Designation: D4549 – 15

Standard Classification System and Basis for Specification for Polystyrene and Rubber-Modified Polystyrene Molding and Extrusion Materials (PS)[1]

This standard is issued under the fixed designation D4549; 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 polystyrene materials, both crystal and rubber modified, suitable for molding and extrusion.

1.2 This classification system and subsequent line callout (specification) are intended to be 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 plastics 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 inherent properties of the material other than those covered by this specification, and the economics.

1.3 The properties included in this specification are those required to identify the compositions covered. Other requirements necessary to identify particular characteristics important to specialized applications are to be specified using the suffixes as given in Section 5.

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

NOTE 1—This standard combines elements from ISO 1622-1-2 and ISO 2897-1-2, but is not equivalent to either ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

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

D1525 Test Method for Vicat Softening Temperature of 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

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

Manual on Presentation of Data and Control Chart Analysis, 8th Edition, Catalog Number: MNL7-8TH-EB

2.2 *ISO Standards:*[3]

ISO 1622-1-2 Polystyrene (PS) Molding and Extrusion Materials—Part 1: Designation System and Basis for Specifications

ISO 1622-2 Polystyrene (PS) Molding and Extrusion Materials—Part 2: Preparation of Test Specimens and Determination of Properties

ISO 2897-1 Impact-Resistant Polystyrene (PS-I) Molding and Extrusion Materials—Part 1: Designation System and Basis for Specifications

ISO 2897-2 Impact-Resistant Polystyrene (PS-I) Molding and Extrusion Materials—Part 2: Preparation of Test Specimens and Determination of Properties

3. Terminology

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

[1] This specification 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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

4. Classification

4.1 Polystyrene materials are classified into groups in accordance with classes and grades as shown in the basic property table (Table PS). Injection molded properties are the preferred standard and are used for the basis of call out examples.

NOTE 2—Since compression molded properties have been removed from the standard with this publication, refer to previous publications of this standard, if interested in these properties.

NOTE 3—An example of this classification system for PS0111 is as follows: The designation PS0111 would indicate: PS = polystyrene as found in Terminology D1600, 01 (group) = crystal polystyrene, 1 (class) = general-purpose, and 1 (grade) = minimum-grade requirements as found in Table PS.

4.1.1 To facilitate the incorporation of future or special materials, the "other/unspecified" category (0) for group, class, and grade is shown in Table PS. The basic properties are obtained from Tables A or B as they apply (see 4.3).

4.2 Reinforced and filled polystyrene materials are classified in accordance with Table PS and Table A. Table PS specifies unreinforced material and Table A the properties after addition of reinforcements or lubricants at the normal levels indicated (see 4.2.1).

4.2.1 *Reinforcements and Additive Materials*—A single letter will be used for the major reinforcement or combination, or both, along with two digits that indicate the percentage of addition by mass with the tolerances tabulated as follows:

Symbol	Material	Tolerance (Based on Total Mass)
C	Carbon and graphite fiber-reinforced	± 2 %
G	Glass	± 2 %
M	Mineral-reinforced	± 2 %
L	Lubricants	Depends upon material and process to be specified
R	Combination of reinforcement or fillers, or both	± 2 %

NOTE 4—This part of the system uses the type and percentages of additive to designate the modification of the basic material. Percentage of additives can be shown on the supplier's Technical Data Sheet unless it is proprietary. If necessary, additional requirements shall be indicated by the use of the suffix part of the system, as given in Section 5.

NOTE 5—Determine ash content of filled or reinforced materials using Test Method D5630 where applicable.

4.2.2 *Table A, Detail Requirements*—An identifying number is made up of the letter A and five digits comprising the cell numbers for the new requirements in the designated order as they appear in Table A.

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

NOTE 6—An example of a reinforced polystyrene of this classification system is as follows: The designation PS0110G15A12332 would indicate the following material requirements from Table A:

0110 = Polystyrene, crystal, from Table PS,
G15 = Glass-reinforced at 15 % nominal (see 4.2.1),
A = Table A for property requirements,
1 = Tensile strength, 50 MPa, min,
2 = Flexural modulus, 4200 MPa, min,
3 = Izod impact, 40 J/m, min,
3 = Deflection temperature, 102°C, min, and
2 = Specific gravity, 1.2, min.
If no properties are specified, the designation would be PS0110G15-A00000.

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

NOTE 7—An example of a special material using this classification system is as follows: The designation PS0110B76013 indicates the following, with the material requirements from Table B:

PS0110	=	Polystyrene, crystal, from Table PS,
B	=	Cell Table B for property requirements,
7	=	Tensile strength, 70 MPa, min,
6	=	Tensile modulus, 2700 MPa, min,
0	=	Unspecified Izod impact
I	=	Vicat softening temperature, 85°C, min, and
3	=	Flow rate, 3.0, min.

TABLE PS Polystyrene Materials, Detail Requirements, Natural Color Only

Group	Description	Class	Description	Grade	Description	Melt Flow Rate, ASTM D1238, Condition 200/5.0 g/10 min, min[A]	Izod Impact, (12.7 by 3.2 mm) ASTM D256, min, J/m[B]	Tensile Strength at Yield, ASTM D638, min, MPa[C, D]	Tensile Modulus, ASTM D638, min, MPa[D]	Vicat Softening Point, ASTM D1525, Rate B, °C, min 1000-g load
						Injection molded	Injection molded	Injection molded	Injection molded	Injection molded
01	Crystal	1	General-Purpose	1		1.0		45	3100	100
				2		5.0		40	3000	95
				3		10.0		35	2900	85
		0	Other	0	Other	Unspecified				Unspecified
02	Rubber-modified	1	Medium-impact	1		1.0	40	34	2500	95
				2		5.0	40	28	2300	90
				3		10.0	40	22	2000	85
				0	Other	Unspecified				Unspecified
		2	High-impact	1		1.0	80	20	2000	95
				2		5.0	80	18	1800	90
				3		10.0	80	16	1600	85
				0	Other	Unspecified				Unspecified
		3	Super-high-impact	1		1.0	120	14	1400	90
				2		5.0	120	12	1200	85
		0	Other	0	Other	Unspecified				Unspecified
00	Other	0		0						

[A] Use pellets, powder, or parts cut into pieces that can fit into the barrel.
[B] Method A, specimen are nominal 3.2-mm thick injection-molded and taken from the center of Type I (D638) specimen.
[C] Values in this column for crystal PS are not yield, but break strengths; crystal PS does not exhibit a yield point.

[D]Tensile properties determined on nominal 3.2-mm thick injection-molded Type I specimen tested at 5 mm/min.

TABLE A Reinforced Polystyrene Materials, Detail Requirements[A]

Designation Order Number	Injection Molded Properties	0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ASTM D638, Type 1 Specimens, min, MPa	Unspecified	50	60	70	80	90	100	110	120	Specify
2	Flexural modulus[A] , ASTM D790, min, MPa	Unspecified	3500	4200	4900	5600	6300	7000	8500	10 000	Specify
3	Izod impact, same specimen as required in Table PS, Footnote B, ASTM D256, min, J/m	Unspecified	10	20	40	60	80	100	120	140	Specify
4	DTUL[B] , ASTM D648, unannealed, 1.82 MPa, min, °C	Unspecified	94	98	102	106	110	114	118	122	Specify
5	Specific gravity, ASTM D792, min	Unspecified	1.1	1.2	1.4	1.6	1.8	2.0	2.2	2.4	Specify

[A]Method A: nominal 3.2 by 12.7 - mm sample: 50 - mm span: 1.3 - mm/min cross-head rate tangent modulus.
[B]Deflection temperature of plastics under flexural load (12.7 by 3.2-mm) sample.

TABLE B Unreinforced Polystyrene Materials, Detail Requirements

Designation Order Number	Injection Molded Properties	0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ASTM D638, Type 1 Specimens, min MPa	Unspecified	10	20	30	40	50	60	70	80	Specify
2	Tensile modulus, ASTM D638, min, MPa	Unspecified	1200	1500	1800	2100	2400	2700	3000	3300	Specify
3	Izod impact, same specimen as required in Table PS, Footnote B, ASTM D256, min, J/m	Unspecified	10	25	50	100	150	200	250	300	Specify
4	Vicat softening point, ASTM D1525, min, °C, Rate B	Unspecified	85	90	95	100	105	110	115	120	Specify
5	Melt flow rate, ASTM D1238, Condition 200/5.0, min, g/10 min	Unspecified	0.5	1.0	3.0	5.0	7.0	9.0	12.0	15.0	Specify

5. Suffix Requirements

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 is 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.

NOTE 8—Properties of pigmented or colored PS materials can differ from the properties of natural or unpigmented PS material, depending on the choice of colorants and the concentration. The main property affected is ductility, as illustrated by a reduction in Izod impact strength. If specific properties of pigmented PS materials are necessary, prior testing between the materials supplier and end user should be initiated.

6. Basic Requirements

6.1 Basic requirements from the property tables or cell tables are always in effect unless these requirements are superseded by specific suffix requirements, which always take precedence.

7. General Requirements

7.1 The material composition shall be uniform and shall conform to the requirements specified herein.

8. Detail Requirements

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

8.2 For the purpose of determining conformance, all specified limits for a specification (line callout) based on this classification system are absolute limits, as defined in Practice E29.

8.3 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.

9. Sampling

9.1 Sampling shall be statistically adequate to satisfy the requirements of 13.4.

9.2 A batch or lot shall be construed as a unit of manufacture as prepared for shipment and can consist of a blend of two or more "production runs."

10. Sample Preparation—Injection- or Compression-Molding Process

10.1 The test specimens shall be molded by an injection molding process as follows.

10.2 For injection-molded samples, 220 ± 10 °C is the melt temperature and 50 ± 10 °C is the mold temperature.

10.2.1 The injection velocity for molding specimens shall be 200 ± 100 mm/s. Average injection velocity of the flow front through the critical measurement area of the specimen is calculated using the following equation:

$$AIV = \frac{\pi d^2 Va}{4ns} \quad (1)$$

where:

d = screw diameter, (mm)
Va = screw advance speed, (mm/s)
n = number of mold cavities, and
s = cross-sectional area of the specimen, (mm^2)

NOTE 9—The mold must have balanced flow for this equation to be valid.

10.3 Izod Impact specimens shall be obtained from the central portion of a Test Method D638, Type 1 tensile bar. The apex of the milled notch shall be at the center (within 1 mm) of the tensile bar length. In accordance with Test Methods D256, the distance between the apex of the notch and the impacted end of the specimen shall be 32 ± 1 mm, however the length of specimen that is contained within the vise is required to be at least 22 mm.

10.4 The recommended flexural modulus specimen is a Test Method D638, Type 1 tensile bar. The loading nose of the flexural apparatus shall be placed within 3 mm of the center of the tensile bar.

11. Conditioning

11.1 Test specimens shall be conditioned at 23 ± 2°C for at least two hours before performing the required tests.

11.2 Conduct tests in the atmosphere of 23 ± 2 °C.

12. Test Methods

12.1 Determine the properties enumerated in this specification by means of the ASTM test methods as they apply, unless otherwise stated herein.

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 those tests which ensure process control during manufacture: melt flow rate and Izod impact.

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 specification. 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).

NOTE 10—The ASTM publication *Manual on Presentation of Data and Control Chart Analysis,* 8th Edition, Catalog Number: MNL-8TH-EB, provides detailed information about statistical process control.

13.5 A report of the test results shall be furnished when requested. The report shall consist of results of the lot-acceptance inspection for the shipment and the results of the most recent periodic-check inspection.

14. Packaging and Package Marking

14.1 For packing, packaging, and marking, the provisions of Practice D3892 apply.

15. Keywords

15.1 high-impact polystyrene; line callout; plastics; polystyrene; specification

APPENDIX

(Nonmandatory Information)

X1. ASTM/DoD CROSS REFERENCE

ASTM	MIL-P-21347D
PS0110 G36A60742 JM093	Type I
PS0210 G36A40912 JM085PA213	Type II

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D4549 - 11) that may impact the use of this standard. (September 1, 2015)

(1) Revised Sections 9 and 13 to conform with ASTM Guide D5740.

(2) Added Note 10.