



Designation: D 4549 – 003

## Standard Specification for Polystyrene and Rubber-Modified Polystyrene Molding and Extrusion Materials (PS)<sup>1</sup>

This standard is issued under the fixed designation D 4549; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope\*

1.1 This specification covers polystyrene materials, both crystal and rubber modified, suitable for molding and extrusion. Recycled polystyrene products are addressed in Specification D 5676.

1.2 This specification is intended to be a means of calling out plastic materials used in the fabrication of end items or parts. Material selection should 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 can be called out using the suffixes as given in Section 5.

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:

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<sup>1</sup> This specification 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 Nov. August 10, 20003. Published February 2001. ~~Originally published as D 4549 – 85; approved in 1985. Last previous edition approved in 2000 as D 4549 – 9800.~~ October 2003.

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

- D 256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics<sup>2</sup>
  - ~~D 618 Practice for Conditioning Plastics for Testing<sup>2</sup>~~
  - D 638 Test Method for Tensile Properties of Plastics<sup>2</sup>
  - D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position<sup>2</sup>
  - D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials<sup>2</sup>
  - D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement<sup>2</sup>
  - D 883 Terminology Relating to Plastics<sup>2</sup>
  - D 1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer<sup>2</sup>
  - D 1525 Test Method for Vicat Softening Temperature of Plastics<sup>2</sup>
  - D 1600 Terminology for Abbreviated Terms Relating to Plastics<sup>2</sup>
  - D 2584 Test Method for Ignition Loss of Cured Reinforced Resins<sup>3</sup>
  - D 3892 Practice for Packaging/Packing of Plastics<sup>3</sup>
  - D 4000 Classification System for Specifying Plastic Materials<sup>3</sup>
  - D 5676 Specification for Recycled Polystyrene Molding and Extrusion Materials<sup>4</sup>
  - E 105 Practice for Probability Sampling of Materials<sup>5</sup>
- 2.2 *ISO Standards:*<sup>6</sup>
- ISO 1622-1-2 Polystyrene (PS) Molding and Extrusion Materials
  - ISO 2897-1-2 Impact Resistant Polystyrene (PS-I) Molding and Extrusion Materials

### 3. Terminology

3.1 *Definitions* — For definitions of technical terms pertaining to plastics used in this specification, see Terminology D 883.

### 4. Classification

4.1 Polystyrene materials are classified into groups ~~according to~~ 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 D 1600, 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 can be 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—Ash content of filled or reinforced materials may be determined using Test Method D 2584 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.

<sup>2</sup> Annual Book of ASTM Standards, Vol 08.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 08.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 08.03.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>6</sup> Available from American National Standards Institute (ANSI), 25 W. 42nd St., 43rd Floor, New York, NY 10036.

4.2.2.1 Although the values listed are necessary to include the range of properties available in existing materials, users should not infer that 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 would indicate 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 D 1238, Condition 200/5.0 g/10 min, min <sup>A</sup>	Izod Impact, (12.7 by 3.2 mm) ASTM D 256, min, J/m <sup>B</sup>	Tensile Strength at Yield, ASTM D 638, min, MPa <sup>C,D</sup>	Tensile Modulus, ASTM D 638, min, MPa <sup>D</sup>	Vicat Softening Point, ASTM D 1525, 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	
02	Rubber-modified	0	Other	0	Other	Unspecified				Unspecified	
				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
00	Other	0	Other	0	Other	Unspecified				Unspecified	
				0		5.0	120	12	1200	85	

<sup>A</sup> Specimen may be pellets, powder, or parts cut into pieces that can fit into the barrel.

<sup>B</sup> Method A, specimen are nominal 3.2-mm thick injection-molded and taken from the center of Type I (D 638) specimen.

<sup>C</sup> Values in this column for crystal PS are not yield, but break strengths; crystal PS does not exhibit a yield point.

<sup>D</sup> 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<sup>A</sup>**

Designation Order Number	Injection Molded Properties	0	1	2	3	4	5	6	7	8	9
1	Tensile strength, ASTM D 638, Type 1 Specimens, min, MPa	Unspecified	50	60	70	80	90	100	110	120	Specify
2	Flexural modulus <sup>A</sup> , ASTM D 790, 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 D 256, min, J/m	Unspecified	10	20	40	60	80	100	120	140	Specify
4	DTUL <sup>B</sup> , ASTM D 648, unannealed, 1.82 MPa, min, °C	Unspecified	94	98	102	106	110	114	118	122	Specify
5	Specific gravity, ASTM D 792, min	Unspecified	1.1	1.2	1.4	1.6	1.8	2.0	2.2	2.4	Specify

<sup>A</sup> Method A: nominal 3.2 by 12.7 - mm sample: 50 - mm span: 1.3 - mm/min cross-head rate tangent modulus.

<sup>B</sup> 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 D 638, Type 1 Specimens, min MPa	Unspecified	10	20	30	40	50	60	70	80	Specify
2	Tensile modulus, ASTM D 638, 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 D 256, min, J/m	Unspecified	10	25	50	100	150	200	250	300	Specify
4	Vicat softening point, ASTM D 1525, min, °C, Rate B	Unspecified	85	90	95	100	105	110	115	120	Specify
5	Melt flow rate, ASTM D 1238, 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 requirements are needed that supersede or supplement the property table or cell table requirements, they shall be specified through the use of suffixes. In general, the first suffix letter indicates the special requirements needed and the second letter indicates the condition or test method, or both, with a three-digit number indicating the specific requirement. The suffixes that may be used are listed in Table 3 of Classification System D 4000.

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 Table PS, as they apply, 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.

## 9. Sampling

9.1 Sampling shall be in accordance with the sampling procedure prescribed in Practice E 105 or statistically adequate to satisfy the requirements of 13.4. A lot of material shall be considered as a unit of manufacture as prepared for shipment, and may consist of two or more production runs or batches.

## 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,  $220 \pm 10$  °C is the melt temperature and  $50 \pm 10$  °C is the mold temperature.

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

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

where:

$d$  = screw diameter,

$Va$  = screw advance speed,

$n$  = number of mold cavities, and

$s$  = cross-sectional area of the specimen.

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 D 638, 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 D 256, the distance between the apex of the notch and the impacted end of the specimen shall be  $32 \pm 1$  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 D 638, 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 in the standard laboratory atmosphere in accordance with Procedure A of Practice D-618 at  $23 \pm 2$  °C for at least two hours before performing the required tests.~~

~~11.2 Conduct tests in the standard laboratory atmosphere of  $23 \pm 2$  °C and  $50 \pm 5$  % relative humidity in accordance with Practice D-618.  $23 \pm 2$  °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 shall consist of the tests specified for all requirements of the material under this classification system. 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, sampled, tested, and inspected in accordance with this classification system and that the average values meet the requirements at a confidence level of 95 %.

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 D 3892 apply.

## 15. Keywords

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

**APPENDIX****(Nonmandatory Information)****XI. ASTM/DoD CROSS REFERENCE**

ASTM D 4549

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PS0110 G36A60742 JM093  
PS0210 G36A40912 JM085PA213Type I  
Type II**SUMMARY OF CHANGES**

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

***D 4549 – 03:***

- (1) Added paragraph 10.3: Notch position in the tensile bar.
- (2) Added paragraph 10.4: Recommended use of tensile bar for flexural tests.
- (3) Deleted humidity requirement for conditioning, as well as the requirement for Procedure A of Test Method D 618 in paragraphs 11.1 and 11.2.

***D 4549 – 00:***

- (1) Revised title to include rubber-modified polystyrene.
- (2) Deleted reference to Military Standards and Quality Assurance Provisions for Government/Military Procurement.
- (3) Replaced D 1898 with E 105.
- (4) Removed compression molding conditions and properties from Table PS.
- (5) Clarified specimen and test conditions in Tables PS, A, and B.

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