Designation: D 6394 – 02

Standard Specification for Sulfone Plastics (SP) [1]

This standard is issued under the fixed designation D 6394; 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 specification covers the classification of sulfone plastics suitable for injection molding and extrusion.

1.2 The properties included in this specification are those required to identify the compositions covered. There may be other requirements necessary to identify particular characteristics important to specialized applications. These will be specified by using the suffixes in Section 5.

1.3 This specification is intended to be a means of calling out sulfone plastics 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, and the inherent properties of the material other than those covered by this specification.

1.4 Sulfone polymers, being thermoplastic, are reprocessable and recyclable. This specification allows for the use of those sulfone polymer materials, provided that any specific requirements are met.

1.5 The following safety hazards caveat pertains only to the test method portion, Section 11, of this standard: *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.*

NOTE 1—Reference Guide D 5033 for information and definitions related to recycled plastics.

NOTE 2—There is no equivalent or similar ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics[2]

D 618 Practice for Conditioning Plastics for Testing[2]

D 638 Test Method for Tensile Properties of Plastics[2]

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position[2]

D 789 Test Methods for Determination of Relative Viscosity and Moisture Content of Polyamide (PA)[2]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[2]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]

D 883 Terminology Relating to Plastics[2]

D 1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer[2]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials[3]

D 3892 Practice for Packaging/Packing of Plastics[3]

D 4000 Classification System for Specifying Plastic Materials[3]

D 4019 Test Method for Moisture in Plastics by Coulometric Regeneration of Phosphorus Pentoxide[3]

D 5033 Guide for Development of ASTM Standards Relating Recycling and Use of Recycled Plastics[4]

D 5630 Test Method for Ash Content in Thermoplastics[4]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

2.2 *ISO Standards:*[6]

ISO 1628-1 Determination of the Viscosity of Polymers in Dilute Solution Using Capillary Viscometer—Part 1: General Principles

ISO 1628-5 Determination of the Viscosity of Polymers in Dilute Solution Using Capillary Viscometers

3. Terminology

3.1 Except for terms defined below, the terminology used in this specification is in accordance with Terminologies D 883 and D 1600.

[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] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

[4] *Annual Book of ASTM Standards*, Vol 08.03.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *sulfone plastics, n*—plastics based on any of various aromatic polymers which contain diphenyl sulfone in the backbone of the repeating unit of the molecule.

3.2.1.1 *Discussion*—All of the sulfone polymers which are under this specification contain ether oxygen which is a necessary component of the polymers as in the diphenyl sulfone moiety. Examples of moieties which can be part of the backbone of the repeating unit, in addition to diphenyl sulfone, are diphenyl isopropylidene, and biphenyl. Blends of these polymers can exist as well as co- and ter-polymers. Commercial polymers that are members of this class of thermoplastics include polysulfone (PSU), polyether sulfone (PES), and polyphenylsulfone (PPSU) (see Fig. 1).

4. Classification

4.1 Unreinforced sulfone plastics are classified into groups according to their composition. These groups are subdivided into classes and grades as shown in Table SP.

NOTE 3—An example of this designation system is given below. The designation SP0213 indicates the following:

SP	=	sulfone plastics as defined in Section 3,
02 (Group)	=	polyether sulfone, as defined in Terminology D 1600,
1 (Class)	=	high temperature, and
3 (Grade)	=	minimum requirements given in Table SP.

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 SP. The basic properties of these materials can be obtained from Table A as they apply.

4.2 Reinforced, filled, and lubricated versions of sulfone plastics that are in Table SP are classified in accordance with Tables SP and A. Table SP is used to specify the group of sulfone plastics and Table A 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 *Reinforcements and Additive Materials*—A symbol (single-letter) is used for the major reinforcement or combination, or both, along with two numbers which indicate the percentage of addition by mass with the tolerances tabulated as follows:

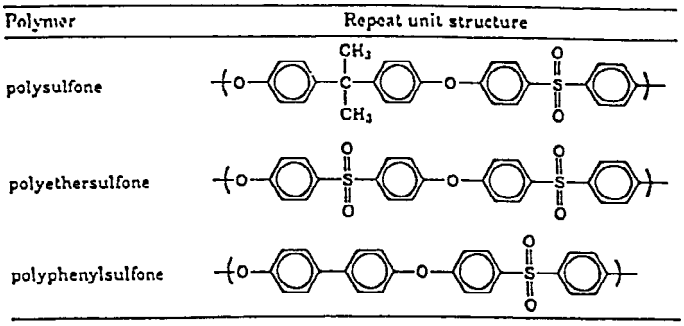

FIG. 1 Repeat Unit Structure

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

NOTE 4—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 should be shown on the supplier's technical data sheet unless they are proprietary in nature. If necessary, additional callout of these reinforcement and additives can be accomplished by use of the suffix part of the system (see Section 5).

4.2.2 Specific requirements for reinforcement, filled, or lubricated sulfone plastics shall be shown by a six-character designation. The designation will consist of the letter "A" and the five digits comprising the cell numbers for property requirements in the 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, users should not infer 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 5—An example of this classification for a reinforced sulfone plastics material is given as follows. The designation SP0213G30A43460 would have the following material requirements:

SP0213	=	poly(ether sulfone) with minimum requirements given in Table SP,
G30	=	glass reinforced at the 30 % nominal level,
A	=	Table A property requirements,
4	=	tensile strength, 95 MPa a minimum,
3	=	flexural modulus, 4.5 GPa minimum,
4	=	Izod impact, 50 J/m minimum,
6	=	deflection temperature, 200°C minimum, and
0	=	unspecified.

If no properties are specified, the designation would be SP0213G30A00000.

5. Suffixes

5.1 Suffixes that may be used are listed in Table 3 of Classification D 4000.

5.2 If the requirements for the poly(ether sulfone) material in 4.2.3 also included flammability requirements, the following example indicates the call-out:

SP0213G30A43460FL310

SP0213G30A43460 = same as in 4.2.3.
From Table 3 in Classification D 4000 the following is obtained:
F = flammability requirements,
L = UL94 recognition required,
3 = 0.8 mm minimum thickness,
1 = vertical burn test, and
0 = V-0 rating.

6. General Requirements

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

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 requirements of Tables SP, A and suffix requirements 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 E 29.

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 may 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 D 3641. Recommended processing conditions are shown in Table 1.

9.2 Before molding, the material shall be dried to a moisture level of no more than 0.05 % as determined by test methods described in either Test Methods D 789 or D 4019.

10. Conditioning

10.1 Test specimens shall be conditioned in the standard laboratory atmosphere in accordance with Procedure A of Practice D 618 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 ± 2°C and 50 ± 5 % relative humidity.

11. Test Methods

11.1 Determine the properties enumerated in this specification by means of Test Methods D 256, D 638, D 648, D 790, D 792, D 1238, and D 5630.

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 *Flow Rate*—As according to Test Method D 1238, using the following conditions:

11.1.3.1 *PSU*—343°C and 2.16 Kg load, or 360°C and 10 Kg load,

11.1.3.2 *PES*—380°C and 2.16 Kg load, or 360°C and 10 Kg load, and

11.1.3.3 *PPSU*—365°C and 5.00 Kg load.

11.1.4 *Deflection Temperature (Test Method D 648)*—Test specimens shall be annealed for 1 h in an air circulating oven at the following temperatures:

11.1.4.1 PSU at 170°C, and

11.1.4.2 PES and PPSU at 200°C.

11.1.5 *Izod Impact (Test Method D 256)*—Test the center portion of a 100-mm specimen which is 3.2 mm wide by 12.7 mm deep.

11.1.6 *Solution Viscosity (ISO1628-5)*—The solvent shall be a 1:1 ratio of phenol to 1,2-dichlorobenzene. A 1 % solution shall be used.

12. Inspection and Certification

12.1 Inspection and certification of the material supplied with reference to a specification based on this standard shall be for conformance to the requirements specified herein.

12.2 Lot acceptance inspection shall be the basis on which acceptance or rejection on the lot is made. The lot acceptance inspection shall consist of the following:

	Unfilled Polymer	Reinforced Polymer	Unfilled Blend	Reinforced Blend
Flow Rate, g/10 min (Test Method D 1238), or Solution Viscosity (ISO 1628-5)	Yes	Yes	Yes	Yes
Ash, % (Test Method D 5630)	No	Yes	No	Yes

NOTE 6—The term *blend* implies a blend of two or more SPs.

NOTE 7—Solution viscosity by ISO 1628-5, using a solution of phenol / 1,2-dichlorobenzene, 1:1 ratio at 1 % concentration as described in ISO 1628-5.

12.3 Periodic check inspection with reference to a specification based upon this specification 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, sampled, tested, and inspected in accordance with this specification and that the average values for the lot meet the requirements of the specification (line callout).

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 plastics as defined in 3.1 of Guide D 5033 if requested, and when requested, the results of the most recent periodic check inspection.

13. Packaging, Packing, and Marking

13.1 The provisions of Practice D 3892 apply to packaging, packing, and marking of containers for plastics materials.

14. Keywords

14.1 line callout; plastics materials; polyethersulfone; polyphenylsulfone; polysulfone; recycled

TABLE SP Requirements for Unreinforced Sulfone Plastics

Group	Description	Class	Description	Grade	Description	Flow Rate,[A] g/10, min.	Deflection Temperature,[B] °C, min.	Tensile Strength,[C] MPa, min.	Flexural Modulus,[D] MPa, min.	Izod Impact,[E] J/m, min.	Specific Gravity[F]
01	Polysulfone	1	General Purpose	1		2.0 - 4.9	174	70	2600	70	1.23 - 1.25
				2		5.0 - 9.0	174	70	2600	70	1.23 - 1.25
				3		9.1 - 30	174	70	2600	70	1.23 - 1.25
				0	Other						
02	Poly(ether sulfone)	1	High Temperature	1		10 - 30	204	83	2900	90	1.36 - 1.38
				0	Other						
03	Poly(phenyl sulfone)	1	High Temperature, Tough	1		9 - 25	204	70	2400	690	1.28 - 1.30
				0	Other						
00	Other	0	Other	0	Other						

[A]Flow rate Test Method D 1238, conditions: PSU: 343°C/2.16 kg; PES: 380°C/2.16 kg; PPSU: 365°C/5.0 kg.
[B]Deflection temperature Test Method D 648, conditions: 1.8 MPa. Use 3.2-mm thick specimens annealed in accordance with Section 11.
[C]Tensile strength Test Method D 638, Type I tensile bar, rate of crosshead motion: 50 mm/min.
[D]Flexural modulus Test Method D 790, specimen 3.2 by 12.7 mm cross section, rate of crosshead motion: 1.3 mm/min.
[E]Izod impact Test Method D 256, test center portion of 100-mm long specimens with nominal dimensions of 3.2 by 12.7 mm.
[F]Specific gravity Test Method D 792.

TABLE A Detailed Requirements of Reinforced Sulfone Plastics

Designation or Order Number	Property	0	1	2	3	4	5	6	7	8	9
1	Tensile strength,[A] D 638, min, MPa[B]	unspecified	50	65	80	95	110	130	150	170	specify value
2	Flexural modulus,[C] D 790 (A), min, GPa[B]	unspecified	2.5	3.5	4.5	5.5	7.0	9.0	10.0	12.0	specify value
3	Izod impact resistance[D] D 256, min, J/m[E]	unspecified	20	30	40	50	70	90	120	150	specify value
4	Deflection temperature at 1.8 MPa,[F] D 648, min, °C	unspecified	150	160	170	180	190	200	210	220	specify value
5	To be determined	unspecified	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

[A]Type I D 638 test specimens, tested at 5 mm/min.
[B]MPa × 145 = psi or kPa × 0.145 = 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 specimens are nominal 3.2 mm wide with a depth of 12.7 mm.
[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.

Table 1 Recommended Processing Conditions

Polymer	Melt Temperature, °C	Mold Temperature,° C	Velocity, mm/s
PSU	345-390	100-160	200 ± 100
PES	345-385	130-170	200 ± 100
PPSU	360-390	140-180	200 ± 100