Designation: D 4804 – 98

Standard Test Method for Determining the Flammability Characteristics of Nonrigid Solid Plastics[1]

This standard is issued under the fixed designation D 4804; 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 These fire-test-response test methods describe small-scale laboratory procedures for determining the comparative burning characteristics of solid plastic materials that, due to specimen thinness and nonrigidity, may *distort* or shrink when tested using Test Method D 3801. A flame is applied to the base of specimens held in a vertical position and the extinguishing times are determined upon removal of the test flame.

1.2 The classification system described in Appendix X1 is intended for quality assurance and the preselection of component materials for products.

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

NOTE 1—These test methods and ISO 9773 are equivalent.

NOTE 2—For rate of burning of nonrigid solid plastics in a horizontal position, formerly Test Method B of these test methods, see Test Method D 635, section 9.4.

1.4 *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 Note 3.

2. Referenced Documents

2.1 *ASTM Standards:*

D 635 Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position[2]

D 1898 Practice for Sampling of Plastics[2]

D 3801 Test Method for Measuring the Comparative Extinguishing Characteristics of Solid Plastics in a Vertical Position[3]

D 5025 Specification for a Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials[4]

D 5207 Practice for Calibration of 20 and 125 mm Test Flames for Small-Scale Burning Tests on Plastic Materials[4]

E 176 Terminology of Fire Standards[5]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[6]

2.2 *ISO Standards:*

ISO 9773–98 Plastics—Determination of Burning Behaviour of Thin Flexible Vertical Specimens in Contact With a Small Flame Ignition Source[7]

3. Terminology

3.1 *Definitions*—For definitions of fire-related terms used in these test methods, refer to Terminology E 176.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *flame-impingement time*, *n*—the time in seconds that the flame from the burner is in contact with the specimen.

3.2.2 *flaming material*, *n*—flaming drips or particles from the specimen which ignite the dry, absorbent surgical cotton placed 300 mm below the test specimen.

3.2.3 *afterflame*, *n*—persistence of flaming of a material, after the ignition source has been removed.

3.2.4 *afterflame time*, *n*—the length of time for which a material continues to flame, under specified conditions, after the ignition source has been removed.

3.2.5 *afterglow*, *n*—persistence of glowing of a material, after cessation of flaming or, if no flaming occurs, after removal of the ignition source.

3.2.6 *afterglow time*, *n*—the length of time for which a material continues to glow under specified test conditions, after the ignition source has been removed or cessation of flaming, or both.

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[1] These test methods are under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

[4] *Annual Book of ASTM Standards*, Vol 08.03.

[5] *Annual Book of ASTM Standards*, Vol 04.07.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

3.2.7 *flame, v*—to undergo combustion in the gaseous phase with emission of light.

3.2.8 *glow, n*—visible light, other than from flaming, emitted by a solid undergoing combustion.

4. Summary of Test Method

4.1 These test methods consist of subjecting the lower end of vertically held specimens to a 20-mm test flame for two 3-s flame applications. The 200 by 50-mm specimens are preformed around a 13-mm diameter mandrel. The afterflame time is recorded after the first flame application and the afterflame and afterglow times are recorded after the second flame application. Information is also recorded on whether or not flaming material drips from the specimens.

5. Significance and Use

5.1 The test results represent the afterflame and afterglow times, in seconds, for a material under the conditions of the test.

5.2 The afterflame and afterglow times and other burning phenomena will vary with thickness. Test data should only be compared with data for material of comparable thickness. Useful information may be obtained from a plot of afterflame and afterglow times versus thickness.

5.3 The effect of material thickness, colors, additives, deterioration, and possible loss of volatile components is measurable.

5.4 The results serve as a reference for comparing the relative performance of materials and can be an aid in material selection.

5.5 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 may not be 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 test method.

6. Apparatus

6.1 *Test Chamber*—An enclosure or laboratory hood with a minimum capacity of 0.5 m^3, free of induced or forced draft during testing. An enclosed laboratory hood with a heat-resistant glass window and an exhaust fan for removing the products of combustion immediately after the tests are recommended. (**Warning**—See Note 3.) Laboratory hoods may have induced drafts even with the exhaust fan off. A positive closing damper may be needed.

NOTE 3—**Warning:** Products of combustion may be toxic.

6.2 *Laboratory Burner*, constructed in accordance with Specification D 5025.

6.3 *Ring Stand*, with a clamp or the equivalent, adjustable for vertical positioning of specimens.

6.4 *Gas Supply*—A supply of technical-grade methane gas with suitable regulator and meter for uniform gas flow. Natural gas having an energy density of 37 ± 1 MJ/m^3 has been found to provide similar results. However, technical-grade methane gas shall be used as the referee gas in cases of dispute. Other fuel gases such as butane, propane, and acetylene have higher energy density and are not suitable.

6.5 *Timer*—Stopwatch or other suitable timing device capable of timing to the nearest 0.5-s.

6.6 *Cotton*—A supply of dry, absorbent 100 % cotton.

6.7 *Desiccator*, containing a suitable drying agent, capable of maintaining a relative humidity not exceeding 20 % at 23°C ± 2°C.

6.8 *Conditioning Room or Chamber*, capable of being maintained at 23 ± 2°C and a relative humidity of 50 ± 5 %.

6.9 *Conditioning Oven*—A full-draft circulating-air oven capable of being maintained at 70 ± 2°C.

6.10 *Specimen Mandrel Guide*, 13 ± 0.5-mm diameter rod.

6.11 *Micrometer*, capable of being read to 0.01 mm.

6.12 *Pressure-Sensitive Adhesive Tape*, of a commercially-available type.

6.13 *Weighing Scale or Balance*, having an accuracy and resolution of 0.01 g.

7. Sampling

7.1 Unless otherwise agreed, material shall be sampled in accordance with the sections on General Sampling Procedures and Specific Sampling Procedures of Practice D 1898.

8. Test Specimen

8.1 Cut at least ten test specimens, 200 ± 5 mm in length by 50 ± 2 mm in width, and of the thickness of material normally supplied, from sheet material. Prepare the test specimens by marking a line across the specimen width, 125 ± 5 mm from the bottom end of the cut specimen. Wrap the longitudinal axis of the test specimen tightly around the longitudinal axis of a 13 ± 0.5-mm diameter mandrel to form a lapped cylinder 200-mm long with the 125-mm line exposed. Use pressure-sensitive tape to secure the overlapping ends of the specimen within the 75-mm portion of the 125-mm mark and at the upper tube section. After the cylinder is formed, remove the mandrel. If the material is prone to developing static charges which make the formation of a cylinder difficult, use a static neutralizing device or material to deionize the unformed specimen.

NOTE 4—For stiff specimens, the pressure-sensitive tape may be reinforced or replaced by nichrome wire wound around the top 75 mm of the specimen.

8.2 Different generic materials, although capable of being wrapped and taped around the mandrel, may exhibit varying degrees of flaring out of the untaped end, some of which may result in nonlapped "U" type specimens. These various forms are considered acceptable to test if the upper end can be formed into the cylinder.

9. Conditioning

9.1 The cylindrical specimens may be prepared before or after the conditioning. Condition specimen sets as follows:

9.1.1 Condition one set of five specimens for at least 48 h at a temperature of 23 ± 2°C and a relative humidity of 50± 5 % prior to testing.

9.1.2 Condition a second set of five specimens in a circulating-air oven for a duration of 168 h at 70 ± 2°C and then cool in a desiccator over anhydrous calcium chloride for at least 4 h at room temperature prior to testing.

9.2 All specimens shall be tested in a laboratory atmosphere of 15 to 35°C and 45 to 75 % relative humidity.

10. Procedure

10.1 Conduct the burning test in a chamber, enclosure, or laboratory hood free of induced or forced draft.

10.2 Support a specimen from the upper 6 mm of the specimen, with the longitudinal axis vertical, by a heavy spring clamp, so that the upper end of the tube is closed to prevent any chimney effects during the test. The lower end of the specimen should be 10 ± 1 mm above the top of the burner tube and 300 ± 10 mm above a horizontal layer of 0.05 to 0.08 g of cotton thinned to an area approximately 50 × 50 mm and a maximum thickness of 61 mm (see Fig. 1, View (*a*)).

10.3 Place the burner remote from the specimen, ignite, and adjust it to produce a blue flame 20 ± 1 mm high. Obtain the flame by adjusting the gas supply and the air ports of the burner until a 20-mm yellow-tipped blue flame is produced. Increase the air supply until the yellow tip just disappears. Measure the height of the flame again, and if necessary, adjust the burner-gas supply to give the proper flame height. The test flame is to be calibrated using Practice D 5207 monthly, when the gas supply or equipment is changed or when test results are questioned.

10.4 Place the test flame centrally under the lower end of the unlapped section of the test specimen (Note 4) with the burner tube 10 ± 1 mm below the specimen for a flame-impingement time of 3± 0.55 s (see Fig. 1, View (*b*)). Withdraw the test flame at least 150 mm away and record the duration of afterflame, in seconds, of the specimen after the removal of the test flame. When flaming of the specimen ceases, immediately replace the test flame under the specimen. After this additional 3 ± 0.55-s flame impingement time, withdraw the test flame again. Record the duration of afterflame and afterglow times in seconds.

NOTE 5—For specimens that flare and are not lapped at the lower end, apply the flame in line with the longitudinal axis of the specimen (see Fig. 1, View (*c*)).

10.5 If the specimen drips molten or flaming material during either flame application, tilt the burner to an angle up to 45° and withdraw the burner slightly from one of the sides of the specimen during the flame applications to avoid dripping into the tube of the burner. If the specimen drips molten or flaming material or is consumed during the test, hand-hold the burner and maintain the proper distance between the bottom of the specimen and the top of the burner tube during the flame application. Ignore any molten strings of the material and always apply the flame to the bottom of the major portion of the specimen.

10.6 Repeat the procedure given in 10.2-10.5 on the remaining specimens for each set.

11. Calculation

11.1 Calculate the total afterflame time for each set of five specimens, t_f, using the following formula:

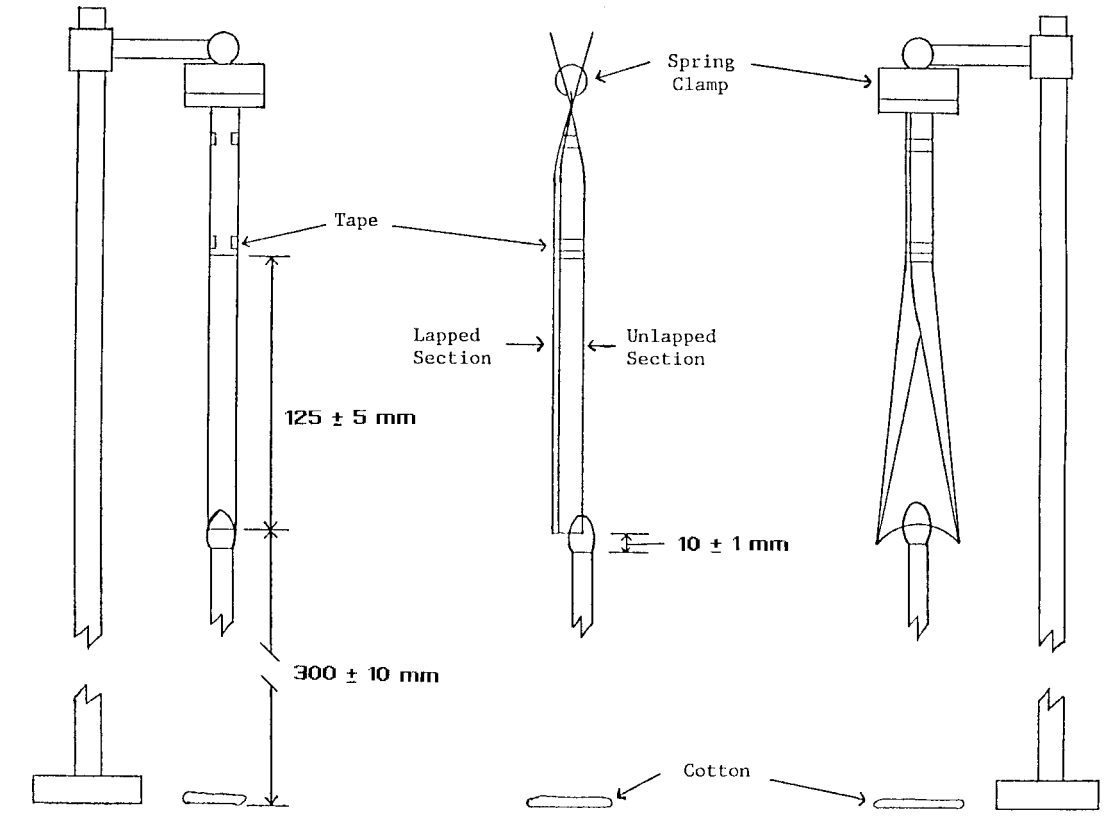

FIG. 1 Test Apparatus

$$t_f = \sum_{i=1}^{i=5} (t_{1,i} + t_{2,i}) \quad (1)$$

where:

t_f = total flaming time, s,
i = individual specimen number,
$t_{1,i}$ = afterflame time after the first flame impingement, s, of the i^{th} specimen, and
$t_{2,i}$ = afterflame time after the second flame impingement, s, of the i^{th} specimen.

11.2 Calculate the arithmetic mean of the afterflame time for each flame impingement, t_1 and t_2, and the afterflame plus afterglow time for the second flame impingement, t_2 plus t_3, recorded for each set of five specimens to the nearest second.

12. Report

12.1 Report the following information:

12.1.1 *Material Identification*—Include generic description, manufacturer, commercial designation, lot number, and color.

12.1.2 *Conditioning or Aging*:

12.1.2.1 Conditioning time at 23 ± 2°C in hours.

12.1.2.2 Cooling time in desiccator in hours.

12.1.3 The total afterflame time for each set of five specimens, t_f.

12.1.4 Duration of afterflame time after first flame impingement, t_1.

12.1.5 Duration of afterflame time after second flame impingement, t_2.

12.1.6 Duration of afterflame and afterglow times after second flame impingement, $t_2 + t_3$.

12.1.7 Whether or not any of the specimens burn up to the 125-mm mark.

12.1.8 Whether or not any of the specimens drip flaming particles which ignite the cotton swatch.

12.1.9 If the material will be classified, indicate the category designation from the Classification System in Appendix X1.

13. Precision and Bias [8]

13.1 Tables 1 and 2 are based on a round robin completed in 1986 in accordance with Practice E 691, involving four materials tested by six laboratories. For each material, all the samples were provided by one source. The individual specimens were cut and distributed by one laboratory. Each laboratory conditioned, at 23°C and 50 % relative humidity, the specimens that it tested. The round robin did not include specimens conditioned at 70°C.

13.1.1 For Tables 1 and 2, each test result was the average of five individual determinations.

[8] Supporting data is available from ASTM Headquarters. Request RR:D20-1146.

TABLE 1 First Impingement, Afterflame Time Only

Material	Afterflame Time, s				
	Average	s_r [A]	S_R [B]	I_r [C]	I_R [D]
Polyimide (PI)	0.3	0.4	0.7	1.1	2.0
Polyurethane (PUR)	0.8	0.7	0.7	2.0	2.0
Polyethylene terephthalate (PET)	2.3	0.7	0.9	2.0	2.5
Poly(vinyl fluoride) (PVF)	6.0	4.4	4.4	12.5	12.5

[A] s_r = within-laboratory standard deviation of the average.
[B] S_R = between-laboratory standard deviation of the average.
[C] I_r = 2.83 s_r, and
[D] I_R = 2.83 S_R.

TABLE 2 Second Impingement, Afterflame and Afterglow Times

NOTE 1—None of the materials exhibited afterglow; therefore, afterflame plus afterglow is the same as afterflame only, after the second impingement.

Material	Afterflame Time, s				
	Average	s_r [A]	S_R [B]	I_r [C]	I_R [D]
Polyimide (PI)	0.0	. . .	. . .	. . .	. . .
Polyurethane (PUR)	1.3	1.2	1.2	3.4	3.4
Polyethylene terephthalate (PET)	2.1	0.8	1.4	2.3	4.0
Poly(vinyl fluoride) (PVF)	7.2	3.8	6.2	10.8	14.7

[A] s_r = within-laboratory standard deviation of the average.
[B] S_R = between-laboratory standard deviation of the average.
[C] 2.83 s_r, and
[D] 2.83 S_R.

NOTE 6—**Caution:** The explanations of I_r and I_R given in 13.2-13.2.3 are only intended to present a meaningful way of considering the *approximate* precision of this test method. The data in Tables 1 and 2 should not be rigorously applied to acceptance or rejection of material, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories.

Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 13.2-13.2.3 then would be valid for such data.

13.2 *Concept of I_r and I_R*—If s_s and s_R have been calculated from a large enough body of data, and for test results that were averages from testing five specimens.

13.2.1 *Repeatability, I_r*—In comparing two test results for the same material, obtained by the same operator using the same equipment on the same day, the two test results should be judged not equivalent if they differ by more than the I_r value for that material.

13.2.2 *Reproducibility, I_R*—In comparing two test results for the same material, obtained by different operators using different equipment on different days, the two test results should be judged not equivalent if they differ by more than the I_R value for that material.

13.2.3 Any judgment in accordance with 13.2.1 and 13.2.2 would have an approximate 95 % probability of being correct.

13.3 *Bias*—There are no recognized standards on which to base an estimate of bias for these test methods.

14. Keywords

14.1 flammability; plastics, nonrigid; plastics, solid; vertical position

APPENDIX

(Nonmandatory Information)

X1. CLASSIFICATION SYSTEM FOR DETERMINING THE COMPARATIVE BURNING CHARACTERISTICS OF NONRIGID SOLID MATERIALS IN A VERTICAL POSITION

X1.1 This appendix describes a classification system that can be used to characterize the burning behavior of nonrigid materials, supported in a vertical position, in response to a small-flame ignition source. The use of a category designation code is optional and is determined by examining the test results of materials tested by this test method. Each category code represents a preferred range of performance levels that simplifies description in material designations or specifications and may assist certification bodies to determine compliance with applicable requirements.

X1.2 The behavior of specimens may be classified in one of the categories shown in Table X1.1 by selecting the appropriate column using test results to answer the conditional questions posed.

TABLE X1.1 Material Classifications

Criteria Conditions	VTM-0	VTM-1	VTM-2
Afterflame time for each individual specimen t_1 or t_2.	≤10s	≤30s	≤30s
Total afterflame time for any condition set (t_1 plus t_2 for the five specimens)	≤50s	≤250s	≤250s
Afterflame plus afterglow time for each individual specimen after the second flame application ($t_2 + t_3$)	≤30s	≤60s	≤60s
Afterflame or afterglow of any specimen up to the 125-mm mark	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

X1.3 Recording the category designation in the test report is optional.

X1.4 If only one specimen from a set of five specimens fails to comply with the requirements of 11.1.3 or the total number of seconds of flaming is in the range of 51 to 55 s for VTM-0 or 251 to 255 for VTM-1 or VTM-2, an additional set of five specimens shall be tested. All specimens from this second set shall comply with the appropriate requirements in order for the material in that thickness to be classified VTM-0, VTM-1, or VTM-2.

X1.5 If the material does not comply with this criteria, the material may be tested in accordance with Test Method D 635.

SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D-20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes or reasons for the changes, or both.

D 4804–98:

(1) Test Method B has been removed and relocated in Test Method D 635.
(2) Added an ISO equivalency statement (Note 1).
(3) Added an option to use a Classification System to categorize materials (1.2, 12.1.9 and Appendix X1).
(4) Added references to Practices D 5207 and E 691, Terminology E 176 and ISO 9773. Removed reference to D 635.
(5) Provided terminology for afterflame, afterflame time, afterglow, and afterglow time (3.2.3, 3.2.4, 3.2.5 and 3.2.6).
(6) Removed references to inch-pound units and added tolerances to critical dimensions for harmonization with ISO 9773.
(7) Added a micrometer (6.11), pressure-sensitive adhesive tape (6.12) and a weighing scale or balance (6.13) to the apparatus section.
(8) Added a note to use wire to wrap specimens if the tape is not adequate (Note 3).
(9) Added requirements for the amount of cotton to be used (10.2).
(10) Added a requirement to calibrate the flame to Practice D 5207 (10.3).
(11) Removed the calculation for the standard deviation and added a calculation for determining the total afterflame time and the arithmetic mean of the afterflame time (11.1 and 11.2).