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Designation: ~~D5205 – 16~~ D5205 – 24

Standard Classification System and Basis for Specification for Polyetherimide (PEI) Molding and Extrusion Materials[1]

This standard is issued under the fixed designation D5205; 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 U.S. Department of Defense.

1. Scope*

1.1 This classification system covers unfilled, filled, and reinforced polyetherimide 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 is to 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.~~

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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 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 can be made by those having expertise in the plastic 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 standard.

1.4 ~~Polyetherimide materials, being thermoplastic, are reprocessable and recyclable.~~ This classification system allows for the use of ~~those~~recycled polyetherimide materials, provided that all ~~specific requirements of this classification system~~ specification requirements are met.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

1.6 The following precautionary caveat pertains only to the test methods portion, Section ~~12~~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~~safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given at the end of 5.4.

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

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

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1.7 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
D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
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
D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D1600 Terminology for Abbreviated Terms Relating to Plastics (Withdrawn 2024)[3]
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
D3892 Practice for Packaging/Packing of Plastics
D4000 Classification System for Specifying Plastic Materials
D5630 Test Method for Ash Content in Plastics
D5740 Guide for Writing Material Standards in the Classification D4000 Format
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
E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials

2.2 *Military Standards:*[4]

MIL-P-46184 Plastic Molding and Extrusion Materials, Polyetherimide (PEI).
MIL-M-24519 Molding Plastics, Electrical, Thermoplastic

2.3 *Underwriters Laboratories Standards:*[5]

UL 94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

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3. Terminology

3.1 ~~*Definitions*—~~The terminology used in this classification system is in accordance with Terminologies D883 and D1600.

~~3.2 *Abbreviation*—The polyetherimide materials will be designated "PEI" as specified in Terminology D1600.~~

~~4. Classification~~

~~4.1 Unfilled polyetherimide materials are classified into groups according to their composition. These groups are subdivided into classes and grades as shown in Table PEI.~~

~~NOTE 2—An example of this classification system is given as follows. The designation ASTM D5205 PEI 0114 indicates the following:~~

~~PEI~~	~~= polyetherimide as found in Terminology D1600,~~
~~01~~	~~= polyetherimide (group),~~
~~1~~	~~= general purpose (class), and~~
~~4~~	~~= requirements given in Table PEI (grade).~~

[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.

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

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

[5] 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 (0) for group, class, and grade is shown in Table PEI. The basic properties of these materials can be obtained from Tables A or B as they apply.

4.2 Reinforced, pigmented, filled, and lubricated versions of polyetherimide materials are classified in accordance with Tables PEI and A or B. Table PEI is used to specify the unreinforced material and Table A or B is used to specify the property requirements after the addition of reinforcements, pigments, fillers, or lubricants at the nominal level indicated (see 4.2.1).

4.2.1 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 as follows:

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)	Depends upon material and process—to be specified
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—If necessary, additional requirements are specified using suffixes as described in Section 5. Any special tolerances, when levels are below 5 %, are to be specified. Ash content of filled or reinforced materials are determined using Test Method D5630 where applicable.

4.2.2 Specific requirements for reinforced, filled, or lubricated polyetherimide materials shall be shown by a six-character designation. The designation will consist of the letter "A" or "B" and the five digits comprising the cell numbers for the property requirements in the order as they appear in Tables A or B.

4.2.2.1 Although the values listed 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 materials is not shown, or is not important, the use of "O"-grade classification shall be used for reinforced materials in this system.

NOTE 4—An example of this classification for a polyetherimide material is given as follows. The designation ASTM D5205 PEI0110G10A48266 would indicate the following material requirements:

PEI 0110	= general-purpose polyetherimide from Table PEI,
G10	= glass reinforced at nominal 10 % level,
A	= Table A property requirements,
4	= 110-MPa tensile strength, min,
8	= 13790-MPa flexural modulus, min,
2	= 4 g/10 min; melt flow, min,
6	= 205-MPa flexural strength, min, and
6	= 230°C deflection temperature, min.

If no properties are specified, the designation would be ASTM D5205 PEI0110G10A00000.

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 suffixes can be found in Classification System D4000 (Table 3) and are to be used for additional requirements as appropriate. Additional suffixes will be added to that standard as test methods and requirements are developed and requested.

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~~5.3 Electrical requirements are designated by a suffix which uses the letter E followed by two digits. These digits refer to use of Table 1.~~

	~~First Digit~~
~~0~~	~~= specimen to be specified by user~~
~~1~~	~~= specimens as appropriate for test methods as defined in Table 1~~
	~~Second Digit~~
~~0~~	~~= to be specified by user~~
~~1~~	~~= meets requirements of Table 1, Column A~~
~~2~~	~~= meets requirements of Table 1, Column B~~
~~3~~	~~= meets requirements of Table 1, Column C~~
~~4~~	~~= meets requirements of Table 1, Column D~~
~~5~~	~~= meets requirements of Table 1, Column E~~

~~5.4 Flammability requirements are designated by a suffix that uses the letter F followed by two digits. (**Warning—**By publication of this classification system and its use of flammability ratings, ASTM does not intend that their use in any way reflects hazards presented under actual fire conditions.)~~

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TABLE ~~1~~2 Electrical Detail Requirements

NOTE 1—Resin samples should be dried 4 h at 160°C in an air-circulating oven before molding specimens to be used in these tests.

Property	Condition[A]	Units	A	B	C	D	E
Dielectric constant,[B] max	48/50 + D24/23						
1 KHz, 50 % RH, 23°C		...	3.2	3.7	3.7	3.8	...
1 MHz		...	...	...	...	...	3.5
Dissipation factor,[B] max	48/50 + D24/23						
1 KHz, 50 % RH, 23°C		...	0.0015	0.0016	0.0017	0.0017	...
2450 MH, 50 % RH, 23°C		...	0.003	...	...	...	...
1 MH, 50 % RH, 23°C		...	...	...	...	...	0.007
Volume resistivity,[C] min	24/23/50	ohm-cm	10^{16}	10^{16}	10^{16}	10^{16}	...
Dielectric strength,[D] min (1.6-mm thickness, in oil, S/T)	48/ 50 + 96/23/50	KV/mm (V/mil)	23.6	23.0	22.0	21.0	17.0
Specific gravity[E]	...	...	1.27	1.34	1.42	1.51	...

[A] In accordance with Practice D618.
[B] See Test Methods D150.
[C] See Test Methods D257.
[D] See Test Methods D149.
[E] See Test Method D792 (tolerance ± 0.02).

First Digit

0	= to be specified by user,
1	= product is tested according to UL94 at 3.05 mm minimum thickness,
2	= product is tested according to UL94 at 1.47 mm minimum thickness,
3	= product is tested according to UL94 at 0.71 mm minimum thickness,
4	= product is tested according to Test Method D2863,
5	= product is tested according to Test Method E662.

Second Digit

0	= To be specified by user
1	= 94V-0 flammability class
2	= 94V-1 flammability class
3	= 94V-2 flammability class
4	= 94-5V flammability class
5	= Oxygen index 44 % minimum
6	= Specific optical density, flaming mode, D4 ≤ 2, D max ≤ 50.

4. General Requirements Classification

4.1 Unfilled polyetherimide materials are classified into groups according to their composition. These groups are subdivided into classes and grades as shown in the basic property table, Table PEI.

NOTE 2—An example of this classification system is given as follows. The specification ASTM D5205 PEI 0114 indicates the following:

PEI	= polyetherimide as found in Terminology D1600,
01	= polyetherimide (group),
1	= general purpose (class), and
4	= requirements given in Table PEI (grade).

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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 PEI. The basic properties of these materials can be obtained from Tables A or B as they apply.

4.2 The plastic compositions shall be uniform and shall conform to the requirements specified herein.Reinforced, pigmented, filled, and lubricated versions of polyetherimide materials are classified in accordance with Tables PEI and A or B. Table PEI is used to specify the unreinforced material and Table A or B is used to specify the property requirements after the addition of reinforcements, pigments, fillers, or lubricants at the nominal level indicated (see 4.2.1).

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TABLE PEI Polyetherimide Materials Detail Requirements

NOTE 1—The values listed were developed for "natural colors." Pigments or other additives, or both, can alter these properties.

Group	Description	Class	Description	Grade	Description[A]	Flow Rate,[B] Test Method D1238, g/10 min	Specific Gravity, Test Method D792	Deflection[C] Temperature (DTUL), min, Test Method D648, °C, min	Tensile[D] Strength, Test Method D638, MPa, min	Flexural[E] Strength, Test Methods D790, MPa, min	Flexural[E] Modulus, Test Methods D790, MPa, min
01	Polyetherimide	1	General Purpose	1		< 2	1.25–1.30	194	103	152	3030
				2		2–8	1.25–1.30	194	103	152	3030
				3		6–12	1.25–1.30	194	103	152	3030
				4		10–16	1.25–1.30	194	103	152	3030
				5		15–22	1.25–1.30	194	103	152	3030
				6		20–30	1.25–1.30	192	90	138	2900
				7		> 30	1.25–1.30	190	83	138	2900
				0	Other	...	...	...	...	...	...
		2	Impact Modified	1		< 2	1.22–1.28	180	83	117	2410
				2		2–8	1.22–1.28	180	83	117	2410
				3		6–12	1.22–1.28	180	83	117	2410
				4		10–16	1.22–1.28	180	83	117	2410
				5		15–22	1.22–1.28	180	83	117	2410
				6		20–30	1.22–1.28	180	69	103	2280
				7		> 30	1.22–1.28	180	69	103	2280
				0	Other	...	...	...	...	...	...
		0	Other	0	Other	...	...	...	...	...	...
02	PEI Chemical	1	General Purpose	1		<2	1.25–1.30	198	93	128	2760

Group	Description	Class	Description	Grade	Description[A]	Flow Rate,[B] Test Method D1238, g/10, min	Specific Gravity, Test Method D792	Deflection[C] Temperature (DTUL), min, Test Method D648, °C, min	Tensile[D] Strength, Test Method D638, MPa, min	Flexural[E] Strength, Test Methods D790, MPa, min	Flexural[E] Modulus, Test Methods D790, MPa, min
	—Resistant			2		2–8	1.25–1.30	198	–93	128	2760
				3		6–12	1.25–1.30	198	–93	128	2760
				4		10–16	1.25–1.30	198	–93	128	2760
				5		15–22	1.25–1.30	198	–93	128	2760
				6		20–30	1.25–1.30	196	–90	124	2760
				7		> 30	1.25–1.30	196	–90	124	2760
				0	Other	...	...	...	...	...	...
		2	Impact-Modified	1		< 2	1.22–1.28	184	–69	–90	2070
				2		2–8	1.22–1.28	184	–69	–90	2070
				3		6–12	1.22–1.28	184	–69	–90	2070
				4		10–16	1.22–1.28	184	–69	–90	2070
				5		15–22	1.22–1.28	184	–69	–90	2070
				6		20–30	1.22–1.28	184	–69	–90	2070
				7		> 30	1.22–1.28	184	–69	–90	2070
				0	Other	...	...	...	...	...	...
		3	High-Heat Resistant	1		< 2	1.27–1.32	215	–97	145	2760
				2		2–8	1.27–1.32	215	–97	145	2760
				3		6–12	1.27–1.32	215	–97	145	2760
				4		10–16	1.27–1.32	215	–97	145	2760
				5		15–22	1.27–1.32	215	–97	145	2760
				6		20–30	1.27–1.32	215	–97	145	2760
				7		> 30	1.27–1.32	215	–97	145	2760
				0	Other	...	...	...	...	...	...
		4	High-Heat Impact-Modified	1		< 2	1.23–1.30	200	–69	103	2070
				2		2–8	1.23–1.30	200	–69	103	2070
				3		6–12	1.23–1.30	200	–69	103	2070
				4		10–16	1.23–1.30	200	–69	103	2070
				5		15–22	1.23–1.30	200	–69	103	2070
				6		20–30	1.23–1.30	200	–69	103	2070
				7		> 30	1.23–1.30	200	–69	103	2070
		0	Other	0	Other	...	...	...	...	...	...
03	PEI Heat-	1	General-Purpose	1		< 2	1.27–1.31	210	103	145	2760
	—Resistant			2		2–8	1.27–1.31	210	103	145	2760
				3		6–12	1.27–1.31	210	103	145	2760
				4		10–16	1.27–1.31	210	103	145	2760
				5		15–22	1.27–1.31	210	103	145	2760
				6		20–30	1.27–1.31	210	–90	131	2760
				7		> 30	1.27–1.31	210	–90	131	2760
				0	Other	...	...	...	...	...	...
		2	Impact-Modified	1		< 2	1.22–1.28	196	–69	110	2070
				2		2–8	1.22–1.28	196	–69	110	2070
				3		6–12	1.22–1.28	196	–69	110	2070
				4		10–16	1.22–1.28	196	–69	110	2070
				5		15–22	1.22–1.28	196	–69	110	2070
				6		20–30	1.22–1.28	196	–69	110	2070
				7		> 30	1.22–1.28	196	–69	110	2070
				0	Other	...	...	...	...	...	...
		3	High-Heat	1		< 2	1.28–1.32	225	103	138	2760
				2		2–8	1.28–1.32	225	103	138	2760
				3		6–12	1.28–1.32	225	103	138	2760
				4		10–16	1.28–1.32	225	103	138	2760
				5		15–22	1.28–1.32	225	103	138	2760
				6		20–30	1.28–1.32	225	103	138	2760
				7		> 30	1.28–1.32	225	103	138	2760
				0	Other	...	...	...	...	...	...
		4	High-Heat Impact-Modified	1		< 2	1.24–1.28	210	–69	–97	2070
				2		2–8	1.24–1.28	210	–69	–97	2070
				3		6–12	1.24–1.28	210	–69	–97	2070
				4		10–16	1.24–1.28	210	–69	–97	2070
				5		15–22	1.24–1.28	210	–69	–97	2070
				6		20–30	1.24–1.28	210	–69	–97	2070
				7		> 30	1.24–1.28	210	–69	–97	2070
				0	Other	...	...	...	...	...	...
		0	Other	0	Other	...	...	...	...	...	...
04	PEI—Flexible	1	General-Purpose	1		< 2	1.16–1.20	N/A[F]	–34	–52	–690

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