Designation: E 84 – 05ε1

An American National Standard

Standard Test Method for Surface Burning Characteristics of Building Materials[1]

This standard is issued under the fixed designation E 84; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ε[1] NOTE—Editorial corrections were made throughout in August 2005.

1. Scope

1.1 This fire-test-response standard for the comparative surface burning behavior of building materials is applicable to exposed surfaces such as walls and ceilings. The test is conducted with the specimen in the ceiling position with the surface to be evaluated exposed face down to the ignition source. The material, product, or assembly shall be capable of being mounted in the test position during the test. Thus, the specimen shall either be self-supporting by its own structural quality, held in place by added supports along the test surface, or secured from the back side.

1.2 The purpose of this test method is to determine the relative burning behavior of the material by observing the flame spread along the specimen. Flame spread and smoke developed index are reported. However, there is not necessarily a relationship between these two measurements.

1.3 The use of supporting materials on the underside of the test specimen has the ability to lower the flame spread index from those which might be obtained if the specimen could be tested without such support. These test results do not necessarily relate to indices obtained by testing materials without such support.

1.4 Testing of materials that melt, drip, or delaminate to such a degree that the continuity of the flame front is destroyed, results in low flame spread indices that do not relate directly to indices obtained by testing materials that remain in place.

1.5 The values stated in inch-pound units are to be regarded as the standard.

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

1.7 *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..*

1.8 *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]

A 390 Specification for Zinc-Coated (Galvanized) Steel Poultry Fence Fabric (Hexagonal and Straight Line)

C 1186 Specification for Flat Non-Asbestos Fiber-Cement Sheets

C 1396/C 1396M Specification for Gypsum Board

D 4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials

D 4444 Test Methods for Use and Calibration of Hand-Held Moisture Meters

E 69 Test Method for Combustible Properties of Treated Wood by the Fire-Tube Apparatus

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

E 160 Test Method for Combustible Properties of Treated Wood by the Crib Test[3]

E 162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

E 176 Terminology of Fire Standards

E 286 Test Method for Surface Flammability of Building Materials Using an 8-ft (2.44-m) Tunnel Furnace[3]

E 2231 Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface

[1] This test method is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.22 on Surface Burning.

Current edition approved Feb. 1, 2005. Published March 2005. Originally approved in 1950. Last previous edition approved in 2004 as E 84 – 04.

[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.

[3] Discontinued.

Burning Characteristics

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method refer to Terminology E 176. The term flame spread index from Terminology E 176 is of particular interest to this standard and is defined in 3.1.1.

3.1.1 *flame spread index*, *n*—a number or classification indicating a comparative measure derived from observations made during the progress of the boundary of a zone of flame under defined test conditions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *smoke developed index*, *n*—a number or classification indicating a comparative measure derived from smoke obscuration data collected during the test for surface burning characteristics.

3.2.2 *surface flame spread*, *n*—the propagation of a flame away from the source of ignition across the surface of the specimen.

4. Significance and Use

4.1 This test method is intended to provide only comparative measurements of surface flame spread and smoke density measurements with that of select grade red oak and fiber-cement board surfaces under the specific fire exposure conditions described herein.

4.2 This test method exposes a nominal 24-ft (7.32-m) long by 20-in. (508-mm) wide specimen to a controlled air flow and flaming fire exposure adjusted to spread the flame along the entire length of the select grade red oak specimen in 5½ min.

4.3 This test method does not provide for the following:

4.3.1 Measurement of heat transmission through the tested surface.

4.3.2 The effect of aggravated flame spread behavior of an assembly resulting from the proximity of combustible walls and ceilings.

4.3.3 Classifying or defining a material as noncombustible, by means of a flame spread index by itself.

5. Apparatus

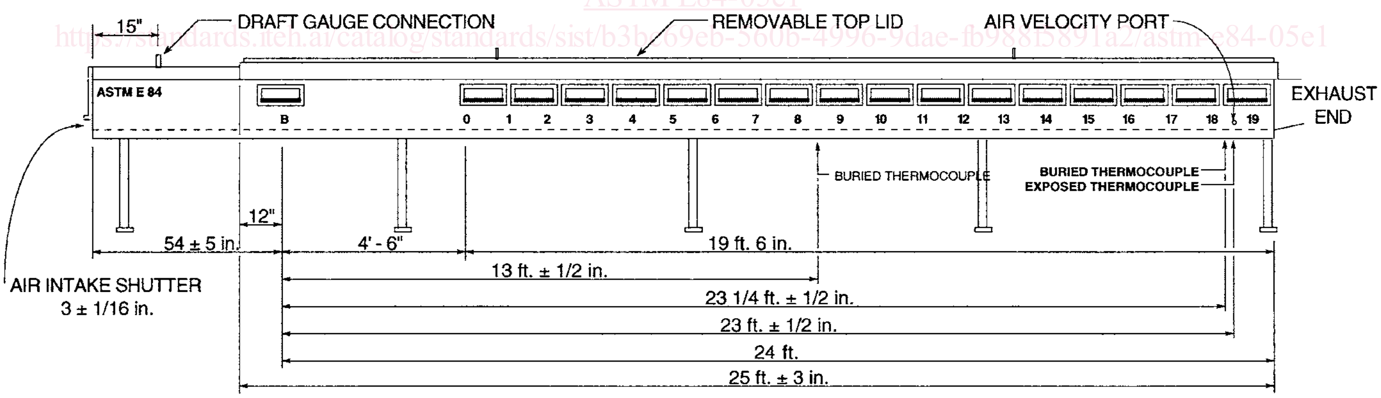
5.1 *Fire Test Chamber*—See Figs. 1-5.

5.1.1 The fire test chamber is a rectangular horizontal duct with a removable lid. The inside dimensions are as follows:

Width:	17 ¾ ± ¼ in. (451 ± 6.3 mm) measured between the top ledges along the side walls, and 17 ⅝ ± ⅜ in. (448 ± 10 mm) at all other points.
Depth:	12 ± ½ in. (305 ± 13 mm) measured from the bottom of the test chamber to the top of the ledges on which the specimen is supported. This measurement includes the ⅛ in. (3.2 mm) thickness of the 1 ½ in. (38 mm) wide woven fiberglass gasket tape.
Length:	25 ft ± 3 in. (7.62 m ± 76 mm).

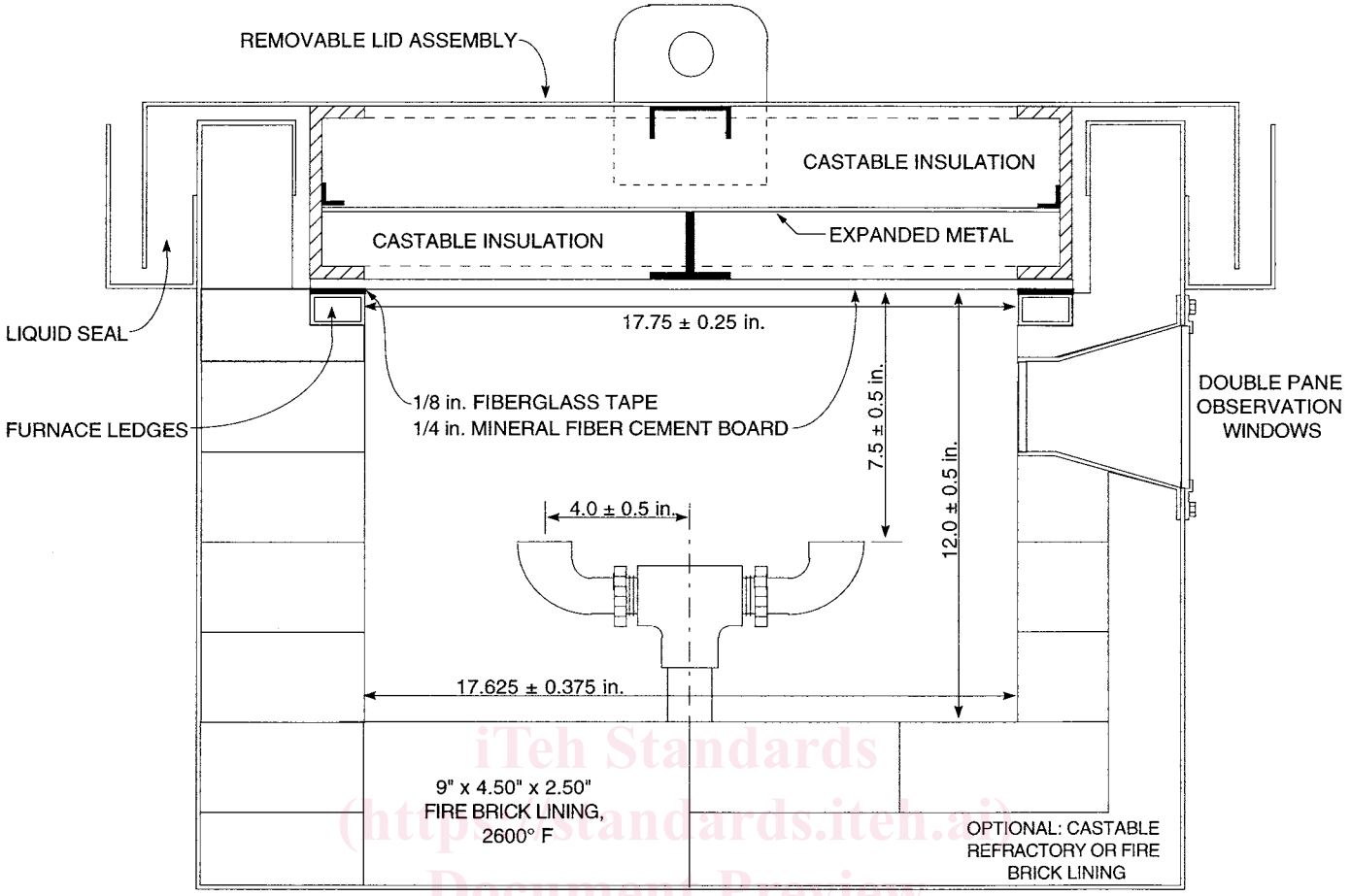
5.1.2 The sides and base of the chamber shall be lined with an insulating firebrick with the dimensions of 4 ½ in. by 9 in. by 2 ½ in. thick as illustrated in Fig. 2. The insulating firebrick shall have the following properties:

Maximum Recommended Temperature	2600°F	(1424°C)
Bulk Density	50 ± 3 lb/ft^3	(0.77 ± 0.046 g/cm^3)
Thermal Conductivity at Mean Temperature of	Btu•in./hr•ft^2•°F	W/m•°C
400°F (205°C)	1.7	0.24
800°F (425°C)	1.9	0.27
1200°F (650°C)	2.2	0.32
1600°F (870°C)	2.6	0.37
2000°F (1095°C)	3.2	0.46
2400°F (1315°C)	3.9	0.56



Inch–Pound Units	SI Units
3 ± 1/16 in.	76.2 ± 1.6 mm
12 in.	304.8 mm
15 in.	381 mm
54 ± 5 in.	1.37 m ± 127 mm
4 ft. 6 in.	1.37 m
19 ft. 6 in.	5.94 m
13 ft. ± 1/2 in.	3.96 m ± 12.7 mm
23 1/4 ft. ± 1/2 in.	7.1 m ± 12.7 mm
23 ft ± 1/2 in.	7.0 m ± 12.7 mm
24 ft.	7.32 m
25 ft. ± 3 in.	7.62 m ± 76.2 mm

FIG. 1 Test Furnace, Showing Some Critical Dimensions (Not a Construction Drawing)



Inch–Pound Units	SI Units	Inch–Pound Units	SI Units	Inch–Pound Units	SI Units
4.0 ± 0.5 in.	101.6 ± 13 mm	17.625 ± 0.375 in.	447.7 ± 9.5 mm	9 in.	228.6 mm
7.5 ± 0.5 in.	190.5 ± 13 mm	2600°F	1427°C	4.5 in.	114.3 mm
12.0 ± 0.5 in.	317.5 ± 13 mm	1/8 in.	3.2 mm	2.5 in.	63.5 mm
17.75 ± 0.25 in.	450.9 ± 6.4 mm	1/4 in.	6.4 mm		

FIG. 2 Test Furnace Showing Critical Dimensions (Not a Construction Drawing)

5.1.3 One side of the chamber shall be provided with double observation windows[4] with the inside pane flush mounted (see Fig. 2). Exposed inside glass shall be 2 ¾ ± ⅜ by 11 + 1, −2 in. (70 ± 10 by 279 + 25 − 50 mm). The centerline of the exposed area of the inside glass shall be in the upper half of the furnace wall, with the upper edge not less than 2.5 in. (63 mm) below the furnace ledge. The window shall be located such that not less than 12 in. (305 mm) of the specimen width can be observed. Multiple windows shall be located along the tunnel so that the entire length of the test sample is observable from outside the fire chamber. The windows shall be pressure tight in accordance with 7.2 and 7.2.1.

5.1.4 The ledges shall be fabricated of structural materials[5] capable of withstanding the abuse of continuous testing. The ledges shall be level with respect to the length and width of the chamber and each other. The ledges shall be maintained in a state of repair commensurate with the frequency, volume, and severity of testing occurring at any time.

5.1.5 *Lid*:

5.1.5.1 The lid shall consist of a removable noncombustible metal and mineral composite structure as shown in Fig. 2 and of a size necessary to cover completely the fire test chamber and the test samples. The lid shall be maintained in an unwarped and flat condition. When in place, the lid shall be completely sealed to prevent air leakage into the fire test chamber during the test.

5.1.5.2 The lid shall be insulated with a minimal thickness of 2 in. (51 mm) castable insulation or mineral composite material having physical characteristics comparable to the following:

Maximum effective use temperature of at least:	1200°F (650°C)
Bulk density	21 lb/ft^3 (336 kg/m^3)
Thermal conductivity at 300 to 700°F (149 to 371°C)	0.50 to 0.71 Btu·in./h·ft^2·°F (0.072 to 0.102 W/m·K)

5.1.5.3 The entire lid assembly shall be protected with flat sections of nominal ¼-in. (6.3-mm) fiber-cement board meeting the properties of Annex A3. This protective board shall be

[4] Heat-resistant glass, high-silica, 100 % silica glass, nominal ¼-in. thick has been found suitable for the interior pane. Borosilicate glass, nominal ¼-in. thick has been found suitable for the exterior pane.

[5] High-temperature furnace refractory. Zirconium silicate, or water-cooled steel tubing have been found suitable for this purpose.

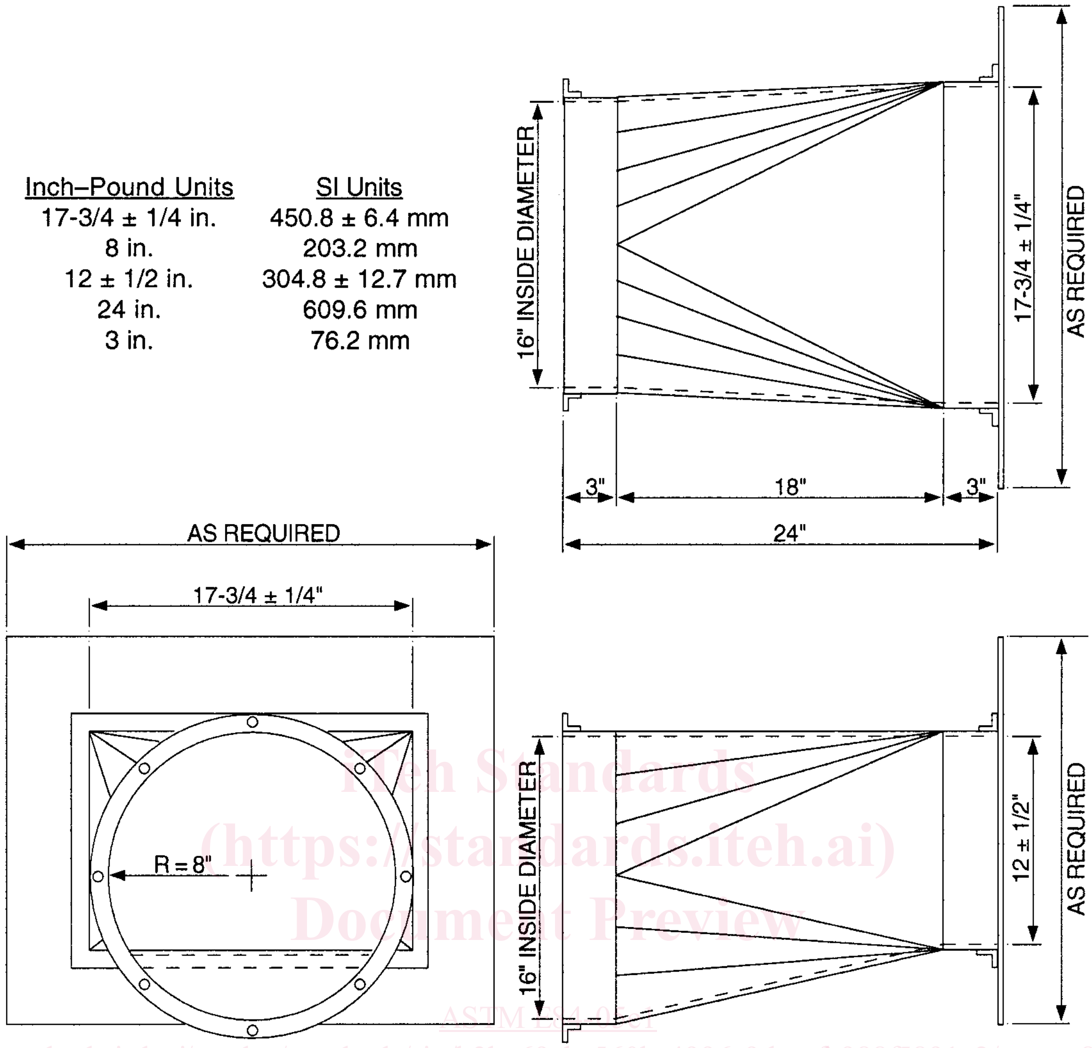


FIG. 3 Typical Exhaust End Transition (Not a Construction Drawing)

maintained in sound condition through continued replacement. The protective board is to be secured to the furnace lid or place on the back side of the test specimen.

5.1.6 *Gas Burners*:

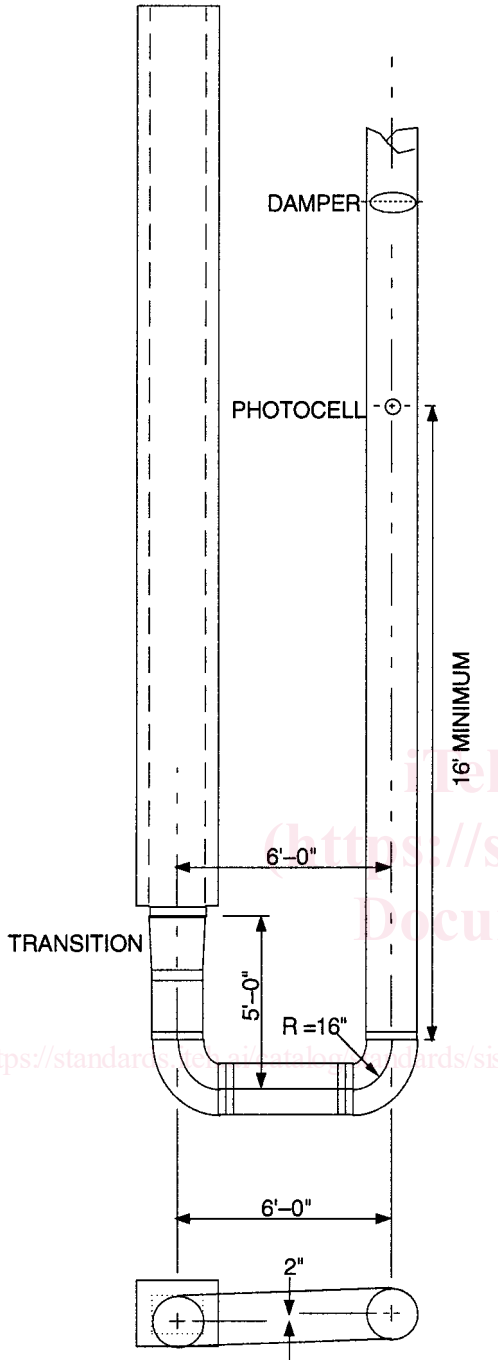
5.1.6.1 One end of the test chamber shall be designated as the "fire end". This fire end shall be provided with two gas burners delivering flames upward against the surface of the test sample (see Fig. 2). The burners shall be spaced 12 in. (305 mm) from the fire end of the test chamber, and 7 ½ ± ½ in. (190 ± 13 mm) below the under surface of the test sample. Gas to the burners shall be provided through a single inlet pipe, distributed to each port burner through a tee-section. The outlet shall be a ¾ in. NPT elbow. The plane of the port shall be parallel to the furnace floor, such that the gas is directed upward toward the specimen. Each port shall be positioned with its centerline 4 ± ½ in. (102 ± 13 mm) on each side of the centerline of the furnace so that the flame is distributed evenly over the width of the exposed specimen surface (see Fig. 2).

5.1.6.2 The controls used to assure constant flow of gas to the burners during period of use shall consist of a pressure regulator, a gas meter calibrated to read in increments of not more than 0.1 ft^3 (2.8 L), a manometer to indicate gas pressure in inches of water, a quick-acting gas shut-off valve, and a gas metering valve.

5.1.7 *Air Intake*:

5.1.7.1 An air intake shutter shall be located 54 ± 5 in. (1372 ± 127 mm) upstream of the burner, as measured from the burner centerline to the outside surface of the shutter (see Fig. 1). The air intake is to be fitted with a vertically sliding shutter extending the entire width of the test chamber. The shutter shall be positioned so as to provide an air inlet port 3 ± 1⁄16 in. (76 ± 2 mm) high measured from the floor level of the test chamber at the air intake point.

5.1.7.2 To provide air turbulance for proper combustion, turbulance baffling shall be provided by positioning six refractory firebricks (as defined in 5.1.2) along the side walls of the chamber. With the long dimension vertical, 4 ½ in. (114-mm) dimension along the wall, place the bricks as follows from the centerline of the burner ports:



INCH-POUND UNITS	SI UNITS
16 in.	406.4 mm
2 in.	50.8 mm
5 ft.	1.52 m
6 ft.	1.83 m
16 - 40 ft.	4.88 - 12.2 m

FIG. 4 Plan View—Typical Duct System (Not a Construction Drawing)

On the window side at 7, 12, and 20 ± ½ ft (2.1, 3.7, and 6.1 ± 0.2 m)
On the opposite side at 4 ½ , 9 ½ , and 16 ± ½ ft (1.3, 2.9, and 4.9 ± 0.2 m)

5.1.7.3 The movement of air shall be by an induced draft system having a total draft capacity of at least 0.15 in. (3.8 mm) water column with the sample in place, the shutter at the fire end open the normal 3 ± 1⁄16 in. (76 ± 2 mm), and the damper in the wide open position. A draft gage tap to indicate static pressure shall be inserted through the top at the midwidth of the tunnel, 1 ± 0.5 in. (25 ± 12 mm) below the ceiling, 15 ± 0.5 in. (381 ± 12 mm) downstream from the inlet shutter (see Fig. 1).

5.1.8 *Exhaust End*:

5.1.8.1 The other end of the test chamber is designated as the exhaust end. The exhaust end shall be fitted with a gradual rectangular-to-round transition piece, not less than 20 in. (508 mm) in length, with a cross-sectional area of not less than 200 in.^{2} (1290 cm^2) at any point (see Fig. 3).

5.1.8.2 The transition piece shall in turn be fitted to a 16 in. (406 mm) diameter duct pipe. A typical duct system shown in Fig. 4 contains two 90° elbows (see Fig. 5) with the exhaust duct running beside the fire test chamber. In order to comply with this typical design, the vertical centerline of the exhaust duct system is identical to that of the fire test chamber.

5.1.8.3 The exhaust duct is to be insulated with at least 2 in. (51 mm) of high temperature mineral composition material from the exhaust end of the fire chamber to the photometer location.

5.1.8.4 An exhaust fan shall be installed at the end of the exhaust duct. The air flow shall be controlled as specified in 5.1.11.

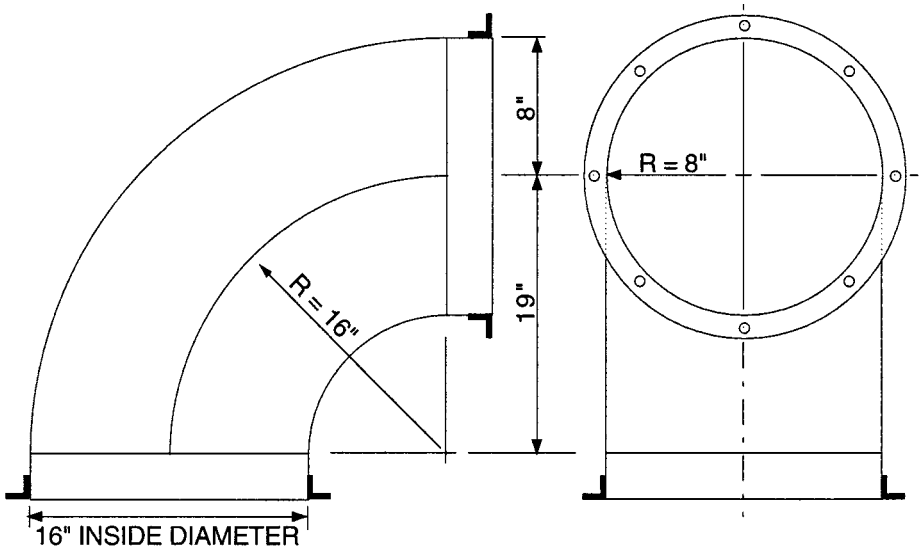
5.1.8.5 An alternative exhaust duct layout design shall demonstrate equivalency by meeting the requirements specified in Section 7.

5.1.9 *Photometer System*:

5.1.9.1 A photometer system consisting of a lamp[6] and photocell[7] shall be mounted on a horizontal section of the 16-in. (406-mm) diameter vent pipe at a point where it will be preceded by a straight run of pipe (at least 12 diameters or 16 ft (4.88 m) and not more than 30 diameters or 40 ft (12.19 m) from the vent end of the chamber, and with the light beam directed upward along the vertical axis of the vent pipe. The vent pipe shall be insulated with at least 2 in. (51 mm) of high-temperature mineral composition material, from the vent end of the chamber to the photometer location. The photoelectric cell of which the output is directly proportional to the amount of light received shall be mounted over the light source and connected to a recording device having a minimum operating chart width of 5 in. (127 mm) with an accuracy within ±1 % of full scale, for indicating changes in the attenuation of incident light by the passing smoke, particulate, and other effluent. The distance between the light source lens and the photocell lens shall be 36 ± 4 in. (914 ± 102 mm). The

[6] The sole source of supply of the apparatus known to the committee at this time is 12-V sealed beam, clear lens, auto spot lamp, No. 4405, from General Electric, Nela Park, OH. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[7] The sole source of supply of the apparatus known to the committee at this time is No. 856BB from Weston Instruments, Wauconda, IL. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.



Inch–Pound Units	SI Units
16 in.	406.4 mm
8 in.	203.2 mm
19 in.	482.6 mm

FIG. 5 Typical Duct Elbow (Not a Construction Drawing)

cylindrical light beam shall pass through 3-in. (76-mm) diameter openings at the top and bottom of the 16-in. diameter duct, with the resultant light beam centered on the photocell.

5.1.9.2 Linearity of the photometer system shall be verified periodically by interrupting the light beam with calibrated neutral density filters. The filters shall cover the full range of the recording instrument. Transmittance values measured by the photometer, using neutral density filters, shall be within ±3 % of the calibrated value for each filter.

5.1.10 *Draft Regulating Device*:

5.1.10.1 An automatically controlled damper to regulate the draft pressure shall be installed in the vent pipe down-stream of the smoke-indicating attachment. The damper shall be provided with a manual override.

5.1.10.2 Other manual or automatic draft regulation devices, or both, are allowed to be incorporated to help maintain fan characterization and air-flow control throughout the test.

5.1.11 *Thermocouples*:

5.1.11.1 A No. 18 Awg (1.02-mm) thermocouple, with ⅜ ± ⅛ in. (9.5 ± 3.2 mm) of the junction exposed in the air, shall be inserted through the floor of the test chamber so that the tip is 1 ± 1/32 in. (25.4 ± 0.8 mm) below the top surface of the gasketing tape and 23 ft ± ½ in. (7.0 m ± 13 mm) from the centerline of the burner ports at the center of its width.

5.1.11.2 Two No. 18 Awg (1.02 mm) thermocouples are embedded below the floor surface of the test chamber. These thermocouples shall be mounted at distances of 13 ft ± ½ in. (3.96 m ± 13 mm) and 23 ¼ ft ± ½ in. (7.09 m ± 13 mm) measured from the centerline of the burner ports. The thermocouples shall be inserted from below the fire test chamber through the firebrick until the tip of the thermocouple is ⅛ ± 1/32 in. (3.2 ± 0.8 mm) below the floor surface. The tip of the thermocouples shall be covered with refractory or portland cement, carefully dried to avoid cracking.

6. Test Specimens

6.1 Specimens shall be representative of the materials which the test is intended to examine. The report shall include information on the composition needed for identification of the test specimen as described in 11.1.1.

6.2 The specimen shall be provided in one of two ways: (1) a continuous, unbroken length; (2) sections that will be joined or butted end-to-end.

6.3 The size of the test specimen shall be:

Width: between 20 and 24 in. (508 and 610 mm)

Length: 24 ft + 12 in. — 6 in.

Thickness: maximum 4 in. (101 mm).

NOTE 1—The test apparatus is not designed for testing at thicknesses greater than 4 in. (101 mm), but has the ability to be modified if required. This is accomplished through (a) modifications to the test apparatus lid to maintain an airtight seal, and (b) the introduction, usually of additional sample/lid supports above the test apparatus ledges. Due to the composition of some materials, test results obtained at a thickness greater than 4 in. (101 mm) will potentially vary from results of a test on the same material tested at a thickness of 4 in. (101 mm) or less.

6.4 The test specimen shall be conditioned to a constant weight at a temperature of 73.4 ± 5°F (23 ± 2.8°C) and at a relative humidity of 50 ± 5%.

6.5 The upstream end of the fire test chamber shall be filled with a 14 ± ⅛ —in. (356 ± 3 mm) length of uncoated 16–guage (0.053 to 0.060 in.) steel plate positioned on the specimen mounting ledge in front of and under the leading edge of the specimen.