EVERFLON™ PTFE

Properties Handbook

Polytetrafluoroethylene

EVERFLON ACADEMIC

Introduction

Everflon™ is a registered trademark of the C&F Group for its fluoropolymer resins.Everflon™ PTFE fluoropolymer resins are part of the C&F family of fluorine-based products that also includes Everflon™ FEP,Everflon™ ETFE and Everflon™ PFA fluoropolymer resins and Everflon™ PVDF fluoropolymers.

These materials can be used to make a variety of articles having a combination of mechanical, electrical, chemical, temperature, and friction-resisting properties unmatched by articles made of any other material. Commercial use of these and other valuable properties combined in one material has established Everflon™ PTFE resins as outstanding engineering materials for use in many industrial and military applications. Everflon™ PTFE resins may also be compounded with fillers or reinforcing agents to modify their performance in use.

The design and engineering data presented in this handbook are intended to assist the design engineer in determining where and how Everflon™ PTFE resins may best be used. It is recommended that the design engineer work closely with an experienced fabricator because the method of fabrication may markedly affect not only production costs, but also the properties of the finished article.

Commercially Available Everflon™ PTFE Fluoropolymers

Everflon™ PTFE	Resin Characteristics	Applications
M40 Granular	A resin designed to be molded into shapes	High-performance mechanical/electrical applications requiring excellent end-use performance Skived tapes, films, sheets Machined gaskets, packings, mechanical seals
G401 Granular	A free-flow resin ideal for isostatic molding,Designed for low preform pressure,Improved surface smoothness	Shallow molds Ball valve seats Pipe linings Seals Valves Valve plugs
F100 Fine Powder	Low-reduction ratio;High-pressure resin	Unsintered tape Coaxial cable Low-reduction ratio wire and cable coating
F500 Fine Powder	General-purpose resin;Medium-reduction ratio;Excellent color and clarity;Accepts filter exceptionally well	Electrical tape and sleeving Wire and cable coating Unsupported tube Heat-shrinkable tubing
F1000 Fine Powder	High degree of stress crack resistance	Wire and cable insulation Small tubing
D60 Dispersion	60% Solid content dispersion	Coating
MV1 Micropowder	1 um partical size	Additive to lubrication
MV3 Micropowder	3 um partical size	Additive to ink and coating
MVP Micropowder	9 um partical size	Additive to plastic and elastomer

Typical Properties of Everflon™ PTFE

Property	ASTM Method	Unit	PTFE Granular Resin	PTFE Fine Powder
Tensile Strength, 23 °C	D4894/4895	MPa (psi)	31.0	20.7 min
Elongation, 23 °C	D4894/4895	%	400	200 min.
MIT Flex, 2 kg load	D2176		Did not break at 10^6 cycles	
Flex Modulus, 23 °C	D790	MPa	345–620	275–620
Stretching Void Index	D4895	—	—	15–200+
Impact Strength, Izod	D256	J/m		
–40 °C		—	80	133–267
21 °C		—	106	—
24 °C		—	160	—
77 °C		—	>320	—
204 °C		—	No break	No break
Hardness, Durometer	D2240	Shore D	55	50–65
Coefficient of Linear Thermal Expansion per °C	E228	mm/mm·°C	10×10^{-5}	—
Thermal Conductivity, 4.6 mm		W/m·K	0.25	—
Specific Heat	D4591	kJ/kg·K		
20 °C			1.4	1.5
40 °C			1.2	1.5
150 °C			1.3	1.3
260 °C			1.5	1.4
Thermal Instability Index	D4894/4895		50 max.	50 max.
Deformation Under Load, 23 °C	D621	%		
3.4 MPa			<0.5	<0.5
6.9 MPa			2	2
14 MPa			10	5
Heat Deflection Temperature	D648	°C		
450 kPa			73	140
1800 kPa			45	55
Dielectric Strength, Short Time	D149	kV/mm (V/mil)	24	24
Surface Arc-Resistance	D495	sec	>300	>300
Volume Resistivity	D257	ohm·cm	$>10^{18}$	$>10^{18}$
Surface Resistivity	D257	ohm·sq	$>10^{18}$	—
Dielectric Constant, 60 to 2×10^9 Hz	D150		2.1	2.1
Dissipation Factor, 60 to 2×10^9 Hz	D150		<0.0001	—
Water Absorption, 24 hr	D570	%	<0.01	<0.01
UL 94 Flame Rating			94 V-0	94 V-0
Resistance to Weathering			Excellent	Excellent
Static Coefficient of Friction Against Polished Steel			0.05–0.08	—
Specific Gravity	D4894/4895		2.16	2.1–2.3

Mechanical Properties

Strength and Stiffness

Everflon™ PTFE fluoropolymer resins are engineering materials whose performance in any particular application may bepredicted by calculation in the same manner as for other engineering materials. However, just as properties of woods are different from those of metals, the properties of Everflon™ PTFE fluoropolymer resins are different from those of other engineering materials. From the following data, strength and stiffness values can be selected that, with appropriate safety factors, will allow standard engineering formulas to be used in designing parts.

Compressive Stress

Compression and strain are indicated at three temperatures for Everflon™ PTFE fluoropolymer resins. Stress-strain curves for compression are similar to those for tension at low values of strain.

However, as strain increases, the curves become less similar. Yield points for compression and tension occur at about the same stress values. For compression, the lower strains at higher stress may be a result of analyzing test data on the basis of original cross-sections.

Poisson's Ratio

Poisson's ratio is 0.46 at 23 °C and approaches a limiting value of 0.50 with increasing temperature.

Electrical Properties

Dielectric Constant

The dielectric constant of Everflon™ PTFE fluoropolymer resins shows less change over a wide range of temperatures and frequencies than any other solid material. This value remains essentially constant at 2.1 over the entire frequency spectrum.

Everflon™ PTFE fluoropolymer resin specimens have been heat-aged at 300 °Cfor six months, and then cooled to room temperature for measurement, with no change in dielectric constant. Non-fluoropolymer insulating materials do not show these properties.

Dissipation Factor

The dissipation factor of Everflon™ PTFE fluoropolymer resins remains below 0.0004 over a frequency range up to 10^8 Hz.

The dissipation factor of Everflon™ PTFE fluoropolymer resins remains quite constant. For Everflon™ PTFE fluoropolymer resins at room temperature, it reaches a peak at about 10^9 Hz. This peak value is 0.0004 for Everflon™ PTFE fluoropolymer resins. Theoretical analysis of this phenomenon and spot checks indicate that as temperature increases, the peak will occur at higher frequencies.

Dielectric Strength

The dielectric strength of Everflon™ PTFE fluoropolymer resins is high and does not vary with temperature and thermal aging. Initial dielectric strength is very high (600V/mil for 1.5 mm thickness) as measured by the ASTM short-time test. As with any material, the value drops as thickness of specimen increases.

Life at high dielectric stresses is dependent on corona discharge. The absence of corona, as in special wire constructions, permits very high voltage stress without damage to Everflon™ PTFE fluoropolymer resins. Changes in relative humidity or physical stress imposed upon the material do not diminish life at these voltage stresses.

Chemical Properties

Resistance to Chemical Attack

Everflon™ PTFE fluoropolymer resins are essentially chemically inert. Up to the upper use temperature (260 °C) for Everflon™ PTFE fluoropolymer resins, only very few chemicals are known to chemically react with these resins, i.e., molten alkali metals, turbulent liquid, or gaseous fluorine, and a few fluorochemicals, such as chlorine trifluoride, ClF3, or oxygen difluoride, OF2, which readily liberate free fluorine at elevated temperatures.

The unique degree of inertness of Everflon™ PTFE fluoropolymer resins reflects their chemical structure. Molecules of Everflon™ PTFE fluoropolymer resins are formed simply from strong carbon-carbon and superstrong carbon-fluorine interatomic bonds; moreover, the fluorine atoms form a protective sheath around the carbon core of each molecule. This structure also produces other special properties, such as insolubility and low-surface adherability and friction.

To a minor degree, halogenated organic chemicals may be absorbed by fluoropolymer resins. This will cause a very small weight change and, in some cases, slight swelling. If absorption is very high, it usually indicates a fabricated part of high porosity.

Permeability

Fluoropolymer resins may be permeated to a limited extent by some substances. Permeation rates are generally comparable to those observed for other thermoplastics.

For more detailed data on exposure of Everflon™ PTFE fluoropolymer resins to chemical media, please contact your representative.

Weathering

Parts fabricated of Everflon™ PTFE fluoropolymer resins are virtually unaffected by weather. Conclusive tests on samples exposed for 15 yr to practically all climatic conditions confirm these weather-resistant properties.

Thus, where applications demand the ultimate in dependability under these conditions, these resins are the answer. Resistance to extreme heat, cold, and ultraviolet light encountered in radar and other lectronic components, such as antenna bushings, are excellent examples of the value of this material to the industrial designer.

Thermal Properties

Thermal Expansion

A marked change in volume of 1.0 to 1.8% is evident for Everflon™ PTFE fluoropolymer resins in the transition zone from 18–25 °C. A part that has been machined on either side of this zone will obviously change dimensions if permitted to go through the zone. Thus, final operating temperature of a precision part must be accurately determined.

Measurement on a production basis must allow for this volume change if the transition zone is traversed in either manufacture or operation of the part.

Low Temperature Properties

Parts fabricated of Everflon™ PTFE fluoropolymer resins exhibit high strength, toughness, and self-lubrication at low temperatures. Everflon ™ PTFE fluoropolymer resins are useful from –268 °C and are highly flexible from –79 °C.

Thermal Conductivity and Specific Heat

The average thermal conductivity of Everflon™ PTFE fluoropolymer resin is 1.7 ± 0.3 Btu·in/hr·ft2·°F. The average heat capacity is 0.3 Btu/lb·°F for Everflon™ PTFE fluoropolymer resins. These data were obtained at temperatures ranging from 20–260 °C.

Heat Distortion

Temperatures obtained for heat distortion of Everflon™ PTFE fluoropolymer resins are 122 °C for a stress of 66 psi and 56 °C for a stress of 264 psi(ASTM D648).

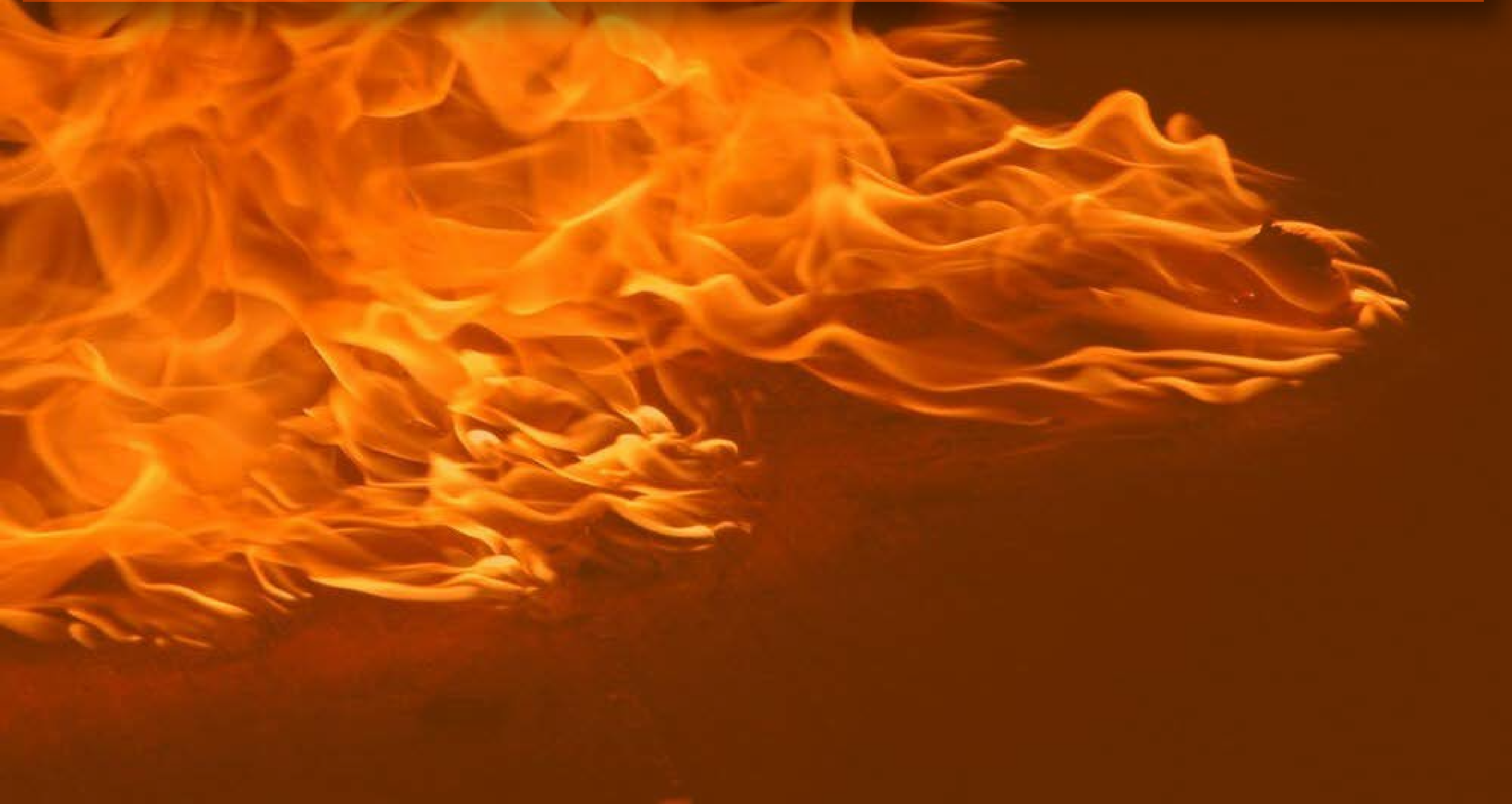
Elastic Memory

Parts made from Everflon™ PTFE fluoropolymer resins tend to return to their original dimensions after a deformation, but the process of recovery may require a long time. A fabricated part that creeps or deforms over a period of time under stress will recover its original shape when stress is removed and the part is raised to sintering temperature. However, partial recovery will occur at lower temperatures. At any given temperature, recovery to be expected at that temperature is substantially complete in 15 min or less, but extent of recovery increases with increased temperature.

Decomposition at Elevated Temperatures

Rate of decomposition of a part of Everflon™ PTFE fluoropolymer resin depends on the particular resin, temperature, heat-exposure time, and, to a lesser extent, pressure and nature of the environment.

For most applications, these decomposition rates are small enough below the maximum service temperature (260 °C for Everflon™ PTFE fluoropolymer resins resins), that no special precautions are necessary.Where temperatures run above 343 °C during fabrication, proper ventilation is required.



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