Designation: D 6779 – 03

Standard Classification System for Polyamide Molding and Extrusion Materials (PA)[1]

This standard is issued under the fixed designation D 6779; 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 classification system covers polyamide materials suitable for molding and extrusion. Some of these compositions are also suitable for application from solution.

1.2 This classification system allows for the use of recycled polyamide materials provided that the requirements as stated in this classification system 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 classification system 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 the performance required of the part, the environment to which it will be exposed, the fabrication process to be employed, the costs involved, and the inherent properties of the material other than those covered by this classification system.

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

1.6 The following precautionary caveat pertains only to the test methods portion, Section 11, of this classification system. *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 requirements prior to use.*

NOTE 1—This classification system is similar to ISO 1874-1/-2 1993, although the technical content is significantly different.

2. Referenced Documents

2.1 *ASTM Standards:*

D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials[2]

D 789 Test Methods for Determination of Relative Viscosity and Moisture Content of Polyamide (PA)[3]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[3]

D 883 Terminology Relating to Plastics[3]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[3]

D 3892 Practice for Packaging/Packing of Plastics[4]

D 4000 Classification System for Specifying Plastic Materials[4]

D 6260 Test Method for Gravimetric Determination of Carbon Black in Nylon Materials (PA)[5]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[6]

2.2 *IEC/ISO Standards:*[7]

IEC 60243-1:1998 Electrical Strength of Insulating Materials—Test Methods—Part 1: Tests at Power Frequencies

IEC 60250:1969 Recommended Methods for the Determination of the Permittivity and Dielectric Dissipation Factor of Electrical Insulating Materials at Power, Audio and Radio Frequencies Including Metre Wavelengths

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: Plastic and Ebonite

ISO 179-1:2000 Plastics—Determination of Charpy Impact Strength—Part 1: Non-instrumented Impact Test

ISO 294-1:1996 Plastics—Injection Moulding of Test Specimens of Thermoplastic Materials—Part 1: General Principles, Multipurpose-Test Specimens and Bars

[1] This classification system is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials (Section D20.15.09).

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[2] *Annual ASTM Book of Standards*, Vol 10.01.

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

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

[5] *Annual ASTM Book of Standards*, Vol 08.03.

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

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

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

ISO 307:1994 Determination of Viscosity Number of Polyamides In Dilute Solutions
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 1183:1987 Plastics—Methods for Determining the Density and Relative Density of Non-Cellular Plastics
ISO 1874-1:1992 Plastics—Polyamide (PA) Homopolymers and Copolymers for Moulding and Extrusion—Part 1: Designation
ISO 1874-2.2:1996 Plastics—Polyamide (PA) Homopolymers and Copolymers for Moulding and Extrusion—Part 2: Preparation of Test Specimens and Determination of Properties
ISO 3167 Plastics, Multipurpose Test Specimens
ISO 3451-4:1998 Plastics—Determination of Ash—Part 4: Polyamides
ISO 11357-1:1997 Plastics—Differential Scanning Calorimetry—Part 1: General Principles
ISO 11357-3:1999 Plastics—Differential Scanning Calorimetry—Part 3: Determination of Temperature and Enthalpy of Melting and Crystallization
ISO 15512:1999 Plastics—Determination of Water Content

3. Terminology

3.1 The terminology used in this classification system is in accordance with Terminologies D 883 and D 1600.

4. Classification

4.1 Polyamide materials are classified into groups in accordance with their composition. These groups are subdivided into classes and grades as shown in the Basic Property Table (Table PA).

NOTE 2—An example of this classification system for unreinforced polyamide is given as follows: The designation PA0123 indicates the following:

PA	=	polyamide as found in Terminology D 1600,
01 (group)	=	polyamide 66,
2 (class)	=	heat stabilized, and
3 (grade)	=	with a minimum viscosity number of 210 and the requirements given in Table PA.

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 5, 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 follows:

Symbol	Material	Tolerance (Based on the Total Mass)
C	carbon- and graphite-fiber-reinforced	±2 %
G	glass-reinforced	±2 %
L	lubricants (such as PTFE, graphite, silicone, and molybdenum disulfide)	Depends upon 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 polyamide is given as follows: The designation PA012G35 indicates the following:

PA	=	polyamide as found in Terminology D 1600,
01 (group)	=	polyamide 66,
2 (class)	=	heat stabilized, and
G35 (grade)	=	nominal 35 % glass with the requirements given in Table PA.

NOTE 4—This part of the classification system uses percent of reinforcements or additives, or both, in the callout of the modified basic material. The types and percentages of reinforcements and additives should be shown on the supplier's technical data sheet unless they are proprietary in nature. If necessary, additional control 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 5 are included in the nearest PA grade designation. For example, a material with a nominal glass fiber level of 33 % is included with Grade G35 as shown in Note 4.

NOTE 6—Ash content of filled or reinforced materials may be determined using Test Method ISO 3451-4.

4.2 Variations of polyamide materials that are not in Table PA are classified in accordance with Tables PA and A or B. Table PA is used to specify the group of polyamide and Table A or B is used to specify property requirements.

4.2.1 Specific requirements for variations of polyamide materials shall be shown 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 Tables A and 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, is not important or does not meet the Table PA requirements, the use of "0" grade classification shall be used for reinforced materials in this classification system.

NOTE 7—An example of this classification system for a reinforced polyamide material is given as follows. The designation PA0110G30A42270 would indicate the following material requirements:

PA0110	=	Polyamide 66, from Table PA,
G30	=	Glass reinforced at 30 % nominal,
A	=	Table A property requirements,
4	=	Tensile strength, 140 MPa, min,
2	=	Tensile modulus, 4500 MPa, min,
2	=	Charpy impact, 5.0 kJ/m^2, min,
7	=	Deflection temperature at 1.8 MPa, 200°C, min, and
0	=	Unspecified.

If no properties are specified, the designation would be PA0110G30A00000.

NOTE 8—When a grade of polyamide is not fully identified by a standard callout, it is possible to specify all table properties by the use of an addition of Classification D 4000 suffixes. Suffix values will override the PA table values. An example of an unreinforced polyamide material is given as follows: PA0212KN023. This example is a general purpose, low

viscosity PA6 material where K denotes tensile properties, N denotes tensile modulus with ISO 527 as the test method, and 023 denotes a value of 2300 MPa. This value for tensile modulus overrides the normal table value. This example can be applied to replace all table values, that is, tensile stress, notched Charpy impact, and heat deflection temperature.

4.3 To facilitate the specification of special materials where the basic property table does not reflect the properties required, Table B has been incorporated into this classification system. This table will be used in a manner similar to Table A.

NOTE 9—Pigmented or colored polyamides can differ significantly from the natural polymers in mechanical properties depending on the choice of colorants and concentrations. The main property affected is ductility, as illustrated by a reduction in Charpy impact and elongation values. In a typical white pigmented polyamide, elongation losses of up to 50 % and Charpy impact losses of up to 30 % are common. If specific properties of pigmented materials are necessary, Table B may be employed to specify property requirements.

NOTE 10—An example of a special material using this classification system is as follows: The designation PA0220B54220 would indicate the following material requirements from Table B:

PA0220	=	Polyamide 6, heat stabilized, from Table PA,
B	=	Table B property requirements,
5	=	Tensile strength, 70 MPa, min,
4	=	Tensile modulus, 2400 MPa, min,
2	=	Charpy impact, 4.0 kJ/m^2, min,
2	=	Deflection temperature at 1.8 MPa, 55°C, min, and
0	=	unspecified.

TABLE PA Requirements for Polyamides Dry-as-Molded[A,B]

Group	Description	Class	Description	Grade	Description[C]	Viscosity Number, ISO 307, min, mL/g	Density,[D] ISO 1183 g/cm^3	Tensile Strength, ISO 527-1 and ISO 527-2, MPa, min	Tensile Modulus,[E] ISO 527-1 and ISO 527-2, MPa, min	Charpy Impact Resistance, ISO 179/ 1eA, kJ/m^2, min	Deflection Temperature,[F] ISO 75-1 and ISO 75-2, at 1.8 MPa, °C, min
01	PA66	1	General-purpose	1		135	1.13 to 1.15	70	2300	3.3	60
				2		165	1.13 to 1.15	70	2300	3.3	60
				3		210	1.13 to 1.15	70	2300	3.3	60
				4		270	1.13 to 1.15	70	2300	3.3	60
				5	recycled	115	1.13 to 1.15	70	2300	3.3	60
				6	recycled	135	1.13 to 1.15	70	2300	3.3	60
				G15	15 % glass	. . .	1.20 to 1.26	100	4000	3.0	215
				G20	20 % glass	. . .	1.25 to 1.33	115	5000	4.0	220
				G25	25 % glass	. . .	1.29 to 1.37	140	6000	5.0	225
				G35	35 % glass	. . .	1.35 to 1.45	170	8000	7.0	235
				G40	40 % glass	. . .	1.42 to 1.52	175	9000	8.0	235
				G45	45 % glass	. . .	1.45 to 1.55	180	10 000	9.0	240
				M40	40 % mineral	. . .	1.45 to 1.55	80	5000	2.0	100
				0	other						
		2	Heat-stabilized	1		135	1.13 to 1.15	70	2300	3.0	60
				2		165	1.13 to 1.15	70	2300	3.0	60
				3		210	1.13 to 1.15	70	2300	3.0	60
				4		270	1.13 to 1.15	70	2300	3.0	60
				5	recycled	115	1.13 to 1.15	70	2300	3.0	60
				6	recycled	135	1.13 to 1.15	70	2300	3.0	60
				G15	15 % glass	. . .	1.20 to 1.26	100	4000	3.0	220
				G25	25 % glass	. . .	1.29 to 1.37	140	6000	5.0	225
				G30	30 % glass	. . .	1.32 to 1.42	160	7000	6.0	230
				G35	35 % glass	. . .	1.35 to 1.45	170	8000	7.0	235
				G40	40 % glass	. . .	1.43 to 1.53	175	9000	8.0	235
				G45	45 % glass	. . .	1.45 to 1.55	180	10 000	9.0	240
				M40	40 % mineral	. . .	1.45 to 1.55	80	5000	2.0	100
				R20	20 % filler	. . .	1.23 to 1.31	70	3200	1.5	. . .
				R40	40 % filler	. . .	1.43 to 1.53	100	5500	2.5	200
				0	other						
		3	Nucleated	1		135	1.13 to 1.15	80	2500	2.8	60
				2		165	1.13 to 1.15	80	2500	2.8	60
				3		210	1.13 to 1.15	80	2500	2.8	60
				4		270	1.13 to 1.15	80	2500	2.8	60
				5	recycled	115	1.13 to 1.15	80	2500	2.8	60
				6	recycled	135	1.13 to 1.15	80	2500	2.8	60
				0	other						
		4	Nucleated, heat-stabilized	1		Requirements the same as corresponding grades under Group 01, Class 3					
				2							
				3							
				4							
				5							
				0	other						
		5	Impact-modified	1		. . .	1.06 to 1.12	52	1700	9.0	50
				2	recycled	. . .	1.06 to 1.12	50	1600	8.0	50
				G15	15 % glass	. . .	1.15 to 1.23	85	3000	6.0	210
				G35	35 % glass	. . .	1.31 to 1.41	110	5500	6.0	225

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				0	other						
		6	Impact-modified, heat-stabilized	1		. . .	1.08 to 1.12	52	1700	9.0	50
				2	recycled	. . .	1.08 to 1.12	50	1600	8.0	50
				G15	15 % glass	. . .	1.15 to 1.23	85	3000	6.0	210
				G35	35 % glass	. . .	1.31 to 1.41	110	5500	6.0	225
				M40	40 % mineral	. . .	1.45 to 1.55	75	4500	4.0	. . .
				R35	35 % filler	. . .	1.38 to 1.48	80	5500	3.0	200
				0	other						
		7	Toughened	1		. . .	1.06 to 1.10	42	1500	40	45
				2	recycled	. . .	1.05 to 1.11	40	1300	35	45
				G15	15 % glass	. . .	1.15 to 1.23	70	2800	9.0	180
				G35	35 % glass	. . .	1.28 to 1.38	110	5500	11	220
				0	other						
		8	Toughened, heat-stabilized	1		. . .	1.06 to 1.10	42	1500	40	45
				2	recycled	. . .	1.05 to 1.11	40	1300	35	45
				G15	15 % glass	. . .	1.15 to 1.23	70	2800	9.0	180
				G35	35 % glass	. . .	1.28 to 1.38	110	5500	11	220
				G45	45 % glass	. . .	1.39 to 1.49	130	8000	10	230
				M35	35 % mineral	. . .	1.37 to 1.47	70	3800	6.0	. . .
				0	other						
		9	Weather-stabilized[G]	1		135	1.13 to 1.17	80	2400	2.5	60
				2	recycled	115	1.13 to 1.17	65	2200	2.0	60
				0	other						
		0	Other	0	other						
02	PA6	1	General-purpose	1		100	1.12 to 1.14	75	2400	4.0	50
				2		135	1.12 to 1.14	70	2200	3.0	50
				3		150	1.12 to 1.15	70	2200	3.0	50
				4		200	1.12 to 1.15	70	2200	3.0	50
				G15	15 % glass		1.20 to 1.28	110	4200	4.0	170
				G25	25 % glass		1.28 to 1.36	135	5000	6.5	180
				G30	30 % glass		1.32 to 1.40	150	7000	7.5	180
				G35	35 % glass		1.38 to 1.44	155	7500	8.0	180
				M30	30 % mineral		1.30 to 1.40	70	3200	2.4	50
				M40	40 % mineral		1.44 to 1.52	75	4500	4.0	70
				R40	40 % glass/ mineral		1.42 to 1.50	100	6000	3.0	180
				0	other						
		2	Heat-stabilized	1		100	1.12 to 1.14	75	2400	4.0	50
				2		135	1.12 to 1.14	70	2200	3.0	50
				3		150	1.12 to 1.15	70	2200	3.0	50
				4		200	1.12 to 1.15	70	2200	3.0	50
				5	recycled	135	1.12 to 1.14	70	2000	3.0	50
				G5	5 % glass		1.16 to 1.22	85	2500	2.5	110
				G15	15 % glass		1.20 to 1.28	110	4200	4.0	180
				G25	25 % glass		1.28 to 1.36	135	5000	6.5	190
				G30	30 % glass		1.32 to 1.40	150	7000	7.5	190
				G35	35 % glass		1.38 to 1.44	155	7500	8.0	190
				G45	45 % glass		1.46 to 1.54	175	10 000	10	190
				G50	50 % glass		1.52 to 1.60	175	10 000	10	190
				G65	65 % glass		1.70 to 1.78	175	13 000	10	200
				M30	30 % mineral		1.30 to 1.40	70	3200	2.4	50
				M35	35 % mineral		1.39 to 1.47	70	3500	3.0	60
				M40	40 % mineral		1.44 to 1.52	75	4500	4.0	70
				R20	20 % glass/ mineral		1.25 to 1.33	80	3200	2.5	120
				R40	40 % glass/ mineral		1.42 to 1.50	100	6000	3.0	190
				0	other						
		3	Nucleated and lubricated	1		100	1.12 to 1.14	70	2300	2.5	50
				2		135	1.12 to 1.14	70	2300	2.5	50
				3		150	1.12 to 1.15	75	2300	2.5	50
				4		200	1.12 to 1.15	80	2300	2.5	50
				0	other						
		4	Nucleated and heat-stabilized	1		100	1.12 to 1.14	70	2300	2.5	50
				2		135	1.12 to 1.14	70	2300	2.5	50
				3		150	1.12 to 1.15	75	2300	2.5	50
				4		200	1.12 to 1.15	80	2300	2.5	50
				5	recycled	135	1.12 to 1.14	70	2100	2.5	50

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				0	other						
		5	Impact-modified	1			1.05 to 1.12	45	1700	30	45
				2			1.05 to 1.18	55	2000	6.0	45
				3			1.05 to 1.18	40	1000	6.0	35
				G15	15 % glass		1.15 to 1.24	75	3300	9.0	130
				G30	30 % glass		1.30 to 1.40	135	6500	15	180
				G35	35 % glass		1.32 to 1.42	135	6800	15	190
				G40	40 % glass		1.39 to 1.47	135	8000	10	200
				0	other						
		6	Impact-modified, heat-stabilized	1			1.05 to 1.12	45	1700	30	45
				2			1.05 to 1.18	55	2000	6.0	45
				3			1.05 to 1.18	40	1000	6.0	35
				4			1.05 to 1.18	25	1000	30	30
				G15	15 % glass		1.15 to 1.24	75	3300	9.0	130
				G30	30 % glass		1.30 to 1.40	135	6500	15	180
				G35	35 % glass		1.32 to 1.42	135	6800	10	190
				G40	40 % glass		1.39 to 1.47	135	8000	10	200
				M35	35 % mineral		1.35 to 1.45	65	3200	3.0	50
				M40	40 % mineral		1.39 to 1.47	65	3200	3.0	50
				0	other						
		7	Flexural-modified, heat-stabilized	1	injection molding		1.05 to 1.16	55	2375 max	10	45
				2	extrusion		1.05 to 1.16	30	2000 max	7.0	25
				3	blends		1.05 to 1.10	35	1700 max	4.5	35
				0	other						
		0	Other	0	other						
03[H]	PA11	1	General purpose	1		115 to 140	1.01 to 1.06	35	900	4.0	36
				2		160 to 190	1.01 to 1.06	35	900	6.0	36
				0	other						
		2	Heat-stabilized	1		115 to 140	1.01 to 1.06	35	900	4.0	36
				2		160 to 190	1.01 to 1.06	35	900	6.0	36
				3	black	160 to 190	1.01 to 1.06	35	900	4.0	36
				4		210 to 255	1.01 to 1.06	35	900	6.0	36
				0	other						
		3	Plasticized	1		170 to 200	1.01 to 1.06	30	370	25	36
				0	other						
		4	Plasticized, Heat Stabilized	1		180 to 240	1.01 to 1.06	35	500	25	36
				2		170 to 200	1.01 to 1.06	35	400	25	36
				3		115 to 140	1.01 to 1.06	30	350	25	36
				4	black	175 to 240	1.01 to 1.06	35	400	25	36
				5		170 to 190	1.01 to 1.06	30	370	25	36
				6		200 to 230	1.01 to 1.06	35	370	25	36
				7	black	160 to 240	1.01 to 1.06	35	340	25	36
				0	other						
		0	Other	0	other						
04	PA12	1	General purpose	1		100 to 210	1.00 to 1.06	30	800	2.5	35
				2		100 to 210	1.00 to 1.06	35	1000	2.5	35
				3		211 to 270	1.00 to 1.06	35	1000	2.5	35
				4		271 to 340	1.00 to 1.06	35	1000	2.5	35
				0	other						

TABLE PA Requirements for Polyamides Dry-as-Molded[A,B]

Group	Description	Class	Description	Grade	Description[C]	Viscosity Number, ISO 307, min, mL/g	Density,[D] ISO 1183 g/cm^3	Tensile Strength, ISO 527-1 and ISO 527-2, MPa, min	Tensile Modulus,[E] ISO 527-1 and ISO 527-2, MPa, min	Charpy Impact Resistance, ISO 179/ 1eA, kJ/m^2, min	Deflection Temperature,[F] ISO 75-1 and ISO 75-2, at 1.8 MPa, °C, min
		2	Heat-stabilized	1		100 to 150	1.00 to 1.06	35	800	2.5	35
				2		151 to 210	1.00 to 1.06	35	800	2.5	35
				3		211 to 280	1.00 to 1.06	35	1000	2.5	35
				G15	15 % glass		1.10 to 1.20	75	3000	10	160
				G25	25 % glass		1.10 to 1.25	90	3000	15	160
				G30	30 % glass		1.15 to 1.30	95	4000	15	160
				G40	40 % glass		1.30 to 1.45	100	4500	15	160
				R30	30 % filler		1.18 to 1.32	55	3500	5.0	100
				0	other						
		3	Nucleated	1		100 to 180	1.00 to 1.06	35	800	1.0	35
				2		181 to 250	1.00 to 1.06	35	800	1.0	35
				0	other						
		4	Plasticized	1		100 to 280	1.00 to 1.06	30	300 to 550	15	
				2		100 to 280	1.00 to 1.06	30	450 to 750	10	
				0	other						
		5	Plasticized, heat-stabilized	1		100 to 280	1.00 to 1.06	20	200 to 350	20	
				2		100 to 280	1.00 to 1.06	30	300 to 550	15	
				3		100 to 280	1.00 to 1.06	30	450 to 750	10	
				4		100 to 280	1.00 to 1.06	35	550 to 950	5.0	
				0	other						
		0	Other	0	other						
05	PA612	1	General purpose	1		100 to 139	1.05 to 1.07	50	1800	2.0	45
				2		140 to 199	1.05 to 1.07	50	1800	2.5	45
				3		200	1.05 to 1.07	50	1800	3.0	45
				G35	35 % glass		1.28 to 1.38	140	7000	9.0	175
				G45	45 % glass		1.38 to 1.48	150	8500	11	180
				0	other						
		2	Heat-stabilized	1		140	1.05 to 1.07	50	1800	2.0	45
				G20	20 % glass		1.17 to 1.25	105	4500	5.0	170
				G30	30 % glass		1.25 to 1.33	120	5500	5.0	170
				G35	35 % glass		1.28 to 1.38	140	7000	9.0	175
				0	other						
		3	Weather-stabilized[G]	1		140	1.05 to 1.07	50	1800	1.5	45
				0	other						
06	PA46	1	General-purpose	1		170	1.16 to 1.20	85	2300	6.0	
				2		195	1.16 to 1.20	85	2300	6.0	140
				0	other						
		2	Heat-stabilized	1		165	1.16 to 1.20	85	2300	6.0	140
				2		195	1.16 to 1.20	85	2300	6.0	140
				G15	15 % glass		1.25 to 1.31	125	5000	3.6	240
				G30	30 % glass		1.38 to 1.42	175	8000	7.5	280
				G40	40 % glass		1.48 to 1.53	195	10 000	10.0	280
				G50	50 % glass		1.58 to 1.63	210	12 000	12.0	280
				R50	50 % filler		1.60 to 1.67	140	9000	4.0	280
				0	other						
		3	Flame-retardant[I], heat-stabilized	1			1.32 to 1.36	45	2250	4.0	140
				G15	15 % glass		1.55 to 1.59	115	6000	4.5	270
				G30	30 % glass		1.63 to 1.69	155	10 000	7.5	280
				G40	40 % glass		1.76 to 1.80	145	11 000	8.0	280
				G45	45 % glass		1.75 to 1.79	165	12 000	8.0	280
				0	other						

TABLE PA Requirements for Polyamides Dry-as-Molded[A,B]

Group	Description	Class	Description	Grade	Description[C]	Viscosity Number, ISO 307, min, mL/g	Density,[D] ISO 1183 g/cm^3	Tensile Strength, ISO 527-1 and ISO 527-2, MPa, min	Tensile Modulus,[E] ISO 527-1 and ISO 527-2, MPa, min	Charpy Impact Resistance, ISO 179/ 1eA, kJ/m^2, min	Deflection Temperature,[F] ISO 75-1 and ISO 75-2, at 1.8 MPa, °C, min
		4	Impact-modified, heat-stabilized	1			1.08 to 1.12	40	1500	50	70
				0	other						
		5	Wear-resistant, heat-stabilized	1			1.16 to 1.20	75	2200	3.0	140
				0	other						
		0	Other	0	other						
07	PA6T/ MPMDT	1	Heat-stabilized	G35	35 % glass		1.42 to 1.52	200	10 000	8.0	250
				G45	45 % glass		1.53 to 1.63	210	12 000	8.0	250
				0	other						
		0	Other	0	other						
08	PA66 copoly-mers + blends	1	PA66/6 General purpose	G15	15 % glass		1.20 to 1.26	90	3500	3.0	180
				G35	35 % glass		1.35 to 1.45	160	7500	8.0	190
				G45	45 % glass		1.45 to 1.55	180	8500	10	200
				0	other						
		2	66/6 heat-stabilized	G15	15 % glass		1.20 to 1.26	90	3500	3.0	180
				G25	25 % glass		1.29 to 1.37	115	4500	6.5	190
				G35	35 % glass		1.35 to 1.45	160	7500	8.0	190
				G45	45 % glass		1.45 to 1.55	180	8500	10	200
				M20	20 % mineral		1.25 to 1.33	70	3000	4.0	
				M30	30 % mineral		1.35 to 1.45	75	4000	3.0	
				M40	40 % mineral		1.45 to 1.55	75	4000	3.0	
				0	other						
		3	66 + 6 general purpose	G15	15 % glass		1.20 to 1.26	100	4000	3.0	200
				G35	35 % glass		1.35 to 1.45	170	8000	9.0	210
				G45	45 % glass		1.45 to 1.55	190	10 000	10	220
				0	other						
		4	66 + 6 heat-stabilized	M20	20 % mineral		1.25 to 1.33	70	3000	3.0	
				M40	40 % mineral		1.45 to 1.55	75	4500	3.0	
		0	Other	0	other						
09	PA6 copoly-mer + blends	1	PA6 + polypropy-lene blend	1			1.00 to 1.05	50	2000	7.0	50
			Heat-stabilized	G35	35 % glass		1.23 to 1.33	150	8500	9.0	200
				R35	35 % filler		1.28 to 1.38	53	6000	2.0	135
				0	other						
		0	Other	0	other						
10	PA6T/66	1	Heat-stabilized	G35	35 % glass		1.41 to 1.51	175	9000	6.0	270
				G45	45 % glass		1.52 to 1.62	205	12000	7.5	270
				G60	60 % glass		1.72 to 1.82	230	19000	8.0	270
				0	other						
		2	High heat, heat stabi-lized	G35	35 % glass		1.39 to 1.49	180	9000	6.0	285
				G45	45 % glass		1.49 to 1.59	210	12000	9.0	285
				G60	60 % glass		1.72 to 1.82	240	19000	8.0	285
				0	other						
		3	Impact-modified	G15	15 % glass		1.17 to 1.27	90	4500	6.5	245
				G30	30 % glass		1.29 to 1.39	155	7500	6.5	255
				0	other						
		4	Flame-retardant	G35	35 % glass		1.63 to 1.73	150	9000	7.0	260
				G45	45 % glass		1.73 to 1.85	165	12000	7.0	265
				0	other						
		5	Lubricated	G35	35 % glass		1.38 to 1.48	165	8500	6.0	285
				0	other						
		6	General Purpose	1	20 % glass, reflective		1.41 to 1.51	95	7000	5.5	285
				0	other						
		0	Other	0	other						

TABLE PA Requirements for Polyamides Dry-as-Molded[A,B]

Group	Description	Class	Description	Grade	Description[C]	Viscosity Number, ISO 307, min, mL/g	Density,[D] ISO 1183 g/cm^3	Tensile Strength, ISO 527-1 and ISO 527-2, MPa, min	Tensile Modulus,[E] ISO 527-1 and ISO 527-2, MPa, min	Charpy Impact Resistance, ISO 179/ 1eA, kJ/m^2, min	Deflection Temperature,[F] ISO 75-1 and ISO 75-2, at 1.8 MPa, °C, min
11	PAMXD6	1	General purpose	G50	50 % glass		1.64 to 1.66	255	18 000	10	230
				G60	60 % glass		1.76 to 1.78	280	21 000	8.0	230
				0	other						
		0	Other	0	other						
12	PA6T/6I/66	1	Heat stabilized	G35	35 % glass		1.41 to 1.51	195	9500	7.0	265
				G45	45 % glass		1.52 to 1.62	220	14000	7.0	265
				G60	60 % glass		1.72 to 1.82	250	20000	7.0	265
				M40	40 % mineral		1.49 to 1.59	93	6000	2.5	140
				R40	40 % glass/ mineral		1.49 to 1.59	130	8000	3.0	225
				R65	65 % glass/ mineral		1.82 to 1.92	115	13000	2.0	260
				0	other						
		2	Heat stabilized, high strength	R65	65 % glass/ mineral		1.76 to 1.86	175	14500	4.5	265
				0	other						
		3	Impact-modified	1			1.09 to 1.19	58	1800	12	110
				2			1.06 to 1.16	43	1700	25	105
				3			1.05 to 1.15	50	1700	5.0	80
				4			1.08 to 1.18	62	2000	12	115
				5			1.08 to 1.18	58	1800	12	110
				6			1.09 to 1.19	52	1800	2.0	100
				G15	15 % glass		1.23 to 1.33	125	5500	5.5	240
				G25	25 % glass		1.30 to 1.40	160	7500	6.5	255
				0	other						
		4	Plating	M40	40 % mineral		1.43 to 1.53	55	3000	2.0	115
				0	other						
		5	Flame-retardant	G35	35 % glass		1.64 to 1.74	160	12000	5.5	250
				G45	45 % glass		1.74 to 1.84	170	14000	5.5	250
				0	other						
		7	Lubricated	M30	30 % mineral		1.37 to 1.47	85	5700	2.0	170
				M40	40 % mineral		1.49 to 1.59	75	5500	2.5	150
				G45	45 % glass		1.53 to 1.63	220	14000	7.0	260
				0	other						
		8	General Purpose	G35	35 % glass, reflective		1.50 to 1.60	145	8500	5.5	255
				0	other						
		0		0	other						
00	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] Refer to 9.1 for source of test pieces.

[C] No descriptions are listed unless needed to describe a special grade under the class. All other grades are listed by requirements.

[D] Test Methods D 792 is an acceptable alternative method.

[E] 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 %.

[F] Deflection temperature shall be determined with the specimen in the flatwise position (Method A_f).

[G] Weatherable nylon typically contains 1.90 to 2.25 % carbon black as determined in accordance with methods found in Test Method D 6260. It is possible that materials incorporating other pigments or soluble stabilizers, or both, may prove adequate for particular applications.

[H] Relative Viscosities for Group 03 were generated from a correlation with Test Methods D 789, utilizing an Ubbelohde viscometer, and m-Cresol as the solvent. Refer to Table X3.1, Note B for more specific information.

[I] For specific flammability requirements, use the proper suffix from Classification D 4000, for example, FL310 = V0 at 0.8 mm.

TABLE A Detail Requirements: Reinforced Polyamides[A,B]

Designation Order Number	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ISO 527, min, MPa[C]	unspecified	35	70	105	140	175	210	245	280	specify value[D]
2	Tensile modulus, ISO 527, min, MPa	unspecified	1500	4500	7500	10 500	13 500	16 500	19 500	22 500	specify value[D]
3	Charpy impact, ISO 179/1eA, min, kJ/m^2	unspecified	2.5	5.0	7.5	10.0	12.5	15.0	22.5	30.0	specify value[D]

TABLE A Detail Requirements: Reinforced Polyamides[A,B]

Designation Order Number	Property	0	1	2	3	4	5	6	7	8	9
4	Deflection temperature, ISO 75, Method A, 1.8 MPa, min, °C[E]	unspecified	50	85	110	135	160	185	200	235	specify value[D]
5	To be determined	unspecified	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

[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] Refer to 9.1 for source of test specimens.
[C] Crosshead speed shall be 50 mm/min ± 10 % unless the specimen exhibits brittle failure (no yield point) and a strain at break of <10 % in which case crosshead speed shall be 5 mm/min ± 25 %.
[D] If a specific value is required, it must appear on the drawing or contract, or both.
[E] Deflection temperature shall be determined with the specimen in the flatwise position (Method A_f).

TABLE B Detail Requirements: Unreinforced Polyamides[A,B]

Designation Order Number	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ISO 527, min, MPa[C]	unspecified	10	25	40	55	70	85	100	115	specify value[D]
2	Tensile modulus, ISO 527 min, MPa	unspecified	300	1000	1700	2400	3100	3800	4500	5200	specify value[D]
3	Charpy impact, ISO 179/1eA, min, kJ/m^2	unspecified	2.0	4.0	6.0	10.0	14.0	18.0	24.0	30.0	specify value[D]
4	Deflection temperature, ISO 75, Method A, 1.8 MPa, min, °C[E]	unspecified	40	55	70	85	100	115	130	145	specify value[D]
5	To be determined	unspecified	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

[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] Refer to 9.1 for source of test specimens.
[C] Crosshead speed shall be 50 mm/min ± 10 % unless the specimen exhibits brittle failure (no yield point) and a strain at break of <10 % in which case crosshead speed shall be 5 mm/min ± 25 %.
[D] If specific value is required, it must appear on the drawing or contract, or both.
[E] Deflection temperature shall be determined with the specimen in the flatwise position (Method A_f).

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 material shall conform to the requirements prescribed in Tables PA, A, and B, and 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 specified 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 Test pieces for relevant test methods shall be based on the injection molded ISO 3167 type multipurpose test specimen. All tests shall be conducted on as-molded (not annealed) specimens conditioned dry-as-molded. The following pieces are to be used for the listed relevant test methods:

Test Piece	Relevant Test Method
ISO 3167 Type 1A bar	Tensile strength by ISO 527 Tensile modulus by ISO 527
80 ± 2 mm by 10 ± 0.2 mm by 4 ± 0.2 mm cut from the center portion of ISO 3167 Type 1A bar	Charpy impact resistance by ISO 179/1eA Deflection temperature by ISO 75/Method Ar
Specimen approximately 10 by 10 by 4 mm cut from center of ISO 3167 Type 1A bar	Density by ISO 1183

9.2 The test specimens shall be prepared by an injection molding process as specified in ISO 294. Recommended processing temperatures are shown in Table 1.

NOTE 11—Test specimens of PA 6 and PA 66 copolymers and blends

TABLE 1 Process Temperatures for Injection Molding of Specimens

Polyamide	Viscosity Number		Plastic Melt Temperature, °C	Mold Surface Temperature, °C
PA 6	<200	unfilled	260	80
	>200	unfilled	270	80
		filled	290	80
PA 46		unfilled	305	80
		filled	305	80
PA 66		unfilled	290	80
		filled	290	80
PA11		unfilled	288	38
PA12	<210	unfilled	220	60
	>210	unfilled	240	60
		filled	240	80
PA612	<200	unfilled	250	80
	>200	unfilled	270	80
		filled	270	80
PA 6T/66		filled	325	100
PA6T/6I/66		filled	325	130
PA 6T/MPMDT		filled	325	140

may be prepared at the same process temperatures as specified for their homopolymers, without significant property loss. Selection of process temperature is made based on the major polymer component.

NOTE 12—Consult ISO 1874-2, Table 1, for a more comprehensive listing of the Conditions for Injection Moulding of Test Specimens.

9.3 Molding material-granules of the molding material used in preparation of test specimens shall contain no more than 0.2 % moisture, with the exception of PA 46 which will contain no more than 0.05 % moisture.

NOTE 13—If the moisture content exceeds the limits stated above, the material may be dried by a variety of methods such as raising the temperature of the material to 80 to 100°C in a vacuum or in a stream of dry nitrogen using a desiccant-bed drier. Drying should be continued until the moisture content is within the stated limits.

10. Conditioning

10.1 *Conditioning*—Test data shall be obtained using dry-as-molded specimens, defined as those specimens that are sealed in containers that are impermeable to water vapor within one hour after removal from the mold. Maximum moisture content of specimens shall be 0.2 %. No moisture shall be intentionally added to reach this level. Condition specimens a minimum of 24 h in sealed containers at 23 ± 2°C.

NOTE 14—Physical properties of most nylon resins are highly dependent upon the moisture content of the molded item. The user is referred to the manufacturer's literature for details.

10.2 *Test Conditions*—Conduct tests, other than solution viscosity or those tests conducted at elevated temperature, in the standard laboratory atmosphere of 23 ± 2°C and 50 ± 5 % relative humidity. Individual specimens shall not be removed from sealed containers until immediately before testing.

11. Test Methods

11.1 Determine the properties enumerated in this classification system 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 classification system 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 the tests listed as they apply:

12.2.1 Relative viscosity, or viscosity number, or both,

12.2.2 Moisture content per ISO 15512,

12.2.3 Reinforcement content,

12.2.4 Carbon black content (weather-stabilized materials), and

12.2.5 Heat stabilizer content (heat-stabilized materials, supplier's test showing positive presence).

12.3 Periodic-check inspection with reference to a specification based upon this classification system shall consist of the tests specified for all requirements of the material under this classification system. Inspection frequency shall be adequate to ensure 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, sampled, tested, and inspected in accordance with this classification system 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 results of the lot-acceptance inspection for the shipment and the results of the most recent periodic-check inspection.

13. Packing, Packaging, and Marking

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

14. Keywords

14.1 classification; classification system; line callout; polyamide; recycle; specification

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 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. Electrical Requirements

S2.1 The electrical property requirements for initial material qualification of electrical grade materials are given in Table S2.1 and the test methods in Table S2.2.

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.

S4. Conditioning

S4.1 *Nomenclature:*

S4.1.1 *Condition A*—Dry-as-molded. See Section 10.

S4.1.2 *Condition C*—Humidity conditioning.

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

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 —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 the 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.

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.

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

S5.1.3 *Step-by-Step Test*—Step-by-step testing shall be done after a short-time test. Voltage increments for the step-by-step test shall be determined from short-time results as follows:

Breakdown by short-time test, kV	Increment for step-by-step test, kV
≤12.5	0.5
>12.5 to ≤25	1.0
>25 to ≤50	2.5
>50 to ≤100	5.0
>100	10.0

TABLE S2.1 Property Values for Initial Electrical Qualification Testing

Property	Units	Value Required for Each Type of Compound Unreinforced PA			Reinforced PA	
		Type III[A] Grade E	Type VI[A] Grade E	Type VIA[A] Grade E	Type I[A] Grade A	Type II[A] Grade A
Insulation resistance, min	ohms	5×10^{12}	5×10^{12}	5×10^{12}	. . .	. . .
Dielectric strength						
step-by-step test, min	kV/mm	14.8	14.8	14.8	. . .	. . .
short-time test, min	kV/mm	. . .	. . .	. . .	14.8	14.8
Dielectric constant @ 1 MHz, max		4.0	4.0	4.0	4.2	4.2
Dissipation factor @ 1 MHz, max		0.11	0.11	0.11	0.025	0.025

[A] Types as described in Appendix X3.

TABLE S2.2 Sampling and Conditioning for Initial Qualification

Property	Test Method	Test Method Modified per	Specimens	Number Tested	Conditioning	
					Unreinforced PA	Reinforced PA
Insulation resistance	ASTM D 257	S5.1	60 × 60 × 2 mm plaque	3	C-96/23/50	. . .
Dielectric strength	IEC 60243		60 × 60 × 2 mm plaque			
step-by-step test				5	C-96/23/50	. . .
short-time test				5	. . .	A
Dielectric constant	IEC 60250		60 × 60 × 2 mm plaque	5	C-96/23/50 + D-48/50 + D-0.5/23	A
Dissipation factor	IEC 60250		60 × 60 × 2 mm plaque	5	C-96/23/50 + D-48/50 + D-0.5/23	A

APPENDIXES

(Nonmandatory Information)

X1. VISCOSITY CONVERSION: ASTM TEST METHODS D 789 and ISO 307

X1.1 The relation between relative viscosity in 90 % HCOOH (Test Methods D 789) and viscosity number in 96 % H_2SO_4 (ISO 307) was developed in an interlaboratory round-robin study by ISO TC-61 Subcommittee 9/Work Group 8 (Plastic Materials/Polyamides). Seven laboratories, including 3 U.S. laboratories (Allied, DuPont, and Monsanto), participated in the work. A 95 ± 9 % between-laboratory confidence interval was predicted for the measurements.

X1.2 For convenience, a conversion table and graph (Fig. X1.1) are provided using the following established relationship:

$$VN = A + B \times ln\,(RV) \quad \text{(X1.1)}$$

where:
VN = viscosity number (ISO 307),
RV = relative viscosity (Test Methods D 789),
A = -206.52124, and
B = 90.23355.

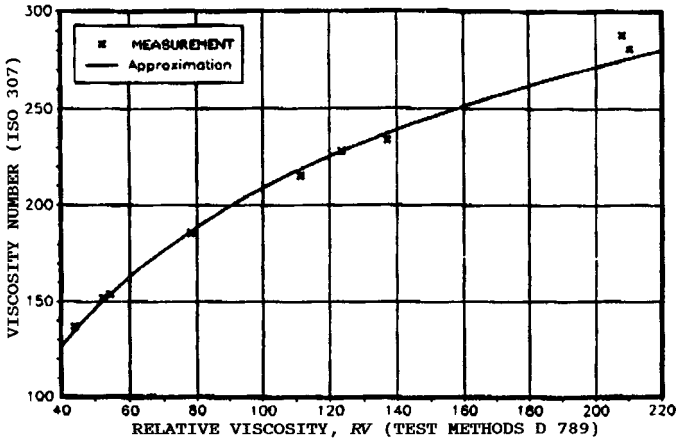

FIG. X1.1 Nylon 6 and Nylon 66 Viscosity Correlation Relative Viscosity in 90 % HCOOH (Test Methods D 789) versus Viscosity Number in 96 % $H2SO_4$ (ISO 307)

X2. MELTING POINT

X2.1 The nominal melting point of the various polyamide polymers shown in Table PA are listed below. The typical range for melting point determination is ±5°C.

X2.2 The melting point shall be determined using ISO 11357-3 except the heating rate shall be 10°C/min. The melting point, Tm, is obtained from the second melting curve.

Group	Description	Tm, °C
01	PA 66	262
02	PA 6	222
03	PA 11	190
04	PA 12	178
05	PA 612	212
06	PA 46	290
07	PA 6T/MPMDT	300
10	PA 6T/66	310

X3. CROSS-REFERENCES TO MIL-M-20693B AND L-P-395C

ASTM D6779	MIL-M-20693B
PA0111	Type I
PA0121	Type IA
PA0191	Type II
PA0511	Type III
PA0511	Type III, Grade E
PA0211	Type IV
PA0311	Type VI
PA0311	Type VI, Grade E
PA0321	Type VIA
PA0321	Type VIA, Grade E
ASTM D6779	L-P-395C
PA02G30	Type I, Grade A and Grade B
PA01G40	Type II, Grade A and Grade B

SUMMARY OF CHANGES

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

D 6779 - 03:

(*1*) Revised PA11 requirements in Table PA.

D 6779 - 02:

(*1*) Addition of callout for Group 10 (PA6T/66) in Table PA.

(*2*) Addition of Group 12 for PA6T/6I/66 materials in Table 1.