



Standard Classification System for Poly(Ether Ether Ketone) (PEEK) Molding and Extrusion Materials¹

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1. Scope

1.1 This classification system covers poly(ether ether ketone) materials suitable for injection molding and extrusion. This classification system allows for the use of recycled materials provided that all specification requirements are met.

1.2 The properties included in this standard 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 the suffixes in Section 5.

1.3 This classification system and subsequent line callout (specification) are intended to provide means of calling out poly(ether ether ketone) materials used in the fabrication of end items or parts. It is not intended for the selection of materials. It is recommended that material selection 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 cost involved, and the inherent properties of the material other than those covered by this specification.

1.4 Poly(ether ether ketone), commonly referred to as PEEK, is a member of the poly(aryl ether ketone) or PAEK family. Specification D6262 covers properties of PAEK shapes and includes shapes produced from PEEK.

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

1.5 The following precautionary caveat pertains only to the test method 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.*

¹ This test method 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. Referenced Documents

2.1 ASTM Standards:²

- D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
- D257 Test Methods for DC Resistance or Conductance of Insulating Materials
- D570 Test Method for Water Absorption 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
- D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
- D3171 Test Methods for Constituent Content of Composite Materials
- D3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials
- D3418 Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
- 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

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.

- D4000** Classification System for Specifying Plastic Materials
- D4812** Test Method for Unnotched Cantilever Beam Impact Resistance of Plastics
- D5630** Test Method for Ash Content in Plastics
- D5740** Guide for Writing Material Standards in the Classification Format
- D6262** Specification for Extruded, Compression Molded, and Injection Molded Basic Shapes of Poly(aryl ether ketone) (PAEK)
- 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
- 2.2 *Underwriters' Laboratories Standards*.⁴
- UL94** Standard for Tests for Flammability of Plastic Materials

3. Terminology

3.1 Except for terms defined below, 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 *poly(ether ether ketone)*, *n*—a polymer in which the repeated structural unit contains an aromatic ketone and two aromatic ether linkages. (C₁₉H₁₂O₃)

4. Classification

4.1 Poly(ether ether ketone) materials are classified into groups that are subdivided into classes and grades as shown in the Basic Property Table (Table PEEK).

NOTE 2—An example of a specification based on this classification system is given below. The specification PEEK012GF30 indicates the following:

PEEK	= Poly(ether ether Ketone) as found in Terminology D1600
01 (Group)	= General Purpose
2 (Class)	= Low Flow
GF30 (Grade)	= 30 % Glass-Filled, with corresponding requirements shown in Table PEEK.

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>.

4.1.1 To facilitate incorporation of future or special materials the “Other” category for group (00), class (0), and grade (0) is shown in Table PEEK. The basic properties for these materials are obtained from Table A as they apply.

4.2 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.

4.2.1 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 that 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 is not used for functional mixtures. Thus, the letter designation G for glass, E for beads or spheres or balls, and 33 for percent by weight, 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 Table 1. Form and structure letter designations are shown in Table 1a.

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 are often shown on the supplier’s technical data sheet unless they are proprietary in nature. If necessary, additional callout of these reinforcement and additives is accomplished by use of the suffix part of the system (see Section 5).

4.2.2 Although the values listed in Table A 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.

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

NOTE 4—An example of the use of this classification system for specifying a special poly(ether ether ketone) plastics material is given as follows. The specification PEEK0120GF30A43460 would have the following material requirements:

PEEK0120	= poly(ether ether ketone) from Table PEEK,
GF30	= glass reinforced at the 30 % nominal level,
A	= Table A property requirements,
4	= tensile strength, 130 MPa min,
3	= flexural modulus, 4.5 GPa min,
4	= Izod impact, 60 J/m min,
6	= deflection temperature, 275°C min, and
0	= unspecified.

If no properties are specified, the designation would be: PEEK0120GF30A00000.

TABLE PEEK Requirements for Poly(Ether Ether Ketone) Plastics

Group	Description	Class	Description	Grade	Description	Melt Viscosity, ^A Pa·s	Deflection Temperature, ^B °C, min	Tensile Strength, ^C MPa, min	Flexural Modulus, ^D GPa, min	Izod Impact, ^E J/m, min	Specific Gravity ^F		
01	General Purpose	1	Very Low Flow	1	Unfilled	400-650	149	80	3.4	80	1.27-1.32		
				0	Other								
		2	Low Flow	1	Unfilled	300-500	149	90	3.4	53	1.28-1.32		
				CF20	20 % Carbon Fiber	475-930	300	164	10.0	6.4	1.34-1.39		
				CF30	30 % Carbon Fiber	480-1360	300	194	13.1	80	1.38-1.43		
				CF40	40 % Carbon Fiber	550-1280	300	190	20.0	80	1.43-1.47		
				GF15	15 % Glass Fiber	270-900	300	100	4.5	50	1.34-1.42		
				GF20	20 % Glass Fiber	310-1000	300	120	5.0	60	1.40-1.46		
				GF30	30 % Glass Fiber	425-1200	300	155	9.0	88	1.48-1.54		
				0	Other								
				3	Intermediate Flow	1	Unfilled	275-410	149	93	3.4	53	1.28-1.32
						2	Unfilled	220-330	149	93	3.4	43	1.28-1.32
						0	Other						
				4	High Flow	1	Unfilled	105-180	149	93	3.4	37	1.28-1.32
						CF30	30 % Carbon Fiber	200-700	300	217	18.9	59	1.37-1.43
						GF15	15 % Glass Fiber	120-390	300	90	5.0	40	1.37-1.43
						GF20	20 % Glass Fiber	140-390	300	120	5.0	55	1.40-1.48
		GF30	30 % Glass Fiber			175-500	300	155	9.0	75	1.48-1.55		
		0	Other										
		1	Unfilled			70-120	149	85	3.1	25	1.25-1.32		
		5	Very High Flow	CF30	30 % Carbon Fiber	90-400	300	200	15.0	50	1.37-1.43		
				GF30	30 % Glass Fiber	90-320	300	165	9.5	65	1.47-1.56		
				GF60	60 % Glass Fiber	315-690	300	180	15.0	65	1.70-1.90		
0	Other												
02	Wear Resistant	1	Low Flow	L10	Reduced Friction	140-625	145	85	3.1	130	1.33-1.37		
				L20	Reduced Friction	280-625	145	70	2.8	50	1.37-1.43		
				R30		210-720	270	125	6.2	53	1.42-1.48		
				R45		180-650	280	145	17.0	53	1.48-1.52		
				0	Other								
		2	High Flow	R30	Reduced Friction	160-400	270	115	6.5	40	1.41-1.48		
				0	Other								
		3	High Flow, High Modulus	R30	Reduced Friction	160-400	270	140	11.5	35	1.37-1.47		
				0	Other								
		00	Other	0		0	Other						

Physical properties, other than melt viscosity, were determined using injection molded specimens.

^ATest Method D3835 conditions 400°C and 1000/s.

^BTest Method D648 Method A at 264 psi, measured on 3.2 mm specimens annealed for 2 hours at 200°C.

^CTest Method D638 Unreinforced tested at 50 mm/min. Reinforced tested at 5.0 mm/min. For unreinforced materials tensile strength is reported as stress at yield; for reinforced materials tensile strength is reported as stress at break.

^DTest Method D790.

^ETest Method D256.

^FTest Method D792.

TABLE A Detail Requirements of Special Poly(Ether Ether Ketone) Plastics Using ASTM Methods

Designation or Order Number	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ^A D638, min, MPa ^B	unspecified	70	90	110	130	150	170	190	210	specify value
2	Flexural modulus, ^C D790, (A), min, GPa ^B	unspecified	3.0	3.5	4.5	5.5	7.0	9.0	11.0	13.0	specify value
3	Izod impact resistance, ^D D256, min, J/m ^E	unspecified	30	40	50	60	80	100	120	150	specify value
4	Deflection temperature at 1.8 MPa, ^F D648, min, °C	unspecified	140	150	200	245	260	275	290	305	specify value
5	To be determined	unspecified

^AType I D638 test specimens, unreinforced tested at 50 mm/min, Reinforced tested at 5.0 mm/min.

^BMPa × 145 = psi.

^CTest specimens are nominal 3.2 mm in depth by 12.7 mm wide. Span is a nominal 50 mm. Rate of crosshead is 0.05 mm/min using Method 1.

^DTest specimens are nominal 3.2 mm wide with a depth of 12.7 mm.

^EJ/m × (1.873 × 10⁻²) = ft lb/in. or ft lb/in. × 53.38 = J/m.

^FTest specimens are nominal 3.2 mm deep by 12.7 mm wide. Measured on specimens annealed for 2 hours at 200°C.

TABLE 1 Reinforcement-Filler and Tolerances

Symbol	Material	Tolerance
C	Carbon and graphite reinforced	±3 %
G	Glass fiber reinforced	±2 %
L	Lubricants	Depends upon the material and process—to be specified
M	Mineral reinforced	±3 %
R	Combination of reinforcements or fillers, or both	±3 %

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

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.

5.2 A list of suitable suffixes is found in Table 3 of Classification System **D4000** and are to be used for additional requirements as appropriate. Additional suffixes will be added to that standard as test methods and requirements are requested.

5.3 If the requirements for the poly(ether ether ketone) in **4.2.3** also include flammability requirements, the following example illustrates the call-out.

PEEK0120GF30A43460FB35

PEEK0120GF30A43460 = Same as for **4.2.3**,
 F = Flammability requirements,
 B35 = Oxygen Index by ASTM **D2863**,
 35 % min.

6. General Requirements

6.1 Basic requirements from the property table (Table PEEK) or cell table (Table A) are always in effect unless superseded by specific suffix requirements, which always take precedence. Properties in Table A supersede properties in Table PEEK.

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 respective requirements of Tables PEEK, A, and the suffix as they apply.

7.2 For purposes of determining conformance, all specified limits for a specification (line callout) based on this classification system 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 with the limiting value. Conformance or nonconformance is based on this comparison.

8. Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of **12.4**.

8.2 A batch or lot shall be defined as a unit of manufacture as prepared for shipment and is permitted to consist of a blend of two or more production runs.

9. Specimen Preparation

9.1 The test specimens shall be prepared by injection molding process in accordance with Practice **D3641**.

9.1.1 Before molding the material shall be dried to a moisture level of no more than 0.05 % as determined by test methods described in Test Method **D6869**. Another acceptable method for checking moisture levels is the conventional loss in weight analyzer. The test conditions are 200°C for 10 minutes or until moisture is no longer evolved.

9.1.2 Molding conditions are:

Mold Temperature, °C: 175 - 205

Melt Temperature, °C: 370 - 410

10. Conditioning

10.1 Test specimens shall be conditioned in the standard laboratory atmosphere in accordance with Procedure A of Practice **D618** for a minimum of 24 h before performing the required tests.

10.2 Conduct those tests influenced by ambient conditions in the standard laboratory atmosphere of 23°C and 50 % relative humidity as defined in section 3.1.2 of Practice **D618**.

11. Test Methods

11.1 Determine the properties enumerated in this specification by means of tests referenced in Section **2**.

11.1.1 The number of tests shall be consistent with the requirements of Section **8** and **12.4**.

11.1.2 All test specimens shall be 3.2 by 12.7 mm, unless otherwise specified.

11.1.3 *Melt Viscosity*—In accordance with **D3835**, using the following conditions: 400°C and shear rate of 1000/s.

11.1.4 *Izod Impact*—In accordance with Test Method **D256**.

11.1.5 *Deflection Temperature (Test Method D648 Method A at 264 psi)*—Measured on specimens annealed for 2 hours at 200°C.

11.1.6 *Tensile (Test Method D638)*—Unreinforced tested at 50 mm/min, reinforced tested at 5.0 mm/min. For unreinforced materials tensile strength refers to tensile stress at yield; for reinforced materials tensile strength refers to tensile stress at break.

NOTE 5—Significant errors have been found to occur when testing at the wrong speed. For example, when three lots of PEEK 0121 were tested at both speeds the following average results were obtained:

Tensile Stress at Yield		% Elongation at Break	
50 mm/min (2 in./min)	5 mm/min (0.2 in./min)	50 mm/min (2 in./min)	5 mm/min (0.2 in./min)
14215 psi (98 MPa)	13461 psi (93 MPa)	18.7	78.0

12. Inspection and Certification

12.1 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. The lot acceptance inspection shall consist of the following:

12.2.1 Melt Viscosity (D3835)

12.2.2 Specific Gravity (D792)

12.3 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 specification. 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 and 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 6—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, Packing, and Marking

13.1 The provisions of Practice D3892 apply to packaging, packing, and marking of containers for plastics materials.

14. Keywords

14.1 line callout; plastics materials; poly(ether ether ketone); recycled

SUPPLEMENTARY REQUIREMENTS

SUPPLEMENTARY REQUIREMENTS FOR SPECIAL END USES

The following supplementary requirements shall apply only when specified by the inquiry, contract, or order for agencies of the U.S. Government.

S1. Special End Uses of Poly(Ether Ether Ketone) PEEK Plastics

S1.1 Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of acceptance testing in accordance with 12.2 of this classification system. Except as otherwise specified, the supplier shall utilize its own facilities or any commercial laboratory acceptable to the U.S. Government. The U.S. Government reserves the right to perform any of the testing or inspections set forth in the specification requirements.

S2 Physical and Mechanical Requirements for Poly(Ether Ether Ketone) PEEK Plastics

S2.1 Material properties, in addition to those in Tables PEEK and A, if required for initial material qualifications (such as those described in MIL-P-46183) are given in Table S2.1.

S3 Quality Assurance for Poly(ether ether ketone), PEEK, Plastics

S3.1 *Acceptance Criteria*—For the purpose of these supplementary requirements only, the lot acceptance tests shall consist of tests for specific gravity, melt flow rate (for unreinforced materials only), and heat deflection temperature.

S3.2 *Sample Size*—The minimum number of test specimens to be tested shall conform to the requirements of the respective test method or, if different, by agreement with the customer.

S3.3 *Test Methods*—Testing shall be in accordance with the methods specified in Table PEEK, A, and S.

TABLE S2.1 MIL-P-46183 Requirements

Properties	1	2	3	4	5	6
	Type I	Type II			Type III	
	Unreinforced	(Glass Fiber Reinforced)			(Carbon Fiber Reinforced)	
		Class 1 (10 % GFR)	Class 2 (20 % GFR)	Class 3 (30 % GFR)	Class 1 (20 % CFR)	Class 2 (30 % CFR)
Specific gravity at 23°C, ASTM D792	1.30 ± 0.04	1.37 ± 0.04	1.44 ± 0.04	1.49 ± 0.04	1.38 ± 0.04	1.42 ± 0.04
Tensile strength (at 23°C), MPa (psi), min, ASTM D638	90 (13 000)	110	120 (17,400)	152 (22,000)	159 (23,000)	185 (27,000)
(at 200°C), MPa (psi)	20 (2,900)	(16,000)				
Tensile elongation at break, % min, ASTM D638	10	5	4	3	5	1
Flexural modulus MPa (psi), min, ASTM D790	3,400 (500,000)	5,000 (730,000)	6,200 (900,000)	6,900 (1,000,000)	10,300 (1,500,000)	12,800 (1,850,000)
Izod impact at 6.13 mm (0.25 in.) specimen, J/m (ft-lb/in.) notched min, ASTM D256	na	50 (0.9)	60 (1.1)	80 (1.5)	45 (0.8)	50 (0.9)
Impact strength, 6.13 mm (0.25 in.) specimen, J/m (ft-lb/in.) unnotched, min, ASTM D4812	na	na	na	na	400 (8.0)	530 (10.0)
Melting point, °C (°F), min, ASTM D3418	334 (633)	na	na	na	na	na
Glass transition temperature, T _g , °C (°F), min, ASTM D3418	143 (289)	na	na	na	na	na
Heat deflection temperature at 1820 kPa (264 psi), min, ASTM D648	149 (300)	na	na	na	na	na
Volume resistivity, ohm-cm, ASTM D257	10 ¹⁵	na	na	10 ¹⁵	na	1200
Dielectric strength, 3.1 mm (0.125 in.) thick specimen, volts/mil, ASTM D149	400	na	na	450	na	na
Oxygen index, 3.2 mm (0.125 in.) thick specimen, % min, ASTM D2863	35	35	35	35	35	35

APPENDIX

(Nonmandatory Information)

X1. CROSS REFERENCE TO MIL-P-46183

X1.1 See [Table X1.1](#).

TABLE X1.1 Cross Reference to MIL-P-46183

D8033	MIL-P-46183
PEEK0120S1 or PEEK0140S1 or PEEK0121 or PEEK0141	Type I
PEEK0120GF10S2 or PEEK0140GF10S2	Type II Class 1
PEEK0120GF20S3 or PEEK0140GF20S3	Type II Class 2
PEEK0120GF30S4 or PEEK0140GF30S4 or PEEK012GF30 or PEEK014GF30	Type II Class 3
PEEK0120CF20S5 or PEEK0140CF20S5 or PEEK012CF20	Type III Class 1
PEEK0120CF30S6 or PEEK0140CF30S6 or PEEK012CF30 or PEEK014CF30	Type III Class 2

X1.2 Examples of the callout using the supplemental requirements:

PEEK0140CF20S5

PEEK0120S1

- PEEK = Table PEEK
- 01 = General purpose poly(ether ether ketone)
- 2 = Low Flow
- 0 = Unspecified grade
- S = Table S
- 1 = Unreinforced PEEK having properties as specified in column 1 of Table S

- SP = Table PEEK
- 01 = General purpose poly(ether ether ketone)
- 4 = High Flow
- 0 = Unspecified grade
- CF20 = Carbon fiber reinforced at the 20% nominal level
- S = Table S

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