



## Standard Specification for Thermoplastic Polyester (TPES) Materials<sup>1</sup>

This standard is issued under the fixed designation D 4507; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 1. Scope

1.1 This specification covers thermoplastic polyester materials suitable for molding or extrusion.

1.2 This specification is intended to be a means of calling out plastic materials used in the fabrication of end use items or parts. It is not intended for the selection of materials. Material selection should be made by those having expertise in the plastics field after careful consideration of the design and performance required of the part, the environment to which it will be exposed, the fabrication process to be employed, the inherent properties of the material other than those covered by this specification, and the economics.

1.3 The properties included in this specification are those required to identify the compositions covered. There may be other requirements necessary to identify particular characteristics important to specialized applications. These will be agreed upon between the user and the supplier, by using the suffixes as given in Section 5.

1.4 The values stated in SI units, as detailed in Practice E 380, are to be regarded as the standard.

1.5 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

NOTE 1—This specification is similar to ISO 7792/1-1985 (E), although the technical content is significantly different.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 256 Test Methods for Impact Resistance of Plastics and Electrical Insulating Materials<sup>2</sup>
- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing<sup>2</sup>
- D 635 Test Method for Rate of Burning and/or Extent and

Time of Burning of Self-Supporting Plastics in a Horizontal Position<sup>2</sup>

D 638 Test Method for Tensile Properties of Plastics<sup>2</sup>

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load<sup>2</sup>

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials<sup>2</sup>

D 792 Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement<sup>2</sup>

D 883 Terminology Relating to Plastics<sup>2</sup>

D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer<sup>2</sup>

D 1929 Test Method for Ignition Properties of Plastics<sup>2</sup>

D 2843 Test Method for Density of Smoke from the Burning or Decomposition of Plastics<sup>3</sup>

D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)<sup>3</sup>

D 3418 Test Method for Transition Temperatures of Polymers by Thermal Analysis<sup>3</sup>

D 3713 Test Method for Measuring Response of Solid Plastics to Ignition by a Small Flame<sup>3</sup>

D 3801 Test Method for Measuring the Comparative Extinguishing Characteristics of Solid Plastics in a Vertical Position<sup>3</sup>

D 3892 Practice for Packaging/Packing of Plastics<sup>3</sup>

D 4000 Classification System for Specifying Plastic Materials<sup>3</sup>

D 4019 Test Method for Moisture in Plastics by Coulometry<sup>3</sup>

D 4603 Test Method for Determining Inherent Viscosity of Poly(Ethylene Terephthalate (PET))<sup>4</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>5</sup>

E 84 Test Method for Surface Burning Characteristics of Building Materials<sup>6</sup>

E 162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source<sup>6</sup>

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)<sup>5</sup>

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<sup>2</sup> Annual Book of ASTM Standards, Vol 08.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 08.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 08.03.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>6</sup> Annual Book of ASTM Standards, Vol 04.07.

F 814 Test Method for Specific Optical Density of Smoke Generated by Solid Materials for Aerospace Applications<sup>7</sup>

2.2 *Military Standard:*<sup>8</sup>

MIL-P-46161A(MR) Plastic Molding Material—Polyterephthalate Thermoplastic, Glass Fiber Reinforced

2.3 *Underwriters Laboratories Standard:*

UL 94 Standards for Tests for Flammability for Parts in Devices and Appliances

2.4 *ISO Standard:*

ISO 7792/1–1985 (E) Plastics—Polyalkylene Terephthalates—Part 1<sup>9</sup>

### 3. Terminology

3.1 For definitions of the technical terms pertaining to plastics used in this specification, see Terminology D 883.

### 4. Classification

4.1 Unreinforced thermoplastic polyester materials are classified into groups according to their chemical composition. These groups are subdivided into classes and grades, as shown in Table TPES.

NOTE 2—An example of this classification system is as follows. The designation TPES 113 would indicate:

TPES = thermoplastic polyester,  
 1 = PBT (group),  
 1 = general purpose (class), and  
 3 = requirements given in Table TPES (grade).

4.1.1 To facilitate the incorporation of future or special materials, the “other/unspecified” category (0) for group, class, and grade is shown in Table TPES. The basic properties can be obtained from Tables A or B as they apply (see 4.3).

4.2 Reinforced versions of the materials are classified in accordance with Tables TPES and A or B. Table TPES specifies the unreinforced material and Tables A or B the properties after the addition of reinforcements at the nominal level indicated (see 4.2.1).

4.2.1 A single letter will be used for the *major* reinforcement or combination, or both, along with two digits that indicate the percent of addition by mass with the tolerances tabulated as follows:

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

NOTE 3—This part of the system uses percent of reinforcements or additives, or both, in the callout of the modified basic material. The types and percent of reinforcements and additives should be shown on the supplier’s technical data sheet unless they are proprietary in nature. If

necessary, additional callout of these reinforcements and additives can be accomplished by the use of the suffix part of the system (see Section 5).

4.2.2 Specific requirements for reinforced, filled, or lubricated thermoplastic polyester materials shall be shown by a six-character designation. The designation will consist of the letter A or B and the five digits comprising the cell numbers of the property requirements in the order as they appear in Tables A or B.

4.2.2.1 Although the values listed are necessary to include the range of properties available in existing materials, users should not infer that every possible combination of the properties exists or can be obtained.

4.2.3 When the grade of the basic material is not known, or is not important, the use of “0” grade classification shall be used for reinforced materials in this system.

NOTE 4—An example of a reinforced thermoplastic polyester of this classification system is as follows. The designation TPES 310G30A22450 would indicate the following material requirements from Table A:

TPES 310 = PET copolymer, from Table TPES,  
 G30 = Glass reinforced at 30 % nominal glass content (see 4.2.1),  
 A = Table A for property requirements,  
 2 = Tensile strength, 50 MPa, min,  
 2 = Flexural modulus, 2700 MPa, min,  
 4 = Izod impact, 60 J/m, min,  
 5 = Deflection temperature, 185°C, at 1.82 MPa, min, and  
 0 = Unspecified.

If no properties are specified, the designation would be TPES 310G30A00000.

4.3 Table B has been incorporated into this specification to facilitate the classification of special materials where Table TPES or Table A does not reflect the required properties. Table B shall be used in the same manner as Table A.

NOTE 5—Mechanical properties of pigmented or colored thermoplastic polyester materials can differ from the mechanical properties of natural thermoplastic polyester material, depending on the choice of colorants and the concentration. The main property affected is ductility, as illustrated by a reduction in Izod impact strength and tensile elongation values. If specific properties of pigmented thermoplastic polyester materials are necessary, prior testing between the materials supplier and end user should be initiated. Once these agreements are reached, a classification using Table B should be employed to ensure proper property compliance.

NOTE 6—An example of a special material using this classification system is as follows. The designation TPES 210B54220 would indicate the following material requirements from Table B:

TPES 210 = PET, unmodified, from Table TPES,  
 B = Table B for property requirements,  
 5 = Tensile strength, 45 MPa, min,  
 4 = Flexural modulus, 1500 MPa, min,  
 2 = Izod impact, 35 J/m, min,  
 2 = Deflection temperature, 45°C, at 1.82 MPa, min, and  
 0 = Unspecified.

### 5. Suffixes

5.1 When additional requirements are needed that are not covered by Tables TPES, A or B, then those requirements shall be designated through the use of suffixes. A list of suffixes can be found in Classification D 4000, Section 7, suffix requirements. In general, the first suffix letter indicates the special requirement needed, and the second letter indicates the condition or test method, or both, with a three-digit number indicating the specific requirement.

F = Flammability.

<sup>7</sup> Annual Book of ASTM Standards, Vol 15.03.

<sup>8</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

<sup>9</sup> Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

Second letter A = Test Method D 635 (burning rate):  
 000 = To be specified by user  
 B = Test Method D 2863 (oxygen index)  
 Three-digit number = value %, max  
 C = Test Method D 1929, Procedure A (flash-ignition)  
 Three-digit number = value, °C, min  
 D = Test Method D 1929, Procedure B (self-ignition)  
 Three-digit number = value, °C, min  
 E = Test Method D 3713  
 000 = To be specified by user  
 F = Test Method D 3801  
 000 = To be specified by user  
 G = Test Method E 162

First two digits indicate minimum specimen thickness:

00	To be specified	05	3.00 mm
01	0.25 mm	06	6.00 mm
02	0.40 mm	07	9.00 mm
03	0.80 mm	08	12.70 mm
04	1.60 mm	09	>12.70 mm

Third digit indicates the flame spread:

1	15 max	5	100 max
2	25 max	6	150 max
3	50 max	7	200 max
4	75 max	8	>200

H = Test Method E 84  
 000 = To be specified by user  
 J = Federal Motor Vehicle Safety Standard (FMVSS) 302  
 00 = To be specified by user  
 [Other test method under review, Test Method D 2843]  
 K = Density of smoke, Test Method D 2843  
 000 = To be specified by user, L = optic density of smoke, Test Method F 814 000 = to be specified by user  
 L = UL 94

First digit indicates minimum specimen thickness:

	Molding Materials, mm	Thin Films, µm
0	To be specified	to be specified
1	0.25	25.0
2	0.40	50.0
3	0.80	75.0
4	1.60	100.0
5	2.50	125.0
6	3.00	150.0
7	6.00	175.0
8	12.70	200.0
9	>12.70	>200.0

Second digit indicates type of flame test:

- 1 = Vertical (94 V)
- 1 = Horizontal (94 H)
- 3 = 125 mm flame (94 to 5V)
- 4 = Vertical thin materials (94 VTM)

Third digit indicates the flame rating:

- 0 = (94 V/94 VTM) 0—refer to UL 94
- 1 = (94 V/94 VTM) 1—refer to UL 94
- 2 = (94 V/94 VTM) 2—refer to UL 94
- 3 = (94 HB) 1—burn rate < 40 mm/min
- 4 = (94 HB) 2—burn rate < 75 mm/min
- 5 = (94 to 5V) A no holes on plaques
- 6 = (94 to 5V) B with holes on plaques
- 7 = (94 foam) 1 refer to UL 94
- 8 = (94 foam) 2 refer to UL 94
- 9 = (94 foam) H refer to UL 94

NOTE 7—If the requirements for the reinforced thermoplastic polyester material also include flammability requirements, the callout for TPES 110 G30 A44460 FL410 would indicate the following material requirements:

TPES 110 = PBT general-purpose, from Table TPES,  
 G30 = Glass-reinforced at 30 % nominal glass content,  
 A = Table A property requirements,  
 4 = Tensile strength, 95 MPa, min,  
 4 = Flexural modulus, 5500 MPa, min,  
 4 = Izod impact, 60 J/m, min,  
 6 = Deflection temperature, 205°C, at 1.82 MPa, min,  
 0 = Unspecified,  
 F = Flammability requirements,

L = UL 94,  
 4 = Minimum wall thickness 1.60 mm,  
 1 = Vertical flame test, and  
 0 = (94 V/94 VTM) 0—refer to UL 94.

## 6. Basic Requirements

6.1 Basic requirements from property or cell tables, as they apply, are always in effect unless these requirements are superseded by specific suffix requirements, which always take precedence.

## 7. General Requirements

7.1 The material composition shall be uniform and shall conform to the requirements specified herein.

## 8. Detail Requirements

8.1 The material shall conform to the requirements prescribed in Tables TPES, A, and B and suffix requirements, as they apply.

8.2 Observed or calculated values obtained from analysis, measurement, or testing shall be rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limiting value, in accordance with the rounding-off method of Practice E 29. The value obtained is compared directly with the specified limiting value. Conformance or nonconformance with the specification is based on this comparison.

## 9. Sampling

9.1 Sampling shall be statistically adequate to satisfy the requirements of Section 13.4. A lot of resin shall be considered as a unit of manufacture as prepared for shipment and may consist of a blend of two or more “production runs” or batches of material.

## 10. Specimen Preparation

10.1 The test specimens shall be molded by either an injection or compression molding process as specified in the *Annual Book of ASTM Standards*, for the specific products tested, or they shall be molded as specified by the resin supplier.

## 11. Conditioning

11.1 Test specimens shall be conditioned in the standard laboratory atmosphere, in accordance with Procedure A of Practice D 618, before performing the required tests.

11.2 Conduct tests in the standard laboratory atmosphere of  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5\%$  relative humidity in accordance with Practice D 618. Flow rate specimen conditioning is specified in the table notes.

## 12. Test Methods

12.1 Determine the properties enumerated in this specification by means of the test methods referenced.

## 13. Inspection and Certification

13.1 Inspection and certification of the material supplied in accordance with this specification shall be in conformance with the requirements specified herein.