



Designation: **D5336–15a** **D5336 – 21**

Standard Classification System and Basis for Specification for Polyphthalamide (PPA) Injection Molding Materials¹

This standard is issued under the fixed designation D5336; 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 polyphthalamide (PPA) materials suitable for injection molding.

1.2 The properties included in this classification system are those required to identify the compositions covered. Other requirements necessary to identify particular characteristics important to specialized applications are to be specified by using suffixes as given in Section 5.

1.3 This classification system allows for the use of recycled materials provided that all specification requirements are met.

1.4 This classification system is intended to be a means of calling out plastics materials used in the fabrication of end items or parts. It is not intended for the selection of materials. Material selection can be made by those having expertise in the plastics field only 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 (see **IEEE/ASTM SI-10**). The values given in parentheses are for information only.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in 11.7.1.

NOTE 1—There is no known ISO equivalent to this standard. ISO 16936-1/-2 for polyamides may also be used to describe and classify these PPA materials, but the technical content is significantly different.

NOTE 2—ASTM Standard **D6779** on polyamide materials also includes PPA materials in its coverage of various polyamide chemistries. This standard gives additional information for classification and specification for PPA compositions classified as Group 10 (PA6T/66), Group 12 (PA6T/6I/66) and Group 13 (PA6T/6I) in ASTM Standard **D6779** and includes provisions for other PPA compositions to utilize the classification presented.

1.7 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

¹ This standard 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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*A Summary of Changes section appears at the end of this standard

2. Referenced Documents

2.1 *ASTM Standards:*²

- D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
- D618 Practice for Conditioning Plastics for Testing
- D638 Test Method for Tensile Properties of Plastics
- D648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
- D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- D883 Terminology Relating to Plastics
- D1600 Terminology for Abbreviated Terms Relating to Plastics
- D2857 Practice for Dilute Solution Viscosity of Polymers
- D3418 Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
- D3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials
- ~~D3801 Test Method for Measuring the Comparative Burning Characteristics of Solid Plastics in a Vertical Position~~
- ~~D3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer~~
- D3892 Practice for Packaging/Packing of Plastics
- D4000 Classification System for Specifying Plastic Materials
- D5225 Test Method for Measuring Solution Viscosity of Polymers with a Differential Viscometer
- D5630 Test Method for Ash Content in Plastics
- D6779 Classification System for and Basis of Specification for Polyamide Molding and Extrusion Materials (PA)
- D6869 Test Method for Coulometric and Volumetric Determination of Moisture in Plastics Using the Karl Fischer Reaction (the Reaction of Iodine with Water)
- D7209 Guide for Waste Reduction, Resource Recovery, and Use of Recycled Polymeric Materials and Products (Withdrawn 2015)³
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System

2.2 *Underwriters Laboratories Standard:*

- UL94 Standard for Tests for Flammability of Plastic Materials⁴

2.3 *ISO Standards:*⁵

- ~~ISO 75-1 Determination of Temperature of Deflection Under Load—Part Under Load—Part 1: General Test Methods~~
- ~~ISO 75-2 Determination of Temperature of Deflection Under Load—Part Under Load—Part 2: Plastics and Ebonite~~
- ~~ISO 179-1 Determination of Charpy Impact Strength—Part 1: Non-Instrumented Impact Test~~
- ~~ISO 294-1 Injection Moulding of Test Specimens of Thermoplastic Materials—Part 1: General Principles, Multipurpose-Test Specimens and Bars~~
- ISO 527-1 Determination of Tensile Properties—Part 1: General Principles
- ISO 527-2 Determination of Tensile Properties—Part 2: Testing Conditions
- ISO 3451-1 Determination of Ash General Methods
- ISO 3451-4 Determination of Ash, Polyamides
- ISO 15512 Determination of Water Content
- ISO 16396-1/-2 Plastics — Polyamide (PA) moulding and extrusion materials

3. Terminology

3.1 *Definitions*—The terminology used in this classification system is in accordance with Terminologies **D883** and **D1600**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *polyphthalamide, PPA, n*—a polyamide in which residues of terephthalic acid or isophthalic acid or a combination of the two comprise at least 55 molar percentage of the dicarboxylic acid portion of the repeating structural units in the polymer chain.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from Underwriters Laboratories (UL), 333 Pfingsten Rd., Northbrook, IL 60062-2096, <http://www.ul.com>.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

4. Classification

4.1 The polyphthalamide materials are designated “PPA,” as specified in Terminology **D1600**.

4.2 Unreinforced polyphthalamide materials are classified into groups according to crystallinity. These groups are subdivided into classes and grades as shown in Table PPA.

NOTE 3—An example of this classification system is as follows:

The designation PPA0121 would indicate from Table PPA:

PPA	= Polyphthalamide as found in Terminology D1600
01 (Group)	= Semicrystalline PPA
2 (Class)	= Low-temperature molding material
1 (Grade)	= With the corresponding requirements shown in Table PPA

4.2.1 To facilitate the incorporation of future or special materials, the “other/unspecified” category (00) for group, (0) for class, and (0) for grade is shown. The basic properties of the material can be obtained from Table A as they apply.

4.3 Reinforced and lubricated versions of the polyphthalamide materials are classified in accordance with Tables PPA and A, where Table PPA specifies the unreinforced material and Table A the properties after the addition of reinforcements or lubricants at the nominal level indicated (see **4.3.1**).

NOTE 4—This part of the classification system uses the percent of reinforcements or additives, or both, in the callout of the modified basic material. The types and percentages of reinforcements and additives is sometimes shown on the supplier’s technical data sheet. If necessary additional callout of these reinforcements and additives can be accomplished by use of the suffix 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 grade designation. For example, a material with a nominal glass fiber level of 33 % is included with Grade G35.

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TABLE PPA Requirements for Unreinforced Polyphthalamide Resins

Group	Description	Class	Description	Grade	Description	Inherent Viscosity ^A , dL/g	Melting Temperature, ^B °C	Glass Transition ^B , Tg, °C
01	semicrystalline	1	high-temperature molding	1		0.80-1.06	305-320	115-130
				2		0.70-1.00	315-330	115-130
	PPA	2	low-temperature molding	0	Other			
				1		0.80-1.05	320-335	90-105
				2		0.85-0.95	290-305	85-95
				3		0.85-1.05	300-315	85-95
0	Other	0	Other					
00	Other	0	Other	0	Other			

^APractice D2857 or Test Method D5225 with conditions as specified in 11.7 of this classification system.

^BTest Method D3418 using a heating rate of 10°C/min.

TABLE A Detail Requirements of Special Reinforced PPAs Using ASTM Methods

NOTE—All mechanical properties are determined on dry-as-molded injection molded specimens.

Property	0	1	2	3	4	5	6	7	8	9
Inherent viscosity, ^A Test Method D2857 or D5225, dL/g, min	^B	0.60	0.7	0.75	0.8	0.85	0.9	0.95	1	^C
Tensile strength, Test Method D638 ^D , MPa ^E (psi), min	^B	45 (6500)	75 (10 900)	90 (13 000)	100 (14 500)	135 (19 600)	200 (29 000)	230 (33 400)	255 (37 000)	^C
Flexural modulus, Test Method D790 ^F , GPA (kpsi), min	^B	1.5 (218)	2.5 (363)	3.0 (435)	5.5 (798)	6.5 (943)	10.0 (1450)	13.5 (1958)	15.0 (2175)	^C
Izod impact, Test Method D256 ^G J/m ^H (ft-lbf/in), min	^B	20 (0.38)	40 (0.75)	60 (1.1)	90 (1.6)	100 (1.9)	350 (6.6)	500 (9.4)	650 (12.1)	^C
Deflection Temperature Test Method D648 ^I , °C, min	^B	100	125	160	185	210	235	260	285	^C

^ASee 11.7 of this classification system for specific conditions.

^BUnspecified requirement.

^CSpecific value must be given in call-out.

^DTest Method D638, Type I tensile bar. The speed of testing shall be as described in 11.2 of this classification system.

^EMPa × 145 = psi.

^FTest Method D790 with a 1-mm (0.05-in./min) testing speed.

^GTest Methods D256, Test Method A.

^HJ/m × 0.01873 = ft-lb/in.

^ITest Method D648, using 1820-kPa (264-psi) stress.

TABLE B Detail Requirements of Special Reinforced PPAs Using ISO Methods

NOTE—All mechanical properties are determined on dry-as-molded injection molded specimens.

Property	0	1	2	3	4	5	6	7	8	9
Tensile strength, ISO 527 MPa min ^A	^B	45	75	90	100	135	200	230	255	^C
Tensile modulus, ISO 527 GPa min ^D	^B	1.5	3.5	5.5	7.5	9.5	12.0	14.0	18.0	^C
Charpy, ISO 179-1, J/m ² , min ^E	^B	2.0	4.0	5.5	7.5	9.0	11.0	13.0	15.0	^C
Deflection Temperature Under Load, ISO 75-2 method Af, °C, min ^F	^B	100	125	160	185	210	235	260	285	^C
To be determined	^B									

^AISO 527, Type IA tensile bar. The speed of testing shall be as described in 12.2 of this classification system.

^BUnspecified requirement.

^CSpecific value must be given in call-out.

^DISO 527, Type 1A tensile bar. The Speed of testing shall be 1 mm/min.

^EISO 179-1, Test specimen shall be taken from the center portion of multipurpose tensile bar.

^FISO 75-2, The test specimen shall be taken from the center portion of the multipurpose tensile bar, 4 mm thick, and tested in the flatwise position.

4.3.1 Reinforced, filled, and lubricated variations of the basic materials are identified by a single letter from Table 1 that indicates the filler and/or reinforcement used and two digits to indicate the nominal quantity in percent by weight. A second letter, from Table 1A, when desired, is used to indicate the form or structure of the reinforcement and/or filler, but not used for functional mixtures. Thus, a letter designation G for glass, E for beads or spheres or balls, and 33 for percent by weight, GE33, specifies a reinforced or filled material with 33 percent by weight in the form of glass beads, spheres or balls. The reinforcement letter designations and associated tolerance levels are shown in the previous table (1). Form and structure letter designations are shown in the following table (1A).

TABLE 1 Reinforcement-Filler^A Symbols^B and Tolerances

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

^AAsh content of filled and/or reinforced materials is to be determined using either Test Method D5630 or ISO 3451-1:2003 where applicable.

^BAdditional symbols will be added to this table as required.

TABLE 1A Symbols for the Form or Structure of Fillers and Reinforcing Materials

Symbol	Form or Structure
C	Chips, cuttings
D	Fines, powders
E	Beads, spheres, balls
F	Fiber
G	Ground
H	Whiskers
K	Knitted fabric
L	Layer
M	Mat (fabric, thick)
N	Non-woven (fabric, thin)
P	Paper
R	Roving
S	Flake
T	Cord
V	Veneer
W	Woven fabric
Y	Yarn
X	Not specified

4.3.2 Tables A and B Detail Requirements—An identifying number is made up of the letter “A” or “B,” depending on whether ASTM or ISO test methods are used, and five digits comprising the cell numbers in the order in which the properties appear.

4.3.2.1 Although the values listed in Tables A and B are necessary to include the range of properties available in existing materials, this does not imply that every possible combination of the properties exists or can be obtained.

4.3.3 An example of this classification system for a 33 % glass-reinforced polyphthalamide material, using ASTM test methods (Table A) is as follows:

PPA0121G33A56577

PPA0121	=	Semicrystalline, low-temperature molding grade polyphthalamide from Table PPA,
G33	=	Glass reinforced at 33 % nominal,
A	=	Table A property requirements,
5	=	Inherent viscosity, min 0.85 dL/g,
6	=	Tensile strength, min 200 MPa,
5	=	Flexural modulus, min 6.5 GPa,
7	=	Izod impact, min 500 J/m,
7	=	Deflection temperature, min 260°C, and

If no properties are specified, the designation would be PPA0121G33.

5. Suffixes

5.1 When additional requirements are needed for the materials covered in this classification system that are not covered in Tables PPA, A, or B, then those requirements shall be designated through the use of suffixes.

5.1.1 A list of suffixes found in Classification System D4000 (Table 3) is useful for additional requirements as appropriate.

~~5.2 Flammability callouts were changed in 2007. Therefore callouts written before 2007 are different from those written in 2007 and later.~~

~~5.2.1 If the requirements for the polyphthalamide material in 4.3.3 also included flammability requirements, the following example illustrates the call-out based on ASTM D4000-04:~~

	PPA0121G33A06577FL34
PPA0121G33A06577 = Same as 4.3.3	
F	= Flammability requirements
L	= UL94 recognition required
3	= UL recognition at 0.80 mm min thickness
4	= UL rating 94V-0

~~5.2.2 The following example illustrates the call-out based on ASTM D4000-07:~~

	PPA0121G33A06577FF003
PPA0121G33A065770 = Same as 4.3.3	
F	= Flammability requirements
F	= Vertical burn rate by ASTM D3801 or UL 94V
0	= Rating of designation V-0
03	= 0.80 mm minimum specimen thickness

6. General Requirements

6.1 Basic requirements from Tables PPA and A or B, as they apply, are always in effect unless these requirements are superseded by specific suffix requirements, which always take precedence. Properties in Tables A and B supersede properties in Table PPA when reinforced or filled materials are specified.

6.2 The material compositions shall be uniform and shall conform to the requirements specified herein.

7. Detail Requirements

7.1 The materials shall conform to the requirements prescribed in Tables PPA and A or B, and the suffix requirements as they apply.

7.2 For the purpose of determining conformance, all specified limits for a specification (line callout) are absolute limits, as defined in Practice E29.

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

8. Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of 12.4. A batch/lot of material shall be considered as a unit of manufacture as prepared for shipment, and is permitted to consist of two or more “production runs” or batches.

9. Specimen Preparation

9.1 Mold test specimens by an injection molding process (see Practice D3641 or ISO 294). Use the following conditions:

Class	Grade	Melt Temperature° C (°F)	Mold Temperature min, °C (°F)
1	1	325-335 (620-635)	135 (275)
2	2	335-345 (635-650)	135 (275)
2	1 and 3	330-345 (625-650)	65 (150)
2	2	320-330 (605-625)	65 (150)

9.2 Materials used in the preparation of test specimens shall contain no more than 0.2 % moisture.

NOTE 6—If the moisture content exceeds the limits previously stated, drying the material by methods such as at a temperature of 80 - 100°C in vacuum or in a stream, of nitrogen or in a desiccant bed dryer, or both, until the moisture content is within the stated limits have been found to be satisfactory.

10. Conditioning

10.1 Obtain test data using dry-as-molded specimens, defined as those that upon removal from the mold are immediately sealed in containers that are impermeable to water vapor. Condition specimens a minimum of 2 h in sealed containers at $23 \pm 2^\circ\text{C}$ prior to testing.

NOTE 7—Physical properties of polyphthalamides are dependent upon the moisture content of the molded item. Refer to the manufacturers' literature for details. Due to their aromatic nature, PPAs pick up moisture at a significantly slower rate than aliphatic polyamides such as PA6 and PA66, and are thus less susceptible to this issue than those polyamides.

10.2 Conduct tests, other than solution viscosity and those conducted at elevated temperatures, in the standard laboratory atmosphere (see Practice D618) of $23 \pm 2^\circ\text{C}$ and $50 \pm 10\%$ relative humidity. Do not remove individual specimens from sealed containers until immediately before testing.

NOTE 8—The tolerance specified is the maximum allowed variation around the set points. It is not to be taken as the range of acceptable set points.

11. Test Methods

11.1 Determine the properties enumerated in this classification system by means of test methods referenced.

11.2 *Tensile Strength*—Test Method D638, using a Type I test specimen or ISO 527, using Type 1A specimens. A testing speed of 5 mm (0.2 in.)/min or 50 mm (2.0 in.)/min if elongation exceeds 10 %.

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NOTE 9—ASTM D638 and ISO 527 could yield different results.

11.3 *Flexural Strength*—Test Methods D790, using a testing speed of 1 mm (0.05 in.)/min.

11.4 *Izod Impact*—Test Methods D256, Test Method A.

11.5 *Charpy Impact*—ISO 179-1, Method 1eA

11.6 *Deflection Temperature*—Test Method D648, using a maximum outer fiber stress of 1.82 Mpa (264 psi), or ISO 75-2, Method Af with a specimen height of 4.0 mm.

NOTE 10—Test Method D648 and ISO 75-2 will probably yield different heat distortion temperatures.

11.7 *Inherent Viscosity (IV)*—Test Method D2857 or D5225 with the following modifications:

11.7.1 *Solvent*—~~Prepare~~ Use a filtered solution containing a 60/40 weight percent of phenol/ tetrachloroethane (TCE). (**Warning**—Phenol tetrachloroethane is a very dangerous solvent. It is toxic by ingestion, inhalation, and absorption. Refer to the appropriate material safety data sheet for information on the proper handling of this material.)

11.7.2 *Sample Size*—Use a sample size of 0.400 ± 0.003 g of resin/100 mL of solvent. IV determinations are not recommended for materials that contain fillers or reinforcements. However, if the sample does contain filler, select the appropriate sample size from the following table: