Designation: D5336 – 15a

# Standard Classification System and Basis for Specification for Polyphthalamide (PPA) Injection Molding Materials[1]

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 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 and health 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.

## 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
D6869 Test Method for Coulometric and Volumetric Determination of Moisture in Plastics Using the Karl Fischer Reaction (the Reaction of Iodine with Water)

[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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[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.

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

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 Materials[4]

2.3 *ISO Standards:*[5]
ISO 75-1 Determination of Temperature of Deflection Unnder Load – Part 1:General Test Methods
ISO 75-2 Determination of Temperature of Deflection Unnder 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

## 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.

## 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 2—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 3—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 4—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.

[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.

**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 | | | 0 | Other | | | |
| | | 2 | low-temperature molding | 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 | 0 | Other | | | |
| 00 | Other | 0 | Other | 0 | Other | | | |

[A]Practice D2857 or Test Method D5225 with conditions as specified in 11.7 of this classification system.
[B]Test 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, 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] |

[A]See 11.7 of this classification system for specific conditions.
[B]Unspecified requirement.
[C]Specific value must be given in call-out.
[D]Test Method D638, Type I tensile bar. The speed of testing shall be as described in 11.2 of this classification system.
[E]MPa × 145 = psi.
[F]Test Method D790 with a 1-mm (0.05-in.)/min testing speed.
[G]Test Methods D256, Test Method A.
[H]J/m × 0.01873 = ft-lb/in.
[I]Test 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] | | | | | | | | | |

[A]ISO 527, Type IA tensile bar. The speed of testing shall be as described in 12.2 of this classification system.
[B]Unspecified requirement.
[C]Specific value must be given in call-out.
[D]ISO 527, Type 1A tensile bar. The Speed of testing shall be 1 mm/min.
[E]ISO 179-1, Test specimen shall be taken from the center portion of multipurpose tensile bar.
[F]ISO 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 |

[A]Ash content of filled and/or reinforced materials is to be determined using either Test Method D5630 or ISO 3451-1 where applicable.
[B]Additional 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

PPA0121G33A65770 = 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 | 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 5—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 ± 2°C prior to testing.

NOTE 6—Physical properties of polyphthalamides are dependent upon the moisture content of the molded item. Refer to the manufacturers' literature for details.

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

NOTE 7—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 %.

NOTE 8—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 9—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 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:

| % 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 10—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:

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

11.7.3 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.

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

11.7.5 *Calculation:*

$$IV = \ln(S_t / B_t)/C \quad (2)$$

where:

$IV$ = inherent viscosity at 30°C, dL/g,
$S_t$ = average sample flow time, s,
$B_t$ = average blank flow time, s, and
$C$ = polymer concentration, g/dl.

11.8 *Moisture*—Test methods D6869 or ISO 15512, Method B.

## 12. Inspection and Certification

12.1 Inspection and certification of the materials 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 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 12.4.

12.2.1 Inherent viscosity only for unreinforced or unfilled polymer as described in Table PPA.

12.2.2 Moisture content, and

12.2.3 Filler content (see Test Method D5630 or ISO 3451), when applicable.

12.3 A periodic check inspection shall consist of the tests specified for all requirements of the materials 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).

NOTE 11—The ASTM publication, *Manual on Presentation of Data and Control chart Analysis, 7th Edition*, Stock number MNL7A, provides detailed information about statistical process control.

12.5 A report of test results shall be furnished when requested. The report shall consist of results of the lot-acceptance inspection for the shipment, the percent by weight of recycled plastic, as defined in 3.1.47 of Guide D7209, if requested, and the results of the most recent periodic-check inspection.

## 13. Packaging and Marking

13.1 For packing, packaging, and practice marking, the provisions of Practice D3892 apply.

## 14. Keywords

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

# APPENDIX

**(Nonmandatory Information)**

## X1. CALCULATION FOR VISCOSITY NUMBER (VN)

X1.1 Viscosity number (VN) is defined as the ratio of the viscosities of the (dilute) solution of the polymer to the viscosity of the solvent divided by the concentration of the polymer in the solvent. In this instance efflux time (t) can be substituted for viscosity (η).

$$VN = ((t - t_c / t_o - t_{oc}) - 1)/C \quad (0)$$

$VN$ = viscosity number,
$t$ = flow time of the sample,
$t_c$ = Hagenbach correction of the solution,
$t_o$ = flow time of the solvent,
$t_{oc}$ = Hagenbach correction of the solvent, and
$C$ = polymer concentration.

Assuming the correction factors for the solution and solvent approach zero the equation becomes,
$VN = ((t / t_o) - 1) / C$, or when using the symbols as in 11.7.5 of this standard,

$$VN = ((S_t / B_t) - 1)/C \quad (0)$$

$VN$ = viscosity number,
$S_t$ = average sample flow time,
$B_t$ = average solvent flow time, and
$C$ = polymer concentration.

To further elaborate on the situation where the IV is known and the VN needs to be calculated, we note that 11.7.5 by the equation: $IV = ln\ (S_t / B_t) / C$.

This can be re-arranged to: $(S_t / B_t) = e^{(C \times IV)}$

Substituting in the VN equation, this leads to:
$VN = (e^{(C \times IV)} - 1 / C)$

Using the above relation for C = 0.4 of PCTE as used in 11.7 of this standard, leads to following correlation table (Table X1.1).

**TABLE X1.1 Correlation Table**

| IV | VN | IV | VN | IV | VN | IV | VN |
|---|---|---|---|---|---|---|---|
| 0.70 | 81 | 0.82 | 97 | 0.94 | 114 | 1.06 | 132 |
| 0.71 | 82 | 0.83 | 98 | 0.95 | 116 | 1.07 | 134 |
| 0.72 | 83 | 0.84 | 100 | 0.96 | 117 | 1.08 | 135 |
| 0.73 | 85 | 0.85 | 101 | 0.97 | 119 | 1.09 | 137 |
| 0.74 | 86 | 0.86 | 103 | 0.98 | 120 | 1.10 | 138 |
| 0.75 | 87 | 0.87 | 104 | 0.99 | 121 | 1.11 | 140 |
| 0.76 | 89 | 0.88 | 105 | 1.00 | 123 | 1.12 | 141 |
| 0.77 | 90 | 0.89 | 107 | 1.01 | 124 | 1.13 | 143 |
| 0.78 | 92 | 0.90 | 108 | 1.02 | 126 | 1.14 | 144 |
| 0.79 | 93 | 0.91 | 110 | 1.03 | 127 | 1.15 | 146 |
| 0.80 | 94 | 0.92 | 111 | 1.04 | 129 | 1.16 | 148 |
| 0.81 | 96 | 0.93 | 113 | 1.05 | 130 | 1.17 | 149 |

NOTE: Using a different concentration or a different solvent would change the results.

## SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D5336 - 15) that may impact the use of this standard. (October 1, 2015)

*(1)* Added Guide D7209 to 2.1.
*(2)* Revised Table 1.
*(3)* Added Note 3, Note 4, and Note 7, and subsequent notes were renumbered.
*(4)* Revised 4.3.
*(5)* Added Table 1A.
*(6)* Deleted 4.3.1.1, which is now included in 4.3.1.
*(7)* Revised 12.5.
*(8)* Added Appendix X1.
*(9)* Some editorial changes were made.

Committee D20 has identified the location of selected changes to this standard since the last issue (D5336 - 09) that may impact the use of this standard. (April 1, 2015)

*(1)* This five year review included editorial changes.
*(2)* The title was changed.
*(3)* Added Note 5 and renumbered subsequent notes.
*(4)* Deleted old Section 7. The requirements in old Section 7 are now included in Section 6 and the new Section 7. Renumbered subsequent sections.