



Standard Specification for Extruded, Compression Molded, and Injection Molded Basic Shapes of Poly(aryl ether ketone) (PAEK)¹

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INTRODUCTION

This specification is intended to be a means of calling out plastic product used in the fabrication of end items or parts.

1. Scope

1.1 This specification covers requirements and methods of test for the material, dimensions, and workmanship, and the properties of extruded, compression molded, and injection molded PAEK sheet, plate, rod, and tubular bar manufactured from PAEK.

1.2 The properties included in this specification are those required for the compositions covered. Requirements necessary to identify particular characteristics important to specialized applications may be described by using the classification system given in Section 4.

1.3 This specification allows the use of key clad plastics² (see Section 4).

1.4 The values are stated in inch-pound units and are regarded as the standard in all property and dimensional tables. For reference purposes, SI units are also included in Table 1.

1.5 The following precautionary caveat pertains only to the test method portion Section 11, 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 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

2.1 ASTM Standards:

D 256 Test Method for Determining the Pendulum Impact Resistance of Notched Specimens of Plastics³

¹ This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.20 on Plastic Products (Section D20.20.02).

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² As defined in Guide D 5033.

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

D 618 Practice for Conditioning Plastics for Testing³

D 638 Test Method for Tensile Properties of Plastics³

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Materials³

D 883 Terminology Relating to Plastics³

D 3892 Practice for Packaging/Packing of Plastics³

D 4000 Classification System for Specifying Plastics Materials³

D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics⁴

2.2 ANSI Standards:

Z1.4-1993 Sampling Procedures and Tables for Inspection by Attributes⁵

3. Terminology

3.1 Definitions:

3.1.1 *plate, n*—flat stock 1/4 in. [6.4 mm], or greater.

3.1.2 *recycled plastic shape, n*—a product made from up to 100 % recycled plastic.

3.1.3 *rod, n*—solid cylindrical shape with a minimum diameter of 1/8 in. [3.2 mm].

3.1.4 *sheet, n*—flat stock less than and including 1/4 in. [6.4 mm] thickness.

3.1.5 *tubular bar, n*—annular shapes with minimum inside diameter of 3/8 in. [3.5 mm] and minimum wall thickness of 1/16 in. [1.6 mm].

3.1.6 *virgin plastic shape, n*—product that is produced from 100 % plastic resin that has not been subjected to subsequent melt processing.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 For definitions of other technical terms pertaining to plastics used in this specification, see Terminology D 883 or Guide D 5033.

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

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

4. Classification and Material

4.1 Product shape and size as defined in the applicable purchase order.

4.2 This specification covers product extruded as listed in Table S-PAEK. Products included in the designations reference Classification D 4000 callout where applicable.

4.2.1 The type of PAEK extruded, compression molded, and injection molded product may be categorized by type, grade and class depending on resin and filler compositions as defined in Table S-PAEK.

4.2.2 Every type of PAEK shape may be categorized into one of several grades as follows:

4.2.2.1 *Grade 1 — General Purpose*—Extruded, compression molded or injection molded product made using only 100 % virgin PAEK resin.

4.2.2.2 *Grade 2 — Recycle Grade*—Extruded, compression molded or injection molded product made using any amount up to 100 % of recycled thermoplastic PAEK.

4.3 The type, class and grade is further differentiated based on dimensional stability (elevated temperature excursion test), Table S-PAEK and dimensional requirements, Tables A and B.

4.4 Property Tables:

4.4.1 Table S-PAEK may be used to describe extruded, compression molded, and injection molded products.

4.4.2 Table 1 may also be used to describe extruded, compression molded, and injection molded products not included in Table S-PAEK via a cell callout which includes the applicable Table S-PAEK PAEK type and specific properties (Designations 1 through 7).

4.4.3 To facilitate the incorporation of future or special materials not covered by the Table S-PAEK, the “as specified” category (OO) for type, class and grade is shown on the table with the basic properties to be obtained from Table 1, as they apply.

4.4.4 Reinforcements and additive materials. A symbol (single-letter) will be used for the major reinforcement or combination, or both, along with two numbers which indicate the percentage of addition by mass with the tolerances as tabulated below. This must be included in all Table 1 callouts.

Symbol	Material	Tolerance (Based on the Total Mass);
C	Carbon and graphite fiber	± 2 %
G	Glass	± 2 %
L	Lubricants (for example, PTFE, graphite, silicone and molybdenum disulfide)	± 2 %
M	Mineral	± 2 %
R	Combinations of reinforcements by agreement between supplier and the user for the total reinforcement or fillers, or both	± 3 %

4.5 *Callout Designation*—A one-line system shall be used to specify PAEK materials covered by this specification. The system uses predefined cells to refer to specific aspects of this specification, as illustrated below:

4.5.1 Description:

4.5.1.1 *Example 1*—Extruded natural PAEK extruded rod:

CELL CALLOUT: S-PAEK0111

S-PAEK01 = Product made from PAEK resin in accordance with Table S-PAEK

1 = Unfilled class
1 = General purpose grade product

4.5.1.2 *Example 2*—Compression molded natural PAEK plate.

CELL CALLOUT: S-PAEK0211

S-PAEK02 = Product made from PAEK in accordance with Table S-PAEK
1 = Unfilled class
1 = General purpose grade product

4.5.2 The two examples illustrate how a one-line, alpha-numeric sequence can identify the product composition, commercial parameters and physical characteristics of extruded or compression molded product. A space must be used as a separator between the specification number and the type designation. No separators are needed between type, class and grade. When special notes are to be included, such information should be preceded by a comma. Special tolerances must be noted at time of order and are inserted after the grade in parenthesis and preceded by a comma.

5. Physical Property Requirements

5.1 The physical property values listed within this specification’s tables are to be considered minimum specification values. Any requirement for specific test data for a given production lot should be specified at the time of order. Physical properties for products not yet included in Table S-PAEK may be specified using Table 1 for extruded, compression molded, and injection molded products.

6. Dimensional Requirements

6.1 The type, class, and grade is further differentiated based on dimensional stability (elevated temperature excursion test), Table S-PAEK, and dimensional requirements, Tables A and B. Products shall be produced within commercial tolerances and with the lowest stress levels for machined parts as delineated in Tables A and B for extruded products. The manner in which the tolerances are obtained is not relevant.

6.2 Tubular bar and compression molded dimensions shall be supplied in the unfinished condition, unless otherwise specified at time of order, sufficient to finish to the nominal dimension ordered.

6.3 The maximum allowable camber or bow, or both, shall be within the limits referenced in Tables A and B.

7. Workmanship, Finish, and Appearance

7.1 *Appearance*—The color of products shall be as published by the shapes manufacturer. They shall be uniform in color throughout the thickness. Specific colors and color matching only as agreed to by order. Physical properties may be affected by colors.

7.2 *Finish*—All products shall be free of blisters, wrinkles, cracks, gouges and defects that restrict commercial use of the product. Special surface finish shall be supplied only when specified in the purchase order or contract.

7.3 *Defects*—All products shall be free of voids, dirt, foreign material and embedded particles exceeding 1/32 in. [0.8 mm] maximum diameter as defined below.

7.3.1 The criteria for determining the internal cleanliness shall be external visual inspection. A maximum number of two

internal defects per square foot of plate/sheet and one foot length of rod and tubular bar. Clusters of defects less than $\frac{1}{32}$ in. [0.8 mm] diameter are to be counted as a single defect.

8. Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of this specification as applicable (see 2.2).

8.2 For purposes of sampling, an inspection lot for examination and tests shall consist of all material of the same type, class, and grade and nominal size submitted for inspection at one time.

9. Number of Tests

9.1 Routine lot inspection shall consist of all the criteria specified in the applicable product tables.

9.2 The criteria listed in these product tables and definitions are sufficient to establish conformity of the sheet, plate, rod or tubular bars to this specification. When the number of test specimens is not stated in the test method, a single determination may be made. If more than single determinations and separate portions of the same sample are made, the results shall be averaged. The final result shall conform to the requirements prescribed in this specification.

10. Test Conditions

10.1 *Conditioning of Specimens*—The specification values and dimensions are based on conditioning techniques outlined in Procedure A of Practice D 618.

10.2 *Standard Temperature*—The tests shall be conducted at the standard laboratory temperature of $73.4 \pm 3.6^\circ\text{F}$ [$23 \pm 2^\circ\text{C}$] and $50 \pm 5\%$ RH.

11. Test Methods

11.1 Tensile stress at break, elongation at break, and tensile modulus (tangent) in accordance with Test Method D 638, at the rate of 0.2 in. [5 mm]/min.

11.1.1 All plate and sheet specimens are in accordance with Type I of Test Method D 638.

11.1.2 All rod specimens are in accordance with Type I of Test Method D 638.

11.1.3 All tubular bar specimens are in accordance with Type I of Test Method D 638.

11.2 Dimensional Stability:

11.2.1 *Specimen Preparation (a Minimum of Three Test Samples Required):*

11.2.1.1 *Rods and Tubular Bar*—Prepare each specimen by cutting a 1.5 in. [35 mm] long slice from the shape to be tested. The slice shall then be machined, using a coolant and good machining practices to a length of 1.000 ± 0.005 in. [25 ± 0.13 mm]. Each end of the specimen shall have a machined surface.

11.2.1.2 *Plate and Sheer*—The test is not applicable to sheet under $\frac{3}{16}$ in. [4.8 mm] thick. Each specimen shall consist of a 2 in. [25 mm] diameter disc machined from the flat (diameter shall equal test specimen thickness with a minimum of 2.0 in. [25 mm]). Use the same care in the machining as described above. The thickness of the specimen shall be that of the original flat from which it was cut, no machining being done on the top or bottom faces.

11.2.2 *Testing Procedure*—Place the specimen in an oil bath consisting of polyalkylene glycol or an air circulating oven and heated to the applicable temperature for PAEK type as noted below. Measure the outside diameter and thickness or length of the specimen as applicable at $73.4 \pm 1.8^\circ\text{F}$ [$23 \pm 1^\circ\text{C}$] to the nearest 0.0001 in. [0.0025 mm]. See 11.2.2.1. After 6 h, the specimen shall be allowed to slowly cool to room temperature at a rate not to exceed 40°F [22°C] per hour. Then measure the specimen at $73.4 \pm 1.8^\circ\text{F}$ [$23 \pm 1^\circ\text{C}$] and calculate the percent change in each dimension.

11.2.2.1 Test temperatures:

$$\text{PAEK} = 400 \pm 5.4^\circ\text{F} [204 \pm 3^\circ\text{C}] \quad (1)$$

11.2.3 *Reproducibility*—Inter-laboratory reproducibility is being determined and will be added within one year. Precision statement will be finalized and included within two years.

11.3 Lengthwise Camber and Widthwise Bow:

11.3.1 Make all measurements for camber and bow using the maximum distance rod, sheet, or plate deviates from the straight line extended from edge to edge when measured in accordance with 11.3.2. The shape shall be oriented such that the weight of the product doesn't influence the results.

11.3.2 Rod, Sheet and Plate.

11.3.2.1 *Rod*—Rod will be laid on side and measured with concave side facing the straight edge. Camber is measured from the straight edge to the maximum concave point on rod. Camber may not exceed the values of Table A for extruded or compression molded product.

11.3.2.2 *Sheet and Plate up to and Including $\frac{5}{8}$ in. [16 mm] Thick*—Plate up to and including $\frac{5}{8}$ in. [16 mm] in thickness shall meet the requirements of Table B for extruded or compression molded products with a straight edge, positioned in a lengthwise and widthwise direction, with the plate standing on its edge.

11.3.2.3 *Sheet and Plate Greater than $\frac{5}{8}$ in. [16 mm] Thick*—Plate above $\frac{5}{8}$ in. [16 mm] thick shall not exceed the requirements of Table B for extruded or compression product on the lengthwise ends and widthwise edges when laid on a flat surface (crown side down).

11.3.3 *Reproducibility*—Inter-laboratory reproducibility is being determined and will be added within one year. The precision statement will be finalized and included within two years.

11.4 Squareness (Based on a 4 ft [120 cm] Nominal Length:

11.4.1 Measure and compare diagonal lengths (corner to corner). Accept the product if the difference is $\frac{1}{16}$ in. [1.6 mm] or less and the measured minimums diagonal meets the following requirements: 1 ft wide is $49\frac{1}{2}$ in. [125.5 cm] minimum; 2 ft wide is $53\frac{3}{4}$ in. [136.5 cm] minimum; and 4 ft wide is 68 in. [1463.0 cm] minimum.

11.4.2 If the diagonal difference exceeds $\frac{1}{16}$ in. [1.6 mm] proceed to measure the gap (that is the deviation from a 2 ft [60 cm] framing square). The maximum allowable gap shall not exceed $\frac{1}{8}$ in. [3.2 mm] except for the 1 ft [30 cm] wide sizes of sheet and plate that should not exceed $\frac{1}{16}$ in. [1.6 mm].

11.4.3 *Reproducibility*—Inter-laboratory reproducibility is being determined and will be added within one year. The precision statement will be finalized and included within two years.

11.5 Flexural modulus shall be in accordance with Test Method D 790, specimen $\frac{1}{4}$ in. [1.4 mm] thick maximum, testing speed 0.11 in. [2.9 mm]/min.

11.6 Izod impact shall be in accordance with Fig. 4 of Test Method D 256 notched, $\frac{1}{4}$ in. [1.4 mm] thick maximum specimen.

12. Certification

12.1 When requested at the time of order, the purchaser shall be furnished a certification that the lot is made from the required peek plastic (percent recycle, if applicable) and meets the requirements of this specification.

13. Packing, Packaging, and Marketing

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

14. Ordering Information

14.1 All shapes covered by this standard shall be ordered using the proper callout designation (see 4.5).

15. Keywords

15.1 PAEK; plates-PAEK; recycled-PAEK; recycled plastic; rod-PAEK; shapes-PAEK; sheet-PAEK; tubular bar-PAEK



TABLE S-PAEK Requirements for PAEK (Poly(aryl ether ketone)) Shapes

Type	Description	Class	Description	Grade	Applicable Classification D 4000 Call-out	Ultimate Tensile Stress, psi [MPa], min	Tensile Elongation, % at break, min	Tensile Modulus, psi [MPa], min	Dimensional Stability, max, %
01	General Purpose (E)	1	Unfilled	1	PAEK0000000 D42070	12 000 [82]	10	420 000 [2896]	0.4
	General Purpose (E)	2	30 % Glass fiber	2	PAEK0000 G30D84300	13 000 [90]	1	900 000 [6207]	0.4
	General Purpose (E)	3	30 % Carbon fiber	3	PAEK0000 C30G85300	22 000 [151]	1	1 100 000 [7586]	0.4
	General Purpose (E)	4	Bearing Grade	4	PAEK0000 R30D73200	15 000 [103]	1	800 000 [5517]	0.4
02	General Purpose (E)	0	...	0
	General Purpose (C)	1	Unfilled	1	PAEK0000000 D42070	10 000 [69]	2	400 000 [2758]	0.4
	General Purpose (C)	2	30 % Glass fiber	2	PAEK0000 G30D84300	11 000 [76]	1	425 000 [2896]	0.4
	General Purpose (C)	3	30 % Carbon fiber	3	PAEK0000 C30G85300	15 000 [103]	1	500 000 [3448]	0.4
03	General Purpose (C)	4	Bearing Grade	4	PAEK0000 R30D73200	10 000 [69]	1	400 000 [2758]	0.4
	General Purpose (C) Other PAEK	0	...	0	as specified as specified



TABLE A Dimensional Requirements for Extruded PAEK Rods^A

Size, in. ^B	Diameter Tolerance, in. ^B	Roundness TIR, in. ^B	Camber, in. ^B
1/16	+0.002/-0	0.002	2-1/2 in./8 ft
3/16	+0.002/-0	0.002	2-1/2 in./8 ft
1/4	+0.002/-0	0.002	2-1/2 in./8 ft
3/8	+0.002/-0	0.002	2-1/2 in./8 ft
1/2	+0.002/0	0.002	2-1/2 in./8 ft
5/8	+0.002/-0	0.002	2-1/2 in./8 ft
3/4	+0.002/-0	0.002	2-1/2 in./8 ft
7/8	+0.002/-0	0.002	2-1/2 in./8 ft
1	+0.002/-0	0.002	1-1/4 in./8 ft
1-1/8	+0.005/-0	0.005	1-1/4 in./8 ft
1-1/4	+0.005/-0	0.005	1-1/4 in./8 ft
1-3/8	+0.005/-0	0.005	1-1/4 in./8 ft
1-1/2	+0.005/-0	0.005	1-1/4 in./8 ft
1-5/8	+0.005/-0	0.005	1-1/4 in./8 ft
1-3/4	+0.005/-0	0.005	1-1/4 in./8 ft
1-7/8	+0.005/-0	0.005	1-1/4 in./8 ft
2	+0.005/-0	0.010	1-1/4 in./8 ft
2-1/8 to 2-5/8	+0.030/-0	0.030	1-1/4 in./8 ft
2-3/4 to 3	+0.030/-0	0.060	1/4 in./4 ft
3-1/4 to 4	+0.250/-0	0.060	1/4 in./4 ft
4-1/4 to 5	+0.250/-0	0.060	1/4 in./4 ft
5-1/4 to 6	+0.250/-0	0.060	1/4 in./4 ft
Over 6	+0.250/-0	0.060	1/4 in./4 ft

^ABased on dry-as-manufactured condition and proper product storage and handling.

^BTo convert inches to millimetres multiply by 25.40.

TABLE B Dimensional Requirements for Extruded PAEK Sheets and Plates^A

Note 1—Squareness requirement listed in 11.4.

Size, in. ^A	Thickness Tolerances, in. ^A	Length Camber ^A	Width Bow ^A
1/16	±0.005	3/4 in./4 ft	3/16 in./2 ft
3/32	±0.005	3/4 in./4 ft	3/16 in./2 ft
1/8	±0.005	3/4 in./4 ft	3/16 in./2 ft
3/16	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
1/4	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
5/16	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
3/8	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
7/16	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
1/2	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
5/8	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
3/4	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
7/8	+0.025/-0	3/4 in./4 ft	3/16 in./2 ft
1	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
1 1/8	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
1 1/4	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
1 3/8	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
1 1/2	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
1 5/8	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
1 3/4	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
1 7/8	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
2	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft
Over 2	+0.025/-0	1/4 in./4 ft	1/16 in./2 ft


^ATo convert inches to millimeters multiply by 25.40.



TABLE 1 Additional Detail Requirements—Reinforced/Unreinforced PAEK Shapes

Note 1—The applicable table (including resin type and fillers) must precede this table designation.

Designation Order Number	Property	1	2	3	4	5	6	7	8	9
1	Tensile Stress, Test Method D 638, psi [MPa], min	8000 [55]	10 000 [69]	12 000 [83]	16 000 [110]	20 000 [138]	25 000 [172]	29 000 [200]	32 000 [221]	Specify Value
2	Elongation at Break, Test Method D 638, min, %	0.5	1	3	5	10	20	50	100	Specify Value
3	Tensile Modulus, Test Method D 638, psi [MPa], min	300 000 [2073]	500 000 [3448]	800 000 [5517]	1 100 000 [7586]	1 400 000 [9655]	1 700 000 [11 724]	2 000 000 [11 793]	7 300 000 [15 862]	Specify Value
4	Dimensional Stability per 11.2, max, %	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.5	Specify Value
5	Flexural Modulus, Test Method D 790, psi [MPa], min	350 000 [2400]	500 000 [3448]	650 000 [4482]	900 000 [6207]	1250 000 [8621]	1 650 000 [11 379]	2 100 000 [14 482]	2 600 000 [17 931]	Specify Value
6	Impact, Test Method D 256, ft lbs/in. of notch [J/m of notch], min	0.4 [21]	0.6 [32]	0.8 [43]	1.0 [53]	2.0 [107]	3.0 [160]	4.5 [240]	6.0 [320]	Specify Value
7	To be determined

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