

NFPA®

270

**Standard Test Method for
Measurement of Smoke
Obscuration Using a Conical
Radiant Source in a
Single Closed Chamber**

2018



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NFPA® 270

Standard Test Method for

Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber

2018 Edition

This edition of NFPA 270, *Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber*, was prepared by the Technical Committee on Fire Tests. It was issued by the Standards Council on November 10, 2017, with an effective date of November 30, 2017, and supersedes all previous editions.

This edition of NFPA 270 was approved as an American National Standard on November 30, 2017.

Origin and Development of NFPA 270

The first edition of this standard, in 1998, was based on the 1997 edition of NFPA 258, *Standard Research Test Method for Determining Smoke Generation of Solid Materials*, with minor revisions. Originally, NFPA 258 was used for research and product development. NFPA 270 was developed so that it could be used within the regulatory community for enforcement purposes. This document was developed under a different title and number designation so as not to confuse the end user, and to establish and clarify the intention and limitations that are now part of the standard.

The 2002 edition of this standard was updated to incorporate the *Manual of Style for NFPA Technical Committee Documents* requirements and editorial updates.

The 2008 edition of this standard contained mainly editorial revisions and revised definitions for consistency with other standards.

The 2013 edition of this standard reconfirmed of the previous edition with updates to referenced standards.

The 2018 edition updates the pressure sensor requirements to reflect modern technology and includes updates to referenced codes and standards.

Technical Committee on Fire Tests

Barry L. Badders, Jr., *Chair*
Intertek Testing Services, TX [RT]

Farid Alfawakhiri, American Iron and Steel Institute, IL [M]
James A. Burns, New York State Department, NY [E]
Rep. Firemen's Association of the State of New York
Karen C Carpenter, Southwest Research Institute, TX [RT]
Gordon H. Damant, Inter-City Testing & Consulting Corp. of California, CA [SE]
Rick D. Davis, National Institute of Standards & Technology, MD [RT]
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William E. Fitch, Phyrefish.com, FL [SE]
Richard G. Gann, Gaithersburg, MD [SE]
Marcelo M. Hirschler, GBH International, CA [SE]
Paul A. Hough, Armstrong World Industries, Inc., PA [M]
William E. Koffel, Koffel Associates, Inc., MD [SE]
Sergei V. Levchik, Israel Chemicals Ltd. (ICL-IP), NY [M]
Rep. ACC-North American Flame Retardant Alliance

James Andrew Lynch, The Fire Solutions Group, PA [SE]
John Martell, Professional Fire Fighters of Maine/IAFF, ME [L]
Rep. International Association of Fire Fighters
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Kathleen A. Newman, Firetect, CA [M]
Arthur J. Parker, JENSEN HUGHES, MD [SE]
Michael L. Savage, Sr., City of Rio Rancho, NM [E]
Michael Schmeida, Gypsum Association, OH [M]
David T. Sheppard, U.S. Bureau of Alcohol, Tobacco, Firearms & Explosives, MD [RT]
Dwayne E. Sloan, UL LLC, NC [RT]
Stanislav I. Stoliarov, University of Maryland, MD [SE]
Kuma Sumathipala, American Wood Council, VA [M]
Dong Zeng, FM Global, MA [I]
Rep. FM Global

Alternates

Erik H. Anderson, Koffel Associates, Inc., MD [SE]
(Alt. to William E. Koffel)

Jesse J. Beitel, JENSEN HUGHES, MD [SE]
(Alt. to Arthur J. Parker)

Richard J. Davis, FM Global, MA [I]
(Alt. to Dong Zeng)

Timothy Earl, GBH International, MI [SE]
(Alt. to Marcelo M. Hirschler)

Sam W. Francis, American Wood Council, PA [M]
(Alt. to Kuma Sumathipala)

Stephen Paul Fuss, U.S. Bureau of Alcohol, Tobacco, Firearms & Explosives, MD [RT]
(Alt. to David T. Sheppard)

Justin A. Geiman, Fire and Risk Alliance LLC, MD [SE]
(Alt. to James Andrew Lynch)

Karl Dana Houser, Intertek, PA [RT]
(Alt. to Barry L. Badders, Jr.)

Marc L. Janssens, Southwest Research Institute, TX [RT]
(Alt. to Karen C Carpenter)

Ineke Van Zeeland, Canadian Wood Council, Canada [M]
(Alt. to Rodney A. McPhee)

Matthew T. Vinci, International Association of Fire Fighters, DC [L]
(Alt. to John Martell)

Robert J. Wills, American Iron and Steel Institute, AL [M]
(Alt. to Farid Alfawakhiri)

Luke C. Woods, UL LLC, MA [RT]
(Alt. to Dwayne E. Sloan)

Joe Ziolkowski, American Furniture Manufacturers Association, NC [M]
(Voting Alternate)

Nonvoting

Robert H. Barker, American Fiber Manufacturers Association, VA [M]
Rep. American Fiber Manufacturers Association

Rohit Khanna, U.S. Consumer Product Safety Commission, MD [C]
Rep. U.S. Consumer Product Safety Commission

Tracy L. Vecchiarelli, NFPA Staff Liaison

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A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex E. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope.

1.1.1 This is a fire-test-response standard.

1.1.2* This test method provides a means of measuring smoke obscuration resulting from subjecting essentially flat materials, products, or assemblies (including surface finishes) not exceeding 25 mm in thickness to specified levels of thermal irradiance from a conical heater, in a single closed chamber, in the absence or presence of a pilot flame, and when placed in a horizontal orientation.

1.1.3 The principal fire-test-response characteristic obtained from this test method shall be the specific optical density of

smoke from the specimens tested, which is obtained as a function of time, for a period of 10 minutes.

1.1.4 Other fire-test-response characteristics are also permitted to be determined.

1.1.5 An optional fire-test-response characteristic measurable with this test method shall be the mass optical density, which is the specific optical density of smoke divided by the mass lost by the specimens during the test.

1.1.6 The fire-test-response characteristics obtained from this test are specific to the specimen tested, in the form and thickness tested, and are not inherent properties of the material, product, or assembly tested.

1.1.7* This test method does not provide information on the fire performance of the test specimens under fire conditions other than those conditions specified in this test method.

1.1.8 This standard measures and describes 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.

1.1.9* Fire testing of products and materials is inherently hazardous, and safeguards for personnel and property shall be employed in conducting these tests.

1.1.10 This standard does not purport to address all of the safety problems, if any, associated with its use.

1.1.11 It shall be the responsibility of the user of this standard to establish the necessary safety and health practices and determine the applicability of regulatory limitations prior to use.

1.2 Purpose. (Reserved)

1.3 Application.

1.3.1 Summary of Test Method.

1.3.1.1 Energy Source.

1.3.1.1.1 This test method shall employ a conically shaped, electrically heated radiant energy source contained within a stainless steel tube and positioned so as to produce an irradiance level of up to 50 kW/m², averaged over the center of the exposed surface of an essentially flat specimen, mounted horizontally, to determine smoke obscuration inside a closed chamber.

1.3.1.1.2 The actual irradiance levels used for standard testing shall be 25 kW/m² and 50 kW/m².

1.3.1.2 Specimen. The specimen shall be 75 mm × 75 mm at a thickness not exceeding 25 mm and shall be mounted horizontally within a holder.

1.3.1.3 Pilot Flame.

1.3.1.3.1 The exposure shall be conducted in the absence or in the presence of a pilot flame as described in 4.3.6.1.

1.3.1.3.2 Where the pilot flame is present, the test shall be deemed to be in the "flaming" mode; if the pilot flame is absent, the test shall be deemed to be in the "nonflaming" mode.

1.3.1.4 Light Transmissions.

1.3.1.4.1 The test specimens shall be exposed to nonflaming or flaming conditions within a closed chamber.

1.3.1.4.2 A photometric system with a vertical light path shall be used to measure the varying light transmission as smoke accumulates.

1.3.1.4.3 The light transmittance measurements shall be used to calculate the specific optical density of the smoke generated during the test.

1.3.1.5 Exposure.

1.3.1.5.1 The specimens shall be exposed to two conditions out of the four standard exposure conditions, to be chosen by the test requester.

1.3.1.5.2 The four standard exposure conditions shall be as follows:

- (1) Flaming at an irradiance of 25 kW/m²
- (2) Flaming at an irradiance of 50 kW/m²
- (3) Nonflaming at an irradiance of 25 kW/m²
- (4) Nonflaming at an irradiance of 50 kW/m²

1.3.1.5.3 The default conditions for testing, unless specified otherwise, shall be those in the flaming mode.

1.3.1.5.4 Exposures to other irradiances shall also be permitted.

1.3.1.6* Mass Optical Density. Mass optical density shall be an optional fire-test-response characteristic obtained from this test method by using a load cell that continuously monitors the mass of the test specimen.

1.3.2 Significance and Use.

1.3.2.1* Specific Optical Density.

1.3.2.1.1 This test method shall provide a means for determining the specific optical density of the smoke generated by specimens of materials, products, or assemblies under the specified exposure conditions.

1.3.2.1.2 Values determined by this test method shall be specific to the specimen in the form and thickness tested and shall not be inherent fundamental properties of the material, product, or assembly.

1.3.2.1.3 Closely repeatable or reproducible experimental results shall not be expected from this test method when tests are conducted for a given material, product, or assembly while introducing variations in properties such as specimen thickness or density.

1.3.2.2* Physiological Aspects. Physiological aspects associated with vision shall not be measured by this test method.

1.3.2.3* Smoke Obscuration. Predicting the smoke obscuration to be generated by the specimens upon exposure to heat or flame under any fire conditions other than those specified shall not be permitted.

1.3.3 Limitations.

1.3.3.1 Behavior. Any of the following behaviors during a test shall render that test invalid:

- (1) Self-ignition in the nonflaming mode

- (2) A specimen being displaced from the zone of controlled irradiance so as to touch the pilot burner or the pilot flame
- (3) Extinction of the pilot flame (even for a short period of time) in the flaming mode
- (4) Molten material overflowing the specimen holder

1.3.3.2* Data Evaluation. Evaluation of the data obtained, together with the individual masses, shall assist in assessing the reasons for any observed variation in measurements.

1.3.3.3* Sample Thickness. The results of the test shall apply only to the thickness of the sample being tested.

1.3.3.4* Sensitivity. Sensitivity to variations shall require that when changing to another sample to be tested, it shall first be necessary to clean and remove from the walls all accumulated residues to ensure that chemical or physical recombination with the effluents or residues produced as a result of the thermal irradiance does not affect the data obtained.

1.3.3.5* Test Conditions. Specimens shall be subjected to one or more specific sets of laboratory test conditions.

1.3.3.5.1 The results shall be valid only for the fire-test-exposure conditions described in this test.

1.3.3.5.2 This test method shall not be used to predict changes in the fire-test-response characteristics where different test conditions are substituted or end-use conditions are changed.

1.3.3.6* Optical Density. Information relating the specific optical density measurement obtained by this test method to the mass lost by the specimen during the test shall be obtained only by using the (optional) load cell to determine the mass optical density.

1.3.3.7* Dynamic Measurements. This test method shall not use dynamic measurements.

1.3.3.8 Smoke Obscuration. Therefore, the smoke obscuration values obtained shall not represent conditions of open fires.

1.4 Units and Formulas. The values stated in SI units shall be considered the required values of this standard.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. (Reserved)

2.3 Other Publications.

2.3.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E176, *Standard Terminology of Fire Standards*, 2015ae1.

2.3.2 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandinnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO 5659-2, *Plastics — Smoke generation — Part 2: Determination of optical density by a single-chamber test*, 3rd edition, 2012.

ISO 13943, *Fire safety — Vocabulary*, 2008.

2.3.3 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1 Shall. Indicates a mandatory requirement.

3.2.2 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions. For definitions of terms used in this test method, refer to the terminology contained in ASTM E176, *Standard Terminology of Fire Standards*, and ISO 13943, *Fire safety — Vocabulary*.

3.3.1 Assembly. A unit or structure composed of a combination of materials or products, or both.

3.3.2 Composite. A combination of materials that are generally recognized as distinct entities, for example, coated or laminated materials.

3.3.3 Continuous (as related to data acquisition). Conducted at data collection intervals of 5 seconds or less.

3.3.4 Exposed Surface. That surface of the specimen subjected to the incident heat.

3.3.5 Mass Optical Density (MOD). The ratio of the optical density of smoke to the mass loss of the test specimen, multiplied by the volume of the test chamber and divided by the length of the light path.

3.3.6 Sample. An amount of the material, product, or assembly to be tested that is representative of the item as a whole.

3.3.7 Self-ignition. The initiation of combustion as evidenced by the observed presence of flame.

3.3.8 Smoke Obscuration. The reduction of light transmission by smoke, as measured by light attenuation.

3.3.9 Time to Ignition. Time between the start of the test and the presence of a flame on or over most of the specimen surface for a period of at least 4 seconds.

Chapter 4 Test Apparatus

4.1 General. The apparatus shall consist of an airtight test chamber with provision for containing a sample holder, radiator cone, pilot burner, light transmission and measuring system, and other ancillary facilities for controlling the conditions of operation during a test as shown in Figure 4.1.

4.2 Test Chamber.

4.2.1 Fabrication. The test chamber shall be fabricated from laminated panels, the inner surfaces of which shall consist of either a porcelain-enameled metal not more than 1 mm thick or an equivalent coated metal that is resistant to chemical attack and corrosion and capable of being easily cleaned. (See Figure 4.1 and Figure 4.2.1.)

4.2.1.1 The internal dimensions of the chamber shall be 914 mm ± 3 mm long, 914 mm ± 3 mm high, as shown in Figure 4.2.1, and 610 mm ± 3 mm deep.

4.2.1.2 The chamber shall be provided with a hinged front-mounted door with an observation window and a removable opaque door cover to the window to prevent light from entering the chamber.

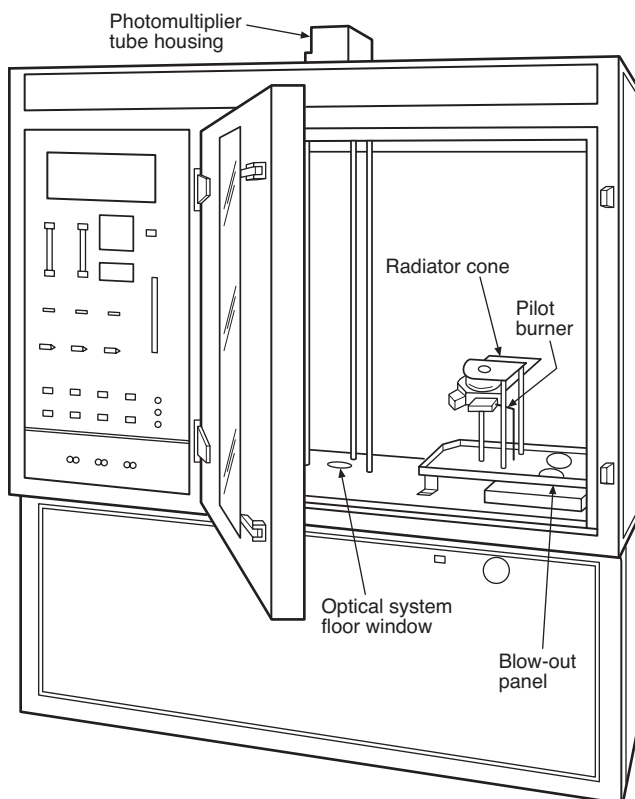


Figure 4.1 Typical Arrangement of Test Chamber.

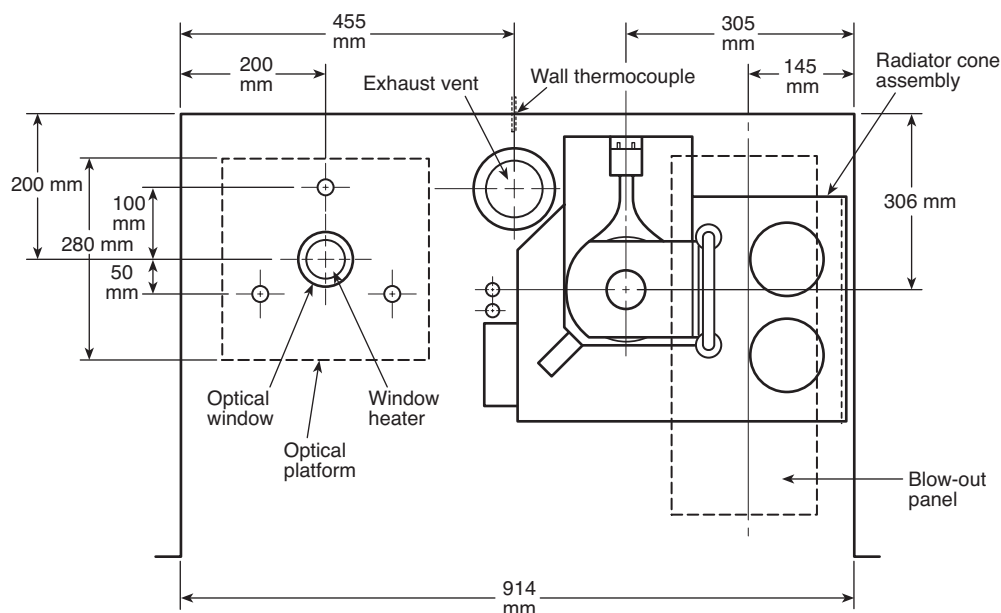


Figure 4.2.1 Plan View of Typical Test Chamber.

4.2.2* Panel. A safety blow-out panel consisting of a sheet of aluminum foil not greater than 0.04 mm thick and having a minimum area of 80,600 mm² shall be provided in the chamber, fastened in such a way as to provide an airtight seal.

4.2.3 Optical Windows.

4.2.3.1 Two optical windows, each with a diameter of 75 mm $\pm$ 1 mm, shall be mounted, one each in the top and the bottom of the cabinet, at the position shown in Figure 4.2.1, with their interior faces flush with the outside of the cabinet lining.

4.2.3.2* The underside of the window on the floor shall be provided with an electric heater of approximately 9 W capacity in the form of a ring, which shall be capable of maintaining the upper surface of the window at a temperature of at least 50°C and which shall be mounted around the window's edge so as not to interrupt the light path.

4.2.3.3 Optical platforms 8 mm $\pm$ 0.1 mm thick shall be mounted around the windows on the outside of the chamber and shall be held rigidly in position relative to each other by three metal rods, each with a diameter of at least 12.5 mm, extending through the chamber and fastened securely to the platforms.

4.2.4 Other Cabinet Openings.

4.2.4.1 Other openings in the cabinet shall be provided for the required services, as specified.

4.2.4.2 Cabinet openings shall be capable of being closed so that a positive pressure up to 1.5 kPa above atmospheric pressure can be developed inside the chamber as described in 4.2.6 and maintained when checked in accordance with Sections 4.6 and 7.6.

4.2.4.3 All components of the chamber shall be capable of withstanding a greater internal positive pressure than the safety blow-out panel.

4.2.5 Inlet Vent. An inlet vent with a shutter shall be provided at the top of the chamber, either on the front or on the roof, and away from the radiator cone, and an exhaust vent with a shutter shall be provided in the bottom of the chamber to lead, via flexible pipe with a diameter of 50 mm to 100 mm, to an extraction fan capable of creating a negative pressure of at least 0.5 kPa.

4.2.6* Chamber Pressure Control Facilities.

4.2.6.1 Provision shall be made for controlling the pressure inside the test chamber.

Δ 4.2.6.2 A pressure sensor (such as a manometer or pressure transducer) with a range up to 5 kPa shall be provided to monitor chamber pressure and leakage.

4.2.7 Thermocouple Junction.

4.2.7.1 A thermocouple measuring junction made from wires of a diameter not greater than 1 mm shall be mounted on the inside of the back wall of the chamber, at the geometric center, by means of an insulating disc (such as polystyrene foam) that has a thickness of 6.5 mm $\pm$ 0.2 mm and a diameter of not more than 20 mm attached with an adhesive intended for such purposes.

4.2.7.2 The thermocouple junction shall be connected to a recorder, meter, or data acquisition unit, and the system shall be capable of measuring temperatures in the range of 35°C to 60°C as described in 9.1.3.3.

4.3 Sample Support and Heating Arrangements.

4.3.1 Radiator Cone.

4.3.1.1 Heating Element. The radiator cone, as shown in Figure 4.3.1.1, shall consist of a heating element of nominal rating 450 W contained within a stainless steel tube, 2210 mm $\pm$ 5 mm in length and 6.5 mm $\pm$ 0.2 mm in diameter, coiled into the shape of a truncated cone and fitted into a shade.

4.3.1.1.1 The shade shall have an overall height of 45 mm $\pm$ 0.04 mm, an internal diameter of 55 mm $\pm$ 1 mm, and an internal base diameter of 110 mm $\pm$ 3 mm.

4.3.1.1.2 The shade shall consist of two layers of 1 mm $\pm$ 0.1 mm thick stainless steel with a 10 mm $\pm$ 0.5 mm thickness of ceramic fiber insulation of nominal density 100 kg/m³ sandwiched between them.

4.3.1.1.3 The heating element shall be clamped by two plates at the top and bottom of the element.

4.3.1.2 Radiator Cone Irradiance.

4.3.1.2.1 The radiator cone shall be capable of providing irradiance in the range of 10 to 50 kW/m² at the center of the surface of the specimen.

4.3.1.2.2 When the irradiance is determined at two other positions, 25 mm $\pm$ 2 mm each side of the specimen center, the irradiance at those two positions shall be not less than 85 percent or not more than 115 percent of the irradiance at the center of the specimen.

4.3.1.3* Irradiance Control.

4.3.1.3.1 The irradiance of the radiator cone shall be controlled by reference to the averaged reading of two Type K thermocouples.

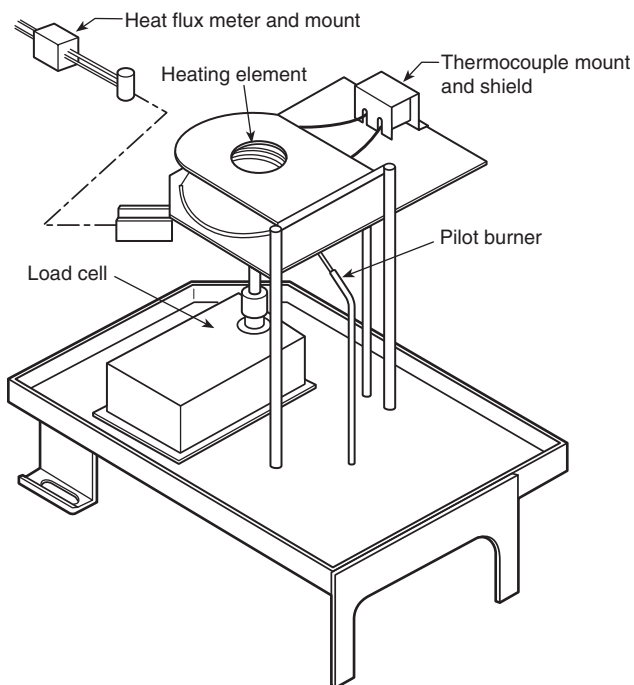


Figure 4.3.1.1 Typical Framework for Support of Radiator Cone, Specimen Holder, Flux Meter, and Load Cell.

4.3.1.3.2 The thermocouples shall have a 1.6 mm $\pm$ 0.2 mm outside diameter, sheathed with an unexposed hot junction; mounted diametrically opposite, in contact with, but not welded to, the heating element; and positioned at one-third the distance from the top surface of the cone.

4.3.1.4* Heater Temperature.

4.3.1.4.1 The temperature at the heater shall be controlled and shall be held steady to $\pm 2^\circ\text{C}$.

4.3.1.4.2 The temperature controller for the radiator cone shall be of the proportional, integral, and derivative type 3-term controller with thyristor stack fast-cycle or phase-angle control of not less than 10 A maximum rating.

4.3.1.4.3 Capacity for adjustment of integral time between 10 seconds and 50 seconds and differential time between 25 seconds and 30 seconds shall be provided to permit matching with the response characteristics of the heater.

4.3.1.4.4 The temperature input range shall be 0°C to 1000°C .

4.3.1.4.5 Automatic cold junction compensation of the thermocouple shall be provided.

4.3.1.4.6 Alternative devices that give equivalent results shall be permitted to be accepted.

4.3.2 Framework for Radiator Cone.

4.3.2.1 Vertical Rods. The radiator cone shall be secured to the vertical rods of the support framework and shall be located so that the lower rim of the radiator cone shade is 25 mm $\pm$ 1 mm above the upper surface of the specimen when oriented in the horizontal position as shown in Figure 4.3.2.1(a) and Figure 4.3.2.1(b).

4.3.2.2 Base. The base of the specimen holder shall contain a height adjustment device to ensure a consistent distance between the radiator cone and the specimen surface.

4.3.3 Radiator Shield.

4.3.3.1 Construction. The cone heater shall be provided with a removable radiator shield to protect the specimen from the irradiance prior to the start of the test.

4.3.3.1.1 The radiator shield shall be made of noncombustible material with a total thickness not to exceed 12 mm.

4.3.3.1.2 The radiator shield shall comply with one of the following:

- (1) A water-cooled radiator shield coated with a durable matte black finish of surface emissivity $\epsilon = 0.95 \pm 0.05$
- (2) A radiator shield with a metallic reflective top surface to minimize radiation transfer but not water cooled
- (3) A radiator shield with a ceramic, nonmetallic surface that minimizes radiation transfer to the specimen surface but not water cooled

4.3.3.2* Mobility. The radiator shield shall be equipped with a handle or other means for quick insertion and removal.

4.3.3.3 Stability. The cone heater base plate shall be equipped with the means for holding the radiator shield in position and allowing its quick removal.

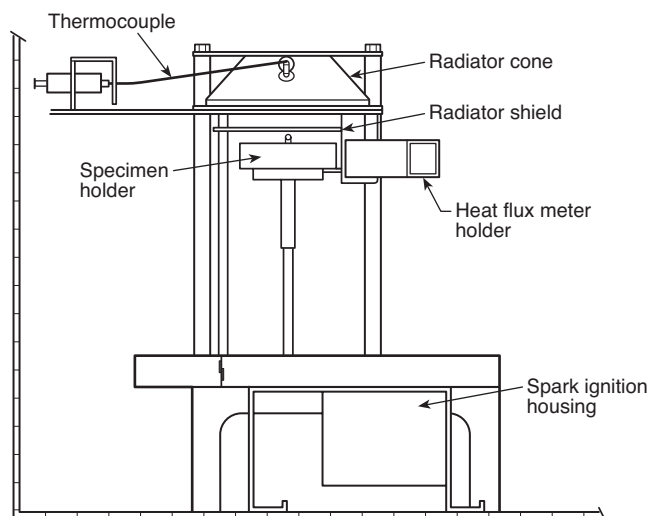


Figure 4.3.2.1(a) Typical Arrangement of Radiator Cone, Specimen Holder, and Radiator Shield (side view), with Load Cell for Mass Optical Density Determination.

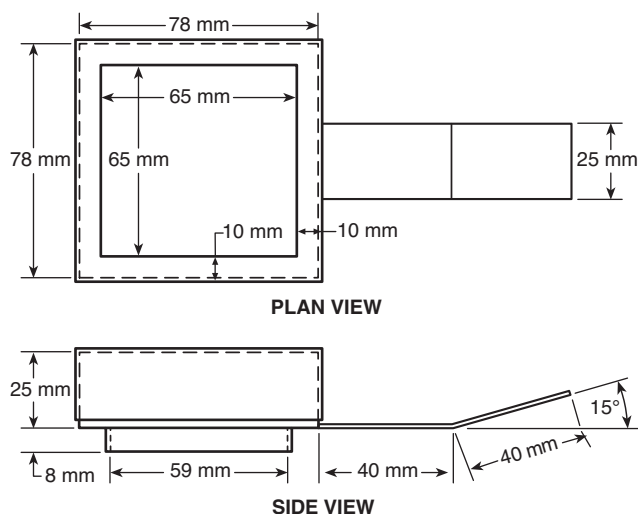


Figure 4.3.2.1(b) Specimen Holder.

4.3.4 Heat Flux Meter.

4.3.4.1* Target.

4.3.4.1.1 The heat flux meter shall be of the foil (Gardon) or thermopile (Schmidt-Boelter) type with a design range of at least 50 kW/m^2 .

4.3.4.1.2 The target receiving the radiation shall have a flat, circular face of $10 \text{ mm} \pm 1 \text{ mm}$ diameter, coated with a durable matte black finish.

4.3.4.1.3 The target shall be water cooled.

4.3.4.2* Recorder. The heat flux meter shall be connected directly to a recorder or data acquisition unit so that it is capable, when calibrated, of recording heat fluxes of 25 kW/m^2 and 50 kW/m^2 to an accuracy of $\pm 1 \text{ kW/m}^2$.

4.3.4.3 Calibration. The heat flux meter system shall be calibrated by comparing its response with that of a primary reference standard, when exposed to irradiances of 25 kW/m^2 and $50 \text{ kW/m}^2 \pm 1 \text{ kW/m}^2$, averaged over the $10 \text{ mm} \pm 1 \text{ mm}$ diameter area of the heat flux meter. (See Section B.1.)

4.3.5 Specimen Holders.

4.3.5.1 Refractory Fiber Blanket. The specimen holder base shall be lined with a low-density (nominal 65 kg/m^3) refractory fiber blanket with a minimum thickness of 10 mm as shown in Figure 4.3.2.1(b).

4.3.5.2 Application. Wrapped specimens less than 25 mm thick backed by at least one sheet of noncombustible insulating board shall be permitted to be used without a layer of refractory mineral fiber blanket if necessary to accommodate the specimens' thickness as described in 6.7.3.

4.3.5.3 Retainer Frame and Wire Grid.

4.3.5.3.1* A retainer frame and wire grid shall be used for all tests.

4.3.5.3.2 The wire grid shall be $75 \text{ mm} \pm 1 \text{ mm}$ square with $20 \text{ mm} \pm 0.5 \text{ mm}$ square holes constructed from $2 \text{ mm} \pm 0.2 \text{ mm}$ stainless steel rod welded at all intersections.

4.3.6* Pilot Burner.

4.3.6.1 Flame. The flame from the single-flame burner shall have a length of $30 \text{ mm} \pm 5 \text{ mm}$ and shall be positioned horizontally $10 \text{ mm} \pm 1 \text{ mm}$ above the top face of the specimen as shown in Figure 4.3.6.1.

4.3.6.2 Color. The color of the flame shall be blue with a yellow tip.

4.3.6.3 Location. The tip of the burner shall reach the edge of the specimen itself as shown in Figure 4.3.6.1.

4.4 Gas Supply.

4.4.1 A mixture of propane of at least 95 percent purity and at a pressure of $3.5 \text{ kPa} \pm 1 \text{ kPa}$ and air at a pressure of $170 \text{ kPa} \pm 30 \text{ kPa}$ shall be supplied to the burner.

4.4.2 Each gas shall be fed to the point at which they are mixed and supplied to the burner.

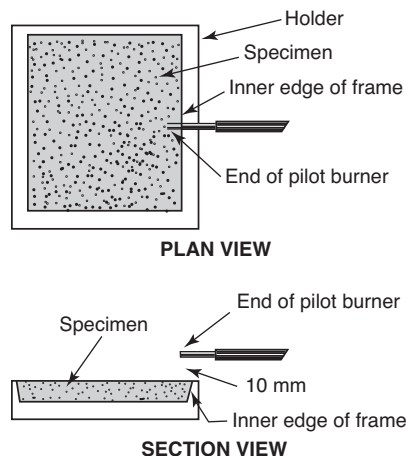


Figure 4.3.6.1 Detailed Location of Pilot Burner.