Premium thermoplastics for engineering applications

KYNAR® & KYNAR FLEX® PVDF

Performance Characteristics & Data

ATOFINA

Table of Contents


High Performance Film


Rotomolded Structures


High Purity Piping

ATOFINA Chemicals, Inc. produces high performance chemicals and polymers. Headquartered in Philadelphia, USA, ATOFINA Chemicals, Inc. has sales of $2 billion and employs more than 3,200 people worldwide. ATOFINA Chemicals, Inc. is part of ATOFINA, the world's 5th largest chemical company with sales of $17 billion. ATOFINA, Paris, France, is the chemical segment of TotalFinaElf, the world's 5th largest oil and gas company. (NYSE:TOT)

Applications

KYNAR® PVDF components are used extensively in the high purity semiconductor market (low extractible values), the pulp and paper industry (chemically resistant to halogens and acids), nuclear waste processing (radiation and hot acid applications), and the general chemical processing industry (chemical and temperature applications). KYNAR fluoropolymers have also met specifications for the food and pharmaceutical processing industries.

KYNAR FLEX® resins, a series of PVDF-based fluoropolymers that are similar to KYNAR resins in purity and chemical resistance, possess unique qualities of additional chemical compatibility in high pH solutions, increased impact strength at ambient and colder temperatures, and increased clarity. The improved impact and elongation properties have proven especially beneficial in lining applications.

Chemical Handling Systems

KYNAR® PVDF wet bench constructed to meet clean room FM 4910 smoke and flame protocol.

Electrical Cable Insulation and Jacketing

KYNAR FLEX® PVDF jacketed cable is "networking" computers, telephones, and security alarm systems.

Architectural Finishes

KYNAR 500®-based finish gleams like armor from Philadelphia's landmark 945-foot skyscraper, One Liberty Place.

TABLE I

KYNAR® Homopolymer Series

PHYSICAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	460	1000 SERIES[2]	700 SERIES[2]	370[3]
Refractive Index	D542 / at Sodium D line 77°F		1.42	1.42	1.42	—
Specific Gravity	D792 / 73°F		1.75 — 1.77	1.76 — 1.78	1.77 — 1.79	1.84 — 1.88
Water Absorption	D570 / 20°C Immersion/ 24 Hours	%	0.02 — 0.04	0.01 — 0.03	0.01 — 0.03	0.04 — 0.06

MECHANICAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	460	1000 SERIES[2]	700 SERIES[2]	370[3]
Flexural Strength @ 5% Strain	D790 / 73°F	psi	7,000 — 9,000	8,500 — 11,000	8,500 — 11,000	20,000 — 30,000
Flexural Modulus	D790 / 73°F	psi	200,000 — 260,000	240,000 — 335,000	240,000 — 335,000	800,000 — 1,000,000
Tensile Yield Elongation	D638 / 73°F	%	10 — 15	5 — 10	5 — 10	0 — 4
Tensile Yield Strength	D638 / 73°F	psi	5,000 — 7,500	6,500 — 8,000	6,000 — 8,000	5,000 — 8,000
Tensile Break Elongation	D638 / 73°F	%	50 — 250	20 — 100	50 — 200	0 — 20
Tensile Break Strength	D638 / 73°F	psi	4,500 — 7,000	5,000 — 7,000	5,000 — 7,000	5,500 — 8,000
Tensile Modulus	D638 / 73°F	psi	150,000 — 200,000	200,000 — 335,000	200,000 — 335,000	450,000 — 750,000
Compressive Strength	D695 / 73°F	psi	8,000 — 10,000	10,000 — 15,000	10,000 — 15,000	20,000 — 25,000
Deflection Temperature	D648 / at 264 psi	°F	176 — 194	220 — 230	221 — 239	230 — 260
Deflection Temperature	D648 / at 66 psi	°F	234 — 284	—	257 — 284	270 — 300
Impact Strength Notched Izod	D256 / 73°F	Ft-Lb/In	2 — 4	2 — 4	2 — 4	0.75 — 1.50
Impact Strength Unnotched Izod	D256 / 73°F	Ft-Lb/In	15 — 40	20 — 80	20 — 80	5 — 10
Hardness	D2240 / 73°F	Shore D	75 — 80	77 — 82	76 — 80	74 — 79
Tabor Abrasion	CS-17 1000g:pad	mg/1000 cycles	7 — 9	5 — 9	5 — 9	—
Coefficient of Friction - Static vs. Steel	ASTM D 1894 73°F		0.23	0.22	0.20	0.18
Coefficient of Friction - Dynamic vs. Steel	ASTM D 1894 73°F		0.17	0.15	0.14	0.12

THERMAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	460	1000 SERIES[2]	700 SERIES[2]	370[3]
Melting Temperature	D3418	°F	311 — 320	337 — 340	329 — 338	329 — 338
Tg (DMA)	@ 1 Hz	°F	-41 — -37	-41 — -37	-41 — -37	-41 — -37
Coefficient of Linear Thermal Expansion	D696	10E-5/°F	5.0 — 7.0	6.6 — 8.0	6.6 — 8.0	2.0 — 2.5
Thermal Conductivity	ASTM D433	BTU-in/hr.ft^2.°F	1.18 — 1.32	1.18 — 1.32	1.18 — 1.32	—
Specific Heat	DSC	BTU/Lb.°F	0.28 — 0.36	0.28 — 0.36	0.28 — 0.36	—
Thermal Decomposition TGA	1% wt. loss/ in air	°F	707	707	707	707
Thermal Decomposition TGA	1% wt. loss/ in nitrogen	°F	770	770	770	770
Thermal Decomposition TGA	Ash weight %/ in air	%	0 — 5	0 — 5	0 — 5	—

ELECTRICAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	460	1000 SERIES[2]	700 SERIES[2]	370[3]
Dielectric Strength 73°F	D149 / 73°F	KV/Mil	1.6	1.6	1.7	—
Dielectric Constant 73°F	D150 / 100 Hz		8.0 — 9.5	8.0 — 9.5	8.0 — 9.5	—
Dielectric Constant 73°F	D150 / 1 kHz		7.5 — 9.0	7.5 — 9.0	7.5 — 9.0	33.5
Dielectric Constant 73°F	D150 / 10 kHz		7.3 — 8.8	7.3 — 8.8	7.3 — 8.8	—
Dielectric Constant 73°F	D150 / 100 kHz		7.0 — 8.5	7.0 — 8.5	7.0 — 8.5	28.8
Dielectric Constant 73°F	D150 / 1 MHz		6.2 — 7.0	6.2 — 7.0	6.2 — 7.0	—
Dielectric Constant 73°F	D150 / 100 MHz		4.5 — 5.5	4.5 — 5.5	4.5 — 5.5	—
Dissipation Factor 73°C	D150 / 100 Hz		0.10 — 0.16	0.10 — 0.16	0.10 — 0.16	—
Dissipation Factor 73°C	D150 / 1 kHz		0.01 — 0.03	0.01 — 0.03	0.01 — 0.03	0.06
Dissipation Factor 73°C	D150 / 10 kHz		0.02 — 0.04	0.02 — 0.04	0.02 — 0.04	—
Dissipation Factor 73°C	D150 / 100 kHz		0.02 — 0.07	0.02 — 0.07	0.02 — 0.07	0.08
Dissipation Factor 73°C	D150 / 1 MHz		0.10 — 0.13	0.10 — 0.17	0.10 — 0.13	—
Dissipation Factor 73°C	D150 / 100 MHz		0.15 — 0.21	0.17 — 0.25	0.15 — 0.21	—
Volume Resistivity	D257 / DC 68°F/ 65% R.H.	ohm-cm	2×10^{14}	2×10^{14}	2×10^{14}	1×10^{11}

FLAME & SMOKE PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	460	1000 SERIES[2]	700 SERIES[2]	370[3]
Burning Rate	UL / Bulletin 94		V — 0	V — 0	V — 0	V — 0
Limiting Oxygen Index	D2868	% O_2	44	60	44 / 60[4]	44

1. Typical property values; should not be construed as sales specifications. **2.** The KYNAR 700 PVDF and KYNAR 1000 PVDF series span a wide range of melt viscosities (see page 12). Please contact an ATOFINA representative for typical values on specific grades. **3.** Filled wih graphite powder to reduce mold shrinkage. **4.** Optional product available with higher LOI.

TABLE II

KYNAR FLEX® Copolymer Series

PHYSICAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Refractive Index	D542 / at Sodium D line 77°F		1.40	1.41	1.41	1.41	1.41
Specific Gravity	D792 / 73°F		1.80 — 1.82	1.78 — 1.80	1.76 — 1.79	1.76 — 1.79	1.76 — 1.79
Water Absorption	D570 / 20°C Immersion/ 24 Hours	%	0.04 — 0.07	0.04 — 0.07	0.03 — 0.05	0.03 — 0.05	0.03 — 0.05

MECHANICAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Flexural Strength @ 5% Strain	D790 / 73°F	psi	1,500 — 2,500	2,000 — 3,500	3.000 — 5,000	3.000 — 5,000	3.000 — 5,000
Flexural Modulus	D790 / 73°F	psi	28,000 — 36,000	49,000 — 58,000	90,000 — 120,000	160,000 —180,000	90,000 — 120,000
Tensile Yield Elongation	D638 / 73°F	%	12 — 25	10 — 20	10 — 20	10 — 20	10 — 20
Tensile Yield Strength	D638 / 73°F	psi	1,700 — 2,800	2,600 — 3,500	2,900 — 4,000	4,500 — 5,500	3,500 — 5,000
Tensile Break Elongation	D638 / 73°F	%	500 — 800	200 — 400	200 — 400	200 — 400	300 — 550
Tensile Break Strength	D638 / 73°F	psi	4,000 — 6,000	3,300 — 4,000	3,500 — 6,000	4,000 — 6,000	5,000 — 7,000
Tensile Modulus	D638 / 73°F	psi	35,000 — 55,000	50,000 — 90,000	80,000 — 130,000	110,000 — 140,000	80,000 — 130,000
Compressive Strength	D695 / 73°F	psi	2,000 — 3,000	3,500 — 4,500	4,500 — 6,000	6,000 — 8,500	4,500 — 6,000
Deflection Temperature	D648 / at 264 psi	°F	80 — 100	95 — 125	104 — 131	100 — 131	110 — 130
Deflection Temperature	D648 / at 66 psi	°F	—	120 — 150	140 — 167	140 — 167	130 — 170
Impact Strength Notched Izod	D256 / 73°F	Ft-Lb/In	NO BREAK	NO BREAK	12 — 20	2 — 10	NO BREAK
Impact Strength Unnotched Izod	D256 / 73°F	Ft-Lb/In	NO BREAK	NO BREAK	NO BREAK	NO BREAK	NO BREAK
Hardness	D2240 / 73°F	Shore D	55 — 60	62 — 67	65 — 70	70 — 75	65 — 70
Tabor Abrasion	CS-17 1000 g:load	mg/1000 cycles	28 — 33	21 — 25	16 — 19	6 — 9	16 — 19
Coefficient of Friction - Static vs. Steel	ASTM D 1894 73°F		0.49	0.55	0.33	0.26	0.31
Coefficient of Friction - Dynamic vs. Steel	ASTM D 1894 73°F		0.54	0.54	0.33	0.19	0.30

THERMAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Melting Temperature	D3418	°F	240 — 250	266 — 273	285 — 293	311 — 320	325 — 331
Tg (DMA)	@ 1 Hz	°C	-46 — -40	-44 — -40	-42 — -39	-41 — -37	-42 — -39
Coefficient of Linear Thermal Expansion	D696	10E-5/°F	8.5 — 10.8	9.0 — 12.0	7.0 — 10.3	7.0 — 10.3	7.0 — 10.3
Thermal Conductivity	ASTM D433	BTU-in/hr.ft^2.°F	1.00 — 1.25	1.00 — 1.25	1.00 — 1.25	1.00 — 1.25	1.00 — 1.25
Specific Heat	DSC	BTU/Lb.°F	0.28 — 0.36	0.28 — 0.36	0.28 — 0.36	0.28 — 0.36	0.28 — 0.36
Thermal Decomposition TGA	1% wt. loss/ in air	°F	707	707	707	707	707
Thermal Decomposition TGA	1% wt. loss/ in nitrogen	°F	770	770	770	770	770
Thermal Decomposition TGA	Ash weight %/ in air	%	0 — 5	0 — 5	0 — 5	0 — 5	0 — 5

ELECTRICAL PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Dielectric Strength 73°F	D149 / 73°F	KV/Mil	0.8 — 1.1	1.1 — 1.3	1.3 — 1.5	1.3 — 1.6	1.3 — 1.5
Dielectric Constant 73°F	D150 / 100 Hz		10.9 — 13.5	10.5 — 12.1	9.4 — 10.6	9.0 — 10.2	8.7 — 10.2
Dielectric Constant 73°F	D150 / 1 kHz		10.4 — 12.0	8.9 — 11.4	7.9 — 10.0	7.1 — 8.9	7.8 — 9.3
Dielectric Constant 73°F	D150 / 10 kHz		9.5 — 11.3	8.6 — 9.8	8.1 — 9.6	7.0 — 8.4	7.4 — 8.5
Dielectric Constant 73°F	D150 / 100 kHz		9.2 — 10.8	8.2 — 9.4	7.6 — 8.9	6.8 — 8.5	7.1 — 8.4
Dielectric Constant 73°F	D150 / 1 MHz		7.6 —8.7	7.1 — 8.5	6.4 — 7.7	6.1 — 7.3	5.7 — 7.6
Dielectric Constant 73°F	D150 / 100 MHz		4.5 — 5.8	3.8 — 4.7	3.5 — 4.3	3.5 — 4.0	3.2 — 3.9
Dissipation Factor 73°C	D150 / 100 Hz		0.06 — 0.10	0.05 — 0.09	0.09 — 0.14	0.10 — 0.22	0.08 — 0.14
Dissipation Factor 73°C	D150 / 1 kHz		0.05 — 0.10	0.02 — 0.07	0.02 — 0.04	0.01 — 0.03	0.02 — 0.04
Dissipation Factor 73°C	D150 / 10 kHz		0.06 — 0.15	0.05 — 0.10	0.05 — 0.07	0.04 — 0.09	0.05 — 0.11
Dissipation Factor 73°C	D150 / 100 kHz		0.10 — 0.15	0.09 — 0.13	0.04 — 0.09	0.05 — 0.10	0.08 — 0.10
Dissipation Factor 73°C	D150 / 1 MHz		0.16 — 0.26	0.17 — 0.19	0.14 — 0.18	0.11 — 0.16	0.12 — 0.17
Dissipation Factor 73°C	D150 / 100 MHz		0.25 — 0.29	0.21 — 0.24	0.19 — 0.21	0.16 — 0.18	0.18 — 0.19
Volume Resistivity	D257 / DC 68°F/65% R.H.	ohm-cm	2×10^{14}	2×10^{14}	2×10^{14}	2×10^{14}	2×10^{14}

FLAME & SMOKE PROPERTIES[1]	STANDARD/CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Burning Rate	UL / Bulletin 94		—	V — 0	V — 0	V — 0	—
Limiting Oxygen Index	D2868	% O_2	42/95[2]	42/95[2]	42/75[2]	42/75[2]	42/95[2]

1. Typical property values; should not be construed as sales specifications.
2. Optional product available with higher LOI.

Design Properties for KYNAR® Resins

Chemically Resistant Fabrics

GENERAL PHYSICAL AND MECHANICAL PROPERTIES

KYNAR® and KYNAR FLEX® fluoropolymers are strong and tough as reflected by their tensile properties and impact strengths. Compared with many thermoplastics, KYNAR fluoropolymers have excellent resistance to creep and fatigue; yet, in thin sections such as films, filament, and tubing, KYNAR PVDF components are flexible and transparent. As a material of construction for pumps and pipes, KYNAR resins exhibit excellent resistance to abrasion. Where load bearing is important, KYNAR fluoropolymers are rigid and resistant to creep under mechanical stress and load.

KYNAR 500® fluoropolymers are widely used as base resins for long-lasting exterior coatings because they are resistant to sunlight and other sources of ultraviolet radiation. All KYNAR and KYNAR FLEX resin grades are interchangeably weldable, giving the design professional the option of combining rigid and flexible materials in a given application.

Tables I and II (pgs. 2-3) list the typical properties of the KYNAR and KYNAR FLEX fluoropolymer resin grades.

LINEAR EXPANSION

The linear expansion of the low-to-high viscosity KYNAR 700 homopolymer resin series and the KYNAR 460 homopolymer resin grade is shown in Figure 1 for the temperature range –120° to 160°C (–184° to 320°F).

THERMAL PROPERTIES

KYNAR resins have excellent thermal stability. The general thermal properties are shown in Tables I and II (Homopolyer Series and Copolymer Series (pgs. 2-3). Prolonged exposure at 250°C (482°F) in air does not lead to loss of weight. No oxidative or thermal degradation has been detected during continuous exposure of KYNAR resins at 150°C (302°F) for a period of five years. As Thermogravimetric Analysis (TGA) thermograms indicate, KYNAR homopolymer resins are thermally stable up to 375°C (707°F) when heated in air at the rate of 5°C/min (9°F/min).

At temperatures greater than 375°C (707°F), thermal decomposition of KYNAR resins takes place with the evolution of hydrogen fluoride (HF). The melt processing range of KYNAR resins is very broad – from slightly above its melting point of 155° – 170°C (311° – 338°F) to over 300°C (572°F). It is typically processed at temperatures from 190 – 265°C (374° – 509°F).

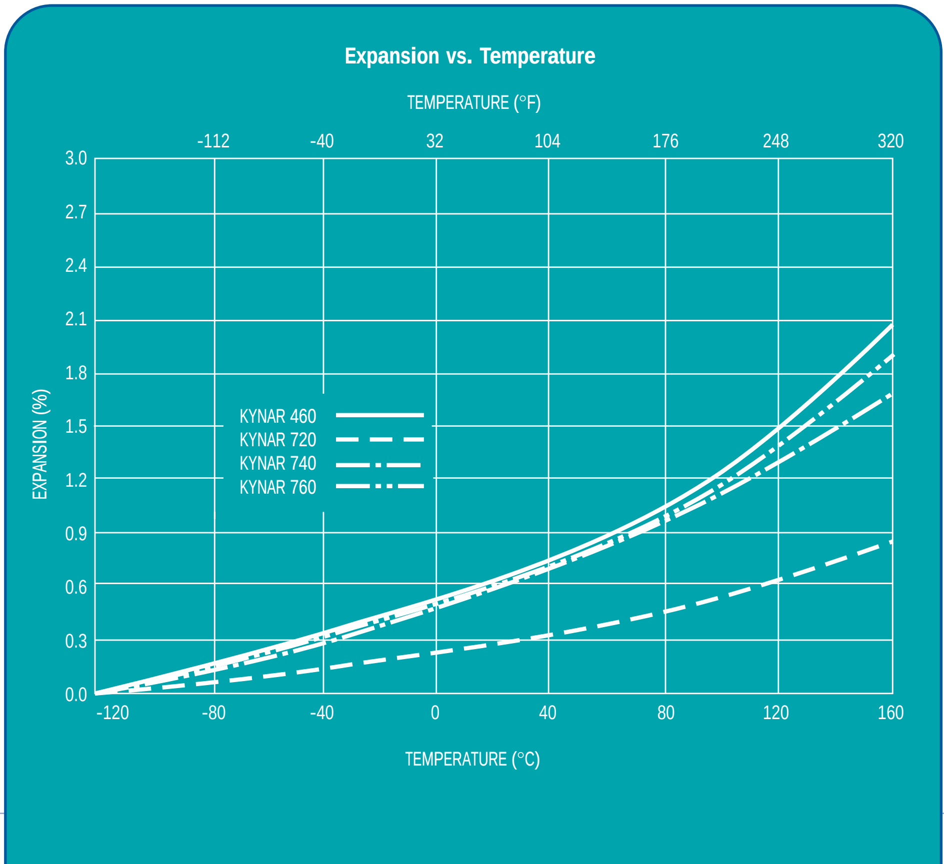
In general, KYNAR resins are some of the easiest fluoropolymers to process and can be recycled without detriment to their physical and mechanical properties. Similar to most thermoplastics, KYNAR resins will discolor and degrade during processing if the processing temperature is too high, the residence time is too long, or the shear rate is too high.

Please review the Product Safety section for more information.

STRENGTH AND TOUGHNESS

The ambient temperature tensile strength at yield of 5,000-8,000 psi (35-55 MPa) and the unnotched impact strength of 15-80 ft-lb/in (800-4270 kJ/m) show that all grades of KYNAR homopolymer resin are both strong and tough. These characteristics are retained over a wide range of temperatures, as shown in Figure 2.

FIGURE 1



FLEXURAL CREEP

The long-term resistance of KYNAR resins to flexural creep at elevated temperatures is given in Figure 3. This data indicates that KYNAR resins are suitable for many applications in which load-bearing characteristics are important. Likewise, the short-term flexural creep resistance of KYNAR homopolymer resins reflects superior load-bearing performance.

TENSILE CREEP

Figure 4 shows the low tensile creep of KYNAR resins when subjected to constant stress of 100 psi (0.69 MPa) over time. The outstanding tensile creep resistance of KYNAR resins over time is maintained even at temperatures as extreme as 140°C (284°F).

CRYSTALLINITY

KYNAR resins crystallize in at least three forms designated alpha, beta, and gamma. Normally, KYNAR resins crystallize from the melt predominantly in the alpha form. The degree of crystallinity and the type of crystalline forms present depend on the KYNAR resin grade and the processing conditions. Rapid cooling (quenching) of the melt impedes crystallization and promotes a smaller crystallite size. Slow cooling or heating below the melting point (annealing) perfects the crystallization process and relaxes stresses. In addition, orientation below the melting point will enhance crystallization and change properties.

The crystalline state of KYNAR resin influences its properties; therefore, it is important to select the proper processing conditions to achieve the optimum in physical properties. In general, for long-term performance, KYNAR PVDF fabricated parts should be cooled slowly and/or annealed below the melting point to stabilize the crystalline state of the parts. With increased crystallinity, parts will show higher values for yield strengths, modulus, and hardness.

FIGURE 2

Ultimate Tensile Strength vs. Temperature for Various Grades of KYNAR Resin.

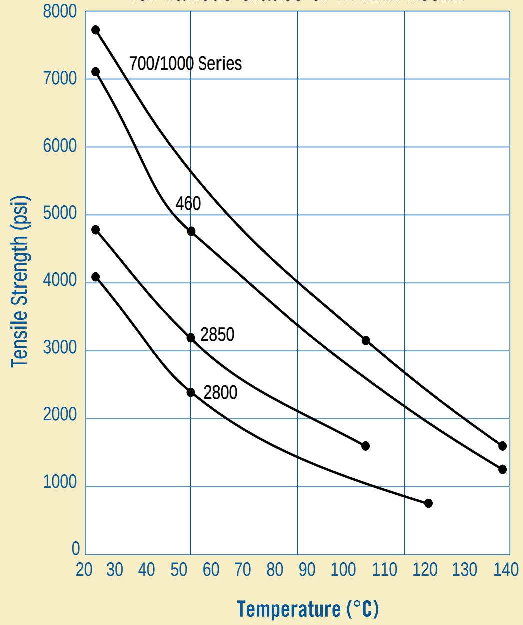


FIGURE 3

Flexural Creep of KYNAR Homopolymer Resins at High Stresses as a Function of Time and Temperature.

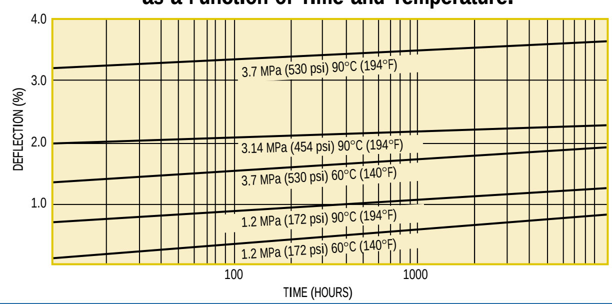
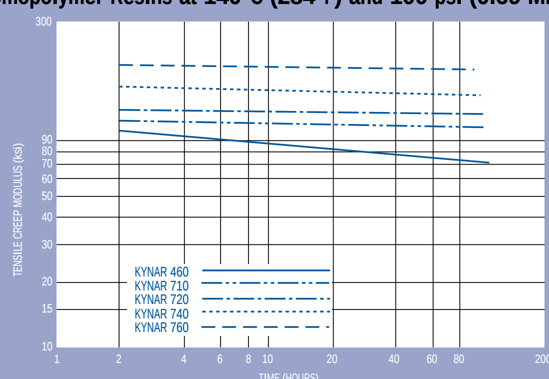


FIGURE 4

Long-Term Tensile Creep Resistance for Various Grades of KYNAR Homopolymer Resins at 140°C (284°F) and 100 psi (0.69 MPa).



Design Properties for Special Applications

ELECTRICAL PROPERTIES

The electrical properties of KYNAR® PVDF resins are shown in Homopolymer and Copolymer Tables I and II (pgs. 2-3). The combination of high dielectric strength and excellent mechanical properties over a broad temperature range is the reason that KYNAR resins are used for thin-wall primary insulation and as a jacket for industrial control wiring. Although its high dissipation factor limits the use of KYNAR resins at high frequencies, this property becomes an advantage in the fabrication of parts utilizing dielectric heating strengths.

DIELECTRIC VARIATIONS WITH TEMPERATURE AND TIME

Values reflect the method of sample preparation, which influences the characteristics of the polymer that dictate the electrical properties. Above 1 MHz, the dependence of these properties on frequency, temperature, and nature of the sample is complex.

OPTICAL PROPERTIES

KYNAR PVDF films up to 0.005 inches (0.125 mm) thick are transparent to translucent. The transmission spectrum in Table III shows how light transmission varies with thickness for KYNAR resin. See Figure 5 for the infrared absorption spectrum.

STABILITY TO EFFECTS OF WEATHER AND ULTRAVIOLET RADIATION

Table IV shows that KYNAR PVDF film maintains its mechanical properties throughout many years of outdoor exposure. Clear films, exposed to the sun at a 45° angle south, retain their tensile strength over a 17-year period. During the first few months of exposure when normal crystallization takes place, the percentage of elongation at break decreases to a level that remains essentially constant with time.
In addition, the weathered films remain flexible and capable of being bent 180° without cracking.

LITHIUM-ION POLYMER BATTERY

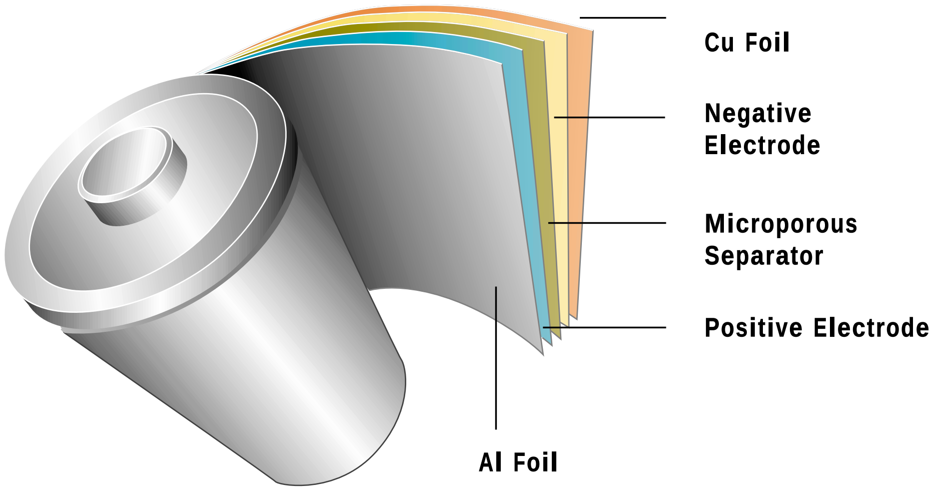


TABLE III: Percentage Transmission of Extruded KYNAR PVDF Film in the Ultraviolet Region (200–400 nm) as a Function of Thickness.

	UV WAVELENGTH (nm)					
Thickness mm (in.)	200	240	280	320	360	400
0.038 (0.0015)	34.4	53.8	66.3	72.6	77.8	81.2
0.051 (0.002)	24.4	45.6	58.8	67.8	74.4	78.5
0.102 (0.004)	3.2	15.0	30.5	44.5	53.8	61.4
0.178 (0.007)	0.4	1.9	8.1	17.5	26.4	35.0
0.279 (0.011)	0	0.6	2.7	7.5	14.7	21.9
0.508 (0.020)	0	0	0.2	0.5	2.5	5.0

Tower Packings

TABLE IV: Stress/Strain Properties of 0.204 mm (0.008 in) Weathered KYNAR PVDF Film Determined by ASTM Method D882.

Property	Units	Before Exposure	After Outdoor Exposure (17 yrs.)
Tensile Strength	SI	47.5 MPa	59.0 MPa
	English	6,900 psi	8,500 psi
Elongation at Break	%	46	10

OUTGASSING UNDER HIGH VACUUM

KYNAR® homopolymer resins exhibit extremely low weight loss when exposed to high vacuum. At 100°C (212°F) and a pressure of 5 x 10^{-6} torr, the measured rate of weight loss is 13 x 10^{-11} g/cm²s.

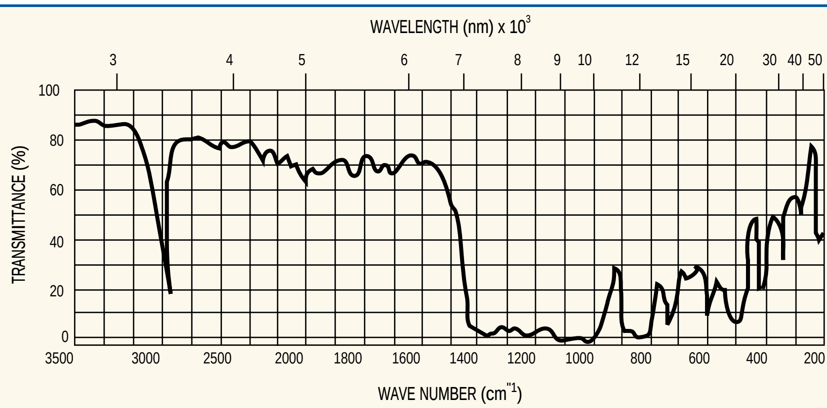
FUNGUS RESISTANCE

KYNAR resins will not support growth of fungi when tested as described in Method 508 of Military Standard 810B (June 15, 1967).

Double-Containment Piping

FIGURE 5

Infrared Absorption Spectrum of KYNAR PVDF Film



KYNAR FLEX 2850 Lined Pipe

Solid Pipes

SOLUBILITY

KYNAR® resins have limited solubility. Table V lists active, intermediate, and latent solvents. Generally, KYNAR resins are not soluble in aliphatic hydrocarbons, aromatic hydrocarbons, chlorinated solvents, alcohols, acids, halogens, and basic solutions. KYNAR FLEX® tends to be slightly more soluble due to the lower crystallinity attributed to the resin.

RESISTANCE TO NUCLEAR RADIATION

The resistance of KYNAR® fluoropolymers to nuclear radiation is excellent. The original tensile strength of the resin is essentially unchanged after exposure to 1,000 megarads (Mrads) of gamma radiation from a Cobalt-60 source at 50°C (122°F) and in high vacuum (10^{-6} torr). The impact strength and elongation are slightly reduced due to cross-linking. This stability to effects of radiation, combined with chemical resistance, has resulted in the successful use of KYNAR components in nuclear reclamation plants. Tables VI and VII show minimal changes in tensile properties of KYNAR homopolymer and KYNAR FLEX® resins exposed to electron beam radiation in doses up to 20 Mrads according to ASTM D882 testing.

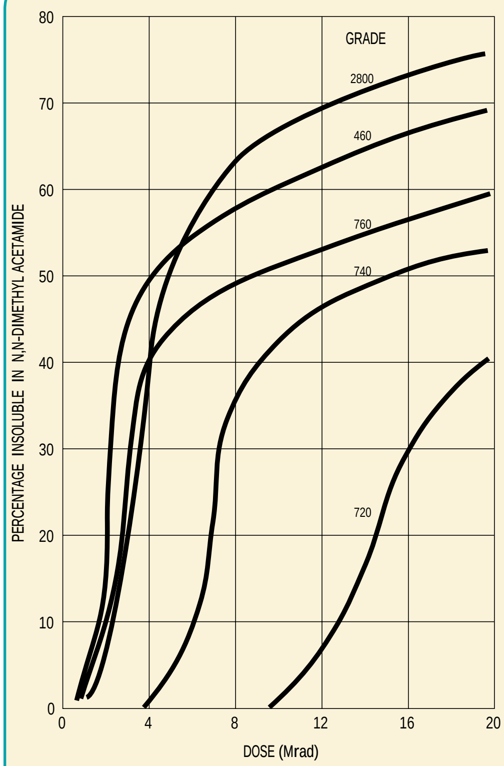
RADIATION CROSS-LINKING

The different grades of KYNAR® homo-polymer and copolymer resins are readily cross-linked and do not degrade when irradiated with moderate doses of high energy electron or gamma radiation. The efficiency of cross-linking is influenced by the grade; that is, molecular weight variations are important. Figure 6 shows the response of various grades to high energy electron beam irradiation in terms of the amount of polymer that becomes insoluble in dimethyl acetamide (DMAC), an excellent solvent for non-cross linked PVDF resins. Examples of KYNAR PVDF-fabricated products utilizing radiation technology are heat-shrinkable tubing and insulated wire capable of withstanding high temperatures.

TABLE V: Solvents

SOLVENTS								
ACTIVE* SOLVENTS			INTERMEDIATE* SOLVENTS			LATENT* SOLVENTS		
Solvent	Boiling Point (°C)	Flash Point (°C)	Solvent	Boiling Point (°C)	Flash Point (°C)	Solvent	Boiling Point (°C)	Flash Point (°C)
Acetone	56	-18	Butyrolactone	204	98	Methyl Isobutyl Ketone	118	23
Tetrahydrofuran	65	-17	Isophorone	215	96	N-Butyl Acetate	135	24
Methyl Ethyl Ketone	80	-6	Carbitol Acetate	217	110	Cyclohexanone	157	54
Dimethyl Formamide	153	67				Diacetone Alcohol	167	61
Dimethyl Acetamide	166	70				Diisobutyl Ketone	169	49
Tetramethyl Urea	177	75				Ethyl Acetoacetate	180	84
Dimethyl Sulfoxide	189	35				Triethyl Phosphate	215	116
Trimethyl Phosphate	195					Propylene Carbonate	242	132
N-Methyl-2-Pyrrolidone	202	95				Kodaflex Triacetin	258	146
						Dimethyl Phthalate	280	149
						Glycol Ethers**	≥118	≥40
						Glycol Ether Esters**	≥120	≥30
* Solvent will dissolve at least 5-10 weight percent KYNAR resin at ambient temperature.			* As a rule, intermediate solvents do not dissolve or swell KYNAR resin at room temperature; they solvate KYNAR resin at elevated temperatures and on cooling to ambient, retain KYNAR resin in solution.			NOTE: Generally for ketones: the longer the chain and the greater the branching, the less active the ketone. * As a rule, letent solvents do not dissolve or substantially swell KYNAR resin at room temperature. They solvate KYNAR resin at elevated temperatures, but on cooling, KYNAR resin crystallizes (e.g., precipitates from the solute). ** Based on ethylene glycol, diethylene glycol, and propylene glycol.		

FIGURE 6



Insoluble Fraction of Various Grades of KYNAR Homopolymer and KYNAR FLEX Copolymer After Electron Beam Irradiation.

Chemical Handling Systems

KYNAR® PVDF glove box constructed to resist a combination of radioactivity and acids.

Manifold Assembly

TABLE VI: Radiation Cross-linked KYNAR PVDF Tensile Modulus Versus Radiation Dose Exposure (Kpsi).

RESIN GRADE	0	2 Mrads	4 Mrads	8 Mrads	20 Mrads
KYNAR 460	170	180	170	200	190
KYNAR 720	230	220	230	220	240
KYNAR 740	200	230	200	220	220
KYNAR 760	200	190	190	210	220
KYNAR FLEX 2850	130	130	120	130	130

TABLE VII: Radiation Cross-linked KYNAR PVDF Ultimate Tensile Strength Versus Radiation Dose Exposure (psi).

RESIN GRADE	0	2 Mrads	4 Mrads	8 Mrads	20 Mrads
KYNAR 460	6200	6300	6000	6900	7200
KYNAR 720	7400	7400	7300	7300	8400
KYNAR 740	6900	6900	6900	7200	7900
KYNAR 760	6300	6500	6700	7400	7800
KYNAR FLEX 2850	4700	4700	4900	4900	5600

WELDING

Several methods of fusion welding KYNAR® PVDF components are possible. The most common and successful approaches to welding KYNAR PVDF components are heat contact welding and hot gas (or air) using a welding rod. Ultrasonic, hot lamination, resistance heating, spin welding, and radio frequency are all methods usable to bond KYNAR PVDF to itself with varied success.

Contact welding is performed by holding two sections, which have each been heated to create a molten layer of resin, in position with adequate pressure until the polymer has congealed and cooled. Depending on the cross-sectional thickness of parts assembled in this way, the depth of the molten polymer will vary. Common terminology for forms of contact welding are lap joint, socket fusion, and butt joint.

Tools, fixtures, or some form of equipment must be provided to hold parts welded in this manner in position. Commercial welding equipment is available for this purpose.

Heating temperatures required to adequately produce a molten condition of the conforming KYNAR® PVDF surfaces will range from 220°– 288°C (425°– 550°F). Heating time cannot be easily predicted as this will depend on watt density of heating elements and size, as well as the geometry of the parts to be joined.

Normally some molten polymer will exude from the open edges of the joint formed in this way to create a bead. This bead can be carefully removed by machining if it interferes with the normal operation of the welded assembly.

Welding in this manner should be performed when ambient temperatures are in the vicinity of 20° – 30°C (70° – 100°F). Higher temperatures could be beneficial but lower could be disappointing. Slow cooling and/or annealing of welded assemblies is preferred.

Hot gas welding, using a welding rod, is a common way to construct KYNAR PVDF lined components such as metals and fiber-reinforced plastics. Typically the stock shape supplier has a qualifying program due to the skills needed to accomplish this method of welding. ATOFINA suppliers can recommend fabrication experts with experience in this method of welding KYNAR fluoropolymers.

MELT BEHAVIOR

As shown in Table VIII, KYNAR® resin grades cover a broad range of melt viscosities to satisfy the various needs of the fabricator.

KYNAR resin grade selection is important and depends on the type of fabrication and the specific design of the tooling and finished part. In virtually all cases it is recommended that the fabricator consult with the local ATOFINA sales representative.

TABLE VIII: MELT BEHAVIOR	ASTM D3835 MELT VISCOSITY	ASTM D1238 MELT FLOW RATE	MELT FLOW RATE LOAD
	450°F K POISE@100 sec^-1	450°F g/10 min	Lb (Kg)
KYNAR 460	23.0 ± 29.5	6.0 ± 14.0	47.5 (21.6)
KYNAR 710	4.0 ± 8.0	20.0 ± 35.0	8.36 (3.8)
KYNAR 720	6.0 ± 12.0	7.0 ± 23.0	8.36 (3.8)
KYNAR 740	15.0 ± 23.0	6.0 ± 25.0	27.5 (12.5)
KYNAR 760	23.0 ± 29.0	2.0 ± 4.0	27.5 (12.5)
KYNAR 1000	15.0 ± 20.0	1.5 ± 2.5	11.0 (5.0)
KYNAR 6000	7.0 ± 11.0	2.0 ± 4.0	11.0 (5.0)
KYNAR 9000	5.0 ± 8.0	16.0 ± 40.0	11.0 (5.0)
KYNAR 370	8.0 ± 13.0		
KYNAR FLEX 2850-00	23.0 ± 27.0	3.0 ± 8.0	27.5 (12.5)
KYNAR FLEX 2850-02	16.0 ± 20.0	10.0 ± 20.0	27.5 (12.5)
KYNAR FLEX 2850-07	16.0 ± 20.0	10.0 ± 20.0	27.5 (12.5)
KYNAR FLEX 2800-00	23.0 ± 27.0	3.0 ± 8.0	27.5 (12.5)
KYNAR FLEX 2800-20	12.0 ± 20.0	1.0 ± 6.0	11.0 (5.0)
KYNAR FLEX 2750-01	20.0 ± 25.0	4.0 ± 10.0	27.5 (12.5)
KYNAR FLEX 3120	20.0 ± 26.0	2.0 ± 6.0	27.5 (12.5)
KYNAR SUPER FLEX 2500	8.0 ± 15.0		

Viscosity and Melt Flow Rates for standard grades. Specialty grades can vary in melt flow behavior. Melt point information is listed in Tables I and II. Consult your ATOFINA representative for individual Technical Data Sheets.

Welded Lined Pipe

Vessel Lining

EXTRUSION

Smooth KYNAR® PVDF products of all types – rod, sheet, film, pipe, tubing, monofilament, and wire insulation – can be extruded at relatively high rates. No extrusion aids, lubricants, or heat stabilizers are needed. While equipment with materials of construction similar to those used for processing PVC and polyolefins is adequate, ATOFINA offers technical service to discuss tooling and processing of KYNAR PVDF. Gradual transition screws having L/D ratios of at least 20:1 and ample metering sections are recommended. Special die designs facilitate the proper distribution and homogeneity of the melt. Extrusion temperatures vary from 232°– 288°C (450°– 550°F) depending on the shape being extruded. For very thin sections, such as fine caliper wire insulation, the temperature at the extreme tip of the die is held at 316°C (600°F) or higher as required for heat polishing.

Water quenching is used for wire insulation, tubing and pipe; whereas, sheet and film extruded from slit dies are frequently crystallized on polished steel rolls operating between 66°– 140°C (150°– 284°F). Extruded, blown, or flat film can be uniaxially and/or biaxially oriented to sub-mil thickness. Monofilament is extrusion spun into a water bath and then oriented and heat set at elevated temperatures.

MOLDING

KYNAR resins are readily molded in conventional compression, transfer, and injection molding equipment. In compression and transfer operations, pellets preheated in an oven or dielectric preheater to a range from 215° – 232°C (420° – 450°F) are charged to a heated mold between 188° and 199°C (370° and 390°F) with sufficient pressure. Time is then allowed for complete flow and fusion. For heavy sections, the part must be cooled to 93°C (200°F) under pressure to prevent vacuum voids and distortion. Annealing cycles will provide for increased dimensional stability by relieving residual stresses.

The relatively high melt viscosity of KYNAR resins makes proper mold design an important factor in injection molding. Large diameter nozzle openings, sprues, and gates are recommended. Although operating conditions will vary depending on the part, typical temperatures for the barrel, nozzle, and mold are listed below.

In both molding and extrusion operations, care must be taken to eliminate "hang-up" areas where molten resin can collect and thermally decompose if residence time is excessive. Drying of resin before processing is usually not necessary. Recommended processing temperatures are included in Table X.

TABLE IX: EXTRUSION	BARREL REAR °F	BARREL MIDDLE °F	BARREL FRONT °F	HEAD °F	DIE °F
KYNAR 460	325-375	400-450	430-480	450-480	450-495
KYNAR 710	325-375	360-425	375-440	380-430	380-450
KYNAR 720	340-380	370-430	375-450	380-440	380-450
KYNAR 740	350-390	390-450	400-470	380-450	380-470
KYNAR 760	360-390	400-450	410-470	400-460	400-490
KYNAR 1000	360-390	390-450	410-470	380-450	400-490
KYNAR 6000	350-390	370-430	400-460	380-450	380-470
KYNAR 9000	340-380	370-430	390-450	380-450	370-450
KYNAR 370	350-390	390-450	400-470	380-450	380-480
KYNAR SUPER FLEX 2500	300-350	320-360	330-360	330-380	330-400
KYNAR FLEX 2750	310-360	330-360	330-360	330-400	350-420
KYNAR FLEX 2800	325-350	385-440	400-480	350-420	380-460
KYNAR FLEX 2850	340-370	370-430	375-450	380-460	390-470
KYNAR FLEX 3120	340-370	370-430	375-450	380-440	370-450

Baseline operating parameter. Actual melt process profile may vary based on conditions.

TABLE X: MOLDING	BARREL REAR °F	BARREL MIDDLE °F	BARREL FRONT °F	NOZZLE °F	MOLD °F	MOLD SHRINKAGE
KYNAR 460	390-450	410-470	430-500	450-510	120-200	1.5-3.0%
KYNAR 710	370-410	370-420	375-440	370-440	120-200	1.5-3.0%
KYNAR 720	370-410	370-430	375-450	370-450	120-200	1.5-3.0%
KYNAR 740	380-430	390-450	400-470	380-470	120-200	1.5-3.0%
KYNAR 760	395-450	400-460	410-480	400-490	120-200	1.5-3.0%
KYNAR 1000	380-450	390-460	400-480	380-490	120-200	1.5-3.0%
KYNAR 6000	380-430	390-450	400-470	380-470	120-200	1.5-3.0%
KYNAR 9000	370-410	370-430	375-450	370-450	120-200	1.5-3.0%
KYNAR 370	380-430	390-450	400-470	380-470	120-200	0.75-2.0%
KYNAR SUPER FLEX 2500	310-350	320-360	320-380	320-400	90-170	1.0-2.5%
KYNAR FLEX 2750	320-360	330-380	330-400	350-420	100-180	1.0-2.5%
KYNAR FLEX 2800	375-410	385-440	400-480	380-490	120-200	1.0-2.5%
KYNAR FLEX 2850	375-410	385-440	400-480	380-490	120-200	1.5-3.0%
KYNAR FLEX 3120	370-410	370-430	375-450	370-450	120-200	1.0-2.5%

Designers should assume the highest shrinkage on first pass. Shrinkage can be varied based on processing techniques.

BURNING STUDIES

Testing in accordance with ASTM D2863 indicates that KYNAR® homopolymer resin has a limiting oxygen index (LOI) of 43, that is, a 43% oxygen environment is needed for the polymer to continue to burn. Underwriters Laboratories (UL) gives KYNAR homopolymer resins a vertical burn rating of 94 V-O. Sheets of metal coated with KYNAR resin exhibit zero flame spread when tested in accordance with the ASTM E-84 tunnel test.

KYNAR PVDF resins have been tested and found to meet many standards that other polymers fail to meet. KYNAR® 740 PVDF homopolymer piping, tested in accordance with Underwriters Laboratories Canada (ULC) S102.2M88, meets the flame and smoke criteria with a zero flame spread and 45 smoke generation. This earned a favorable listing in the ULC Building Materials Directory related to standard method of test for surface burning characteristics of flooring, floor covering, and miscellaneous material and assemblies. Kynar 740-02 resin meets the UL 1887 Steiner Tunnel Test with a zero flame propagation, 0.02 peak optical density, and a zero average optical density.

KYNAR FLEX® 2850-02 and KYNAR 740-02 homopolymers became the first thermoplastics to meet ASTM E-84, earning a favorable rating for flame spread and smoke generation. Additionally, KYNAR 740-02 has been listed by BOCA National Building Code for drainage pipe and fitting installations in noncombustible plenums.

KYNAR and KYNAR FLEX resins meet or exceed the requirements for UL 910 (Modified Steiner Tunnel Test for wire and cable). These same KYNAR FLEX resins have been tested and found to comply with UL 2024, a test designed for fiber-optic conduit used in plenums.

KYNAR homopolymer resins and KYNAR FLEX 2850 resin meet both the Factory Mutual 4910 (FM 4910) and corresponding UL 2360 burn test criteria. These recent flame and smoke standards were established for semiconductor clean room environments where fires can cause high value losses, making it essential that fire be contained within the ignition zone.

KYNAR FLEX 2950-05 and KYNAR SUPER FLEX® 2500-20 were tested and passed FAR 25.853 testing standards designed for Federal Aviation Administration (FAA) smoke density and toxicity performance. Please contact your ATOFINA sales representative for further information related to specific requirements.

UL 910 Tunnel Test Apparatus

TABLE XI: ASTM E-84 (UL 723) Testing of KYNAR FLEX 740-02 Resin for Surface Burning Characteristics of Building Materials.

Classification	Value Assigned
Flame Spread	0
Smoke Developed	10

Plenum Waste Drainage Piping System

Wet Bench

KYNAR Sheet for Wet Bench Fabrications

Chemical Resistance

CHEMICAL RESISTANCE OF KYNAR® FLUOROPOLYMER

Many factors can affect the chemical resistance of materials. These include, but are not limited to, exposure time, concentration of chemical, extremes of temperature and pressure, frequency of temperature and pressure cycling or both, attrition due to abrasive particles, and the type of mechanical stress imposed. The fact that certain combinations of chemicals and mechanical load can induce stress cracking in many otherwise chemically resistant materials, both metallic and nonmetallic, is of particular significance. In general, the broader molecular weight distribution of KYNAR resins will result in greater resistance to stress cracking.

Factors such as permeability and adhesion affect the resistance of KYNAR PVDF coatings. Consequently, coatings may not exhibit exactly the same properties as melt-processed KYNAR resin. Maximum use temperature for dispersion-applied coatings should not exceed 100°C (212°F). However, assuming chemical resistance is still adequate, laminated systems can be used from 120° – 135°C (248° – 275°F).

Operating parameters are dependent on the particular application of KYNAR resin and differ from those experienced in either laboratory testing or apparently similar field service. Because corrosive fluids or vapors are often mixtures of various individual chemicals, it is strongly recommended that trial installations be evaluated under actual service conditions.

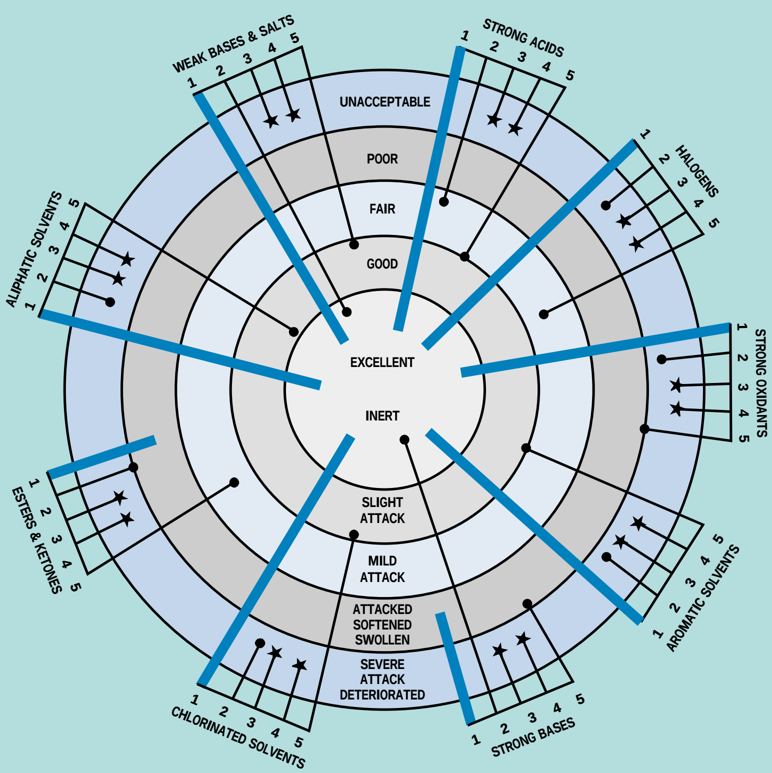
For example, immersion testing of KYNAR resins in individual chemicals at a specific operating temperature, will not necessarily predict the performance of KYNAR PVDF-fabricated components when they are exposed to an exothermic reaction between the individual chemicals.

The chemical resistance of KYNAR fluoropolymer is indicated in the bull's-eye chart (see Figure 7). An alphabetic listing of chemicals with maximum usage temperature is available upon request from the ATOFINA Technical Polymers Business Unit. In the chart on this page, the behavior of KYNAR homopolymer resin at 93°C (200°F) in nine general chemical species is compared with that of other well-known plastics. The rating system ranges from unacceptable severe attack in the outer segment of the circle to excellent inert in the bull's-eye.

KYNAR ratings are based on long-term immersions assuming worst case scenarios.

FIGURE 7

Chemical Resistance of KYNAR Homopolymer Resin vs. Other Well-Known Plastics at 93°C (200°F)



1 KYNAR Polyvinylidene fluoride – Type I
2 Polypropylene
3 Polyvinylidene chloride
4 Polyvinyl chloride – Type I*
5 Polyester (glass fiber reinforced)

**Above recommended operating temperature of plastic*

PURITY OF KYNAR® RESINS

Components formed from natural KYNAR® resins and KYNAR FLEX® resins do not produce particulate contaminants. Unpigmented KYNAR resins are 100% pure fluoropolymer and require no further additives in processing. KYNAR resins do not require stiffeners, stabilizers, or antioxidants, as do PVC, PE and PP. Nor do they call for the addition of external lubricants, such as calcium stearate, to the resin as a processing aid, as has been the case with some other PVDF resins.

Piping systems using natural KYNAR resins under dynamic flow conditions will not release particulates into the fluid stream. Table XII gives metallic ion extractible data generated from KYNAR PVDF and KYNAR FLEX PVDF pellets exposed to hot deionized water (DI) in a 24-hour static test.

Supply & Return Lines,
showing point of ozone injection.

Ozone Injector

TABLE XII: METHOD–ICP MASS SPECTROSCOPY

DI Water Extractions

All results from independent laboratory tests.
Levels of Metallic Ions – KYNAR FLEX 2800, KYNAR 740 • 24 hours/80°C

Element	Amount Detected (parts per billion)	Element	Amount Detected (parts per billion)
Aluminum	< 0.10	Mercury	< 0.01
Antimony	< 0.08	Molybdenum	< 0.02
Arsenic	< 0.03	Neodymium	< 0.09
Barium	< 0.08	Nickel	< 0.08
Beryllium	< 0.06	Niobium	< 0.03
Bismuth	< 0.15	Palladium	< 0.10
Boron	< 0.20	Platinum	< 0.13
Cadmium	< 0.08	Praseodymium	< 0.10
Cerium	< 0.04	Rhenium	< 0.10
Cesium	< 0.08	Rhodium	< 0.10
Chromium	< 0.26	Rubidium	< 0.01
Cobalt	< 0.10	Ruthenium	< 0.12
Copper	< 0.08	Samarium	< 0.06
Dysprosium	< 0.01	Silver	< 0.03
Erbium	< 0.05	Strontium	< 0.10
Europium	< 0.03	Tantalum	< 0.08
Gadolinium	< 0.05	Tellurium	< 0.25
Gallium	< 0.40	Terbium	< 0.10
Germanium	< 0.03	Thallium	< 0.08
Gold	< 0.03	Thorium	< 0.03
Hafnium	< 0.10	Thulium	< 0.04
Holmium	< 0.10	Tin	< 0.25
Indium	< 0.07	Titanium	< 0.10
Iridium	< 0.02	Tungsten	< 0.02
Lanthanum	< 0.05	Uranium	< 0.03
Lead	< 0.07	Vanadium	< 0.11
Lithium	< 0.30	Ytterbium	< 0.04
Lutetium	< 0.05	Yttrium	< 0.03
Magnesium	< 0.07	Zinc	< 0.05
Manganese	< 0.06	Zirconium	< 0.11

KYNAR® FLUOROPOLYMER

A brief summary of the many studies relating to the safe use of KYNAR fluoropolymers is given in the following paragraphs. For more detail, with the fabrication and application of KYNAR PVDF components, read "Product Safety Bulletin-KYNAR Fluoropolymer Products" and the appropriate Material Safety Data Sheets available from ATOFINA Chemicals, Inc., Technical Polymers, 2000 Market Street, Philadelphia, PA 19103.

REGULATORY STATUS OF KYNAR® POLYVINYLIDENE FLUORIDE

KYNAR homopolymer resins may be safely used in articles intended for repeated contact with food per Title 21, Code of Federal Regulations, Chapter 1, part 177.2510. KYNAR copolymer resin meets part 177.2600.

KYNAR homopolymer resins are acceptable for use in processing or storage areas in contact with meat or poultry food products prepared under federal inspection according to the U.S. Department of Agriculture (USDA).

KYNAR homopolymer resins comply with the criteria in "3-A Sanitary Standards for Multiple-Use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment, Serial No. 2000."

KYNAR homopolymer and KYNAR FLEX® copolymer resin grades have been tested and are in compliance with United States Pharmacopia (USP) Classification VI.

KYNAR homopolymer resin grades have been listed with the National Sanitation Foundation (NSF) under Standard 61 for potable water applications, NSF 51 for food equipment, and NSF 14 for pressure-rated piping.

KYNAR homopolymer and copolymer resin grades also meet FDA regulations for single use in polyolefins to 1% concentrates.

RECOMMENDED SAFETY PRECAUTIONS FOR MELT FABRICATING

KYNAR resins are relatively nontoxic and non-hazardous under typical handling conditions. Mechanical malfunctions or human error, however, may lead to thermal decomposition with evolution of toxic hydrogen fluoride (HF). Precautions must be taken to prevent excessive inhalation and physical contact with hydrogen fluoride should decomposition take place. Unlike PVC, KYNAR resins will stop decomposing when the heat source is removed and the temperature of the melt is allowed to fall to normal processing temperature.

Additives, such as mica, asbestos, glass fibers, certain formulations of titanium dioxide, and very finely divided metals, may catalyze thermal decomposition rates during processing and should be used with caution. It is strongly recommended that the fabricator consult with the local ATOFINA sales representative before using any additives.

ATOFINA Plant
Calvert City, Kentucky

KYNAR® PVDF deionized water (DI) wash system providing superior resin purity.

KYNAR® and KYNAR FLEX® PVDF Products

COMPOSITIONS AVAILABLE

Powder: White, nonhygroscopic, approximately 5 micrometer particles loosely agglomerated: sieve size-through 14 mesh. Bulk about 18 lbs./cu. ft.

Pellets: Natural resin translucent, off-white hemispheres. Bulk density approximately 60 lbs./cu. ft.

Latex: Approx. 18.5 lbs./gal. Of nominal 18% (by weight) solids with a density of 1.10 ± 0.1 g/cc.

PELLETS	POWDER	FABRICATION METHOD	CHARACTERISTICS
710		Injection Molding	Very High MFR*, Melt Point 165 – 172°C
720		Injection Molding & Extrusion	High MFR, Melt Point 165 – 172°C
740		Injection Molding & Extrusion	Medium MFR, Melt Point 165 – 172°C
740 Red		Injection Molding & Extrusion	Medium MFR, Melt Point 165 – 172°C Pigmented Red
760		Compression Molding & Extrusion	Low MFR, Melt Point 165 – 172°C
1000 HD		Injection Molding & Extrusion	Medium MFR, Melt Point 165 – 172°C
6000 HD		Injection Molding	High MFR, Melt Point 165 – 172°C
9000 HD		Injection Molding	Very High MFR, Melt Point 165 – 172°C
370		Injection Molding	Low Melt Shrinkage, Carbon Filled, High MFR
EXAD 2000		Extrusion	Extrusion Aid
EXAD 3000		Extrusion	Extrusion Aid
KYNAR FLEX 2750-01		Extrusion & Molding	Very Flexible, Melt Point 130 – 138°C
KYNAR FLEX 2800-00		Extrusion	Flexible, Melt Point 140 – 145°C
KYNAR FLEX 2800-01		Extrusion	Flexible, Lubricant Additive 140 – 145°C
KYNAR FLEX 2800-20		Extrusion & Molding	Flexible, Medium MFR, 140 – 145°C
KYNAR FLEX 2850-00		Extrusion & Molding	Flexible, Melt Point 155 – 160°C
KYNAR FLEX 2850-02		Extrusion & Molding	Flexible, Melt Point 155 – 160°C, LOI >75
KYNAR FLEX 2850-04		Extrusion & Molding	Flexible, Melt Point 155 – 160°C, High MFR
KYNAR FLEX 2850 Black		Extrusion & Molding	Flexible, Melt Point 155 – 160°C, Pigmented Black
KYNAR FLEX 2900-02		Extrusion & Molding	Flexible, Melt Point 140 – 145°C, LOI >75
KYNAR FLEX 2900-04		Extrusion & Molding	Flexible, Melt Point 140 – 145°C, High MFR, LOI >75
KYNAR FLEX 2950-05		Extrusion & Molding	Very Flexible, High MFR, Melt Point 130-138°C, LOI >95
KYNAR FLEX 3120-50		Extrusion & Molding	Flexible, Melt Point 163-168°C, Medium MFR
KYNAR FLEX 3120-WR		Rotomolding	Melt Point above 160°C
KYNAR FLEX 2850-WR		Rotomolding	Melt Point 155-160°C
KYNAR	201	Toners	Low MFR, Melt Point 155 – 160°C
	301-F	Toners, Dispersions	Fine Milled Powder, Melt Point 155 – 160°C
	711	Binders, Additives, etc.	Very High MFR, Melt Point 165 – 172°C
	721	Binders, Additives, etc.	High MFR, Melt Point 165 – 172°C
	741	Binders, Additives, etc.	Medium MFR, Melt Point 165 – 172°C
	761	Binders, Additives, etc.	Low MFR, Melt Point 165 – 172°C
	KYNAR FLEX 2751-00	Binders, Additives, etc.	Flexible, Melt Point 130 – 138°C
	KYNAR FLEX 2801-00	Binders, Additives, etc.	Flexible, Melt Point 140 – 145°C
	KYNAR FLEX 2821-00	Binders, Additives, etc.	Flexible, Medium Melt Flow Rate 140 – 145°C
	KYNAR FLEX 2851-00	Binders, Additives, etc.	Flexible, Melt Point 155 – 160°C
Emulsion Latex 32		Impregnating Fabrics	Water Base, Fine Particle Size

KYNAR® and KYNAR FLEX ® are registered trademarks of ATOFINA Chemicals, Inc., for their polyvinylidene fluoride resins.

*MFR (Melt Flow Rate)

Industrial Uses for KYNAR® and KYNAR FLEX® PVDF Products

Pulp and Paper
bleaching operations

Semiconductor
high purity, no leachates, flame resistant

Nuclear
superior radiation resistance

Mining
abrasion resistant; chloride resistant

Metal Prep
high temperature acid resistance

Pharmaceutical
USP Class VI, ozone sterilizable

Petrochemical
alkylation units; hydrocarbon mixtures

Food & Beverage
FDA, USDA, 3-A listed

Wastewater
ultraviolet resistant; fungus resistant

Pesticides
halogen resistance and low permeation

Institutional
low smoke and flame properties

General Chemical
hot acids, halogens, alcohols, aromatics, oxidants, mild bases, and aliphatics

USA Technical Center, King of Prussia, Pennsylvania

Plant Site
Pierre-Benite, France

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KYNAR® polyvinylidene fluoride, the homopolymer of 1,1-difluoroethene, is a tough engineering thermoplastic that offers a unique balance of properties. It has the characteristic stability of fluoropolymers when exposed to harsh thermal, chemical, and ultraviolet environments, while the alternating CH_2 and CF_2 groups along the polymer chain provide a unique polarity that influence its solubility and electric properties. Thus, KYNAR resins, in addition to being readily melt-processed by standard methods of molding and extrusion, especially at elevated temperatures, can be dissolved in polar solvents such as organic esters and amines. This selective solubility is an advantage in the preparation of corrosion-resistant coatings for chemical process equipment and long-life architectural finishes on building panels.

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