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Standard Specification for Nylon Injection and Extrusion Materials (PA)¹

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INTRODUCTION

This specification is intended to be 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 plastics 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 inherent properties of the material other than those covered by this specification, and the economics.

1. Scope

1.1 This specification covers nylon materials suitable for injection molding and extrusion. Some of these compositions are also suitable for compression molding and application from solution.

1.2 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 shall be agreed upon between the user and the supplier, by using the suffixes as given in Section 5.

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

1.4 The following safety 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.* A specific hazards statement is given in 11.2.

2. Referenced Documents

2.1 ASTM Standards:

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies²

D 150 Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials²

D 256 Test Methods for Impact Resistance of Plastics and Electrical Insulating Materials³

D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials³

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing³

D 638 Test Method for Tensile Properties of Plastics³

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load³

D 789 Test Methods for Determination of Relative Viscosity, Mating Point, and Moisture Content of Polyamide (PA)³

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials³

D 792 Test Methods for Density and Specific Gravity (Relative Density) and Density of Plastics by Displacement³

D 883 Terminology Relating to Plastics³

D 1600 Terminology for Abbreviated Terms Relating to Plastics³

D 1897 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials³

D 1898 Practice for Sampling of Plastics³

D 2584 Test Method for Ignition Loss of Cured Reinforced Resins⁴

D 3418 Test Method for Transition Temperatures of Polymers by Thermal Analysis⁴

D 3892 Practice for Packaging/Packing of Plastics⁴

D 4000 Classification System for Specifying Plastic Materials⁴

E 29 Practice for Using Significant Digits in Test Data to

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

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² Annual Book of ASTM Standards, Vol 10.01.

³ Annual Book of ASTM Standards, Vol 08.01.

⁴ Annual Book of ASTM Standards, Vol 08.02.

Determine Conformance with Specifications⁵

- 2.2 *Military and Federal Specifications and Standards:*⁶
MIL-STD-105 Sampling Procedure and Tables for Inspection by Attributes
L-P-410 Plastic, Polyamide (Nylon) Rigid: Rods, Tubes, Flats, Molded and Cast Parts
VV-I-530 Insulating Oil, Electrical (for Transformers, Switches, and Circuit Breakers)
- 2.3 *Underwriters Laboratories:*⁷
UL 94 Standards for Tests for Flammability for Parts in Devices and Appliances
- 2.4 *ISO Standard:*⁸
ISO 307 Determination of Viscosity Number of Polyamides in Dilute Solutions

3. Terminology

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

4. Classification

4.1 Unreinforced nylon materials are classified into groups according to their chemical composition. These groups are subdivided into classes and grades as shown in the Basic Property Table (Table PA).

NOTE 1—An example of this classification system is as follows. The designation PA0123 would indicate:

- PA = polyamide (nylon) as found in Terminology **D 1600**,
- 01 (group) = 66 nylon,
- 2 (class) = heat stabilized, and
- 3 (grade) = with a minimum relative viscosity of 100 and the requirements given in Table 1.

4.1.1 To facilitate the incorporation of future or special materials not covered by the Basic Property Table, the “other/unspecified” category (O) for group, class, and grade is shown on the table with the basic properties to be obtained from Tables A or B as they apply (see 4.3).

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

4.2.1 Reinforcements and additive materials. A symbol (single-letter) will be used for the major reinforcement or combination, or both, along with two numbers which indicate the percentage of addition by mass with the tolerances as tabulated below.

Symbol	Material	Tolerance (Based on the Total Mass)
C	Carbon and graphite fiber	± 2 %
G	Glass	± 2 %

Symbol	Material	Tolerance (Based on the Total Mass) by agreement between the supplier and the user
L	Lubricants (for example, PTFE, graphite, silicone, and molybdenum disulfide)	
M	Mineral	± 2 %
R	Combinations of reinforcements or fillers, or both	± 3 % for the total reinforcement

NOTE 2—This part of the system uses percent of reinforcements or additives, or both, in the control 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 established by the use of the suffix part of the system, Section 5.

NOTE 3—Ash content of filled or reinforced materials may be determined using Test Method **D 2584** where applicable.

4.2.2 *Table A, Detail Requirements—Reinforced Nylons*—An identifying number is made up of the letter A and five digits comprising the cell numbers for the new requirements in the designated order as they appear in Table A.

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

4.2.3 When the grade of the basic material is not known or is not important, the use of “0” grade classification will be used for reinforced materials in this system. (See **Note 6**.)

NOTE 4—An example of a reinforced nylon of this classification system is as follows. The designation PA0315G30A22450 would indicate the following material requirements from Table A:

- PA0315 = 11 nylon, from Table PA,
- G30 = glass reinforced at 30 % nominal (see 4.2.1),
- A = Table A property requirements,
- 2 = 70 MPa tensile strength, min,
- 2 = 4500 MPa flexural modulus, min,
- 4 = 100 J/m Izod impact, min,
- 5 = 160°C deflection temperature at 1.82 MPa, min, and
- 0 = unspecified.

If no properties are specified, the designation would be PA0315G30A00000.

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 specification. This table will be used in a manner similar to Table A.

NOTE 5—Pigmented or colored nylons 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 Izod impact and elongation values. In a typical white pigmented nylon, elongation losses of up to 50 % and Izod impact losses of up to 30 % are common. If specific properties of pigmented nylons are required, a testing program should be arranged by the material supplier or the end user, or both. Once these arrangements are reached, a cell callout using Table B should be employed to insure proper property compliance.

NOTE 6—An example of a special material using this classification system is as follows. The designation PA0220B54220 would indicate the following, with the material requirements from Table B:

- PA0220 = 6 nylon, heat stabilized, from Table PA,
- B = Table B property requirements,
- 5 = 70 MPa tensile strength, min,
- 4 = 2400 MPa flexural modulus, min,
- 2 = 40 J/m Izod impact, min,
- 2 = 55°C deflection temperature at 1.82 MPa, min, and
- 0 = unspecified.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.
⁶ Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
⁷ Available from Underwriters Laboratories, Inc., Publication Stock, 333 Pfingsten Road, Northbrook, IL 60062.
⁸ Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

TABLE PA Requirements for Nylon Dry-as-Molded

Group	Description	Class	Description	Grade	Description ^A	Relative Viscosity, ^B min, ASTM D 789	Melt Point, °C, ASTM D 3418, DTA or DSC ^{C,D}	Specific Gravity, ASTM D 792	Tensile Strength, ^E ASTM D 638, min, MPa	Elongation ^F (ultimate) ASTM D 638, %, min	Flexural Modulus, ^F ASTM D 790, min, MPa	Izod Impact Resistance, ^G ASTM D 256, min, J/m	Deflection Temperature, ^H °C, min, ASTM D 648 @ 1.82 MPa	Moisture ^I "as received," ASTM D 789, %, max	
01	66 Nylon	1	General-purpose	1		45	250–265	1.13–1.15	76	50	2 600	50	63	0.25	
				2		60	250–265	1.13–1.15	76	50	2 600	50	63	0.20	
				3		100	250–265	1.13–1.15	76	50	2 600	50	63	0.15	
				4		200	250–265	1.13–1.15	76	100	2 600	50	63	0.15	
				5	recycled	35	250–265	1.13–1.15	76	10	2 600	50	63	0.30	
				6	recycled	45	250–265	1.13–1.15	76	25	2 600	50	63	0.25	
				7	recycled	45	250–265	1.13–1.15	76	50	2 600	50	63	0.25	
				0	other										
		2	Heat-stabilized	1		45	250–265	1.13–1.15	76	40	2 600	40	63	0.25	
				2		60	250–265	1.13–1.15	76	40	2 600	40	63	0.20	
				3		100	250–265	1.13–1.15	76	40	2 600	40	63	0.15	
				4		200	250–265	1.13–1.15	76	100	2 600	40	63	0.15	
				5	recycled	35	250–265	1.13–1.15	76	10	2 600	40	63	0.30	
				6	recycled	45	250–265	1.13–1.15	76	20	2 600	40	63	0.25	
				7	recycled	45	250–265	1.13–1.15	76	40	2 600	40	63	0.25	
				0	other										
		3	Nucleated	1		45	250–265	1.13–1.15	83	20	2 800	40	63	0.25	
				2		60	250–265	1.13–1.15	83	20	2 800	40	63	0.20	
				3		100	250–265	1.13–1.15	83	20	2 800	40	63	0.15	
				4		200	250–265	1.13–1.15	83	20	2 800	40	63	0.15	
				5	recycled	45	250–265	1.13–1.15	83	15	2 600	40	63	0.25	
				6	recycled	45	250–265	1.13–1.15	83	20	2 600	40	63	0.25	
				0	other										
				4	Nucleated, heat-stabilized	1		Requirements the same as corresponding grades under Group 1 Class 3							
		2													
		3													
		4													
		0	other												
5	Highly nucleated	1		45	250–265	1.13–1.15	90	5	2 900	40	63	0.25			
		2		60	250–265	1.13–1.15	90	5	2 900	40	63	0.20			
		3		100	250–265	1.13–1.15	90	5	2 900	40	63	0.15			
		4		200	250–265	1.13–1.15	90	5	2 900	40	63	0.15			
		0	other												
6	Impact-modified	1		...	250–265	1.09–1.11	58	55	1 700	150	...	0.20			
		2		...	250–265	1.06–1.09	48	50	1 500	800	...	0.20			
		3	recycled	...	250–265	1.09–1.11	50	40	1 600	80	60	0.20			
		0	other												
7	Impact-modified, heat-stabilized	1		...	250–265	1.09–1.11	58	55	1 700	150	60	0.20			
		2		...	250–265	1.06–1.09	48	50	1 500	800	63	0.20			
		3	recycled	...	250–265	1.09–1.11	50	40	1 600	90	60	0.20			
		0	other												
8	Weather-stabilized ^J	1		45	250–265	1.14–1.16	83	20	2 700	40	65	0.20			
		2	recycled	...	250–265	1.14–1.16	65	10	2 500	30	...	0.20			
		0	other												
9	Flexural-modified, heat-stabilized	1		80	190–220	1.12–1.16	45	250	525 max	150	...	0.20			
		0	other												

TABLE PA Requirements for Nylon Dry-as-Molded

Group	Description	Class	Description	Grade	Description ^A	Relative Viscosity, ^B min, ASTM D 789	Melt Point, °C, ASTM D 3418, DTA or DSC ^{C,D}	Specific Gravity, ASTM D 792	Tensile Strength, ^E ASTM D 638, min, MPa	Elongation ^F (ultimate) ASTM D 638, %, min	Flexural Modulus, ^F ASTM D 790, MPa	Izod Impact Resistance, ^G ASTM D 256, min, J/m	Deflection Temperature, ^H °C, min, ASTM D 648 @ 1.82 MPa	Moisture ^I "as received," ASTM D 789, %, max		
		0	Other	0	other											
02	6 Nylon	1	General-purpose	1		30	210–225	1.12–1.14	76	40	2 600	40	58	0.20		
				2		40	210–225	1.12–1.14	76	40	2 600	50	58	0.20		
				3		50	210–225	1.12–1.14	76	100	2 600	50	58	0.20		
				4		95	210–225	1.12–1.14	76	150	2 600	55	58	0.20		
				5		200	210–225	1.12–1.14	76	200	2 600	55	58	0.20		
				6	recycled	30	210–225	1.12–1.14	68	25	2 600	40	58	0.20		
				7	recycled	40	210–225	1.12–1.14	68	35	2 600	40	58	0.20		
				8	recycled	40	210–225	1.12–1.14	76	40	2 600	40	58	0.20		
				0	other											
				2	Heat-stabilized	1		30	210–225	1.12–1.14	76	40	2 600	40	58	0.20
		2				40	210–225	1.12–1.14	76	40	2 600	50	58	0.20		
		3				50	210–225	1.12–1.14	76	100	2 600	50	58	0.20		
		4				95	210–225	1.12–1.14	76	150	2 600	55	58	0.20		
		5				200	210–225	1.12–1.14	68	200	2 600	55	58	0.20		
6	recycled	30	210–225			1.12–1.14	68	25	2 600	40	58	0.20				
7	recycled	40	210–225			1.12–1.14	68	35	2 600	40	58	0.20				
8	recycled	40	210–225			1.12–1.14	76	40	2 600	40	58	0.20				
0	other															
G10	10 % glass	...	...			...	...	70	...	3 200	25	135	...
G15	15 % glass	...	...	...	...	105	...	4 500	40	185	...		
G30	30 % glass	...	...	...	...	140	...	7 500	75	200	...		
G45	45 % glass	...	...	...	...	175	...	10 500	100	200	...		
G00	other															
M35	35 % mineral	...	...	...	...	63	...	3 600	50	...	...			
M40	40 % mineral	...	...	...	...	80	...	4 100	25	85	...		
M00	other															
R20	20 % filler	...	...	...	...	90	...	4 200	25	185	...		
R40	40 % filler	...	...	...	...	105	...	6 200	25	185	...		
R00	other															
3	Nucleated		1		30	210–225	1.12–1.15	82	10	2 800	35	63	0.20			
			2		40	210–225	1.12–1.15	82	10	2 800	40	63	0.20			
			3		50	210–225	1.12–1.15	82	50	2 800	40	63	0.20			
			4		95	210–225	1.12–1.15	82	100	2 800	45	63	0.20			
			5		200	210–225	1.12–1.15	82	100	2 800	45	63	0.20			
			6	recycled	30	210–225	1.12–1.15	70	10	2 800	35	63	0.20			
			7	recycled	40	210–225	1.12–1.15	70	10	2 800	40	63	0.20			
			8	recycled	40	210–225	1.12–1.15	82	10	2 800	40	63	0.20			
			0	other												
			4	Nucleated, heat-stabilized		1										
2																
3																
4																
5																
6																
7																
8																

Requirements the same as corresponding grades under Group 2 Class 3

TABLE PA Requirements for Nylon Dry-as-Molded

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				0	other									
		5	Flexural-modified	1		...	185–225	1.05–1.16	27	50	700 max	80	33	0.20
				2		...	185–225	1.05–1.16	34	50	1 400 max	80	35	0.20
				3		...	185–225	1.05–1.16	41	50	2 100 max	80	38	0.20
				4		...	185–225	1.05–1.16	55	50	2 800 max	80	44	0.20
				0	other									
		6	Flexural-modified, heat-stabilized	1										
				2										
				3										
				4										
				0	other									
		7	Impact-modified	1		...	185–225	1.05–1.16	55	50	1 890	55	44	0.20
				2		...	185–225	1.05–1.16	27	50	690	105	33	0.20
				3		...	185–225	1.05–1.16	27	50	550	265	33	0.20
				4		...	185–225	1.05–1.16	27	50	275	425	33	0.20
				5	recycled	...	210–225	1.05–1.16	55	30	1 890	69	65	0.20
				0	other									
		8	Impact-modified, heat-stabilized	1										
				2										
				3										
				4										
				0	other									
		0	Other	0	other									
03	11 Nylon	1	General-purpose	1		1.53–1.58	185–195	1.03–1.06	41	200	900	55	35	0.15
				2		1.59–1.67	185–195	1.03–1.06	45	200	900	55	40	0.12
				3		1.67–1.82	185–195	1.03–1.06	45	200	900	55	40	0.10
				4		1.83–2.00	185–195	1.03–1.06	48	200	900	55	40	0.08
				5	hydrolysis-resistant ^K	1.83–2.00	185–195	1.03–1.06	48	200	900	55	40	0.08
				0	other									
		2	Heat-stabilized	1		1.59–1.67	185–195	1.03–1.06	45	200	900	55	40	0.12
				2		1.67–1.82	185–195	1.03–1.06	45	200	900	55	40	0.10
				3		1.83–2.00	185–195	1.03–1.06	48	200	900	55	40	0.08
				4	hydrolysis-resistant	1.83–2.00	185–195	1.03–1.06	48	200	900	55	40	0.08
				0	other									
		3	Highly plasticized	1		1.59–1.67	185–195	1.03–1.06	45	250	300	80	35	0.10
				2		1.67–1.82	185–195	1.03–1.06	52	250	300	80	35	0.08
				3		1.83–2.00	185–195	1.03–1.06	52	250	300	80	35	0.08
				4		2.00 min	185–195	1.03–1.06	52	250	300	80	35	0.08
				0	other									
		4	Highly plasticized, heat-stabilized	1										
				2										

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<https://standards.iteh.ai/catalog/standards/sist/8eal0e-bd3e-21492f68e53e/astm-d4066-94b>

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				3										
				4										
				0	other									
		5	Moderately plasticized	1		1.59–1.67	185–195	1.03–1.06	45	250	350	80	35	0.10
				2		1.83–2.00	185–195	1.03–1.06	52	250	350	80	35	0.08
				3		1.59–1.67	185–195	1.03–1.06	45	225	450	80	35	0.08
				4		1.83–2.00	185–195	1.03–1.06	52	225	450	80	35	0.08
				5		1.83–2.00	185–195	1.03–1.06	52	225	600	80	35	0.08
				0	other									
		6	Moderately plasticized, heat-stabilized	1										
				2										
				3										
				4										
				5										
				0	other									
		0	Other	0	other									
04	12 Nylon	1	General-purpose	1		1.50–2.05	170–185	1.01–1.06	30	140	800	25 ^L	35 ^M	0.10
				2		1.50–2.05	170–185	1.01–1.06	35	150	1 000	25	35	0.10
				3		2.06–2.35	170–185	1.01–1.06	35	150	1 000	25	35	0.10
				4		2.36–2.70	170–185	1.01–1.06	35	150	1 000	25	35	0.10
				0	other									
		2	Heat-stabilized	1		1.50–1.75	170–185	1.00–1.06	35	150	800	25 ^L	35 ^M	0.10
				2		1.76–2.05	170–185	1.00–1.06	35	150	800	25	35	0.10
				3		2.06–2.40	170–185	1.00–1.06	35	150	1 000	25	35	0.10
				0	other									
		3	Nucleated	1		1.50–1.90	170–185	1.00–1.06	35	100	800	10 ^L	35 ^M	0.10
				2		1.91–2.25	170–185	1.00–1.06	35	100	800	25	35	0.10
				0	other									
		4	Plasticized	1		1.50–2.40	165–180	1.00–1.06	30	180	300–550	200 ^L	...	0.10
				2		1.50–2.40	165–180	1.00–1.06	30	200	300–550	200	...	0.10
				3		1.50–2.40	170–185	1.00–1.06	30	200	450–750	100	...	0.10
				0	other									
		5	Plasticized, heat-stabilized	1		1.50–2.40	160–175	1.00–1.06	20	200	200–350	200 ^L	...	0.10
				2		1.50–2.40	165–180	1.00–1.06	30	180	300–550	200	...	0.10
				3		1.50–2.40	165–180	1.00–1.06	30	200	300–550	200	...	0.10
				4		1.50–2.40	170–185	1.00–1.06	30	200	450–750	100	...	0.10
				5		1.50–2.40	170–185	1.00–1.06	35	200	550–950	50	...	0.10
				0	other									
		0	Other	0	other									
05	69 Nylon	1	General-purpose	1		30	208–220	1.07–1.09	60	50	1 900	40	47	0.20
				2		45	208–220	1.07–1.09	60	50	1 900	40	47	0.20
				3		100	208–220	1.07–1.09	60	50	1 900	40	47	0.20
				0	other									
		2	Heat-stabilized	1		30	208–220	1.07–1.09	60	50	1 900	40	47	0.20
				2		45	208–220	1.07–1.09	60	50	1 900	40	47	0.20

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