**Designation: ~~D4804 – 20~~ D4804 – 23**

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

This standard is issued under the fixed designation D4804; 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 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, distort, shrink, and/or are consumed up to holding clamp when tested using Test Method D3801. 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—This standard is equivalent to ISO 9773, IEC 60695-11-10, and UL 94 (Section 11).

NOTE 2—For rate of burning of nonrigid solid plastics in a horizontal position, formerly Test Method B of this test method, see Test Method D635.



1.4 This test method is not intended to cover plastics when used as materials for building construction or finishing.

1.5 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see 6.1.1.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties.

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***A Summary of Changes section appears at the end of this standard**

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D635 Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
D883 Terminology Relating to Plastics
D3801 Test Method for Measuring the Comparative Burning Characteristics of Solid Plastics in a Vertical Position
D5025 Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials
D5207 Practice for Confirmation of 20-mm (50-W) and 125-mm (500-W) Test Flames for Small-Scale Burning Tests on Plastic Materials
E176 Terminology of Fire Standards
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E2935 Practice for Evaluating Equivalence of Two Testing Processes

2.2 *ISO Standards:*[3]

ISO 9773:1998 Plastics—Determination of Burning Behaviour of Thin Flexible Vertical Specimens in Contact With a Small Flame Ignition Source
ISO 13943 Fire Safety—Vocabulary

## 3. Terminology

3.1 *Definitions*—For definitions of terms relating to plastics, the definitions in this test method are in accordance with Terminology D883. For terms relating to fire, the definitions in this test method are in accordance with Terminology E176 and ISO 13943. In case of conflict, the definitions given in Terminology E176 shall prevail. For terms relating to precision and bias and associated issues, the terms used in this test method are in accordance with the definitions in Terminology E456.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *flaming material*—flaming drips or particles from the specimen which ignite the dry, absorbent 100 % surgical cotton placed 300 mm ± 10 mm below the test specimen.

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

3.2.4 *afterflame time*—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*—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*—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.

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

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

## 4. Summary of Test Method

4.1 This test method consists of subjecting the lower end of vertically held specimens to a 20 ± 1 mm test flame for two 3-second flame applications. The 200 ± 5 mm by 50 ± 2 mm specimens are preformed around a 13 ± 0.5 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.

[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 American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

## 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 shall only be compared with data for material of the same comparable 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 will not always 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. If a draft is noted with the exhaust fan off, further measures are needed to eliminate the draft, such as adding a positive closing damper. The inside surfaces of the chamber shall be of a dark color. When a light meter, facing towards the rear of the chamber is positioned in place of the test specimen, the light level shall be less than 20 lx.



6.1.1 **Warning—**Products of combustion are toxic. Provide an exhause fan for removing the products of combustion immediately after the test.

NOTE 3—Placing a mirror in the hood, to provide a rear view of the test specimen, has been found useful.

6.2 *Laboratory Burner,* constructed in accordance with Specification D5025.



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 (Min. 98 % pure) with suitable regulator and meter for uniform gas flow. Natural gas having an energy density of 37 ± 1 $MJ/m^3$ (1000 $Btu/ft^3$) 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-seconds.

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

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

6.8 *Conditioning Room or Chamber,* capable of being maintained at 23 ± 2°C and a relative humidity of 50 ± 10 %.

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.

6.14 *Stainless steel or nichrome wire,* of diameter 0.2 mm to 0.5 mm.

## 7. Sampling

7.1 Unless otherwise agreed, material shall be sampled in accordance with good statistical practice.

## 8. Test Specimens

8.1 Since the results of tests carried out on test specimens of different colors, thicknesses, densities, molecular masses, directions of orientation, or containing different levels or amounts of additives, fillers, or reinforcements, are potentially different, apply the additional considerations indicated in 8.1 through 8.1.3.

8.1.1 When conducting tests on test specimens at the minimum and maximum densities, melt flows and levels of fillers or of reinforcements, consider only those test results representative of the complete range, if the test results yield the same burning characteristics, including the same flame test classification.

8.1.2 If the burning characteristics, including flame test classification, are not essentially the same for all test specimens representing the range tested, consider the test results only that apply to those materials for which the actual color, thickness, density, molecular mass, melt flow characteristics and level of additives, fillers, and or reinforcements have been tested. Test additional specimens for intermediate ranges of each property.

8.1.3 Un-pigmented test specimens and test specimens with the highest level of organic and inorganic pigment loading by weight are considered representative of the color range, if the test results yield the same flame test classification. When certain pigments are known to affect flammability characteristics, they are also to be tested. Test specimens to be tested are those that:

*(a)* contain no pigments (natural)
*(b)* contain the highest level of organic pigments
*(c)* contain the highest level of inorganic pigments
*(d)* contain pigments which are known to adversely affect flammability characteristics



8.2 All specimens shall be cut from a representative sample of the material (sheets or end-products). After any cutting operation, care shall be taken to remove all dust and any particles from the surface; cut edges shall have a smooth finish.

8.3 Standard specimens shall be 200 ± 5 mm long, 50 ± 2 mm wide and a maximum of 0.25 mm thick. Measure the thickness of each to the nearest 0.01 mm and note the measurements.

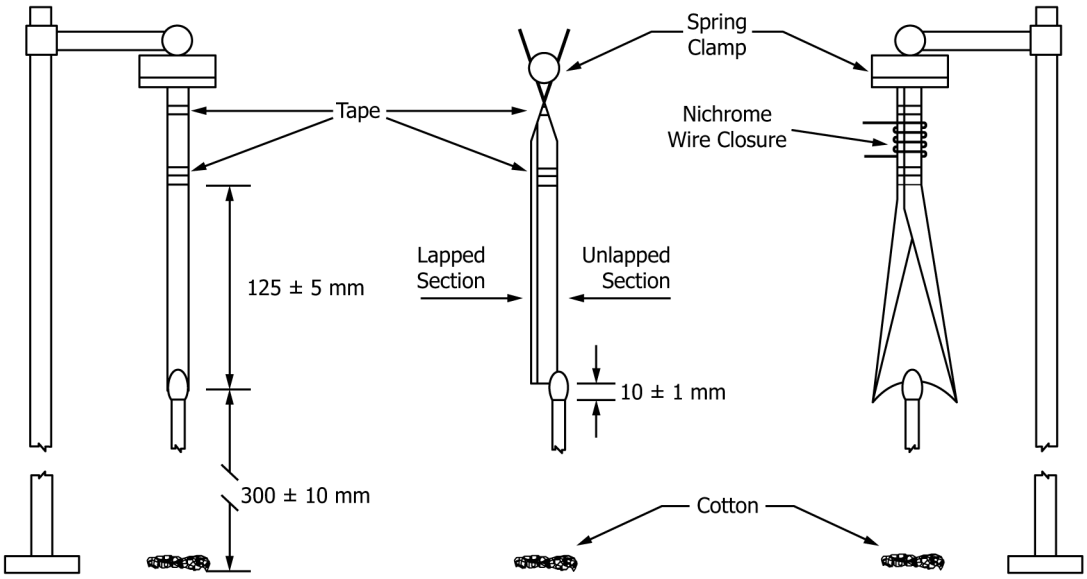
8.3.1 Specimens >0.25 mm thick can be subjected to this test method if the specimens due to their thinness and nonrigidity, distort, shrink and/or are consumed up to holding clamp when tested using Test Method D3801.

8.3.2 Tests made on specimens of different thicknesses and made in different directions of anisotropy are not always comparable.

8.4 Specimens shall be prepared by marking a line across the specimen width 125 mm ± 5 mm from one end (bottom) of the cut specimen. The longitudinal axis of the specimen shall be wrapped tightly around the longitudinal axis of the mandrel to form a lapped cylinder with the 125-mm line exposed. The overlapping portions of the specimens shall be secured within the upper 75-mm segment above the 125-mm mark and at the upper end of the tube with pressure-sensitive adhesive tape. The mandrel shall then be removed. If the material is prone to developing static charges that make the formation of a cylinder difficult, it is acceptable to deionize the unformed specimen using a device or material intended for that purpose.

8.5 A minimum of 20 specimens shall be prepared. Prepare additional specimens for retest purposes, if necessary.

8.6 It is possible that different generic materials, although capable of being wrapped and taped around the mandrel, will exhibit varying degrees of flaring out of the untaped end, some of which will potentially result in nonlapped “U” type specimens. These




**(a)** Front View of Specimen Lapped at Lower End

**(b)** Side View of Specimen Lapped at Lower End

**(c)** Back View of Specimen Not Lapped at Lower End

**FIG. 1 Test Apparatus**



various forms are considered acceptable to test if it is possible to form the upper end into the cylinder. When testing stiff specimens, reinforce or replace the pressure-sensitive tape by wrapping nichrome wire around the top 75 mm of the specimen. See Fig. 1(c).

## 9. Conditioning

9.1 Prepare the cylindrical specimens before 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 ± 10 % 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 capable of maintaining a relative not exceeding 20 % at 23 ± 2°C for at least 4 h at room temperature prior to testing.

9.1.3 Upon removal from the conditioning environment, specimens shall be tested within 30 minutes.

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

9.3 Cotton shall be conditioned in the desiccator for at least 24 hours prior to use. Once removed from the desiccator, the cotton shall be used within 30 minutes.

## 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 shall 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 by 50 mm and a maximum thickness of 6 mm (see Fig. 1, View (*a*)).

10.2.1 To form the horizontal layer, it is acceptable to pull a small portion (approximately 13 by 25 mm) of cotton from the supply with the fingers and then thin and spread the cotton into a 50 by 50 mm square having a free-standing thickness of 6 mm.

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 ± 1 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 D5207 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 with the burner tube 10 ± 1 mm below the specimen for a flame-application time of 3 ± 0.5 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 ± 0.5-s flame application time, withdraw the test flame again. Record the duration of afterflame and afterglow times in seconds.

NOTE 4—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:

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



where:

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

11.2 Calculate the arithmetic mean of the afterflame time for each flame application, $t_1$ and $t_2$, and the afterflame plus afterglow time for the second flame application, $t_2$ 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 application, $t_1$.

12.1.5 Duration of afterflame time after second flame application, $t_2$.

**TABLE 1 First Application, Afterflame Time Only**

| Material | Afterflame Time, s | | | | |
|---|---|---|---|---|---|
| | Average | $s_r$[A] | $S_R$[B] | $r$[C] | $R$[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] $r = 2.83\ s_r$, and
[D] $R = 2.83\ S_R$.

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

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[4]

13.1 The precision of this test method is based on an interlaboratory study conducted in 1986. Six laboratories tested four different materials. Every "test result" represents an individual determination. Each laboratory was asked to submit five replicate test results, from a single operator, for each material. Practice E691 was followed for the design and analysis of data, the details are given in ASTM Research Report No. RR:D20-1146.



13.2 **Warning—**The data in Tables 1 and 2 shall not be rigorously applied to acceptance or rejection of material, as those data are specific to the interlaboratory study and are not necessarily representative of other lots, conditions, materials, or laboratories. Users of this test method shall apply the principles outlined in Practice E691 to generate data specific to their laboratory and materials, or between specific laboratories.

13.3 Equivalence testing on numerical data from two sources shall be conducted according to E2935.



13.4 *Bias*—There are no recognized standards on which to base an estimate of bias for this test method.

## 14. Keywords

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

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