



Standard Classification System for Reinforced and Filled Poly(Phenylene Sulfide) (PPS) Injection Molding and Extrusion Materials Using ASTM Methods¹

This standard is issued under the fixed designation D 4067; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This classification system covers reinforced and filled poly(phenylene sulfide) materials suitable for injection molding and extrusion.

1.2 This classification system is not intended for the selection of materials, but only as a means to call out plastic materials to be used for the manufacture of parts. The selection of these materials shall be made by personnel with expertise in the plastics field where the environment, inherent properties of the materials, performance of the parts, part design, manufacturing process, and economics are considered.

1.3 The properties included in this classification system are those required to identify the compositions covered. If necessary, other requirements identifying particular characteristics important to specific applications shall be designated by using the suffixes given in Section 5 or Classification System D 4000.

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

1.5 This precautionary statement pertains only to the test method portion of this classification system, Section 12. *This standard does not purport to address all of the safety concerns 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.*

NOTE 1—There is no known ISO equivalent to this standard.

2. Referenced Documents

2.1 ASTM Standards:²

D 256 Test Methods for Determining the Izod Pendulum

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.

Current edition approved September 10, 2003. Published November 2003. Originally approved in 1982. Last previous edition approved in 1996 as D 4067 – 96.

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.

Impact Resistance of Plastics²

D 618 Practice for Conditioning Plastics for Testing²

D 638 Test Method for Tensile Properties of Plastics²

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position²

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials²

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement²

D 883 Terminology Relating to Plastics²

D 1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer²

D 1600 Terminology for Abbreviated Terms Relating to Plastics²

D 1898 - 68(1989) Practice for Sampling of Plastics³

D 3418 Test Method for Transition Temperatures of Polymers by Differential Scanning Calorimetry²

D 3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials²

D 3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer²

D 3892 Practice for Packaging/Packing of Plastics²

D 4000 Classification System for Specifying Plastic Materials²

D 5630 Test Method for Ash Content in Plastics²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specification²

E 595 Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment²

E 662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials²

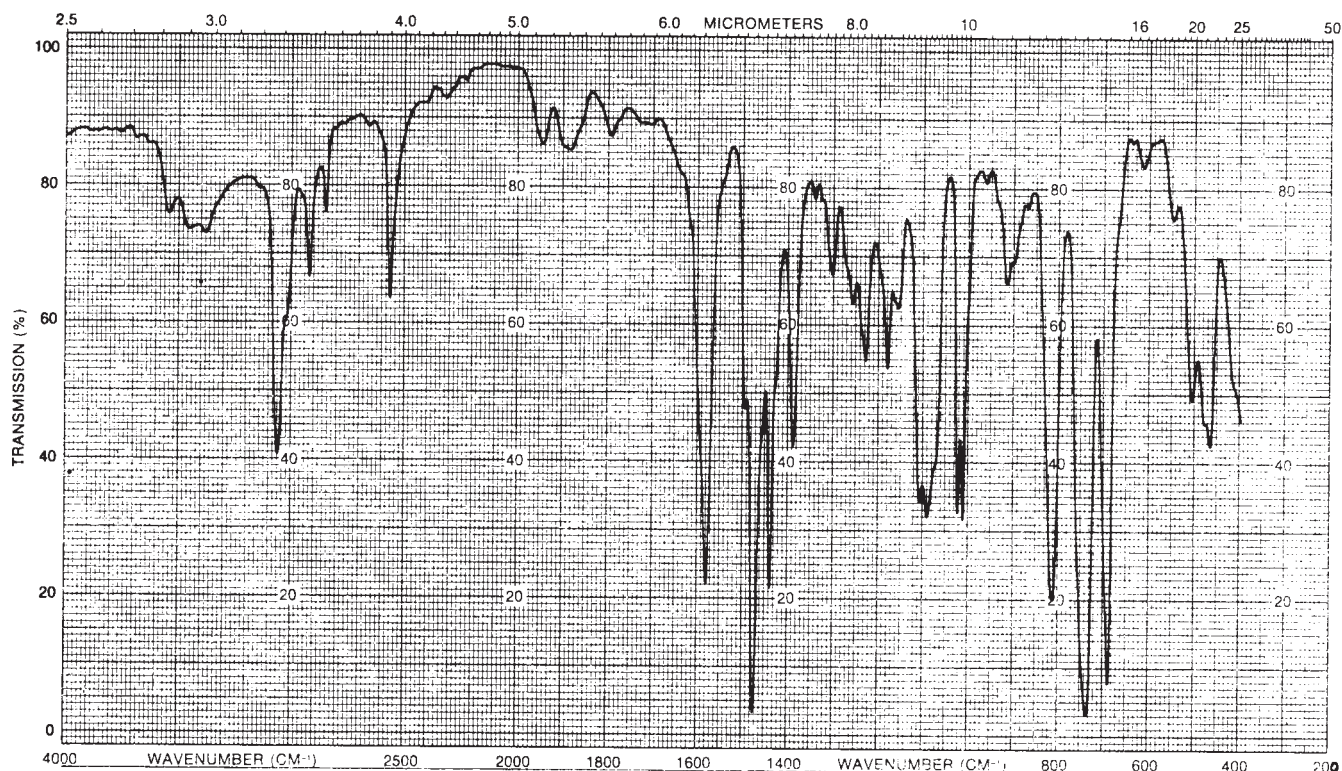
2.2 Military Standards:⁴

MIL-P-46174 (MR) Plastic Molding Material, Polyphenylene Sulfide, Glass Fiber Reinforced

³ Discontinued; see 1997 Annual Book of ASTM Standards, Vol 08.01.

⁴ Available from Standardization Documents, Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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



Phase—Liquid
Cell thickness—0.025 mm
Sample—Pyrolyzate
Prism—NaCl

FIG. 1 Infrared Spectrum of Poly(phenylene sulfide) Pyrolyzate

MIL-M-24519 Molding Plastics, Electrical, Thermoplastic
2.3 ISO Standard.⁵

ISO 527-2 Plastics—Determination of Tensile Properties—
Part 2: Test Conditions for Moulding and Extrusion
Plastics

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St.,
4th Floor, New York, NY 10036.

TABLE A Physical Property Requirements

Designation Order	Property/ASTM Test Method	Units	0	1	2	3	4	5	6	7	8	9
1	Tensile strength, min D 638 ^A	MPa ^B	^C	60	80	110	120	130	160	180	200	^D
2	Flexural modulus, min D 790 ^E	MPa ^B	^C	7 000	10 000	12 000	14 000	17 000	20 000	23 000	26 000	^D
3	Izod impact strength, min D 256 ^F	J/m ^G	^C	28	40	52	70	80	90	100	110	^D
4	Flexural strength, min D 790 ^E	MPa ^B	^C	85	105	135	165	195	225	255	285	^D
5	Density, min D 792	g/cm ³	^C	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	^D

^A Type I specimens, 3.18 mm thickness, crosshead speed of 5 mm/min.

^B MPa × 145 = psi.

^C Unspecified.

^D Specific value (must be shown).

^E Tangent modulus of elasticity. Test specimens are 3.18 by 12.7 mm and tested with a crosshead speed of 1.3 mm/min ± 50 % with a span to depth ratio of 16:1.

^F Test specimens are 3.18 mm thick with a notch radius of 0.25 mm and tested by Method A.

^G J/m × 18.73 × 10⁻³ = ft-lbf/in.

3. Terminology

3.1 Definitions:

3.1.1 The definitions used in this classification system are in accordance with Terminology D 883 and Terminology D 1600.

4. Classification

4.1 There is currently no group, class, or grade distinction and no basic property table is given.

NOTE 2—Where no basic property table exists, the generic family designation will be followed by three zeros, for example: PPS 000.

4.1.1 Table A shall be used to specify the physical property requirements that shall be shown by a six-character designation. The designation shall consist of the letter A and the five digits comprising the cell numbers for the property requirements in the order as they appear in Table A.

4.1.1.1 The values listed are necessary to include the range of properties available in existing materials. However, this does not imply that every possible combination of properties exists or can be obtained with the current state of technology.

4.2 A single letter shall be used to indicate the major category of the reinforcement, along with two numbers that indicate the percentage of additive(s) by mass, with the tolerances as tabulated below:

Category	Material	Tolerance (Based on the total mass)
C	Carbon and graphite fiber-reinforced	±2 percentage points
G	Glass-reinforced ≤15 % glass content	±2 percentage points
	>15 % glass content	±3 percentage points
L	Lubricants (such as PTFE, graphite, silicone, and molybdenum disulfide) or lubricants with fillers/reinforcements	By agreement between the supplier and the user.
M	Mineral-reinforced	±2 percentage points
R	Reinforced-combination/mixtures of reinforcements or other fillers/reinforcements.	±3 percentage points based on the total reinforcement.

NOTE 3—This part of the system 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 the use of the suffix part of the system, as given in Section 5. Special agreements on tolerances may be needed below 5 % levels.

NOTE 4—An example of this classification system for a poly(phenylene sulfide) material is as follows: The designation PPS000G40A42043 would indicate the following material requirements from Table A:

PPS000	=	poly(phenylene sulfide) material,
G40	=	glass-reinforced at 40 % nominal level,
A	=	Table A physical property requirements,
4	=	tensile strength, min 120 MPa,
2	=	flexural modulus, min 10 000 MPa,
0	=	Izod impact strength, unspecified,
4	=	flexural strength, min 165 MPa, and
3	=	density, min 1.60 g/cm ³ .

If no properties are specified, the designation would be PPS000G40A00000.

5. Suffixes

5.1 When additional requirements are needed that are not covered by the basic requirements or cell table requirements, they shall be indicated through the use of suffixes. Electrical, flammability or other requirements shall be designated by the appropriate suffix from Table 3 of Classification System D 4000.

5.1.1 If applicable, heat deflection temperature shall be designated using the following suffix:

Y = Heat deflection temperature as designated by the following digits:

First Digit

1 = Test Method D 648, 1820 kPa

Second Digit

1 = minimum of 260°C

2 = other minimum temperature (°C) - specify

NOTE 5—Heat treating the test specimens at 260°C for 4 h is permitted to achieve high heat deflection temperatures.

6. Basic Requirements

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

7. General Requirements

7.1 The plastics composition shall be uniform and shall conform to the requirements specified herein. The color and form of the material shall be as agreed upon between the supplier and the user.

8. Detail Requirements

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

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

8.2.1 In the absolute method, an observed value or a calculated value is not rounded off, but is to be compared directly to the specified limiting value. Conformance or non-conformance with the specification is based on this comparison.

9. Sampling

9.1 Unless otherwise agreed upon between the user and the supplier, the materials shall be sampled in accordance with the sampling procedure prescribed in Practice D 1898 - 68(1989). Adequate statistical sampling shall be considered an acceptable alternative. A batch or lot of resin shall be considered as a unit of manufacture as prepared for shipment. It is acceptable to blend two or more production runs to create a batch or lot.

10. Specimen Preparation

10.1 The test specimens shall be prepared by injection molding in accordance with Practice D 3641. Processing conditions are:

Drying	2 h at 135°C
Plastic melt temperature	305 - 335°C
Mold temperature	140°C minimum
Average injection velocity	200 ± 100 mm/s
Plastic Hold Pressure	600 bar minimum

11. Conditioning

11.1 *Conditioning*—Condition test specimens at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity for not less than 40 h prior to testing in accordance with Procedure A of Practice D 618, where conditioning is specified.

11.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity unless otherwise specified.

12. Test Methods

12.1 Determine the properties of the material according to the test methods in 2.1, using the specimens and protocols specified in Table A and applicable Suffixes, as required.

12.1.1 The number of tests shall be consistent with the requirements of Section 9 and paragraph 13.4.

12.2 *Reinforcement Concentrations*—Test Method D 5630, using a temperature of 815°C for inorganic fillers/reinforcements. Carbon fiber, graphite fiber, and other organic reinforcements require special methods that shall be agreed upon between the supplier and the user.

13. Inspection and Certification

13.1 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.

13.2 Lot-acceptance inspection shall be the basis on which acceptance or rejection of the lot is made. The lot-acceptance inspection shall consist of apparent shear viscosity (Test Method D 3835) or flow rate (Test Method D 1238, 315/5.0); reinforcement or filler content (Test Method D 5630); and, tensile strength (Test Method D 638, Type 1 bar or ISO 527-2, Type 1A bar).

13.3 Periodic check inspection with reference to a specification based upon this classification system shall consist of the tests for all requirements of the material under the specifica-

tion. 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 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).

13.5 A report of test results shall be furnished when requested. The report shall consist of results of the lot-acceptance inspection for the shipment and may include the results of the most recent periodic-check inspection. If requested, the report shall include that recycled, reconstituted, recycled-regrind, recovered or reprocessed, or both, poly(phenylene sulfide) plastic was used and the nominal weight percent.

14. Packaging and Marking

14.1 Provisions of Practice D 3892 apply for packaging, packing, and marking of containers for plastic materials. Other packaging or marking, or both, is acceptable when agreed upon by the purchaser and the supplier.

15. Keywords

15.1 plastic materials; poly(phenylene sulfide)

SUPPLEMENTARY REQUIREMENTS

The following supplementary items shall become part of this classification system when applicable, as agreed upon between the user and the supplier.

S1. *Approval*—Material submitted by a new supplier shall be approved by the user. Material or test specimens submitted by the supplier and intended for evaluation, shall be accompanied by the supplier's laboratory test report.

S1.1 *New Sources*—The user may elect to accept shipment temporarily on the supplier's certification.

S2. *Infrared Spectrophotometry or Thermal Analysis, or Both*—If requested by the user, infrared or thermal analysis, or both, shall be conducted on materials supplied to this classification system. The curves established for initial approval shall constitute the reference standard and shall be kept on file at the user's laboratory. All samples shall produce curves that correspond to the reference standard when tested under the same conditions as those specified on the master set of curves.

S2.1 In the event such analyses are to be designated as required of the supplier, this must appear on the part drawing or purchase contract, or both, as agreed upon between user and supplier.

NOTE S00006—A useful procedure for IR is to place approximately 0.5 g of finely divided sample into a test tube and rapidly apply heat in order

to pyrolyze the sample. Pyrolysis vapors that condense on the cooler portions of the tube can then be removed for appropriate IR analysis.

NOTE S00007—Melting characteristics of PPS materials shall be determined by Test Method D 3418 with reference standards agreed upon by the user and supplier. Appropriate Suffix Designations consistent with Classification System D 4000 shall be used to define requirements for Melting Point.

S3. *Outgassing and Smoke Generation:*

S3.1 In aircraft and aerospace applications that require specification of outgassing, or in combustion modes the amount of smoke generated, these requirements shall be agreed upon by the user and supplier with limiting values clearly defined using the Standard D 4000 Suffix System.

S3.1.1 *Specific Optical Density*—If required, shall be determined by Test Method E 662 in both the flaming and smoldering modes. Maxima, D_{\max} shall be stipulated using the Suffix System of Classification System D 4000.

S3.1.2 *Outgassing*—If required for aerospace applications, shall be determined in accordance with Test Method E 595. Requirements shall be defined using an appropriate Suffix designation.

APPENDIX

(Nonmandatory Information)

X1. CROSS REFERENCE FROM MIL-P-46174 (MR) TO ASTM CLASSIFICATION SYSTEM D 4067

X1.1 This classification system contains pertinent specification items from MIL-P-46174 (MR) and MIL-M-24519, for plastic molding material, poly(phenylene sulfide), glass reinforced. (MIL-P-46174(MR) has been cancelled, replaced with Classification System D 4067. The MIL-P-46174(MR) information included here is for historical reference only.)

X1.2 The following cross reference designations are believed to accurately provide comparable callout information relative to the intent of the designated military specifications. It is recommended that someone knowledgeable in the requirements of the military specifications review this information before use.

ASTM D4067	MIL-P-46174 (MR)
PPS000G15A21221	Class 15 Grade A
PPS000G15A21221 EA117ED041EE020	Class 15 Grade E
ASTM D4067	MIL-P-46174 (MR)
PPS000G30A32332	Class 30 Grade A
PPS000G30A32332 EA117ED041EE020	Class 30 Grade E
PPS000G40A43443	Class 40 Grade A
PPS000G40A43443 EA117ED041EE020	Class 40 Grade E
PPS000G50A54454	Class 50 Grade A
PPS000G50A54454 EA117ED041EE020	Class 50 Grade E
ASTM D4067	MIL-M-24519
PPS000A00330E01EA124	GST-40F

X1.3 If additional property requirements need to be specified, appropriate suffixes are to be used as needed.

SUMMARY OF CHANGES

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

- (1) Five year review conducted (April 2003).
- (2) Changed title from a “Standard Specification” to a “Standard Classification System” and added “Using ASTM Methods.”
- (3) Changed all occurrences of “polyphenylene sulfide” to “poly(phenylene sulfide),” including title.
- (4) Added ISO equivalency statement.
- (5) Revised Referenced Documents section.
- (6) Removed permissive language in 1.3, 4.1.1.1, 9.1, and numerous places in Supplementary Requirements.
- (7) In footnote A under Table A, removed “Type IV” as a specimen type and removed statement that table values were generated using Type IV specimens.
- (8) In section 4.2, added “or lubricants with fillers/reinforcements” to Material Types under Category L.
- (9) In 5.1, deleted all suffix references except “Y” and added statement advising that other requirements shall be designated using D 4000 suffix protocols.
- (10) In 5.1, moved statement concerning how to obtain high

heat deflection temperatures after “1 = minimum of 260°C” to Note 5.

- (11) Added number 2 for second digit of heat deflection temperature designation to 5.1.
- (12) Removed Section 10, revised subsequent section numbers, and added statement on number of tests as 12.1.1.
- (13) Changed practice for injection molding and revised processing conditions in 10.1 (previously 11.1)
- (14) Added 12.1 and 12.1.1 and specified test method in 12.2.
- (15) Deleted previous Section 14 and renumbered subsequent sections.
- (16) Revised previous Section 15 (now section 13), Inspection and Certification.
- (17) Added statement to 14.1.
- (18) Deleted Table 1.
- (19) Deleted S3.1.3, S4, and S5 from Supplementary Requirements section.
- (20) In X1.1, added statement concerning obsolescence of Mil-P-41674(MR).
- (21) Added Keywords and Summary of Changes sections.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).