



Standard Specification for Polycarbonate (PC) Unfilled and Reinforced Material¹

This standard is issued under the fixed designation D 3935; 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 unfilled and reinforced polycarbonate and polycarbonate copolymer materials suitable for injection molding, blow molding, and extrusion. Some of these compositions may also find use for compression molding or application from solution.

1.2 The properties in this specification are those required for identifying the compositions covered. There may be other requirements necessary for identifying particular characteristics important to specific applications. Those may be specified by using the suffixes in accordance with Section 5.

1.3 The values stated in SI units are to be regarded as the standard.

NOTE 1—This specification is similar to ISO 7391 – 1987 in title only. The technical content is significantly different.

1.4 The following hazards caveat pertains only to the test methods portion, Section 12, of this specification. *This standard does not purport to address all 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 or regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics²
- D 638 Test Method for Tensile Properties of Plastics²
- D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position²
- D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials²

- D 792 Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement²
- D 883 Terminology Relating to Plastics²
- D 1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer²
- D 1600 Terminology for Abbreviated Terms Relating to Plastics²
- D 2584 Test Method for Ignition Loss of Cured Reinforced Resins³
- D 3892 Practice for Packaging/Packing of Plastics⁴
- D 4000 Classification System for Specifying Plastic Materials⁴
- D 5630 Test Method for Ash Content in Plastics⁴
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵
- E 169 Practices for General Techniques of Ultraviolet–Visible Quantitative Analysis⁶
- 2.2 ISO Standard:⁷
- ISO 7391–1987 Plastics—Polycarbonate Molding and Extrusion Materials (Part 1: Designation—1987) (Part 2: Preparation of Test Specimens and Determination of Properties)

3. Terminology

3.1 *Definitions*—The terminology used in this specification is in accordance with Terminologies D 883 and D 1600. The polycarbonate materials will be designated PC as specified in Terminology D 1600.

4. Classification

4.1 Unfilled polycarbonate materials are classified into groups according to their composition. These groups are subdivided into classes and grades as shown in Table PC

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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 08.03.

⁵ Annual Book of ASTM Standards, Vol 14.02.

⁶ Annual Book of ASTM Standards, Vol 14.01.

⁷ Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

TABLE PC Polycarbonate Materials and Detail Requirements

Note— The values are for naturals; colors may be different.

Group	Description	Class	Description	Grade	Description ^A	Flow Rate, ^B Test Method D 1238, g/10 min	Specific Gravity, Test Method D 792	Izod Impact, ^C Test Methods D 256, J/m, min	Tensile Yield Strength ^D Test Method D 638, MPa, min	Elongation at Break ^D	Flexural Modulus, ^E Test Methods D 790, MPa, min	Deflection Tempera- ture, Test Method D 648, ^F °C, min
01	PC	1	general purpose	1		>24	1.19–1.22			use Table B		
				2		15 to 30	1.19–1.22			use Table B		
				3		12 to 20	1.19–1.22	640	55	100	2000	126
				4		9 to 18	1.19–1.22	750	60	105	2100	126
				5		6 to 13	1.19–1.22	750	60	110	2200	128
				6		4 to 8	1.19–1.22	750	60	110	2200	128
				7		<5	1.19–1.22	780	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		2	flame-retarded ^G	1		>24	1.19–1.22			use Table B		
				2		15 to 30	1.19–1.22			use Table B		
				3		12 to 20	1.19–1.22	640	55	100	2000	126
				4		9 to 18	1.19–1.22	640	60	100	2100	126
				5		6 to 13	1.19–1.22	640	60	105	2200	128
				6		4 to 8	1.19–1.22	640	60	110	2200	128
				7		<5	1.19–1.22	640	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		3	UV ^H stabilized	1		>24	1.19–1.22			use Table B		
				2		15 to 30	1.19–1.22			use Table B		
				3		12 to 20	1.19–1.22	640	55	100	2000	124
				4		9 to 18	1.19–1.22	750	60	105	2100	124
				5		6 to 13	1.19–1.22	750	60	110	2100	126
				6		4 to 8	1.19–1.22	750	60	110	2200	126
				7		<5	1.19–1.22	750	60	110	2200	128
				0	other	...	...	...	...	...	...	...
		4	impact-modified	1		6 to 15	1.18–1.22	375 ^I	50	90	1900	121
				0	other	...	...	...	...	...	...	...
		5	FDA ^J compliant formulations	1		>24	1.19–1.22			use Table B		
				2		15 to 30	1.19–1.22			use Table B		
				3		12 to 20	1.19–1.22	640	55	100	2000	126
				4		9 to 18	1.19–1.22	750	60	105	2100	126
				5		6 to 13	1.19–1.22	750	60	110	2200	128
				6		4 to 8	1.19–1.22	750	60	110	2200	128
				7		<5	1.19–1.22	780	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
02	PC copolymer- flame retarded	1	general purpose	1		>24	1.22–1.26			use Table B		
				2		15 to 30	1.22–1.26			use Table B		
				3		12 to 20	1.22–1.26	80	60	100	2100	128
				4		9 to 18	1.22–1.26	80	60	110	2200	128
				5		6 to 13	1.22–1.26	90	60	110	2200	130
				6		4 to 8	1.22–1.26	90	60	110	2200	130
				7		<5	1.22–1.26	90	60	110	2200	132
				0	other	...	...	...	...	...	...	...
		2	UV ^H stabilized	1		>24	1.22–1.26			use Table B		
				2		15 to 30	1.22–1.26			use Table B		
				3		12 to 20	1.22–1.26	80	60	100	2100	126
				4		9 to 18	1.22–1.26	80	60	110	2200	126
				5		6 to 13	1.22–1.26	90	60	110	2200	128
				6		4 to 8	1.22–1.26	90	60	110	2200	130
				7		<5	1.22–1.26	90	60	110	2200	130
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
03	PC copolymer high-heat resin	1	general purpose	1		TBD	1.18–1.22	80	63	40	1700	150
				0	other	...	...	...	...	...	...	...
		2	UV ^H stabilized	1		TBD	1.18–1.22	80	63	40	1700	148
				0	other	...	...	...	...	...	...	...
		3	impact-modified	1		TBD	...	...	...	use Table B	...	...
				0	other	...	...	...	...	...	...	...
		4	FDA ^J compliant formulation	1		TBD	1.18–1.22	80	63	40	1700	150
				0	other	...	...	...	...	...	...	...
04	PC copolymer homopolymer intermediate heat blends	1	general purpose	1		TBD	1.18–1.22	480	65	60	1900	138
				0	other	...	...	...	...	...	...	...

TABLE *Continued*

Note— The values are for naturals; colors may be different.

Group	Description	Class	Description	Grade	Description ^A	Flow Rate, ^B Test Method D 1238, g/10 min	Specific Gravity, Test Method D 792	Izod Impact, ^C Test Methods D 256, J/m, min	Tensile Yield Strength ^D	Elongation at Break ^D	Flexural Modulus, ^E Test Methods D 790, MPa, min	Deflection Tempera- ture, Test Method D 648, ^F °C, min
									Test Method D 638, MPa, min	Test Method D 638, MPa, min		
05	PC copolymer low-heat standard flow	2	UV ^H stabilized	1		TBD	1.18–1.22	480	65	60	1900	136
				0	other	...	...	...	...	...	...	...
		3	impact-modified	1		TBD	...	...	use Table B			
				0	other	...	...	...	...	...	...	...
		4	FDA ^J compliant formulation	1		TBD	1.18–1.22	480	65	60	1900	138
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
		1	general purpose	1		>50	1.18–1.22	use Table B				
				2		nominal 45	1.18–1.22	570	50	100	2070	104
				3		nominal 29	1.18–1.22	620	50	100	2070	106
				4		nominal 18	1.18–1.22	770	50	100	2160	107
				5		nominal 10	1.18–1.22	810	50	100	2200	108
				0	other	...	...	...	...	...	...	...
				1		>50	1.18–1.22	use Table B				
				2		nominal 45	1.18–1.22	570	50	100	2070	102
				3		nominal 29	1.18–1.22	620	50	100	2070	104
				4		nominal 18	1.18–1.22	770	50	100	2160	105
				5		nominal 10	1.18–1.22	810	50	100	2200	106
				0	other	...	...	...	...	...	...	...
		3	impact-modified	0	other	...	...	...	...	...	...	...
				0	other	...	...	...	...	...	...	...
		4	FDA ^J compliant formulations	1		>50	1.18–1.22	use Table B				
				2		nominal 45	1.18–1.22	570	50	100	2070	104
				3		nominal 29	1.18–1.22	620	50	100	2070	106
				4		nominal 18	1.18–1.22	770	50	100	2160	107
				5		nominal 10	1.18–1.22	810	50	100	2200	108
				0	other	...	...	...	...	...	...	...
		5	flame-retarded ^G	1		TBD	1.18–1.22	use Table B				
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
06	PC copolymer low-heat easy flow	1	general purpose	1		TBD	1.18–1.22	use Table B				
				0	other	...	...	...	...	...	...	...
		2	UV stabilized ^H	1		TBD	1.18–1.22	...	...	use Table B	...	...
				0	other	...	...	...	...	...	...	...
		3	impact-modified	1		TBD	1.17–1.22	...	...	use Table B	...	...
				0	other	...	...	...	...	...	...	...
		4	FDA ^J compliant formulations	1		TBD	1.18–1.22	...	...	use Table B	...	...
				0	other	...	...	...	...	...	...	...
		5	flame-retarded ^G	1		TBD	1.18–1.22	...	...	use Table B	...	...
				0	other	...	...	...	...	...	...	...
		0	other	0	other	...	...	...	...	...	...	...
99	PC other ^I	0	other	0	other	...	...	...	...	...	...

^A All grades are listed by performance requirements.

^B Use condition 300/1.2 for Groups 01, 02, and 05. Define the conditions for other groups in the suffixes as needed.

^C Test specimens are 3.2 mm thick, with a notch radius of 0.25 mm, tested by Method A.

^D Test specimens are Type I tensile bars, 3.2 mm thick, tested at a crosshead speed of 50 mm/min.

^E Test specimens are 3.2 by 12.7 mm, tested by Method I, Procedure A (Tangent), at a crosshead speed of 1.3 mm/min and a span-to-depth ratio of 16 to 1.

^F Test specimens are 3.2 mm thick, tested at 1820 kPa, and are not annealed before testing.

^G Use suffix letter F, with the appropriate digits given in Classification D 4000, to define specific requirements.

^H Refer to Practices E 169 for testing procedure. Specific requirements shall be stated in the purchase order or contract.

^I Test specimens for Group 1, Class 4, Grade 1 are 6.4 mm thick with a notch radius of 0.25 mm and are tested by Method A.

^J Manufactured in compliance with Food Additive Regulation 21CFR177.1580 governing polycarbonate resins for food-contact applications..

NOTE 2—An example of this classification system is as follows: the designation PC0214 indicates:

PC = polycarbonate as found in Terminology D 1600,
02 = polycarbonate copolymer-flame retarded (group),
1 = general purpose (class), and
4 = requirements given in Table PC.

4.1.1 To facilitate the specification of new, special, or recycled materials, the “other” category (0) for class or grade, or both, may be used as indicated in Table PC. The properties of these materials may be specified using Tables A, B, or R as they apply.

4.2 Reinforced, pigmented, filled, and lubricated versions of polycarbonate materials may be classified in accordance with Tables PC and A, B, or R. Table PC is used to specify basic materials, and Tables A or B are used to specify the property requirements after the addition of reinforcement, pigments, fillers, or lubricants at the nominal level indicated (see 4.2.1). Table R is used for recycled materials.

4.2.1 A single letter shall be used to indicate the major category of the reinforcement, along with two numbers indicating the nominal percentage of additive(s) by mass, with the tolerances as tabulated as follows:

Category	Material	Tolerance (Based on the Total Mass)
C	carbon and graphite fiber-reinforced	±2 percentage points
G	glass-reinforced	
	<15 % glass content	±2 percentage points
	>15 % glass content	±3 percentage points
L	lubricants (such as PTFE, graphite, silicone, and molybdenum disulfide)	depends on material and process—to be specified
M	mineral-reinforced	±2 percentage points
R	combination/mixtures of reinforcements or other fillers/reinforcements	±3 percentage points based on total reinforcement

NOTE 3—If necessary, additional requirements may be specified using suffixes, in accordance with Section 5. Special agreements on tolerances may be required when levels are below 5 %. The ash content of filled or reinforced materials may be determined using Test Method D 2584 where applicable.

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

4.2.2.1 Although the values listed in Tables A and B 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 shown, or is not important, a “0” grade classification shall be used for reinforced materials in this system.

NOTE 4—An example of this classification system for reinforced polycarbonate material is as follows: the designation PC0110G10A22230 indicates:

PC0110 = general-purpose polycarbonate from Table PC,
 G10 = glass reinforced at nominal 10 % level,
 A = Table A property requirements,
 2 = 60-MPa tensile strength, min,
 2 = 3000-MPa flexural modulus, min,
 2 = 80-J/m Izod impact strength, min,
 3 = 125°C deflection temperature, min, and
 0 = unspecified.

If no properties are specified, the designation is PC0110G10A00000.

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

NOTE 5—The mechanical properties of polycarbonates can be affected by the amounts and types of additives and colorants used. The most often observed effect is a change in the ductility of the material as evidenced in reductions of up to 90 % in Izod impact strength and 25 % or more in tensile elongation. A classification using Table PC and Table B should be used if properties of pigmented or specially formulated polycarbonates need to be specified.

NOTE 6—An example of this classification system for a special polycarbonate material is as follows: the designation PC0110B34720 indicates:

PC0110 = general-purpose polycarbonate from Table PC,
 B = Table B property requirements,
 3 = 60-MPa tensile strength, min,

4 = 2100-MPa flexural modulus, min,
 7 = 640-J/m Izod impact strength, min,
 2 = 105°C deflection temperature, min, and
 0 = unspecified.

4.4 The short- and long-term mechanical properties of polycarbonate materials can be affected adversely by their prior processing as well as end-use exposure to chemicals, weathering, and secondary finishing steps. Efforts to reuse materials may include direct feedback into the system from which they are generated, or they could involve isolation for reuse at other times into other processes or parts. Most manufacturer’s literature contains recommendations regarding direct feedback practices to aid the user in maintaining the properties of the original materials as much as possible. When polycarbonate resins are isolated and reprocessed in conjunction with fillers, additives, colorants, etc., there is a special risk that the properties of the final products may not be equal to those obtained when “virgin” resins are used. While the test specimen properties called out in this specification may be used to screen these materials, the user should take precautions to ensure that parts made from these materials meet the desired parameters. Group and class designations from Table PC, used in conjunction with Grade Designation 0, allow line callouts to be defined for recycled resins. The group, class, and grades given should be used with the property ranges from Table R, as appropriate. Table R lists two impact and two tensile properties to allow callouts for both filled and unfilled resins. It is intended that only one be used in a given callout and that the unused properties be given an 0, “unspecified,” cell designation.

4.5 When property requirements involving ISO criteria are to be specified, cell Tables C through H, as defined in Classification D 4000, should be used. Appropriate suffixes, detailing specimen dimensions, test speeds, etc., must also be defined when using these tables.

5. Suffixes

5.1 When requirements not covered by the basic cell tables need to be specified, suffixes shall be defined in accordance with Classification D 4000.

5.2 Requirements specified by suffix references always take precedence over values from the property or cell tables for the same properties.

6. General Requirements

6.1 The plastic compositions shall be uniform and shall conform to the requirements herein.

7. Detail Requirements

7.1 Test specimens for the various materials shall conform to the requirements in accordance with Tables PC, A, B, and R and the suffix requirements, as they apply.

7.2 For the purpose of determining conformance with the requirements of this specification, all specified limits in this specification are absolute limits in accordance with Practice E 29.

7.2.1 With the absolute method, an observed or calculated value is not rounded but is compared directly with the specified limiting value. Conformance, or lack thereof, is based on this comparison.

TABLE A Reinforced Polycarbonate Materials, Detail Requirements

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile strength, Test Method D 638, MPa, ^A min at break	unspecified	40	60	80	100	120	140	160	180	^B
2	Flexural modulus, Test Methods D 790, MPa, ^C min	unspecified	2 100	3 000	4 500	6 000	7 500	9 000	10 500	12 000	^B
3	Izod impact, Test Methods D 256, Method A, J/m, ^D min	unspecified	58	80	100	120	140	160	180	200	^B
4	Deflection temperature under load, Test Method D 648, at 1.82 MPa, °C, ^E min	unspecified	105	120	125	140	145	151	157	160	^B
5	To be determined	unspecified	...	...	...	...	...	...	...	...	...

^A Test specimens are Type I bars at 3.2-mm thickness, tested at a crosshead speed of 5 mm/min.

^B Specific value must be shown.

^C Test specimens are 3.2 by 12.7 mm and tested by Method I, Procedure A (tangent), with a crosshead speed of 1.3 mm/min and a span-to-depth ratio of 16 to 1.

^D Specimens are 3.2 mm thick with a notch radius of 0.25 mm.

^E Test specimens are 3.2 mm thick and are not annealed before testing.

TABLE B Unreinforced Polycarbonate Materials, Detail Requirements

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Tensile strength, Test Method D 638, MPa, ^A min at yield	unspecified	40	50	60	70	80	90	100	110	^B
2	Flexural modulus, Test Methods D 790, MPa, ^C min	unspecified	1200	1500	1800	2100	2400	2700	3000	3300	^B
3	Izod impact, Test Methods D 256, Method A, J/m, ^D min	unspecified	55	105	210	315	420	530	640	750	^B
4	Deflection temperature under load, Test Method D 648, at 1.82 MPa, °C, ^E min	unspecified	100	105	120	125	130	145	157	160	^B
5	To be determined	unspecified	...	...	...	...	...	...	...	...	...

^A Test specimens are Type I bars at 3.2-mm thickness, tested at a crosshead speed of 5 mm/min.

^B Specific value must be shown.

^C Test specimens are 3.2 by 12.7 mm and tested by Method I, Procedure A (tangent), with a crosshead speed of 1.3 mm/min and a span-to-depth ratio of 16 to 1.

^D Specimens are 3.2 mm thick with a notch radius of 0.25 mm.

^E Test specimens are 3.2 mm thick and are not annealed before testing.

TABLE R Recycled Polycarbonate Materials, Detail Requirements

Designation Order Number	Property	Cell Limits									
		0	1	2	3	4	5	6	7	8	9
1	Izod impact, ^A Test Methods D 256, Method A, J/m, min	unspecified	53	80	105	270	430	535	640	750	^B
2	Izod impact, ^A Test Methods D 256, Method E, J min force resulting in "no breaks"	unspecified	5	10	15	20	25	30	35	40	^B
3	Flexural modulus, ^C Test Methods D 790, MPa, min Procedure A (tangent) at 1.3-mm/min test speed	unspecified	1 200	1 800	2 400	3 000	5 000	7 000	10 000	12 000	^B
4	Tensile strength at yield, ^D Test Method D 638, MPa, min (use with unreinforced resins at test speed 50 mm/min)	unspecified	40	50	60	70	80	90	100	110	^B
5	Tensile strength at break, ^D Test Method D 638, MPa, min (use with reinforced resins at test speed 5 mm/min)	unspecified	40	60	80	100	120	140	160	180	^B

^A Specimens are 3.2 mm thick with a notch radius of 0.25 mm.

^B Specific value must be shown.

^C Test specimens are 3.2 by 12.7 mm and tested by Method I with a span-to-depth ratio of 16 to 1.

^D Test specimens are Type I bars at 3.2-mm thickness.

8. Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of 13.5. A lot of material 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.

9. Number of Tests

9.1 The number of tests shall be consistent with the requirements of Section 8 and 13.2.

10. Specimen Preparation

10.1 Unless otherwise specified, test specimens for materials classifiable into Groups 01 or 02 shall be prepared by injection molding using the following conditions:

	Mold Temperature, °C	Material Melt Temperature, °C
Unfilled and unreinforced	70–95 (when MFR > 8 g/10 min)	275–290 (when MFR > 8 g/10 min)
Unfilled and unreinforced	80–115 (when MFR < 8 g/10 min)	290–345 (when MFR < 8 g/10 min)
Filled and reinforced	80–115	300–350

10.1.1 All materials classifiable into Groups 01 and 02 should be dried for at least 3 h at 125°C before molding.

10.2 Unless otherwise specified, test specimens for materials classifiable into Groups 03 and 04 shall be prepared by injection molding using the following conditions:

	Mold Temperature, °C	Material Melt Temperature, °C
Unfilled and unreinforced	80–100	330–375
Filled and reinforced	consult manufacturer for recommended molding conditions	

10.2.1 All materials classifiable into Groups 03 and 04 should be dried for at least 3 h at 130°C before molding.

10.3 Test specimens for materials not classifiable into Groups 01, 02, 03, or 04 should be prepared by injection molding, as prescribed by the manufacturer.

10.3.1 Materials not classifiable into Groups 01, 02, 03, or 04 should be dried in accordance with the recommendations of the manufacturer.

11. Conditioning

11.1 Condition test specimens at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity for not less than 40 h prior to testing.

12. Test Methods

12.1 Determine the properties enumerated in this specification using the referenced test methods.

13. Inspection and Certification

13.1 Inspection and certification of the materials supplied in reference to this specification shall be for conformance to the requirements specified therein.

13.2 Lot acceptance inspection shall be the basis on which acceptance or rejection of a lot is made and shall consist of the test listed as it applies: Test Method D1238, Melt Flow Rate.

13.3 To ensure certifiability in accordance with 13.5, periodic check inspection shall consist of tests for all of the requirements specified using the classification system in this specification.

13.4 A report of the test results shall be furnished when requested by the purchaser and shall consist of the lot acceptance inspection results in accordance with 13.2. The results of the most recent periodic check inspection shall also be furnished whenever requested by the purchaser.

13.5 Certification shall be that the material was manufactured, sampled, inspected, and tested in accordance with this specification and that the average values meet the requirements at a 95 % confidence level.

14. Packing, Packaging, and Package Marking

14.1 The provisions of Practice D 3892 apply for the packaging, packing, and marking of containers for plastics materials.

15. Keywords

15.1 line-callout specification; plastics; polycarbonate resins; recycled plastics; specification

APPENDIX

(Nonmandatory Information)

X1. CROSS REFERENCES

TABLE X1.1 Cross-Reference Designations for This Specification and Government Specifications

Government Specifications	Previous Line Callout, Specification D 3935 (1987)	Revised Specification D 3935-94 Line Callout
General purpose L-P-393A	PC110B30720E01F02	PC0110B30740EB140ED030EE150EG010FL012
Glass reinforced MIL-P-81390		
Type I	PC110G40A60840E02F01	PC0110G40A60840EB150ED037EE150EG001FL024
Type II	PC110G20A50640E02F01	PC0110G20A50640EB150ED037EE150EG001FL024
Type III	PC110G20A50340E02F01	PC0110G20A50340EB150ED037EE150EG001FL024

X1.1 The cross references in Table X1.1 between the designations of government specifications and this specification are provided for information only.

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