Designation: E2187 – 16

An American National Standard

Standard Test Method for Measuring the Ignition Strength of Cigarettes[1]

This standard is issued under the fixed designation E2187; 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.

INTRODUCTION

The most common initiating event in a fatal fire in the United States is the dropping of a lit cigarette onto a bed or piece of upholstered furniture. The cigarette coal heats the furnishing materials to the point where smoldering combustion begins, perhaps followed by a transition to flaming combustion. Since limiting the frequency of ignitions is a principal approach to reducing fire loss, it is desirable to establish a test method for the propensity of a cigarette to ignite soft furnishings. This test method uses standard substrates to determine the extent to which, as the substrate draws heat from the cigarette, the cigarette combustion remains strong enough to be capable of initiating a fire.

1. Scope

1.1 This fire-test-response standard provides a standard measure of the capability of a cigarette, positioned on one of four standard substrates, to generate sufficient heat to continue burning and thus potentially cause ignition of bedding or upholstered furniture.

1.2 This method has value as a predictor of the relative propensity of a cigarette to ignite upholstered furnishings.

1.3 This method is applicable to cigarettes that burn along the length of a tobacco column.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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

1.6 *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.* For specific hazard statements, see Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E176 Terminology of Fire Standards

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E1352 Test Method for Cigarette Ignition Resistance of Mock-Up Upholstered Furniture Assemblies

E1353 Test Methods for Cigarette Ignition Resistance of Components of Upholstered Furniture

2.2 *NFPA Standards:*[3]

NFPA 260 Standard Methods of Tests and Classification Systems for Cigarette Ignition Resistance of Components of Upholstered Furniture

NFPA 261 Standard Method of Test for Determining Resistance of Mock-up Upholstered Furniture Material Assemblies to Ignition by Smoldering Cigarettes

2.3 *Other Standard:*[4]

Standard for the Flammability of Mattresses and Mattress Pads, 16 Code of Federal Regulations, Part 1632

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method refer to Terminology E176.

3.2 *Definitions of Terms Specific to This Standard:*

[1] This test method is under the jurisdiction of ASTM Committee E05 on Fire Standards and is the direct responsibility of Subcommittee E05.15 on Furnishings and Contents.

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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.

[3] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269, http://www.nfpa.org.

[4] Available from the Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001; http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title16/16cfr1632_main_02.tpl.

3.2.1 *full-length burn, n*—the outcome of a determination in which the cigarette burns to or past the front plane of the tipping paper, which covers the filter and perhaps a short section of the tobacco column in a filter tip cigarette, or past the tips of the metal pins (see 7.5) if the cigarette has no filter.

4. Summary of Test Method

4.1 This test method measures the probability that a cigarette, placed on a substrate, will generate sufficient heat to maintain burning of the tobacco column. Each determination consists of placing a lit cigarette on the horizontal surface consisting of a set number of layers of filter paper or a single layer of filter paper on a thin sheet of full hard 302 stainless steel (**1**).[5] Observation is made of whether or not the cigarette continues to burn to the beginning of the tipping paper. Forty determinations (comprising a test) are performed to obtain the relative probability that the cigarette will continue burning despite heat abstraction by the substrate.

5. Significance and Use

5.1 The most common initiating event in a fatal fire is the dropping of a cigarette onto a bed or piece of upholstered furniture, according to statistics provided by the National Fire Protection Association (**2**). Test Methods E1352 and E1353 and tests NFPA 261 and NFPA 260 have been developed to evaluate the susceptibility of upholstered furniture mock-ups and components to ignition by cigarettes. Federal Standard 16 CFR Part 1632, Standard for the Flammability of Mattresses and Mattress Pads, was promulgated to reduce the likelihood that mattresses and mattress pads would ignite from a lighted cigarette.

NOTE 1—While Test Methods E1352 and E1353 were originally equivalent to NFPA 261 and 260, respectively, this is no longer the case.

5.2 This test method enables comparison of the relative ignition strength of different cigarette designs.

5.3 In this procedure, the specimens are subjected to a set of laboratory conditions. If different conditions are substituted or the end use conditions are changed, it may not be possible, using this test, to predict quantitative changes in the fire test response characteristics measured. Therefore, the quantitative results are valid only for the fire test exposure conditions described in this procedure.

6. Hazards

6.1 This test method involves the use of combustible materials that are exposed to ignition sources. Consequently, the user shall take proper precautions to avoid thermal injuries.

6.1.1 Personnel shall be instructed on general procedures to handle an unwanted fire. Appropriate fire extinguishing equipment shall be provided to suppress any fires that exceed normal controlled limits.

6.2 Personnel shall take proper precautions to avoid inhaling combustion products.

6.2.1 Exhaust systems shall be checked regularly to ensure that they are removing all products of combustion from the workspace.

6.2.2 Respiratory equipment shall be made available for personnel.

6.3 The user shall ensure that all burning has ceased before discarding used test materials. An appropriate closed metal waste container shall be used in each fire test laboratory for safe disposal of specimens and test assemblies after being exposed to heat and fire.

7. Apparatus and Equipment

7.1 *Test and Conditioning Environment*—An environmental conditioning room shall be maintained which provides an area adequate for conditioning both cigarettes and filter paper specimens. This room shall be capable of maintaining a relative humidity of 55 ± 5 % and a temperature of 23 ± 3°C (73 ± 5°F) and shall be continuously monitored. The room in which the tests are conducted, which may also be the conditioning room, shall be maintained within the same temperature and relative humidity ranges.

7.2 *Constant Humidity Box*—Alternatively, cigarettes and filter paper shall be stored in a box of sufficient size to hold the needed quantities of filter paper and cigarettes. The interior of the box shall be maintained at a relative humidity of 55 ± 5 % and a temperature of 23 ± 3°C (73 ± 5°F) and shall be continuously monitored. A tray containing a saturated solution of sodium bromide (NaBr) in water will provide the appropriate relative humidity when the box temperature is as prescribed. The box shall be located convenient to the test chamber such that test materials shall not be exposed to a non-conditioned environment for more than 5 min between their removal from the box and the beginning of a test.

7.3 *Test Chamber*—A test chamber of the design photographed in Fig. 1 shall be constructed of clear plastic such as polymethylmethacrylate (PMMA), nominally 6 mm (0.25 in.) in thickness. The inside dimensions shall be: height: 340 ± 25 mm (13.4 ± 1 in.), width: 292 ± 6 mm (11.5 ± 0.25 in.), depth: 394 ± 6 mm (15.5 ± 0.25 in.). The full front panel of the chamber shall be hinged, with a latch to effect positive closure. The top of the chamber shall have a flattop cylindrical chimney of height 165 ± 13 mm (6.5 ± 0.5 in.) and inside diameter 152 ± 6 mm (6.00 ± 0.25 in.). The chimney shall be centered on the chamber top and sealed to the chamber top panel.

7.4 *Substrate Holder:*

7.4.1 A cylindrical support, shown in Fig. 2, shall be made of PMMA or similarly rigid material, dimensioned as follows. The outer diameter shall be 165 ± 1 mm (6.50 ± 0.04 in.), the inner diameter shall be 127 ± 1 mm (5.00 ± 0.04 in.), and the height shall be 50 ± 1 mm (1.97 ± 0.04 in.). A recess in the top, 10 ± 2.5 mm (0.40 ± 0.10 in.) deep, shall expand the inner diameter to 152 ± 1 mm (6.00 ± 0.04 in.). Three or four legs shall raise the bottom of the holder approximately 20 mm (0.80 in.) above the chamber floor.

NOTE 2—The outer diameter of the metal rim is not to exceed the inner diameter of the recess in the filter paper holder.

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

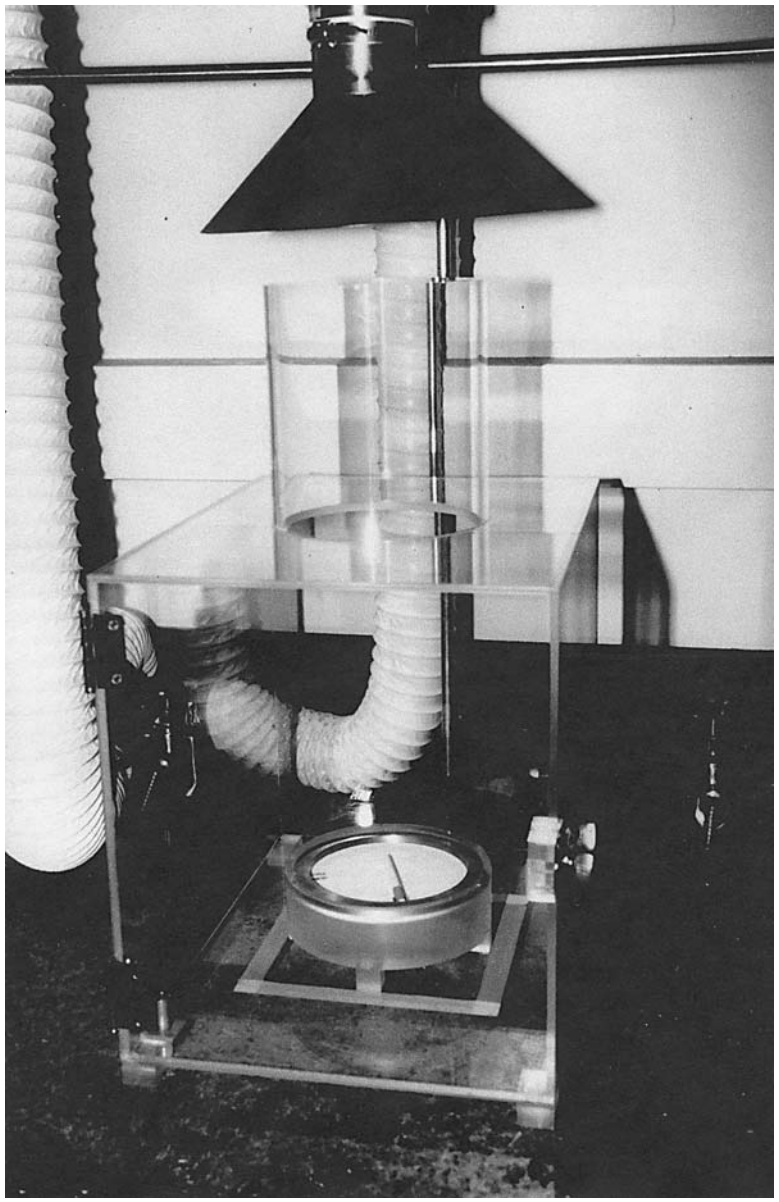

FIG. 1 Photograph of Test Chamber and Holder for the Filter Paper Substrates

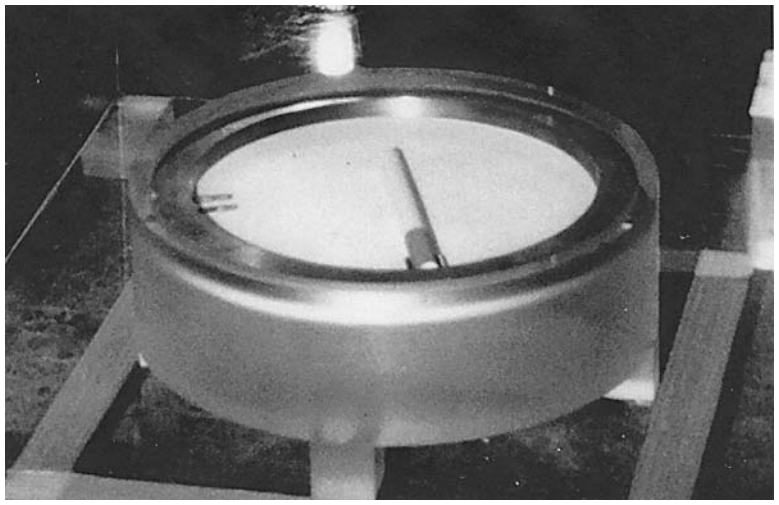

FIG. 2 Close-up of Test Cigarette, Filter Paper Holder, Metal Pins and Metal Rim

7.4.2 An adapter ring to support the stainless steel/paper substrate shall be made of PMMA or a similarly rigid material, dimensioned as follows. The outer diameter shall be 165 ± 1 mm (6.50 ± 0.04 in.), the inner diameter shall be 126 ± 1 mm (4.98 ± 0.04 in.), and the height shall be 15.5 ± 1 mm (0.61 ± 0.04 in.). A recess in the bottom, 10.0 ± 1 mm (0.40 ± 0.04 in.) deep, shall decrease the outer diameter to 150 ± 1 mm (5.90 ± 0.04 in.). The top surface of the adapter shall be flat to within ±0.03 mm (0.001 in.). A schematic of the adapter ring is shown in Fig. 3. The assembled support for the stainless steel substrate is shown in Fig. 4.

7.5 *Metal Rim*—A circular brass or other dense metal rim, shown in Fig. 2, shall be used to hold the sheets of filter paper flat against each other. The outside diameter of the rim shall be 150 ± 2 mm (5.90 ± 0.08 in.). The inner diameter shall be 130 ± 2 mm (5.1 ± 0.08 in.). The rim surface shall be flat and smooth. A pair of parallel metal pins, each approximately 1 mm in diameter and 8.1 ± 0.05 mm (0.32 ± 0.02 in.) apart, shall protrude 17 ± 4 mm (0.65 ± 0.15 in.) toward the center of the rim. The pins are to be spaced to keep the non-ignited end of a conventional 25 mm circumference cigarette from rolling, but without pressuring the cigarette. If cigarettes of significantly different diameter are to be tested, other pairs of pins, appropriately spaced, shall be inserted into the rim.

7.5.1 The mass of the rim shall be 600 ± 10 g. If the mass of a rim is lower, a stacked second rim shall bring the total mass to 600 ± 10 g.

7.6 *Cigarette Holder*—A holder shall be used to support the lit cigarette in a horizontal position in the test chamber prior to placement of the cigarette onto the filter paper substrate. The holder shall not clamp the cigarette nor stress it in any other manner, nor shall it contact the cigarette within a nominal 30 mm (1.2 in.) of its lit end.

7.7 *Cigarette Ignition System*—A system consisting of an air draw component and an ignition source shall be used to ignite the test cigarettes. The cigarette shall be supported in a horizontal position. A butane gas lighter capable of producing a stable luminous flame 15 ± 3 mm (0.6 ± 0.1 in.) in length or a hot coil igniter shall be used for lighting the cigarette. The airflow and the draw time through the lit cigarette shall be sufficient to establish a coal to within ±1 mm of the mark 5 mm (0.2 in.) from the tip of the cigarette. Appropriate filtering media shall be used downstream of the cigarette to remove smoke and condensable combustion gases in order to prevent contamination of the downstream components.

FIG. 4 Close-up of a Test Cigarette on the Stainless Steel/Paper Substrate

7.8 *Exhaust Hood*—A chemical or canopy hood shall be used for removing combustion products from the test room. Air flow through the hood shall be sufficient to remove cigarette and substrate combustion products while not being high enough to influence the combustion processes in the test chamber(s). (See 8.1.2.)

7.9 *Extinguishment*—Following a determination, the cigarette and sheets of filter paper shall be completely extinguished, for example, by smothering or by application of water.

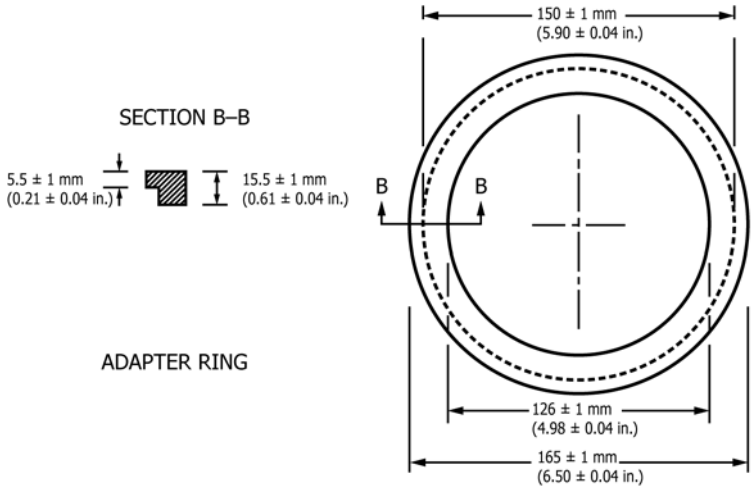

FIG. 3 Schematic of the Adapter Ring to Support the Stainless Steel Substrate

8. Calibration and Standardization

8.1 Calibrations of equipment shall be carried out as noted below and at any time when equipment or test conditions indicate that evaluation and re-calibration are necessary. The time intervals for calibrations stated in this method shall be considered to be the minimum.

8.1.1 The test chambers shall be checked before use to minimize air leakage so that the smoke plume from a cigarette rises undisturbed during testing. Door seals shall be checked visually to ensure that they are closed flush against the chamber's side wall and the latching device secures the door tightly. All construction seams shall be inspected to ensure they are airtight and no cracks shall be visible on any surface of the test chamber. If leaks are detected, measures shall be taken to ensure that these areas are again made sufficiently air tight.

8.1.2 Stability of air inside the test chamber shall be determined daily by placing a lit cigarette in the test position on three or more layers of filter paper, then closing the chamber door. Air movement in the chamber shall be observed to ensure that smoke being emitted by the cigarette is rising vertically and is not showing turbulence within nominally 150 mm (ca. 6 in.) above the lit end of the cigarette. If turbulence is noted, then (*a*) the test chamber shall be checked for leaks, (*b*) the test chamber locations shall be evaluated for excess air flow in the laboratory, and (*c*) the air flow of the exhaust system shall be evaluated as the source of the disturbance.

8.1.3 The humidity and temperature sensors used to record environmental conditions in the conditioning room or the chamber and test room shall be checked for accuracy each week.

8.1.4 At least every 30 days of active testing, the laboratory shall verify the performance of the total test system and operator using a test cigarette whose ignition propensity using ASTM E2187 has been established.

NOTE 3—Standard Reference Material 1082, a standardized cigarette obtainable from the National Institute of Standards and Technology, has been widely used for this purpose. This information is provided for the convenience of users of this standard and does not constitute an endorsement by ASTM.

9. Test Specimens and Standard Substrate Assemblies

9.1 Cigarette test specimens and the filter paper and stainless steel substrate materials are sensitive to contamination. Test cigarettes shall be handled only by the last nominal 25 mm (1 in.) of the end of the cigarette that is not to be lit. The sheets of filter paper and the stainless steel sheets shall not be handled in the vicinity where the cigarette will contact the paper and steel during a test. In all cases, the materials shall be handled with dry hands only.

NOTE 4—The use of clean, dry, non-powdered surgical gloves can mitigate incidental contamination of the test materials while maintaining operator dexterity.

9.2 *Cigarettes:*

9.2.1 Cigarette test specimens shall be protected from physical or environmental damage while in handling and storage. It is important that the specimens not be crushed or deformed in any manner. Measures shall be taken to ensure that the specimens are not contaminated while in storage and they shall be protected from degradation by insects. If the specimens are to be stored by the testing laboratory for more than one week, they shall be placed in a freezer at 0°C (32°F) to −20°C (−4°F) reserved for the sole protection of cigarette specimens to minimize the risk of contamination.

9.2.2 Prior to testing, cigarette test specimens shall be marked, using a #2 or softer graphite pencil or other marking device, 5 ± 1 mm and 15 ± 1 mm (0.2 and 0.6 in., each ±0.04 in.) from the end of the cigarette that will be lit. These marks are used to establish the start (11.4) and completion (11.5.4) of a uniform pre-burn period, respectively. Neither the process of marking the cigarette nor the mark itself shall significantly affect the cigarette burn rate.

9.3 *Substrates:*

9.3.1 The filter paper substrates consist of nominal 150 mm (6 in.) diameter circles of Whatman #2 ash-free cellulosic filter paper. Substrates are formed by placing multiple layers of filter paper into the holder assembly, then placing the metal rim on top to ensure good contact between the layers. All sheets of filter paper shall be oriented with the rough surface facing upward, where discernible.

NOTE 5—In an interlaboratory study of alternate filter papers for use in ASTM E2187, data have indicated that for some cigarette designs, slightly different test values could be obtained depending on whether the rough surface or the smooth surface of the Whatman No. 2 filter paper was facing upward (**3**).

9.3.2 The paper/steel substrate consists of a single sheet of nominal 150 mm (6 in.) diameter circle of filter paper centered on top of a nominal 159 mm (6.25 in.) by 150 mm (6.0 in.) rectangle of full hard 302 stainless steel shim stock. The substrate is formed by centering the 302 stainless steel sheet on the adapter ring, centering a sheet of filter paper on top of the steel, centering the metal rim on top of the filter paper, and then placing the metal rim weight on top. The steel sheet shall be oriented concave down, when discernible. The sheet of filter paper shall be oriented with the rough surface facing upward, when discernible. This sheet of filter paper need not be Whatman No. 2, but shall comply with the specifications in 9.4.

NOTE 6—In principle, a steel/paper substrate could consist of a 150 mm diameter piece of full hard 302 stainless steel shim stock and a piece of 150 mm diameter filter paper. These would be supported in the same manner as the substrates consisting of 3, 10, or 15 layers of filter paper, that is, without the adapter ring. However, data demonstrating the equivalence to the rectangular sheet and its support hardware have not been published.

9.4 *Filter Paper:*

9.4.1 For paper from a manufacturer's batch to be used in the filter paper substrates, the mean mass of 15 sheets of the conditioned filter paper shall be 26.1 ± 0.5 g. This shall be determined by weighing five samples of 15 sheets, each sample being from a different box from the manufacturer's batch. The standard deviation of the five samples shall be no more than 0.3 g. For paper from a manufacturer's batch to be used in the stainless steel/filter paper substrate, the mean mass of 15 sheets of the conditioned filter paper shall be 26.2 ± 0.5 g, determined in the same manner.

9.4.2 For paper from a manufacturer's batch to be used in the filter paper substrates, the mean mass of 15 sheets of the dried paper shall be 24.7 ± 0.5 g. This shall be determined by

weighing five samples of 15 sheets, each sample being from a different box from the manufacturer's batch. Each set of 15 sheets shall have been stored at 60 ± 2°C for at least 16 h, placed in a sealed plastic bag upon removal from the oven, cooled to 23 ± 3°C, and weighed within 3 min of opening the bag. The standard deviation of the five samples shall be no more than 0.3 g. For paper from a manufacturer's batch to be used in the stainless steel/filter paper substrate, the mean mass of 15 sheets of the conditioned filter paper shall be 24.9 ± 0.7 g, determined in the same manner.

9.4.3 For paper from a manufacturer's batch to be used in the stainless steel/filter paper substrate, the moisture content of the conditioned paper, relative to the dried paper, shall be 5.0 ± 0.6 % by mass.

9.5 *Stainless Steel*—The 302 stainless steel piece shall be flat, not from a roll. The thickness shall be 0.203 ± 0.004 mm (0.00800 ± 0.00016 in.) thick. The flatness shall be determined according to 11.3.

10. Conditioning

10.1 Cigarettes shall be conditioned at a relative humidity of 55 ± 5 % and a temperature of 23 ± 3°C (73 ± 5°F) for at least 24 h prior to testing. The cigarettes shall be placed in a clean, open container, with the number of cigarettes being sufficiently small as to enable free air access to the specimens, for example, a maximum of 20 cigarettes in a 250 mL polyethylene or glass beaker.

10.2 Boxes of filter paper shall be conditioned at a relative humidity of 55 ± 5 % and a temperature of 23 ± 3°C (73 ± 5°F) for at least one week prior to testing. The top of each 100 sheet box of filter paper shall be removed prior to being placed in the conditioning room or box. The top opening of the box shall not be obstructed. The paper sheets need not be removed from the box. Alternatively, sets of no more than 15 sheets of filter paper shall be conditioned at a relative humidity of 55°C ± 5 % and a temperature of 23 ± 3°C for at least 8 h prior to testing. These filter paper sets shall have been removed from the box and shall be stored upright with at least 1 mm spacing between the sets to enable free access of air to the specimens.

10.3 The stainless steel sheets shall be individually (that is, not stacked) conditioned at a temperature of 23 ± 3°C (73 ± 5°F) for at least 2 h prior to testing.

11. Procedure

11.1 Turn on the exhaust system designated for removal of test combustion products 30 min prior to beginning testing.

11.2 Ensure that the filter paper holder, with the adapter ring when testing using the stainless steel substrate, is in the test chamber at the geometric center of its bottom. Cover the chimney on the test chamber.

11.3 If using filter paper substrates, conduct the test beginning with 15 layers of filter paper except as indicated in Annex A1. Select the number of layers of filter paper for the scheduled determinations using the procedure in Annex A1. All sheets of filter paper shall be oriented with the rough surface facing upward. If using the stainless steel/filter paper substrate, ensure that the stainless steel sheet is sufficiently flat as follows. Prior to testing, place the steel sheet concave downward on a surface that is flat to within 0.025 mm (0.001 in.) over an area of at least 200 by 200 mm (7.9 by 79. in). The sheet is not sufficiently flat if a 2 mm diameter precision ground steel rod, in contact with the flat surface, can be inserted between the sheet and the flat surface at any point on the perimeter of the sheet.

NOTE 7—Some suggested flat surfaces are granite plates of at least 25 mm (1 in.) thickness or aluminum tool and jig plates of at least 19 mm (0.75 in.) thickness.

11.3.1 If the relative humidity and temperature in the test room cannot be maintained within the specified ranges, the substrate materials and cigarettes shall be sealed in plastic bags in the conditioning room and transported. Care shall be taken to ensure that test materials are protected from physical damage during transport and prior to use.

11.3.2 Immediately before testing with a filter paper substrate, place the proper number of filter papers on the filter paper holder and place the metal test rim on top. Discard filter papers that will not lay flat. When testing using the stainless steel/filter paper substrate, place the steel sheet and the filter paper on the adapter ring and place the metal rim and, if needed to meet the mass requirement in 7.5, the circular weight on top.

11.3.3 Place the cigarette holder on the floor of the chamber, just forward of the center of the filter paper holder.

11.4 Without delay, remove a cigarette from the conditioned space. Insert the unmarked end of the cigarette into the cigarette ignition system and hold it in a horizontal position. Turn on the air draw. Hold the ignition flame or hot wire coil just in front of the marked end of the cigarette for as long as is necessary to achieve uniform ignition without passing the 5 mm mark. During the ignition process, the cigarette shall be rotated as needed to obtain an approximately symmetrical burn.

11.4.1 If the operator is performing concurrent determinations in multiple test chambers, the operator shall not light a third cigarette until each of the first two cigarettes has been placed on its respective set of filter papers. No more than two cigarettes shall be in the pre-burn stage at any time.

11.4.1.1 This provision need not be followed by an individual test operator if that operator has demonstrated that lifting the restriction does not introduce error that significantly changes either the measured ignition strength or the uncertainty of that measurement. This determination shall be the responsibility of the testing laboratory.

11.5 Holding the cigarette vertically, coal end up, transport the cigarette to the test chamber.

NOTE 8—It has been found that holding a 600 mL beaker over the lit cigarette is helpful in mitigating the likelihood of a foreign object or room air current impacting the cigarette during transport and thus leading to the need to terminate the determination.

11.5.1 Place the lit cigarette, in a horizontal position with the cigarette paper seam up, in the cigarette holder.

11.5.2 Simultaneously close the door and remove the chimney cover.

11.5.3 If the cigarette self-extinguishes while in the cigarette holder, terminate the determination and record the results

as a self-extinguishment, noting that this occurred in the holder. This attempt shall count as a valid determination. The test operator shall be permitted to re-use this substrate. However, if the room is not at the standard conditioning temperature and humidity (see 7.1), the substrate materials shall first be reconditioned in a constant humidity box (see 7.2).

11.5.4 When the cigarette has burned to the 15 mm mark, simultaneously cover the chimney and open the chamber door, gently remove the cigarette from the holder, and move the holder to the front corner of the test chamber.

11.5.5 Gently lay the cigarette with the ash still attached onto the top of the filter papers so that the non-ignited end is placed between the appropriately sized cigarette anti-roll parallel metal pins. (Fig. 2). The cigarette paper seam shall be turned up. Do not drop the cigarette onto the substrate and do not press the coal into the substrate. If the ash falls off during any part of the transport or positioning process, terminate the determination and begin again; do not count the attempt.

11.5.6 Without delay, simultaneously remove the chimney cover and gently close the door.

11.6 Observe the burning cigarette. The smoke plume near the cigarette must remain undisturbed. If it does not, the chamber and exhaust system shall be re-checked as in 8.1.2. If the chamber and exhaust system are behaving properly, but the particular test cigarettes continue to produce disturbed smoke plumes, this observation shall be noted on the test sheet.

11.7 Record the following results:

(1) Any of the tobacco column burns to or past the front plane of the tipping paper (filter tip cigarettes) or past the tips of the metal pins (see 7.5) for non-filter tip cigarettes; or

(2) The burning ceases before reaching the front plane of the tipping paper (filter tip cigarettes) or the tips of the metal pins for non-filter tip cigarettes.

(3) The observations stated in 11.5.3 and 11.6.

11.8 Ensure that neither the cigarette nor the filter papers are burning.

11.9 Open the test chamber door to allow air to circulate throughout its volume. After the chamber has cleared, prepare for the next determination.

11.10 The stainless steel substrate shall be cleaned after each determination. Lay the stainless steel substrate on the clean, flat surface used in 11.3. Using a soft laboratory wipe that has been wetted with ethanol or isopropanol, gently wipe the top surface of the stainless steel to remove any char residue or other contaminants. After carefully removing the stainless steel substrate from the flat surface, wipe the flat surface to remove any residual contamination. Ensure that the stainless steel substrate is dry before proceeding with the next determination.

11.11 Repeat the determination with each cigarette 40 times per test. Calculate the fraction of determinations in which the cigarettes burned their full length. This fraction is the test result.

12. Test Report

12.1 Results shall be reported for a minimum of one test on each of the four substrates for which testing is required. In the absence of a substrate requirement, reports shall be reported, as described in Annex A1.

TABLE 1 Repeatability and Reproducibility Limits for a Test Involving 40 Replicate Determinations

NOTE 1—*r*: band within which differences among repeat test results (same laboratory) will fall about 95 % of the time.

R: band within which differences among test results from different laboratories will fall about 95 % of the time.

n: number of full-length burns within which differences among repeat test results (same laboratory) will fall about 95 % of the time.

N: number of full-length burns within which differences among test results from different laboratories will fall about 95 % of the time.

P	r (n)	R (N)
0.05 or 0.95	0.10(4)	0.11 (4)
0.10 or 0.90	0.13(5)	0.16 (6)
0.20 or 0.80	0.18(7)	0.21 (8)
0.30 or 0.70	0.20(8)	0.24(10)
0.40 or 0.60	0.22(9)	0.26(10)
0.50	0.22(9)	0.26(10)

12.2 Report the following information for each test:

12.2.1 Laboratory name and name of person performing the determinations,

12.2.2 The temperature and relative humidity in the laboratory and (if used) the conditioning box,

12.2.3 Date and start time of each determination,

12.2.4 Cigarette identification,

12.2.5 Number of layers of filter paper per determination or identification of the substrate as a single layer of filter paper over a full hard 302 stainless steel sheet,

12.2.6 The fraction of determinations in which the cigarettes burned past the front plane of the tipping paper (filter tip cigarettes) or past the tips of the metal pins for non-filter tip cigarettes, and

12.2.7 The observations noted in 11.5.3 and 11.6.

13. Precision and Bias

13.1 *Precision*—The precision of a test method nearly identical to this was established during an interlaboratory evaluation of the three filter paper substrates conducted according to Practice E691. The principal difference was that the cigarettes were supported in a vertical rather than a horizontal position during the pre-burn period (11.5). The evaluation involved 9 laboratories, 5 cigarette types, and 3 substrates, each with a different number of filter papers. See Ref **(4)**. The precision associated with the steel/paper substrate has not yet been established.

13.2 The calculated repeatability, *r*, and reproducibility, *R*, limits for the three filter paper substrates have been determined for 40 determinations in a test and the fractions of cigarettes that produced full-length burns (*P*):

13.2.1 If either interval contains negative values they are to be omitted. The equivalent limits for the steel/paper substrate have not yet been determined.

13.3 *Bias*—This test method has no bias because the value for the ignition strength is determined solely in terms of this test method itself.

14. Keywords

14.1 bed flammability; cigarette; fire; furniture flammability; ignition; ignition propensity

ANNEX

(Mandatory Information)

A1. PROCEDURE FOR SELECTION OF SUBSTRATE ASSEMBLIES FOR TESTING

A1.1 The performance of a cigarette design shall be evaluated on substrates required by the regulatory authority or the customer. If testing is only required on the metal/paper substrate, the remainder of this Annex is to be disregarded.

A1.2 In the absence of any regulatory guidance and information about the likely performance of the cigarette design, testing shall begin with 15 layers of filter paper.

A1.2.1 If full length burning of the cigarette is observed in over 90 % of the determinations with 15 layers, then it shall be presumed that testing on 3 or 10 layers would also produce virtually all full length burns and no testing on those substrate assemblies shall be performed. (See Appendix X1)

A1.2.2 If full length burning is observed in under 90 % of the determinations with 15 layers, then testing shall proceed using 10 layers. If full length burning is observed in over 90 % of the tests with 10 layers, then it shall be presumed that testing on 3 layers would also produce virtually all full length burns and no testing on those shall be performed. If full length burning is observed in under 90 % of the tests with 10 layers, then testing shall proceed using 3 layers.

A1.3 If there is information about the likely performance of a cigarette design that suggests a low tendency to ignite furnishings, the test operator shall have the option to begin testing with 10 or 3 layers of filter paper.

A1.3.1 Starting with 10 layers. If full length burning is observed in over 10 % of the tests with 10 layers, testing shall proceed using 15 layers. It shall be presumed that testing on the assemblies using 3 layers would also produce virtually all full length burns and no testing on that substrate assembly shall be performed. If full length burning is observed in under 10 % of the tests with 10 layers, then testing using 15 layers shall not be performed and testing shall proceed using 3 layers.

A1.3.2 Starting with 3 layers. If full length burning is observed in under 10 % of the tests with 3 layers, then testing using 10 and 15 layers shall not be performed. If full length burning is observed in over 10 % of the tests with 3 layers, testing shall proceed using 10 layers. If full length burning is observed in over 10 % of the tests with 10 layers, testing shall proceed using 15 layers.

A1.4 The test report shall address the performance of a cigarette on all types of substrate assemblies. For those assemblies on which no testing was performed, as prescribed in A1.2 and A1.3, the outcome of the trial shall be described as "Substrate not required to be tested."

APPENDIX

(Nonmandatory Information)

X1. IGNITION SUSCEPTIBILITY OF SUBSTRATE ASSEMBLIES

X1.1 During the development of this test method, it was established **(4)** that the filter paper substrates showed a systematic progression in measuring ignition strength, i.e., the capability of potentially initiating a fire while heat is being drawn from the cigarette. Additional data have recently been developed for two commercial cigarettes **(5)**. In Table X1.1, the cigarettes are listed in decreasing order of ignition strength. The cigarettes with high percentages of full-length burns on the filter paper substrates generate enough heat to keep burning and thus are more likely to ignite soft furnishings than the cigarettes with lower such percentages. This means that, relative to a substrate assembly using 3 or 10 layers of filter paper, the 15 layer assembly requires a stronger heat source (cigarette) for full length burning.

X1.2 Table X1.1 also shows that the substrates used in this test method produce results consistent with those from a similar method that measures the propensity of cigarettes to ignite substrates made of standard cotton fabrics and a flexible polyurethane foam.

X1.3 Analysis of the data from the cigarette industry studies of 500 and 300 upholstery fabrics **(6, 7, 8)** has shown that most

TABLE X1.1 Percent Ignitions or Full Length Burns on Test Method Substrates
[data from Ref (4) except as noted]

Substrate → Cigarette ↓	3 layers	Duck #10	10 layers	Duck #6	15 layers	Duck #4
B	100	100	100	92	94	73
503	100	100	100	100	100	53
Conventional (5)	100	100	100	100	100	19
501	100	100	100	100	100	11
D	100	100	94	73	88	46
E	100	100	100	96	94	0
531	99	98	94	95	88	0
A	100	100	94	92	38	4
F	100	100	100	79	19	0
Banded (5)	39	37	8	50	12	3
529	57	30	6	8	2	0
530	6	3	0	0	0	0

fabrics (80 % and 70 %, respectively) that discriminated among four test cigarettes ranked these cigarettes in the same order as did the cotton duck test fabrics (**9, 10, 11**). In both studies, the remainder of the test fabrics produced some reversal of cigarette rankings.

X1.4 There is a good correlation between actual pieces of furniture and mock-ups made of the same materials (**12**).

X1.5 It is thus expected that significantly improved performance on this test method will lead to reduced ignitions of soft furnishings.

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