



Designation: **D4349 – 16** **D4349 – 22**

Classification System and Basis for Specification for Polyphenylene Ether (PPE) Materials¹

This standard is issued under the fixed designation D4349; 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 the basic polymers and copolymers known as polyphenylene ethers and polyphenylene oxides, as well as filled, modified, and reinforced versions. Recycled materials are included in this standard as Class 5 of Table PPE.

NOTE 1—~~Addition~~ The addition to the natural polymer or copolymer of pigments, colorants, or other additives can cause the final composition to no longer meet the requirements specified for the natural polymer or copolymer.

NOTE 2—The preferred abbreviation for polyphenylene ether is PPE, as noted in Terminology **D1600**.

1.2 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 standard.

1.3 There may be other requirements necessary to identify particular characteristics important to specific applications. These are to be specified by using the suffixes described in Section 5. <https://standards.iteh.ai/catalog/standards/sist/f8bdac88-7fcd-4a1b-91d8-27894fedaf44/astm-d4349-22>

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

NOTE 3—There is no known ISO equivalent to this standard.

1.5 *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.*

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](#)

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.

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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

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
D3892 Practice for Packaging/Packing of Plastics
D4000 Classification System for Specifying Plastic Materials
D5630 Test Method for Ash Content in Plastics (Withdrawn 2022)³
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
2.2 *Underwriters Laboratories:*
UL 94 Standards for Tests for Flammability for Parts in Devices and Appliances⁴
2.3 *ISO Standards:*⁵
ISO 3451-1 Plastics—Determination of ash—Part 1: General methods

3. Terminology

- 3.1 The terminology used in this classification is in accordance with Terminologies **D883** and **D1600**.
- 3.2 The polyphenylene ether materials will be designated PPE as specified in Terminology **D1600**.

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

⁴ Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, <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 Polyphenylene ether-based materials are classified into groups according to their compositions. These groups are subdivided into classes and grades, as shown in Basic Property Table PPE.

NOTE 4—An example of this classification system is as follows:

The specification ASTM D4349 PPE 0223 would indicate:

| | | |
|-----|---|-----------------------------------------|
| PPE | = | polyphenylene ether, |
| 02 | = | polystyrene-modified material (Group), |
| 2 | = | flame retarded (Class Description), and |
| 3 | = | requirements given in Table PPE. |

4.1.1 Reinforced, filled, and lubricated versions of PPE materials are classified according to the reinforcement used and the nominal level, by weight percent, of the reinforcement. The grade is identified by a single letter that indicates the filler or reinforcement used and two digits that indicate the nominal quantity in percent by weight. Thus, a grade containing 15 % glass reinforcement would be indicated by PPE0110 G15. This callout indicates:

PPE = polyphenylene ether ___ as found in Terminology D1600,

01 = unmodified (group),

1 = general purpose (class),

0 = other (grade), and

G15 = 15 % glass reinforcement

The reinforcement letter designations and associated tolerance levels are shown in [Table 1](#).

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

| Symbol | Material | Tolerance |
|--------|-------------------------------------------------------------|----------------------------------------------------|
| C | Carbon and graphite | ±2 % |
| D | Alumina trihydrate | ±2 % |
| E | Clay | ±2 % |
| F | Cellulose | ±2 % |
| G | Glass | ±2 % |
| H | Aramid | ±2 % |
| J | Boron | ±2 % |
| K | Calcium carbonate | ±2 % |
| L | Lubricants (for example: PTFE, graphite) | Depends upon material and process—to be specified. |
| M | Mineral | ±2 % |
| N | Natural organic (for example: cotton, sisal, hemp, flax) | ±2 % |
| P | Mica | ±2 % |
| Q | Silica | ±2 % |
| R | Combinations of reinforcements and/or fillers | ±3 % |

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

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

NOTE 5—This part of the system uses the type and percentage of additives, fillers, and reinforcements to designate the modification of the basic material. The types and percentages are sometimes shown on the supplier's technical data sheet. If necessary, additional control of these compositional variables can be accomplished using the suffix part of the system, Section 5.

NOTE 6—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 as shown in 4.1.1.

4.1.1.1 Although the values listed are necessary to include the standards of properties available in existing materials, not every possible combination of the properties exist or can be obtained.

TABLE PPE Requirements for Polyphenylene Ether (PPE) Materials

NOTE 1—Values given are for natural materials only. Other colors can be different.^A

| Group Description | Class Description | Grade Description | Heat Deflection, min | | Specific Gravity, ASTM D792, min | Tensile Strength, MPa, min | Flexural Modulus, MPa, min | Izod Impact, J/m, min | |
|--------------------------|-------------------------------|-------------------------------|------------------------------------|--------------------------------------------|----------------------------------|----------------------------|----------------------------|-----------------------|-----|
| | | | at 1.82 MPa, D648, ^B °C | at 0.450, 0.455 MPa, D648, ^B °C | | | | | |
| 01 Unmodified | 1 general purpose | 0 other | E | | | | | | |
| | 2 flame retarded ^F | 0 other | E | | | | | | |
| | 0 other | 0 other | E | | | | | | |
| 02 PS modified materials | 1 general purpose | 1 | 90 | N/A ^G | 1.03 | 32 | 1750 | 265 | |
| | | 2 | 100 | N/A ^G | 1.03 | 38 | 1900 | 240 | |
| | | 3 | 100 | N/A ^G | 1.03 | 44 | 2150 | 185 | |
| | | 4 | 110 | N/A ^G | 1.04 | 55 | 2300 | 160 | |
| | | 5 | 130 | N/A ^G | 1.05 | 57 | 2300 | 160 | |
| | | 0 other | ... | ... | ... | ... | ... | ... | ... |
| | 2 flame retarded ^F | 1 | 67 | N/A ^G | 1.06 | 36 | 2200 | 190 | |
| | | 2 | 80 | N/A ^G | 1.07 | 40 | 2250 | 130 | |
| | | 3 | 85 | N/A ^G | 1.07 | 48 | 2350 | 100 | |
| | | 4 | 105 | N/A ^G | 1.07 | 55 | 2350 | 160 | |
| | | 5 | 125 | N/A ^G | 1.08 | 60 | 2500 | 160 | |
| | | 0 other | ... | ... | ... | ... | ... | ... | ... |
| | 03 PA modified materials | 1 general purpose | 1 | N/A ^G | 145 | 1.05 | 50 | 2000 | 170 |
| 2 | | | N/A ^G | 155 | 1.05 | 50 | 2000 | 160 | |
| 3 | | | N/A ^G | 170 | 1.05 | 50 | 1800 | 530 | |
| 4 | | | N/A ^G | 180 | 1.05 | 55 | 2000 | 185 | |
| 5 | | | N/A ^G | 195 | 1.05 | 58 | 2200 | 160 | |
| | | 0 other | ... | ... | ... | ... | ... | ... | |
| | | 2 flame retarded ^F | 0 other | E | | | | | |
| | | 0 other | 0 other | ... | ... | ... | ... | ... | |
| 04 Other | 1 general purpose | 0 other | ... | ... | ... | ... | ... | ... | |
| | 2 flame retarded ^F | 0 other | ... | ... | ... | ... | ... | ... | |
| | 0 other | 0 other | ... | ... | ... | ... | ... | ... | |
| 05 Rework modified | 1 general purpose | 0 other | ... | ... | ... | ... | ... | ... | |
| | 2 flame retarded ^F | 0 other | ... | ... | ... | ... | ... | ... | |
| | 0 other | 0 other | ... | ... | ... | ... | ... | ... | |

- ^A Use Tables A and B where necessary for colored materials.
^B See Table 2 for drying and molding conditions. Table 3 for test specimen sizes.
^C MPa × 145 = psi.
^D J/m × 0.01873 = ft·lbf/in.
^E Unfilled materials currently not available. Use Table A.
^F Flammability ratings determined in accordance with UL 94.
^G N/A—Not applicable for grade description.

TABLE A Reinforced Polyphenylene Ether Materials, Details Requirements

| Designation Order Number | Property | Cell Limits | | | | | | | | | |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------|-------------|------|------|------|------|------|------|------|--------|---------------|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | Heat deflection temperature, ^A D648, ^B 1.82 MPa, °C, min | unspecified | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | specify value |
| 2 | Heat deflection temperature, ^A D648, ^B 0.45 MPa, °C, min D648, ^B 0.455 MPa, °C, min | unspecified | 180 | 190 | 200 | 210 | 220 | 230 | 240 | 250 | specify value |
| 3 | Tensile strength, D638, ^B MPa, ^C min | unspecified | 45 | 55 | 65 | 80 | 100 | 120 | 140 | 160 | specify value |
| 4 | Flexural modulus, D790, ^B MPa, ^C min | unspecified | 2000 | 3000 | 4000 | 5000 | 6000 | 7500 | 9000 | 10 500 | specify value |
| 5 | Izod impact, D256, ^B J/m, ^D min | unspecified | 25 | 50 | 75 | 100 | 125 | 150 | 200 | 250 | specify value |

^A For specifying HDT use the “order number” corresponding to the appropriate test conditions for the material being defined. It is intended that one or the other of these requirements be used unless specific agreement between the supplier and the user requires both.

^B See Table 3 for test specimen sizes.

^C MPa × 145 = psi.

^D J/m × 0.01873 = ft·lbf/in.

TABLE B Unreinforced Polyphenylene Ether Materials, Details Requirements

| Designation Order Number | Property | Cell Limits | | | | | | | | | |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------|-------------|------|------|------|------|------|------|------|------|---------------|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | Heat deflection temperature, ^A D648, ^B 1.82 MPa, °C, min | unspecified | 65 | 75 | 85 | 95 | 105 | 115 | 125 | 135 | specify value |
| 2 | Heat deflection temperature, ^A D648, ^B 0.45 MPa, °C, min D648, ^B 0.455 MPa, °C, min | unspecified | 125 | 135 | 145 | 155 | 165 | 175 | 185 | 195 | specify value |
| 3 | Tensile strength, D638, ^B MPa, ^C min | unspecified | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | specify value |
| 4 | Flexural modulus, D790, ^B MPa, ^C min | unspecified | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 | 3300 | 3600 | specify value |
| 5 | Izod impact, D256, ^B J/m, ^D min | unspecified | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 600 | specify value |

^A For specifying HDT use the “order number” corresponding to the appropriate test conditions for the material being defined. It is intended that one or the other of these requirements be used unless specific agreement between the supplier and the user requires both.

^B See Table 3 for test specimen sizes.

^C MPa × 145 = psi.

^D J/m × 0.01873 = ft·lbf/in.

4.2 When the grade of the basic material is not known, or is not important, the use of “0” grade classification shall be used for reinforced materials in this system.

NOTE 7—An example of this classification system for a reinforced polyphenylene ether is as follows: The designation ASTM D4349 PPE 210G30A22245 indicates the following material requirements from Table A:

| | | |
|---------|--------------|------------------------------------------------------------|
| PPE 210 | = | polystyrene-modified polyphenylene ether from Table PPE, |
| G30 | = | glass-reinforced at nominal 30 % (see 4.2), |
| A | = | Table A Property requirements, |
| 2 | = | 110°C deflection temperature at 1.82 MPa, min, |
| 2 | = | 190°C deflection temperature at 0.45 MPa, min, |
| 2 | = | 190°C deflection temperature at 0.455 MPa, min, |
| 2 | = | 55-MPa tensile strength, min, |
| 4 | = | 5000-MPa flexural modulus, min, and |
| 5 | = | 125-J/m Izod impact, min. |

If no properties are specified, the designation would be ASTM D4349 PPE 210G30A00000.

4.3 Table B has been incorporated into this classification system to facilitate the classification of special materials where Table PPE or Table A do not reflect the required properties. Table B shall be used in the same manner as Table A.

NOTE 8—Mechanical properties of pigmented or colored polyphenylene ether materials can differ from the mechanical properties of natural polyphenylene ether material, depending on the choice and concentration of colorants. The main property affected is ductility, as illustrated by a reduction in Izod impact strength and tensile elongation values. If specific properties of pigmented polyphenylene ether materials are required, a classification using Table B should be used to designate those properties.

NOTE 9—An example of a special material using this classification system is as follows: The designation ASTM D4349 PPE0310B54220 indicates the following, with the material requirements from Table B:

| | | |
|----------|--------------|------------------------------------------------------------|
| PPE 0310 | = | polyamide-modified polyphenylene ether from Table PPE, |
| B | = | Table B Property Requirements, |
| 5 | = | 105°C deflection temperature at 1.82 MPa, min, |
| 4 | = | 155°C deflection temperature at 0.45 MPa, min, |
| 4 | = | 155°C deflection temperature at 0.455 MPa, min, |
| 2 | = | 35-MPa tensile strength, min, |
| 2 | = | 1800-MPa flexural modulus, min, and |
| 0 | = | unspecified Izod Impact. |

<https://standards.iteh.ai/catalog/standards/sist/f8bdac88-7fcd-4a1b-91d8-27894fedaf44/astm-d4349-22>

4.4 Group 5 has been included in Table PPE to allow line call-out designation for “recycle” resins. Class and grades given should be used with the property ranges from Table A or B, as appropriate.

4.5 Requirements for materials tested using ISO specimen dimensions are not covered by this classification system. Classification System **D4000** can be used to list property requirements involving ISO criteria as long as detailed notes describing specimen dimensions, test speeds, and so forth, are included.

5. Suffixes

5.1 When additional requirements are needed and 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, which can be used for additional requirements as appropriate, ~~appropriate~~, is found in Classification System **D4000** (Table 3). Additional suffixes will be added to that standard 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 materials shall conform to the requirements prescribed in Tables PPE, A and B, and suffix requirements, as they apply.

7.2 For the purpose of determining conformance with this classification systems, all specified limits in this standard 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 this classification system is based on this comparison.

8. Sampling

8.1 Sampling shall be statistically adequate to satisfy 12.4.

8.2 A batch or lot is a unit of manufacture as prepared for shipment and can consist of a blend of two or more “production runs.”

9. Specimen Preparation

9.1 The test specimens shall be injection molded.

9.2 Mechanical properties can vary with injection molding conditions. Drying and molding conditions to be used are listed in Table 2.

10. Conditioning

10.1 Where test specimens are stored in controlled temperature/humidity chambers, the chamber atmosphere should be $23 \pm 5^\circ\text{C}$ and $50 \pm 4\%$ RH. Dry, air-conditioned air is acceptable. Otherwise, test specimens shall be conditioned in the standard laboratory atmosphere in accordance with Procedure A of Practice D618 before performing the required tests.

10.2 Testing conditions should be stable for a minimum of 2 h to ensure stable performance of electronics. Conduct those tests influenced by ambient conditions in the standard laboratory atmosphere of $23 \pm 2^\circ\text{C}$ and $50 \pm 10\%$ relative humidity.

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 8.1 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. Lot acceptance inspection includes all those requirements listed in this classification system.

TABLE 2 Drying and Molding Parameters

| Table PPE | Dry Time, h | Dry Temperature, $^\circ\text{C}$ | Melt Temperature, $^\circ\text{C}$ | Mold Temperature, $^\circ\text{C}$ |
|----------------------|----------------|-----------------------------------------|------------------------------------------|------------------------------------------|
| Group 1 | 2.0 | 120 | 355 | 88 |
| Group 2 ^A | 0.5–1.5 | 95–120 | 220–320 | 65–88 |
| Group 3 ^B | 3.0–6.0 | 120 | 300 | 88 |

^A Materials with lower heat deflection values are dried and molded at the lower end of the time and temperatures listed.

^B Material not in sealed packaging will require dry time at the high end of the range listed.