Designation: D5048 – 14

Standard Test Method for Measuring the Comparative Burning Characteristics and Resistance to Burn-Through of Solid Plastics Using a 125-mm Flame[1]

This standard is issued under the fixed designation D5048; 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 method covers a small-scale laboratory procedure for determining the relative burning characteristics and the resistance to burn-through of plastics using small bar and plaque specimens exposed to a 125-mm (500-W nominal) flame.

NOTE 1—This test method is equivalent to IEC 60695-11-20.

NOTE 2—For additional information on comparative burning characteristics of solid plastics in a vertical position, see Test Method D3801.

1.2 This test method was developed for polymeric materials used for parts in devices and appliances. The results are intended to serve as a preliminary indication of their acceptability with respect to flammability for a particular application. The final acceptance of the material is dependent upon its use in complete equipment that conforms with the standards applicable to such equipment.

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

1.4 If found to be appropriate, it is suitable to apply the requirements to other nonmetallic materials. Such application is outside the scope of this technical committee.

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

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

1.7 *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 hazards or fire risk assessment of materials, products, or assemblies under actual fire conditions.*

1.8 *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.* See 6.1.1 for a specific hazard statement.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

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

2.2 *IEC Standard:*[3]

IEC 60695-11-20 Fire Hazard Testing-Part 11-20: Test Flames - 500 W Flame Test Methods

3. Terminology

3.1 *Definitions of Terms*—For definitions of terms related to plastics used in this test method, refer to Terminology D883. For definitions of terms related to fire used in this test method, refer to Terminology E176.

3.2 *Definitions of Terms Specific to This Standard:*

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

[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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[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] Publications of the International Electrotechnical Commission (IEC) are available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

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

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

3.2.4 *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.

3.2.5 *burn-through*—a hole produced in the plaque specimen.

4. Summary of Test Method

4.1 Sets of 13 ± 0.5 mm by 125 ± 5-mm bar specimens and 150 ± 5 mm by 150 ± 5-mm plaque specimens are subjected to a 125-mm flame with a 40 ± 2-mm inner blue cone, for five 5-second flame applications. The afterflame plus afterglow time for the bar specimen is recorded after removal of the fifth flame application. Information is recorded on whether or not flaming material drips from the specimens, and whether or not the plaque specimens exhibit burn-through.

5. Significance and Use

5.1 The test results represent afterflame plus afterglow time, in seconds, for a material under the conditions of the test. The test results for plaques also indicate whether or not the specified flame will burn through a material.

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

5.3 The burning characteristics vary with thickness. Compare test data with data for materials of similar thickness only.

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 test method, the specimens are subjected to specific 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,* enclosure or laboratory hood with a minimum capacity of 0.75 m^3, free of induced or force draft during test. An enclosed laboratory hood with a heat-resistant glass window and an exhaust fan for removing the products of combustion 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. An exhaust fan is recommended for removing the products of combustion immediately after the test.

NOTE 3—The amount of oxygen available to support combustion is important for the conduct of flame tests. When burning times are prolonged, chamber sizes less than 1.0 m^3 do not consistently provide accurate results.

NOTE 4—Placing a mirror in the hood, to provide a rear view of the test specimen, has been found useful.

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

6.3 *Ring Stand,* with a clamp or the equivalent, adjustable for vertical positioning of bar specimens and horizontal positioning of plaque 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 approximately 37 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 *Burning Mounting Fixture,* a fixture capable of positioning the burner at an angle of 20 ± 5° from the vertical.

6.6 *Timing Device,* accurate to 0.5 seconds.

6.7 *Cotton,* a supply of absorbent 100 % surgical cotton.

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

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

6.10 *Conditioning Oven,* a full-draft circulating air oven capable of being maintained at 70 ± 2°C.

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

7. Sampling

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

8. Test Specimens

8.1 The standard bar specimen shall be 13 ± 0.5 by 125 ± 5 mm. The standard plaque specimen shall be 150 ± 5 by 150 ± 5 mm. Bar and plaque specimens shall be in the thickness appropriate to the objectives of the determination. Do not use this test method for materials thicker than 13 mm.

8.2 Surfaces must be smooth and unbroken. Corner radius shall not exceed 1.3 mm. After any cutting operation, remove all dust and any particles from the surface; cut edges are to have a smooth finish.

8.3 The results of tests carried out on test specimens of different, colors, thicknesses, densities, molecular weights, directions of orientation, or with different additives, fillers/reinforcements can be different.

8.3.1 Test specimens in the extremes of the densities, melt flows and fillers/reinforcements contents are to be provided and

considered representative of the range, if the results yield the same flame test classification. If the burning characteristics are not essentially the same for all specimens representing the range, the evaluation is to be limited only to the materials in the densities, melt flows, and fillers/reinforcements contents tested, or additional test specimens in the intermediate densities, melt flows, and fillers/reinforcements contents are to be tested.

8.3.2 Unpigmented 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 are essentially the same. 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

9. Conditioning

9.1 Condition one set of five bar specimens and three plaque specimens for at least 48 h at a temperature of 23 ± 2°C and a relative humidity of 50 ± 10 % prior to testing.

9.2 Condition a second set of five bar specimens and three plaque 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.

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

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

9.5 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 *Procedure A—Test of Bar Specimens:*

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

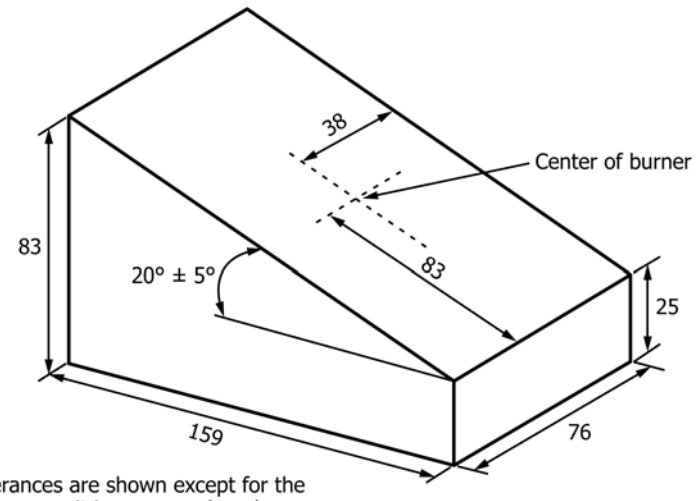
10.1.2 Support a specimen from the upper 6 mm of the specimen, with the longitudinal axis vertical, by the clamp on the ring stand so that the lower end of the specimen is 300 ± 10 mm above a horizontal layer of cotton, approximately 50 by 50 mm, thinned to a maximum uncompressed thickness of 6 mm, maximum weight of 0.05 g to 0.08 grams.

NOTE 5—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.

10.1.3 Adjust the methane gas supply to the burner to produce a gas flow rate of 965 ± 30 mL/min with a back pressure of 125 ± 25 mm water. Place the burner remote from the specimen, ignite, and adjust it so that when the burner is in a vertical position, the overall height of the flame is 125 ± 10 mm, and the height of the inner blue cone is 40 ± 2 mm. Support the burner on the inclined plane of the mounting fixture so that the burner tube is positioned at 20 ± 5° from the vertical.

10.1.4 Apply the flame to one of the lower corners of the specimen at an angle of 20 ± 5° from the vertical, so that the tip of the blue cone is within 0 to 3 mm of the specimen edge without impinging into the specimen (see Fig. 2). Apply the flame for 5 ± 0.5 seconds and then remove the flame for 5 ± 0.5 seconds. Repeat this operation until the specimen has been subjected to five applications of the test flame. If the specimen drips particles, shrinks, or elongates during the test, move the burner so that the tip of the inner blue cone maintains contact with the major portion of the specimen at the corner. When necessary, hand-hold the burner and fixture to accomplish this. After the fifth removal of the test flame, record, in seconds, the total afterflame time and afterflame plus afterglow times. Note whether or not the specimen dripped flaming particles that ignited the cotton.

10.1.5 Repeat the procedure in 10.1.2 – 10.1.4 on the remaining specimens for each set, one set conditioned as described in 9.1 and one set conditioned as described in 9.2.



No tolerances are shown except for the angle because it is an example only.

Dimensions in millimetres

FIG. 1 Burner Mounting Block—Example

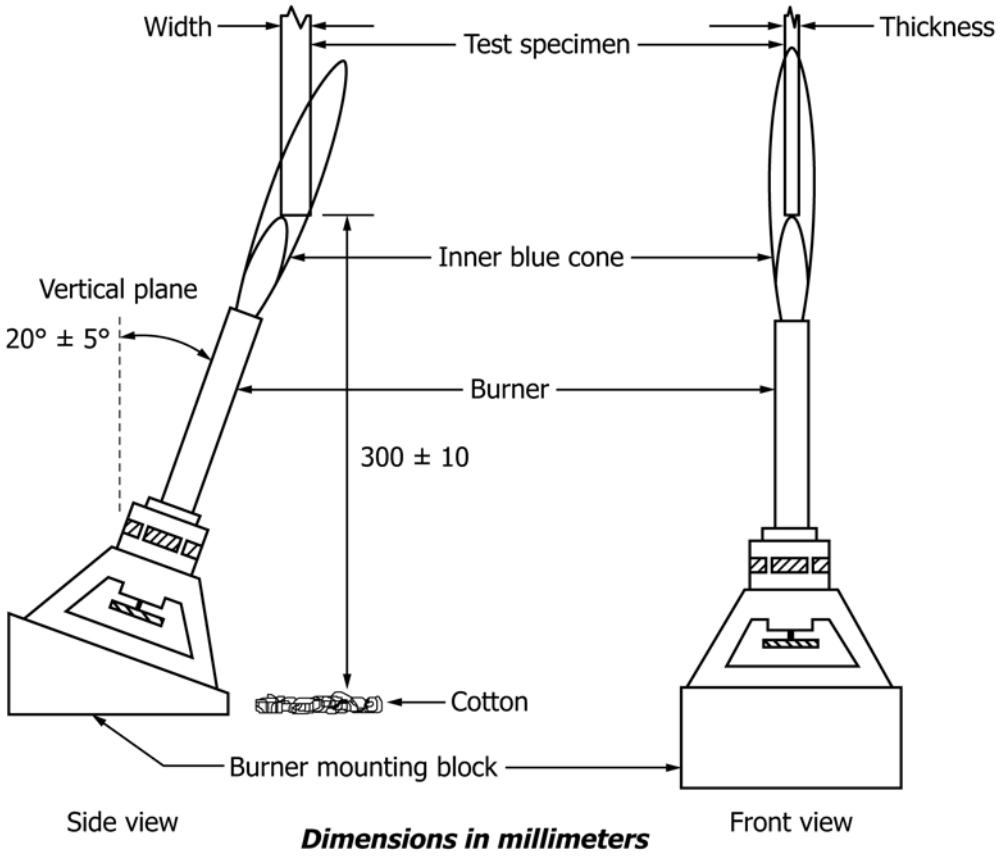


FIG. 2 Procedure A—Test of Bar Specimens

10.1.6 Calculate the arithmetic mean of the afterflame time and afterflame plus afterglow times for each set of five specimens.

10.2 *Procedure B—Test of Plaque Specimens:*

10.2.1 Proceed as in 10.1.1.

10.2.2 Support a plaque specimen at its edges so that it is horizontal, using a clamp and ring stand or other equivalent means.

10.2.3 Proceed as in 10.1.3.

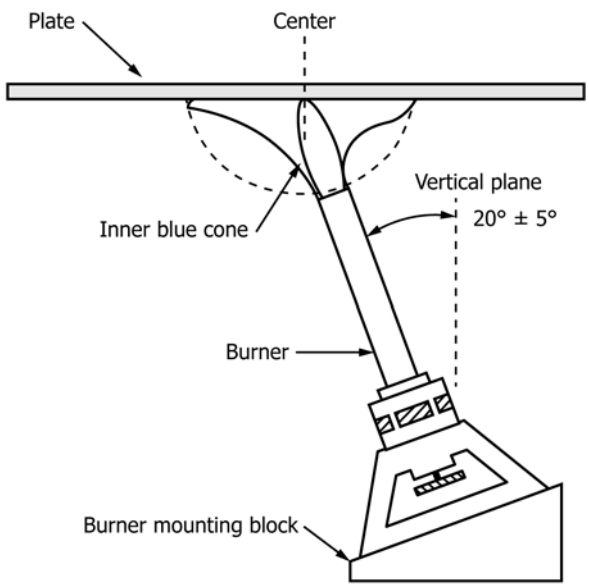


FIG. 3 Procedure B—Test of Plaque Specimens

10.2.4 Apply the flame to the center of the bottom surface of the plaque at an angle of 20 ± 5° from the vertical so that the tip of the inner blue cone is within 0 to 3 mm of the plaque surface, without impinging into the specimen (see Fig. 3). Apply the flame for 5 ± 0.5 seconds and then remove the flame for 5 ± 0.5 seconds. Repeat this operation until the plaque has been subjected to five applications of the test flame. If necessary, hand-hold the burner and fixture so that the tip of the inner blue cone maintains the required distance. After the fifth removal of the test flame, note whether or not the flame burned through the plaque. Flame penetration shall be defined as any visible flame observed on the top surface of the plaque during the test. In addition, no opening greater than 3 mm shall appear after the test and the sample has cooled for 30 seconds.

10.2.5 Repeat the procedure in 10.2.2 – 10.2.4 on the remaining plaques for each set, one set conditioned as described in 9.1 and one set conditioned as described in 9.2.

11. Report

11.1 The complete report shall include the following information:

11.1.1 Generic description, manufacturer, commercial designation, lot number, and color,

11.1.2 Conditioning time at 23 ± 2°C, in hours, for specimens conditioned in accordance with 9.1,

11.1.3 Cooling time in desiccator, in hours, for specimens conditioned in accordance with 9.2,

11.1.4 Average thickness for each set,

11.1.5 Total afterflame time and afterflame plus afterglow times after the fifth flame application for each specimen,

11.1.6 Arithmetic means of afterflame time and afterflame plus afterglow times for each specimen set,

11.1.7 Whether or not any of the specimens drip flaming particles which ignite the cotton swatch, and

11.1.8 Whether or not any of the plaques burn through after the fifth flame application.

12. Precision and Bias

12.1 Tables 1 and 2 are based on a round robin completed in 1988 in accordance with Practice E691, involving seven materials tested by thirteen laboratories. The tests were conducted in accordance with Procedure A, with conditioning described in 9.1. Each test result was the average of five individual determinations. Each laboratory obtained three test results for each material.

12.1.1 Do not apply the data given in Tables 1 and 2 rigorously to accept or reject materials, as this data is specific to the round robin and not necessarily representative of other lots, conditions, materials, or laboratories. It is important that users of this test method conduct experiments, based on statistically appropriate procedures specific to their material and the laboratories involved, to determine repeatability or reproducibility limits for their material.

12.1.2 The explanations shown in 12.2 – 12.2.3 regarding *r* and *R* are intended only to present a meaningful way of considering the approximate precision of these test methods.

12.1.3 Since Procedure B results in go or no-go data, there is no recognized standard for developing a precision statement.

12.2 *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 five specimens:

12.2.1 *Repeatability*—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 shall be judged not equivalent if they differ by more than the *r* value for that material.

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

12.2.3 Any judgment in accordance with 12.2.1 and 12.2.2 would have an approximate 95 % probability of being correct.

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

13. Keywords

13.1 burning characteristics; flammability; plastics; solid; resistance to burn-through; small-scale burning tests; vertical burning tests

TABLE 1 Average Afterflame Time

Material[A]	Average Specimen Thickness, mm	Average Afterflame Time, s				
		Average	S_r[B]	S_R[C]	I[D]	R[E]
Polybutylene Terephthalate I	3.2	0.91	0.35	0.63	0.98	1.76
Polybutylene Terephthalate II	3.1	1.25	0.53	1.09	1.48	3.05
Polyamide	3.2	1.48	0.28	0.85	0.78	2.38
Polycarbonate	3.2	2.17	0.49	1.05	1.37	2.94
Unsaturated Polyester I	1.6	6.37	2.42	5.35	6.78	14.98
Modified Polyphenylene Ether	3.2	10.97	3.75	5.84	10.50	16.35
Unsaturated Polyester II	2.7	110.4	31.0	70.5	86.8	197.3

[A] Specimens conditioned in accordance with 9.1.
[B] S_r = Within-laboratory standard deviation of the average.
[C] S_R = Between-laboratory standard deviation of the average.
[D] $r = 2.8\ S_r$.
[E] $R = 2.8\ S_R$.

TABLE 2 Average Afterflame Plus Afterglow

Material[A]	Average Specimen Thickness, mm	Average Afterflame Plus Afterglow				
		Average	S_r[B]	S_R[C]	I[D]	R[E]
Polyamide	3.2	1.57	0.36	0.93	1.01	2.60
Polycarbonate	3.2	2.23	0.47	1.01	1.32	2.83
Unsaturated Polyester I	1.6	8.18	1.99	5.43	5.57	15.20
Modified Polyphenylene Ether	3.2	11.04	3.75	5.80	10.50	16.24
Polybutylene Terephthalate I	3.2	12.13	1.97	3.54	5.52	9.91
Polybutylene Terephthalate II	3.1	12.52	1.02	3.16	2.86	8.85
Unsaturated Polyester II	2.7	110.5	30.9	70.3	86.5	196.8

[A] Specimens conditioned in accordance with 9.1.
[B] S_r = Within-laboratory standard deviation of the average.
[C] S_R = Between-laboratory standard deviation of the average.
[D] $r = 2.8\ S_r$.
[E] $R = 2.8\ S_R$.

APPENDIX

(Nonmandatory Information)

X1. CLASSIFICATION SYSTEM FOR THE COMPARATIVE BURNING CHARACTERISTICS AND RESISTANCE TO BURN-THROUGH OF SOLID PLASTICS USING A125-mm FLAME

TABLE X1.1 Materials Classifications[A]

Criteria Conditions	5VA	5VB
Individual bar specimen afterflame plus afterglow time after the fifth flame application, s	<60	<60
Was the cotton indicator ignited by flaming particles or drops from any bar specimen?	no	no
Did the flame penetrate through (burn-through) any of the individual plaques?	no	yes

[A] If only one specimen from a set of five bar specimens or one plaque from a set of three plaques for a given preconditioning treatment does not comply with all criteria for a category, another set of five bar specimens or three plaques subjected to the same preconditioning shall be tested. All specimens or plaques from the second set shall comply with all specified criteria for the category.

X1.1 This appendix describes a classification system that can be used to characterize the burning behavior of solid plastics in response to a 125-mm 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 is in use by certification bodies to determine compliance with applicable requirements.

X1.2 The material shall 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.

X1.3 Materials classified 5VA or 5VB shall also comply with the criteria for materials classified either V-0 or V-1 described in D3801, Appendix X1, in the same bar test specimen thickness, to assess the extent of burning to the holding clamp.

X1.4 Recording the category designation in the test report is optional.

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D5048 - 09) that may impact the use of this standard. (May 1, 2014)

(1) Clarified editorially the applicable standards in 3.1.
(2) Reworded 4.1 for clarity and added tolerance for the specimen dimension and flame height.
(3) Clarified editorially the applicable standard in 6.2.
(4) Clarified the requirements in 6.4 for Methane and Natural gas (harmony with D5207, clause 6.9.1 and D4804, clause 6.4 respectively). Also added the options to use other gases as fuel (harmony with D4804).
(5) Revised the tolerance for the burner positioning angle in 6.5 from 2 to 5 degrees to align with clause 10.2.4 and Fig. 1.
(6) Clarified editorially the wording in 6.6, 10.1.4, and 10.2.4.
(7) Clarified the cotton type in 6.7.
(8) Clarified the requirements for type of drying agent in 6.8.
(9) Harmonized the oven temperature tolerance in 6.10 and 9.2 with D4804 and aligned with D618.
(10) Added 6.11: reference to the usage of micrometer for specimen thickness measurement (harmony with D4804 and D3801).
(11) Reworded 8.3 and 8.3.2 for clarity.
(12) Revised the humidity requirements for laboratory ambient 9.4 to be in harmony with UL 94 (Sixth Edition) and IEC 60695-11-10 (clause 8.1.3).
(13) Added lower limitation for the weight of the cotton in 10.1.2 to be in harmony with D4804.
(14) Added tolerance for the gas flow rate in 10.1.3 to be in harmony with UL 94 (clause 9.5.2) and IEC 60695-11-3 (clause 4.1).
(15) Revised Fig. 2 to include the correct angle of the mounting block.
(16) Harmonized the minimum criteria for 5V classification in X1.3 requiring D3801 compliance with UL 94.