Designation: E 1995 – 04a

An American National Standard

Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber, With the Test Specimen Oriented Horizontally[1]

This standard is issued under the fixed designation E 1995; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This is a fire-test-response standard.

1.2 This test method provides a means of measuring smoke obscuration resulting from subjecting essentially flat materials, products, or assemblies (including surface finishes), not exceeding 25 mm [1 in.] in thickness, in a horizontal orientation, exposed to specified levels of thermal irradiance, from a conical heater, in the presence of a pilot flame, in a single closed chamber. Optional testing modes exclude the pilot flame.

1.3 The principal fire-test-response characteristic obtained from this test method is the specific optical density of smoke from the specimens tested, which is obtained as a function of time, for a period of 10 min.

1.4 An optional fire-test-response characteristic measurable with this test method is the mass optical density (see Annex A1), which is the specific optical density of smoke divided by the mass lost by the specimens during the test.

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

1.6 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. For limitations of this test method, see 5.5.

1.7 Use the SI system of units in referee decisions; see IEEE/ASTM SI-10. The inch-pound units given in brackets are for information only.

1.8 *This test method is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.*

1.9 Fire testing of products and materials is inherently hazardous, and adequate safeguards for personnel and property shall be employed in conducting these tests. This test method may involve hazardous materials, operations, and equipment. See also 6.2.1.2, Section 7, and 11.7.2.

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 2843 Test Method for Density of Smoke from the Burning or Decomposition of Plastics

D 4100 Test Method for Gravimetric Determination of Smoke Particulates from Combustion of Plastic Materials

D 5424 Test Method for Smoke Obscuration of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration

E 84 Test Method for Surface Burning Characteristics of Building Materials

E 176 Terminology of Fire Standards

E 603 Guide for Room Fire Experiments

E 662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials

E 906 Test Method for Heat and Visible Smoke Release Rates for Materials and Products

E 1354 Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter

E 1474 Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components or

[1] This test method is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.21 on Smoke and Combustion Products.

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

Composites Using a Bench Scale Oxygen Consumption Calorimeter

E 1537 Test Method for Fire Testing of Upholstered Furniture Items

E 1590 Test Method for Fire Testing of Mattresses

IEEE/ASTM SI-10 Practice for Use of the International System of Units (SI): The Modernized Metric System

2.2 *ISO Standards:*[3]

ISO Guide 52—Glossary of Fire Terms and Definitions

ISO 3261 Fire Tests–Vocabulary

ISO 5659-2 Determination of Specific Optical Density by a Single-Chamber Test

ISO 5725 Precision of Test Methods—Determination of Repeatability and Reproducibility for Standard Test Method by Interlaboratory Tests

2.3 *British Standards:*

BS 6809 Method of Calibration of Radiometers for Use in Fire Testing[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology E 176 and ISO 3261. In case of conflict, the definitions given in Terminology E 176 shall prevail.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *composite*, *n*—a combination of materials, which generally are recognized as distinct entities, for example coated or laminated materials.

3.2.3 *continuous (as related to data acquisition)*, *adj*—conducted at data collection intervals of 5s or less.

3.2.4 *essentially flat surface*, *n*—surface where the irregularity from a plane does not exceed ±1 mm.

3.2.5 *exposed surface*, *n*—that surface of the specimen subjected to the incident heat.

3.2.6 *flaming mode*, *n*—the mode of testing that uses a pilot flame.

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

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

3.2.8 *mass optical density*, *n*—the ratio of the optical density of smoke and the mass loss of the test specimen, multiplied by the volume of the test chamber and divided by the length of the light path.

3.2.8.1 *Discussion*—The mass optical density as determined in this test method is not an intrinsic material property; it is a function of the test procedure and conditions used.

3.2.9 *Nonflaming mode*, *n*—the mode of testing that does not use a pilot flame.

3.2.10 *sample*, *n*—an amount of the material, product, or assembly, to be tested, which is representative of the item as a whole.

3.2.11 *smoke obscuration*, *n*—the reduction in visibility due to smoke (ISO Guide 52).

3.2.12 *specimen*, *n*—the actual section of material, product, or assembly, to be placed in the test apparatus.

3.2.13 *time to ignition*, *n*—time between the start of the test and the presence of a flame on the specimen surface for a period of at least 4s.

4. Summary of Test Method

4.1 This test method assesses the reduction of light by smoke obscuration from a burning sample. The test method employs a conically-shaped, electrically-heated, radiant-energy source to produce irradiance levels of 25 and 50 kW/m^2, averaged over the center of the exposed surface of an essentially flat specimen, and mounted horizontally inside a closed chamber. The equipment is suitable for testing at irradiance levels of up to 50 kW/m^2.

4.2 The specimen is 75 by 75 mm [3 by 3 in.], at a thickness not exceeding 25 mm [1 in.] and is mounted horizontally within a holder.

4.3 The exposure is conducted in the presence or in the absence of a pilot flame (see details in 6.3.6). If a pilot flame is used for ignition, the test is deemed to be in the "flaming" mode; if a pilot flame is not used, the test is deemed to be in the "nonflaming" mode.

4.4 The test specimens are exposed to flaming or nonflaming conditions within a closed chamber. A photometric system with a vertical light path is used to measure the varying light transmission as smoke accumulates. The light transmittance measurements are used to calculate the specific optical density of the smoke generated during the test.

4.5 The specimens are exposed to two conditions, out of the four standard exposure conditions, to be chosen by the test requester. The four standard exposure conditions are: flaming mode at an irradiance of 25 kW/m^2, flaming mode at an irradiance of 50 kW/m^2; nonflaming mode at an irradiance of 25 kW/m^2; and, nonflaming mode at an irradiance of 50 kW/m^2. Unless specified otherwise, conduct testing in the two flaming mode exposure conditions (see 8.3, X1.3 and X1.4). Exposures to other irradiances also are possible.

4.6 Mass optical density is an optional fire-test-response characteristic obtainable from this test method, by using a load cell, which continuously monitors the mass of the test specimen (see Annex A1).

5. Significance and Use

5.1 This test method provides a means for determining the specific optical density of the smoke generated by specimens of materials, products, or assemblies under the specified exposure conditions. Values determined by this test are specific to the specimen in the form and thickness tested and are not inherent fundamental properties of the material, product, or assembly tested.

5.2 This test method uses a photometric scale to measure smoke obscuration, which is similar to the optical density scale

[3] Available from International Standardization Organization, P.O. Box 56, CH-1211; Geneva 20, Switzerland, or from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from British Standards Institute (BSI), 389 Chiswick High Rd., London W4 4AL, U.K.

for human vision. The test method does not measure physiological aspects associated with vision.

5.3 At the present time no basis exists for predicting the smoke obscuration to be generated by the specimens upon exposure to heat or flame under any fire conditions other than those specified. Moreover, as with many smoke obscuration test methods, the correlation with measurements by other test methods has not been established.

5.4 The current smoke density chamber test, Test Method E 662, is used by specifiers of floor coverings and in the rail transportation industries. The measurement of smoke obscuration is important to the researcher and the product development scientist. This test method, which incorporates improvements over Test Method E 662, also will increase the usefulness of smoke obscuration measurements to the specifier and to product manufacturers.

5.4.1 The following are improvements offered by this test method over Test Method E 662: the horizontal specimen orientation solves the problem of melting and flaming drips from vertically oriented specimens; the conical heat source provides a more uniform heat input; the heat input can be varied over a range of up to 50 kW/m^2, rather than having a fixed value of 25 kW/m^2; and, the (optional) load cell permits calculations to be made of mass optical density, which associates the smoke obscuration fire-test-response characteristic measured with the mass loss.

5.5 *Limitations*[5]:

5.5.1 The following behavior during a test renders that test invalid: a specimen being displaced from the zone of controlled irradiance so as to touch the pilot burner or the pilot flame; extinction of the pilot flame (even for a short period of time) in the flaming mode; molten material overflowing the specimen holder; or, self-ignition in the nonflaming mode.

5.5.2 As is usual in small-scale test methods, results obtained from this test method have proven to be affected by variations in specimen geometry, surface orientation, thickness (either overall or individual layer), mass, and composition.

5.5.3 The results of the test apply only to the thickness of the specimen as tested. No simple mathematical formula exists to calculate the specific optical density of a specimen at a specimen thickness different from the thickness at which it was tested. The literature contains some information on a relationship between optical density and specimen thickness **[1]**.[6]

5.5.4 Results obtained from this test method are affected by variations in the position of the specimen and radiometer relative to the radiant heat source, since the relative positioning affects the radiant heat flux (see also Appendix X2).

5.5.5 The test results have proven sensitive to excessive accumulations of residue in the chamber, which serve as additional insulators, tending to reduce normally expected condensation of the aerosol, thereby raising the measured specific optical density (see 5.5.8.3 and 11.1.2).

5.5.6 The measurements obtained have also proven sensitive to differences in conditioning (see Section 10). Many materials, products, or assemblies, such as some carpeting, wood, plastics, or textiles, require long periods to attain equilibrium (constant weight) even in a forced-draft conditioning chamber. This sensitivity reflects the inherent natural variability of the sample and is not specific to the test method.

5.5.7 In this procedure, the specimens are subjected to one or more specific sets of laboratory test conditions. If different test conditions are substituted or the end-use conditions are changed, it is not necessarily possible by or from this test method to predict changes in the fire-test-response characteristics measured; therefore, the results are valid only for the fire test exposure conditions described in this procedure.

5.5.8 This test method solves some limitations associated with other closed chamber test methods, such as Test Method E 662 **[2-5]** (see 5.4.1). The test method retains some limitations related to closed chamber tests, as detailed in 5.5.8.1-5.5.8.5.

5.5.8.1 Information relating the specific optical density obtained by this test method to the mass lost by the specimen during the test is possible only by using the (optional) load cell, to determine the mass optical density (see Annex A1).

5.5.8.2 All specimens consume oxygen when combusted. The smoke generation of some specimens (especially those undergoing rapid combustion and those which are heavy and multilayered) is influenced by the oxygen concentration in the chamber. Thus, if the atmosphere inside the chamber becomes oxygen-deficient before the end of the experiment, combustion may ceases for some specimens; therefore, it is possible that those layers furthest away from the radiant source will not undergo combustion.

5.5.8.3 The presence of walls causes losses through deposition of combustion particulates.

5.5.8.4 Soot and other solid or liquid combustion products settle on the optical surfaces during a test, resulting in potentially higher smoke density measurements than those due to the smoke in suspension.

5.5.8.5 This test method does not carry out dynamic measurements as smoke simply continues filling a closed chamber; therefore, the smoke obscuration values obtained do not represent conditions of open fires.

6. Apparatus and Ancillary Equipment

6.1 *General*—The apparatus (Fig. 1) consists of an air-tight test chamber with provision for containing a sample holder, radiation cone, pilot burner, a light transmission and measuring system and other ancillary facilities for controlling the conditions of operation during a test.[7]

6.2 *Test Chamber*:

6.2.1 *Construction*:

6.2.1.1 Fabricate the test chamber (Figs. 1 and 2) from laminated panels, the inner surfaces of which shall consist of either a porcelain-enamelled metal, not more than 1 ± 0. 1 mm [0.04 ± 0.004 in.] thick, or an equivalent coated metal, which is resistant to chemical attack and corrosion and capable of easy cleaning. The internal dimensions of the chamber shall be 914 ± 3 mm long, 914 ± 3 mm high and 610 ± 3 mm deep

[5] Some of these limitations are common to many small scale fire-test-response methods.

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

[7] A list of suppliers for such equipment is available from ASTM Headquarters.