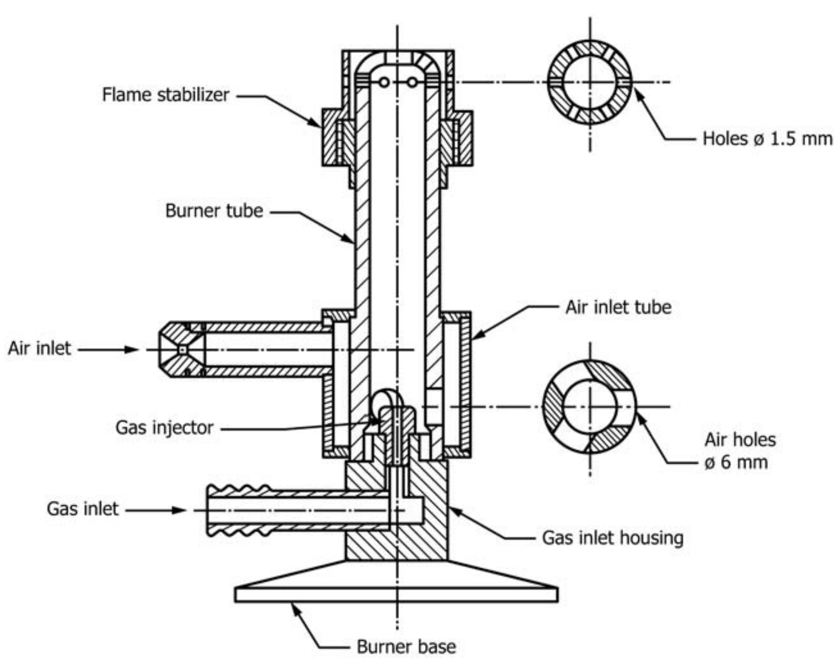


FIG. 23 Premixed Burner for 1 kW Flame (IEC 60695-11-2)

air, metered at 10 ± 0.5 L/min, at 23°C, 101 kPa) and propane (of purity greater than 98 % and at a flow rate equivalent to 650 ± 30 mL/min, at 23 °C, 101 kPa) are metered separately to the base of the burner barrel.

10.2.3 The area of impingement on the exposed surface of a test specimen is approximately 20 cm^2.

10.3 *Burner for Vertical Tray Tests:*

10.3.1 This ignition source is described in Test Methods D5424 and D5537 and also in some other vertical cable tray standards, including UL 1685, UL 2556, IEEE 383, IEEE 1202 and IEC 60332-3. It consists of a gas burner, with a Venturi mixer, which allows vertically oriented test specimens to be exposed to a large-area premixed flame (Fig. 24).

10.3.2 The ignition source is a 254-mm strip or ribbon-type propane gas burner with an air/gas Venturi mixer. The flame-producing surface of the burner consists essentially of a flat metal plate that is 341 mm long and 30 mm wide. The plate has an array of 242 holes drilled in it. The holes are to be 1.35 mm in diameter, on 3.2 mm centers in three staggered rows of 81, 80, and 81 holes each, to form an array measuring 257 mm by 5 mm. The array of holes is centered on the plate.

10.3.3 A guide is attached to the burner or stand such that the leading edge of the burner face is located quickly and accurately 76 ± 5 mm horizontally away from the nearest surface of the cables during the burn period of the test.

10.3.4 A flowmeter is inserted in both the propane and the air lines feeding the burner to measure the flow rates of these gases during the test. The propane flowmeter needs to be capable of measuring at least 230 cm^3/s, and the air flowmeter needs to be capable of measuring at least 1330 cm^3/s. Flow rate measurements need to be accurate to within 3 %. Mass flow controllers with recordable outputs are permitted alternatives.

10.3.5 Compressed air is supplied to the burner, either bottled or from a compressed air system. The air needs to be filtered sufficiently so as to eliminate any contaminants that might affect the test results. The air needs to have a dew point no greater than 0 °C as measured by a dew point measuring device. The air flow rate is 1280 ± 80 cm^3/s, when corrected to standard temperature and pressure (20°C and 101 kPa).

10.3.6 The propane used is CP grade propane (99 % pure), having a heat content of approximately 50.8 MJ/kg (93.0 MJ/m^3 at 20 °C, 101 kPa), for the burner. The propane flow rate is 220 ± 8 cm^3/s when corrected to standard temperature and pressure (20°C and 101 kPa). This propane flow will provide a theoretical heat output of 20 kW. The actual heat output is less, due to incomplete combustion of the propane at the burner.

NOTE 3—The heat output of 20 kW approximately corresponds to 70,000 BTU/hr.

10.3.7 This ignition source is used in some test methods to expose test specimens with the burner oriented perpendicularly to the vertical tray and in some other test methods with the burner oriented at an angle of 20º, as shown in Fig. 25 (Test Method D5424). The latter exposure, while providing the same heat input, is more severe. Normal test duration is an exposure period of 20 min.

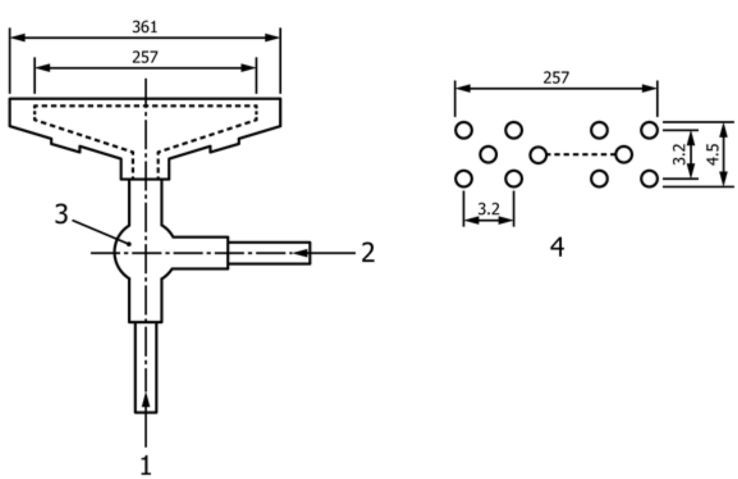
10.3.8 This ignition source can also be used for higher heat inputs.

10.4 *Burner for Riser Cable Tests:*

10.4.1 This ignition source is described in UL 1666. It is a gas burner that allows vertically oriented test specimens to be exposed to a large-area premixed flame and to assess whether test specimens spread flame from one floor to another. It is more severe than the ignition source in 10.3.

10.4.2 The burner consists of piping plus a steel diffuser plate (Fig. 26).

10.4.3 The fuel is commercial grade propane of approximately 83.1 MJ/m^3 heat content. The test flame is to produce approximately 154.5 kW. The burner flame is ignited with a



Key
1 Compressed-air entry
2 Propane gas entry
3 Venturi air-gas mixer
4 242 round holes, 1.32 mm in diameter, on 3.2 mm centres, staggered in three rows of 81, 80 and 81 holes, centred on the face of the burner

FIG. 24 Premixed Burner for Vertical Cable Tray Tests (dimensions in mm; IEC 60332-3)

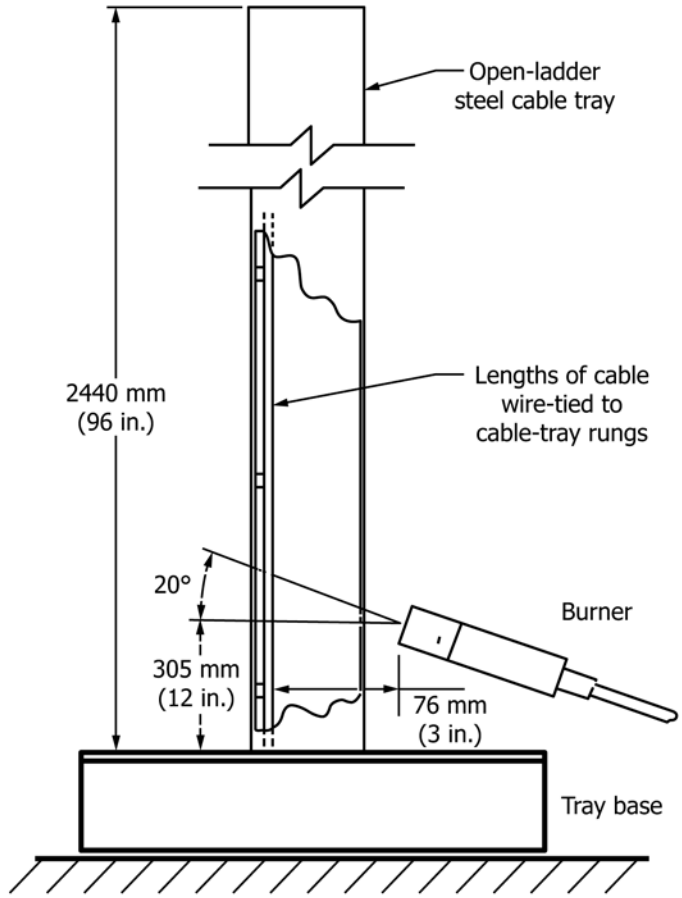


FIG. 25 Angled (at 20º) Application of Premixed Burner for Vertical Cable Tray Tests (Test Method D5537)

pilot and the burner flame is increased to 1657 ± 86 cm^3 to start the test. The test flame is normally applied to the cable for 30 min.

NOTE 4—The heat output of 154.5 kW approximately corresponds to 527,500 BTU/hr.

10.5 *Burner for Steiner Tunnel Tests:*

10.5.1 This ignition source is described in Test Method E84 and is also similar to that described in NFPA 262. Note that the test specimen exposure conditions and other test apparatus considerations are different between Test Method E84 and NFPA 262. The burner is used for assessing flame spread and smoke release. Fig. 27 shows the burner within the fire test chamber.

10.5.2 One end of the test chamber (designated as the "fire end") is provided with two gas burners delivering flames upward against the surface of the test sample (see Fig. 27). The burners are spaced 292 ± 6 mm from the fire end (or air-inlet end) of the test chamber, and 191 ± 6 mm below the removable top cover. The burner is located 1320 ± 51 mm downstream, of the air-inlet shutter, as measured from the burner centerline to the outside surface of the shutter.

10.5.3 Gas to the burners is provided through a single inlet pipe, distributed to each port burner through a tee-section. The outlet is a nominal 19 mm elbow. The plane of the ports needs to be parallel to the furnace floor, such that the gas is directed upward toward the test specimen. Each port needs to be positioned with its centerline 102 ± 6 mm on each side of the centerline of the furnace so that the burner flame is distributed evenly over the width of the exposed test specimen surface.

10.5.4 A vertically sliding shutter, extending the entire width of the test chamber, is provided at the air-inlet end of the fire test chamber. The shutter is positioned to provide an air-inlet opening 76 ± 2 mm high, measured from the floor level of the test chamber and across the full width of the chamber.

10.5.5 The controls used to ensure constant flow of gas to the burners during period of use consist of a pressure regulator, a gas meter constructed to read in increments of not more than 2.8 L, a gauge to indicate gas pressure in Pascal (or in inches of water), a quick-acting gas shut-off valve, a gas metering valve and an orifice plate, in combination with a manometer to assist in maintaining uniform gas flow conditions.

10.5.6 To provide air turbulence for proper combustion, turbulence-inducing baffles are provided by positioning six refractory firebricks (229 mm long, 114.5 mm wide, and 64 mm thick; long dimension vertical and 114.5 dimension parallel to the wall) along the side walls of the chamber at distances of 1.98 m ± 152 mm, 3.96 m ± 152 mm, and 5.79 m ± 152 mm on the window side (without obstructing the windows) and 1.37 m ± 152 mm, 2.90 m ± 152 mm, and 4.88 m ± 152 mm on the opposite side, as measured from the centerline of the gas burner to the centerline of the firebricks.

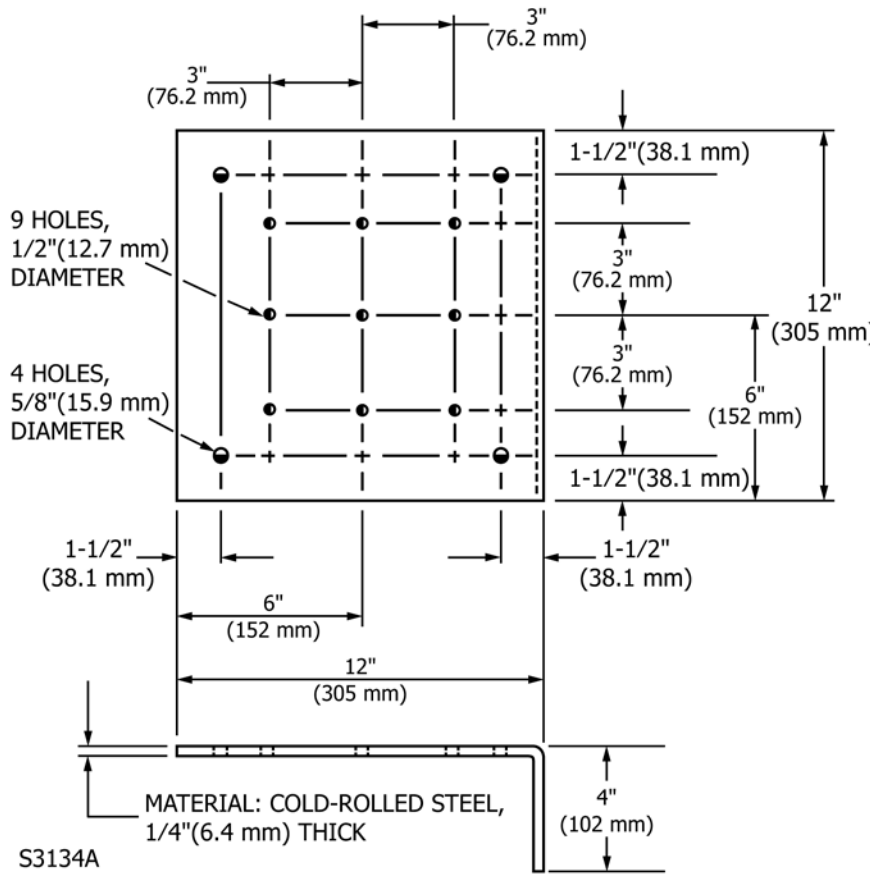


FIG. 26 Diffusion Plate for Riser Cable Test Burner

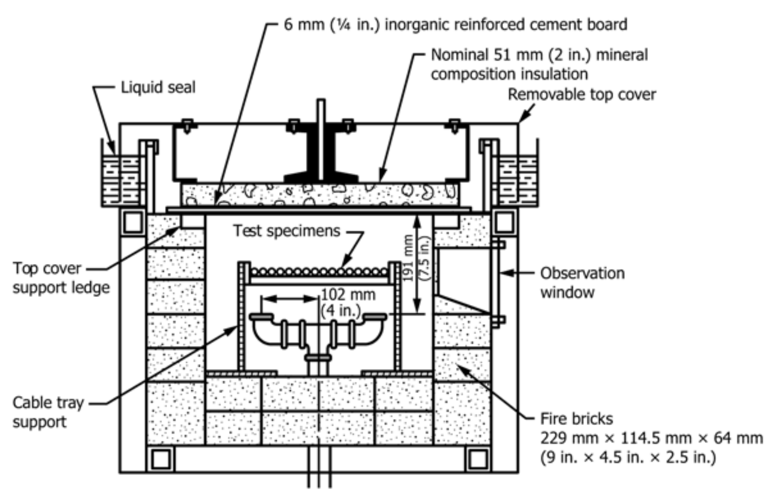


FIG. 27 Burner for Plenum Cable Test, Within the Fire Test Chamber (NFPA 262)

10.5.7 The test fire, which produces a nominal 86 kW, is fueled with methane gas of a minimum 98 % purity and with a high heating value of 37 ± 0.5 MJ/m^3, determined using a gas calorimeter or as documented by the fuel supplier. The gas supply needs to be adjusted initially to 86 ± 2 kW. The gas pressure, the pressure differential across the orifice plate, and the volume of gas used are recorded in each test.

NOTE 5—The heat output of 86 kW approximately corresponds to 294,000 BTU/hr.

10.5.8 The fuel supply, methane gas, is adjusted to the required flow as described in section 10.5.6, with the air-inlet shutter providing an opening of 76 mm ±1.5 mm for a test period of 10 minutes.

10.5.9 To maintain airflow control throughout each test run, the exhaust duct damper needs to be controlled by a closed-loop feedback system with respect to the air-inlet draft gauge static pressure. Throughout the test, the air supply needs to be maintained at a temperature of 18.3 to 26.7°C and a relative humidity of 45 to 60%.

10.5.10 The gas burner needs to be ignited remotely, using an electronic ignition system.

10.6 *Burner for Single Fuel Package Calorimeter:*

10.6.1 This burner is described in NFPA 289 and is intended for assessing fire-test response characteristics of individual fuel packages.

10.6.2 The ignition source for the test is a gas burner with a nominal 305 × 305 mm porous top surface of a refractory material. The refractory material through which the gas is supplied is a minimum 102 mm layer of white Ottawa silica sand, used to provide the horizontal surface through which the gas is supplied, as shown in Fig. 28.

10.6.3 The top surface of the burner through which the gas is applied is located horizontally 305 ± 50 mm above a protective barrier on which the test specimen is located.

10.6.4 The gas supply to the burner is propane of CP grade (99 % purity) or having a net heat of combustion of 46.5 ± 0.5 MJ/kg. Flow rates of gas are calculated using a net heat of combustion of propane of 85 MJ/m^3 at standard conditions of 101 kPa pressure and 20°C temperature. The gas flow rate is metered throughout the test, with an accuracy of at least ±5 percent. The heat output to the burner needs to be controlled within ±5 % of the prescribed value.

10.6.5 The gas supply to the burner needs to produce a net heat output of any of the following for a total of 15 min., but the burner is capable of being used at other heat outputs:

(1) 20 kW
(2) 40 kW
(3) 70 kW
(4) 100 kW
(5) 160 kW
(6) 300 kW

10.6.6 Burner controls need to be provided for automatic shutoff of the gas supply if flameout occurs.

10.6.7 The burner is ignited by a pilot burner or a remotely controlled spark igniter.

10.7 *Room Corner Test Burner:*

10.7.1 This burner is described in NFPA 265 and in NFPA 286 and is intended for assessing fire-test response characteristics of materials in a room-corner configuration.

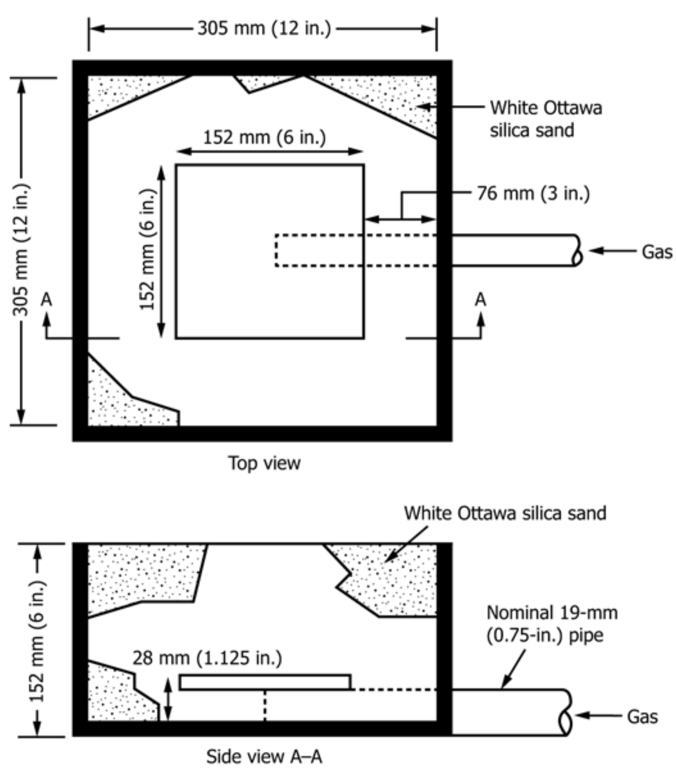


FIG. 28 Burner for Individual Fuel Package Calorimeter (NFPA 289)

10.7.2 The ignition source used in NFPA 265 uses the same burner described in 10.6 but the gas flow rates used are as follows: 40 kW for 5 min. and 150 kW for a further 10 min. The ignition source is placed at a distance of 50 mm from each wall in one corner.

10.7.3 The ignition source used in NFPA 286 uses the same burner described in 10.6 but the gas flow rates used are as follows: 40 kW for 5 min. and 160 kW for a further 10 min. The ignition source is placed flush against the two walls in a corner.

10.8 *Square Tube Propane Burner:*

10.8.1 This burner is described in Test Method E1537, a test method for assessing fire-test response characteristics of upholstered furniture. See Fig. 29 and Fig. 30.

10.8.2 The burner is constructed with 250 ± 10 by 250 ± 10 mm of 13 ± 1 mm outside diameter, stainless steel tubing, with 0.89 ± 0.05 mm wall thickness. The front side has 14 holes pointing straight out and spaced 13 ± 1 mm apart, and nine holes pointing straight down and spaced 13 ± 1 mm apart. The right and left sides have six holes pointing straight out and spaced 13 ± 1 mm apart, and four holes pointing inward at a 45° angle and spaced 50 ± 2 mm apart. All holes are of 1 ± 0.05 mm diameter. The straight arm of the burner is 1.07 ± 0.05 m long and welded on to the rear of the front side at a 30° angle. Mount the burner on an adjustable height pole at a height of 460 ± 13 mm and balance it by a counterweight or other appropriate mechanism.

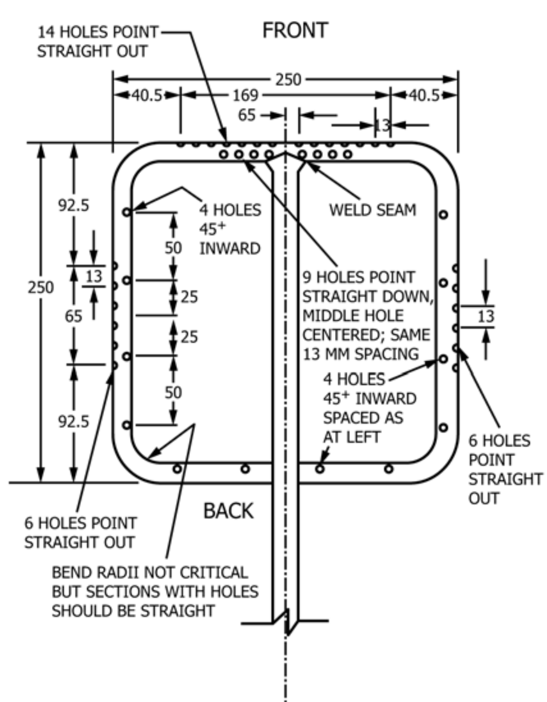
10.8.3 The ignition source uses propane gas, with a known net heat of combustion of 46.5 ± 0.5 MJ/kg, as the fuel for this ignition source. The flow rate of propane is metered and kept constant throughout the test. The gas flow rate is 13 ± 0.25 L/min and is used for a total of 80 s. The gas flow rate is measured at a pressure of 101 kPa (standard atmospheric pressure, measured at the flow gage) and a temperature of 20°C.

10.9 *T-shaped Propane Burner:*

10.9.1 This ignition source is described in Test Methods E1590 and E1822, test methods for assessing fire-test response characteristics of mattresses and stacked chairs. See Fig. 31.

10.9.2 The gas burner is constructed in the shape of a T. The burner is made of stainless steel, with wall thicknesses of 0.89 ± 0.05 mm. The head of the T is constructed to be 205 ± 10 mm long and 13 ± 1 mm in outer diameter. The ends of the T are plugged. The burner is constructed with two sets of holes equally spaced and centered along the head of the burner and oriented 90° to one another. One set consists of 14 holes and the other of nine holes, with each hole spaced 13 ± 1 mm from the next. The holes are 1 ± 0.04 mm in diameter.

10.9.3 The handle of the burner is constructed of stainless steel, with the same diameter and thickness as the head and is welded to the head. When the 14 holes in the head are oriented 45° above the horizontal and the nine holes are oriented 45° below the horizontal, the handle is approximately 30° above the horizontal. The handle is constructed such that it is at least 450 mm long, in order to facilitate its attachment to the support and the propane line. To deliver the propane to the burner, flexible tubing is used to feed into the handle of the burner. The flow rate of propane is maintained constant while the propane gas flame is lit. The burner is mounted on an adjustable pole, with a counterweight if necessary, in order to allow the burner



NOTE 1—All tubing 13 mm outside diameter, stainless steel, 0.89 mm wall thickness.
NOTE 2—All holes 1 mm in diameter.
NOTE 3—All units are mm unless otherwise noted.

FIG. 29 Plan View of Square Gas Burner (Test Method E1537)

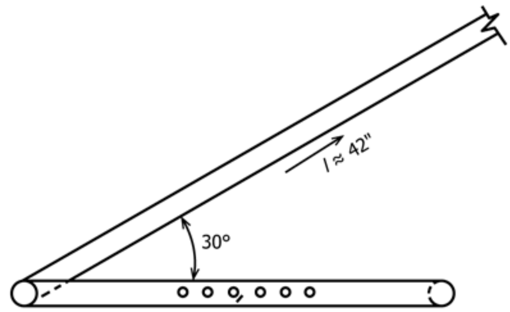


FIG. 30 Side View of Square Gas Burner (Test Method E1537)

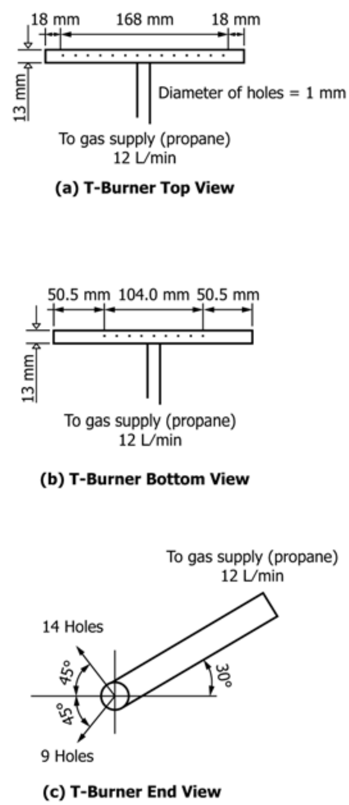


FIG. 31 View of T-shaped Gas Burner (Test Method E1590): (a), Burner Head Showing Top Set of Holes; (b), Burner Head Showing Bottom Set of Holes and (c), Side View of Burner Showing Orientation of the Head with the Handle

to be positioned in the proper location for ignition of the test specimen and then swung out of the way after the propane gas flame is turned off.

10.9.4 Propane gas, with a known net heat of combustion of 46.5 ± 0.5 MJ/kg, is used as the fuel for this ignition source. The flow rate of propane is metered and kept constant throughout the test. The gas burner is used at a flow rate of 12 ± 0.25 L/min for a total of 180 s. The gas flow rate is measured at a pressure of 101 kPa (standard atmospheric pressure, measured at the flow gage) and a temperature of 20 °C.

10.10 *Dual T-shaped Propane Burner:*

10.10.1 This ignition source is described in 16 CFR 1633 and in ISO 12949, which are test methods for assessing fire-test response characteristics of mattresses.

10.10.2 The ignition source consists of two T-shaped burners. One burner impinges flames on the top surface of the upholstery item. The second burner impinges flames on the side of the upholstery item. Each of the burners is constructed from stainless steel tubing, 12.7 mm in diameter with 0.89 ± 0.5 mm wall thickness. Each burner needs to incorporate a standoff foot to set its distance from the test specimen surface. Both burners are mounted with a mechanical pivot point, but the side burner is locked in place to prevent movement about this pivot in normal usage. The top burner, however, is free to rotate about its pivot during a burner exposure and is lightly weighted so as to exert a downward force on the upholstery item top through its stand-off foot so that the burner follows a receding top surface on the test specimen. The combination of burner stand-off distance and propane gas flow rate to the burners determines the heat flux they impose on the surface of the test specimen so that both of these parameters are tightly controlled.

10.10.3 *Top Surface Burner*—The T head of the top surface burner (or horizontal burner) is 305 ± 2 mm long with gas tight plugs in each end. Each side of the T contains 17 holes equally spaced over a 135 mm length, 8.5 ± 0.1 mm apart. The holes on each side begin 8.5 mm from the centerline of the burner head. The holes are drilled with a #56 drill and are to be 1.17 to 1.22 mm in diameter. The holes are pointed 5° out of the plane. This broadens the width of the heat flux profile imposed on the surface of the test specimen.

10.10.4 *Side Surface Burner*—The T head of the side surface burner (vertical burner) is constructed similarly to the top surface burner, except that its overall length is 254 ± 2 mm. Each side of the burner head contains 14 holes spaced evenly over a 110 mm length, 8.5 ± 0.1 mm apart. The holes are drilled with a #56 drill and are to be 1.17 to 1.22 mm in diameter. The holes are pointed 5° out of the plane.

10.10.5 *Burner Stand-Off*—The burner stand-off on each burner consists of a collar fixed by a set screw onto the inlet tube of the burner head. The collar holds a 3 mm diameter stainless steel rod having a 12.7 × 51 mm long, 2 to 2.5 mm-thick stainless steel pad welded on its end with its face (and long axis) parallel to the T head of the burner. The foot pad needs to be displaced about 10 to 12 mm from the longitudinal centerline of the burner head so that it does not rest on the test specimen in an area of peak heat flux. A short section (9.5 mm outer diameter, about 80 mm long) of copper tubing is placed in the inlet gas line just before the burner, to facilitate making the burner nominally parallel to the test specimen surface (by a procedure described in this section). The copper tube on the top surface burner needs to be protected from excessive heat and surface oxidation by wrapping it with a suitable layer of high temperature insulation. Both copper tubes are to be bent by hand in the burner alignment process. They need to be replaced if they become work-hardened or crimped in any way. The gas inlet lines (12.7 mm OD stainless steel tubing) serve as arms leading back to the pivot points and beyond, as shown in Fig. 6 of this part. The length to the pivot for the top burner is approximately 1000 mm.

10.10.6 *Burner Frame*—A frame holds the burners and their pivots, which are adjustable vertically in height. All adjustments (burner height, burner arm length from the pivot point, counterweight positions along the burner arm) are facilitated by the use of knobs or thumbscrews as the set screws. The three point footprint of the burner frame, with the two forward points on wheels, facilitates burner movement and burner stability when stationary.

10.10.7 *Burner Arms*—The metal arms attached to the burners are attached to a separate gas control console by flexible, reinforced plastic tubing (6 mm ID by 9.5 mm OD). The gas control console is mounted separately so as to facilitate its safe placement outside of the test room throughout the test procedure. The propane gas lines running between the console and the burner assembly are anchored on the assembly before running to the burner inlet arms. A 1.5 m ± 25 mm length of flexible, reinforced tubing between the anchor point and the end of each burner inlet allows free movement of the top burner about its pivot point. The top burner arm has a pair of moveable cylindrical counterweights that are used, as described below, to adjust the downward force on the stand-off foot.

10.10.8 *Burner Head*—Each burner head has a separate pilot light consisting of a 3 mm OD copper tube with an independently controlled supply of propane gas. The tube terminates within 10 mm of the center of the burner head. It is essential to set the pilot flame size small enough so as not to heat the test specimen before the timed burner exposure is begun.

10.10.9 Use propane gas, with a known net heat of combustion of 46.5 ± 0.5 MJ/kg, as the fuel for this ignition source. Meter the flow rate of propane and keep it constant throughout the test. Use the top gas burner at a flow rate of 12.9 ± 0.1 L/min for a total of 70 s. Use the side gas burner at a flow rate of 6.6 ± 0.05 L/min for a total of 70 s. Measure the gas flow rate at a pressure of 101 ± 5 kPa (standard atmospheric pressure, measured at the flow gage) and a temperature of 20 ± 5°C.

10.11 *Burners from ISO 9705 Room Corner Test:*

10.11.1 The default ignition source from ISO 9705 is a propane gas burner having a nominal 170 by 170 mm square top surface layer of a porous, inert material. The top portion of the porous material is a minimum 45 mm of sand. The construction is such that even gas flow is achieved over the entire opening area.

10.11.1.1 The burner is ignited with a remote-controlled ignition device, for example a pilot burner or a spark igniter, and is provided with controls for gas supply shut-off if flameout occurs or if there is a gas leak.

10.11.1.2 The burner is placed on the floor in a corner opposite to the doorway wall. The top surface of the burner through which the gas is supplied is located horizontally, 145 mm off the floor, and the burner enclosure is in contact with both walls in the corner. The burner walls are in contact with the specimen.

10.11.1.3 The burner is supplied with natural grade propane of at least 95 % purity and the gas flow to the burner is measured throughout the test with an accuracy of at least ±3 %, with the heat output to the burner controlled within ±5 % of the prescribed value. Flow rates of gas are calculated using a net heat of combustion of propane of 46.4 MJ/kg.

10.11.1.4 This ignition source is typically used with a net heat output of 100 kW during the first 10 min after ignition and then increased to 300 kW for a further 10 min.

10.11.2 An alternative ignition source for ISO 9705 is the same burner defined in 10.6.

10.12 *Premixed Burner for Lightweight Vertical Fabrics:*

10.12.1 This burner, described in NFPA 701, test method 1, and intended for vertical test specimens, consists of a tapered laboratory burner with grid-top adjustable channels, which provide a premixed flame.

10.12.2 The burner fuel is methane gas that is at least 97 % pure. The gas is contained in a cylinder equipped with a pressure-reducing valve and gauges to allow maintenance of a pressure of 17.5 ± 2.0 kPA at the flow gauge. The gas flow rate is measured and controlled by means of a gas flow gauge with a flow control valve. Hose or tubing with at least a 6-mm bore is used. The control valve at the tank is not to be used to control the flow through the flow gauge. The flow valve at the tank is fully open during the test.

10.12.3 The burner is placed so that it is 25 ± 2 mm from the face of the test specimen and with the center axis of the burner horizontal and perpendicular to the bottom of the center seam in the test specimen. Position adjustments are made by moving the support base and by adjusting the height and angle of the burner.

10.12.4 The gas is turned on fully at the burner control valve and allowed to flow for 20 ± 1 s before it is ignited.

10.12.4.1 The center of the lower edge of the test specimen is exposed to the igniting flame for 45 ± 1 s.

10.12.4.2 After the 45-s exposure, the burner is turned on its mount so that its center axis is parallel to the plane of the specimen, and then the gas flow is turned off using the control valve on the burner.

11. Other Sources

11.1 *Paper Ignition Sources*—A variety of ignition sources have been based on paper. Typically they have been replaced by gas burners, but they often still exist as alternative ignition sources, primarily in non-mandatory appendixes. However, they are still used in some instances for regulatory purposes. Examples of paper ignition sources can be found in the appendixes of the test method used for school bus seat assemblies (Test Method E2574/E2574M) and of the test method used for upholstered furniture (Test Method E1537). Further details of these paper bags are discussed below.

11.1.1 *Paper Bag in Test Method E2574/E2574M Appendix*—The ignition source is a paper bag with approximate dimensions of 180 by 280 by 460 mm, containing enough double sheets of newspaper (black print only, approximately 560 by 710 mm in size) so that the total combined mass of paper is 200 ± 15 g. The paper is crumpled loosely, to fit inside the bag.

NOTE 6—The sheets of newspaper used are best free of photographs and have a typical amount of writing.

11.1.2 *Paper Ignition Sources in Metal Containers*—Both California Technical Bulletin 133 and California Technical Bulletin 121 contain ignitions sources consisting of paper in a metal container, as described below.

11.1.2.1 California Technical Bulletin 133 includes three ignition sources, with paper contained in a steel box, differing only in the design of the steel box. Each ignition source consists of five double sheets of loosely wadded newspaper (black print only). Each double sheet of newspaper has dimensions of 560 by 710 mm with the total weight of newspaper being 90 ± 5 g. The newspaper is not tightly crumpled, but loosely wadded to approximately fill the selected ignition box. This ignition source is used to assess the burning behavior of upholstered furniture, and the test specimen is an upholstered furniture item or a full-scale mock-up. The ignition box is placed on the seating area of the upholstered furniture test specimen.

(1) It has been shown that the intensity of this ignition source is equivalent to that of the square tube gas burner in 10.8.[13]

11.1.2.2 California Technical Bulletin 121 contains an ignition source with paper contained in a galvanized metal container. The ignition source consists of 10 double sheets of loosely wadded newspaper. Each newsprint double sheet has approximate dimensions of 584 by 711 mm and an approximate weight of 18.5 ± 0.5 g. The container is approximately 254 mm high, 318 mm in top diameter, and 229 mm in bottom diameter. The newsprint is positioned in the container so that it is approximately level with the top of the container. This ignition source is used to assess the burning behavior of mattresses and the test specimen is a mattress for a single person. The container with the newsprint is placed beneath the mattress and supported such that the center of the container is at the geometric center of the bottom mattress surface. The height of the mattress support is adjusted so that the bottom surface of the mattress is 26 ± 6 mm above the top of the metal container.

11.2 *Wood Cribs*—Various different types of wood cribs have been used as ignition sources and, in some cases, are still being used. The most common ones are large wood crib ignition sources used for building materials (such as in large tests in UL 1040, UL 1715 or FM 4880) and they are addressed in 11.2.1. Wood ignition sources are also used, in smaller scale, for upholstered furniture composites, as discussed in 11.2.2. Wood cribs used as burning brands in Test Method E108 are discussed in 11.2.3.

11.2.1 *Large Wood Cribs:*

11.2.1.1 *Wood Crib used in UL 1040*—This wood crib is used to ignite test specimens placed on a roof above two walls. The wood crib weighs 347 ± 4.5 kg and has dimensions of 1.22 by 1.22 m by a height of 1.07 m. The wood crib is constructed of 12 tiers of strips of kiln dried spruce, pine, fir, or other soft wood having a density similar to those named. The wood is dried to a moisture content of 9 – 13 %. Each strip is nominally 1.22 m long and has a cross section of nominally 38 by 89 mm. Within the crib, the strips in each tier are placed at right angles to the strips in the tier below. The wood crib is placed 305 mm from each wall in the corner. The wood crib is ignited with two torches formed from 89 by 152 mm long rolls of cotton waste, each saturated with 0.23 kg of alcohol or n-heptane.

11.2.1.2 *Wood Crib used in UL 1715*—This wood crib is used to ignite test specimens placed on walls, ceiling or both walls and ceiling of a test room comprised of three walls and a ceiling. The wood crib weighs nominally 13.61 ± 0.45 kg and has dimensions of 381 by 381 by 381 mm. The wood crib is constructed of 10 tiers of strips of spruce, pine, or fir lumber. Each strip is nominally 381 mm long and has a cross section of 38 by 38 mm. Each tier consists of five parallel strips arranged with equal spacing between strips. Within the tier the strips are placed at right angles to the strips in the tier below. Adjacent

[13] Ohlemiller, T. J., and Villa, K., "Furniture Flammability: An Investigation of the California Technical Bulletin 133 Test, Part II: Characterization of the Ignition Source and a Comparable Gas Burner," NISTIR 90-4348, 1990.

tiers are fastened to each other by chisel-point staples of nails at each point of contact between strips. The wood crib is conditioned at 48.9 ± 5.5°C and 20 ± 5 % relative humidity until constant weight is achieved. Immediately prior to the test, the weight of the wood crib is adjusted to 13.61 ± 0.45 kg by the addition of conditioned strips. The wood crib is placed above a set of four bricks, each nominally 102 by 102 by 76 mm, positioned to provide a 76 mm space between the floor and the lower surface of the crib. A pile of shredded wood excelsior, fully fluffed, weighing 0.45 kg is to be arranged between the bricks and is to cover an area approximately 533 by 533 mm. The excelsior is to be wetted with 18 mL of absolute ethyl alcohol and the crib set in place at a distance of 25 mm from each wall in the corner. The excelsior is ignited at several points using a fireplace match or equivalent.

11.2.1.3 *Wood Crib used in FM 4880*—This wood crib is used to ignite test specimens placed in a corner on either two walls or two walls and a ceiling. The wood crib consists of conditioned oak pallets (with 6.1 % moisture content), weighing 340 ± 4.5 kg and measuring 1065 by 1065 mm. The pallets are stacked a minimum of 1.5 m high at the intersection (corner) of assembly walls and placed 305 mm from each wall. The stack of pallets is ignited with two cellucotton rolls soaked in 0.24 L of gasoline in a plastic bag placed inside the bottom pallet in the stack.

11.2.2 *Materials for Small Wood Cribs*—These ignition sources are described in British Standard BS 5852. The wood cribs in 11.2.2.6 through 11.2.2.9 are constructed with wood and cotton, in accordance with 11.2.2.1 through 11.2.2.4.

11.2.2.1 Dry softwood pine lumber (ponderosa pine) that has been conditioned to constant humidity in accordance with 11.2.2.4 is used as the wood.

11.2.2.2 Long-fiber, pure, dry, untreated, surgical grade cotton not more than 6 mm and not less than 4 mm thick is used as the cotton. The cotton needs to be kept in a desiccator until just prior to use.

11.2.2.3 The wood cribs are constructed so that the sticks in each layer are parallel to one another and at right angles to the sticks in the adjacent layer. The sticks in each layer are placed as far away from each other as possible (except for the two main cribs forming the base of crib 6), without overlap at the ends, forming a square-sectioned crib. The sticks are glued together with wood adhesive. Cotton, in accordance with 11.2.2.2, is placed at the bottom of the cribs, with the "fluffy" side up. The cotton is glued to the sticks at the bottom of the crib with minimal amounts of wood adhesive.

11.2.2.4 The wood cribs are conditioned in a controlled environment with a constant humidity of 50 ± 5 % relative humidity at 23 ± 3°C until they reach constant weight.

11.2.2.5 These ignition sources are applied in BS 5852 to determine the burning behavior of upholstered furniture composites or complete items of upholstered furniture.

(1) The test specimens consist of either (a) upholstered furniture mock-ups (with both a vertical and a horizontal cushion), representative of an upholstery material and a filling material (or foam), with or without an interliner, or (b) of acutal upholstered furniture items. The two cushions comprising the test specimen are placed in a metal frame.

(2) The wood crib is placed on the test specimen so that the bottom of the crib rests nests at the junction between the vertical and horizontal portions of the test specimen, with the lint at the bottom of the crib and with the crib touching the vertical face of the test specimen and the bottom stick of the crib placed horizontally.

11.2.2.6 *Crib 4*—The crib is constructed with ten sticks, each of which is 40 ± 2 mm long and has a square section of 6.5 ± 0.5 mm. There are 5 layers of 2 sticks each. The total mass of sticks is 8.5 ± 0.5 g. The bottom of the crib is covered by a flat horizontal layer of cotton approximately 40 by 40 mm in area. This crib has been estimated to have an approximate intensity of 125 W.

11.2.2.7 *Crib 5*—The crib is constructed with 20 sticks, each of which is 40 ± 2 mm long and has a square section of 6.5 ± 0.5 mm. There are 10 layers of 2 sticks each. The total mass of sticks is 17.0 ± 1.0 g. The bottom of the crib is covered by a flat horizontal layer of cotton approximately 40 by 40 mm in area. This crib has been estimated to have an approximate intensity of 250 W.

11.2.2.8 *Crib 6*—The crib consists of an outside crib and an inside crib. The outside crib is constructed with eight sticks, each of which is 80 ± 2 mm long and has a square section of 12.5 ± 0.5 mm. There are 4 layers of 2 sticks each. The inside crib is constructed with 10 sticks, each of which is 40 ± 2 mm long and has a square section of 6.5 ± 0.5 mm. There are 5 layers of 2 sticks each. The total mass of sticks is 60.0 ± 2.0 g. The bottom of the inside crib is covered by a flat horizontal layer of cotton approximately 40 by 40 mm in area. This crib has been estimated to have an approximate intensity of 900 W.

11.2.2.9 *Crib 7*—The crib consists of an outside crib and an inside crib. The outside crib is constructed with 18 sticks, each of which is 80 ± 2 mm long and has a square section 12.5 ± 0.5 mm. There are 9 layers of 2 sticks each. The inside crib is constructed with 8 sticks, each of which is 40 ± 2 mm long and has a square section of 6.5 ± 0.5 mm. There are 5 layers of 2 sticks each. The total mass of sticks is 126.0 ± 4.0 g. The bottom of the inside crib is covered by a flat horizontal layer of cotton approximately 40 by 40 mm in area. This crib has been estimated to have an approximate intensity of 2 kW. It has been estimated that this crib has an intensity approximating that of 4 double sheets of full size newspaper.

11.2.3 Wood cribs used as burning brands for roofing ignition (Test Method E108).

11.2.3.1 Three sizes of wood cribs are used in Test Method E108, namely Class A, Class B, and Class C brands. Before application to the roof deck, the brands are ignited by subjecting them, for a required period of time, to the flame of a gas burner of such size that, during the process of ignition, the brands are enveloped in the burner flame.

11.2.3.2 The Class A test brand consists of a grid 305 mm (12 in.) square and approximately 57 mm (2¼ in.) thick, made of dry Douglas fir lumber free of knots and pitch pockets. Use 36 nominal 25 by 25 by 305 mm (1 by 1 by 12 in.) strips, dressed on all four sides to 19 by 19 mm (¾ by ¾ in.) and placed in three layers of twelve strips each with strips spaced 6.4 mm (¼ in.) apart. Place these strips at right angles to those in adjoining layers and nail at each end of each strip on one face and in a diagonal pattern on the other face. The dry weight of the finished brand is 2000 ± 150 g at the time of test.

(1) Nails used in the construction of Class A brands are No. 16, 38 mm (1½ in.) long bright, flat head, diamond point, wire nails. Sixty-eight nails weighing approximately 42 g are used for Class A brands.

11.2.3.3 The Class B test brand consists of a grid 152 mm (6 in.) square and approximately 57 mm (2¼ in.) thick, made of dry Douglas fir lumber free of knots and pitch pockets. Use 18 nominal 25 by 25 by 152 mm (1 by 1 by 6 in.) strips placed in three layers of six strips each with strips spaced 6.4 mm (¼ in.) apart. Place these strips at right angles to those in adjoining layers and nail at each end of each strip on one face and in a diagonal pattern on the other face. The dry weight of the finished brand is 500 ± 50 g at the time of test.

(1) Nails used in the construction of Class B brands are No. 16, 38 mm (1½ in.) long bright, flat head, diamond point, wire nails. Thirty-two nails weighing approximately 21 g are used for Class B brands.

11.2.3.4 The Class C test brand consists of a piece of dry non-resinous white pine lumber, free of knots and pitch pockets, 38 by 38 by 19.8 mm (1½ by 1½ by 25⁄32 in.) thick with a saw kerf 3 mm (⅛ in.) wide, half the thickness of the brand across the center of the top and bottom faces. The saw kerfs on opposite faces are at right angles to each other. The dry weight of the finished brand is 9¼ ± 1¼ g at the time of the test.

12. Keywords

12.1 diffusion flame ignition; flaming ignition; glowing ignition; ignition source; non-flaming ignition; piloted ignition; premixed flame ignition; radiant heat; smoldering ignition