Designation: D 5927 – 03

Standard Specification for Thermoplastic Polyester (TPES) Injection and Extrusion Materials Based on ISO Test Methods[1]

This standard is issued under the fixed designation D 5927; 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.

INTRODUCTION

This material specification is intended to provide a callout system for thermoplastic polyester materials based on ISO test methods.

1. Scope*

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

1.2 This specification allows for the use of recycled thermoplastic polyester materials provided that the requirements as stated in this specification are met. The proportions of recycled material used, as well as the nature and amount of any contaminant, however, cannot be covered practically in this specification.

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 may be specified by using the suffixes as given in Section 5.

1.4 This classification system and subsequent line callout (specification) are intended to provide a means of calling out plastic materials used in the fabrication of end items or parts. It is not intended for the selection of materials. Material selection should be made by those having expertise in the plastic 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 used, the costs involved, and the inherent properties of the material other than those covered by this specification.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 The following hazards caveat pertains only to the test methods 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—This specification is similar to ISO 7792-1:1995 and ISO 7792-2:1988, although the technical content is significantly different.

2. Referenced Documents

2.1 *ASTM Standards:*

D 883 Terminology Relating to Plastics[2]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 3892 Practice for Packaging/Packing of Plastics[3]

D 4000 Classification System for Specifying Plastic Materials[3]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[4]

2.2 *IEC and ISO Standards:*[5]

IEC 112 Recommended Method for Determining the Comparative Tracking Index of Solid Insulation Materials

IEC 243 Recommended Methods of Test for Electrical Strength of Solid Insulating Materials at Power Frequencies

ISO 62 Plastics—Determination of Water Absorption

ISO 75-1:1993 Plastics—Determination of Temperature of Deflection Under Load—Part 1: General Test Methods

ISO 75-2:1993 Plastics—Determination of Temperature of Deflection Under Load—Part 2: Plastics and Ebonite

ISO 179-1:1993 Plastics—Determination of Charpy Impact Strength

ISO 291:1997 Plastics—Standard Atmospheres for Conditioning and Testing

[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.

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

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

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

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

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

ISO 294-1:1996 Plastics—Injection Moulding of Test Specimens of Thermoplastic Materials—Part 1: General Principles, Multipurpose-Test Specimens (ISO Mould Type A) and Bars (ISO Mould Type B)
ISO 527-1:1993 Plastics—Determination of Tensile Properties—Part 1: General Principles
ISO 527-2:1993 Plastics—Determination of Tensile Properties—Part 2: Testing Conditions
ISO 604 Plastics—Determination of Compressive Properties
ISO 1133:1997 Plastics—Determination of the Melt Mass-Flow Rate (MFR) and the Melt Volume-Flow Rate (MVR) of Thermoplastics
ISO 1183:1987 Plastics—Methods for Determining the Density and Relative Density of Non-Cellular Plastics
ISO 3451-2:1984 Plastics—Determination of Ash—Part 2: Polyalkylene Terephthalates
ISO 7792-1:1995 Plastics—Saturated Polyester (SP) Moulding and Extrusion Materials—Part 1: Designation System and Basis for Specification
ISO 7792-2:1988 Plastics—Polyalkylene Terephthalates—Part 2: Preparation of Test Specimens and Determination of Properties

2.3 *Underwriters Laboratories (UL):*[6]
UL 94 Test for Flammability of Plastic Materials for Parts in Devices and Appliances

2.4 *National Technical Information Service (NTIS):*[7]
AD297457 Procedure and Analytical Method for Determining Toxic Gases Produced by Synthetic Compounds

3. Terminology

3.1 *Definitions*—The terminology used in this specification is in accordance with Terminologies D 883 and D 1600.

4. Classification

4.1 Thermoplastic polyester materials are classified into groups according to their composition. These groups are subdivided into classes and grades, as indicated in the basic property table (Table TPES).

NOTE 2—An example of this classification system is as follows. The designation TPES 0113 would indicate:

TPES	=	thermoplastic polyester as found in Terminology D 1600,
01 (group)	=	PBT,
1 (class)	=	general purpose, and
3 (grade)	=	requirements given in Table TPES.

4.1.1 Grades of reinforced or filled versions, or both, of the basic materials are identified by a single letter that indicates the reinforcement or filler used and two digits, in multiples of five, that indicate the nominal quantity in percent by weight. Thus, a letter designation G for glass reinforced and 35 for percent or reinforcement, G35, specifies a material with a nominal glass level of 35 %. The reinforcement letter designations and associated tolerance levels are shown as tabulated as follows:

Symbol	Material	Tolerance
C	carbon- and graphite-fiber-reinforced	±2 %
G	glass-reinforced	±2 %
L	lubricants (such as PTFE, graphite, silicone, and molybdenum disulfide)	depends on material and process—to be specified
M	mineral-reinforced	±2 %
R	combinations of reinforcements or fillers, or both	±3 %

NOTE 3—An example of this classification system for reinforced thermoplastic polyester is given as follows. The designation TPES 021G30 indicates the following:

TPES	=	thermoplastic polyester as found in Terminology D 1600,
02 (group)	=	PET,
1 (class)	=	unmodified, and
G30 (grade)	=	nominal 30 % glass with the requirements given in Table TPES.

NOTE 4—This part of the classification system uses the percent of reinforcements or fillers, or both, in the callout of the modified base material. The types and percentages of reinforcements and fillers 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 use of the suffix part of the system (see Section 5).

NOTE 5—Materials containing reinforcements or fillers, or both, at nominal levels not in multiples of five are included in the nearest TPES designation. For example, a material with a nominal glass content of 28 % is included with Grade G30.

NOTE 6—The ash content of filled or reinforced materials may be determined using ISO 3451-2:1984.

4.2 Variations of thermoplastic polyester materials that are not included in Table TPES are classified in accordance with Table TPES and Table A or B. Table TPES is used to specify the group of thermoplastic polyester, and Table A or B is used to specify property requirements.

4.2.1 Specific requirements for variations of thermoplastic polyester materials shall be indicated by a six-character designator. The designation will consist of the letter "A" or "B" and the five digits comprising the cell numbers for the property requirements in the order as they appear in Table A or B.

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

4.2.2 When the grade of the basic material is not known or is not important, the use of "0" grade classification shall be used for materials in this system (see Note 7).

NOTE 7—An example of a reinforced thermoplastic polyester of this classification system is as follows. The designation TPES 0310G30A22450 would indicate the following material requirements from Table A:

TPES0310	=	PET copolymer, from Table TPES,
G30	=	glass-reinforced at 30 % nominal glass content,
A	=	Table A for property requirements,
2	=	tensile strength, 50 MPa, min,
2	=	tensile modulus, 2700 MPa, min,
4	=	Charpy impact, 6.0 kJ/m^2, min,
5	=	deflection temperature, 185°C, at 1.8 MPa, min, and
0	=	unspecified.

If no properties are specified, the designation would be TPES 0310G30A00000.

[6] Available from Underwriters Laboratories, 333 Pfingsten Rd., Northbrook, IL 60062–2096.
[7] Available from NTIS, 5285 Port Royal Rd., Springfield, VA 22161.

TABLE A Detailed Requirements:[A] Reinforced or Filled Thermoplastic Polyesters

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ISO 527-1:1993 and ISO 527-2:1993, min, MPa[B]	unspecified	35	50	70	95	115	140	175	210	specify value[C]
2	Tensile modulus, ISO 527-1:1993 and ISO 527-2:1993, min, MPa[D]	unspecified	1 400	2 700	4 100	5 500	6 900	8 000	10 000	12 500	specify value[C]
3	Charpy impact, ISO 179:1993, min, kJ/m^2[E]	unspecified	1.5	3.0	4.5	6.0	8.5	11.0	13.5	17.5	specify value[C]
4	Deflection temperature under load at 1.8 MPa, ISO 75-1:1993 and ISO 75-2:1993, min, °C[F]	unspecified	50	100	120	150	185	205	220	235	specify value[C]
5	To be determined	...	...	...	...	...	...	...	...	...	...

[A] It is recognized that detailed test values, particularly Charpy impact, may not predict nor even correlate with the performance of parts molded of these materials.
[B] Tensile strength shall be determined using a Type 1A tensile specimen as described in ISO 527-2:1993. Crosshead speed shall be 5 mm/min ± 20 %.
[C] If a specific value is required, it must appear on the drawing or contract, or both.
[D] Tensile modulus shall be determined using a Type 1A tensile specimen as described in ISO 527-2:1993 at a test speed of 1 mm/min ± 20 %.
[E] The test specimen shall be 80 ± 2 by 10 ± 0.2 by 4 ± 0.2 mm, cut from the center of the Type 1A tensile specimen and tested as described in ISO 179:1993, Method 1eA.
[F] The test specimen size shall be 80 ± 2 by 10 ± 0.2 by 4 ± 0.2 mm, cut from the center of the Type 1A tensile specimen. The requirements are based on unannealed test specimens.

TABLE B Detailed Requirements:[A] Special Thermoplastic Polyesters

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ISO 527-1:1993 and ISO 527-2:1993, min, MPa[B]	unspecified	10	30	35	40	45	50	60	80	specify value[C]
2	Tensile modulus, ISO 527-1:1993 and ISO 527-2:1993, min, MPa[D]	unspecified	100	350	1000	1500	2000	2500	3000	4000	specify value[C]
3	Charpy impact, ISO 179:1993, min, kJ/m^2[E]	unspecified	2.0	3.5	5.0	8.0	13.0	18.0	25.0	50.0	specify value[C]
4	Deflection temperature under load at 1.8 MPa, ISO 75-1:1993 and ISO 75-2:1993, min,° C[F]	unspecified	30	45	60	70	80	90	100	115	specify value[C]
5	To be determined	...	...	...	...	...	...	...	...	...	...

[A] It is recognized that detailed test values, particularly Charpy impact, may not predict nor even correlate with the performance of parts molded of these materials.
[B] Tensile strength shall be determined using a Type 1A tensile specimen as described in ISO 527-2:1993. Crosshead speed shall be 50 mm/min ± 10 %.
[C] If a specific value is required, it must appear on the drawing or contract, or both.
[D] Tensile modulus shall be determined using a Type 1A tensile specimen as described in ISO 527-2:1993 at a test speed of 1 mm/min ± 20 %.
[E] The test specimen shall be 80 ± 2 by 10 ± 0.2 by 4 ± 0.2 mm, cut from the center of the Type 1A tensile specimen and tested as described in ISO 179:1993, Method 1eA.
[F] The test specimen size shall be 80 ± 2 by 10 ± 0.2 by 4 ± 0.2 mm, cut from the center of the Type 1A tensile specimen. The requirements are based on unannealed test specimens.

TABLE 1 Recommended Processing Conditions

Material	Melt Temperature, °C	Mold Temperature, °C	Average Injection Velocity, mm/s	Hold Pressure Time, s	Total Cycle Time, s
PBT, unfilled semicrystalline	260 ± 3	80 ± 5	200 ± 100	20 ± 5	40 ± 5
PBT, filled semicrystalline	260 ± 3	80 ± 5	200 ± 100	20 ± 5	40 ± 5
PET, unfilled amorphous	285 ± 3	20 ± 5	200 ± 100	20 ± 5	40 ± 5
PET, unfilled semicrystalline	275 ± 3	135 ± 5	200± 100	20 ± 5	40 ± 5
PET, filled semicrystalline	285 ± 3	135 ± 5	200± 100	20 ± 5	40 ± 5
PET, filled semicrystalline, nucleated	285 ± 3	110 ± 5	200± 100	20 ± 5	40 ± 5
PET, filled semicrystalline, flame-retarded	275± 3	135 ± 5	200± 100	20 ± 5	40 ± 5
PET, filled semicrystalline, flame-retarded, nucleated	275 ± 3	110 ± 5	200± 100	20 ± 5	40 ± 5
PCT, unfilled amorphous	300 ± 3	20 ± 3	200 ± 100	20 ± 5	40 ± 5
PCT, unfilled semicrystalline	300 ± 3	120 ± 5	200± 100	20 ± 5	40 ± 5
PCT, filled semicrystalline	300 ± 3	120 ± 5	200± 100	20 ± 5	40 ± 5
PEN, unfilled amorphous	300 ± 3	20 ± 3	200 ± 100	20 ± 5	40 ± 5

TABLE TPES Detail Requirements for Thermoplastic Polyesters[A]

Group	Description	Class	Description	Grade	Description[B]	Flow Rate, ISO 1133:1997, g/10 min	Density, ISO 1183:1987, g/cm^3	Tensile Strength, ISO 527-1:1993 and ISO 527-2: 1993,[C] min, MPa	Tensile Modulus, ISO 527-1:1993 and ISO 527-2:1993,[D] min, MPa	Charpy Impact ISO 179:1993,[E] min, kJ/m^2	Deflection Temperature at 1.8 MPa, ISO 75-1: 1993 and ISO 75-2:1993,[F] min, °C
01	Polybutylene terephthalate (PBT)	1	general purpose	1		<6 250/2.16[G]	1.28 to 1.34	45	1 800	3.0	...
				2		<12 250/2.16[G]	1.28 to 1.34	45	1 800	3.0	...
				3		<20 250/2.16[G]	1.28 to 1.34	45	1 800	3.0	...
				4		<35 250/2.16[G]	1.28 to 1.34	45	1 800	3.0	...
				5		<60 250/2.16[G]	1.28 to 1.34	45	1 800	3.0	...
				6		<100 250/2.16[G]	1.28 to 1.34	45	1 800	3.0	...
				G10	10 % glass	...	1.34 to 1.38	70	4 000	3.0	145
				G15	15 % glass	...	1.36 to 1.47	75	4 500	3.0	160
				G20	20 % glass	...	...	80	6 000	4.5	...
				G30	30 % glass	...	1.50 to 1.59	85	7 000	6.0	190
				G40	40 % glass	...	1.58 to 1.65	115	10 000	6.0	190
				R40	40 % filler	...	1.54 to 1.64	85	9 000	3.0	180
				0	other						
		2	impact modified	1		<20 250/5.0[G]	1.16 to 1.32	20	1 000	45	...
				G05	5 % glass	...	1.26 to 1.36	35	2 300	7.0	55
				G10	10 % glass	...	1.25 to 1.35	35	3 500	3.3	85
				G15	15 % glass	...	1.31 to 1.37	45	3 000	7.0	130
				G30	30 % glass	...	1.42 to 1.53	70	7 000	7.0	145
				R40	40 % filler	...	1.49 to 1.59	60	5 000	7.0	150
				0	other						
		3	flame-retarded	1	unfilled		1.38 to 1.52	40	2 000	0.7	40
				G10	10 % glass	...	1.45 to 1.55	60			130
				G15	15 % glass	...	1.48 to 1.60	62	5 000	3.0	180
				G30	30 % glass	...	1.58 to 1.75	85	7 000	4.0	165
				R30	30 % filler	...	1.71 to 1.77	80	8 000	4.0	185
				R35	35 % filler	...	1.60 to 1.77	60	8 000	2.0	175
				0	other						...
		4	flame-retarded, impact-modified	1		...	1.26 to 1.36	25	1 200	20	45
				0	other						
		0	other	0	other						
02	Polyethylene terephthalate (PET)	1	unmodified	1		<20.0 285/2.16[H]	1.26 to 1.43	50			60
				G15	15 % glass	...	1.26 to 1.52	75	4 000	3.0	160
				G20	20 % glass	...	1.43 to 1.60	80			190
				G30	30 % glass	...	1.46 to 1.65	115	7 500	7.0	200
				G40	40 % glass	...	1.59 to 1.75	120	11 000	5.0	200
				G45	45 % glass	...	1.64 to 1.85	120	12 000	7.0	210
				G55	55 % glass	...	1.76 to 1.86	160	15 000	5.0	220
				R15	15 % filler	...	1.35 to 1.45	70	4 000	1.0	90
				R35	35 % filler	...	1.53 to 1.65	70	8 500	3.0	165
				R40	40 % filler	...	1.54 to 1.70	85	10 000	4.0	185
				R45	45 % filler	...	1.65 to 1.76	90	12 000	3.0	200
				0	other						
		2	impact-modified	G15	15 % glass	...	1.35 to 1.45	60	3 000	5.0	170
				G30	30 % glass	...	1.46 to 1.56	100	7 000	9.0	205
				G35	35 % glass	...	1.49 to 1.59	85	6 000	15.0	200
				0	other						
		3	flame-retarded	G15	15 % glass	...	1.50 to 1.67	70	5 000	3.5	175
				G20	20 % glass	...	1.56 to 1.70	80			190
				G30	30 % glass	...	1.62 to 1.78	95	8 000	4.0	200

TABLE TPES[A] *Continued*

Group	Description	Class	Description	Grade	Description[B]	Flow Rate, ISO 1133:1997, g/10 min	Density, ISO 1183:1987, g/cm^3	Tensile Strength, ISO 527-1:1993 and ISO 527-2: 1993,[C] min, MPa	Tensile Modulus, ISO 527-1:1993 and ISO 527-2:1993,[D] min, MPa	Charpy Impact ISO 179:1993,[E] min, kJ/m^2	Deflection Temperature at 1.8 MPa, ISO 75-1: 1993 and ISO 75-2:1993,[F] min, °C
				G40	40 % glass	...	1.71 to 1.83	100			200
				G45	45 % glass	...	1.75 to 1.85	140	12 000	8.0	215
				R45	45 % filler	...	1.70 to 1.91	80	11 000	3.0	180
				0	other	...					
		0	other	0	other						
03	PET copolymer	1	PETG[I]	1		...	1.20 to 1.35	40			50
				0	other						
		0	other	0	other						
04	PBT copolymer	1	general purpose	0	other			...			...
		2		G30	30 % glass		1.55 to 1.75	90	9 000	2.0	150
				0	other						
		0	other	0	other	...					
05	Blend PBT and polycarbonate (PBT + PC)	1	general purpose	1		<28 265/5[G]	1.20-1.24	58	2 500	13	90
				G10	10 % glass	...	1.25-1.36	50	2 700	2.0	90
				G30	30 % glass	...	1.46-1.54	80	7 000	6.0	125
				0	other						
		2	impact-modified	1		<17 250/5[G]	1.17-1.21	47	1 500	44	73
				2		<13 265/5[G]	1.17-1.21	45	1 200	35	77
				G10	10 % glass	...	1.27-1.31	50	2 700	6.0	89
				0	other						
		0	other	0	other						
06	Blend (PBT + PET)	1	general purpose	1		...	...	...			...
				G15	15 % glass	...	1.36 to 1.48	60			170
				G30	30 % glass	...	1.47 to 1.60	70	8 000	7.0	180
				G40	40 % glass	...	1.58 to 1.70	80			200
				R30	30 % filler	...	1.50 to 1.60	90	7 000	4.0	190
				R40	40 % filler	...	1.52 to 1.67	65	8 000	2.0	180
				0	other						
		2	impact-modified	R30	30 % filler	...	...	70	6 500	3.0	145
				R40	40 % filler	...	1.49 to 1.67	60			150
				0	other						
		0	other	0	other						
08	Blend PBT and thermoplastic elastomer ether ester (PBT + TEEE)	1	general purpose	1		<25 240/2.16[J]	1.18 to 1.24	10			...
				2		<25 250/2.16[J]	1.0 to 1.3	7	200	30	...
				3		<25 250/2.16[J]	1.16 to 1.32	20	1 000	40	40
				0	other						...

TABLE TPES[A] *Continued*

Group	Description	Class	Description	Grade	Description[B]	Flow Rate, ISO 1133:1997, g/10 min	Density, ISO 1183:1987, g/cm^3	Tensile Strength, ISO 527-1:1993 and ISO 527-2: 1993,[C] min, MPa	Tensile Modulus, ISO 527-1:1993 and ISO 527-2:1993,[D] min, MPa	Charpy Impact ISO 179:1993,[E] min, kJ/m^2	Deflection Temperature at 1.8 MPa, ISO 75-1: 1993 and ISO 75-2:1993,[F] min, °C
		0	other	0	other						[GHIJ]
09	Blend PCTG[K] and PC (PCTG + PC)	1	unmodified	1	chemical and medium heat resistance	...	1.17 to 1.23	48			75
				2	chemical and low heat resistance	...	1.18 to 1.24	45			65
				0	other						
		0	other	0	other						
10	Poly(1,4-cyclo-hexylene-dimethylene terephthalate) (PCT)	1	unmodified	1	unfilled	...	1.18 to 1.33	55			60
				G15	15 % glass	...	1.25 to 1.40	70			210
				G20	20 % glass	...	1.30 to 1.45	85	5 000	5.5	235
				G30	30 % glass	...	1.37 to 1.52	100	7 000	6.0	240
				G40	40 % glass	...	1.46 to 1.60	115			240
				R30	30 % filler	...	1.37 to 1.52	80			235
				R40	40 % filler	...	1.49 to 1.63	90			240
				0	other						
		2	flame-retarded	G15	15 % glass	...	1.44 to 1.58	70			185
				G20	20 % glass	...	1.47 to 1.61	80			200
				G30	30 % glass	...	1.54 to 1.68	95			220
				G40	40 % glass	...	1.63 to 1.77	100			225
				R40	40 % filler	...	1.65 to 1.80	80			210
				0	other						
		0	other	0	other						
11	PCT copolymer	1	PCTA[L]	1	unfilled	...	1.20 to 1.30	50			60
				G15	15 % glass	...	1.27 to 1.37	55			190
				G20	20 % glass	...	1.37 to 1.41	60			220
				G30	30 % glass	...	1.38 to 1.48	60			250
				0	other						
		2	PCTG[K]	1	unfilled	...	1.16 to 1.30	40			60
				G10	10 % glass	...	1.22 to 1.36	65			70
				G20	20 % glass	...	1.28 to 1.42	85			70
				G30	30 % glass	...	1.38 to 1.52	95			70
				0	other						
		0	other	0	other						
12	Blend (PCT + PC)	1	unmodified	1	chemical and high heat resistance	...	1.15 to 1.21	47			85
				0	other						
		0	other	0	other						
13	Blend (PBT + PETG)	1		G30	30 % glass		1.43 to 1.53	90			150
				0	other						
		0	other	0	other						

[A] Data on 4-mm test specimens may be limited, and the minimum values may be changed in a later revision after a statistical database of sufficient size is generated.
[B] No descriptions are listed unless needed to describe a special grade under the class. All other grades are listed by requirements.
[C] Tensile strength shall be determined using a Type 1A tensile specimen as described in ISO 527-2:1993. The crosshead speed shall be 50 mm/min ± 10 % unless the specimen exhibits brittle failure (no yield point) and strain at break of <10 % in which case crosshead speed shall be 5 mm/min ±25 %.
[D] Tensile modulus shall be determined using a Type 1A tensile specimen as described in ISO 527-2:1993 at a test speed of 1 mm/min ± 20 %.
[E] Charpy shall be determined on a specimen 80 ± 2 by 10 ± 0.2 by 4 ± 0.2 mm, cut from the center of the Type 1A tensile specimen, as described in ISO 179:1993, Method 1eA.
[F] Deflection temperature shall be determined on an unannealed specimen 80 ± 2 by 10 ± 0.2 by 4 ± 0.2 mm, cut from the center of the Type 1A tensile specimen, as described in ISO 75-2:1993, Method Af.
[G] The moisture content of the specimen shall be below 0.02 %.
[H] The moisture content of the specimen shall be below 0.005 %.
[I] Polyethylene terephthalate, glycol modified (PETG).
[J] The moisture content of the specimen shall be below 0.01 %.
[K] Poly(1,4-cyclohexylenedimethylene terephthalate), glycol modified (PCTG).
[L] Poly(1,4-cyclohexylenedimethylene terephthalate), acid modified (PCTA).

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

NOTE 8—The 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 used to ensure proper property compliance.

NOTE 9—An example of a special material using this classification system is as follows. The designation TPES0210B54220 would indicate the following material requirements from Table B:

TPES0210	=	PET, unmodified, from Table TPES,
B	=	Table B for property requirements,
5	=	tensile strength, 45 MPa, min,
4	=	tensile modulus, 1500 MPa, min,
2	=	Charpy impact, 3.5 kJ/m^2, min,
2	=	deflection temperature, 45°C, at 1.8 MPa, min, and
0	=	unspecified.

5. Suffixes

5.1 When additional requirements are needed that are not covered by the basic requirements or cell table requirements, they shall be indicated through the use of suffixes.

5.2 A list of suffixes can be found in Classification D 4000 (Table 3) and may be used for additional requirements, as appropriate. Additional suffixes will be added to that classification system as test methods and requirements are developed and requested.

6. General Requirements

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

6.2 The plastics composition shall be uniform and shall conform to the requirements specified herein.

7. Detail Requirements

7.1 The materials shall conform to the requirements listed in Tables TPES, A, and B and the suffix requirements as they apply.

7.2 For purposes of determining conformance, all specified limits for a specification (line callout) based on this classification system are absolute limits, as defined in Practice E 29.

7.2.1 With the absolute method, an observed value or a calculated value is not rounded, but is to be compared directly with the limiting value. Conformance or nonconformance is based on this comparison.

8. Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of 12.4.

8.2 A batch or lot shall be constituted as a unit of manufacture as prepared for shipment and may consist of a blend of two or more production runs.

9. Specimen Preparation

9.1 The moisture content of the molding material for the preparation of test specimens shall not exceed 0.005 % for unreinforced polyethylene terephthalate homopolymers and copolymers and 0.02 % for all other polyester compositions. Material having a moisture content above these limits shall be dried according to the instructions of the manufacturer.

9.2 The test specimens shall be prepared by an injection molding process as specified in ISO 294-1:1996. Recommended processing conditions for polyester homopolymers are given in Table 1.

10. Conditioning

10.1 Test specimens shall be conditioned in accordance with ISO 291:1997 for at least 16 h at 23 ± 2°C and 50 ± 5 % relative humidity.

11. Test Methods

11.1 Determine the properties enumerated in this specification by means of the test methods referenced in Section 2.

11.1.1 The number of tests shall be consistent with the requirements of Section 8 and 12.4.

12. Inspection and Certification

12.1 Inspection and certification of the material supplied with reference to a specification based on this specification shall be for conformance to the requirements specified herein.

12.2 Lot acceptance inspection shall be the basis on which acceptance or rejection of the lot is made. The lot acceptance inspection shall consist of (*1*) flow rate and (*2*) reinforcement content.

12.3 Periodic check inspection with reference to a specification based on this specification shall consist of the tests for all requirements of the material under the specification. The inspection frequency shall be adequate to ensure that the material is certifiable in accordance with 12.4.

12.4 Certification shall be that the material was manufactured by a process in statistical control and sampled, tested, and inspected in accordance with this specification and that the average values for the lot meet the requirements of the specification (line callout).

12.5 A report of the test results shall be furnished when requested. The report shall consist of the results of the lot acceptance inspection for the shipment and the results of the most recent periodic check inspection.

13. Packaging, Packing, and Marking

13.1 The provisions of Practice D 3892 apply to the packaging, packing, and marking of containers for plastic materials.

14. Keywords

14.1 classification; classification system; international commerce; line callout; plastic materials; thermoplastic polyesters (TPES)

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the inquiry, contract, or order for agencies of the U.S. Government.

S1. SPECIAL END USES

S1.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all testing and inspections. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the government. The government may reserve the right to perform any of the testing or inspections set forth in the specification requirements. This testing ensures qualification on a one time basis unless the manufacturer makes a significant change in formulation, raw material, or process.

S2. PHYSICAL REQUIREMENTS

S2.1 The physical and electrical property requirements for initial material qualification are given in Table S2.1 and the test methods in Table S2.2. Unless otherwise stated, the values are minimum requirements.

S3. QUALITY ASSURANCE

S3.1 *Acceptance Criteria*—Failure to conform to requirements in Table S2.1 shall result in rejection of the material.

S3.2 *Sample Size*—The minimum number of test specimens to be tested shall be as specified in Table S2.2.

S3.3 *Test Method*—Testing shall be in accordance with the methods specified in Table S2.2.

S3.4 *Conditioning*—Standard test specimens shall be conditioned before testing as specified in Table S2.2 and described in Section S4.

TABLE S2.1 Property Values for Initial Physical and Electrical Qualification Testing

Property	Units	Value Required for Each Type of Compound				
		Type PT-F	Type GPT-7.5	Type GPT-15F	Type GCT-30F	Type GET-30F
Flammability	—	V-0	V-0	V-0	V-0	V-0
Water absorption	%, max	0.40	0.35	0.35	0.30	0.30
Compressive strength	MPa	83	86	93	121	121
Dielectric strength						
Short time test 1	kV/mm	13.8	14.2	14.6	15.7	15.7
Short time test 2	kV/mm	12.8	13.0	13.4	14.8	14.8
Tracking index	V	180	180	180	200	180

S4. CONDITIONING

S4.1 *Nomenclature:*

S4.1.1 *Condition A*—As received.

S4.1.2 *Condition C*—Humidity conditioning.

S4.1.3 *Condition D*—Immersion conditioning in distilled water.

S4.1.4 *Condition E*—Temperature conditioning.

S4.1.5 *Condition des*—Desiccation condition; cooling over silica gel or calcium chloride in a desiccator at 23°C for 16 to 20 h after temperature conditioning.

S4.2 *Designation*—Conditioning procedures shall be designated as follows:

S4.2.1 A capital letter indicating the general conditioning.

S4.2.2 A number indicating, in hours, the duration of conditioning.

S4.2.3 A number indicating in °C, the conditioning temperature.

S4.2.4 A number indicating the relative humidity when it is controlled.

S4.3 *Tolerances:*

S4.3.1 *Relative Humidity*—Standard tolerance shall be ±5 %.

S4.3.2 *Temperature*—Standard tolerance shall be ± 2°C. For water immersion the standard tolerance shall be ± 1°C.

NOTE S00001—The numbers shall be separated from each other by slant (/) marks, and from the capital letter by a dash (-). A sequence of conditions shall be denoted by use of a plus (+) sign between successive conditions.

Examples: C-96/23/50—Humidity condition; 96 h at 23°C and 50 % R.H.
D-48/50 —Immersion condition; 48 h at 50°C.
E-48/50 —Temperature condition; 48 h at 50°C.

S5. TEST METHOD MODIFICATION

S5.1 *Dielectric Strength:*

S5.1.1 The test shall be performed under oil at a frequency not exceeding 100 Hz at the temperature of the final conditioning.

S5.1.2 *Short-Time Test*—The voltage shall be increased uniformly at the rate of 500 V/s.

S6. TOXICITY REQUIREMENTS

S6.1 Thermoplastic molding compounds shall be tested for toxicity in accordance with NTIS AD297457. Specimens shall meet the requirements in Table S6.1, expressed as the maximum level permissible.

TABLE S2.2 Sampling and Conditioning for Initial Qualification Testing

Property to be Tested	Test Method	Test Method Modified per	Specimens	Number Tested	Conditioning	Units
Flammability	UL 94		125 × 13 mm × thickness	10	per UL 94	per UL 94
Compressive strength	ISO 604		25 × 10 × 4 mm	5	E-48/50+C-96/23/50	MPa, average, min
Water absorption	ISO 62		50 mm disk, 3 mm thick	3	E-24/100+des+D-48/50	%, average, max
Dielectric strength:	IEC 243	S5.1	60 × 60 × 2 mm			kV/mm,
Short-time test			plaque	3	E-48/50+C-96/23/50	average, min
Short-time test				3	E-48/50+D-48/50	
Tracking index	IEC 112		80 × 10 × 4 mm	4	A	V

TABLE S6.1 Toxicity When Heated

Compounds	Units	Type PT-F	Type GPT-7.5F	Type GPT-15F	Type GCT-30F	Type GET-30F
Carbon dioxide	ppm	2 500	2 500	2 500	15 000	15 000
Carbon monoxide	ppm	1 000	1 000	1 000	1 000	1 000
Ammonia	ppm	2 500	2 500	2 500	2 500	2 500
Aldehydes as HCHO	ppm	50	50	50	50	50
Cyanide as HCN	ppm	60	60	60	60	60
Oxides of nitrogen as NO_2	ppm	100	100	100	100	100
Hydrogen chloride	ppm	100	100	100	100	100

APPENDIX

(Nonmandatory Information)

X1. CROSS REFERENCES TO MIL-M-24519

X1.1 The cross references in Table X1.1 between the government specification, MIL-M-24519, and Specification D 5927 are provided for information purposes only.

TABLE X1.1 Cross References

MIL-M-24519	Specification D 5927[A]
PT-F	TPES0131
GPT-7.5F	TPES013G10
GPT-15F	TPES013G15
GPT-30F	TPES013G30
GCT-30F	TPES102G30
GET-30F	TPES023G30

[A] Electical requirements in MIL-M-24519 do not differentiate these polyester grades and, therefore, are not included in Specification D 5927 cross references. A typical electrical call-out for these grades based on Classification System D 4000 is EA130ED040EE300EF050.

SUMMARY OF CHANGES

This section identifies the location of selected changes to this specification. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of this specification. This section may also include descriptions of the changes or reasons for the changes, or both.

D 5927 – 03:
(*1*) Revised Table TPES.
D 5927 – 00:
(*1*) In Tables TPES, A and B, flexural modulus was replaced by tensile modulus and Izod impact was replaced by Charpy impact.
(*2*) ISO references were updated to reflect the changes to Tables TPES, A and B.

D 5927 – 99a:
(1) Added S4.3 through S4.3.2.
D 5927 – 99:
(1) Added Supplementary Requirements section.
(*3*) Notes 7 and 9 were revised to reflect the use of tensile modulus and Charpy impact as callouts.
D 5927 – 97:
(1) Revised appendix.