# NFPA 265
## Standard Method of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings

## 1998 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

## IMPORTANT NOTICE ABOUT THIS DOCUMENT

NFPA codes and standards, of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards.

The NFPA disclaims liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this document available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the NFPA list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

## NOTICES

All questions or other communications relating to this document and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA documents during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

Users of this document should be aware that this document may be amended from time to time through the issuance of Tentative Interim Amendments, and that an official NFPA document at any point in time consists of the current edition of the document together with any Tentative Interim Amendments then in effect. In order to determine whether this document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments, consult appropriate NFPA publications such as the *National Fire Codes*® Subscription Service, visit the NFPA website at www.nfpa.org, or contact the NFPA at the address listed above.

A statement, written or oral, that is not processed in accordance with Section 16 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

The NFPA does not take any position with respect to the validity of any patent rights asserted in connection with any items which are mentioned in or are the subject of this document, and the NFPA disclaims liability of the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Users of this document should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so.

## Licensing Policy

**NFPA 265**

**Standard Methods of**

# Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings

**1998 Edition**

This edition of NFPA 265, *Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings*, was prepared by the Technical Committee on Fire Tests and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 18–21, 1998, in Cincinnati, OH. It was issued by the Standards Council on July 16, 1998, with an effective date of August 5, 1998, and supersedes all previous editions.

This edition of NFPA 265 was approved as an American National Standard on August 6, 1998.

## Origin and Development of NFPA 265

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

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

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

## Technical Committee on Fire Tests

**Jesse J. Beitel,** *Chair*
Hughes Assoc. Inc., MD [SE]

**April L. Berkol,** ITT Sheraton Corp., NY [U]
Rep. American Hotel & Motel Assn.
**John A. Blair,** The DuPont Co., DE [M]
Rep. Society of the Plastics Industry Inc.
**William P. Chien,** State of New York Dept. of Fire Prevention & Control, NY [E]
**William E. Fitch,** Omega Point Laboratories Inc., TX [RT]
**Sam W. Francis,** American Forest & Paper Assn., PA [M]
**Thomas W. Fritz,** Armstrong World Industries Inc., PA [M]
**James R. Griffith,** Southwest Research Inst., TX [RT]
**Marcelo M. Hirschler,** GBH Int'l, CA [SE]
**Alfred J. Hogan,** Reedy Creek Improvement District, FL [E]
Rep. Fire Marshals Assn. of North America
**Karl D. Houser,** Gypsum Assn., DC [M]
**William E. Koffel, Jr.,** Koffel Assoc. Inc., MD [SE]
**James R. Lawson,** U.S. Nat'l Inst. of Standards and Technology, MD [RT]
**Gerald E. Lingenfelter,** American Ins Services Group Inc., NY [I]
**William S. Metes,** Underwriters Laboratories Inc., IL [RT]
**George E. Meyer,** Warnock Hersey, Inc., CA [RT]
**John W. Michener,** Milliken Research Corp., SC [M]
Rep. American Textile Mfrs. Inst. Inc.
**James A. Milke,** University of Maryland, MD [SE]
**James C. Norris,** Union Carbide Corp., TN [M]
**John Roberts,** Underwriters' Laboratories of Canada, ON, Canada [RT]
**T. Hugh Talley,** Hugh Talley Co., TN [M]
Rep. Upholstered Furniture Action Council
**David K. Tanaka,** Factory Mutual Research Corp., MA [I]
**Richard P. Thornberry,** The Code Consortium, Inc., CA [SE]
**Robert J. Wills,** American Iron & Steel Inst., AL [M]
**Peter J. Gore Willse,** Industrial Risk Insurers, CT [I]
Rep. Industrial Risk Insurers

### Alternates

**Delbert F. Boring, Jr.,** American Iron & Steel Inst, OH [M]
(Alt. to R. J. Wills)
**Tony Crimi,** Underwriters' Laboratories of Canada, ON, Canada [RT]
(Alt. to J. Roberts)
**Philip J. DiNenno,** Hughes Assoc. Inc., MD [RT]
(Alt. to J. J. Beitel)
**Richard G. Gann,** U.S. Nat'l Inst. of Standards and Technology, MD [RT]
(Alt. to J. R. Lawson)
**Richard D. Gottwald,** Society of the Plastics Industry, DC [M]
(Alt. to J. A. Blair)
**Marc L. Janssens,** Southwest Research Inst., TX [RT]
(Alt. to J. R. Griffith)
**Gene V. Paolucci,** Yasuda Fire & Marine Insurance Co. of America, NY [I]
(Alt. to G. E. Lingenfelter)
**R. Joseph Pearson,** Inchcape Testing Services NA Inc., NY [RT]
(Alt. to G. E. Meyer)
**William A. Thornberg,** Industrial Risk Insurers, CT [I]
(Alt. to P. J. G. Willse)
**James J. Urban,** Underwriters Laboratories Inc., IL [RT]
(Alt. to W. S. Metes)
**Kay M. Villa,** American Textile Mfrs. Inst., DC [M]
(Alt. to J. W. Michener)
**Joe Ziolkowski,** American Furniture Mfrs. Assoc., NC [M]
(Alt. to T. H. Talley)

### Nonvoting

**Robert H. Barker,** American Fiber Mfrs. Assn., DC [M]
(Alt. to T. L. Jilg)
**James F. Hoebel,** U.S. Consumer Product Safety Commission, MD
**Tod L. Jilg,** Hoechst Celanese Corp., NC [M]
Rep. to American Fiber Mfrs. Assn.
**Herman H. Spaeth,** Novato, CA
(Member Emeritus)

**Walter P. Sterling,** NFPA Staff Liaison

*This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of this document.*

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

**Committee Scope:** This Committee shall have primary responsibility for documents on fire testing procedures, for reviewing existing fire test standards and recommending appropriate action to NFPA; for recommending the application of and advising on the interpretation of acceptable test standards for fire problems of concern to NFPA technical committees and members; and for acting in a liaison capacity between NFPA and the committees of other organizations writing fire test standards. This Committee does not cover fire tests that are used to evaluate extinguishing agents, devices, or systems.

## Contents

**Chapter 1 General** . . . . . . . . . . . . . . . . . . . . . . . . . . **265**– 4
1-1 Scope . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **265**– 4
1-2 Significance . . . . . . . . . . . . . . . . . . . . . . . . . . **265**– 4
1-3 Summary of Method . . . . . . . . . . . . . . . . . . . **265**– 4
1-4 Definitions . . . . . . . . . . . . . . . . . . . . . . . . . . . **265**– 4

**Chapter 2 Test Equipment** . . . . . . . . . . . . . . . . . . . . **265**– 5
2-1 Ignition Source . . . . . . . . . . . . . . . . . . . . . . . **265**– 5
2-2 Compartment Geometry and Construction. . **265**– 5

**Chapter 3 Specimen Mounting and Installation**. . . . **265**– 6
3-1 Specimen Mounting. . . . . . . . . . . . . . . . . . . . **265**– 6
3-2 Specimen Installation . . . . . . . . . . . . . . . . . . **265**– 6

**Chapter 4 Environmental Conditions**. . . . . . . . . . . . **265**– 7
4-1 Fire Room Environment . . . . . . . . . . . . . . . . **265**– 7

**Chapter 5 Instrumentation**. . . . . . . . . . . . . . . . . . . . **265**– 7
5-1 Room Instrumentation . . . . . . . . . . . . . . . . . **265**– 7
5-2 Canopy Hood and Exhaust Duct . . . . . . . . . . **265**– 8
5-3 Instrumentation in Exhaust Duct . . . . . . . . . **265**– 9

**Chapter 6 Calibration**. . . . . . . . . . . . . . . . . . . . . . . . **265**–11
6-1 Calibration and Documentation of Ignition Source and Test Equipment . . . . . . . . . . . . . . . . . . . **265**–11
6-2 Calibration . . . . . . . . . . . . . . . . . . . . . . . . . . **265**–12
6-3 Smoke Measurement Calibration. . . . . . . . . **265**–12
6-4 Gas Analyzers Calibration. . . . . . . . . . . . . . . **265**–12

**Chapter 7 Test Procedure** . . . . . . . . . . . . . . . . . . . **265**–12
7-1 Procedure . . . . . . . . . . . . . . . . . . . . . . . . . . . **265**–12

**Chapter 8 Calculations**. . . . . . . . . . . . . . . . . . . . . . **265**–12
8-1 Flow Rate Equations . . . . . . . . . . . . . . . . . . . **265**–12
8-2 Smoke Measurement Equations . . . . . . . . . . **265**–13
8-3 Release Rate of Combustion Gases . . . . . . . . **265**–13
8-4 Symbols . . . . . . . . . . . . . . . . . . . . . . . . . . . . **265**–13

**Chapter 9 Documentation** . . . . . . . . . . . . . . . . . . . **265**–14
9-1 Report. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **265**–14

**Appendix A Explanatory Material** . . . . . . . . . . . . . . . **265**–14

**Appendix B Acceptance Criteria** . . . . . . . . . . . . . . . . **265**–16

**Appendix C Referenced Publications** . . . . . . . . . . . . **265**–17

**Appendix D Bibliography**. . . . . . . . . . . . . . . . . . . . . **265**–17

**NFPA 265**

**Standard Methods of**

# Fire Tests for Evaluating Room Fire Growth Contribution of Textile Wall Coverings

**1998 Edition**

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

Information on referenced publications can be found in Appendix C.

## Chapter 1 General

### 1-1 Scope.

**1-1.1** This standard describes a method for determining the contribution of textile wall coverings to room fire growth during specified fire exposure conditions. This method shall be used to evaluate the flammability characteristics of textile wall coverings where such materials constitute the exposed interior surfaces of buildings.

**1-1.2** This method is not intended to evaluate the fire endurance of assemblies, nor is it able to evaluate the effect of fires originating within a wall assembly. The method is not intended for the evaluation of floor or ceiling finishes. This test method shall not apply to fabric-covered, lower-than-ceiling-height, freestanding, prefabricated panel furniture systems or demountable, relocatable, full-height partitions used in open building interiors. Freestanding panel furniture systems shall include all freestanding panels that provide visual separation, acoustical separation, or both and are intended to be used to divide space or that support components to form complete work stations. Demountable, relocatable, full-height partitions shall include demountable, relocatable, full-height partitions that fill the space between the finished floor and the finished ceiling.

### 1-2 Significance.

**1-2.1** This method of test shall measure certain fire performance characteristics of textile wall covering materials in an enclosure under specified fire exposure conditions. It shall determine the potential extent to which the textile wall covering materials contribute to fire growth in a room and the potential for fire spread beyond the room, under the particular conditions simulated.

The method of test shall provide the following:

(a) Extent of fire growth in the test room
(b) Rate of heat release by the specimen
(c) Total heat released by the specimen
(d) Time to flashover in the test room, if it occurs
(e) Time to flame extension beyond the doorway of the test room, if it occurs
(f) Total heat flux incident to the floor of the test room
(g) Upper level gas temperature in the test room
(h) Smoke obscuration, as determined in the exhaust duct
(i) Production of carbon monoxide, as determined in the exhaust duct
(j) Emissions of other combustion gases, as determined in the exhaust duct

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

**1-2.2** The method of test shall not provide the following:

(a) The full information concerning toxicity of combustion gases
(b) Fire resistance of wall/ceiling systems

### 1-3 Summary of Method.

**1-3.1** The sample shall be tested by one of the two protocols described. The Method A protocol shall use a corner test exposure with the specimens mounted on two walls of the test compartment. The Method B protocol shall use the same test in a compartment having three fully lined walls.

These methods shall use a gas burner to produce a diffusion flame to expose the walls in the corner of a room 8 ft × 12 ft × 8 ft (2.4 m × 3.7 m × 2.4 m). The burner shall produce a prescribed rate of heat output of 40 kW for 5 minutes followed by 150 kW for 10 minutes, for a total exposure period of 15 minutes. The contribution of the textile wall covering to fire growth shall be measured by constant monitoring of the incident heat flux on the center of the floor, the temperature of the gases in the upper part of the room, the rate of heat release, the smoke release, and the time to flashover. The test shall be conducted with natural ventilation to the room provided through a single doorway of 30 in. × 80 in. (0.8 m × 2.0 m). The combustion products shall be collected in a hood feeding into a plenum that is connected to an exhaust duct in which measurements of the gas velocity, temperature, and concentrations of selected gases are made.

**1-3.2** Flashover shall be determined to have occurred when any two of the following conditions have been attained:

(a) Heat release rate exceeds 1 MW
(b) Heat flux at floor exceeds 20 kW/$m^2$
(c) Average upper layer temperature exceeds 1112°F (600°C)
(d) Flames exit doorway
(e) Autoignition of paper target on floor occurs

### 1-4 Definitions.

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

**Shall.** Indicates a mandatory requirement.

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

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

# Chapter 2 Test Equipment

## 2-1 Ignition Source.

**2-1.1** The ignition source for the test shall be a gas burner with a nominal 12 in. × 12 in. (305 mm × 305 mm) porous top surface of refractory material *(see Figure 2-1.1)*. This refractory material, through which the gas is supplied, shall be a 1-in. (25.4-mm) thick porous ceramic fiberboard over a 6-in. (152-mm) plenum. Alternatively, a minimum 4-in. (102-mm) layer of Ottawa sand shall be permitted to be used to provide the horizontal surface through which the gas is supplied.

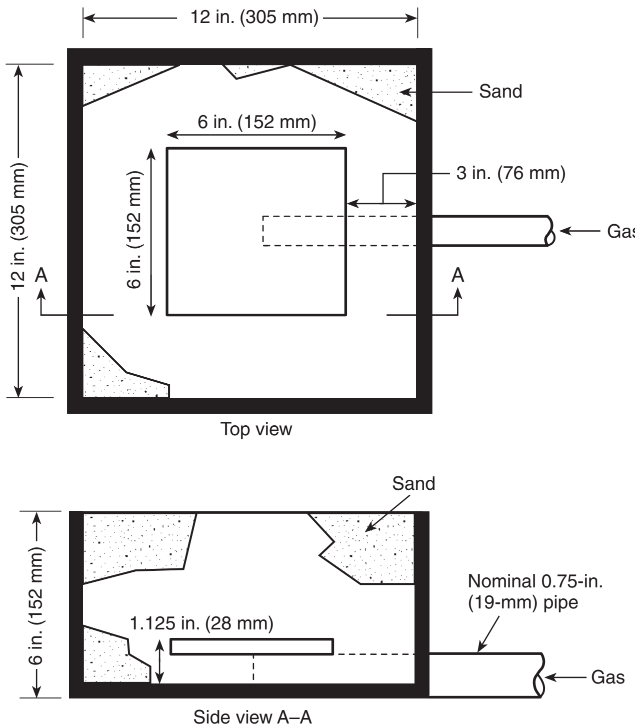


**Figure 2-1.1 Gas burner.**

**2-1.2** The top surface of the burner, through which the gas is applied, shall be located horizontally 12 in. (305 mm) above the floor. The burner enclosure shall be located such that the edge of the diffusion surface is located 2 in. (51 mm) from both walls, in a corner of the room, opposite the door *(see Figure 2-1.1)*.

**2-1.3*** The gas supply to the burner shall be of C.P. grade propane (99 percent purity or better). The burner shall be capable of producing a net heat output of 40 kW ± 1 kW for 5 minutes followed by a net heat output of 150 kW ± 5 kW for 10 minutes. Flow rates shall be calculated using the net heat of combustion of propane or 2280 Btu/ft$^3$ (85 MJ/m$^3$) at standard conditions of 68°F (20°C) temperature and 14.70 psia (100 kPa) pressure. The gas flow rate shall be metered throughout the test, with an accuracy of within ±3 percent.

**2-1.4*** The heat output from the burner shall be controlled to within ±5 percent. The burner design shall allow switching from 40 kW to 150 kW within 10 seconds.

**2-1.5** The burner shall be ignited by a pilot burner or a remotely controlled spark ignitor.

**2-1.6** Burner controls shall be provided for automatic gas supply shutoff if flameout occurs.

## 2-2 Compartment Geometry and Construction.

**2-2.1*** The interior dimensions of the floor of the fire room, when the specimens are in place, shall measure 8 ft ± 3.9 in. × 12 ft ± 3.9 in. (2.44 m ± 0.1 m × 3.66 m ± 0.1 m). The finished ceiling shall be 8 ft ± 3.9 in. (2.44 m ± 0.1 m) above the floor. There shall be four walls at right angles defining the compartment. *(See Figure 2-2.1.)*

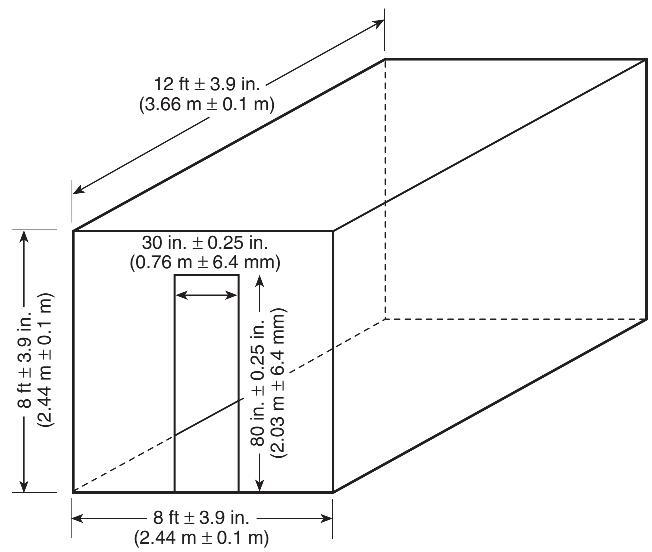


**Figure 2-2.1 Interior room dimensions and interior doorway dimensions.**

**2-2.2*** The room shall be placed indoors in an essentially draftfree, heated space, large enough to ensure that there is no influence of the surroundings on the test fire.

**2-2.3** There shall be a 30 in. ± 0.25 in. × 80 in. ± 0.25 in. (0.76 m ± 6.4 mm × 2.03 m ± 6.4 mm) doorway in the center of one of the 8 ft × 8 ft (2.44 m × 2.44 m) walls, and no other wall, floor, or ceiling openings that allow ventilation.

**2-2.4*** The test compartment shall be a framed (with wood or metal studs) or a concrete block structure. The inside surface of the walls, ceiling, and floor shall be of type X gypsum wallboard or of calcium silicate board of 46 lb/ft$^3$ (736 kg/m$^3$) density. The nominal thickness of the inside surface shall be at least 0.5 in. (12 mm).

**2-2.5** The door frame shall be constructed to remain unchanged during the test period to a tolerance of ±1 percent in height and width.

## Chapter 3 Specimen Mounting and Installation

### 3-1 Specimen Mounting.

**3-1.1*** Test specimens shall be mounted on a substrate that is appropriate to the intended application. Where a manufacturer specifies use of an adhesive, specimens shall be mounted in a manner that uses the adhesive and application rate specified by the manufacturer and that is comparable to actual field installations.

**3-1.2** Where a specimen exhibits a distinct direction, the sample shall be mounted such that the machine direction is vertical, unless the manufacturer indicates that a different method of mounting is to be used in actual installations.

### 3-2 Specimen Installation.

**3-2.1** The specimen assembly shall be installed on the interior wall surfaces of the test room as described in 3-2.2 or 3-2.3.

**3-2.2** For the Method A test protocol, the specimen assembly shall be installed on the left sidewall and the rear wall (as viewed from the room door) and as illustrated in Figure 3-2.2. Vertically installed portions of specimen assemblies shall extend 2 ft (0.6 m) from the ceiling and shall be installed for the full 8-ft (2.44-m) width of the rear wall and the full 12-ft (3.66-m) length of the left sidewall.

**3-2.3** For the Method B test protocol, specimen assemblies shall be installed to cover fully both 8 ft × 12 ft (2.44 m × 3.66 m) walls and the 8 ft × 8 ft (2.44 m × 2.44 m) wall not having the door.

**3-2.4*** Prior to testing, the mounted specimen shall be conditioned to approximate equilibrium in an atmosphere at a temperature of 70°F ± 5°F (21°C ± 3°C) and a relative humidity of 50 percent ± 5 percent. Equilibrium is reached when a representative piece of the specimen has achieved constant mass. Constant mass is reached when two successive weighing operations, carried out at an interval of 24 hours, do not differ by more than 0.1 percent of the mass of the test piece, or 0.0035

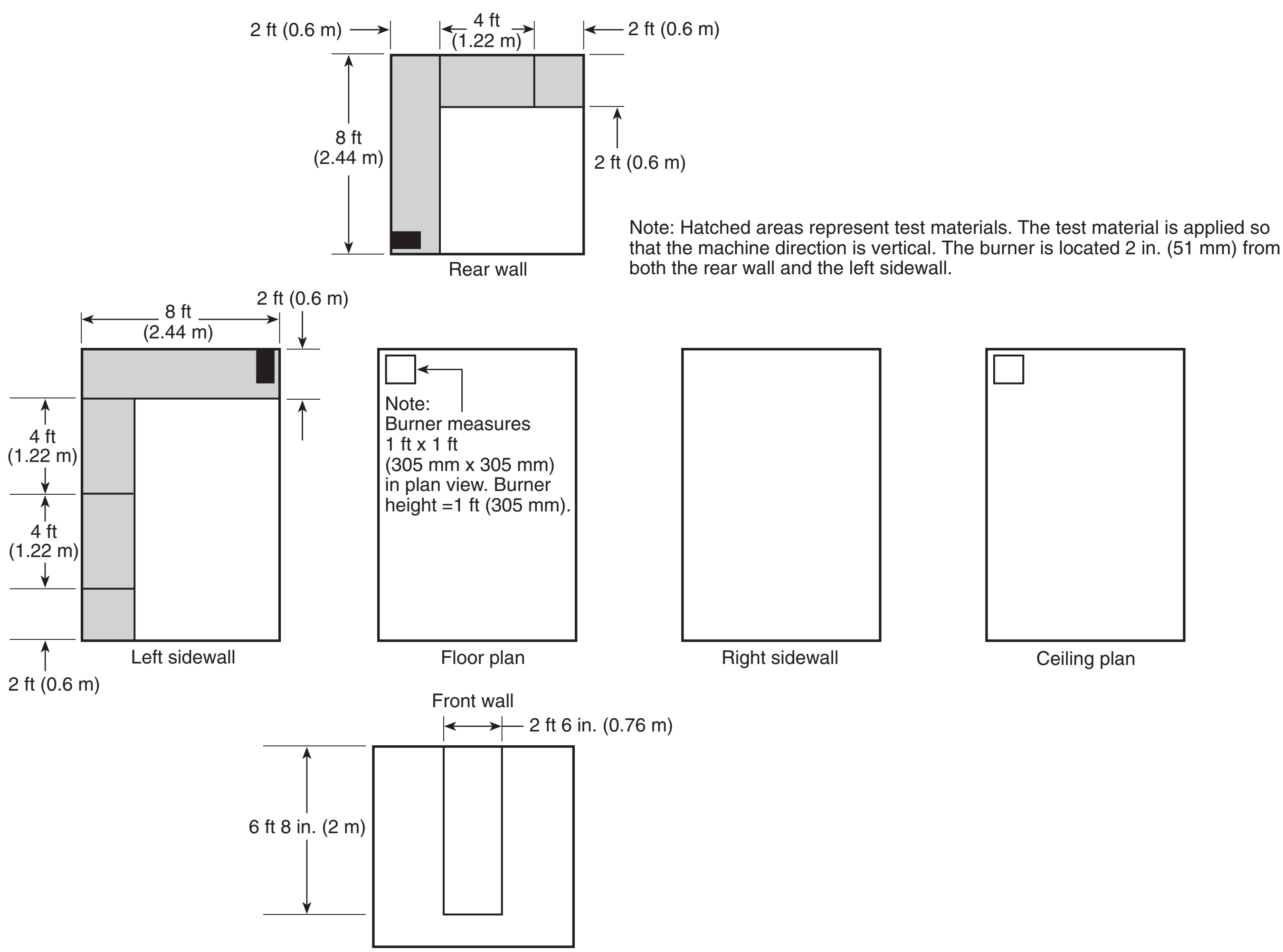


**Figure 3-2.2 Specimen mounting for Method A test protocol.**

oz (0.1 g), whichever is greater. The specimens shall be tested as soon as possible after removal from such conditions, if test room conditions differ from the above. The time shall be reported between removal from conditioning room and start of testing.

## Chapter 4 Environmental Conditions

**4-1 Fire Room Environment.**

**4-1.1** The test building in which the fire room is located shall have vents for the discharge of combustion products and have provisions for fresh air intake, so that no oxygen-deficient air shall be introduced into the fire room during the test. Prior to the start of the test, the ambient air at the mid-height entrance to the compartment shall have a velocity of less than 100 ft/min (0.5 m/sec) in any direction, as measured at a horizontal distance of 3 ft (0.91 m) from the center of the doorway. The building shall be of adequate size, so that there shall be no smoke accumulation in the building below the level of the top of the fire compartment.

**4-1.2** The ambient temperature in the test building at locations around the fire compartment shall be above 40°F (4°C), and the relative humidity shall be less than 75 percent for the duration of the test.

**4-1.3** The following ambient conditions shall be maintained:

(a) The ambient temperature in the fire room, measured by one of the thermocouples in 5-1.3.2, shall be in the range of 64°F to 75°F (18°C to 24°C).

(b) The ambient relative humidity in the fire room shall be 50 percent ± 5 percent.

## Chapter 5 Instrumentation

**5-1 Room Instrumentation.**

**5-1.1** The following instrumentation shall be provided for this test.

**5-1.2* Heat Flux.** A total heat flux gauge (calorimeter) shall be mounted at a height of 1.1 in. ± 0.9 in. (26 mm ± 25 mm) above the floor surface, facing upward, in the geometric center of the test room. *(See Figure 5-1.2.)*

**5-1.2.1*** The gauge shall be of the Gardon (foil) or Schmidt-Boelter (thermopile) type with a full-scale design range of 50 $kW/m^2$. The target receiving radiation shall be a circular flat surface, not more than 0.4 in. (15 mm) in diameter and coated with a matte black finish, having a view angle of 180 degrees. The target shall be contained within a water-cooled body whose front face shall be of polished metal, flat, coinciding with the plane of the target, and circular, with a diameter of not more than 2 in. (50 mm). The heat flux gauge shall have an accuracy of within ±3 percent and a repeatability within 0.5 percent. During operation, the heat flux gauge shall be maintained at a constant temperature [within ±5°F (±3°C)] above the dew point by water supplied at a temperature of 122°F to 149°F (50°C to 65°C).

**5-1.2.2** The calibration of the heat flux gauge shall be checked, whenever required, by comparing the calibration with two similar instruments held as reference standards and not used for any other purpose. One of the reference standards shall be fully calibrated at yearly intervals.

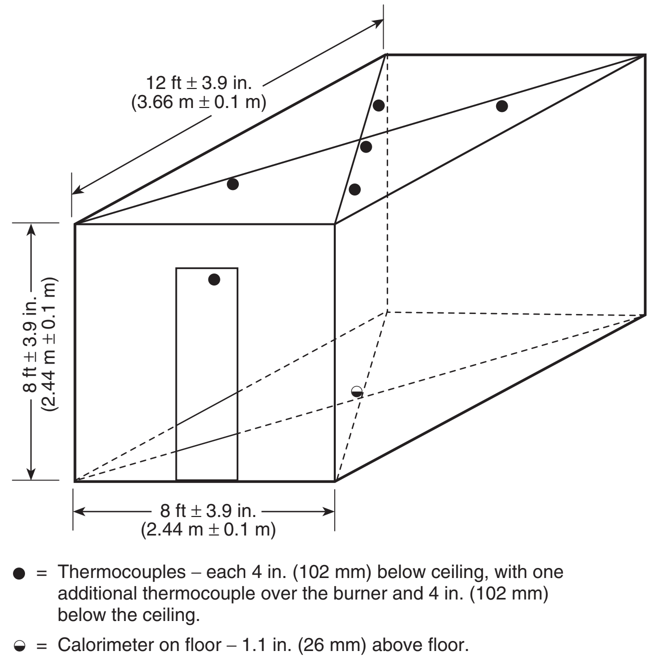


**Figure 5-1.2 Thermocouple and calorimeter placement.**

**5-1.3* Thermocouples.** Bare Type K Chromel Alumel® thermocouples, 20 mil (0.5 mm) in diameter, shall be used at each required location. The thermocouple wire within 0.5 in. (13 mm) of the bead shall be run along expected isotherms to minimize conduction errors. The insulation between the Chromel and Alumel wires shall be stable to at least 2000°F (1100°C), or the wires shall be separated.

**5-1.3.1** A thermocouple shall be located in the interior plane of the door opening on the door centerline, 4 in. (102 mm) from the top. *(See Figure 5-1.2.)*

**5-1.3.2** Thermocouples shall be located at six positions, 4 in. (102 mm) below the ceiling. These thermocouples shall be located at the center of the ceiling, at the center of each of the four ceiling quadrants, and directly over the center of the ignition burner. The thermocouples shall be mounted on supports or shall penetrate through the ceiling with their junctions 4 in. (102 mm) away from a solid surface *(see Figure 5-1.2)*. There shall be no attachments to the test specimens. Any ceiling penetration shall be just large enough to permit passage of the thermocouples. Spackling compound or ceramic fiber insulation shall be used to backfill the holes around the thermocouple wire.

**5-1.4** Two paper target flashover indicators shall be placed on the floor of the test room *(see Figure 5-1.4)*. The targets shall consist of a single piece of newsprint crumpled into an approximate 6-in. (152-mm) diameter ball.

**5-1.5*** Photographic and video equipment shall be used to record the spread of fire in the room and the fire projection from the door of the room. The location of the camera shall avoid interference with airflow. The interior wall surfaces of the test room adjacent to the corner in which the burner is located shall be marked with a 12-in. (0.3-m) grid. A clock shall appear in all photographic and video records showing

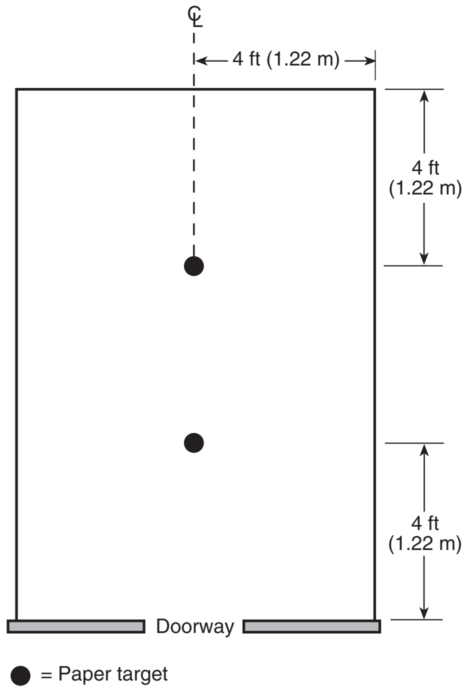


**Figure 5-1.4 Plan view of paper target arrangement.**

the time to at least the nearest 1 second from the start of the test. This clock shall be synchronized with all other measurements, or other provisions shall be made to correlate the photographic and video records with time. Color slides or photographs shall be taken at intervals not greater than 15 seconds for the first 3 minutes of the test and at intervals not greater than 2 minutes thereafter for the duration of the test. A continuous video recording shall also be made.

**5-2 Canopy Hood and Exhaust Duct.**

**5-2.1** A hood shall be installed immediately adjacent to the door of the fire room. The bottom of the hood shall be level with the top surface of the room. The face dimensions of the hood shall be at least 8 ft × 8 ft (2.44 m × 2.44 m), and the depth shall be 3.6 ft (1.1 m). The hood shall feed into a plenum having a 3 ft × 3 ft (0.91 m × 0.91 m) cross section. The plenum shall be a minimum height of 3 ft (0.91 m). This height shall be permitted to be increased to a maximum of 6 ft (1.8 m) to satisfy building constraints. The exhaust duct connected to the plenum shall be at least 16 in. (406 mm) in diameter, shall be horizontal, and shall be permitted to have a circular aperture of at least 12 in. (305 mm) at its entrance or mixing vanes in the duct. *[See Figures 5-2.1(a) and 5-2.1(b).]*

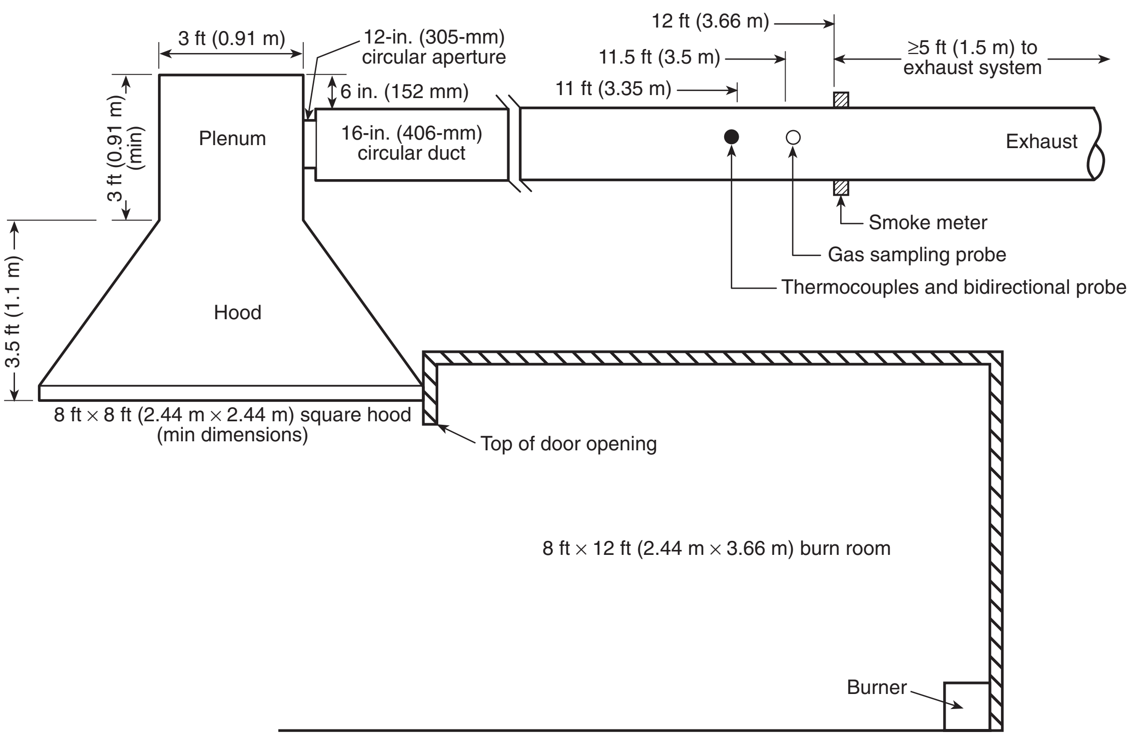


**Figure 5-2.1(a) Canopy hood and exhaust duct.**

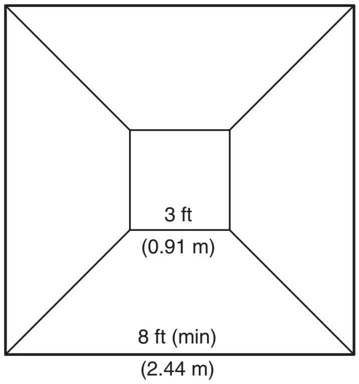


**Figure 5-2.1(b) Plan view of canopy head.**

**5-2.2** The hood shall have sufficient draft to collect all of the combustion products leaving the room. During the test, this draft shall be capable of moving up to 7000 standard $ft^3/min$ ($3.4\ m^3/sec$) equivalent to 16,100 $ft^3/min$ ($7.6\ m^3/sec$) at 750°F (399°C). Provision shall be made so that the draft can operate at 1000 to 7000 standard $ft^3/min$ (0.47 to $3.4\ m^3/sec$). Mixing vanes shall be required in the duct if concentration gradients are found to exist.

**5-2.3** An alternative exhaust system design shall be permitted to be used if the design meets the requirements outlined in Chapter 6 and the performance requirements in 5-2.2.

**5-3 Instrumentation in Exhaust Duct.**

**5-3.1** The exhaust collection system shall be constructed with the following requirements: a blower, a steel hood, a duct, a bidirectional probe, a thermocouple(s), an oxygen measurement system, a smoke obscuration measurement system (white light photocell lamp/detector or laser), and a combustion gas sampling and analysis system.

**5-3.2*** A bidirectional probe or an equivalent measuring system shall be used to measure gas velocity in the duct. A typical probe, shown in Figure 5-3.2, shall consist of a short, stainless steel cylinder that is 1.75 in. (44 mm) long and has an 0.875-in. (22-mm) inside diameter with a solid diaphragm in the center. The pressure taps on either side of the diaphragm shall support the probe. The axis of the probe shall run along the centerline of the duct, 11 ft (3.35 m) downstream from the entrance. The taps shall be connected to a pressure transducer that shall be able to resolve pressure differences of 0.001 psi (0.25 Pa) in $H_2O$.

**5-3.3** One pair of thermocouples shall be placed 11 ft (3.4 m) downstream of the entrance to the horizontal duct. The pair of thermocouples shall straddle the center of the duct and shall be separated 2 in. (50 mm) from each other. *[See Figure 5-2.1(a).]*

**5-3.4 Sampling Line.**

**5-3.4.1*** The sampling line tubes shall be constructed of a material that will not affect the concentration of the combustion gas species to be analyzed. The following sequence of the gas train shall be used: sampling probe, soot filter, cold trap, gas path pump, vent valve, drying column, flow controller, and oxygen analyzer *(see Figure 5-3.4.1)*. The gas train shall also include spanning and zeroing facilities.

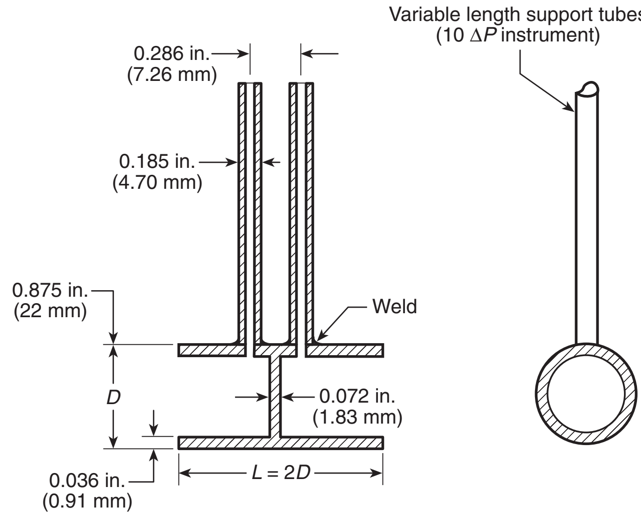


**Figure 5-3.2 Bidirectional probe.**

**5-3.4.2*** For each gas analyzer used, the system delay time for the analyzer to reach a 90 percent response to a step change in the gas concentration shall be determined.

**5-3.5* Oxygen Concentration.** A gas sampling tube shall be located 11.5 ft (3.5 m) downstream from the entrance to the duct at the geometric center of the duct [to within $^1/_2$ in. (13 mm) of the center], to obtain a continuously flowing sample for determining the oxygen concentration of the exhaust gas as a function of time. A suitable filter and cold trap shall be placed in the line ahead of the analyzer to remove particulates and water. The oxygen analyzer shall be of the paramagnetic or polarographic type and shall be capable of measuring oxygen concentration in a range of 21 percent to 15 percent, with a relative accuracy of 50 ppm in this concentration range. The signal from the oxygen analyzer shall be within 5 percent of its final value and shall occur within 30 seconds of introducing a step change in composition of the gas stream flowing past the inlet to the sampling tube. The oxygen analyzer shall include an absolute pressure transducer for gas pressure variations. There shall also be a rotameter on the outlet of the oxygen analyzer.

**5-3.6 Carbon Dioxide Concentration.** The gas sampling tube described in 5-3.5, or an alternative gas sampling tube at the same location, shall be used to provide a continuous sample for the measurement of the carbon dioxide concentration using an analyzer with a range of 0 to 20 percent, with a maximum relative error of 2 percent of full scale. The total system-response time between the sampling inlet and the meter shall be no longer than 30 seconds to reach a value within 5 percent of the final value, after the introduction of a step change in composition of the gas stream flowing past the inlet to the sampling tube.

**5-3.7 Carbon Monoxide Concentration.** The gas sampling tube described in 5-3.5, or an alternative gas sampling tube at the same location, shall be used to provide a continuous sample for the measurement of the carbon monoxide concentration using an analyzer with a range of 0 to 10 percent, with a maximum relative error of 2 percent of full scale. The total system-response time between the sampling inlet and the meter

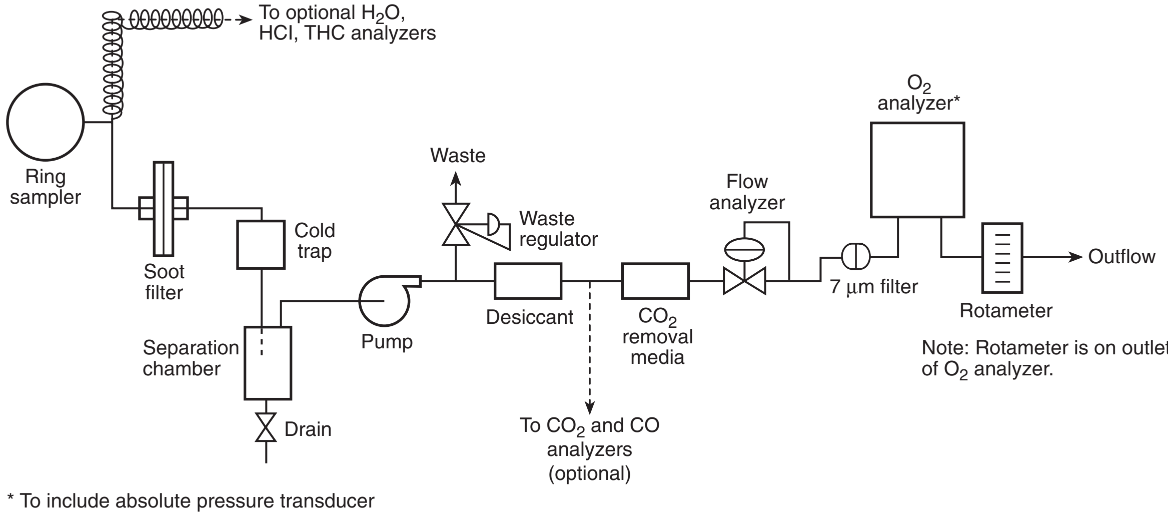


**Figure 5-3.4.1 Schematic of gas train and mass train.**

shall be no longer than 30 seconds to reach a value within 5 percent of the final value, after the introduction of a step change in composition of the gas stream flowing past the inlet to the sampling tube.

**5-3.8 Smoke Obscuration Measurement.**

**5-3.8.1** An optical system shall be installed for measurement of light obscuration across the centerline of the exhaust duct. The optical density of the smoke shall be determined by measuring the light transmitted with a photometer system consisting of a white light source and a photocell/detector or a laser system for measurement of light obscuration across the centerline of the exhaust duct.

**5-3.8.2*** A white light photometer system shall consist of a lamp, lenses, an aperture, and a photocell. See Figure 5-3.8.2 for further details. The system shall be constructed so that soot deposits on the optics during a test do not reduce the light transmission by more than 5 percent.

**5-3.8.3*** A helium–neon laser system shall consist of silicon photodiodes as main beam and reference detectors and electronics to derive an extinction and to set a zero reading. The system shall be designed for split yoke mounting in two pieces, which are rigidly coupled together, but resiliently attached to the exhaust duct by means of refractory gasketing. A 0.5 mW to 2 mW helium–neon laser beam shall be projected horizontally across the exhaust duct. See Figures 5-3.8.3(a) and 5-3.8.3(b) for further details.

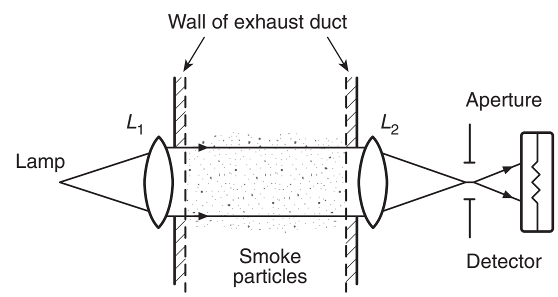


**Figure 5-3.8.2 Optical system using a white light.**

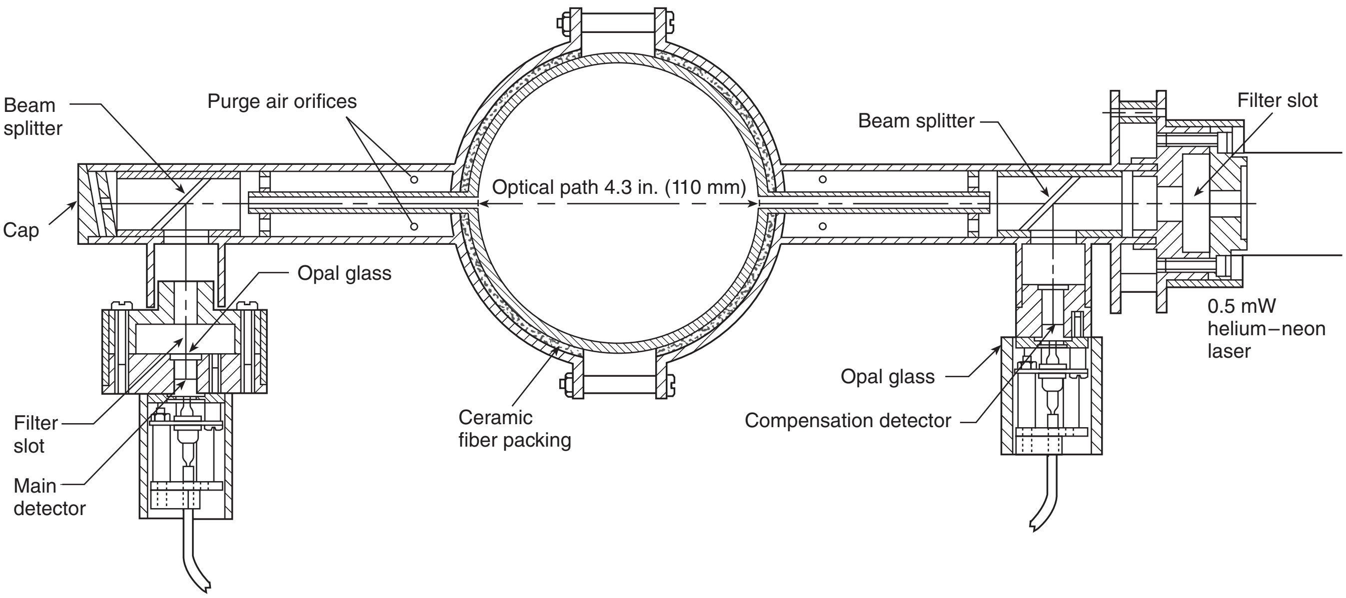


**Figure 5-3.8.3(a) Laser extinction beam.**

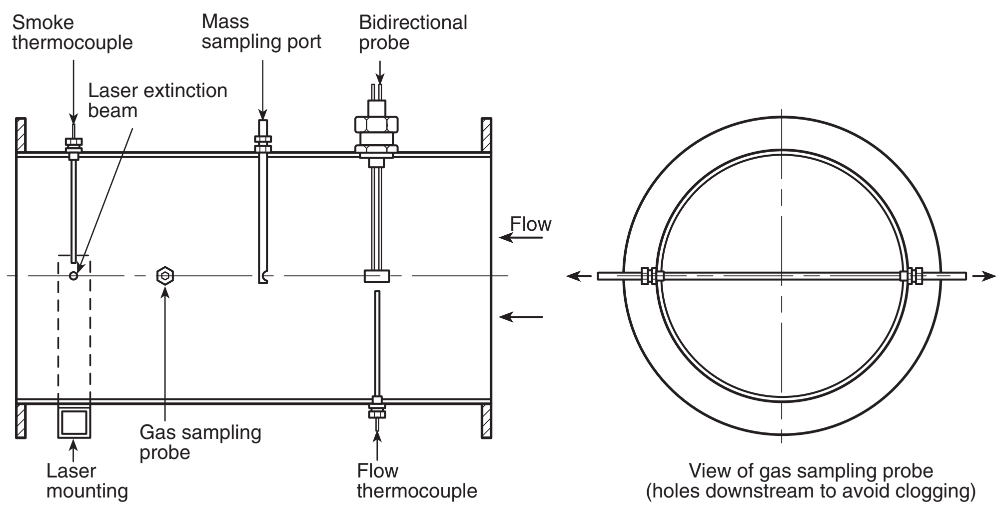


**Figure 5-3.8.3(b) Recommendations for mounting the laser beam and other instrumentation in exhaust duct.**

## Chapter 6 Calibration

### 6-1 Calibration and Documentation of Ignition Source and Test Equipment.

**6-1.1** All instruments shall be calibrated with standard sources after initial installation. The instruments to be calibrated shall be smoke meters, flow or velocity transducers, and gas analyzers.

**6-1.2** A calibration test shall have been performed prior to and within 30 days of any fire test. The calibration test shall use the standard ignition source under the exhaust hood.

**6-1.3** The data resulting from a calibration test shall provide the following:

(a) The output as a function of time, after the burner is activated, of all instruments normally used for the standard fire test

(b) The maximum extension of the burner flame, as recorded by still photographs taken at 30-second intervals or continuous video recording

(c) The temperature and velocity profiles across the duct cross section at the location of the bidirectional probe

(d) The differential pressure across the bidirectional probe

(e) The results in (c) and (d) shall be used to determine the calibration factor, $C$, in the equation in 8-1.3

**6-2* Calibration.** The calibration procedure for heat release measurements shall be as follows:

(a) Estimate an approximate value of the calibration factor $C$ ($C_{est}$) as the product of the cross section of the duct (in square meters) multiplied by 22.1.

(b) Burn propane, as described in 2-1.3, for not less than 15 minutes at a heat release rate of 150 kW ± 5 kW. Take measurements at intervals not greater than 6 seconds. The response of the system to a stepwise change of the heat output from the burner shall be a maximum of 12 seconds to 90 percent of final value. Use a value of combustion expansion factor ($\alpha$) *(see Section 8-4)*, of energy ($E$), and of heat of combustion ($Ht_{comb}$) as follows:

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

(c) Calculate the total heat released and the corrected calibration factor $C_{est}$ so that the total heat released, as determined by the oxygen consumption calculation *(see Chapter 8)*, agrees with the theoretical value obtained from measurement of the volumetric flow rate and weight loss of the fuel, to within ±5 percent, by using the following equation:

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

(d) Use the corrected value of calibration factor for all tests.

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

**6-3 Smoke Measurement Calibration.** The smoke measuring system shall be calibrated initially using two neutral density filters of significantly different values and also at 100 percent transmission. Once this calibration is set, at least the zero value of extinction coefficient (100 percent transmission) shall be verified each day, prior to testing. If departure from the zero line is found at the end of a calibration test, the problem shall be corrected and a new calibration shall be performed in accordance with this chapter.

**6-4* Gas Analyzers Calibration.** Gas analyzers shall be calibrated daily, prior to testing, using manufacturers' instructions.

## Chapter 7 Test Procedure

**7-1 Procedure.**

**7-1.1** Method A protocol and Method B protocol shall follow the same test procedure, except for specimen mounting. Either test method shall be used.

**7-1.2** The test procedure shall be as follows:

(a) Establish an initial volumetric flow rate of at least 1000 standard $ft^3$/min (0.47 $m^3$/sec) through the duct and increase the volume flow rate to 7000 standard $ft^3$/min (3.4 $m^3$/sec) as required to keep the oxygen content above 14 percent and to capture all effluents from the burn room.

(b) Turn on all sampling and recording devices, and establish steady-state baseline readings for at least 3 minutes.

(c) Ignite the gas burner and simultaneously start the clock, and increase the flow rate to provide a rate of heat release of 40 kW ± 1 kW by the burner. Continue the exposure at the 40 kW ± 1 kW level for 5 minutes. Within 10 seconds following the 5-minute exposure, increase the gas flow to provide a rate of heat release by the burner of 150 kW ± 5 kW exposure for 10 minutes.

(d) Take 35-mm color photographs at 30-second intervals, or provide a continuous video recording to document the growth of the fire.

(e) Provide a voice or written record of the fire, which will provide the times of all significant events, such as times of ignition, escape of flames through the doorway, and flashover.

(f) Shut off the ignition burner 15 minutes after start of the test, and terminate the test at that time, unless safety considerations dictate an earlier termination.

(g) Document damage after the test, using words, pictures, and drawings.

## Chapter 8 Calculations

**8-1 Flow Rate Equations.**

**8-1.1*** The calculation methods used to determine the rate of heat release are described in this chapter.

**8-1.2*** The mass flow rate through the duct shall be obtained from the velocity measured with a bidirectional probe *(see 5-3.2)*. The flow rate shall be calculated using a measured velocity profile in the duct.

**8-1.3** The mass flow rate shall be calculated by using the following equation. (Symbols are described in Section 8-4.)

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

**8-1.4*** The oxygen depletion factor shall be calculated according to the following equation:

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

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

$$\dot{q} = \left[E\phi - (E_{CO} - E)\frac{1-\phi}{2}\left(\frac{X_{CO}}{X_{O_2}}\right)\right]\frac{M_{O_2}}{M_e}\left(\frac{\dot{m}}{1 + \phi(\alpha - 1)}\right)(X^0_{O_2})$$

**8-1.5*** The total heat released shall be calculated according to the following equation:

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

**8-2 Smoke Measurement Equations.**

**8-2.1** The extinction coefficient, *k*, shall be calculated from the following equation:

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

**8-2.2** The optical density per unit light path length shall be calculated according to the following equation:

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

**8-2.3** The volumetric flow rate at the smoke meter shall be calculated as the product of the mass flow rate and the temperature at the measurement point (bidirectional probe), corrected by the density of air at the standard temperature (273.15 K) and by the temperature, in K, as shown in the following equation:

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

**8-2.4** Rate of smoke release shall be defined by the following equation:

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

**8-2.5** Total smoke released shall be defined by the following equation:

$$TSR = \int RSR dt$$

**8-3 Release Rate of Combustion Gases.**

**8-3.1** The release rate of carbon monoxide shall be calculated from the following equation:

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

**8-3.2** When other combustion gases are measured, their release rate shall be calculated from the following equation:

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

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

**8-4 Symbols.**

| | | |
|---|---|---|
| $C$ | = | calibration factor for orifice plate or bidirectional probe ($kg^{1/2}$, $m^{1/2}$, or $K^{1/2}$) |
| $E$ | = | net heat released per unit mass of oxygen consumed: 13.1 MJ/kg |
| $E_{CO}$ | = | net heat released per unit mass of oxygen consumed, for carbon monoxide: 17.6 MJ/kg |
| $Ht_{comb}$ | = | heat of combustion of the fuel used: 46.5 MJ/kg for propane |
| $I_o$ | = | light intensity for a beam of parallel light rays, measured in a smokefree environment, with a detector having the same spectral sensitivity as the human eye and reaching the photodetector |
| $I$ | = | light intensity for a parallel light beam having traversed a certain length of smoky environment and reaching the photodetector |
| $k$ | = | extinction coefficient (L/m) |
| $L_p$ | = | light path length of beam through smoky environment, which is equal to the duct diameter (m) |
| $\dot{m}_e$ | = | mass flow rate in exhaust duct (kg/sec) |
| $\dot{m}_{CO}$ | = | release rate of carbon monoxide (kg/sec) |
| $\dot{m}_x$ | = | release rate of combustion product *x* (kg/sec) |
| $M_a$ | = | molecular weight of incoming and exhaust air: 29 kg/kmol |
| $M_{CO}$ | = | molecular weight of carbon monoxide: 28 kg/kmol |
| $M_{O_2}$ | = | molecular weight of oxygen: 32 kg/kmol |
| $M_x$ | = | molecular weight of specimen *X* |
| $OD$ | = | optical density per unit light path length (L/m) |
| $\Delta\rho$ | = | pressure drop across the orifice plate or bidirectional probe (Pa) |
| $\dot{q}$ | = | rate of heat release (kW) |
| $RSR$ | = | rate of smoke release ($m^2$/sec) |
| $\Delta t$ | = | scan period (sec) |
| $T_e$ | = | gas temperature at the orifice plate or bidirectional probe (K) |
| test period | = | duration of test (sec) |
| $THR$ | = | total heat released (MJ) |
| $TSR$ | = | total smoke released ($m^2$) |

| | | |
|---|---|---|
| $\dot{V}_s$ | = | volumetric flow rate at location of smoke meter (value adjusted for smoke measurement calculations) ($m^3$/sec) |
| $X_{CO}$ | = | measured mole fraction of CO in exhaust flow (nondimensional) |
| $X_{CO_2}$ | = | measured mole fraction of $CO_2$ in exhaust flow (nondimensional) |
| $X^0_{CO_2}$ | = | measured mole fraction of $CO_2$ in incoming air (nondimensional) |
| $X_{O_2}$ | = | measured mole fraction of $O_2$ in exhaust flow (nondimensional) |
| $X^0_{O_2}$ | = | measured mole fraction of $O_2$ in incoming air (nondimensional) |
| $X_x$ | = | measured mole fraction of combustion gas *x* in exhaust flow (nondimensional) |
| $\alpha$ | = | combustion expansion factor (nondimensional) (Use a value of 1.105, unless the value for the test specimen, and not the ignition gas, is known.) |
| $\phi$ | = | oxygen depletion factor (nondimensional) |
| $\rho_o$ | = | density of air at 273.15 K: 1.293 (kg/$m^3$) |

## Chapter 9 Documentation

**9-1 Report.** The report shall include the data and information specified in 9-1.1 through 9-1.7.

**9-1.1 Materials.** Materials shall include the following:

(a) Name, thickness, density, and size of the test material, along with other identifying characteristics or labels

(b) Mounting, installation (including attachment method), and conditioning of materials (including all relevant time periods involved)

(c) Layout of specimens in test room (include appropriate drawings)

(d) Relative humidity and temperature of the room and the test building prior to and during the test

**9-1.2 Burner Gas Flow.** The burner gas flow shall be the fuel gas flow to the ignition burner and its calculated rate of heat output.

**9-1.3 Time History of the Total Heat Flux to Floor.** The time history of the total heat flux to floor shall be the total incident heat flux at the center of the floor for the heat flux gauge as a function of time starting 3 minutes prior to the test.

**9-1.4 Time History of the Gas Temperature.** The time history of the gas temperature shall be the temperature of gases in the room, in the doorway, and in the exhaust duct for each thermocouple as a function of time starting 3 minutes prior to the test.

**9-1.5 Time History of the Rate of Heat Release of the Fire.** The rate of heat release shall be calculated from the measured oxygen, carbon monoxide, and carbon dioxide concentrations and the temperature and volumetric flow rate of the gas in the duct. The rate of heat release time history shall be reported, as well as the maximum and average values. Similarly, the rate of heat release and total heat released time history shall be reported, as well as the final value and the values of both every 1 minute.

**9-1.6 Time History of the Fire Growth.** The time history of the fire growth shall be a transcription of the visual, photographic, audio, and written records of the fire test. The records shall indicate the time of ignition of the wall finish, the approximate location of the flame front most distant from the ignition source at intervals not exceeding 15 seconds during the fire test, the time of flashover, and the time at which flames extend outside the doorway. In addition, the still photographs and continuous video recording specified in 5-1.5 shall be supplied. Drawings, photographs, and video recordings showing the extent of the damage of the materials after the test also shall be supplied.

**9-1.7 Time History of Smoke Obscuration.** The smoke obscuration shall be described by means of the optical density, rate of smoke release, and total smoke released measured with the instrumentation in the exhaust duct. The rate of smoke release and optical density time history shall be reported, as well as the maximum and average values. Similarly, the total smoke released time history shall be reported, as well as the final value and the rate of smoke release and total smoke released values every 1 minute.

**9-1.8 Discussion of Performance.** A complete discussion of sample performances shall be conducted and shall include the following:

(a) Flame spread to ceiling during 40-kW exposure

(b) Burning to outer extremities of 2-ft (0.6-m) wide samples mounted vertically in the corner of the room with testing under Method A protocol

(c) Presence of burning droplets on the floor that persist in burning 30 seconds or more

(d) Visibility conditions in the fire test room

(e) Other pertinent details with respect to fire growth

## Appendix A Explanatory Material

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

**A-2-1.3** This corresponds to a propane gas flow rate of approximately 26.9 L/min (for 40 kW) and 100.8 L/min at 150 kW, for propane with a net heat of combustion of 46.5 MJ/kg, under standard conditions of 15 psia (101 kPa) pressure and 68°F (20°C) temperature.

**A-2-1.4** Two typical arrangements for a gas supply are illustrated in Figure B-1. *(See Appendix B.)*

**A-2-2.1** A study by R. D. Peacock and J. N. Breese (NBSIR 82-2516, *Computer Fire Modeling for the Prediction of Flashover*) examined the effect of geometric room changes on the minimum energy required to cause flashover. It showed that increased room height beyond 2.4 m (approximately 8 ft) changed the minimum needed flashover energy (expressed as percent) as follows:

$$\text{percent } 100 + 5.3\Delta H$$

Here $\Delta H$ is the increase in room height (expressed in meters). Thus, for instance, if the height was changed by 7.8 in. (0.2 m), the energy scaling would be changed by 1.06 percent. This is completely insignificant, since few fire measurements can be made to a repeatability or reproducibility of better than 10 percent. The effects of changing floor areas were similarly modest. Room dimensions having a tolerance of ±3.9 in. (±0.1 m) should be entirely adequate for reproducibility.

**A-2-2.2** In order to facilitate the mounting of the instruments and the ignition source, it is convenient to place the test room so that the floor can be reached from underneath.

**A-2-2.4** If self-supporting panels are tested, a separate exterior frame or block compartment is not required.

**A-3-1.1** It has been shown that the specific adhesive used to secure a specimen can significantly affect the fire performance of a wall covering system, and, therefore, the adhesive utilized should be the same as that intended for actual use.

**A-3-2.4** For products where vaporization of solvents occurs (such as those using adhesives) or products containing wood, a conditioning time of 4 weeks is not uncommon.

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

**A-5-1.2.1** Maintenance of the heat flux gauge will normally require a flow rate of at least 0.1 gpm (0.38 L/min).

**A-5-1.3** Metal-clad thermocouples with ceramic powder filling have been found satisfactory for this purpose, but silicone-impregnated, glass-insulated thermocouples are likely to break at temperatures above 1500°F (815°C).

**A-5-1.5** A window that is cut 2 ft (0.61 m) above the floor in the front wall facing the gas burner and fitted with heat-resistant, impact-resistant glazing provides useful photographic access. Any floodlights used should not raise the ambient temperature in the room above what is specified in Chapter 4, namely 86°F (30°C).

**A-5-3.2** A bidirectional probe is preferable to a Pitot-static tube for measuring velocity in the exhaust duct, in order to avoid problems of clogging with soot.

Capacitance transducers have been found to be most stable for this application.

**A-5-3.4.1** Stainless steel sampling lines have been shown to be satisfactory. Alternative designs of the sampling line should give equivalent results.

The recommended approach to a cooling column (to remove water from the combustion gases) is to use a refrigerated column and separation chamber with a drain plug from which the collected water is removed from time to time. Alternate devices shown to give equivalent results are also acceptable.

**A-5-3.4.2** Combustion gas concentration measurements require the use of appropriate time shifts, in order to account for the time required for gas analyzer response and for combustion gas transit time within the sampling system.

**A-5-3.5** A method of determining suitability of oxygen analyzers for making heat release measurements is as follows:

(a) *General.* The type of oxygen analyzer best suited for fire gas analysis is of the paramagnetic type. Electrochemical analyzers or analyzers using zirconia sensors have generally been found not to have adequate sensitivity or suitability for this type of work. The normal range of the instrument to be used is 0 vol to 25 vol percent oxygen. The linearity of paramagnetic analyzers is, normally, better than can be checked by a user laboratory; therefore, verifying their linearity is not necessary. It is important, however, to confirm the noise and short-term drift of the instrument used.

(b) *Procedure.* Check the analyzer suitability using the following steps:

1. Connect two different gas bottles having approximately 2 percentage points apart (for example 15 vol percent and 17 vol percent) to a selector valve at the inlet of the analyzer.
2. Connect the electrical power and let the analyzer warm up for 24 hours, with one of the test gases from (a) flowing through it.
3. Connect a data acquisition system to the output of the analyzer. Quickly switch from the first gas bottle to the second bottle, and immediately start collecting data, taking one data point per second. Collect data for 20 minutes.
4. Determine the drift by using a least-squares analysis fitting procedure to pass a straight line through the last 19 minutes of data. Extrapolate the line back through the first minute of data. The difference between the readings at 0 minutes and at 20 minutes on the fitted straight line represents the short-term drift. Record the drift in units of parts per million of oxygen.
5. The noise is represented by the root-mean-square deviation around the fitted straight line. Calculate that root-mean-square value and record it in units of parts per million of oxygen.

(c) *Analyzer.* The analyzer is suitable for use in heat release measurements if the sum of the drift plus the noise terms is ≤50 ppm oxygen (note that both terms must be expressed as positive numbers).

(d) *Additional Precautions.* A paramagnetic oxygen analyzer is directly sensitive to barometric pressure changes at its outlet port and to flow rate fluctuations in the sample supply stream. It is essential that the flow rate be regulated. Use either a flow rate regulator of the mechanical diaphragm type or an electronic mass flow rate controller. In order to protect against errors due to changes in barometric pressure, one of the following procedures should be used:

1. Control the back pressure to the analyzer with a back pressure regulator of the absolute-pressure type.
2. Electrically measure the actual pressure at the detector element and provide a signal correction for the analyzer output.

See NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter.*

**A-5-3.8.2** The following information is being provided for informational purposes only and has not been independently verified, certified, or endorsed by the NFPA or any of its technical committees. The system described as follows is an example of a white light measuring system that has been found to be satisfactory.

(a) *Lenses.* Plano convex, diameter 40 mm, focal length 50 mm

(b) *Lamp.* Osram Halo Stars, 64410: 6 V, 10 W, or equivalent