Designation: D8366 – 21

Standard Specification for Extruded and Compression Molded Shapes Made from Unfilled Poly(Vinylidene Fluoride) PVDF[1]

This standard is issued under the fixed designation D8366; 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 specification covers the requirements and test methods for the material, dimensions, workmanship, and the properties of extruded sheet, rod and tubular bar manufactured from unfilled PVDF.

1.2 This specification covers the requirements and test methods for the material, dimensions, workmanship, and the properties of extruded and compression molded shapes manufactured from unfilled PVDF.

1.3 The properties included in this specification are those required for shapes made from PVDF polymers. Requirements necessary to identify particular characteristics of the shape are included in Section 5.

1.4 This specification allows for the use of up to 20 % process regrind and reprocessed plastic, total, and of uncontaminated quality.

1.5 The values stated in English Units are to be regarded as the standard in all property and dimensional tables. For reference purposes, SI units are also included.

1.6 The following safety hazards caveat pertains only to the test method or test methods described in this specification. *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.*

1.7 *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]

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

D618 Practice for Conditioning Plastics for Testing

D638 Test Method for Tensile Properties of Plastics

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

D3222 Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating 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

D3892 Practice for Packaging/Packing of Plastics

D4000 Classification System for Specifying Plastic Materials

D5575 Classification System for Copolymers of Vinylidene Fluoride (VDF) with Other Fluorinated Monomers

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this specification and associated with plastics issues refer to the terminology contained in Terminology D883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *copolymer, n*—a polymer made by the reaction of two or more different monomers with units of more than one kind.

[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.

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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.

3.2.2 *homopolymer, n*—a polymeric molecule in which one type of chemical repeat unit or monomer is repeated many times to produce the final macromolecule.

3.2.3 *polyvinylidene fluoride (PVDF), n*—a semi-crystalline polymer made from the repeating monomer of C2H2F2.

3.2.4 *regrind (plastic), n*—a product or scrap such as sprues, runners, sheet, rod and melted strands that have been reclaimed by shredding and granulating for use in-house.

3.2.5 *reprocessed plastic, n*—a thermoplastic prepared from usually melt processed scrap or reject parts by a plastics processor, or from non-standard or non-uniform virgin material.

3.2.6 *post consumer recycled (plastic), n*—material reclaimed by shredding and granulating post consumer material.

3.2.7 *rod, n*—an extruded solid cylindrical shape with a minimum diameter of 1.5875mm (0.0625 in.).

3.2.8 *sheet, n*—flat stock greater than and including 1.016mm (0.040 in.) thickness.

3.2.9 *tubular bar, n*—extruded annular shapes with a minimum inside diameter of 1.5875mm (0.0625 in.), and a minimum wall of 6.35mm (0.25 in.).

3.2.10 *unfilled polyvinylidene fluoride (PVDF) shapes, n*—a shape produced only from polyvinylidene fluoride with no other additives, fillers or pigments.

3.2.11 *virgin polyvinylidene fluoride (PVDF) shape, n*—a shape produced only from polymer direct from manufacturers package without the use of any regrind with no other additives, fillers or pigments.

4. Classification and Material

4.1 Product shape and size as defined in applicable purchase order.

4.2 This specification covers product extruded and compression molded. Products included in designations reference Specification D3222 callouts where applicable.

4.2.1 The PVDF shape product can be categorized by shape, class, type, grade (if applicable), and viscosity, as listed in Table 1. While the use of shape and class to describe the PVDF shape product are mandatory, type, grade and viscosity are optional.

4.2.2 The shape can be described as rod, sheet or tubular bar.

4.2.3 The shape shall be categorized as Class A or Class B based on composition as follows:

4.2.3.1 *Class A—Virgin PVDF Shape*—Extruded or compression molded product made using only 100 % virgin PVDF material with no regrind or reclaimed material.

4.2.3.2 *Class B—General Purpose Shape*—Extruded or compression molded product made using up to 20 % total of PVDF regrind and PVDF reprocessed plastic of uncontaminated quality.

NOTE 1—Use of post-consumer recycled PVDF is not permitted. Caution should be exercised in not using contaminated regrind or contaminated reprocessed PVDF.

4.2.4 Each type of PVDF shape can be further categorized by the following descriptions for the PVDF material used, as follows, listed in Table 1 below:

4.2.4.1 *Type I*—PVDF polymerized in emulsion with properties and values as listed in Table 1.

4.2.4.2 *Type II*—PVDF polymerized in suspension with properties and values as listed in Table 1.

4.2.4.3 *Grade 1*—PVDF polymerized in emulsion with melting point between 156-162°C as listed in Table 1.

4.2.4.4 *Grade 2*—PVDF polymerized in emulsion with melting point between 161-172°C as listed in Table 1.

4.2.4.5 *Viscosity*—Viscosity described as Ultra High Viscosity, High Viscosity, Medium Viscosity and Low Viscosity as listed in Table 1.

NOTE 2—Table 1 in this standard is a copy of Table 1 in ASTM D3222 for PVDF homopolymer materials and is reproduced here for easy access. ASTM D3222 lists viscosity as additional information and its exact value is not required to be provided on the PVDF shape.

TABLE 1 Classification of PVDF Resins

Property		Typical Values or Ranges		
		Type I		Type II
		Grade 1	Grade 2	
Specific Gravity	Gms/cc	1.75-1.79	1.75-1.79	1.76-1.79
Peak Melting Endotherm	°C	156-162	161-172	164-180
Melt Flow Rate	g/10 min (wt in Kg)			
	Ultra High Viscosity	...	0.1-2[A]	0.5-10[A]
	High Viscosity	0.5-8[A]	5-8[B]	0.5-10[C]
	Medium Viscosity	4-18[A]	5-36[B]	0.5-30[D]
	Low Viscosity	...	3.5-45[E]	0.5-60[F]
Apparent Melt Viscosity	Pa's:[G]			
	High Viscosity	2800-3800	2800-3900	2500-4000
	Medium Viscosity	2300-2800	1300-2800	1300-2500
	Low Viscosity	...	100-1300	250-1300

Note: For measuring MFR values of PVDF, the load must be selected based on the viscosity as follows:

[A] = 21.6 Kg
[B] = 12.5 Kg
[C] = 10.0 Kg
[D] = 5 Kg
[E] = 3.8 Kg
[F] = 2.16 Kg
[G] Reported for a shear rate of 100 s^{-1} determined by capillary rheometry at 232°C (450°F) using 0.027 radian (60°) entrance angle die with L/D of 15 and in accordance with procedures of Test Method D3835. Multiply the pascal second values by ten to obtain poise values.

4.3 *Callout Designation*—A one line system shall be used to specify PVDF shapes covered by this specification. The system uses predefined cells to refer to specific aspects of this specification as illustrated below:

TABLE 2 Specification for PVDF Stock Shape[A]

Standard	Shape	Class	Type	Grade	Viscosity
ASTM D8366	Rod, Sheet, or Tubular Bar	A or B (virgin, General Purpose)	I or II (emulsion or suspension)	no designation, 1 or 2	Ultra High, High, Medium or Low

[A]Shape and Class are required while Type, Grade and Viscosity can be specified as needed.

4.3.1 *Examples*—Product can use any amount of classification descriptions, but must call out specific shape configuration and Class as a minimum.

4.3.1.1 *Example 1*—PVDF Sheet made from 100 % virgin PVDF polymerized in emulsion with a melting point of 168°C and a viscosity of 1700 Pa's.

Callout: ASTM D8366 PVDF Sheet, Class A, Type I, Grade 2, Medium Viscosity

NOTE 3—If Grade does not apply, NA can be used, as for example, ASTM D8366 PVDF Sheet, Class A, Type II, Grade NA, Medium Viscosity.

4.3.1.2 *Example 2*—Rod made for General Purpose application using any type of PVDF homopolymer with up to 20 % regrind in final product.

Callout: ASTM D8366 PVDF Rod, Class B

5. Property Requirements

5.1 The physical property values listed within this specification's tables are to be considered within the ranges stated, or as minimum as described herein. Any requirement for specific data for a given production lot must be specified at the time of the order. Physical properties for products not conforming to definition of unfilled homopolymer PVDF are discussed in the non-mandatory Appendix X1.

5.2 The following thermal, physical and mechanical properties of the PVDF shape in this standard shall conform to the minimums listed when following the procedures in Sections 5 and 11 when indicated.

NOTE 4—All testing is on the PVDF shape, not on the PVDF material used to produce the shape.

5.2.1 *Peak Melting Endotherm*—The material from the PVDF shape product covered by this specification shall have a minimum peak melting endotherm for the Type and Grade as shown in Table 1 when testing in accordance with Test Method D3418. For Type I resins, this involves heating a solid specimen of 5 ± 1 mg from room temperature to 200°C at 10°C/minute, maintaining the temperature at 200°C for 5 minutes, followed by cooling at a controlled rate of 10°C/minutes to about 30°C, then reheating at 10°C/minute to 200°C. Record the peak melting endotherm during the second melting cycle. For Type II resins the procedure is the same except that the maximum temperature is 230°C.

NOTE 5—If the type and grade of PVDF are not specified, the PVDF shape product should meet a 156°C to 180°C requirement for this property.

5.2.2 *Specific Gravity*—A solid specimen from the PVDF shape product covered by this specification shall have the specific gravity indicated in Table 1 when tested in accordance with Test Method D792.

NOTE 6—If the type and grade of PVDF are not specified, the PVDF shape product should meet a 1.75 to 1.79 requirement for this property.

5.2.3 *Tensile Properties*—The PVDF shape product covered in this specification shall have a tensile yield strength exceeding 36 MPa (5200 psi) at 23°C ± 2°C (74°F ± 4°F) and a minimum elongation at break of 10 % when tested in accordance with Test Method D638 at 50 mm/min (2 in./min).

5.2.4 *Flexural Modulus*—The PVDF shape product covered in this specification shall have a minimum flexural modulus of 1.31 GPa (190,000 psi) when tested in accordance with Test Method D790.

5.2.5 *Impact Resistance*—The PVDF shape product used to make shapes shall have a minimum izod impact strength of 80.0 J/m (1.5 ft-lbf/in.) when tested in accordance with Test Method D256, except in the case of the use of a low viscosity material as specified in the shape call-out, in which case the minimum impact strength can be minimum 40 J/m or higher, to correspond to ASTM D3222 for PVDF materials.

NOTE 7—Low viscosity PVDF is not likely to be used for extruded or compression molded processes, and is mainly used for injection molded products, which could also be called out per this shape specification.

6. Dimensional Requirements

6.1 Rods, sheets, and plates have different allowances for dimensional tolerances as indicated in Table 3 and Table 4. Products shall be produced within practical commercial tolerances and with the lowest stress levels for machined parts.

6.2 Tubular bar dimensions shall be supplied in unfinished condition unless otherwise specified at time of order sufficient to finish to the nominal dimension ordered.

6.3 The maximum allowable camber or bow, or both, shall be within the limits referenced in Table 3 and Table 4.

7. Workmanship, Finish, and Appearance

7.1 *Appearance*—The color of the Class A or Class B products will generally be a white, off white, or yellowish tint depending on the polymer manufacturer typical natural color and processing conditions. Color across the diameter or thickness can vary as the shapes get larger. If uniform color is desired, that needs to be specified by the user in advance so the supplier can choose either a more color stable grade of

TABLE 3 Dimensional Requirements for Poly(Vinylidene Fluoride) (PVDF) Rods[A]

Size, in.	Diameter Tolerance, in.	Roundness TIR, in.	Camber, in./ft
⅛ to ⅞	+0.002 /−0.001	0.002	2½ /8
1	+0.005 /−0	0.002	1¼ /8
1⅛ to 1¼	+0.005 /−0	0.004	1¼ /8
1⅜ to 1⅞	+0.005 /−0	0.005	1¼ /8
2	+0.005 /−0	0.010	1¼ /8
2⅛ to 2½	+0.030 /−0	0.025	1¼ /8
2⅝ to 6	+0.250 /−0	0.050	¼ /4

[A]To convert inches to millimeters multiply by 25.4.

TABLE 4 Dimensional Requirements for Poly(Vinylidene Fluoride) (PVDF) Sheets and Plates[A]

Size, in.	Thickness Tolerances, in.	Length Camber, in./ft	Width Bow, in./ft
0.010 to 0.188	±10 %	3/4 /4	3/16 /2
1/4 to 2	+0.025 /–0	3/4 /4	3/16 /2
2 1/8 to 3	+0.050 /–0	1/4 /4	1/16 /2
3 1/8 and over	+0.050 /–0	1/4 /4	1/16 /1

[A]To convert inches to millimeters multiply by 25.4.

material, or, adjust their manufacturing process conditions to reduce color variation.

7.2 *Finish*—All products need to be free of blisters, wrinkles, cracks, gouges, and defects that restrict commercial use of the product. A special surface finish shall be supplied only when specified in the purchase order or contract.

7.3 All products need to be free of dirt, foreign material, and embedded particles exceeding 0.762mm (0.03 in.) maximum diameter as defined in 7.3.1. Voids shall be minimized, and it could be appropriate for the user or manufacturer to specify an allowable amount of voids, otherwise, it is considered that the product shall be void free.

7.3.1 The criteria for determining internal cleanliness shall be external visual inspection. A maximum number of three internal defects per square foot of sheet and one foot length of rod and tubular bar shall be allowed. Clusters of defects less than 0.762mm (0.03 in.) in diameter are to be counted as a single defect. Totally defect free units of bar, rod and sheet shall be supplied only when specified in the purchase order or contract.

8. Sampling

8.1 For purposes of sampling, an inspection lot for examination and tests shall consist of all material of the same Class. If Type, Grade, and/or viscosity are called out, the sample needs be of the same.

8.2 The sample needs to match the nominal size submitted for inspection.

9. Number of Tests

9.1 Routine lot inspection shall consist of criteria specified in Section 5 and in Tables 3 and 4.

9.2 The criteria listed in Section 5 and in Tables 3 and 4 are sufficient to establish conformity of the sheet, rod or tubular bars to this specification. When the number of test specimens is not stated in the test method, a single determination is sufficient. If more than single determinations and separate portions of the same sample are made, the results shall be averaged. The final result shall conform to the requirements prescribed in this specification.

10. Test Conditions

10.1 *Specific Gravity, Tensile Properties, Flexural Modulus and Impact Testing:*

10.1.1 Condition the specimens from the PVDF shape product in accordance with Procedure A of Practice D618, except that the period shall be at least 16 hours prior to test.

10.1.2 Conduct the tests at standard laboratory temperature of 23 ± 2°C (73.4°F ± 3.6°F).

11. Test Methods

11.1 Test tensile strength at break in accordance with Test Method D638, at the rate of 50.8mm (2.0 in.)/min.

11.1.1 Test all plate specimens for tensile properties in accordance with Test Method D638.

11.1.2 Test all rod specimens for tensile properties in accordance with Test Method D638.

11.2 *Dimensional Stability:*

11.2.1 Specimen Preparation (A minimum of Three Test Samples Required).

11.2.1.1 *Rods and Tubular Bar*—Prepare each sample by cutting a 1.5 in long slice and using good machining practices to a length of 25.4mm ± 0.127mm (1.000 ± 0.005 in.). Each end of the specimen shall have machined surfaces. A coolant can be used in machining if preferred.

11.2.1.2 *Plate*—Each specimen shall consist of 50.8mm (2 in.) diameter disc machined from the flat (diameter shall equal test specimen thickness with a minimum of 50.8mm). The same care shall be used in the machining as described in 11.2.1.1. The thickness of the specimen shall be that of the original flat from which it was cut, no machining being done on the top or bottom surfaces.

11.2.2 *Testing Procedure*—Measure the outside diameter and thickness of the specimen as applicable at 23 ± 1°C (73.4 ± 1.8°F) at the readability of 0.00254mm (0.0001 in.). All measurements shall be done on the centerline at 90 degrees from the centerline for plate. Also take the measurements for thickness halfway to center, and for the diameter at mid-point. Place the specimen in an air circulating oven heated to 121 ± 5.5°C (275 ± 10°F). After 6 hours, allow the specimen to slowly cool to room temperature at a rate not to exceed 22°C (40°F)/hour. Measure the specimen at 23 ± 1°C (73.4 ± 1.8 °F) and calculate the percent change in each dimension.

11.3 *Lengthwise Camber and Widthwise Bow:*

11.3.1 Make all measurements for camber and bow using the maximum distance rod, sheet or plate deviates from the straight line extended from edge to edge when measured in accordance with 11.3.2. The shape shall be oriented such that the weight of the product does not influence the results.

11.3.2 *Rod and Plate:*

11.3.2.1 *Rod*—Lay rod on its side and measure it with concave side facing a straight edge. Measure camber from the straight edge on to the maximum concave point on the rod. Camber is not to exceed the values of Table 3.

11.3.2.2 *Plate*—Plate shall not exceed the requirements of Table 4 on the lengthwise ends and widthwise edges when laid on a flat surface (crown side up).

11.4 *Squareness (Based on a 4 ft Nominal Length):*

11.4.1 1 foot wide is 304.8mm (49.5 in.) minimum.

11.4.2 2 foot wide is 609.6mm (53.75 in.) minimum.

11.4.3 4 foot wide is 1219.2mm (68.0 in.) minimum.

11.4.4 If the diagonal difference exceeds 1.5875mm (0.0625 in.), proceed to measure the gap (that is, the deviation from a 2 foot square). The maximum allowable gap shall not exceed