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Designation: D 4802 – 94

An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Specification for Poly(Methyl Methacrylate) Acrylic Plastic Sheet[1]

This standard is issued under the fixed designation D 4802; 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 specification covers monolithic methacrylate sheets produced by various processes. For this specification, methacrylate sheet shall be composed of polymerized acrylic monomers of which at least 80 % shall be methyl methacrylate.

NOTE 1—This specification is intended to consolidate the requirements of the Cast Methacrylate Plastic Sheets portion of Fed. Spec. L-P-391D, discontinued Specification D 702. Cast Methacrylate Plastic Sheets, Rods, Tubes and Shapes, and discontinued Specification D 1547, Extruded Acrylic Plastic Sheet.

1.2 This specification is intended to cover acrylic sheet for general-purpose applications. For specialty applications consult the appropriate use standards.

1.3 The following safety hazards caveat pertains only to the test methods portion, Section 8, of this specification: *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.*

NOTE 2—This standard is similar to ISO 7823-1:1987 (E) in title only. The technical content is significantly different.

2. Referenced Documents

2.1 *ASTM Standards:*

D 256 Test Method for Impact Resistance of Plastics and Electrical Insulating Materials[2]
D 542 Test Methods for Index of Refraction of Transparent Organic Plastic[2]
D 570 Test Method for Water Absorption of Plastics[2]
D 638 Test Method for Tensile Properties of Plastics[2]
D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load[2]
D 673 Test Method for Mar Resistance of Plastics[2]
D 756 Practice for Determination of Weight and Shape Changes of Plastics Under Accelerated Service Conditions[2]
D 792 Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement[2]
D 883 Terminology Relating to Plastics[2]
D 1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics[2]
D 1044 Test Method for Resistance of Transparent Plastics to Surface Abrasion[2]
D 1308 Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes[3]
D 1499 Practice for Operating Light- and Water-Exposure Apparatus (Carbon-Arc Type) for Exposure of Plastics[2]
D 2565 Practice for Operating Xenon Arc-Type Light Exposure Apparatus With and Without Water for Exposure of Plastics[4]
D 3002 Recommended Practice for Evaluation of Coatings for Plastics[3]
D 3359 Test Method for Measuring Adhesion by Tape[5]
D 3892 Practice for Packaging/Packing of Plastics[4]
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[6]

2.2 *ISO Standard:*

ISO 7823-1:1987 (E) Plastics—Poly(Methyl Methacrylate) Sheets—Types, Dimensions, and Characteristics[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—The definitions given in Terminology D 883 are applicable to this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bow warp, n*—distortion in the form of a simple curve or arc extending across the sheet and displaced from the horizontal when the sheet is laying flat.

3.2.2 *edge kink warpage, n*—distortion in the form of a twist, wrinkle, or scallop occurring along the perimeter of the sheet.

3.2.3 *letgoes, n*—an area on the sheet over which the initial adhesion between the polymer and the mold glass has been lost before polymerization, causing an uneven surface.

3.2.4 *"S" warp, n*—distortion in the form of a compound curve or "S" shape caused by a nonuniform change in internal stresses.

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[1] This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

Current edition approved March 15, 1994. Published May 1994. Originally published as D 4802 – 88. Last previous edition D 4802 – 93a.

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

[3] *Annual Book of ASTM Standards*, Vol 06.02.

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

[5] *Annual Book of ASTM Standards*, Vol 06.01.

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

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

4. Classification

4.1 *Categories*:

4.1.1 *Category A-1*—Methacrylate sheet typically manufactured by the cell-casting process. This category represents the best optical-quality sheet. It is characterized by the highest long-term design stress and the highest degree of chemical resistance found in methacrylate sheet.

4.1.2 *Category A-2*—Methacrylate sheet typically manufactured by the continuous-casting method. The physical, chemical, and thermal properties are similar to Category A-1 sheet. The optical quality is lower than Category A-1 sheet. This category has better thickness control than that of Category A-1 sheet.

4.1.3 *Category B-1*—Methacrylate sheet manufactured by any of several processes (typically described as continuously manufactured sheet). This sheet possesses lower heat, chemical, and stress-craze resistance than Category A-1 and Category A-2 sheet. It has equivalent or better optical quality and thickness tolerances than Category A-2 sheet.

4.1.4 *Category B-2*—Methacrylate sheet typically manufactured by conventional extrusion processes. This sheet is characterized by excellent thickness control similar to Category A-2 and Category B-1 sheet. This sheet has reduced long-term design stress, chemical resistance, optical quality, and thermal stability.

4.2 *Finish*—The following finishes of methacrylate sheet may be specified. The physical and optical properties in this specification are based on Finish 1 material unless otherwise noted.

4.2.1 *Finish 1*—Smooth or polished.

4.2.2 *Finish 2*—Patterned, including textures and frosting.

4.2.3 *Finish 3*—Abrasion-resistant coated.

4.2.3.1 Finish 3 material can be of any category provided it meets the requirements of that category plus the additional requirements listed in Table 1.

4.2.4 *Type UVA (UV-Absorbing)*—Materials that contain an ultraviolet absorber to limit the transmission of UV radiation through the sheet especially for protection of items sensitive to sunlight or UV radiation.

4.2.5 *Type UVT (UV-Transmitting)*—Materials that do not contain any UV absorbers and are used where there is a need to transmit a greater portion of UV radiation.

4.2.6 For general-purpose applications neither type need be specified. If not specified, materials will usually contain UV absorbers only sufficient to protect the polymer from degradation from exposure to direct sunlight or UV radiation. There are no specific UV-transmission requirements for material of unspecified type.

TABLE 1 Finish 3 Abrasion Resistant Material

Property	Test Method	Requirement
Abrasion resistance, 100 cycles at 500 g load	D 1044	
Haze, max, %		4.0[A]
Mar resistance, 1000 g No. 80 grit	D 673	
Haze, max,%		4.0[A]
Coating adhesion, percent retention, min	see 8.1.13.5	Minimum Classification 4B,[A] Fig. 1, Test Methods D 3359
Chemical resistance, visual examination	see 8.1.14	no change

[A] Tests are to be performed before and after the simulated weathering resistance and the accelerated-service conditions described in 8.1.13.

5. Detail Requirements

5.1 The following applies to all specified limits in this specification. For purposes of determining conformance with this specification, an observed value or a calculated value shall be rounded to the nearest 1 MPa (100 psi) for tensile strength, and for all other properties shall be rounded to the nearest unit in the last righthand place of fingers used in expressing the limiting value, in accordance with the rounding method of Practice E 29.

5.2 Sheet shall conform to the requirements prescribed in Table 2. In addition, Category A-1 sheet shall conform to the the permissible-thickness variations listed in Table 3.

5.3 *Shrinkage*—Test in accordance with 8.1.7.

5.4 *Thermal Stability*—Sheet shall show no evidence of bubbling or blistering when tested in accordance with 8.1.8.

5.5 *Abrasion-Resistant Material*—Finish 3 material (abrasion-resistant coated material) shall meet the requirements of the substrate material it is designated as and the properties shown in Table 1.

5.6 *Workmanship*—Sheet, as delivered, shall be free from warpage, cracks, scratches, blisters, voids, foreign matter, die lines, and other defects that may affect appearance or serviceability.

5.6.1 *Flatness of Sheet*—Sheet shall be free from edge kink warpage and from edge “S” warp when lying on a flat surface. Overall bow warp is permitted for all types of sheet to a maximum of 6.3 mm (0.250 in.) displacement from the horizontal for each 4-ft length, or fraction thereof, of a sheet under its own weight when laying in the horizontal position on a flat continuous surface. “S” warp that disappears or becomes bow warp when turned over is permitted.

5.6.2 *Corner Letgoes for Sheet* (Applicable to Category A-1 and A-2 Sheet Only)—Masked sheet in thicknesses equal to or less than 51 mm (2.008 in.) shall be free of corner letgoes. Unmasked sheet in thicknesses no greater than 6.00 mm (0.236 in.) may have letgoes within any or all of the corner areas that are defined as isosceles triangles with 76.0 mm (3.0 in.) sides. Corner letgoes in unmasked sheets that are thicker than 6.0 mm (0.236) up to and including 51 mm (2.008 in.) are permitted within any or all of the corner areas that are defined as isosceles triangles with 150 mm (5.91 in.) sides. For unmasked sheets, out-of-tolerance corner letgoes, within an isosceles triangle that has no more than twice the allowable length for sides, shall be accepted if removed. For masked and unmasked sheets in thicknesses greater than 51 mm (2.008 in.), letgoes may exist provided they do not extend more than 0.4 mm (0.016 in.) below the surface. For Category A-2 sheet only, edge letgoes less than 0.4 mm (0.016 in.) in depth may exist within 25 mm (0.984 in.) of the sheet edges, provided physical integrity is not impaired.

5.6.3 *Chips and Dirt in Sheet*:

5.6.3.1 *Chips in Sheet of Thickness Equal to or Less Than 51 mm (2.008 in.)*—The maximum permissible chip size shall be 3.2 mm (0.125 in.). Chips that are approximately the maximum permissible size shall not have a frequency greater than 1 chip per 0.4 m^2 (4.3 ft^2) of sheet area. Chips less than 0.8

TABLE 2 Detail Requirements for Cast Methacrylate Plastic Sheets

Property	Test Method	Category			
		A-1	A-2	B-1	B-2
Tensile strength, min, MPa (psi)	D 638	62 (9.0 k)	62 (9.0 k)	62 (9.0 k)	62 (9.0 k)
Elongation at break, min, %	D 638	2	2	2	2[A]
Index of refraction	D 542				
min:		1.48	1.48	1.48	1.48[A]
max:		1.50	1.50	1.50	1.50
Specific gravity	D 792				
min:		1.18	1.18	1.18	1.18[A]
max:		1.20	1.20	1.20	1.20
Luminous transmittance, min, %	D 1003				
<4.5 mm (0.177 in.)		91	91	91	91
>4.5 mm (0.177 in.) ≤32 mm (1.259 in.)		89	89	89	89
>32.0 mm (1.259 in.)≤ 51.0 mm (2.000 in.)		87	87	87	87
Spectral transmittance, max, %	see 8.1.12				
Type UVA only 290 to 330 nm (6.0 mm, 0.236 in.)					
@290 nm		5	5	5	5
@310 nm		5	5	5	5
@330 nm		5	5	5	5
Type UVT only 290 to 400 nm (3.0 mm, 0.118 in.)					
@290 nm		40	40	40	40
@310 nm		70	70	70	70
@340 nm		85	85	85	85
@400 nm		86	86	86	86
Haze, max,%	D 1003	3	3	3	3
Dimensional tolerance, max:					
Thickness, %		see Table 3Table 3	±10	±5	±5
Length and width, mm (in.)		−0.0, + 6.4 (−0.0, + 0.250)	−0.0, + 6.4 (−0.0, + 0.250)	−0.0, + 6.4 (−0.0, + 0.250)	−0.0, + 6.4 (−0.0, + 0.250)
Shrinkage, max, %	see 8.1.7	2.8	2.8	...	...
Transverse:		...	...	0.0	5.0
Machine:		...	...	3.0	8.0
Water absorption, %	D 570 (24-h method)		see Fig. 1Fig. 1	...	[A]
Deflection temperature under flexural load, 1820 kPa (264 psi), °C (°F), min	D 648				
<12.0 mm (0.472 in.)		87 (188.6)	87 (188.6)	87 (188.6)	87 (188.6)
>12.0 mm (0.472 in.) ≤24.0 mm (0.944 in.)		88 (190.4)	88 (190.4)	88 (190.4)	N/A[B]
>24.0 mm (0.944 in.) ≤100 mm (3.937 in.)		93 (199.4)	93 (199.4)	N/A[B]	N/A[B]
Thermal stability		see 8.1.8.1	see 8.1.8.1	see 8.1.8.2	see 8.1.8.2
Impact strength, Izod, J/m (ft-lb/in.), min	D 256, Method A	16.0 (0.3)	16.0 (0.3)	16.0 (0.3)	16.0 (0.3)[A]

[A] For Category B-2 sheet only, properties noted may be determined on the resin from which the sheet is extruded.
[B] Not applicable.

mm (0.031 in.) are to be disregarded unless they form a concentrated pattern that may affect serviceability. Chips from 0.8 mm (0.031 in.) to the maximum permissible size shall not have a frequency greater than 1 per 0.4 m^2 (4.3 ft^2). Chips out of tolerance in size may be knifed off and considered acceptable if the remaining blemish can be removed by polishing, except for Finish 3 sheet which cannot be easily polished. For Finish 3 sheet, the maximum permissible chip size shall be 4.75 mm (0.187 in.); all other requirements above apply except as noted.

5.6.3.2 *Chips in Sheet of Thicknesses Greater Than 51 mm (2.008 in.)*—Chips may be accepted providing they do not extend more than 0.4 mm (0.016 in.) above the surface.

5.6.3.3 *Dirt and Contaminants*—The maximum permissible dirt and contamination dimension shall be 3.2 mm (0.125 in.). Dirt and contaminants less than 0.8 mm (0.031 in.) shall be disregarded unless they form a concentrated pattern that may affect the serviceability of the sheet. The maximum permissible frequency for dimensions ranging from 0.8 mm (0.031 in.) to the maximum permissible for each type of sheet shall be 1 per 0.4 m^2 (4.3 ft^2) of sheet area for thickness up to and including 12.0 mm (0.472 in.). For Finish 3 sheet the maximum permissible dimension for dirt and contaminants shall be 4.8 mm (0.187 in.); all other requirements above apply.

5.6.3.4 *Other Defects*—Minor defects, such as mold or handling scratches, or die lines that can be removed by polishing, shall be permitted provided these are not objectionable individually or in group patterns. Excluding side letgoes for masked and unmasked sheets in thicknesses greater than 51 mm (2.004 in.) and for unmasked sheets that are thicker than 6.0 mm (0.236 in.) up to and including 51 mm (2.004 in.), defects within 25 mm (0.984 in.) of the untrimmed edge of the sheet, that do not significantly reduce mechanical strength of the sheet, shall be permitted. Side letgoes for sheets thicker than 51 mm (2.004 in.) may exist providing they do not extend more than 0.4 mm (0.016 in.) below the surface. Side letgoes for unmasked sheets thicker than 6.0 mm (0.236 in.) up to and including 51 mm (2.004 in.) shall be allowed within a 50 mm (1.97 in.) band from the untrimmed edge of the sheet. For Finish 3 sheet, the maximum permissible length for mold scratches shall be 25 mm (0.984 in.); the maximum permissible length for medium or heavy handling scratches or abrasions shall be 50 mm (1.97 in.); the maximum permissible length of light-handling scratches or abrasions shall be 153 mm (6.024

TABLE 3 Permissible Thickness Variations for Category C-1 Cast Methacrylate Plastic Sheets

Nominal Thickness, mm (in.)[A]	Permissible Thickness Variation, mm (in.)		
	Size 1[B]	Size 2[C]	Size 3[D]
0.75 (0.030)	+0.178 (0.007)[E] −0.229 (0.009)	NA[F]	NA[F]
1.0 (0.039)	+0.152 (0.006)[E] −0.254 (0.010)	NA[F]	NA[F]
1.25 (0.049)	+0.152 (0.006)[E] −0.254 (0.010)	NA[F]	NA[F]
1.5 (0.059)	+0.381 (0.015) −0.483 (0.019)	+0.610 (0.024) −0.686 (0.027)	NA[F]
2.0 (0.079)	+0.356 (0.014) −0.508 (0.020)	+0.559 (0.022) −0.711 (0.028)	NA[F]
2.5 (0.098)	+0.330 (0.013) −0.533 (0.021)	+0.533 (0.021) −0.737 (0.029)	NA[F]
3.0 (0.118)	+0.381 (0.015) −0.635 (0.025)	+0.508 (0.020) −0.762 (0.030)	+0.508 (0.030) −1.02 (0.040)
4.0 (0.157)	+0.406 (0.016) −0.762 (0.030)	+0.559 (0.022) −0.914 (0.036)	+0.737 (0.029) −1.27 (0.050)
4.5 (0.177)	+0.432 (0.017) −0.838 (0.033)	+0.559 (0.022) −0.965 (0.038)	+0.686 (0.027) −1.09 (0.043)
5.5 (0.217)	+0.508 (0.020) −1.02 (0.040)	+0.635 (0.025) −1.14 (0.045)	+0.737 (0.029) −1.27 (0.050)
6.0 (0.236)	+0.508 (0.020) −1.02 (0.040)	+0.635 (0.025) −1.14 (0.045)	+0.508 (0.030) −1.27 (0.050)
8.0 (0.315)	+0.559 (0.022) −1.22 (0.048)	+0.686 (0.027) −1.35 (0.053)	+0.813 (0.032) −1.47 (0.058)
9.0 (0.354)	+0.635 (0.025) −1.40 (0.055)	+0.762 (0.030) −1.52 (0.060)	+0.889 (0.035) −1.65 (0.065)
12.0 (0.472)	+0.635 (0.025) −1.65 (0.065)	+0.762 (0.030) −1.78 (0.070)	+0.889 (0.035) −1.91 (0.075)
16.0 (0.630)	+0.838 (0.033) −1.96 (0.077)	+0.838 (0.033) −1.96 (0.077)	+0.965 (0.038) −2.08 (0.082)
18.0 (0.709)	+0.762 (0.030) −2.03 (0.080)	+0.762 (0.030) −2.03 (0.080)	+1.02 (0.040) −2.29 (0.090)
22.0 (0.866)	+0.660 (0.026) −2.13 (0.084)	+0.660 (0.026) −2.13 (0.084)	+1.17 (0.046) −2.64 (0.104)
24.0 (0.945)	+0.584 (0.023) −2.21 (0.087)	+0.584 (0.023) −2.21 (0.087)	+1.22(0.048) −2.84 (0.112)
32.0 (1.280)	+1.32 (0.052) −2.39 (0.094)	+1.32 (0.052) −2.39 (0.094)	+1.32 (0.052) −2.39 (0.094)
38.0 (1.496)	+1.00 (0.039) −3.07 (0.021)	+1.00 (0.039) −3.07 (0.121)	+1.96 (0.077) −4.04 (0.159)
44.0 (1.732)	+1.24 (0.049) −3.48 (0.137)	+1.24 (0.049) −3.48 (0.137)	+2.34 (0.092) −4.57 (0.180)
51.0 (2.008)	+1.47 (0.058) −3.86 (0.152)	+1.47 (0.058) −3.86 (0.152)	+2.74 (0.108) −5.13 (0.202)
57.0 (2.244)	+1.78 (0.070) −4.22 (0.166)	+1.78 (0.070) −4.22 (0.166)	NA[F]
64.0 (2.520)	+2.01 (0.079) −4.60 (0.081)	+2.01 (0.079) −4.60 (0.181)	NA[F]
70.0 (2.756)	+2.34 (0.092) −4.93 (0.194)	+2.34 (0.092) −4.93 (0.194)	NA[F]
76.0 (2.992)	+2.59 (0.102) −5.28 (0.208)	+2.59 (0.102) −5.28 (0.208)	NA[F]
80.0 (3.150)	+2.89 (0.114) −5.64 (0.222)	+2.89 (0.114) −5.64 (0.222)	NA[F]
90.0 (3.543)	+3.07 (0.121) −6.07 (0.239)	+3.07 (0.121) −6.07 (0.239)	NA[F]
95.0 (3.740)	+3.40 (0.134) −6.40 (0.252)	+3.40 (0.134) −6.40 (0.252)	NA[F]
100.0 (3.937)	+3.61 (0.142) −6.81 (0.268)	+3.61 (0.142) −6.81 (0.268)	NA[F]

[A] Thickness of unshrunk sheet will increase approximately 4 % when it is heated at thermoforming temperatures.

[B] Sizes up to and including 91 by 152 cm (36 by 60 in.) and 102 by 127 cm (40 by 50 in.).

[C] Sizes by larger than Size 1, up to and including 122 by 234 cm (48 by 84 in.), 135 by 203 cm (53 by 80 in.), and 152 by 183 cm (60 by 72 in.).

[D] Sizes larger than Size 2, up to and including 170 by 259 cm (67 by 102 in.) and 183 by 244 cm (72 by 96 in.).

[E] For colorless sheet only, tolerances shall be 0.356 mm (+ 0.014 in.), 0.229 mm (−0.009 in.) for 0.762-mm (0.030-in.) thickness and 0.330 mm (+ 0.013 in.), 0.432 mm (−0.017 in.) for 1.02 mm (0.040 in.) and 1.27-mm (0.050-in.) thicknesses.

[F] Not applicable.

in.); and scratches or abrasions less than 6 mm shall be disregarded unless they form a concentrated pattern that may affect the serviceability of the sheet. For Finish 3 sheet, the maximum permissible frequency for allowable scratches and abrasions as defined above shall be one per 0.4 m^2 (4.3 ft^2) of sheet area.

6. Sampling

6.1 Unless otherwise indicated in Section 8 or Table 2, select a sample from a sheet 3.0 mm thick sufficient to determine conformance of the material to this specification.

NOTE 3—When 6.0-mm-thickness sheet is not available for sampling for spectral-transmittance measurement, other thicknesses may be used for sampling with adjustment of the values found to 6.0-mm thickness. Sheet thicker than 3.0 mm may be selected when agreed upon between the purchaser and the manufacturer. In that case, it may be necessary to machine test specimens to 3.2-mm thickness, which is required for some tests.

7. Number of Tests

7.1 Perform the number of tests indicated in each test method in Section 8. All of the tests listed in Section 8 shall be used to establish conformity of a material to this specification. The average result for the specimens tested shall conform to the requirements prescribed in this specification. It is recommended that routine inspection be limited to the following:

7.1.1 Thickness and dimensions,

7.1.2 Appearance, and

7.1.3 Deflection temperature.

8. Test Methods

8.1 Determine the properties enumerated in this specification in accordance with the following test methods. All test specimens are to be prepared from sheet as received unless stated otherwise in the specific test method, except that for Category B-2 sheet, the properties listed in Table 2 may be determined in the resin from which the sheet is extruded.

8.1.1 *Test Conditions*—Conduct the test in the standard laboratory atmosphere of 23 ± 2.0°C (73.4 ± 1.8°F) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification.

8.1.2 *Index of Refraction*—Test in accordance with Test Methods D 542 using the Refractometric Method.

8.1.3 *Specific Gravity*—Test in accordance with Method A of Test Methods D 792.

8.1.4 *Luminous Transmittance*—For colorless material measure the light transmittance in accordance with Test Method D 1003. The test specimens must be taken from the material as received.

8.1.5 *Haze*—Test in accordance with Test Method D 1003, except that the test specimens shall have a thickness not over 12.7 mm (0.500 in.). Measure haze on colorless material only. The test specimens must be taken from the material as received.

8.1.6 *Water-Absorption*—Test in accordance with Test Method D 570 using the 24-h immersion procedure. Before testing, condition the test specimens for 24 h at 50 ± 3°C (122 ± 5.4°F).

8.1.7 *Shrinkage*:

8.1.7.1 *Procedure A*—For Category A-1 and A-2 materials, test two specimens, each 300 by 300 mm (11.81 by 11.81 in.). On each specimen, mark two fine lines at right angles to each other entirely across the specimen from the midpoints of opposite edges. Place fine gage marks across each of these lines and 50 ± 2.5 mm (1.97 ± 0.1 in.) from the edge of the specimen. Measure the distance between each pair of gage marks to the nearest 0.25 mm. Suspend each specimen from outside the gage marks at one end in a circulating-air oven at 160 ± 10°C (320 ± 18°F) for the length of time specified in the following schedule (see Note 4):

Nominal Thickness, mm (in.)	Heating Time, min
6.0 (0.236) or less	16
9.00 (0.354)	25
12.0 (0.472)	33
18.0 (0.708)	55
24.0 (0.944)	79
38.0 (1.500)	136
51.0 (2.000)	203
55.0 (2.165) and greater	240

After removal from the oven, allow the specimens to cool to 23 ± 1.0°C (73.4 ± 1.8°F), while in the suspended position. Remeasure the distance between each pair of gage marks and calculate the shrinkage as the percent change in distance between gage marks, based on the original distance, as follows:

$$\% \text{ shrinkage} = [(d_1 - d_2)/d_1]\cdot 100 \quad (1)$$

where:
d_1 = original distance, and
d_2 = distance after thermal conditioning.

NOTE 4—For thicknesses falling between those specified, use the heating time for the next higher thickness.

8.1.7.2 *Procedure B*—For Category B-1 and B-2 materials, select three 150 by 150 mm (6 by 6 in.) areas, one near the center area of the sheet. At the approximate center of each area, scribe a line parallel to the machine direction, and a line at 90° to this, to indicate the transverse direction of the sheet. At the point of intersection of the lines, scribe a 125 mm (5 in.) diameter circle. Mark the scribed diameters for identification as machine or transverse direction. Cut the 150 by 150 mm (6 by 6 in.) specimens out of the sheet. Hang the specimens in a circulating-air oven maintained at 50 ± 6°C (122 ± 10°F) for a period of time equal to 2 h for each 0.25 mm (0.01 in.) of sheet thickness (see Note 5). Without cooling, lay the specimens horizontally on a piece of preheated plate glass sprinkled with talcum powder and place in a circulating air oven maintained at 160 ± 10°C (320 ± 18°F). Preheat the plate glass to the test temperature in the oven for at least 15 min before laying the specimens on it. Heat the specimens for the period of time prescribed in the following schedule:

Nominal Thickness, mm (in.)	Heating Period, min
3.0 (0.118) or thinner	15
Over 3.0 (0.118)	30

Remove the plate glass with the specimens from the oven and cool to room temperature in still air. Measure the diameters scribed on the specimen in the machine direction and in the transverse direction. Report the average change in length in each direction as a percent of the original diameter, as follows:

$$\% \text{ shrinkage} = [(l_1 - l_2)/l_1]\cdot 100 \quad (2)$$

where:
l_1 = original length, and
l_2 = average length after thermal conditioning.

NOTE 5—Sheet that has been in storage for prolonged periods may require a longer period of conditioning to avoid the formation of bubbles due to moisture.

8.1.8 *Thermal Stability*:

8.1.8.1 *Procedure A*—For Category A-1 and A-2 materials, test two sheets, each 300 by 300 mm (11.81 by 11.81 in.). Hang each sheet in a circulating-air oven at 180 ± 5°C (356 ± 9°F). Time of heating shall be ½ h for 9.0 mm (0.354) mm thickness and under, 1 h for above 9.0 mm to 24.0 mm (0.944 in.) inclusive, and 2 h for over 24.0 mm thickness. After removal from the oven, allow the sheet to cool to 23 ± 1.0°C (73.4 ± 1.8°F) while hanging vertically. Visually examine the sheets for the presence of bubbles and blisters.

8.1.8.2 *Procedure B*—For Category B-1 and B-2 materials, visually examine the specimens used in 8.1.7.2 for the presence of bubbles and blisters.

8.1.9 *Deflection Temperature Under Flexural Load*—Test in accordance with Test Method D 648 at 1820 kPa (264 psi) loading.

8.1.10 *Tensile Strength and Elongation at Break*—Test in accordance with Test Method D 638, using Type I or Type II specimens at a cross-head speed of 5 mm/min (0.2 in./min).

8.1.11 *Impact Strength (Izod)*—Test in accordance with Method A of Test Methods D 256.

8.1.12 *Spectral Transmittance of Type UVA and UVT Sheet*—Measure the spectral transmittance at each wavelength specified in Table 2 with a suitable spectrophotometer.

8.1.13 *Simulated Weathering Resistance* (Applicable to Finish 3 Material Only):

8.1.13.1 *Ultraviolet Light and Water Exposure*—Three of six specimens measuring at least 100 by 100 mm (4.0 by 4.0 in.) shall be subjected to the water-spray cycle of either of the two methods listed as follows. For one-side-coated sheet, expose the coated side. Run the tests specified in 8.1.13.3, 8.1.13.4, and 8.1.13.5 on the exposed and unexposed specimens.

(*1*) *Carbon Arc*—Practice D 1499 for 1000 ± 10 h.

(*2*) *Xenon Arc*—Practice D 2565 using a cycle of 102 min of light followed by 18 min of light and water spray, borosilicate inner and outer (or equivalent) filter system, and 0.35 W/m^2 at 340 nm irradiance for a total duration of 1400 ± 10 h.

NOTE 6—Xenon arc has been added as an alternative to the carbon arc exposure. The correlation implied by the exposure durations is an estimate based on the ultraviolet light output of these light sources. In case of dispute, carbon arc shall be used as the referee method.

8.1.13.2 *Accelerated Service Conditions*—Expose six specimens in accordance with Procedure A of Practice D 756. Run the tests specified in 8.1.13.3, 8.1.13.4, and 8.1.13.5 after completing the requirements of 9.4, and again after 9.10, of Procedure A of Practice D 756.

8.1.13.3 *Abrasion Resistance*—Test one specimen in accordance with Test Method D 1004, using a 500-g load on each wheel for 100 cycles.

8.1.13.4 *Mar Resistance*—Test one specimen in accordance with Test Method D 673, using 1000 g of No. 80 silicon carbide as the abrasive.

8.1.13.5 *Coating Adhesion*—Test one specimen in accordance with Section 11, Tape Adhesion, of Practice D 3002, except as follows: Clean the surface using isopropyl alcohol with a soft cloth and then air-dry. Make four parallel cuts 3.2 mm (0.125 in.) apart and a similar set of cuts at 90° to the first. Remove the debris with light hand rubbing using Grade 0000 steel wool, being careful not to contaminate the test area with grease or fingerprints. Apply a strip of 25.4 mm(1.0 in.) wide cellulose tape,[8] pressing the tape down firmly without wrinkles or bubbles. Remove the tape immediately by quickly pulling it at a 90° angle. Repeat the tape pull two times, using fresh tape each time in the same grid area, being careful not to contaminate the grid by touching it. Visually compare the area from which the coating has been removed to the standards contained in Fig. 1 of Test Method D 3359.

8.1.14 *Chemical Resistance*—Test one specimen in accordance with the Covered Spot Test of Test Method D 1308 except that a 12.7 by 12.7 mm (0.5 by 0.5 in.) square of filter paper shall be positioned on the surface to be tested and saturated with 1 mL of reagent and covered with a watch glass. After 1 h, remove the glass and filter paper and flush the surface with isopropanol to remove the reagent. Wipe the area dry and examine the effects listed in the Scope of Test Method D 1308. The three tested reagents shall be the following: (*1*) 3 % aqueous solution of trisodium phosphate, (*2*) 40 % aqueous solution of sulfuric acid, and (*3*) reagent-grade toluene.

9. Retest and Rejection

9.1 If any failure occurs, the materials may be retested to establish conformity in accordance with agreement between the purchaser and the seller.

[8] 3M 600 cellulose tape, or equivalent, has been found suitable for this purpose.

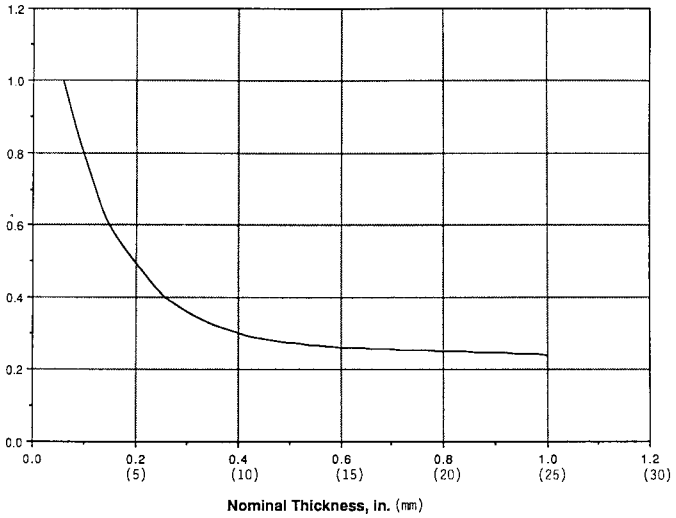

FIG. 1 Maximum Percent Water Absorption *Versus* Thickness

10. Packaging and Package Marking

10.1 *Packaging*—The material shall be packaged in standard commercial containers, so constructed as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery, unless otherwise specified in the contract or order.

10.2 *Package Marking*—Shipping containers shall be marked with the name of the material, category, finish, type, the quality contained therein as defined by the contractor or order under which shipment is made, the name of the manufacturer, lot number, and the number of the contract or order as specified in the contract or order.

10.3 All packing, packaging, and marking provisions of Practice D 3892 shall apply to this specification.

11. Keywords

11.1 acrylic; plastic; PMMA; poly(methyl methacrylate); transparent plastic; sheet

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