



Standard Specification for Extruded and Compression Molded Basic Shapes Made from Thermoplastic Polyester (TPES)¹

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INTRODUCTION

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

1. Scope*

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

1.2 The properties included in this specification are those required for the compositions covered. Use the classification system given in Section 4 to describe requirements necessary to identify particular characteristics important to specialized applications.

1.3 This specification allows the use of recycled 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 and Table S-TPES only.

1.5 The following precautionary caveat pertains only to the test method portions sections 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.

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 (Section D20.15.21).

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² As defined in Guide D7209.

2. Referenced Documents

2.1 ASTM Standards:³

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

D883 Terminology Relating to Plastics

D3892 Practice for Packaging/Packing of Plastics

D4507 Specification for Thermoplastic Polyester (TPES) Materials (Withdrawn 1999)⁴

D4000 Classification System for Specifying Plastic Materials

D5927 Classification System for Thermoplastic Polyester (TPES) Injection and Extrusion Materials Based on ISO Test Methods

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

3. Terminology

3.1 Definitions:

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

3.2 Definitions of Terms Specific to This Standard:

³ 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.

⁴ The last approved version of this historical standard is referenced on www.astm.org.

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

3.2.1 *plate, n*—flat stock ¼ in. (6.4 mm) or greater.

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

3.2.3 *rod, n*—a solid cylindrical shape with a minimum diameter of ⅛ in. (3.2 mm).

3.2.4 *tubular bar, n*—an annular shape with minimum inside diameter of ⅜ in. (9.6 mm) and minimum wall thickness of ⅛ in. (1.6 mm).

4. Classification and Material

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

4.2 This specification covers product extruded and compression molded as listed in Table S-TPES. Products included in the designations reference Specification **D4507** or Specification **D5927** callouts where applicable.

4.2.1 Categorize the type of thermoplastic polyester shape product by type, grade, and class depending on resin and filler compositions as defined in Table S-TPES.

4.2.2 Use the following sections to categorize each type of thermoplastic polyester shape into one of several grades:

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

4.2.2.2 *Grade 2—Recycled*—Extruded or compression molded product made using any amount up to 100 % recycled thermoplastic polyester plastics.

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

4.4 Property Tables:

4.4.1 Use Table S-TPES to describe both extruded or compression molded products.

4.4.2 Use Table 1 also to describe extruded or compression molded products not included in Table S-TPES via a cell callout that includes the applicable Table S-TPES thermoplastic polyester 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-TPES, the “as specified” category (00) for type, class and grade is shown in 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 that 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 reinforced	± 2 %
G	Glass-reinforced	
	< 15 % glass content	± 2 %
	> 15 % glass content	± 3 %
L	Lubricants (for example, PTFE, graphite and silicone)	by agreement between the supplier and the user
M	Mineral	± 2 %
R	Combinations of reinforcements or fillers, or both	± 3 % for the total reinforcement

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

4.5.1 Examples:

4.5.1.1 *Example 1*—Product made from general purpose PBT

CELL CALLOUT: S-TPES0111

S-TPES01 = Product made from PBT in accordance with Table S-TPES

1 = Unfilled class

1 = General purpose grade product

4.5.1.2 *Example 2*—Product made from general purpose PET

CELL CALLOUT: S-TPES0211

S-TPES02 = Product made from PET in accordance with Table S-TPES

1 = Unfilled class

1 = General purpose grade product

4.5.2 These two examples illustrate how a one-line, alphanumeric 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 shall be preceded by a comma. Special tolerances must be noted at time of order and are inserted after the grade in parentheses and preceded by a comma.

5. Ordering Information

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

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. Use Table

1 to specify physical properties for extruded or compression molded products not yet included in Table S-TPES.

7. Dimensional Requirements

7.1 The type, class and grade is differentiated based on dimensional stability (elevated temperature excursion test), as indicated in Table S-TPES.

7.2 Products shall be produced within commercial tolerances and with the lowest stress levels for machined parts as delineated in Tables A and B.

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

7.4 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 resin material color is white to off-white. The product color shall be as published by the shapes manufacturer. They shall be uniform in color throughout the thickness. The specific colors and color matching shall only be as agreed to by order. It is possible that other colors will affect physical properties.

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 $\frac{1}{32}$ in. (0.8 mm) maximum diameter as defined in 8.3.1.

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 and one foot length of rod and tubular bar are allowed. Clusters of defects less than $\frac{1}{32}$ 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, 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 sheet, plate, rod or tubular bars to this specification. When the number of test specimens is not stated in the test method, it is acceptable to make a single determination. 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.

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 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 $50 \pm 10\%$ relative humidity.

12. Test Methods

12.1 Tensile stress break, elongation at break, and tensile modulus (tangent) are in accordance with Test Method D638, at the rate of 0.2 in. (5 mm)/min.

12.1.1 All plate specimens are in accordance with Test Method D638, Type I.

12.1.2 All rod specimens are in accordance with Test Method D638.

12.1.3 All tubular bar specimens are in accordance with Test Method D638.

12.2 Dimensional Stability:

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

12.2.1.1 *Rods and Tubular Bar*—Prepare each specimen by cutting a 1.5 in. (35 mm) long slice from the shape to be tested. Machine the slice using a coolant and good machining practices to a length of 1000 ± 0.005 in. (25 ± 0.13 mm). Each end of the specimen shall have a machined surface.

12.2.1.2 *Plate*—Each specimen shall consist of a 2 in. (50 mm) diameter disc machined from the flat (diameter shall equal test specimen thickness with a minimum of 2.0 in. (50 mm)). The same care shall be used in the machining as described in 12.1.1. 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.

12.2.2 *Testing Procedure*—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). All measurements shall be done on the centerline and 90° from the center line for plate. Also take measurements for thickness halfway to center, and for diameter at mid-point. Place the specimen in a bath consisting of polyalkylene glycol or an air circulating oven heated to the temperatures shown below. After 6 h, allow the specimen to slowly cool to room temperature at a rate not to exceed 40°F (22°C)/h. 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:

$$300 \pm 5^\circ\text{F} \quad (149 \pm 3^\circ\text{C}) \quad (1)$$

12.3 Lengthwise Camber and Widthwise Bow:

12.3.1 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 12.3.2. The shape shall be oriented such that the weight of the product doesn't influence the results.

12.3.2 Rod and Plate:

12.3.2.1 *Rod*—Lay each rod on its side and measure it with concave side facing a straight edge. Measure camber from the straight edge to the maximum concave point on the rod. Camber shall not exceed the values of Table A.

12.3.2.2 *Plate*—Plate shall not exceed the requirements of Table B on the lengthwise ends and widthwise edges when laid on a flat surface (crown side up).

12.4 *Squareness (Based on a 4 ft Nominal Length):*

12.4.1 Measure and compare diagonal lengths (corner to corner). Accept the product if the difference is 1/16 in. (0.4 mm) or less and the measured minimums diagonal meets the following requirements

12.4.1.1 1 ft wide is 49-1/2 in. (125.5 cm) minimum.

12.4.1.2 2 ft wide is 53-3/4 in. (136.5 cm) minimum.

12.4.1.3 4 ft wide is 68 in. (1463.0 cm) minimum.

12.4.2 If the diagonal difference exceeds 1/16 in. (0.4 mm), proceed to measure the gap (which is the deviation from a 2 ft square). The maximum allowable gap shall not exceed 1/8 in. (0.7 mm) except for the 1 ft (25.4 cm) wide sizes of sheet and plate, which shall not exceed 1/16 in. (0.4 mm).

12.5 Flexural modulus is measured in accordance with Test Method D790, specimen 1/4 in. (6.4 mm) thick maximum, testing speed 0.11 in. (2.8 mm)/min. Specimens shall be machined from shape in accordance with the Test Specimens section in Test Method D790.

12.6 Izod impact is measured in accordance with Test Method D256, Method A, Fig. 4, notched. Specimens shall be machined from shape in accordance with Test Method D256, Fig. 6 with 1/4 in. (6.4 mm) width maximum specimen.

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 thermoplastic polyester plastic (percent recycle, if applicable) and meets the requirements of this specification.

14. Packing, Packaging and Marking

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

15. Keywords

15.1 thermoplastic polyester; thermoplastic polyester—PBT; thermoplastic polyester—PET; thermoplastic polyester—plates; thermoplastic polyester—recycled plastic; thermoplastic polyester—plates; thermoplastic polyester—rod; thermoplastic polyester—shapes; thermoplastic polyester—tubular bar

TABLE S-TPES Requirements for Thermoplastic Polyester (TPES) Shapes

Type	Description	Class	Description	Grade	Resin Type	Description	Ultimate Tensile Strength, min, psi (MPa)	Tensile Elongation, % at break (min.)	Tensile Modulus, min, psi (MPa)	Dimen. Stability, max, %	
01	PBT	1	Unfilled	1	TPES0111 ^A	General Purpose	8500 (58)	40	350 000 (2414)	0.4	
					TPES0111 ^B						
					As Specified ^B	Recycled	...	...	...	...
		2	Modified	0	As Specified ^B	As Specified	...	...	...	...
				1	As Specified ^B	General Purpose	...	...	...	...
				0	As Specified ^B	As Specified	...	...	...	...
02	PET	0	As Specified	0	As Specified ^B	As Specified	...	...	...	...
				1	TPES211 ^B	General Purpose	11 500 (79)	15	450 000 (3103)	0.4	
					As Specified ^B	Recycled	...	...	...	...
		2	Modified	0	As specified ^B	As Specified	...	...	...	...
				1	As Specified ^B	General Purpose	...	...	...	...
				0	As Specified ^B	As Specified	...	...	...	...
00	Other Polyesters	0	As Specified	0	As Specified ^B	As Specified	...	...	...	...
				1	As Specified ^B	General Purpose	...	...	...	...
				2	As Specified ^B	Recycled	...	...	...	...
		0	As Specified ^B	As Specified	...	...	...	...

^AIn accordance with Specification D4507.

^BIn accordance with Specification D5927.

TABLE A Dimensional Requirements for Thermoplastic Polyester Rod^A

Size, in. ^A	Diameter Tolerance, in. ^A	Roundness TIR, in. ^A	Camber, in. ^A
1/8 to 7/8 in.	+0.003/-0.001	0.002	2 5/8 in./8 ft
1 in.	+0.005/-0	0.004	1 3/8 in./8 ft
1 1/8 to 1-1/4 in.	+0.005/-0	0.004	1 3/8 in./8 ft
1 3/8 to 1-7/8 in.	+0.005/-0	0.005	1 3/8 in./8 ft
2 in.	+0.008/-0	0.010	1 3/8 in./8 ft
2 1/8 to 2-1/2 in.	+0.030/-0	0.025	1 1/8 in./8 ft
2 5/8 to 6 in.	+0.250/-0	0.050	3/8 in./4 ft

^ATo convert inches to millimetres, multiply by 25.40.

TABLE B Dimensional Requirements for Extruded Thermoplastic Polyester Plates (Grade 1)^{A, B}

Size ^A	Thickness Tolerances ^A	Length Camber ^A	Width Bow ^A
¼ to 2 in.	+0.025/–0	¾ in./4 ft	¼ in./2 ft.
2⅞ to 3 in.	+0.050/–0	¼ in./4 ft	⅛ in./2 ft
3⅞ in. and over	+0.350/–0	¼ in./4 ft	⅝ in./1 ft

^ATo convert inches to millimetres multiply by 25.40.

^BCompression molded plate is supplied sufficiently oversize to finish to nominal dimension listed.

TABLE 1 Additional Detail Requirements—Reinforced/Unreinforced Extruded and Compression Molded Thermoplastic Polyester (The applicable Table S-TPES thermoplastic polyester type (including fillers, see 4.4.4) must precede this table designation.)

Designation Order Number	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile stress Test Method D638 , min, psi (MPa)	Unspecified	5000 (34)	8000 (55)	10 000 (69)	12 000 (83)	14 000 (97)	16 000 (110)	20 000 (138)	25 000 (172)	Specify Value
2	Elongation at break Test Method D638 , %, min	Unspecified	1	3	5	10	20	50	100	200	Specify Value
3	Tensile modulus min. Test Method D638 , min, psi (MPa)	Unspecified	100 000 (690)	300 000 (2073)	400 000 (2760)	500 000 (3448)	600 000 (4137)	800 000 (5516)	100 000 (6895)	1 200 000 (8276)	Specify Value
4	Dimensional stability, % max per 12.2	Unspecified	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.5	Specify Value
5	Flexural modulus, Test Method D790 , min, psi (MPa)	Unspecified	200 000 (1379)	300 000 (2073)	400 000 (2760)	500 000 (3448)	600 000 (4137)	700 000 (4827)	800 000 (5516)	1 500 000 (10 343)	Specify Value
6	Izod impact, Test Method D256 , min ft.lbs./in. of notch (J/M of notch)	Unspecified	0.2 (11)	0.4 (21)	0.6 (32)	1.0 (53)	1.5 (80)	3.0 (160)	4.0 (213)	5.0 (267)	Specify Value
7	To be determined	Unspecified	...	...	...	...	...	...	...	...	...

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D6261 – 13) that may impact the use of this standard. (April 1, 2014)

(1) Corrected specimen description in **12.5** and **12.6** to remove ‘molded.’

Committee D20 has identified the location of selected changes to this standard since the last issue (D6261 – 10) that may impact the use of this standard. (October 1, 2013)

(1) Expanded relative humidity ranges to match those in Practice **D618**.

(2) Replaced withdrawn Guide D5033 with Guide **D7209**.

(3) Removed reproducibility statements, formerly **12.2.3**, **12.3.3**, and **12.4.3**, to align with shape standards.

(4) Revised sampling statement in **9.1**.

(5) Corrected conversion errors in **12.5**, **12.6**, and Table S-TPES.

(6) Negative resolutions:

- specimen type returned to **12.1.1**,
- Clarified wording added to **12.5**, and
- Clarified wording added to **12.6**.

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