Designation: D8033 – 22

Standard Classification System for Poly(Ether Ether Ketone) (PEEK) Molding and Extrusion Materials[1]

This standard is issued under the fixed designation D8033; 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 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—This standard and ISO 23153 address the same subject matter, but differ in technical content.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

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

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)

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

D3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer

[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.

Current edition approved Sept. 1, 2022. Published September 2022. Originally approved in 2016. Last previous edition approved in 2016 as D8033 - 16. DOI: 10.1520/D8033-22

[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**

D3892 Practice for Packaging/Packing of Plastics
D4000 Classification System for Specifying Plastic Materials
D4812 Test Method for Unnotched Cantilever Beam Impact Resistance of Plastics
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 *ISO Standards:*[4]

ISO 23153-1:2020 Plastics—Polyetheretherketone (PEEK) moulding and extrusion materials—Part 1: Designation system and basis for specifications
ISO 23153-2:2020 Plastics—Polyetheretherketone (PEEK) moulding and extrusion materials—Part 2: Preparation of test specimens and determination of properties

2.3 *Underwriters' Laboratories Standards:*[5]

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. ($C_{19}H_{12}O_3$)

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.

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	=	Notched 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.

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[5] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

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	Notched 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
				CF30	30 % Carbon Fiber	650-1500	300	193	16.0	77	1.38-1.43
		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
				CF30	30 % Carbon Fiber	400-850	300	175	15.0	55	1.38-1.43
				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	140-400	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						
		5	Very High Flow	1	Unfilled	70-120	149	85	3.1	25	1.25-1.32
				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.

[A] Test Method D3835 conditions 400°C and 1000/s.
[B] Test Method D648 Method A at 264 psi, measured on 3.2 mm specimens annealed for 2 hours at 200°C.
[C] Test 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.
[D] Test Method D790.
[E] Test Method D256, Method A; test the center portion (64 mm) of the 125 mm long specimen, which is 3.2 mm wide by 12.7 mm deep.
[F] Test 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	Notched Izod impact resistance,[D] D256, Method A, 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	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

[A] Type I D638 test specimens, unreinforced tested at 50 mm/min, Reinforced tested at 5.0 mm/min.
[B] MPa × 145 = psi.
[C] Test 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.
[D] Test the center portion (64 mm) of the 125 mm long specimen, which is 3.2 mm wide by 12.7 mm deep.
[E] J/m × (1.873 × 10^{-2}) = ft lb/in. or ft lb/in. × 53.38 = J/m.
[F] Test 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 %
X	Not specified	To be specified

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 *Notched Izod Impact*—In accordance with Test Method D256, Method A—Test the center portion (64 mm) of the 125 mm long specimen, which is 3.2 mm wide by 12.7 mm deep.

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 classification; classification system; line callout; plastics materials; poly(ether ether ketone); recycled