Designation: D7292 – 12

# Standard Specification for Extruded, Compression-Molded, and Injection-Molded Basic Shapes of Polyamide-Imide (PAI)[1]

This standard is issued under the fixed designation D7292; 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 requirements and methods of test for the material, dimensions, and workmanship of extruded, compression molded, and injection molded parts manufactured from PAI.

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 are described by the classification system given in Section 5.

1.3 This specification allows for the use of recycled materials provided that specification requirements based upon this specification are met.

1.4 The values stated in English units are to be regarded as standard in all property and dimensional tables. For reference purposes, SI units and conversion factors are also included.

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 known ISO equivalent to this standard.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

D618 Practice for Conditioning Plastics for Testing

D638 Test Method for Tensile Properties of Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

D1708 Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens

D3418 Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry

D3892 Practice for Packaging/Packing of Plastics

D4000 Classification System for Specifying Plastic Materials

D5204 Classification System for Polyamide-Imide (PAI) Molding and Extrusion Materials

D7209 Guide for Waste Reduction, Resource Recovery, and Use of Recycled Polymeric Materials and Products

2.2 *ANSI Standard:*[3]

Z1.4-1993 Sampling Procedure and Tables for Inspection by Attributes

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *finished product (F), n*—a product that meets the dimensional criteria of Tables A and B in this specification.

3.1.2 *plate, n*—flat stock with thickness greater than 3⁄16 in. (4.76 mm).

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

3.1.4 *rod, n*—solid extruded cylindrical shape with a minimum diameter of 3⁄32 in. (2.38 mm).

3.1.5 *virgin plastic shape, n*—a shape produced entirely of plastic resin that has not been melt processed more than once.

3.2 *Additional Definitions:*

3.2.1 For definitions of other technical terms pertaining to plastics used in this specification, see Terminology D883 or Guide D7209.

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

Current edition approved Aug. 1, 2012. Published September 2012. Originally approved in 2006. Last previous edition approved in 2006 as D7292 - 06. DOI: 10.1520/D7292-12.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

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

## 4. Applications

4.1 Typical applications for these parts are for products that require low coefficient of friction, good thermal resistance, and toughness up to 250°C. However, usage is not limited to these applications. Specific grades are designed for high strength, wear resistance, low coefficient of friction and reinforced for improved load bearing capacity and non-abrasive wear.

## 5. Classification and Material

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

5.2 This specification covers product manufactured as listed in Table S-PAI. Materials included in the designations reference Classification System D5204 callouts where applicable.

5.2.1 The PAI material used in the product is normally categorized by type, grade, and class depending on resin and filler compositions as defined in Table S-PAI.

5.3 The type, class, and grade are further differentiated based on Table S-PAI, Table A, and dimensional requirements, Table I.

5.4 *Property Tables:*

5.4.1 Table S-PAI is used to describe manufactured parts.

5.4.2 Table I is used to describe products not included in Table S-PAI via a cell callout that includes the applicable Table S-PAI type and specific properties.

5.4.3 To facilitate the incorporation of future or special materials not covered by the Table S-PAI, the "other" category (00) for type, class and grade is shown in the table with the basic properties to be obtained from Table I, as they apply.

5.4.4 *Reinforcements and Additive Materials*—A symbol (single letter) is to 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 I callouts.

| Symbol | Material | Tolerance (Based on the Total Mass) |
|---|---|---|
| C | Carbon and graphite fiber | ±2 % |
| G | Glass fiber | ±2 % |
| L | Lubricants (for example, PTFE, graphite, silicone and molybdenum disulfide) | Depends upon material and process—to be specified |
| M | Mineral | ±2 % |
| R | Combinations of reinforcements or fillers, or both | ±3 % |

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

5.5.1 *Description:*

5.5.1.1 *Example 1*—Extruded PAI rod:

CELL CALLOUT: S-PAI0111
S-PAI01 = Extruded Product made from PAI resin in accordance with Table S-PAI
1 = Class: Electrical grade
1 = Grade: PAI011M03 as specified in Table S-PAI

5.5.1.2 *Example 2*—Product made from injection molded glass filled PAI material:

CELL CALLOUT: S-PAI0231
S-PAI02 = Injection molded product made from PAI resin as specified in Table S-PAI
3 = Class: glass reinforced
1 = Grade: PAI013G30 as specified in table S-PAI

5.5.1.3 *Example 3*—Product not included in Table S-PAI:

CELL CALLOUT: S-PAI 0000 1022500
S-PA0000 = Molded product made from PAI resin

00 = Type Other
0 = Class Other
0 = Grade Other

1 = Minimum Tensile Strength of 10,000 psi
0 = Elongation – no requirement
2 = Minimum tansile Modulus of 400,000 psi
2 = Minimum Flexural Modulus of 550,000 psi
5 = Izod Impact specified value of 4.5 ft-lb/in min
0 = Minimum glass transition temperature – not required
0 = other – not required

5.5.2 The three examples illustrate how a one-line, alphanumeric sequence can identify the product composition, commercial parameters, and physical characteristics of extruded, compression-molded or injection-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 shall 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.

**TABLE S-PAI Additional Detailed Requirements—for Extruded, Compression- and Injection-Molded PAI Shapes**

| Type | Description | Class | Description | Grade | Applicable D5204 Callout | Ultimate Tensile Strength, min. psi (MPa) | Elongation at Break, % min. | Specific Gravity |
|---|---|---|---|---|---|---|---|---|
| 01 | Extruded Shapes | 1 | Electrical Grade | 1 | PAI021M03 | 17 000 (117) | 10 | 1.38–1.44 |
| | | | Other | 0 | As Specified | | | |
| | | 2 | Bearing Grade | 1 | PAI022L15 | 12 000 (83) | 3 | 1.43–1.48 |
| | | | Other | 0 | As Specified | | | |
| | | 3 | Glass Fiber | 1 | PAI023G30 | 18 000 (124) | 2 | 1.57–1.62 |
| | | | Other | 0 | As Specified | | | |
| | | 4 | Carbon Fiber | 1 | PAI023C30 | 8000 (55) | 2 | 1.44–1.49 |
| | | | Other | 0 | As Specified | | | |
| | | 0 | Other | 0 | As Specified | | | |
| 02 | Injection Molded Shapes | 1 | Electrical Grade | 1 | PAI011M03 | | | |
| | | | Other | 0 | As Specified | | | |
| | | 2 | Bearing Grade | 1 | PAI012L15 | | | |
| | | | Other | 0 | As Specified | | | |
| | | 3 | Glass Fiber | 1 | PAI013G30 | | | |
| | | | Other | 0 | As Specified | | | |
| | | 4 | Carbon Fiber | 1 | PA013C30 | | | |
| | | 0 | Other | 0 | As Specified | | | |
| 03 | Compression Molded | 1 | Electrical Grade | 1 | PAI000M30 | 10 000 (69) | 2 | 1.38–1.44 |
| | | | Other | 0 | As Specified | | | |
| | | 2 | Bearing Grade | 1 | PAI000L15 | 10 000 (69) | 2 | 1.43–1.48 |
| | | | Other | 0 | As Specified | | | |
| | | 3 | Glass Fiber | | | | | |
| | | | Other | 0 | As Specified | | | |
| | | 4 | Carbon Fiber | | | | | |
| | | 0 | Other | 0 | As Specified | | | |
| 00 | Other | 0 | Other | 0 | As Specified | | | |

**TABLE A Dimenstional Requirements for Extruded PAI Rod**

| Size (in.) | Roundness Tolerances (in.) | Camber, max. (in.) | |
|---|---|---|---|
| | | 4 ft | 8 ft |
| 0.093 | +0.003/-0 | 0.625 | 2.50 |
| 0.125 | +0.003/-0 | 0.625 | 2.50 |
| 0.250[A] | | 0.625 | 2.50 |
| 0.375[A] | | 0.375 | 1.50 |
| 0.500[A] | | 0.250 | 1.00 |
| 0.625[A] | | 0.250 | 1.00 |
| 0.750[A] | | 0.250 | 1.00 |
| 1.000[A] | | 0.187 | 0.75 |
| 1.250[A] | | 0.187 | 0.75 |
| 1.375[A] | | 0.125 | 0.50 |
| 1.750[A] | | 0.125 | 0.50 |
| 2.000[A] | | 0.125 | 0.50 |

[A]Supply oversized and machine to size.

**TABLE B Dimensional Requirements for Extruded PAI Sheets and Plates**

NOTE 1—Squareness requirements listed in 12.4.

NOTE 2—To convert inches to millimetres, multiply by 25.4

| Size Thickness (in.) | Thickness Tolerance (in.) | Length Camber | Width Bow |
|---|---|---|---|
| 0.187 | n.a. | 0.50/4 ft | 0.062/2 ft |
| 0.250 | +0.025/-0 | 0.50/4 ft | 0.062/2 ft |
| 0.375 | +0.025/-0 | 0.50/4 ft | 0.062/2 ft |
| 0.500 | +0.025/-0 | 0.375/4 ft | 0.062/2 ft |
| 0.625 | +0.025/-0 | 0.375/4 ft | 0.062/2 ft |
| 0.750 | +0.025/-0 | 0.375/4 ft | 0.062/2 ft |
| 1.000 | +0.025/-0 | 0.25/4 ft | 0.062/2 ft |

**TABLE I Additional Detailed Requirements—for Extruded, Compression- and Injection-Molded PAI Shapes**

| Designation Order | Property[A] | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 9[B] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Tensile strength,[C,D] psi, (MPa), min | Unspecified | 10 000 (69) | 12 000 (83) | 14 000 (97) | 16 000 (110) | 20 000 (138) | 25 000 (172) | Specify value |
| 2 | Elongation,[C] %, min | Unspecified | 5 | 10 | 20 | 50 | 100 | 200 | Specify value |
| 3 | Tensile Modulus,[C] psi, (MPa), min | Unspecified | 300 000 (2073) | 400 000 (2760) | 500 000 (3448) | 600 000 (4137) | 800 000 (5516) | 1 000 000 (6895) | Specify value |
| 4 | Flexural modulus,[E] psi, (MPa), min | Unspecified | 450 000 (3100) | 550 000 (3792) | 650 000 (4482) | 750 000 (5171) | 1 000 000 (6895) | 1 500 000 (10 343) | Specify value |
| 5 | Izod Impact[F,G] ft · lb/in., (J/m), min | Unspecified | 0.8 (43) | 1.0 (53) | 2.0 (107) | 3.0 (160) | 4.5 (240) | 6.0 (320) | Specify value |
| 6 | Glass transition temperature (°C) | Unspecified | 270 | 272 | 274 | 276 | 278 | 280 | Specify value |
| 7 | To be determined | Unspecified | | | | | | | Specify value |

[A] Physical property data were determined using injection molded or extruded (as applicable) and postcured specimens.
[B] If a specific value is required it must be shown in the call-out.
[C] See Test Method D638 using the Type I specimen.
[D] MPa × 145 = psi.
[E] See Test Method D790, Method 1, Procedure A.
[F] See Test Method D256, Method A, using the center portion of a Test Method D638, Type I specimen.
[G] J/m × 0.01873 = ft · lb/in.

## 6. Physical Property Requirements

6.1 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 shall be specified at the time of order. Physical properties for products not included in Table S-PAI shall be specified using Table I for extruded, compression- and injection-molded products.

## 7. Dimensional Requirements

7.1 The type, class, and grade is further differentiated by the use of Table S-PAI, and dimensional requirements, Tables A and B. Products shall be produced with the lowest stress levels for machined parts and within commercial tolerances as delineated in Tables A and B. The manner in which the tolerances are obtained is not relevant.

7.2 Tubular bar dimensions shall be supplied in the unfinished condition, unless otherwise specified at the time of order.

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

## 8. Workmanship, Finish, and Appearance

8.1 *Appearance*—The appearance of products shall be as published by the shapes manufacturer.

8.2 *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.

8.3 *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.

8.3.1 The criteria for determining the internal cleanliness shall be external visual inspection. A maximum number of two internal defects per square foot of plate or sheet and one foot length of rod or tubular bar is allowed. Clusters of defects less than 1/32-in. (0.8-mm) diameter are to be counted as a single defect.

## 9. Sampling

9.1 Sampling shall be statistically adequate to satisfy the requirements of this specification as applicable.

9.2 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.

## 10. Number of Tests

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

10.2 The criteria listed in these product tables and definitions are sufficient to establish conformity of the shape to this specification. When the number of test specimens is not stated in the test method, a single determination is sufficient. If more than a single determination is made, the results shall be averaged. The final result shall conform to the requirements prescribed in this specification.

## 11. Test Conditions

11.1 *Conditioning of Specimens*—The specification values and dimensions are based on conditioning techniques outlined in Procedure A of Practice D618.

11.2 *Standard Conditions*—The tests shall be conducted at the standard laboratory conditions of 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 10 % RH.

## 12. Test Methods

12.1 Tensile stress at break, elongation at break, and tensile modulus shall be determined in accordance with Test Method D638 at a rate of 0.1 in./min.

12.2 Glass transition Tg in accordance with Test Method D3418.

12.3 Specific gravity in accordance with Test Methods D792.

12.4 Flexural Modulus in accordance with Test Methods D790, specimen ¼-in. thick maximum.

12.5 Izod Impact in accordance with Test Methods D256, notched, ¼-in. thick maximum specimen.

12.6 *Lengthwise Camber and Widthwise Bow*

12.6.1 All measurements for camber and bow shall be made using the maximum distance that the rod, sheet, or plate deviates from the straight line extended from edge to edge when measured in accordance with 12.3.2. The shape shall be oriented such that the weight of the product does not influence the results.

12.6.2 *Rod*—The rod shall be laid on its side and measured with the concave edge facing the straight edge. Camber is measured from the straight edge to the maximum concave point on rod. Camber shall not exceed the values of Table A for extruded product.

12.6.2.1 *Plate Up to and Including 5/8-in. Thick*—Plate up to and including 5/8 in. in thickness shall meet the requirements of Table B for extruded parts when measured with a straight edge.

12.6.2.2 *Plate Greater than 5/8-in. Thick*—Plate greater than 5/8-in. thick shall not exceed the requirements of Table B on lengthwise ends and widthwise edges when laid on a flat surface (crown side up).

12.7 *Squareness (based on a 4-ft nominal length)*

12.7.1 Measure and compare the diagonal lengths (corner to corner). Accept the product if the difference is 1/16 in. or less and the measured minimums diagonal meets the following requirements:

*(1)* 1-ft wide is 49.5-in. min

*(2)* 2-ft wide is 53.75-in. min

*(3)* 4-ft wide is 68-in. min

If the diagonal difference exceeds 1/16 in., proceed to measure the gap (that is, the deviation from a 2 ft square). The maximum allowable gap shall not exceed 1/8 in. except for the 1-ft wide sized of sheet and plate, which shall not exceed 1/16 in.

## 13. Certification

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

## 14. Packing, Packaging, and Marketing

14.1 All packing, packaging, and marking provisions of Practice D3892 shall apply to this specification.

## 15. Ordering Information

15.1 All shapes covered by this specification shall be ordered using the proper callout designation (see 5.5).

## 16. Keywords

16.1 Polyamide-imide (PAI); plates; recycled plastic; rods; shapes; tubular bar

## SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D7292 - 06) that may impact the use of this standard. (August 1, 2012)

*(1)* Carbon and glass fiber reinforced classes were added to Type 03, compression molded, in Table S-PAI.
*(2)* Classes for "Other" were added to Table S-PAI where needed.
*(3)* Typographical and other errors were corrected, and Example 3 was added to clarify the use of Table I.
*(4)* Minor editorial changes were made.
*(5)* Relative humidity tolerance was increased to ± 10%.