

Solef[®] & Hylar[®] PVDF

Polyvinylidene fluoride
Typical properties



Solvay
Solexis



Solef® and Hylar® PVDF

A remarkable combination of properties

PVDF is a fluorinated semi-crystalline thermoplastic which is obtained by polymerizing vinylidene fluoride. This fluorinated polymer has been manufactured and marketed for more than 30 years, using both suspension process (Solef®) and emulsion process (Hylar®) developed and perfected by Solvay Solexis. PVDF, without any additives, has the intrinsic stability inherent to fluoropolymers, even when exposed to harsh environments. It provides the user with a unique combination of properties leading to longer equipment life. The most important properties of PVDF are listed below:

- Excellent chemical resistance to most aggressive substances and solvents,
- Excellent mechanical strength and toughness,
- High abrasion resistance,
- High temperature capabilities: continuous use service temperature up to 150°C (302°F),
- Excellent ageing resistance,
- High purity,
- Resistance to UV and nuclear radiations,
- Excellent intrinsic fire resistance,
- Low permeability to most gases and liquids,
- Easily melt-processed by standard methods of extrusion and molding,
- Wide range of rigid and flexible grades available.

Besides the PVDF homopolymers, Solvay Solexis offers a wide products range of VF2-HFP copolymers, and VF2-CTFE copolymers which stand out for their better cold temperature behaviour. The VF2-CTFE range comprises the Solef 60000 series, which offers an improved balance between good cold temperature properties and thermomechanical properties of the homopolymers.

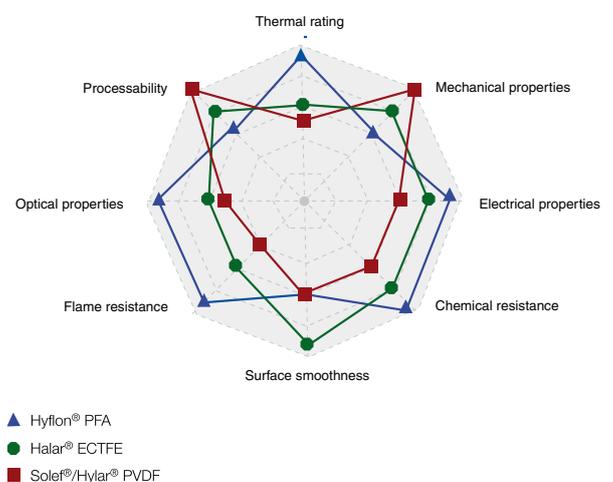
PVDF is extensively used in the general chemical processing industry, the high purity semiconductor market, and the wire and cable industry. Solvay Solexis today offers a growing choice of PVDF grades which are associated with new applications such as the Oil and Gas industry, Automotive, Building industry, Electronics,

Chimney linings, Lithium Batteries, Fuel cells, Food and Pharmaceutical industries.

In addition to the Solef® and Hylar® PVDF resins, Solvay Solexis offers a wide range of other fluoropolymers also easily processed by injection, extrusion, and all conventional processing techniques:

- Halar® ECTFE (copolymer of ethylene and chlorotrifluoroethylene),
- Hyflon® PFA (copolymer of tetrafluoroethylene and perfluoroalkylvinylethers).

Relative performance of Solvay Solexis melt processable fluoropolymers



Assistance in the selection of the most suitable resin and processing conditions is available through Solvay Solexis' commercial and technical teams.

Solef® and Hylar® PVDF - Typical properties

GRADE			Solef® 1000 series					
Major applications			1008	1009	1010	1012		
			Low viscosity all purposes injection	Mean viscosity all purposes injection/extrusion	Medium viscosity all purposes extrusion	High viscosity extrusion		
P = power. G = granules			P & G					
Physical properties		Standards	Units					
Density (23°C/ 73.4°F)		ASTM D 792	g/cm ³					
Water absorption (24h at 23°C / 73.4°F)		ASTM D 570	%					
Melt flow index (230°C/446°F)		ASTM D 1238						
	10kg		-	-	-	5		
	5kg		24	10	6	1.5		
	2.16kg		8	3.5	2	0.5		
Mechanical properties								
Tensile (23°C/ 73.4°F)		ASTM D 638 (1)						
Tensile stress at yield	50mm/min		MPa (psi)		53-57 (7685-8265)			
Tensile stress at break			MPa (psi)		35-50 (5075-7250)			
Elongation at yield			%		5-10			
Elongation at break			%		20-50			
Modulus	1mm/min		MPa (psi)					
			2000-2400 (290000-348000)					
Flexion (23°C/ 73.4°F)		ASTM D 790 (2)						
Maximum load	50mm/min		78 (11310)	77 (11165)	77 (11165)	75 (10875)		
Modulus	2mm/min		MPa (psi)					
			2000-2200 (290000-319000)					
IZOD impact (notched V 10mm - 23°C/ 73.4°F - 4mm thick)		ASTM D 256	55 (1.02)	65 (1.22)	110 (2.06)	150 (2.81)		
Shore D hardness (2mm thick)		ASTM D 2240	-					
Abrasion resistance		TABER CS 17/ 1kg	mg/ 1000 rev					
Friction coefficient: static		ASTM D 1894	-					
	dynamic		0.2-0.4					
			0.2-0.3					
Thermal properties								
Crystallinity by DSC		ASTM D 3418						
Melting point			°C (°F)		172 (342)			
Heat of fusion (80°C/ 176°F to end of melting)			J/ g (Btu/ lb)		64 (28)	64 (28)	63 (27)	60 (26)
Crystallizing point			°C (°F)		140/ 284			
Crystallization heat			J/ g (Btu/ lb)		58 (25)	58 (25)	57 (24)	56 (24)
VICAT point (4mm thick - load 1kg)	ISO 306		171 (340)	171 (340)		170 (338)		
Deflection temperature (4mm thick)	ASTM D 648							
Load 0.46 MPa (66.7 psi)	After annealing		148 (298)	147 (297)	147 (297)	145 (293)		
Load 1.82 MPa (264 psi)			115 (239)	113 (235)	113 (235)	112 (234)		
Glass transition (Tg)	DMTA		°C (°F)					
			-30 (-22)					
Brittleness temperature (on 2mm pressed sheet)	ASTM D 746 A		°C (°F)					
			0-10 (32-50)					
Molding shrinkage			%					
			2-3					
Thermal stability	TGA. T° for 1% w loss in air		°C (°F)					
			375-400 (707-752)					
Linear thermal expansion coefficient	ASTM D 696		10 ⁻⁶ / K (10 ⁻⁶ / °F)					
			120-140 (67-78)					
Thermal conductivity at 23°C (73.4°F)	ISO 8894-2		W/ m.K (Btu-in/ h.ft ² .°F)					
			0.2 (1.4)					
Specific heat	23°C & 100°C (73.4°F & 212°F)		J/ g.K (Btu/ lb.°F)					
			1.2-1.6 (0.28-0.38)					
Electrical properties								
Surface resistivity	ASTM D 257							
Voltage < 1V, after 2min - 500V at 23°C (73.4°F)	DIN 53483	ohm/ square	≥ 1.10 ¹⁴					
Volume resistivity	ASTM D 257							
Intensity = 10mA, after 2min at 23°C (73.4°F)	DIN 53483	ohm.cm	≥ 1.10 ¹⁴					
Fire resistance								
UL-94 Flammability test	UL-94	Class	V-0	-		V-0		
Limiting oxygen index (sheet 3mm thick)	ASTM D 2863	%	44					

(1) Tensile tests performed on extruded sheets (except for Solef 1015: compression molded specimen)

(2) Flexural tests performed on compression molded sheets

(3) Partial break

(4) NS: no significant

(5) Optional products available with a > 90% LOI (code: XXXXX/0009)

(6) Results achieved with formulated grade (code: XXXX/0000)

(7) MFI under 21.6kg/ 230°C

PVDF HOMOPOLYMERS					VF2 - HFP COPOLYMERS				
Solef® 6000 series				Hylar®	Solef®				
1015	6008	6010	6012	460	11008	11010	21216	21508	
Very high viscosity membranes solution	Low viscosity injection	Medium viscosity all purposes extrusion	High viscosity Compression molding	Broad MWD Chain branched extrusion	Low viscosity Wire & Cable extrusion	Medium viscosity Wire & Cable extrusion	Lithium batteries solution	High elongation extrusion	Very Air-
P		P & G		P & G	P & G		P	P & G	
		1.78		1.76			1.78		
		< 0.04		< 0.04			< 0.04		
0.7	-	-	5	2.6	-	-	1.3 ⁷	-	
0.2	24	6	1.5	0.6	24	6	-	24	
-	8	2	0.5	-	8	2	-	8	
		53-57 (7685-8265)		48 (7000)	20-35 (2900-5075)		15-25 (2175-3625)	15-18 (2175-2610)	
		35-50 (5075-7250)		41 (6000)	20-40 (2900-5800)		25-45 (3625-6525)	20-40 (2900-5800)	
		5-10		10	10-12		15-18	12-15	
		20-50		100	200-600		300-650	600-750	
		2000-2400 (290000-348000)		1300 (188500)	1100 (159500)	1050 (152250)	500 (72500)	420 (60900)	
70 (10150)	78 (11310)	77 (11165)	75 (10875)	55 (8000)	40 (5800)	37 (5365)		-	
		2000-2200 (290000-319000)		1500 (217500)	1000 (145000)	900 (130500)	400 (58000)	400 (58000)	
385 (7.20) ³	65 (1.22)	120 (2.24)	160 (3.00)	161 (3.01)	125 (2.34)	170 (3.18)	-	180 (3.37)	
		77		78	72	72	-	60	
		5-10		5-10			5-15		
		0.2-0.4		0.2-0.4			0.2-0.4		
		0.2-0.3		0.2-0.3			0.2-0.3		
171 (340)	172 (342)	172 (342)	171 (340)	160 (320)	160 (320)	160 (320)	135 (275)	135 (275)	
59 (25)	62 (27)	60 (26)	59 (25)	46 (20)	39 (16.8)	38 (16.3)	26 (11.2)	23 (9.9)	
	139 (282)	138 (280)	138 (280)	132 (270)	121 (250)	122 (252)	98 (208)	92 (198)	
53 (23)	58 (25)	56 (24)	54 (23)	46 (20)	37 (15.9)	35 (15.0)	28 (12.0)	24 (10.3)	
		170 (338)		154 (309)	150 (302)	150 (302)	131 (268)	120 (248)	
143 (289)	147 (294)	145 (293)	143 (289)	127 (260)	100 (212)	100 (212)	-	62 (144)	
110 (230)	112 (234)	110 (230)	108 (226)	88 (190)	52 (126)	52 (126)	39 (102)	40 (104)	
		-32 (-26)		-39 (-38)	-29 (-20)	-29 (-20)	-30 (-22)	-29 (-20)	
-10 to 0 (14-32)	0-10 (32-50)	-5 to +5 (23-41)	-10 to 0 (14-32)	-	-17 (1.4)	-18 (0)	-35 (-31)	-22 (-8)	
		2-3		2-3	2-3	2-3	-	2-3	
	375-400 (707-752)	>400 (>752) ⁶	>400 (>752) ⁶	375-400 (707-752)	330-370 (626-698)	330-350 (626-662)	330-350 (626-662)	340-375 (644-707)	340-
		120-140 (67-78)		120-130 (67-72)	140-160 (78-89)		160-180 (89-100)	150-180 (83-100)	210
		0.2 (1.4)		0.2 (1.4)	0.19 (1.3)		0.18 (1.2)	0.18 (1.2)	
		1.2-1.6 (0.28-0.38)		1.3 (0.31)	1.2-1.6 (0.28-0.38)				
		≥ 1.10 ¹⁴		≥ 1.10 ¹⁴	≥ 1.10 ¹⁴				
		≥ 1.10 ¹⁴		≥ 1.10 ¹⁴	≥ 1.10 ¹⁴				
-	V-0		-	V-0	V-0		-	-	
		44		44	44-65 ⁵		44	44-65 ⁵	

Electrical properties

ASTM D 150
Dielectric constant at 1 MHz
Tg delta at 1 MHz

7

0.2

Hylar®	VF2 - CTFE COPOLYMERS				PVDF COMPOUNDS			
	Solef®				Solef®			
	SN	31008	31508	32008	60512	3108/0903	3110/0907	3208/0150
High flexibility dried coatings	High flexibility / High elongation / Cold impact resistance Wire & Cable extrusion			Offshore piping	Anti-static injection	Anti-static extrusion compression molding	Anti-friction injection	Carbon fibers reinforced injection
P & G	P & G			G	G			
1.78	1.76	1.75	1.75	1.77	1.83	1.78	1.8	1.78
< 0.04	< 0.04				< 0.07	< 0.07	< 0.04	< 0.05
-		-		3	-	-	-	-
-		15		1	4.5	2.5	24	9
45		5		-	1.5	-	8	3
10 (1450)	14-35 (2030-5075)			35-40 (5075-5800)	56-60 (8120-8700)	45-60 (6525-8700)	52-56 (7540-8120)	-
17 (2500)	14-30 (2030-4350)			35-40 (5075-5800)	40-60 (5800-8700)	35-50 (5075-7250)	40-60 5800-8700)	80-120 (11600-17400)
20	10-12				3-5	2-5	5-7	-
600	350-600			100-350	20-30	20-50	20-50	1-4
200 (29000)	800 (116000)	500 (72500)	390 (56550)	1300 (188500)	4200 (609000)	2400 (348000)	2600 (377000)	8000 (1160000)
-	33 (4785)	18 (2610)	8 (1160)	-	89 (12905)	80 (11600)	78 (11310)	150 (21750)
200 (29000)	850 (123250)	425 (61625)	200 (29000)	-	4500 (652500)	2400 (348000)	2200 (319000)	7500 (1087500)
NS ⁴	520 (9.72) ³	1000 (18.7) ³	NS ⁴	1000 (18.7) ³	60 (1.12)	110 (2.06)	60 (1.12)	60 (1.12)
38	63	53	47	70	82	77	78	82
5-10	5-15			5-10	5-10			-
0.2-0.4	0.2-0.4				0.2-0.4		<0.2	0.2-0.4
0.2-0.3	0.2-0.3				0.2-0.3		<0.2	0.2-0.3
106 (223)	169 (336)	169 (336)	168 (334)	171 (340)	172 (342)	171 (340)	172 (342)	172 (342)
8 (3.4)	34 (14.6)	26 (11.2)	17 (7.3)	51 (22)	64 (28)	62 (27)	62 (27)	62 (27)
64 (147)	127 (261)	128 (262)	128 (262)	140 (284)	140 (284)	138 (280)	140 (284)	140 (284)
15 (6.4)	32(13.7)	25(10.7)	19 (8.2)	41 (17.6)	58 (25)	56 (24)	58 (25)	58 (25)
-	140 (284)	110 (230)	75 (167)	167 (333)	168 (334)	168 (334)	168 (334)	172 (342)
-	82 (180)	49 (120)	48 (118)	140 (284)	152 (306)	145 (293)	148 (298)	170 (338)
-	48 (118)	36 (97)	-	64 (147)	115 (239)	93 (199)	115 (239)	158 (316)
-41 (-42)	-30 (-22)	-28 (-18)	-28 (-18)	-28 (-18)	-	-32 (-26)	-40 (-40)	-35 (-31)
-	-30 (-22)	-37 (-35)	-53 (-63)	-31 (-24)	0-10 (32-50)	-5 to +5 (23 to 41)	0-10 (32-50)	>0 (>32)
-	2-3				2-3		0.5-1	
370 (644-698)	320-350 (608-662)	320-340 (608-644)			300-350 (572-662)	375-400 (707-752)	375-400 (707-752)	300-400 (626-752)
-230 (117-128)	130-150 (72-83)			130-180 (72-100)	120-140 (67-78)			70-90 (39-50)
0.16 (1.1)	0.18 (1.2)			0.2 (1.4)	0.3 (2.1)	0.3 (2.1)	0.2 (1.4)	0.33 (2.3)
1.3 (0.31)	1.2-1.6 (0.28-0.38)				-	-	-	-
≥ 1.10 ¹⁴	≥ 1.10 ¹⁴				<1.10 ³	<1.10 ³	≥ 1.10 ¹⁴	<10 ⁵
≥ 1.10 ¹⁴	≥ 1.10 ¹⁴				<1.10 ³	<1.10 ³	≥ 1.10 ¹⁴	<10 ⁴
V-0	-	V-0	-	-	-	V-0	-	V-0
44	44-65 ⁵	48-65 ⁵	50-65 ⁵	-	-			

7	7
0.2	0.2

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