Designation: D 635 – 96

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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An American National Standard

Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position[1]

This standard is issued under the fixed designation D 635; 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.

This standard has been approved for use by agencies of the Department of Defense to replace method 2021 of Federal Test Method Standard 406. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers a small-scale laboratory screening procedure for comparing the relative rate of burning and/or extent and time of burning of self-supporting plastics in the form of bars, molded or cut from sheets, plates, or panels, and tested in the horizontal position. This test method should be used to establish relative burning characteristics of plastic materials and should not be used as a fire-hazard test method.

NOTE 1: **Warning**—During the course of combustion, gases or vapors, or both, are evolved which may be hazardous to personnel. **Precaution**—In addition to other precautions, adequate precautions should be taken to protect the operator.

NOTE 2—Additional information on materials which do not burn to the gage mark by this test may be obtained using Test Method D 3801. For tests of flexible plastics in the form of thin sheets and film, reference should be made to Test Methods D 4804. Tests on the burning rate of sheet and plate insulation are covered in Test Methods D 229. Burning characteristics, as measured by minimum oxygen to support combustion, may be determined by Test Method D 2863.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

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 1 and 6.1.

2. Referenced Documents

2.1 *ASTM Standards:*

D 229 Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation[2]
D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load[3]
D 883 Terminology Relating to Plastics[3]
D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)[4]
D 3801 Test Method for Measuring the Comparative Extinguishing Characteristics of Solid Plastics in a Vertical Position[4]
D 4804 Test Methods for Determining the Flammability Characteristics of Nonrigid Solid Plastics[5]
D 5025 Specification for a Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials[5]
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[6]

3. Terminology

3.1 *Definitions*—Definitions used in this test method are in accordance with Terminology D 883, unless otherwise specified.

3.2 *Definition of Term Specific to This Standard:*

3.2.1 *self-supporting plastics*—those plastics which, when mounted with the clamped end of the specimen 10 mm above the horizontal screen, do not sag initially so that the free end of the specimen touches the screen.

4. Summary of Test Method

4.1 A bar of the material to be tested is supported horizontally at one end. The free end is exposed to a specified gas flame for 30 s. Time and extent of burning are measured and reported if the specimen does not burn 100 mm. An average burning rate is reported for a material if it burns to the 100-mm mark from the ignited end.

5. Significance and Use

5.1 Tests made on a material under conditions herein prescribed can be of considerable value in comparing the rate of burning and/or extent and time of burning characteristics of different materials, in controlling manufacturing pro-

[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.30 on Thermal Properties (Section D20.30.03).

Current edition approved Aug. 10, 1996. Published February 1997. Originally published as D 635 – 41. Last previous edition D 635 – 91.

The last revision changed the test flame application method located in 8.3.

[2] *Annual Book of ASTM Standards*, Vol 10.01.
[3] *Annual Book of ASTM Standards*, Vol 08.01.
[4] *Annual Book of ASTM Standards*, Vol 08.02.
[5] *Annual Book of ASTM Standards*, Vol 08.03.
[6] *Annual Book of ASTM Standards*, Vol 14.02.

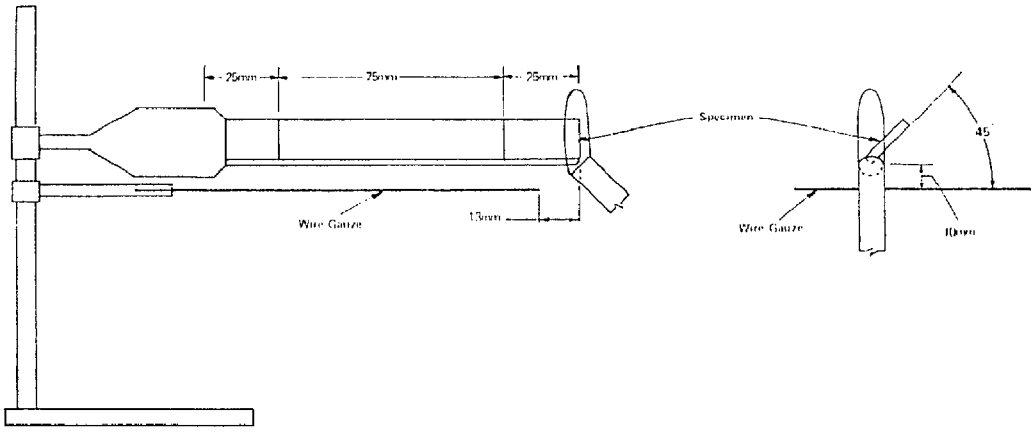

FIG. 1 Test Apparatus

cesses, or as a measure of deterioration or change in these burning characteristics prior to or during use. Correlation with flammability under actual use conditions is not implied.

5.2 The rate of burning 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 burning rate versus thickness.

5.3 Sheet materials that have been stretched during processing may relax during burning and give erratic results unless they are first heated above their deflection temperature, in accordance with Test Method D 648, for a time sufficient to permit complete relaxation.

5.4 Burning tests require that certain variables be arbitrarily fixed, for example, specimen size, energy source and application time, and end points. Materials will be found that are unusually sensitive to one or more of the conditions chosen for this method leading to highly variable results. Additional burning characterization by other methods is highly desirable in such cases (see Note 2).

5.5 This test method is not intended to be a criterion for fire hazard. The fire hazard created by materials depends upon the form and end use of the material. Assessment of fire hazard includes, but is not limited to, many factors, such as ease of ignition, burning rate, flame spread, fuel contribution, intensity of burning, and products of combustion.

6. Apparatus

6.1 *Test Chamber*—a laboratory hood, totally enclosed, with a heat-resistant glass window for observing the test (Note 3). **Caution**—The exhaust fan is turned off during the test and turned on immediately following the test in order to remove products of combustion which may be toxic. Alternatively, the test may be made in a metal cabinet placed inside the hood, leaving the hood exhaust fan turned on. The cabinet must have air holes at the bottom and top. The holes must allow ample passage of air for characteristic burning, and must not allow drafts across the burning specimen.

NOTE 3—A mirror in the chamber, to provide a rear view of the specimen, has been found useful in some enclosures.

6.2 *Ring Stand*—A laboratory ring stand with two small clamps adjustable, by means of a check nut, to any angle.

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

NOTE 4—No significant variations in test results traceable to differences in laboratory gases (propane, several city gas supplies) were observed in results from an extensive interlaboratory study.

6.4 *Wire Gauze*, 20-mesh, 125 mm square.

6.5 *Timing Device*—Stop watch or other timer, with smallest division—1 s or less.

6.6 *Pan of Water.*

6.7 *Scale*, graduated in millimetres.

7. Test Specimens

7.1 At least ten test specimens, 125 ± 5 mm in length by 12.5 ± 0.2 mm in width, and of the thickness of material normally supplied, shall be cut from sheet or molded from each of the samples to be tested. Molded bars 3 to 12 mm in thickness make satisfactory test specimens.

7.2 The specimens shall normally be tested in the as-received conditions unless otherwise specified.

7.3 Each test specimen shall be marked by scribing two lines, 25 mm and 100 mm from one end of the specimen.

7.4 The edges of the test specimens shall be smooth. Sawed edges should be fine sanded to a smooth finish.

8. Procedure

8.1 Clamp the specimen at the end nearest the 100-mm mark, in a support with its longitudinal axis horizontal and its transverse axis inclined at 45° to the horizontal. Under the test specimen clamp a screen of wire gauze (approximately 125 by 125 mm) in a horizontal position 10 mm below the edge of the specimen and with the free end of the specimen even with the edge of the gauze (see Fig. 1). Any material remaining on the screen from the previous test must be burned off or a new screen used for each test. A pan of water should be placed on the floor of the hood in position to catch any burning particles that may drop during the test.

8.2 Place the burner remote from the specimen, ignite, and adjust it to produce a blue flame 20 mm high. Obtain the blue flame by adjusting the gas supply and the air ports of the burner until an approximate 20-mm yellow-tipped blue

TABLE 1 Reporting Specimens Tested

Specimen No.	*t*	(*t*-30)	mm
1	65	35	6
2	74	44	8
3	40	10	5
4	37	7	5
5[A]	900	870	100
6	90	60	10
(14 additional specimens tested; data for 10 omitted in this example)			
17	150	120	15
18	110	80	27
19	70	40	17
20	30	0	5
ATB		123[B]	
AEB			18[B]

[A] Complete burning in a group such as this is unlikely, but this example is added to illustrate the method. Since one specimen burned to the mark, a total of 20 must be tested.

[B] Report average time of burning—125 s; average extent of burning—20 mm.

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.

8.3 Place the burner so that the test flame impinges on the free end of the test specimen to a depth of 6 ± 1 mm, as shown in Fig. 1, starting the stop watch simultaneously. Apply the test flame for 30 ± 1 s without changing its position. Excessive distortion of the specimen during the test may invalidate the results. Remove the burner at 30 s or when the flame front reaches the 25-mm mark, whichever comes first, and place the burner at least 450 mm from the specimens and close the hood.

8.4 Record the time, in seconds, on the watch when the flame front reaches the 25-mm mark, as burning time, t_1.

8.5 Stop the watch when burning (flame) or glowing combustion (visible glow without flame) ceases, *or* when it has proceeded to the mark 100 mm from the free end.

8.6 Record the time, in seconds, on the watch (8.4) as burning time, t.

8.7 If the burning has not reached the 100-mm mark, measure the unburned length to the nearest 1 mm along the lower edge of specimen from the mark. The extent of burning is defined as 100 mm minus the unburned length in the same units.

8.8 If the specimen has burned to or beyond the 100-mm mark, calculate the burning rate as $450/(t - t_1)$ (cm/min).[7]

8.9 Repeat the procedure (8.1 to 8.8) until three specimens have burned to or beyond the 100-mm mark, or ten specimens have been tested. If only one of 10 specimens tested burns to the 100-mm mark or beyond, repeat the procedure (8.1 to 8.8) with ten additional specimens.

9. Report

9.1 *Burning Rate*—If two or more specimens have burned to the 100-mm gage mark, report the average burning rate (cm/min) as the average of the burning rates of all specimens which have burned to the mark.

9.2 *Average Time of Burning* and *Average Extent of Burning*—If none of ten or no more than one of twenty specimens has burned to the 100-mm mark, report the average time of burning and average extent of burning.

9.2.1 *Average Time of Burning (ATB):*

$$ATB = \frac{\Sigma(t - 30\text{ s})}{\text{number of specimens}}$$

rounded (after averaging) to the nearest multiple of 5 s; that is, less than 5 s would be reported if burning or glowing continued less than 3 s after removal of flame. In no case is an ATB of zero to be recorded.

9.2.2 *Average Extent of Burning (AEB):*

$$AEB,\ \text{mm} = \frac{\Sigma(100\text{ mm} - \text{unburned length})}{\text{number of specimens}}$$

rounded (after averaging) to the nearest 5 mm; extent of burning less than 3 mm, report as less than 5 mm, in no case reporting zero. Extent of burning of a single specimen that burns to the mark is counted as 100 mm.

9.3 The complete report should include the following:

9.3.1 Identification of the sample including method of preparation and conditioning,

9.3.2 Average thickness of the specimens to ±1 %,

9.3.3 Number of specimens tested,

9.3.4 Range of time of burning values, and

9.3.5 Range of extent of burning values.

9.3.6 If a specimen does not burn to the mark because of dripping, flowing, or falling burning particles, the report must so indicate.

9.3.7 If a specimen is reignited by burning material on the gauze, the report must so state (see 5.4).

Example: Specimens were tested with the results as shown in Table 1.

9.3.8 The caveat contained in 1.3 herein shall be incorporated in its entirety in the test report issued.

10. Precision and Bias

10.1 *Precision*—Table 2 is based on a round robin completed in 1987 in accordance with Practice E 691, involving three materials tested by eleven laboratories. Each laboratory conducted the tests in a laboratory hood with the hood exhaust essentially turned off. All three materials were classified by the test as possessing an average burning rate. The test result was the average of three specimens that burned to or beyond the 100-mm mark.

10.1.1 Sufficient data are not available to support statistically meaningful precision statements for average time of burning and average extent of burning.

NOTE 5: **Caution**—The explanations of r and R given in 10.2 through 10.2.3 are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 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.

TABLE 2 Average Burning Rate

Material	Rate of Burning, cm/min				
	Average	s_r	s_R	r	R
Polyethylene	1.52	0.07	0.13	0.19	0.37
ABS	2.79	0.21	0.41	0.57	1.15
Acrylic	2.97	0.17	0.22	0.49	0.61

s_r = Within-laboratory standard deviation of the average.
s_R = Between-laboratory standard deviation of the average.
r = 2.8 s_r.
R = 2.8 s_R.

[7] While t_1 and t are in seconds, the calculation converts into cm/min.

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 10.2 through 10.2.3 would then be valid for such data.

10.2 *Concept of r and R*—If s_r and s_R have been calculated from a large enough body of data, and for test results that were averages from testing three specimens:

10.2.1 *Repeatability, 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 r value for that material.

10.2.2 *Reproducibility, 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 R value for that material.

10.2.3 Any judgment in accordance with 10.2.1 and 10.2.2 would have an approximate 95 % probability of being correct.

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

11. Keywords

11.1 extent of burning; flammability; horizontal position; rate of burning; test method; time of burning