Designation: D 5336 – 03

Standard Specification for Polyphthalamide (PPA) Injection Molding Materials[1]

This standard is issued under the fixed designation D 5336; 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 polyphthalamide materials suitable for injection molding.

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

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

1.4 This specification 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 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.

1.5 The values stated in SI units are to be regarded as the standard (see IEEE/ASTM SI-10).

1.6 The following precautionary caveat pertains only to the test methods portion, Section 12, 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.* Specific precautionary statements are given in Note 6.

NOTE 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

D 618 Practice for Conditioning Plastics for Testing

D 638 Test Method for Tensile Properties of Plastics

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position

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

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

D 883 Terminology Relating to Plastics

D 1600 Terminology for Abbreviated Terms Relating to Plastics

D 2857 Practice for Dilute Solution Viscosity of Polymers

D 3418 Test Method for Transition Temperatures of Polymers by Differential Scanning Calorimetry

D 3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials

D 3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer

D 3892 Practice for Packaging/Packing of Plastics

D 4000 Classification System for Specifying Plastic Materials

D 4019 Test Method for Moisture in Plastics by Coulometric Regeneration of Phosphorus Pentoxide

D 5225 Test Method for Measuring Solution Viscosity of Polymers with a Differential Viscometer

D 5630 Test Method for Ash Content in Thermoplastics

D 5740 Guide for Writing Material Standards in the D 4000 Format

E 29 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 Materials[3]

3. Terminology

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

[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] 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] Available from Underwriters Laboratories (UL), Corporate Progress, 333 Pfingsten Rd., Northbrook, IL 60062.

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

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.

4. Classification

4.1 The polyphthalamide materials will be designated" PPA," as specified in Terminology D 1600.

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 2—An example of this classification system is as follows:

The designation PPA0121 would indicate from Table PPA:

PPA	= Polyphthalamide as found in Terminology D 1600
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.

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 PPA	1	high-temperature molding	1		0.80-1.06	305-320	115-130
				0	Other			
		2	low-temperature molding	1		0.85-1.05	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	0	Other			
00	Other	0	Other	0	Other			

[A]Practice D 2857 or Test Method D 5225 with conditions as specified in 12.6 of this specification.

[B]Test Method D 3418 using a heating rate of 10°C/min.

TABLE A Detail Requirements of Special Reinforced PPAs

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 D 2857, dL/g, min	[B]	0.60	0.7	0.75	0.8	0.85	0.9	0.95	1	[C]
Tensile strength, Test Method D 638[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 D 790[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 D 256[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 D 648[I], °C, min	[B]	100	125	160	185	210	235	260	285	[C]

[A]See 12.6 of this specification for specific conditions.

[B]Unspecified requirement.

[C]Specific value must be given in call-out.

[D]Test Method D 638, Type I tensile bar. The speed of testing shall be as described in 12.2 of this specification.

[E]MPa × 145 = psi.

[F]Test Method D 790 with a 1-mm [0.05-in.]/min testing speed.

[G]Test Methods D 256, Test Method A.

[H]J/m × 0.01873 = ft-lb/in.

[I]Test Method D 648, using 1820-kPa [264-psi] stress.

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).

4.3.1 A single letter shall be used to indicate the major reinforcement, or filler, or combinations of reinforcements or fillers, or both, along with two digits that indicate the percentage of additive(s) by total mass, with tolerances as tabulated as follows:

Symbol	Material	Tolerance (Based on the Total Mass)
C	Carbon or graphite fiber	±3 %
G	Glass reinforced	±3 %
L	Lubricants	by agreement between the supplier and the user
M	Mineral	±3 %
R	Combinations of reinforcements or fillers, or both	±3 % for the total reinforcement or filler, or both

4.3.1.1 This part of the specification uses the type and percentage of additive to designate the modification of the basic material. To facilitate this designation, the type and percentage of additive can be shown on the supplier's technical data sheet unless it is proprietary in nature. If necessary, additional requirements shall be indicated by use of the suffix part of the system, as given in Section 5.

4.3.2 *Table A Detail Requirements*—An identifying number is made up of the letter "A" and five digits comprising the cell numbers in the order in which the properties appear.

4.3.2.1 Although the values listed in Table A 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.

4.3.3 An example of this classification system for a 33 % glass-reinforced polyphthalamide material 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 specification that are not covered in Tables PPA or A, then those requirements shall be designated through the use of suffixes.

5.1.1 A list of suffixes can be found in Classification System D 4000 (Table 3) and may be used for additional requirements as appropriate.

5.2 If the requirements for the polyphthalamide material in 4.3.3 also included flammability requirements, the following example illustrates the call-out:

PPA0121G33A56577FL34

PPA0121G33A56577 = 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

6. Basic Requirements

6.1 Basic requirements from Tables PPA and A, as they apply, are always in effect unless these requirements are superseded by specific suffix requirements, which always take precedence.

7. General Requirements

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

8. Detail Requirements

8.1 Test specimens for the various materials shall conform to the requirements prescribed in Tables PPA and A, and the suffix requirements as they apply.

8.2 For the purpose of determining conformance, all specified limits in this specification are absolute limits, as defined in Practice E 29.

8.2.1 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 this specification is based on this comparison.

9. Sampling

9.1 Sampling shall be statistically adequate to satisfy the requirements of 13.4. A lot of material shall be considered as a unit of manufacture as prepared for shipment, and may consist of two or more "production runs" or batches.

10. Specimen Preparation

10.1 Mold test specimens by an injection molding process (see Practice D 3641). Use the following conditions:

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

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

NOTE 3—If the moisture content exceeds the limits previously stated, the material may be dried by a variety of methods such as a temperature of 80 - 100°C in vacuum or a stream, of nitrogen or a desiccant bed dryer, or both, until the moisture content is within the stated limits.

11. Conditioning

11.1 Obtain test data using dry-as-molded specimens, defined as those that immediately upon removal from the mold are sealed in containers that are impermeable to water vapor. Condition specimens a minimum of 12 h in sealed containers at 23 ± 2°C prior to testing.

NOTE 4—Physical properties of polyphthalamides are dependent upon the moisture content of the molded item. The user should refer to the manufacturer's literature for details.

11.2 Conduct tests in the standard laboratory atmosphere (see Practice D 618) of 23 ± 2°C and 50± 5 % relative humidity. Do not remove individual specimens from sealed containers until immediately before testing.

12. Test Methods

12.1 Determine the properties enumerated in this specification by means of test methods referenced.

12.2 *Tensile Strength*—Test Method D 638, using a Type I test specimen and a testing speed of 5 mm [0.2 in.]/min or 50 mm [2.0 in.]/min if elongation exceeds 10 %.

12.3 *Flexural Strength and Modulus*—Test Methods D 790, using a testing speed of 1 mm [0.05 in.]/min.

12.4 *Izod Impact*—Test Methods D 256, Test Method A.

12.5 *Deflection Temperature*—Test Method D 648, using a maximum outer fiber stress of 1820 kPa [264 psi].

12.6 *Inherent Viscosity*—Test Method D 2857 or D 5225 with the following modifications:

12.6.1 *Solvent*—Prepare a filtered solution containing a 60/40 weight percent of phenol/S tetrachloroethane (TCE).

NOTE 5—**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.

12.6.2 *Sample Size*—Use a sample size of 0.400 ± 0.003 g of resin/100 mL of solvent. If the sample contains filler, take the appropriate sample size from the following:

% Ash	Sample Size, g
10	0.4444
20	0.5000
25	0.5333
30	0.5714
35	0.6154
40	0.6666
45	0.7273

NOTE 6—A sample size to produce a resin concentration of 0.4 g/100mL shall be used. The sample sizes shown in the table were calculated by the following equation:

$$\text{sample weight} = \frac{0.4}{100 - \%\ \text{filler}} \times 100 \quad (1)$$

12.6.3 Dissolve the sample in the inherent viscosity (IV) solvent by heating and stirring on a hot plate. Monitor the temperature with a surface thermometer to be sure that it does not exceed 130°C.

12.6.4 If the sample contains a filler, it must be filtered to remove the filler after all of the resin has dissolved.

12.6.5 *Calculation*:

$$IV = \frac{\ln = \frac{S_t}{B_t}}{(S_w)\frac{(100 - \%\ \text{ash})}{100}} \quad (2)$$

where:

IV = inherent viscosity at 30°C, dL/g,
S_t = average sample flow time, s,
B_t = average blank flow time, s, and
S_w = sample weight, g.

12.7 *Moisture*:

12.7.1 Moisture can be determined coulometrically by either of the methods described in 12.8 and 12.9.

12.8 *Moisture Determination Using the Mitsubishi Moisture Analyzer*:

12.8.1 *Scope*—This test method describes the procedure for measuring moisture content of polyphthalamides using the Mitsubishi[4] moisture analyzer.

12.8.2 *Reagents and Apparatus*:

12.8.2.1 *Cathode Solution*—(Aquamicron CS), anode solution (Aquamicron AS), iodine, sample boat, analytical balance (accurate to 0.0001 g), nitrogen (containing less than 5 ppm water), Mitsubishi moisture analyzer or equivalent, sample pushrod.

12.8.3 *Procedure*:

12.8.3.1 Set up the instrument in accordance with the manufacturer's instructions.

12.8.3.2 Set the temperature to 245°C. Set the N_2 sweep gas at a flow rate of 200 mL/min. The N_2 should pass through a predried desiccant tube.

12.8.3.3 Weigh the sample and container to the nearest 0.0001 g. (The sample must be in a sealed serum vial.)

12.8.3.4 Transfer 0.5 to 0.7 g of sample to a clean, dry, sample boat and recap the vial.

12.8.3.5 Insert the sample boat into the sample chamber and start the test.

12.8.3.6 Reweigh the vial, with the remaining sample, accurately to 0.0001 g.

12.8.3.7 The moisture content of the sample is printed out by the instrument.

12.9 *Moisture Determination*—Determine of moisture content of PPA in accordance with Test Method D 4019 except that the oven temperature shall be set at 240°C.

13. Inspection and Certification

13.1 Inspection and certification of the materials supplied under this specification shall be for conformance to the requirements specified herein.

13.2 Lot acceptance inspection shall be the basis on which acceptance or rejection of a lot is made. The lot acceptance inspection shall consist of the following tests that ensure process control during manufacturing as well as those necessary to ensure certifiability in accordance with 13.4.

13.2.1 Inherent viscosity, when applicable,

13.2.2 Moisture content, and

13.2.3 Reinforcement content (see Test Method D 5630), when applicable.

13.3 A periodic check inspection shall consist of the tests specified for all requirements of the materials under this specification. Inspection frequency shall be adequate to ensure the material is certifiable in accordance with 13.4.

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

13.5 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.

14. Packaging and Package Marking

14.1 For packing, packaging, and practice marking, the provisions of Practice D 3892 apply.

15. Keywords

15.1 inherent viscosity; line call-out; moisture analysis; molding material; plastic; polyphthalamide

[4] Available from Mitsubishi Kasei America, Inc., 81 Main St., Suite 401, White Plains, NY 10601.

SUMMARY OF CHANGES

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

D 5336 – 03:

(*1*) The three grades in Group 01, Class 1 have been consolidated to a single Grade.

(*2*) The inherent viscosity ranges for Group 01, Class 2, Grades 1 and 3 have been changed from 0.95-1.05 to 0.85-1.05.

D 5336 – 00:

(*1*) Paragraph 1.3—Added a statement on the use of recycled materials.

(*2*) Note 2 was removed.

(*3*) Section 2—Some reference documents were deleted and others added.

(*4*) Paragraph 3.2.1—The definition of polyphthalmide was modified to accommodate new products.

(*5*) Note 3 was renumbered as Note 2 and was changed to reflect changes in Table PPA.

(*6*) Section 5 was completely revised for simplification.

(*7*) Paragraph 10.1—Note 3 was deleted and replaced by a molding conditions table.

(*8*) Paragraph 10.2—Moisture limits were added.

(*9*) Note 3 was added to provide some guidance for drying the materials before molding.

(*10*) Paragraph 12.2—A testing speed for materials which elongate more than 10 % was added.

(*11*) Paragraph 12.6.1 was simplified.

(*12*) Paragraph 12.7 was expanded to include moisture determination in accordance with Test Method D 4019.

(*13*) Paragraph 12.8 was added to cover moisture determinations by the Mitsubishi moisture analyzer. This was previously covered in paragraph 12.7. In addition, some of the conditions for running this test were revised.

(*14*) Paragraph 12.9 was added to specify conditions for determining moisture in accordance with Test Method D 4019.

(*15*) Table PPA was completely revised to reflect new products available, and mechanical properties were removed.

(*16*) Table A—The inherent viscosity cells were changed to allow for new products. Also, the minimum values in Cell 1 for tensile strength were lowered from 60 to 45 Mpa and for Izod impact from 25 to 20 J/m.

(*17*) A Summary of Changes section was added.