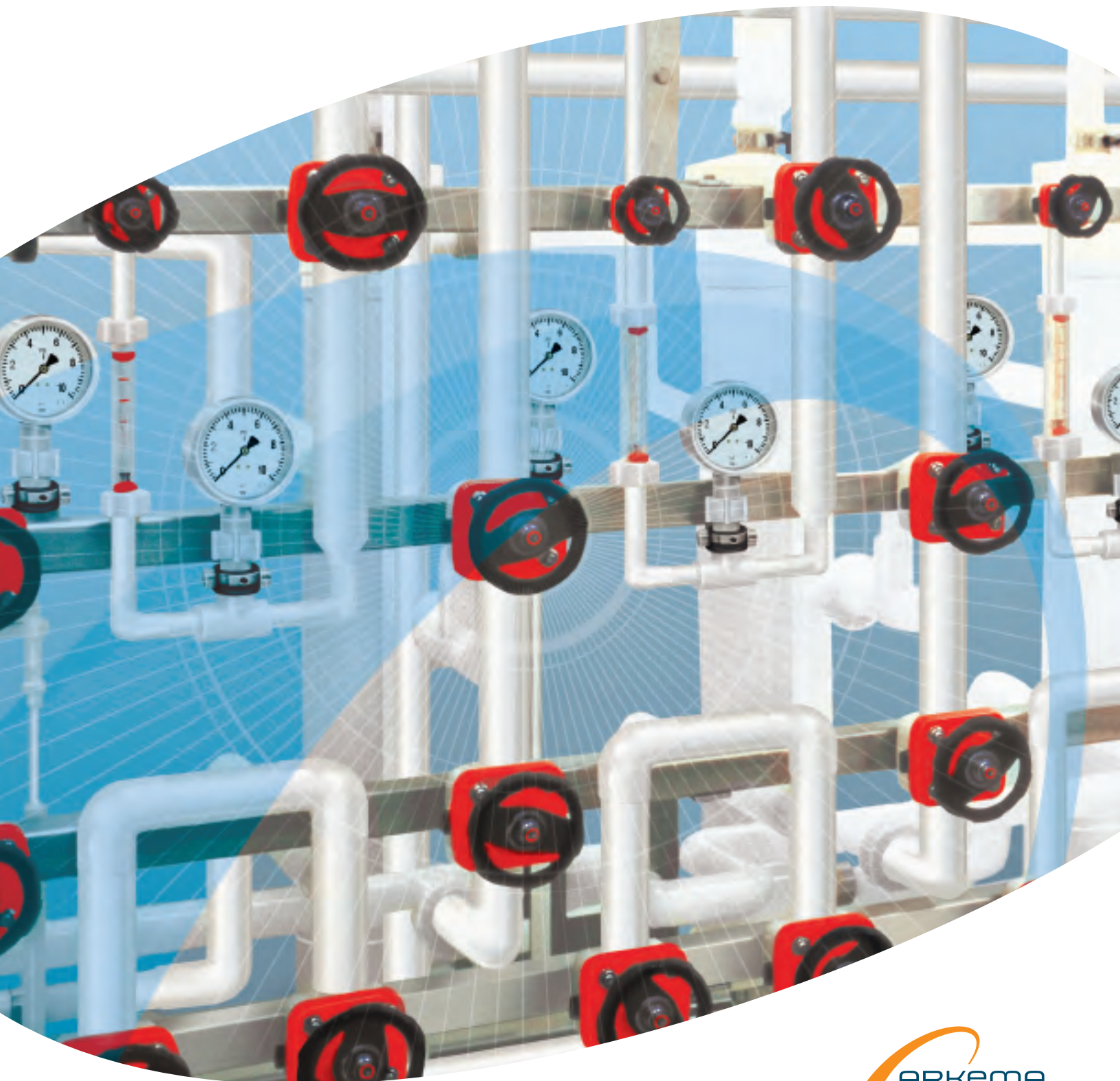


# KYNAR® & KYNAR FLEX® PVDF

PERFORMANCE CHARACTERISTICS & DATA  
THERMOPLASTICS FOR ENGINEERING APPLICATIONS





# KYNAR® & KYNAR FLEX® PVDF

*THERMOPLASTICS FOR ENGINEERING APPLICATIONS*

KYNAR polyvinylidene fluoride is a tough engineering thermoplastic that offers a unique balance of performance properties. It has the characteristic stability of fluoropolymers when exposed to harsh thermal, chemical and ultraviolet environments. KYNAR resins, in addition to being readily melt-processed by standard methods, can be dissolved in polar solvents such as organic esters and amines for coating applications.

## **CHEMICAL PROCESSING**

For chemical and high temperature resistance, low permeability and high mechanical strength, KYNAR PVDF is used as a contact surface for the production, storage and transfer of corrosive fluids. KYNAR PVDF resin is used in mechanical components, fabricated vessels, tanks, pumps, valves, filters, heat exchangers, tower packing, piping systems, as well as other applications.

## **ELECTRICITY & ELECTRONICS**

Its fire-resistance, abrasion resistance, low-smoke emission, chemical and mechanical properties make KYNAR PVDF resin suitable for use in applications such as protective sheathing, plenum and communications wiring insulation and binder resin for battery manufacture.

## **HIGH PURITY**

As semi-conductor and pharmaceutical production require increasingly pure materials, high purity KYNAR PVDF resin grades remain the resins of choice in meeting industry needs. KYNAR PVDF resin has been qualified on a regular basis and notably exceeds requirements of SEMI specification F57. KYNAR PVDF resin regulatory listings include foodstuff use certifications as well as listings for use in other industries, such as healthcare.

## **TRANSPORTATION**

KYNAR PVDF resin is used in both public and private transport vehicles as a barrier liner for automotive fuel line and gas station fuel pipes, in decorative films, as molded and thermoformed body components (weathering, anti-grime/graffiti), and as tanker trailer linings for corrosion protection. KYNAR PVDF resin has strength, durability and versatility that make it a preferred material in automotive wiring harnesses, general coatings, electrochromic technology and plastic optical fibers.

## **ARCHITECTURE**

The excellent outdoor aging and weathering properties of KYNAR 500® PVDF resin led to its use in long-lasting paints for coating metal sheet for the past 40 years. KYNAR 500 can also be used to protect thermoplastics through coextrusion or film lamination techniques to obtain anti-grime and anti-graffiti surfaces with excellent weathering properties.



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# APPLICATIONS

## INDUSTRIAL

KYNAR® PVDF components are used extensively in:

- **the high purity semiconductor market**  
(low extractable values)
- **the pulp and paper industry**  
(chemically resistant to halogens and acids)
- **nuclear waste processing**  
(radiation and hot acid resistant)
- **the general chemical processing industry**  
(extreme chemical and temperature applications)
- **water treatment membranes**  
(industrial and potable water use)

KYNAR fluoropolymers also meet specifications for **food** and **pharmaceutical** processing industries.

KYNAR homopolymer resins are strong, natural engineering fluoropolymers. KYNAR FLEX® resins are a series of PVDF-based copolymers similar to KYNAR homopolymer resins in purity and chemical resistance, but having additional chemical compatibility in high pH solutions, increased impact strength at ambient and low temperatures, and increased clarity.

KYNAR and KYNAR FLEX resins can be fabricated into a wide range of components including:

*Pipes, fittings and valves*  
*Pump assemblies*  
*Sheet and stock shapes*  
*Films*  
*Tubing (Flexible & Rigid)*  
*Tanks and Vessels*  
*Nozzles*  
*Membranes & Filter Housing*  
*Powder Coatings*  
*Foams*

## FOAM

KYNAR PVDF closed cell foams are available in sheets or rolls. KYNAR PVDF foams are of very high purity, very low flammability and are UV and corrosion resistant.

## FILM

KYNAR PVDF film can be used for applications requiring long-term protection. The film is produced by monolayer or multilayer technology as thin, thick, wide or narrow (from 10 to 175 µm), allowing great freedom of design. The commercial range includes both mass-tinted and transparent films, which can be printed with a variety of designs. KYNAR PVDF film can be laminated onto thermoplastic, thermoset and coated metal supports.

## BATTERY

KYNAR PVDF homopolymers and KYNAR FLEX copolymers have gained success in the battery industry as binders for cathodes and anodes in lithium-ion technology, and as battery separators in lithium-ion polymer technology. Arkema has more than forty years of experience in coatings and films to help design thinner, smaller lithium-ion batteries.

## POWDER COATING

KYNAR FLEX® 2850 PC is a functional powder coating system which enables a thick spray coating of KYNAR PVDF resin to be applied to metals for optimum corrosion resistance.

This KYNAR FLEX coating grade features outstanding chemical resistance to acids and ozone, as well as halogens and derivatives. It is easily applied by dry electrostatic spray.

Manufactured with no additives and inherently very pure, KYNAR FLEX 2850 PC complies with United States Pharmacopeia (USP) requirements (Class VI) and Food & Drug Administration (FDA) regulations, and is therefore particularly suitable for coating equipment used in the pharmaceutical, food, chemical and semi-conductor industries.

Flame retardant and thermally stable, KYNAR FLEX 2850 PC coating is also highly abrasion resistant.

KYNAR FLEX 2850 PC coating produces a smooth, high-gloss surface finishes, which enhances its low extraction characteristics and reduces organic deposits and growth.

## PLENUM

Select grades of KYNAR resin easily achieve the flame spread/smoke developed rating of 25/50 when tested in accordance with ASTM E 84. This enables KYNAR pipe to be used in the plenum for applications such as corrosive waste drainage and laboratory chemical systems.

A wide variety of KYNAR FLEX resin grades are offered for use in the plenum cable industry. Cables produced using KYNAR PVDF resin have a zero average, peak optical density and zero flame spread when tested to NFPA 262 (UL 910).

## MEMBRANE

KYNAR PVDF resin is a respected membrane material for applications ranging from bioprocess separations to water purification because it is extremely chemically resistant and thus well suited to aggressive chemical environments. KYNAR PVDF has a high temperature resistance, which makes it appropriate for applications which require high temperature cleaning. KYNAR PVDF tolerates ozone (an oxidant increasingly used for water purification) very well, compared to less robust polymer materials. It is also a high purity resin with FDA and NSF listings, making it compatible with direct food/beverage contact applications.

KYNAR PVDF resin is soluble in several solvents (n-methylpyrrolidone, dimethylacetamide, dimethylsulfoxide, and dimethylformamide) and can be conveniently solution-cast into porous membranes by phase inversion. It is used to manufacture both flat sheet and hollow fiber membranes.

## KYNAR® ADX

KYNAR ADX resins are a new functionalized PVDF product range offering strong adhesion to various substrates. KYNAR ADX can be used in a wide range of applications for markets such as automotive, chemical processing, battery, coatings and packaging.

**In co-extrusion:** KYNAR ADX resin can be combined with most polymers (PE, PA, etc.) to achieve mechanical, chemical and barrier properties.

**In solvent process:** KYNAR ADX resin can be dissolved and applied pure or with fillers to metals as a high adhesion primer or binder.

## ROTOMOLDING

Rotomolding, or rotational molding, is a highly versatile manufacturing option that allows for a wide range of design possibilities at low production costs. KYNAR FLEX® RG resins are specifically designed for rotational molding and offer excellent abrasion resistance and toughness.

Rotomolding allows customers to use KYNAR resin to protect complex geometric and/or enclosed shapes that cannot be lined or coated in a conventional manner.

# PRODUCT RANGE

## POWDER

White, nonhygroscopic, approximately 5 micrometer particles loosely agglomerated: sieve size-through 14 mesh. Bulk density approximately 18 lbs/ft<sup>3</sup>

## PELLETS

Natural resin: translucent, off-white hemispheres. Bulk density approximately 60 lbs/ft<sup>3</sup>

## LATEX

Approximately 18.6 lbs/gal of nominal 18% (by weight) solids with a density of 1.10 ± 0.1 g/cc.

These are typical values, not to be construed as sales specifications.

TABLE I

KYNAR® PVDF GRADE	FABRICATION	MELT VISCOSITY METHOD (ASTM D3835) 450°F K POISE @100 SEC-1	MELT FLOW RATE (ASTM D1238) 450°F g/10 MIN	MELT FLOW RATE LOAD lb (kg)	MELTING POINT	SPECIAL CHARACTERISTICS POINT RANGE
<b>PELLETS</b>						
370	Injection Molding	8.0 - 13.0			165 - 172°C	Low melt shrinkage, carbon filled
460	Injection Molding & Extrusion	23.5 - 29.5	6.0 - 14.0	47.5 (21.6)	155 - 165°C	Broad molecular weight distribution
460 Red	Injection Molding & Extrusion	22.0 - 32.0	3.5 - 18.0	47.5 (21.6)	155 - 165°C	Broad molecular weight distribution, pigmented
710, 710 HDP	Injection Molding	4.0 - 8.0	19.0 - 35.0	8.36 (3.8)	165 - 172°C	HDP indicates higher color stability
720, 720 HDP	Injection Molding & Extrusion	5.0 - 12.0	5.0 - 29.0	8.36 (3.8)	165 - 172°C	HDP indicates higher color stability
740	Injection Molding & Extrusion	15.0 - 23.0	6.0 - 25.0	27.5 (12.5)	165 - 172°C	
740-02	Injection Molding & Extrusion	14.0 - 22.0	7.0 - 28.0	27.5 (12.5)	165 - 172°C	Flame & smoke suppressant
740 Black/Red	Injection Molding & Extrusion	15.0 - 23.0	6.0 - 25.0	27.5 (12.5)	165 - 172°C	Pigmented
760	Extrusion	23.0 - 29.0	2.0 - 6.0	27.5 (12.5)	165 - 172°C	
1000 HD	Injection Molding & Extrusion	15.0 - 20.0	1.5 - 2.5	11.0 (5.0)	165 - 172°C	
6000 HD	Injection Molding	7.0 - 11.0	2.0 - 4.0	11.0 (5.0)	165 - 172°C	
9000 HD	Injection Molding	5.0 - 8.0	16.0 - 40.0	11.0 (5.0)	165 - 172°C	
EXAD 3000	Extrusion	12.0 - 18.0	2.0 - 7.0	11.0 (5.0)	140 - 145°C	Extrusion aid, lubricated
2750-01	Extrusion & Molding	20.0 - 25.0	4.0 - 14.0	27.5 (12.5)	130 - 138°C	Very flexible, lubricated
2800-00	Extrusion	22.0 - 27.0	3.0 - 8.0	27.5 (12.5)	140 - 145°C	Flexible
2800-01	Extrusion	22.0 - 27.0	3.0 - 8.0	27.5 (12.5)	140 - 145°C	Flexible, lubricated
2800-20	Extrusion & Molding	12.0 - 20.0	1.0 - 6.0	11.0 (5.0)	140 - 145°C	Flexible
2850-00	Extrusion & Molding	23.0 - 27.0	3.0 - 8.0	27.5 (12.5)	155 - 160°C	150°C temperature rating
2850-02	Extrusion	16.0 - 20.0	10.0 - 20.0	27.5 (12.5)	155 - 160°C	150°C temperature rating
2850-04	Extrusion & Molding	4.0 - 8.0	8.0 - 25.0	8.36 (3.8)	155 - 160°C	150°C temperature rating
2850-07	Extrusion & Molding	16.0 - 20.0	10.0 - 20.0	27.5 (12.5)	155 - 160°C	150°C temperature rating
2850 Black	Extrusion & Molding	16.0 - 28.0	4.0 - 18.0	27.5 (12.5)	155 - 160°C	150°C temperature rating, pigmented
2900-04	Extrusion & Molding	5.0 - 12.0	4.0 - 17.5	8.36 (3.8)	140 - 145°C	Flexible, flame & smoke suppressant
2950-05	Extrusion & Molding	5.0 - 12.0	4.0 - 17.5	8.36 (3.8)	130 - 138°C	Very flexible, flame & smoke suppressant
3120-15	Extrusion & Molding	5.0 - 12.0	4.0 - 17.5	8.36 (3.8)	161 - 168°C	Flexible, flame & smoke suppressant
3120-50	Extrusion & Molding	20.0 - 26.0	2.5 - 7.5	27.5 (12.5)	161 - 168°C	Flexible, 150°C temperature rating
2500-20	Extrusion & Molding	5.0 - 16.0	1.0 - 15.0	8.36 (3.8)	117 - 125°C	Highest flexibility
<b>POWDER</b>						
201	Toners	28.0 - 34.0	2.0 - 6.0	47.5 (21.6)	155 - 165°C	
301-F	Toners, Dispersion Coatings	28.0 - 34.0	2.0 - 6.0	47.5 (21.6)	155 - 165°C	Fine milled powder
461	Membranes, Binders	23.5 - 29.5	6.0 - 14.0	47.5 (21.6)	155 - 165°C	
711	Binders, Additives, etc.	4.0 - 8.0	19.0 - 35.0	8.36 (3.8)	165 - 172°C	
721	Binders, Additives, etc.	5.0 - 12.0	5.0 - 29.0	8.36 (3.8)	165 - 172°C	
741	Binders, Additives, etc.	15.0 - 23.0	6.0 - 25.0	27.5 (12.5)	165 - 172°C	
761	Binders, Additives, etc.	23.0 - 29.0	2.0 - 6.0	27.5 (12.5)	165 - 172°C	
2751-00	Binders, Additives, etc.	20.0 - 25.0	4.0 - 14.0	27.5 (12.5)	130 - 138°C	Flexible
2801-00	Binders, Additives, etc.	23.0 - 27.0	3.0 - 8.0	27.5 (12.5)	140 - 145°C	Flexible
2821-00	Binders, Additives, etc.	12.0 - 20.0	1.0 - 6.0	11.0 (5.0)	140 - 145°C	Flexible
2501-20	Binders, Additives, etc.	6.0 - 15.0	2.0 - 14.0	8.36 (3.8)	117 - 125°C	Very flexible, very soluble
LBG1	Binders, Additives, etc.	33.0 - 39.0	3.0 - 8.0	(21.6)	148 - 152°C	Li ion battery applications, membrane
LBG2	Binders, Additives, etc.	33.0 - 39.0	3.0 - 8.0	(21.6)	151 - 155°C	Li ion battery applications, membrane
HSV	Binders, Additives, etc.	>35.0	N/A	N/A	158 - 172°C	Li ion battery applications, membrane
<b>OTHER</b>						
2850 PC	Spray Coating Powder	5.0 - 8.0	8.0 - 25.0	27.5 (12.5)	155 - 160°C	Electrostatic spray
Latex 32	Impregnating Fabrics				155 - 160°C	Water base, fine particle size

# KYNAR® HOMOPOLYMER SERIES

TABLE II

PHYSICAL PROPERTIES <sup>1</sup>	STANDARD/CONDITIONS	UNITS	460	1000 SERIES <sup>2</sup>	700 SERIES <sup>2</sup>	370 <sup>3</sup>
Refractive Index	D542/at Sodium D line 77°F (25°C)		1.42	1.42	1.42	—
Specific Gravity	D792/73°F (23°C)		1.75 - 1.77	1.76 - 1.78	1.77 - 1.79	1.84 - 1.88
Water Absorption	D570/68F (20°C) Immersion/24 Hours	%	0.02 - 0.04	0.01 - 0.03	0.01 - 0.03	0.04 - 0.06
MECHANICAL PROPERTIES <sup>1</sup>	STANDARD/CONDITIONS	UNITS	460	1000 SERIES <sup>2</sup>	700 SERIES <sup>2</sup>	370 <sup>3</sup>
Flexural Strength @ 5% Strain	D790/73°F (23°C)	psi (MPa)	7,000 - 9,000 (48 - 62)	8,500 - 11,000 (58 - 76)	8,500 - 11,000 (58 - 76)	20,000 - 30,000 (138 - 207)
Flexural Modulus	D790/73°F (23°C)	psi (MPa)	200,000 - 260,000 (1379 - 1792)	240,000 - 335,000 (1655 - 2310)	240,000 - 335,000 (1655 - 2310)	800,000 - 1,000,000 (5515 - 6895)
Tensile Yield Elongation	D638/73°F (23°C)	%	10 - 15	5 - 10	5 - 10	0 - 4
Tensile Yield Strength	D638/73°F (23°C)	psi (MPa)	5,000 - 7,500 (34 - 52)	6,500 - 8,000 (45 - 55)	6,500 - 8,000 (45 - 55)	5,000 - 8,000 (34 - 55)
Tensile Break Elongation	D638/73°F (23°C)	%	50 - 250	20 - 100	50 - 200	0 - 20
Tensile Break Strength	D638/73°F (23°C)	psi (MPa)	4,500 - 7,000 (31 - 48)	5,000 - 7,000 (34 - 48)	5,000 - 8,000 (34 - 55)	5,500 - 8,000 (38 - 55)
Tensile Modulus	D638/73°F (23°C)	psi (MPa)	150,000 - 200,000 (1034 - 1379)	200,000 - 335,000 (1379 - 2310)	200,000 - 335,000 (1379 - 2310)	450,000 - 750,000 (3102 - 5171)
Compressive Strength	D695/73°F (23°C)	psi (MPa)	8,000 - 10,000 (34 - 69)	10,000 - 15,000 (69 - 103)	10,000 - 15,000 (69 - 103)	20,000 - 25,000 (138 - 172)
Deflection Temperature	D648/at 264 psi (1.82 MPa)	°F (°C)	176 - 194 (80 - 90)	220 - 230 (104 - 110)	221 - 239 (105 - 115)	230 - 260 (104 - 127)
Deflection Temperature	D648/at 66 psi (0.45 MPa)	°F (°C)	234 - 284 (112 - 140)	—	257 - 284 (125 - 140)	270 - 300 (132 - 149)
Impact Strength Notched Izod	D256/73°F (23°C)	Ft-Lb/In	2 - 4	2 - 4	2 - 4	0.75 - 1.50
Impact Strength Unnotched Izod	D256/73°F (23°C)	Ft-Lb/In	15 - 40	20 - 80	20 - 80	5 - 10
Hardness	D2240/73°F (23°C)	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 (23°C)		0.23	0.22	0.20	0.18
Coefficient of Friction - Dynamic vs. Steel	ASTM D 1894 73°F (23°C)		0.17	0.15	0.14	0.12
THERMAL PROPERTIES <sup>1</sup>	STANDARD/CONDITIONS	UNITS	460	1000 SERIES <sup>2</sup>	700 SERIES <sup>2</sup>	370 <sup>3</sup>
Melting Temperature	D3418	°F (°C)	311 - 320 (155 - 160)	337 - 340 (169 - 171)	329 - 342 (165 - 172)	329 - 338 (165 - 170)
Tg (DMA)	@ 1 Hz	°F (°C)	-41 - -37 (-40 - -38)	-41 - -37 (-40 - -38)	-41 - -37 (-40 - -38)	-41 - -37 (-40 - -38)
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 <sup>2</sup> .°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 (°C)	707 (375)	707 (375)	707 (375)	707 (375)
Thermal Decomposition TGA	1% wt. loss/in nitrogen	°F (°C)	770 (410)	770 (410)	770 (410)	770 (410)
ELECTRICAL PROPERTIES <sup>1</sup>	STANDARD/CONDITIONS	UNITS	460	1000 SERIES <sup>2</sup>	700 SERIES <sup>2</sup>	370 <sup>3</sup>
Dielectric Strength 73°F	D149/73°F (23°C)	KV/Mil	1.6	1.6	1.7	—
Dielectric Constant 73°F	D150/100MHz - 100 Hz		4.5 - 9.5	4.5 - 9.5	4.5 - 9.5	28.8 - 33.5
Dissipation Factor 73°C	D150/100 Hz		0.01 - 0.21	0.01 - 0.25	0.01 - 0.21	0.06 - 0.08
Volume Resistivity	D257/DC 68F (20°C)/65% R.H.	ohm-cm	2 x 10 <sup>14</sup>	2 x 10 <sup>14</sup>	2 x 10 <sup>14</sup>	1 x 10 <sup>11</sup>
FLAME & SMOKE PROPERTIES <sup>1</sup>	STANDARD/CONDITIONS	UNITS	460	1000 SERIES <sup>2</sup>	700 SERIES <sup>2</sup>	370 <sup>3</sup>
Burning Rate	UL / Bulletin 94		V - 0	V - 0	V - 0	V - 0
Limiting Oxygen Index (LOI)	D2868	% O <sub>2</sub>	44	60	44 / 60 <sup>4</sup>	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 3). Please contact an Arkema representative for typical values of specific grades.

3. Filled with graphite powder to reduce mold shrinkage.

4. Optional products available with higher LOI.

# KYNAR FLEX® COPOLYMER SERIES

TABLE III

PHYSICAL PROPERTIES <sup>1</sup>	STANDARD / CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Refractive Index	D542/at Sodium D line 77°F (25°C)		1.40	1.41	1.41	1.42	1.41
Specific Gravity	D792/73°F (23°C)		1.80 - 1.82	1.78 - 1.80	1.76 - 1.79	1.77 - 1.80	1.76 - 1.79
Water Absorption	D570/68F (20°C) Immersion/24 Hours	%	—	0.03 - 0.06	0.03 - 0.05	0.03 - 0.05	0.03 - 0.05
MECHANICAL PROPERTIES <sup>1</sup>	STANDARD / CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Flexural Strength @ 5% Strain	D790/73°F (23°C)	psi (MPa)	1,500 - 2,500 (10 - 17)	2,000 - 3,500 (14 - 24)	3,000 - 5,000 (20 - 34)	3,000 - 5,000 (20 - 34)	3,000 - 5,000 (20 - 34)
Flexural Modulus	D790/73°F (23°C)	psi (MPa)	28,000 - 40,000 (192 - 276)	40,000 - 60,000 (276 - 414)	90,000 - 120,000 (620 - 827)	150,000 - 180,000 (1034 - 1241)	90,000 - 120,000 (620 - 827)
Tensile Yield Elongation	D638/73°F (23°C)	%	12 - 25	15 - 25	10 - 20	5 - 15	10 - 20
Tensile Yield Strength	D638/73°F (23°C)	psi (MPa)	1,700 - 2,800 (12 - 19)	2,000 - 3,100 (14 - 21)	2,900 - 5,000 (20 - 34)	4,500 - 6,000 (31 - 41)	3,500 - 5,000 (24 - 34)
Tensile Break Elongation	D638/73°F (23°C)	%	500 - 800	200 - 400	200 - 400	200 - 400	300 - 550
Tensile Break Strength	D638/73°F (23°C)	psi (MPa)	2,000 - 4,500 (14 - 24)	2,900 - 4,000 (20 - 27)	2,500 - 5,000 (17 - 34)	4,000 - 7,000 (27 - 48)	5,000 - 7,000 (34 - 48)
Tensile Modulus	D638/73°F (23°C)	psi (MPa)	35,000 - 55,000 (241 - 379)	40,000 - 65,000 (276 - 448)	80,000 - 130,000 (551 - 896)	150,000 - 220,000 (1034 - 1517)	100,000 - 170,000 (689 - 1172)
Compressive Strength	D695/73°F (23°C)	psi (MPa)	2,000 - 3,000 (14 - 20)	3,500 - 4,500 (24 - 31)	4,500 - 6,000 (31 - 41)	6,000 - 8,500 (41 - 58)	4,500 - 6,000 (31 - 41)
Deflection Temperature	D648/at 264 psi (1.82 MPa)	°F (°C)	80 - 100 (27 - 38)	95 - 125 (35 - 51)	104 - 131 (40 - 55)	100 - 131 (38 - 55)	110 - 130 (43 - 54)
Deflection Temperature	D648/at 66 psi (0.45 MPa)	°F (°C)	—	120 - 150 (49 - 65)	140 - 167 (60 - 75)	140 - 167 (60 - 75)	130 - 170 (54 - 77)
Impact Strength Notched Izod	D256/73°F (23°C)	Ft-Lb/in	NO BREAK	NO BREAK	10 - 20	2 - 8	NO BREAK
Impact Strength Unnotched Izod	D256/73°F (23°C)	Ft-Lb/in	NO BREAK	NO BREAK	NO BREAK	NO BREAK	NO BREAK
Hardness	D2240/73°F (23°C)	Shore D	55 - 60	57 - 62	65 - 70	70 - 75	65 - 70
Tabor Abrasion	CS-17 1000g:pad	mg/1000 cycles	28 - 33	21 - 25	16 - 19	6 - 9	16 - 19
Coefficient of Friction - Static vs. Steel	ASTM D 1894 73°F (23°C)		0.49	0.55	0.33	0.26	0.31
Coefficient of Friction - Dynamic vs. Steel	ASTM D 1894 73°F (23°C)		0.54	0.54	0.33	0.19	0.30
THERMAL PROPERTIES <sup>1</sup>	STANDARD / CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Melting Temperature	D3418	°F (°C)	242 - 257 (117 - 125)	266 - 280 (130 - 138)	284 - 293 (140 - 145)	311 - 320 (155 - 160)	322 - 334 (161 - 168)
Tg (DMA)	@ 1 Hz	°F (°C)	-46 - -40 (-43 - -40)	-44 - -40 (-42 - -40)	-42 - -39 (-41 - -39)	-41 - -37 (-40 - -38)	-42 - -39 (-41 - -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 <sup>2</sup> .°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 (°C)	707 (375)	707 (375)	707 (375)	707 (375)	707 (375)
Thermal Decomposition TGA	1% wt. loss/in nitrogen	°F (°C)	770 (410)	770 (410)	770 (410)	770 (410)	770 (410)
ELECTRICAL PROPERTIES <sup>1</sup>	STANDARD / CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Dielectric Strength 73°F	D149/73°F (23°C)	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	D150/100MHz - 100 Hz		4.5 - 13.5	3.8 - 12.1	3.5 - 10.6	3.5 - 10.2	3.2 - 10.2
Dissipation Factor 73°C	D150/100 Hz		0.05 - 0.29	0.02 - 0.24	0.02 - 0.21	0.01 - 0.22	0.02 - 0.19
Volume Resistivity	D257/DC 68F (20°C)/65% R.H.	ohm-cm	2 x 10 <sup>14</sup>	2 x 10 <sup>14</sup>	2 x 10 <sup>14</sup>	2 x 10 <sup>14</sup>	2 x 10 <sup>14</sup>
FLAME & SMOKE PROPERTIES <sup>1</sup>	STANDARD / CONDITIONS	UNITS	2500	2750/2950	2800/2900	2850	3120
Burning Rate	UL / Bulletin 94		V - 0	V - 0	V - 0	V - 0	V - 0
Limiting Oxygen Index (LOI)	D2868	% O <sub>2</sub>	42/95 <sup>2</sup>	43/95 <sup>2</sup>	42/75 <sup>2</sup>	43/75 <sup>2</sup>	42/95 <sup>2</sup>

1. Typical property values. Should not be construed as sales specifications.  
2. Optional products available with higher LOI.

# GENERAL PHYSICAL & MECHANICAL PROPERTIES

KYNAR® and KYNAR FLEX® PVDF resin grades give the design professional the option to combine rigid and flexible materials when processing. As a material of construction for pumps and pipe, KYNAR resins exhibit excellent resistance to abrasion. KYNAR PVDF can also be manufactured in thin, flexible and transparent sections such as films, filament, and tubing. KYNAR resins are unaffected by sunlight. For information on the ability of KYNAR PVDF to be exposed to other sources of ultraviolet radiation, please contact a Technical Polymers Representative. Tables II and III (pp. 4-5) list typical properties of KYNAR and KYNAR FLEX fluoropolymer resin grades, which display excellent flexural and tensile creep properties.

## STRENGTH & TOUGHNESS

KYNAR and KYNAR FLEX PVDF fluoropolymers are inherently strong and tough as reflected by their tensile properties and impact strength. An ambient temperature tensile strength at yield of 35-55 MPa (5,000-8,000 psi) and an unnotched impact strength of 800-4270 kJ/m (15-80 ft-lbs/in) offered by select resins emphasize this. These characteristics are retained over a wide range of temperatures, as shown in Figures 1 and 2.

## FLEXURAL CREEP

Compared to many thermoplastics, KYNAR fluoropolymers have excellent resistance to tensile creep and fatigue. The long-term resistance of KYNAR resins to flexural creep at elevated temperatures is shown in Figure 3, which illustrates 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

KYNAR fluoropolymers are rigid and resistant to creep under mechanical stress and load. KYNAR resins are able to maintain a low tensile creep when subjected to constant stress. For example, when KYNAR resin is subjected to a stress of 0.69 MPa (100 psi), the resin is able to maintain outstanding resistance even at temperatures as high as 140°C (284°F).

## THERMAL PROPERTIES

KYNAR resins exhibit high thermal stability, as illustrated in Tables II and III. Prolonged exposure of KYNAR resin at 250°C (428°F) in air does not lead to weight loss. No oxidative or thermal degradation has been detected during continuous exposure of KYNAR resins to 150°C (302°F) for a period of ten years. As

thermogravimetric analysis (TGA) thermograms indicate in Figure 4, 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). KYNAR resins thermally decompose at temperatures greater than 375°C (707°F). (Please review KYNAR Material Safety Data Sheet for details and recommendations.) However, the melt processing range of unfilled KYNAR homopolymer resins is very broad – from slightly above the melting point of 155°-170°C (311°-338°F) up to 300°C (572°F). Under certain conditions, KYNAR resin can be processed at higher temperatures. Please consult a technical representative for more information. KYNAR homopolymer is typically processed at temperatures from 180°-265°C (356°-509°F).

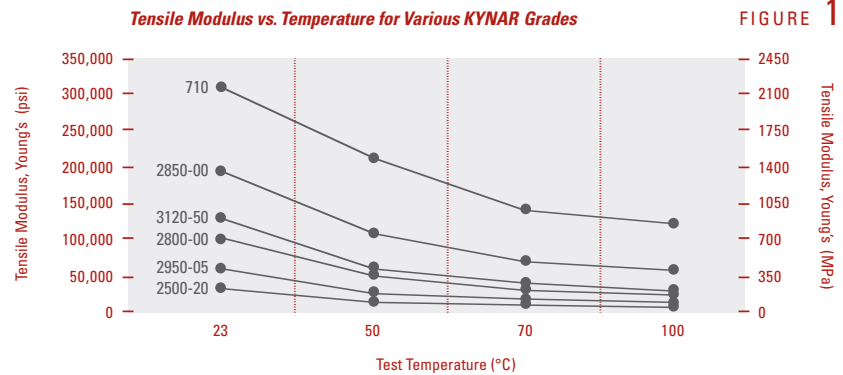
In general, KYNAR resins are some of the easiest fluoropolymers to process. KYNAR resins can be recycled up to three times without detriment to their mechanical properties because KYNAR resin is inherently thermally stable and does not contain additives. Similar to most thermoplastics, KYNAR resins discolor 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.

## LINEAR EXPANSION

Table IV illustrates the linear expansion of various KYNAR and KYNAR FLEX resins for the temperature range of -120° to 160°C (-184° to 320°F).

## CRYSTALLINITY

The degree of crystallinity of the final KYNAR part depends on the resin grade and 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, re-orientation by annealing increases crystallization and long-term performance and stability. With increased crystallinity, parts will have a higher yield strength, modulus and hardness.



**COEFFICIENT OF LINEAR THERMAL EXPANSION ( $\times 10^{-5}/\text{C}$ )**

**TABLE IV**

RESIN GRADE	-40°C	-20°C	0°C	23°C	70°C	85°C
KYNAR® 710	8.9	10.8	12.2	13.4	18.3	20.4
KYNAR 740	8.6	10.2	11.4	12.4	16.7	18.8
KYNAR FLEX® 2800-00	9.7	12.9	15.7	18.5	27.4	32.6
KYNAR FLEX 2950-05	9.7	13.6	17.1	20.2	31.3	37.0
KYNAR FLEX 3120-50	10.2	13.1	15.5	17.5	23.0	24.7



### ELECTRICAL PROPERTIES

The electrical properties of KYNAR® PVDF resins are shown in Tables II and III. Its combination of high dielectric strength and excellent mechanical properties over a broad temperature range has led KYNAR resin to be used for thin-wall primary insulation and as a jacket for industrial control wiring. KYNAR PVDF resin has a high dissipation factor which lends an advantage as a material for parts requiring dielectric high heating strengths such as impedance welding. With proper shielding, KYNAR PVDF resin can be used as jacketing for high frequency data cables because of its excellent flame and smoke performance.

### OPTICAL PROPERTIES

KYNAR PVDF films up to 0.005 inches (0.125 mm) thick are translucent to transparent. The transmission spectrum in Table V shows how UV light transmission varies with thickness for KYNAR resin. Copolymer resins have higher transmission and clarity due to their lower crystallinity.

### STABILITY TO WEATHER & UV EFFECTS

Many years of outdoor exposure in direct sunlight have little effect on the physical properties of KYNAR PVDF. Some increases in tensile strength and reduction in elongation do occur over time.

### OUTGASSING UNDER HIGH VACUUM

KYNAR PVDF resin is a polymer with inherently low outgassing and low condensable film formation. KYNAR homopolymer resins exhibit extremely low weight loss when exposed to high vacuum. At 100°C (212°F) and a pressure of  $5 \times 10^{-6}$  torr, the measured rate of weight loss is only  $13 \times 10^{-11}$  g/cm<sup>2</sup>s.

### FUNGUS RESISTANCE

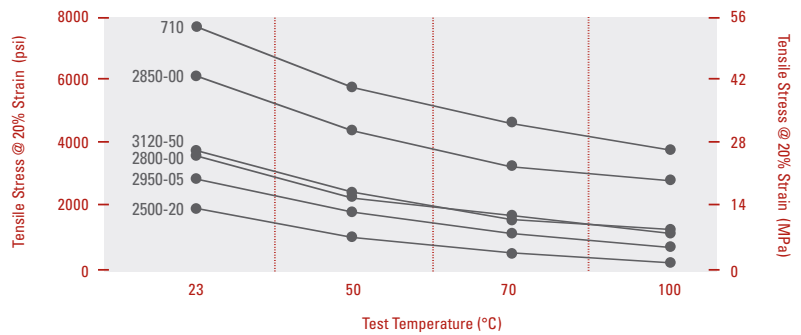
KYNAR resins do not support growth of fungi when tested as described in Method 508 of Military Standard 810B (June 15, 1967).

### OZONE RESISTANCE

Ozone is a powerful oxidizing agent characterized by a high degree of chemical instability. KYNAR PVDF offers excellent chemical resistance to ozone exposure. Please contact a Technical Polymers Representative for additional information.

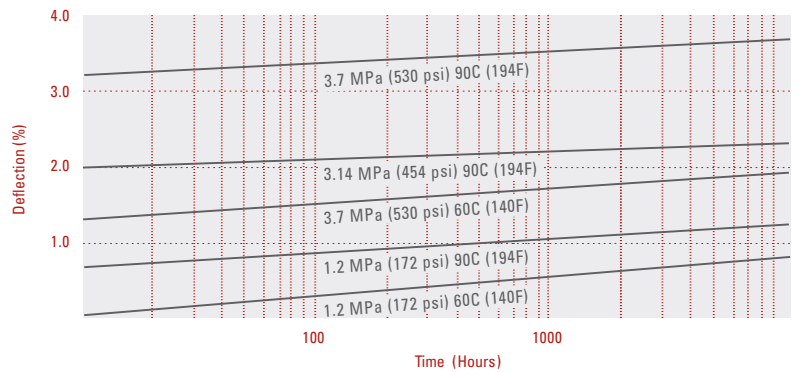
Tensile Stress @ 20% Strain vs. Temperature

FIGURE 2



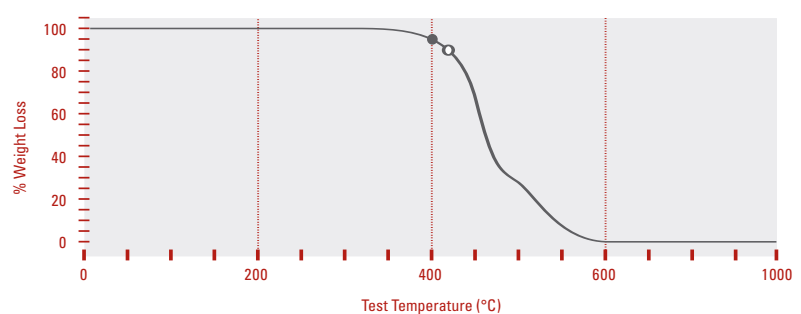
Flexural Creep of KYNAR Homopolymer Resins at High Stresses as a Function of Time + Temperature

FIGURE 3



TGA KYNAR 740

FIGURE 4



% TRANSMISSION IN THE UV REGION AS A FUNCTION OF THICKNESS

TABLE V

THICKNESS MM (IN)	% TRANSMISSION IN ULTRAVIOLET REGION					
	200 NM	240 NM	280 NM	320 NM	360 NM	400 NM
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	0.6	2.7	7.5	14.7	21.9
0.508 (0.020)	0.0	0.0	0.2	0.5	2.5	5.0

# DESIGN PROPERTIES FOR SPECIAL APPLICATIONS

## SOLUBILITY

KYNAR® PVDF resins have limited solubility. Tables VI and VII list active and latent solvents. Generally, KYNAR resins are not soluble in aliphatic hydrocarbons, aromatic hydrocarbons, chlorinated solvents, alcohols, acids, halogens, and basic solutions. KYNAR FLEX® PVDF copolymer tends to be slightly more soluble than the KYNAR PVDF homopolymer due to its lower crystallinity.

## 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 100 megarads (Mrads) of gamma radiation from a Cobalt-60 source at 50°C (122°F) and in high vacuum (10<sup>-6</sup> 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 VIII and IX show minimal changes in tensile properties of KYNAR homopolymer and KYNAR FLEX copolymer 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 homopolymer 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. Examples of KYNAR PVDF-fabricated products utilizing radiation technology are heat-shrinkable tubing and insulated wire capable of withstanding high temperatures.

ACTIVE\* SOLVENTS TABLE VI

SOLVENT	BOILING POINT °C	FLASH POINT °C
Tetrahydrofuran	65	-17
Methyl Ethyl Ketone	80	-6
Dimethyl Formamide	153	67
Dimethyl Acetamide	166	70
Tetramethyl Urea	177	65
Dimethyl Sulfoxide	189	35
Trimethyl Phosphate	195	107
N-Methyl-2-Pyrrolidone	202	95

\*Solvent will dissolve at least 5-10 weight percent KYNAR resin at ambient temperature.

LATENT\*\* SOLVENTS TABLE VII

SOLVENT	BOILING POINT °C	FLASH POINT °C
Acetone	56	-18
Methyl Isobutyl Ketone	118	23
Glycol Ethers***	118	40
Glycol Ether Esters***	120	30
N-Butyl Acetate	135	24
Cyclohexanone	157	54
Diacetone Alcohol	167	61
Diisobutyl Ketone	169	49
Ethyl Acetoacetate	180	84
Butyrolactone	204	98
Isophorone	215	96
Triethyl Phosphate	215	116
Carbitol Acetate	217	110
Propylene Carbonate	242	132
Glyceryl Triacetate	258	146
Dimethyl Phthalate	280	149

\*\*As a rule, latent solvents do not dissolve or substantially swell KYNAR homopolymer resin at room temperature.

\*\*\*Based on ethylene glycol, diethylene glycol, and propylene glycol.

TENSILE MODULUS VS. RADIATION DOSE EXPOSURE (PSI)

TABLE VIII

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

ULTIMATE TENSILE STRENGTH VS. RADIATION DOSE EXPOSURE (PSI)

TABLE IX

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

# BASIC WELDING PRINCIPLES

In order to produce a high quality weld, three parameters must be controlled:

**Temperature:** within a specified range in order to produce the proper melting of the resin.

**Pressure:** excessive pressure must be avoided to avoid forcing the melted resin out of the weld interface.

**Time:** to provide uniform heating throughout the weld zone as the material's low thermal conductivity slows the heat transfer.

After reaching the proper melt conditions, slow cooling is necessary to reduce stress and permit the intermolecular diffusion of the polymer. Testing of welds for physical characteristics such as tensile, bend angle, etc. prior to 12 hours after completion of the weld will produce erroneous results. The weld zone should be allowed to cool to ambient temperature prior to the next weld pass. If the weld zone is not allowed to cool, excessive stress will result, which may cause distortion of the weldment.

In order to produce the highest quality weld, the surfaces to be welded must be clean. The surface should be scraped just prior to every

weld pass. Wiping with a solvent only spreads the contamination!

## WELDING METHODS

Several methods of fusion welding KYNAR® PVDF components are possible. The most common and successful approaches to welding KYNAR® PVDF components are heat contact and hot gas welding using a welding rod. Ultrasonic, hot lamination, infrared (IR), resistance heating, spin and radio frequency welding are all methods suitable for bonding KYNAR resin to itself.

## HOT GAS WELDING

The welding of KYNAR PVDF can be performed using conventional hot gas welding equipment. It is highly recommended that automatic temperature welding equipment be utilized. This type of equipment greatly reduces the possibility of substandard welds due to temperature variations during the welding process. A suitable weld can be defined as one capable of meeting the Deutscher Verben

Fur Schweißen Und Verwandte Verfahren E.V. (DVS) requirements for welder certification. The values in Table X are the current conditions accepted by the DVS as the optimal welding perimeters.

The welding area should be well ventilated so that heat and fumes generated during the welding process are drawn away from the welder. Drafts, excessive air movement and similar conditions that would cause the weld to cool rapidly must be avoided. The weld area must be clean and free of particles that will be attracted to the weld.

## BUTT WELDING OF KYNAR PVDF

The conditions listed in Table XI are recommended starting points for the welding of KYNAR slab. Optimal conditions may vary slightly from these conditions. The welding/cooling times are the suggested times for welding rolled sheets. Flat sheets may be removed sooner because they will not tend to distort if kept flat until cool.

HOT GAS WELDING CONDITIONS AS PER DVS

TABLE X

WELDING PROCESS	WELDING TEMPERATURE °C*	VOL AIR L/MIN	FORCE** 3MM		FORCE** 4MM		WELDING SPEED CM/MIN
			N	LBS	N	LBS	
Fan Welding WF	300 - 320 (570 - 610°F)	40 - 60	10 - 15	2.5 - 3.5	15 - 20	3.5 - 4.5	10 - 15
High Speed WZ	365 - 385 (690 - 725°F)	40 - 60	12 - 17	3 - 4	25 - 35	6 - 8	25 - 40

\*Temperature measured 5 mm inside main outlet of the welding tip.

\*\*Force applied to weld zone through welding gun.

RECOMMENDED WELDING CONDITIONS FOR BUTT WELDING\*

TABLE XI

THICKNESS MM (IN)	TEMPERATURE °C	MELT PRESSURE N/CM <sup>2</sup>	HEATING		WELDING/COOLING	
			TIME (MIN)	PRESSURE N/CM <sup>2</sup>	TIME (MIN)	PRESSURE N/CM <sup>2</sup>
3 3.2 (1/8) 4	235 - 240	15	1:00 1:07 1:15	1.0	6:00 7:00 8:00	30
4.8 (3/16) 5 6 6.4 (1/4)	230 - 235	15	1:29 1:30 1:45 1:50	1.0	9:45 10:00 12:00 12:45	30
7.9 (5/16) 8 9.5 (3/8) 10	225 - 230	15	2:00 2:00 2:35 2:45	1.0	15:45 16:00 18:30 20:00	30
12 12.7 (1/2) 15 15.9 (5/8) 19.1 (3/4) 20	220 - 225	15	3:10 3:15 3:52 4:08 4:53 5:07	1.0	24:0 24:40 30:00 31:00 38:00 40:00	30
22.5 (7/8) 25.4 (1)	215 - 220	15	5:38 6:18	1.0	44:00 50:00	30

\*For processing KYNAR 740 on a Wegener machine.

# PROCESSING EQUIPMENT & MATERIALS OF CONSTRUCTION

## EXTRUSION

Smooth KYNAR® PVDF products of all types can be extruded at high rates without extrusion aids, lubricants or heat stabilizers. KYNAR resins can be processed on standard equipment with materials of construction similar to those used to process PVC or polypropylene. Drying of KYNAR is usually not required; however, it has been shown to reduce some surface blemishes in film, sheet and pipe extrusion.

Polyethylene (PE) can be used as a purge compound at the end of a production run. However, if the extrusion equipment is not properly cleaned after purging, PE will act as a contaminant in subsequent runs, creating weak weld lines. Cast acrylic resin can also be used as a purge compound, and unfilled KYNAR grades can be used to purge flame-retardant KYNAR grades.

## PIPE EXTRUSION

KYNAR 740 resin and KYNAR 1000 resin are the primary grades used in chemical pipe applications. KYNAR 740-02 contains a smoke suppressant package and is primarily used for waste drainage pipe and fittings. KYNAR FLEX® 2850 copolymer can be used for applications requiring higher impact and stress crack resistance.

Standard metering screws with an L/D ratio of 24/1 and a compression ratio of 3/1 are commonly used. The screw should have an even flight distribution between the feed, transition and metering zones. Better temperature and output stability can be achieved by using a barrier-type screw. Maddox and spiral mixers are also acceptable, but pin type mixers are not recommended. Good temperature control of the extruder and tooling is required for optimal processing.

It is important to eliminate areas of melt accumulation, or hang-up points, to prevent KYNAR resin from discoloring. Common areas of melt accumulation include behind the breaker plate, at undercuts and in any other stagnant areas. Screen packs are not typically used.

In-line spider dies are commonly used for producing KYNAR pipe. The design should minimize material inventory in the head and be streamlined to eliminate material hang-up. Spiral dies should be designed similarly and can provide better weld line strength.

The draw down ratio (DDR) for tip and die selection generally ranges from 1.3-2.1 (area DDR), or 1.05-1.5 (OD DDR), but varies based

on the dimensions of the finished pipe. The optimum land length will vary based on pipe size, process conditions and material grade. Extrusion temperatures range between 200°-240°C (392°-464°F), but vary depending on material grade, as well as pipe and tooling size. Lower melt temperatures provide a “stronger” melt and are used when product whiteness is of primary concern.

Pipe is typically sized using a vacuum calibration system equipped with either a solid brass or a brass disk caliper, which is oversized to accommodate material shrinkage. See Table XII for common pipe processing temperatures.

## TUBE EXTRUSION

The technical information mentioned for pipe extrusion (equipment, processing temperatures, etc.) also applies to tube extrusion.

KYNAR homopolymers can typically be calibrated using standard contact sizing equipment similar to that used to produce pipe. The OD DDR used for contact sizing of tubing can range from 1.2-1.5.

All other KYNAR FLEX PVDF resin grades, as well as thin-walled tubing, are best processed using non contact sizing calibrators. See Table XIV for common tube processing temperatures. Please contact our technical group for more information on this process.

## INJECTION MOLDING

Standard injection molding equipment and tooling can be used to process KYNAR resin. No specialty materials of construction are

required, but chrome or nickel plating of polymer contact surfaces is recommended to prevent pitting.

Melt temperatures will vary based on the part geometry, tooling and resin grade. In general, lower melt and mold temperatures can be used effectively with low viscosity KYNAR copolymer grades.

KYNAR resin is best processed with a large sprue or edge gates. To produce the best quality parts, fill the sprue, runners and gates slowly and then ramp up the injection speed until the screw reaches its transfer position. Small pin or subgates can be used for smaller parts and will require faster injection speeds and higher melt temperatures to fill the part. If a process calls for use of a hot runner system, please contact a technical representative before committing to this practice.

KYNAR PVDF resin requires generous venting at the end of the filling process or a burning phenomenon known as dieseling can occur.

KYNAR PVDF resin is a highly crystalline material and will exhibit significant shrinkage. Shrinkage rate is a function of part thickness, flow direction (which is a function of gate type and location) and processing conditions. (See Table XII.)

Voiding is a common problem when molding KYNAR resin due to the polymer's high crystallinity. Good part design practices are required to prevent voiding in thick sections of the part. See Table XV for common injection molding temperatures.

*Arkema technical service is available to discuss tooling and processing of KYNAR PVDF.*

## MOLD SHRINKAGE DATA

TABLE XII

GRADE	% SHRINKAGE*	
	IN FLOW DIRECTION	CROSS FLOW DIRECTION
KYNAR® 370	1.2 - 3.5	0.8 - 3.0
KYNAR 710	1.9 - 3.5	1.6 - 3.0
KYNAR 720	2.0 - 3.5	1.6 - 3.0
KYNAR 740	2.8 - 3.5	1.9 - 3.0
KYNAR FLEX® 2850-04	1.9 - 3.5	1.6 - 3.0
KYNAR FLEX 2800-00	2.5 - 3.5	1.6 - 3.0

\*Measurements taken after 24 hours at ambient conditions.

**PIPE EXTRUSION**

**TABLE XIII**

GRADE	BARREL TEMPERATURE °C				
	REAR	MIDDLE	FRONT	HEAD	DIE
KYNAR® 460	200 - 230	220 - 240	230 - 250	230 - 250	230 - 260
KYNAR 740	190 - 220	200 - 230	210 - 240	210 - 240	210 - 250
KYNAR 1000	190 - 220	200 - 230	210 - 240	210 - 240	210 - 250
KYNAR FLEX® 2850	190 - 220	200 - 230	210 - 240	210 - 240	210 - 250

**TUBE EXTRUSION**

**TABLE XIV**

GRADE	BARREL TEMPERATURE °C				
	REAR	MIDDLE	FRONT	HEAD	DIE
KYNAR® Homopolymer	195 - 220	210 - 240	210 - 240	210 - 240	210 - 250
KYNAR FLEX® 3120	195 - 220	210 - 240	210 - 240	210 - 240	210 - 250
KYNAR FLEX 2850	195 - 220	210 - 240	210 - 240	210 - 240	210 - 250
KYNAR FLEX 2800	195 - 220	210 - 240	210 - 240	210 - 240	210 - 250
KYNAR FLEX 2750	195 - 220	220 - 240	220 - 250	220 - 250	220 - 250
KYNAR SUPERFLEX® 2500	195 - 220	220 - 240	230 - 250	230 - 250	230 - 250

**INJECTION MOLDING**

**TABLE XV**

GRADE	BARREL TEMPERATURE °C				
	REAR	MIDDLE	FRONT	NOZZLE	MOLD
KYNAR® 460	200 - 230	210 - 240	220 - 250	230 - 255	50 - 90
KYNAR 710	190 - 210	200 - 220	200 - 240	200 - 240	50 - 90
KYNAR 720	190 - 210	200 - 220	200 - 240	200 - 240	50 - 90
KYNAR 740	200 - 220	210 - 230	210 - 245	210 - 245	50 - 90
KYNAR 760	200 - 230	210 - 240	220 - 250	230 - 255	50 - 90
KYNAR 1000	200 - 220	210 - 230	210 - 245	210 - 245	50 - 90
KYNAR 6000	190 - 210	200 - 220	200 - 240	200 - 240	50 - 90
KYNAR 9000	190 - 210	200 - 220	200 - 240	200 - 240	50 - 90
KYNAR 370	190 - 210	200 - 220	200 - 240	200 - 240	50 - 90
KYNAR SUPER FLEX® 2500	200 - 220	210 - 230	210 - 245	210 - 245	50 - 90
KYNAR FLEX® 2750-01	200 - 220	210 - 230	210 - 245	210 - 245	50 - 90
KYNAR FLEX 2800-20	200 - 220	210 - 230	210 - 245	210 - 245	50 - 90
KYNAR FLEX 2850-04	190 - 210	200 - 220	200 - 240	200 - 240	50 - 90
KYNAR FLEX 3120-10	190 - 210	200 - 220	200 - 240	200 - 240	50 - 90

# BURNING STUDIES

KYNAR® PVDF resins have been tested and meet many standards that other polymers fail. Table XVI lists test standards for which KYNAR resin has approval. KYNAR 740-02 and KYNAR 1000HD homopolymer, and KYNAR FLEX® 2850-02 copolymer, were the first thermoplastics to meet the ASTM E84 flame spread and smoke development requirement for materials installed in plenums. These resins meet the criteria by having a flame spread/smoke developed index of less than 25/50, respectively. KYNAR 740-02 is listed by the International Code Council for drainage pipe and fitting installations in noncombustible plenums. Foamed KYNAR parts with a density of 0.03 g/cc meet ASTM E84 with a 10/30 rating.

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. KYNAR 740-02 resin meets the Underwriters Laboratories (UL) 1887 Steiner Tunnel Test with a zero flame propagation, 0.02 peak optical density, and a zero average optical density (0, 0.2, 0).

KYNAR and KYNAR FLEX resins meet or exceed the requirements for NFPA 262 (UL 910 Modified Steiner Tunnel Test for Wire and Cable). KYNAR grades that pass the more stringent NFPA 255 (Steiner Tunnel Test for Limited Combustible Applications) are also available. Select KYNAR FLEX resins also

comply with UL 2024, a test designed for fiber-optic conduit used in plenums.

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. Special KYNAR PVDF products are available with an LOI of nearly 100%. UL gives KYNAR homopolymer resins a vertical burn rating of V-0 per UL 94. Also, sheets of metal coated with KYNAR 500 resin exhibit zero flame spread and zero smoke developed when tested in accordance with the ASTM E84 tunnel test.

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 SUPERFLEX® 2500-20 were tested and passed Federal Aviation Regulations (FAR) 25.853 testing standards designed for Federal Aviation Administration (FAA) smoke density and toxicity performance. Please feel free to contact a sales representative for further information related to specific requirements.

## CERTAIN GRADES OF KYNAR® PVDF MEET THE FOLLOWING TEST STANDARDS TABLE XVI

TEST METHOD	PROPERTIES
ASTM E 84 (NFPA 255, UL 723)	Surface Burning Characteristics of Building Materials
ULC S102.2	Canadian Surface Burning Characteristics of Building Materials
NFPA 262 (UL 910)	Flame Travel and Smoke of Wires and Cable for Use in Air-Handling Spaces
UL 2024	Optical Fiber Raceway
FM 4910	Cleanroom Materials Flammability Test Protocol
UL 2360	Combustibility Characteristics of Plastics Used in Semi-Conductor Tool Construction
FAR 25.853	Federal Aviation Administration Smoke Density and Toxicity Performance
ASTM E 662	Optical Density of Smoke Generated by Solid Materials
ASTM E 162	Surface Flammability of Materials Using a Radiant Heat Energy Source
BS 476:7 Class 1Y	British Standard: Fire Tests on Building Materials and Structures
UL Bulletin 94 (V-0)	Test for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 1887	Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics

# CHEMICAL RESISTANCE

## CHEMICAL RESISTANCE OF KYNAR® PVDF FLUOROPOLYMERS

KYNAR® PVDF resins are chemically resistant to a wide range of chemicals. Most acids and acid mixtures, weak bases, halogens, halogenated solvents, hydrocarbons, alcohols, salts and oxidants pose little problem for KYNAR PVDF. At ambient temperatures KYNAR PVDF homopolymers are generally resistant to chemicals with a pH up to 12 and KYNAR FLEX® copolymers are generally resistant to chemicals with a pH up to 13.5.

Many factors can affect a material's chemical resistance. These include, but are not limited to, exposure time, chemical concentration, extreme temperature and pressure, frequency of temperature and pressure cycling, attrition due to abrasive particles, and the type of mechanical stress imposed. The fact that certain combinations of chemical exposure and mechanical load can induce stress cracking in many otherwise chemically resistant materials, both metallic and nonmetallic, is of particular significance. In general, the broad molecular

weight distribution of KYNAR resins results in greater resistance to stress cracking.

Factors such as permeability and adhesion affect the chemical 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 or powder 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.

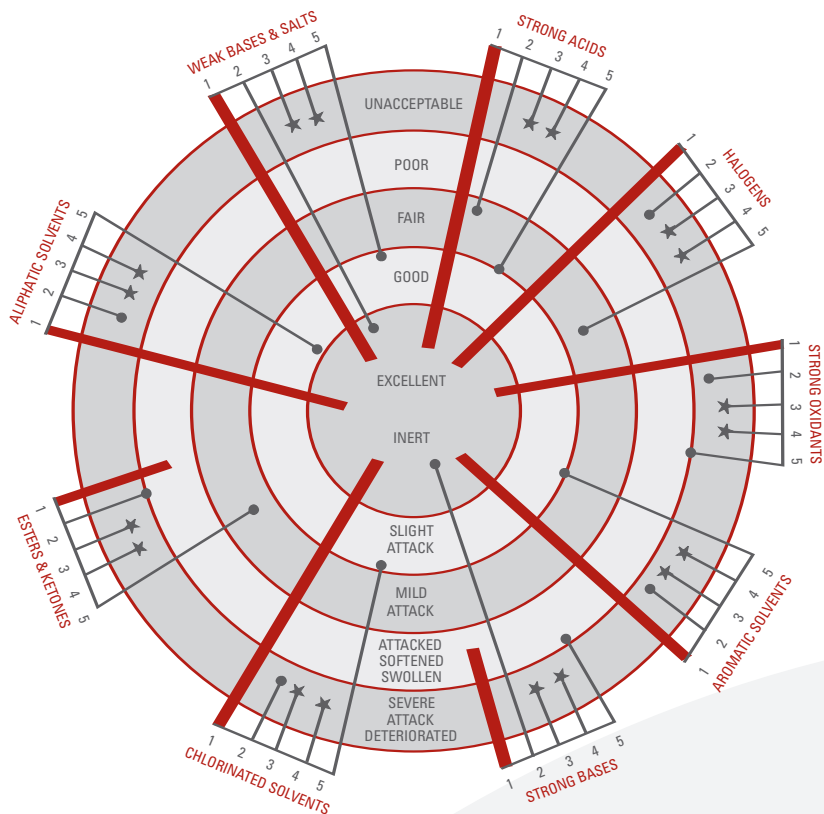
The chemical resistance of KYNAR fluoropolymer is indicated in Figure 5. In this chart, the behavior of KYNAR homopolymer resin at 93°C (200°F) in contact with nine general chemical species is compared with that of other well-known plastics. The rating system ranges from unacceptable severe attack in the outer segment of the circle to excellent (inert) in the bull's-eye.

An alphabetic listing of chemicals and their maximum usage temperature with KYNAR resins is available upon request from the Technical Polymers Business Unit. Chemical applications can be complex and the information provided here should be considered a general guideline. For more information, contact a Technical Service Representative.

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

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

FIGURE 5



- 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

### Typical Chemicals\* Handled by KYNAR® PVDF

- Chlorine
- Bromine (Gaseous)
- Methyl Chloroform
- Bromine Water
- Hydrochloric Acid
- Hydrobromic Acid
- Salt Water
- Bromobenzene
- Chlorobenzene
- Brominated Salts
- Sodium Hypochlorite
- Iodine
- Hot Sugars
- Salicylic Acid
- Sulfuric Acid <98%
- <50% Acetic Acid
- Chlorinated Salts
- Methyl Alcohol
- Phosphoric Acid
- Chromic Acid
- Hydrofluoric Acid
- Nitric Acid

Mixtures of chemicals can create aggressive by-products.

\*Chemical Resistance Chart Available from Arkema Inc.

# PURITY OF KYNAR® RESINS

Components formed from natural KYNAR® and KYNAR FLEX® resins do not produce particulate contaminants. Unpigmented, natural 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 XVII gives metallic ion extractable data generated from KYNAR PVDF and KYNAR FLEX PVDF pellets exposed to hot deionized water (DI) in a 24-hour static test.

## DI WATER EXTRACTIONS [METHOD: ICP MASS SPECTROSCOPY]

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

TABLE XVII

ELEMENT	TEST DETECTION LIMIT (PPB)	AMOUNT DETECTED (PPB)*
Aluminum	0.10	*
Antimony	0.08	*
Arsenic	0.03	*
Barium	0.08	*
Beryllium	0.06	*
Bismuth	0.15	*
Boron	0.20	*
Cadmium	0.08	*
Cerium	0.04	*
Cesium	0.08	*
Chromium	0.26	*
Cobalt	0.10	*
Copper	0.08	*
Dysprosium	0.01	*
Erbium	0.05	*
Europium	0.03	*
Gadolinium	0.05	*
Gallium	0.40	*
Germanium	0.03	*
Gold	0.03	*
Hafnium	0.10	*
Holmium	0.10	*
Indium	0.07	*
Iridium	0.02	*
Lanthanum	0.05	*
Lead	0.07	*
Lithium	0.30	*
Lutetium	0.05	*
Magnesium	0.07	*
Manganese	0.06	*

\* Indicates none detected.

ELEMENT	TEST DETECTION LIMIT (PPB)	AMOUNT DETECTED (PPB)*
Mercury	0.01	*
Molybdenum	0.02	*
Neodymium	0.09	*
Nickel	0.08	*
Niobium	0.03	*
Palladium	0.10	*
Platinum	0.13	*
Praseodymium	0.10	*
Rhenium	0.10	*
Rhodium	0.10	*
Rubidium	0.01	*
Ruthenium	0.12	*
Samarium	0.06	*
Silver	0.03	*
Strontium	0.10	*
Tantalum	0.08	*
Tellurium	0.25	*
Terbium	0.10	*
Thallium	0.08	*
Thorium	0.03	*
Thulium	0.04	*
Tin	0.25	*
Titanium	0.10	*
Tungsten	0.02	*
Uranium	0.03	*
Vanadium	0.11	*
Ytterbium	0.04	*
Yttrium	0.03	*
Zinc	0.05	*
Zirconium	0.11	*



# REGULATORY STATUS OF KYNAR® POLYVINYLIDENE FLUORIDE

KYNAR® PVDF 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 FLEX® PVDF 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 United States 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 resins have been tested and are in compliance with United States Pharmacopeia (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 part 177.1520 for single use in polyolefins to 1% concentrates.

Please contact Arkema to learn which grades of KYNAR homopolymers and copolymers meet these regulatory approvals.

## RECOMMENDED SAFETY PRECAUTIONS FOR MELT PROCESSING

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 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 Technical Polymer sales representative before using any additives.

Please refer to Table XVIII for a brief summary of regulatory listings and approvals. For more details, read "Product Safety Bulletins KYNAR Fluoropolymer Products" and the appropriate Material Safety Data Sheet available at [www.kynar.com](http://www.kynar.com).

## SELECT KYNAR® AND KYNAR FLEX® PVDF GRADES HAVE THE FOLLOWING REGULATORY LISTINGS AND APPROVALS

TABLE XVIII

ORGANIZATION	REGULATION
National Sanitation Foundation (NSF)	NSF-61 Potable Water, NSF-51 Food Equipment, NSF-14 Plumbing System Components
Food & Drug Administration (FDA)	177.2510 & 177.2600 Repeated Contact with Food, 177.1520 Single use Adjuvant for Use in Polyolefins 1% Concentration
United States Department of Agriculture (USDA)	Use in Process or Storage Areas to Contact with Meat or Poultry Food Products
3A Sanitary Standards Inc. (3-A SSI)	Multiple Use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment
United States Pharmacopeia (USP) Class VI	USP Class VI
Chicago Rabbinical Council (CRC)	Kosher Certified

## CONTACT US AROUND THE WORLD

**[www.kynar.com](http://www.kynar.com)**

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2000 Market St.  
Philadelphia, PA 19103  
800.KYNAR.50  
215-419-7647

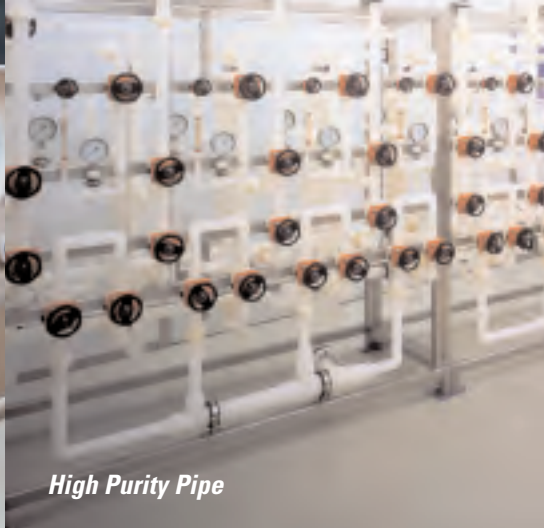
Arkema  
4-8 Cours Michelet  
La Defense 10  
F-92091 Paris La Defense Cedex  
33-1-4900-8178

Arkema South East Asia  
Arkema Pte Ltd  
10 Science Park Road  
#01-01A, The Alpha  
Singapore Science Park II  
Singapore 117684  
65-6419-9018

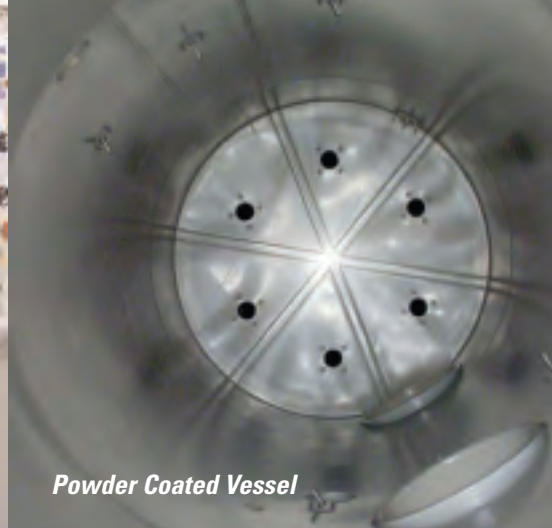
For more information or  
to view additional literature,  
visit [www.kynar.com](http://www.kynar.com).



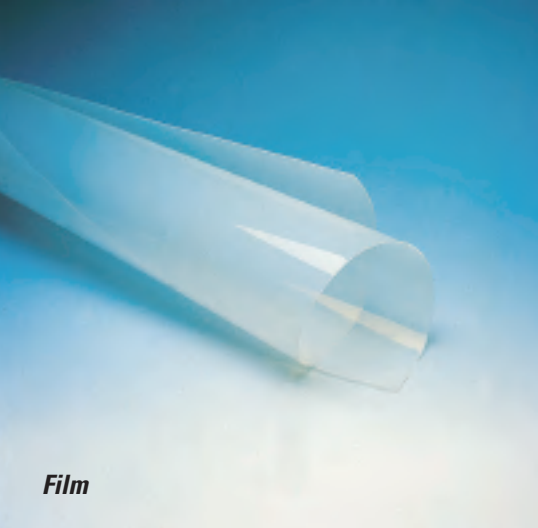
*Lined Glove Box*



*High Purity Pipe*



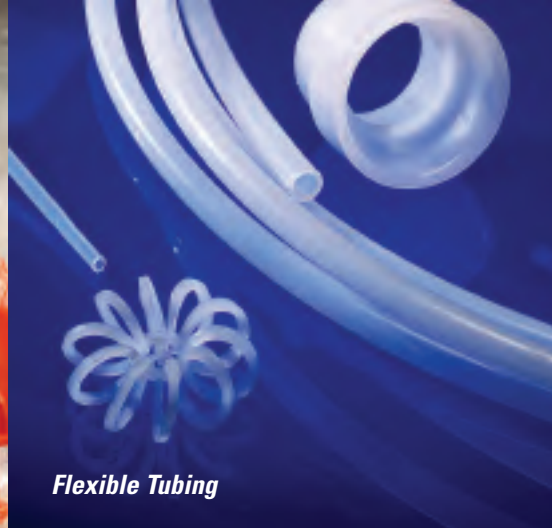
*Powder Coated Vessel*



*Film*



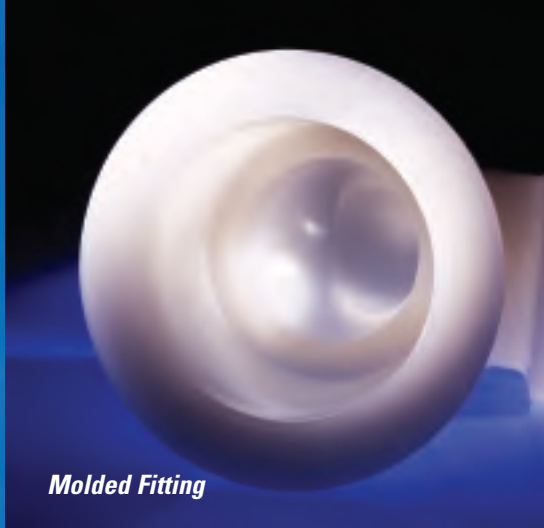
*Tower Packing*



*Flexible Tubing*



*Nozzle*



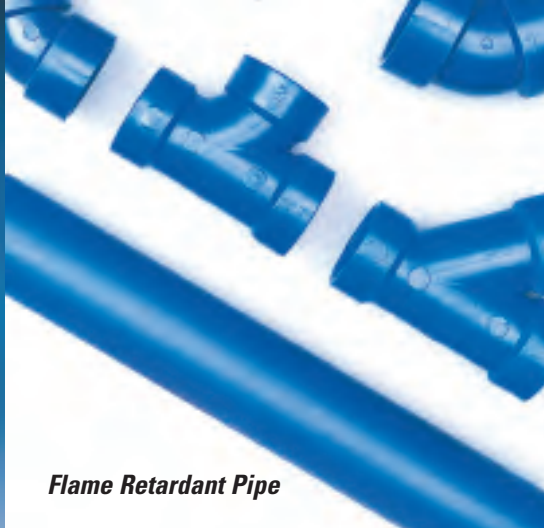
*Molded Fitting*



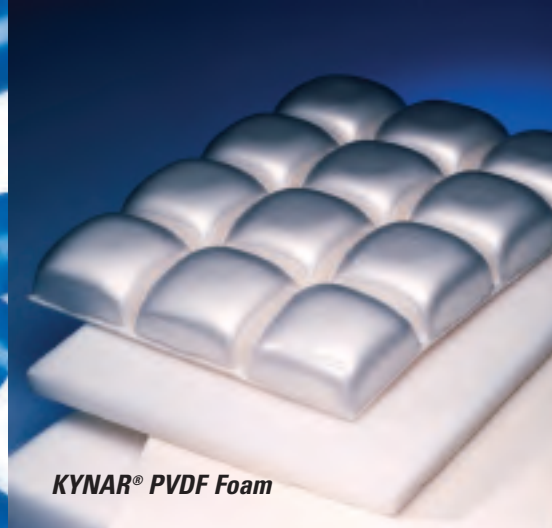
*Plastic-Lined Steel*



*Rotomolded Container*



*Flame Retardant Pipe*



*KYNAR® PVDF Foam*



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The chemical, physical, and toxicological properties of these chemicals may not have been fully investigated. You must use due caution in handling of any such material and follow appropriate, good industrial hygiene and safety precautions to prevent human exposure. Carefully read and understand the information on the Material Safety Data Sheet (MSDS) before beginning work with the materials described in this brochure.

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