

Fisher|Moore

ETHYLENE TETRAFLUOROETHYLENE COPOLYMER TECHNICAL INFORMATION

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Intro

Ethylene Tetrafluoroethylene Copolymer is a fluoropolymer resin developed by Asahi Glass Company of Tokyo Japan.

It is a copolymer comprised of tetrafluoroethylene (C_2F_4) and ethylene (C_2H_4) and has the following basic structure:



ETFE has electrical properties and chemical resistance comparable to those of typical fluoropolymers such as polytetrafluoroethylene (PTFE) and tetrafluoroethylene-hexafluoropropylene (FEP), yet at the same time, is characterized by improved mechanical properties and outstanding processability.

This technical section provides to the best of the knowledge of **Fisher|Moore** data on various characteristics of Asahi ETFE Copolymer Resin formulated for duct coating, the coating of pipes, vessels and other equipment.

Note: All data given herein are measured values, believed to be accurate, but are presented without guarantee, warrantee, or responsibility expressed or implied. This information is provided as a help in evaluating the coating and lining processes of Fisher|Moore and in no way is an endorsement by any fluoropolymer resin supplier.

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Thermal Properties

ETFE used by **Fisher|Moore** is a crystalline thermoplastic with a melting point in the range of 225-270°C. In general, however, it is practical to use ETFE at a continuous service temperature determined by long-term evaluation including change in tensile elongation, which accurately reflects thermal deterioration of the polymer.

1.1 Linear Thermal Expansion Coefficient

The thermal expansion and contraction of polymers is crucial when using polymers as industrial materials or in coatings and linings.

Polymer Coeff. 10 ⁻⁵ /°C	Asahi ETFE	PTFE	PFA	FEP	ECTFE	PVDF	PE	PVC
	11-14	9-11	11-13	8-11	9-11	3-6	11-13	7-12

1.2 Heat Distortion Temperature

The heat distortion temperature represents the temperature at which the test sample bends by 0.254 mm with 4.6 or 18.6 kg/cm² of load applied, and temperature increased at the rate of 2°C/minute. The degree of deformation is only slight, and as a result, the value merely gives a general idea of the polymer's heat resistance.

Polymer	Asahi ETFE	PTFE	PFA	FEP	ECTFE	PVDF	PE	PVC
4.6 kg/cm ²	80	120	70	70	90-115	155	60	65
18.6 kg/cm ²	50	50	50	50	66-76	95	--	--

1.3 Flammability

Although ETFE has ethylene units in the main chain, according to evaluations by UL standard subject 94, it has 94V-0 flammability. Results of ASTM D-165 also show that is not combustible.

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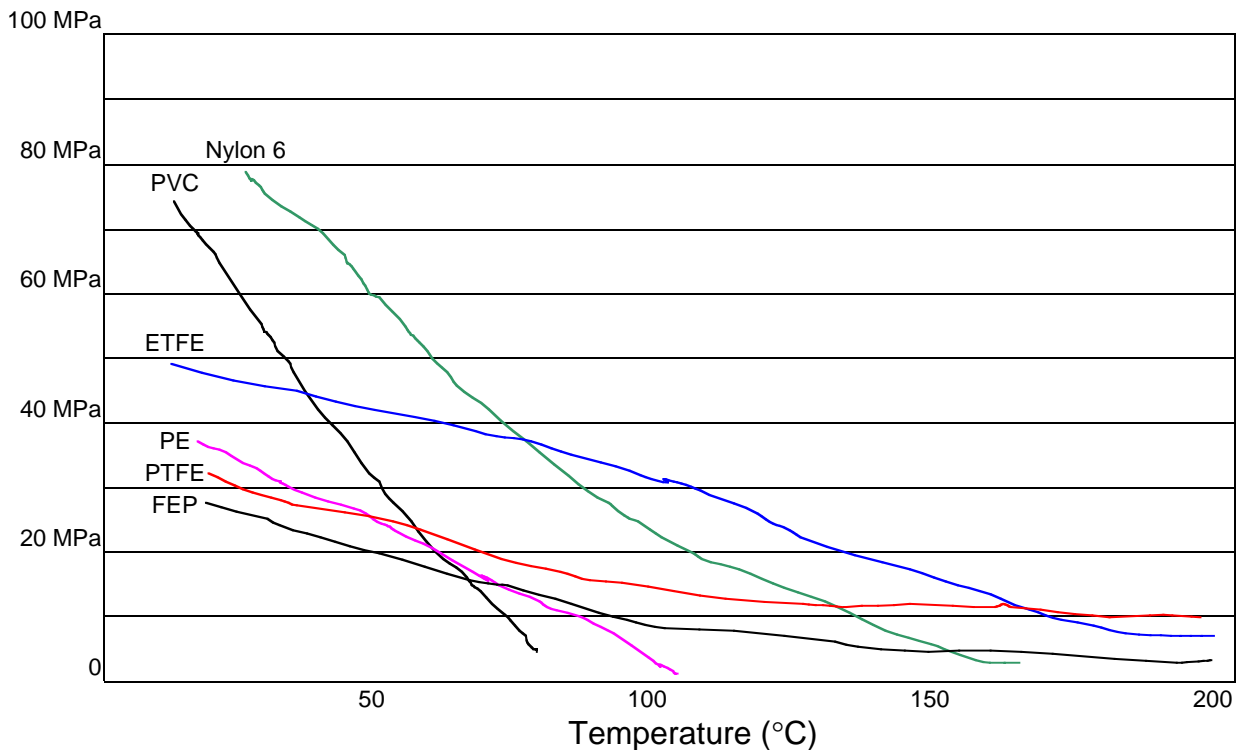
Tensile Properties

ETFE used by **Fisher|Moore** has balanced tensile elongation and strength as well as toughness, ensuring no breakage by impact at room temperature.

2.1 Tensile Properties and Temperature

Chart 1 shows the tensile strength in relation to temperature of ETFE and several other polymers.

Chart 1



Effect on Temperature on Tensile Strength

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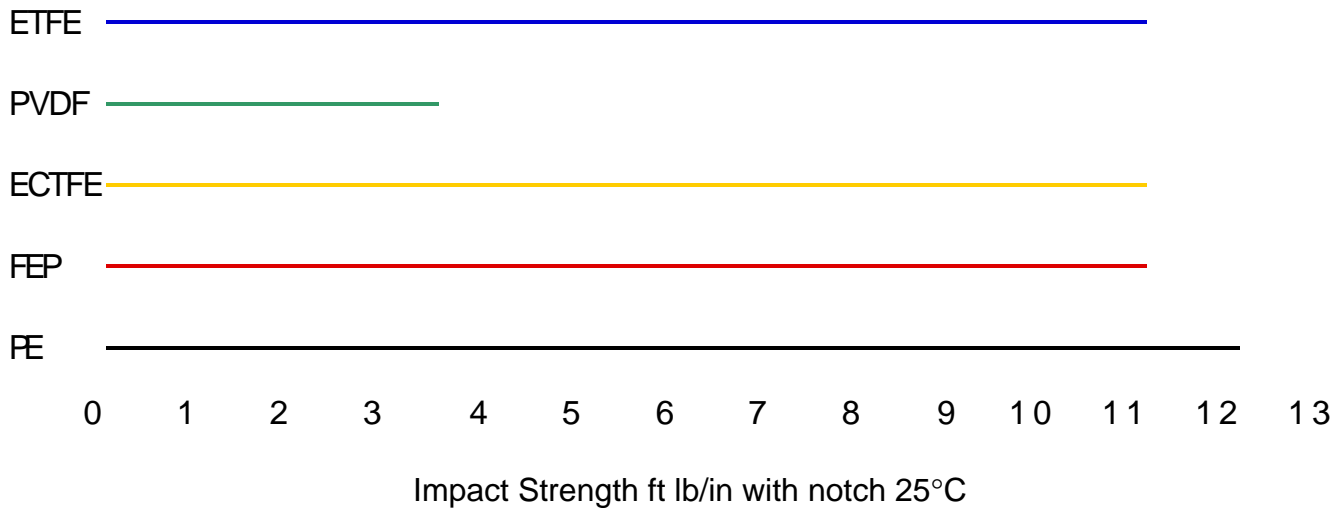
Impact Strength

ETFE resins used by **Fisher|Moore** have an extremely large capacity for absorbing impact energy and maintains excellent impact resistance over a wide range of temperatures even in impact tests with a notch. The test method is the IZOD impact test, ASTM D256. See figure 2.

3.1 Impact Strength

ETFE resins used by **Fisher|Moore** also offer significant resistance to impact at low temperatures. No impact breakage occurs down to -80°C.

Figure 2



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Surface Hardness

Rockwell Hardness measured according to ASTM D785, represented on the R scale for several polymers.

Polymer	Asahi ETFE	PTFE	PFA	FEP	ECTFE	PVDF	PP
Hardness	46	20	50	25	93	110	85

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Mechanical Properties

The ETFE used by **Fisher|Moore** retains the characteristics of the best fluoropolymers but has been improved to overcome the deficiencies found in other ETFE resins in the industry.

Quality control and resin consistency are never disclosed in the manufacturer's published literature. The biggest obstacle experienced by our company during the past decade has been the lack of consistency with some types of fluoropolymer resins.

The ETFE supplied to us by Asahi Glass has proven itself to be superior to other resins we have evaluated and used.

5.1 Mechanical Properties

(Not to be used for specification purposes)

	ETFE	PTFE	PFA	ECTFE	PVDF	PE	PVC (Hard)	NYLON 6	ASTM
Specific Gravity	1.73-1.75	2.1-2.2	2.1-2.2	1.68	1.76-1.77	0.92-0.96	1.3-1.4	1.10-1.14	D792
Tensile Strength (Mpa)	44-54	20-39	32-39	29-32	49-60	Oct-44	40-70	50-80	D638
Percent Elongation (%)	400-450	230-600	340-400	100-200	200-300	20-700	Feb-40	60	D638

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Chemical Resistance of ETFE

ETFE is stable against most chemicals and has resistance to high pH as well as low pH environments. It possesses excellent surface smoothness with an Ra of 2. The smoothness and surface properties provide better resistance to permeation than other types of ETFE and fluoropolymer resins. Resistance to build up biofilms and precipitates is superior to all other fluoropolymers.

6.1 Chemical Resistance

Table 1 shows the various effects of common chemicals upon ETFE. ETFE is affected to some degree by strong oxidizing acids, such as concentrated nitric acid, organic amines and sulfuric acid at high temperature. ETFE has excellent chemical resistance to other inorganic acids and bases and organic solvents. Table 1 also shows the results obtained by using microtensile specimens of 1mm thickness. However, **Fisher|Moore** recommends actual field testing and sample evaluation to determine ultimate suitability. The responsibility for selection of ETFE for a coating and lining material is the customer's alone. This information is provided as a guide for comparison properties alone to other published information.

Such factors as permeability and adhesion are not included in this table since that data is not available at present. Chemical attack and resistance are complex phenomena and are not easily summarized into any simple data sheet or table.

The effect of synergism of various chemical reagents and mixtures is well beyond the scope of this or any simple chart of chemical resistance data. The following information represents the best information available to **Fisher|Moore** and should be used as a guide only.

Table 1

Chemical Categories	Chemical		Temp (°F)	Days	Retention (%)	
					Elongation	Weight Gain
Alkalis	Sodium Hydroxide	10%	120	10	97	0.0
		50%	120	10	100	-0.3
	Potassium Hydroxide	20%	100	10	100	0.0
	Ammonium Hydroxide	15%	66	10	98	0.1
Inorganic Acids	Hydrochloric	35%	100	10	100	0.0
	Sulfuric	78%	121	10	100	0.1
		98%	121	10	100	0.0
	Oleum		25	10	96	1.3
	Nitric	25%	100	14	100	--
		70%	60	10	100	--
		70%	120	7	10	--
	Fuming Nitric		25	10	92	0.6
	Hydrofluoric		25	7	95	0.1
	Phosphoric	30%	100	10	97	-0.4
		85%	121	10	92	0.4
	Chromic	50%	100	10	98	0.3
Other Inorganics Compounds	Chlorine		90	10	94	--
			120	7	85	7.0
			150	10	41	--
	Bromine		60	7	100	0.1
	Hydrogen Peroxide		25	7	100	0.1
	Water		100	7	100	0.0
	Phosphorus Trichloride		75	7	99	--
	Phosphorus Oxychloride		100	7	99	--
	Silicon Tetrachloride		55	7	100	--
	Sulfuric Chloride		70	7	100	--
	Carbon Disulfide		100	30	98	1.0
	Ferric Disulfide	25%	70	7	100	6.0
	Amines	Aniline		25	11	98
120				30	82	1.6
Pyridine		116	11	100	3.8	
Triethylamine		90	11	90	1.5	
Dimethylformamid		25	11	100	0.4	
		120	11	95	2.7	
Dimethylacetamide		121	7	98	3.6	
Aromatic Compounds	Phenol		100	11	100	0.3
	Benzaldehyde		120	11	94	2.3
	Chlorobenzene		25	11	87	0.4
	Nitrobenzene		25	11	98	0.2
	Benzene		80	11	95	2.6
	Toluene		111	11	100	2.6
	Xylene		120	11	80	1.7
	Cresol		120	11	80	1.7
Chlorine Compounds	Chloroform		25	11	100	1.6
	Methylene Chloride		40	11	100	3.9
	Trichloroethylene		87	11	100	4.8
	Perchloroethylene		77	11	100	5.5

Chemical Categories	Chemical	Temp (°F)	Days	Retention (%)	
				Elongation	Weight Gain
Chlorine Compounds (continued)	Ethylene Dichloride	84	11	88	3.8
	Freon 113	47	11	--	3.8
	Epichlorohydrin	117	11	78	3.7
	Benzoyl Chloride	120	30	100	0.0
Ethers	Propylene Oxide	25	11	82	3.2
	Tetrahydrofuran	25	11	98	2.3
	Dioxane	105	11	86	6.0
	Ethylether	25	11	87	1.0
	Cellosolve	121	11	88	1.3
Ketones	Acetone	25	11	97	2.3
	Methylethylketone	25	11	100	1.6
	Methylisobutylketone	25	11	--	0.3
	Acetophenone	121	11	80	2.5
	Cyclohexanone	121	11	72	5.2
Organic Acids	Glacial Acetic Acid	25	11	87	0.7
	Oxalic Acid	120	11	100	0.1
	Citric Acid	120	11	87	0.1
	Stearic Acid	120	11	83	0.1
	Formic Acid	100	11	100	0.1
	Glycolic Acid	120	11	98	0.0
	Chloroacetic Acid	100	11	100	0.6
	Trichloroacetic Acid	100	11	84	2.5
	Phthalic Acid	120	11	100	0.1
	Lactic Acid	119	11	98	0.1
Esters	Ethyl Acetate	25	11	100	2.3
	Butyl Acetate	120	11	88	3.5
	Dimethyl Phthalate	120	11	87	0.4
Alcohols	Methanol	78	11	98	0.3
	Ethanol	78	11	98	0.6
	Cyclohexanol	120	11	88	1.2
	Benzyl Alcohol	120	11	93	0.7
	Propyl Alcohol	97	11	93	0.7
	Diacetone Alcohol	120	11	91	2.8
Other Hydrocarbons	Hexane	69	11	84	1.1
	Mineral Oil	120	11	96	0.2
	Octane	120	11	98	0.2
	Cyclohexane	81	11	94	1.4
	Dimethylsulfoxide	120	11	89	1.5

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FDA and Pharmaceutical Applications

Table 2

USP PHYSIOCHEMICAL TESTS
ESFDA (21 CFR PART 58) USEPA (40CFR PART 160)

ETFE 1020

Test	RESULT	MAXIMUM LIMIT
Heavy Metals	1.0 ppm	1.0 ppm
Buffering Capacity	0.1 ml NaOH	10ml Titrant
Nonvolatile Residue	0.1 mg	15 mg
Residue on Ignition	Waive Pass*	5 mg

*The term "Waive Pass" is assigned with the nonvolatile residue is less than 5mg, indicating the residue on ignition will be less than 5mg.

7.1 USP Class VI

ETFE is thermally stable. Furthermore, no thermal stabilizers are added or required unlike other fluoropolymer resin systems that may have up to 1.5% by weight of compounds that can be extracted and detected in high purity environments.

An ETFE resin specially formulated and tested for fisher|moore has passed all of the requirements of USP Class VI. This resin is designated as ETFE 1020™.

The results of toxicity and extraction tests performed by D&R Testing Institute, Spencerville, Ohio, according to FDA guidelines showed no toxicity and the safety factor to be extremely high.

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Gas and Moisture Permeation

Table 3

Table 4

GAS	PERMEABILITY*	MOISTURE PERMEABILITY*
Oxygen	6.1	1.3
Nitrogen	2.3	*Permeability @23°C 0-90 RH% g/m ² 24 hrs 0.1mm
Helium	63	
Carbon Dioxide	25	
Methane	0.8	

*Permeability @23°C 10⁻¹¹
 cm³ (STP)cm/s/cm² cm HG

8.1 Permeation

The permeation of oxygen, nitrogen, carbon dioxide are approximately constant regardless of film thickness. The activation energy is 6-8 kcal/mol. The gas permeation and moisture permeation of ETFE used by fisher|moore is substantially better than other fluorinated polymers and equals polyethylene and polypropylene. Gas permeability was obtained by ASTM D1431 and moisture permeability by the cup method of ASTM E96. These are shown in Tables 3 and 4 respectively.