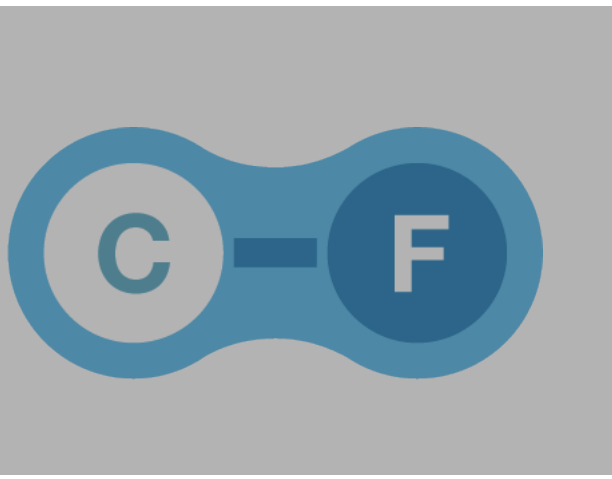
Introduction

Fluoropolymers



EVERFLON
Fluoropolymers

Family

PTFE Fluoropolymers

- Everflon™ PTFE Granule Molding Resins
- Everflon™ Fine PTFE Powders
- Everflon™ Aqueous PTFE Dispersions
- Everflon™ PTFE Fluoroadditives
- Everflon+™ PTFE Composite Resins

Melt Processable Fluoropolymers

- Everflon™ FEP Resins and Dispersions
- Everflon™ PFA Resins and Dispersions
- Everflon™ ETFE Resins
- Everflon+™ Color Fluoropolymers
- Everflon+™ Crosslinked ETFE Resins
- Everflon+™ Fluoropolymer Compound
- Everflon™ Fluoropolymer Foam Resins

Basic information

Polytetrafluoroethylene (PTFE) is produced by the polymerization of tetrafluoroethylene (TFE) monomer, yielding a perfluorinated straight-chain high molecular weight polymer with unique properties.

TFE is polymerized by two different processes, i.e., granular (also called suspension) polymerization and aqueous dispersion (emulsion) polymerization.

In general, PTFE resins are homopolymers of tetrafluoroethylene or, in some special cases, modified homopolymers containing very small amounts (less than 1%) of an additional perfluorinated monomer. Modified homopolymers have special processing and/or enduse characteristics while maintaining the outstanding properties of PTFE.

Many of the unique properties can be explained by the molecular structure of PTFE The carbon-carbon bonds, which form the backbone of the polymer chain, and the carbon-fluorine bonds are extremely strong. The fluorine atoms form a regular, protective sheath over the chain of carbon atoms; this sheath protects the polymer molecule from chemical attack. It also reduces the surface energy, resulting in a low coefficient of friction and non-stick properties.

In order to achieve the desired properties such as toughness and green strength, very high molecular weight is needed (in range of 106 or 107), resulting in an extremely high melt viscosity (1–100 GPa·sec or 1010–1012 P). The material will not flow above its crystalline melting point. Consequently, PTFE could not be fabricated by conventional thermoplastic techniques.

High molecular weight polytetrafluoroethylene is manufactured and sold by Everflon in three main types: granular molding powder, fine powder, and aqueous dispersion, each requiring different fabrication techniques.

Furthermore, each of the three main types is subdivided into a number of grades to suit various end uses more precisely.

Everflon™ PTFE Granular Molding Resins

PTFE granular resins (also called molding powders) are manufactured in a variety of grades to obtain a different balance between handleability and end-use properties.

Granular resins are processed in general by compression molding at ambient temperature, followed by sintering above the crystalline melting point.

Everflon™ PTFE Fine Powders

PTFE fine powders are made by coagulation of PTFE aqueous dispersion. Various grades are available corresponding to specific applications and methods of fabrication and differ in molecular weight and structure.

Fine powders are processed in general by the so-called “paste extrusion” technique; whereby, the powder is first blended with an extrusion aid (lubricant). This wetted powder (paste) is then extruded through a die at ambient temperature; after this formative stage, the lubricant is removed and then the extrudate is sintered above the crystalline melting point. This provides a practical method for producing long lengths of product from a resin that cannot be melt-extruded. PTFE fine powders have the characteristic property that the primary dispersion particles under the effect of shear form fibrils. It is this network of fibrils that gives the useful structural integrity to the extrudate and allows the manufacture of end products with unique performance.

In the case of PTFE fine powder used as an additive, the fibrillation properties are important for drip suppression in thermoplastics.

Everflon™ PTFE Aqueous Dispersions

PTFE aqueous dispersions are milky white dispersions of PTFE particles suspended in aqueous medium, stabilized by wetting agents. The dispersion typically contains 30–60 wt% polymer particles and some surfactant.The PTFE particle characteristics and surfactant type depend on the application. They can be further formulated to meet specific needs by adding other solid or liquid ingredients.

PTFE aqueous dispersions are applied to substrates by spraying, dipping or impregnation. After applying the dispersion on the substrate, the water and surfactants are removed by evaporation and the PTFE is sintered. The substrate needs to be resistant to the typical sintering temperatures of PTFE.

In special cases, such as impregnated packing, the PTFE is left unsintered to maintain flexibility.

PTFE aqueous dispersion can also be used as an additive in thermoplastics (as drip suppressant) or in dusty products to eliminate dust. As with PTFE fine powders, aqueous dispersion particles also fibrillate under shear, and these PTFE fibrils form a web within the host material that holds the dust or avoids the dripping of burning droplets in case of a fire.

Everflon™ PTFE Fluoroadditives

PTFE fluoroadditives are finely divided, freeflowing white powder of PTFE resin. They are a separate and distinctive product line, very different from the wellknown Everflon™ PTFE molding and extrusion powders.

The differences include:

- Lower molecular weight (in range of 2.5 x 10^4 to 25 x 10^4)
- Smaller particles sizes (2–20 µm)
- Different particle shapes and morphology

Everflon™ PTFE fluoroadditives are designed primarily for use as minority components in mixtures with other solid or liquid materials. Even in small quantities, they can impart some of the unique properties of PTFE to various hosts, such as reduced coefficient of friction and mechanical wear, and enhanced abrasion resistance. The product range offers a choice of particle size and morphology to facilitate intimate mixing with dissimilar materials.

Everflon™ Meltable Fluoropolymers

Everflon™ FEP Resins

FEP (perfluorinated ethylene-propylene) resin is a copolymer of TFE and hexafluoropropylene (HFP). It retains most of the desirable characteristics of PTFE, but with a melt viscosity low enough for conventional melt processing.The melting point of FEP is about 260 °C (500 °F) versus a first melting point of PTFE of about 340 °C (644 °F). Continuous service temperature of FEP is 205 °C (401 °F) as compared to 260 °C (500 °F) for PTFE.

FEP resins are available in various grades to meet a variety of processing and end-use requirements. The different grades of FEP vary primarily in molecular weight, while they all provide equivalent temperature rating (205 °C [401 °F]), electrical performance, and chemical resistance. As the molecular weight and, hence, melt viscosity increases, so does the mechanical performance and the resistance to stress cracking; however, these improvements occur at the expense of processing ease and mainly of processing speed. Modified grades are available that offer an improved combination of stress crack resistance and processing speed.

FEP is also available in aqueous dispersion form for coating and impregnation purposes.

Everflon™ ETFE Resins

Everflon™ ETFE resin is a modified copolymer of TFE and ethylene. ETFE is melt-processable and mechanically tougher and stiffer with higher cut-through, abrasion, and creep resistance than PTFE, FEP or PFA resins.

The chemical, dielectric, and thermal properties approach those of the fully fluorinated Everflon™ PTFE, FEP, PFA types, albeit that ETFE is affected to varying degrees by strong oxidizing acids, organic bases (such as amines), and sulfonic acids at high concentrations and near their boiling point. Its other main features include ease of processing, lower density (1.7) than Everflon™ FEP,PFA and PTFE, and improved radiation resistance.

Everflon™ ETFE is suitable for continuous service up to 155 °C (311 °F) based on the standard 20,000 hr criterion.

Everflon™ PFA Resins

Everflon™ PFA resin is a copolymer of TFE and perfluorovinyl ether. PFA is melt-processable with a melting point at about 305 °C (581 °F). Continuous service temperature is equal to that of PTFE, i.e., 260 °C (500 °F).

Everflon™ PFA offers the excellent combination of properties characteristic of Everflon™ fluoropolymers: non-aging, chemical inertness, exceptional dielectric properties, toughness and flexibility, low coefficient of friction, nonstick characteristics, negligible moisture absorption, and excellent weather and UV resistance.

Everflon™ PFA C offers electrical conductivity to dissipate static electricity.

Everflon™ PFA is also available in aqueous dispersion form for coating and impregnation purposes.

The Perfect Solution for Your Design Needs

Problem	Solution:Everflon Fluoropolymers
Adhesion, Release	Extremely low surface energy in the solid state; thus, providing an excellent anti-stick, non-wetting contact surface. Conversely, when these resins are in a molten state, they become low surface-tension liquids—ideal for high-performance, hot-melt adhesives.
Atmospheric Aging	Extremely resistant to oxidation, surface fouling, discoloration, UV, and embrittlement, as proven by tests conducted in Florida for periods of up to 20 years.
Biodegradation	Inert to enzymic and microbiological attack because the pure polymer does not provide nourishment or porosity for these growths.
Contamination	Except for specialized grades, Everflon fluoropolymers are chemically inert and pure. They generally contain no additives (plasticizers, stabilizers, lubricants, or antioxidants) that could contaminate process fluids.
Corrosion	Resistance to even the most aggressive organic and inorganic chemicals and solvents over a broad temperature range.
Dielectric Instability	High dielectric strength, low dielectric constant, low loss factors, and extremely high specific resistance. Everflon fluoropolymers surpass most materials in their level and stability of dielectric properties over a broad range of environmental conditions.
Flammability	Remarkable resistance to high temperature and flames because of very high melting points and auto-ignition temperatures, as well as exceptional thermal degradation thresholds. Flame propagation characteristics, such as rate of heat release and smoke generation, are very low.
Friction and Wear	One of the lowest coefficients of friction of any solid material. Abrasion resistance is adaptable to demanding environments by using inorganic fillers, such as glass fiber, graphite, and powdered metals.
Heat	Property retention after exposure to temperatures beyond the limit of almost all other thermoplastics and elastomers. Depending on the end-use requirements, these resins are often rated for continuous service at temperatures as high as 260 °C (500 °F). In certain cases,they can also withstand short excursions to higher temperatures.
Humidity	Extremely hydrophobic and completely resistant to hydrolysis. Good barriers to water permeation; typical properties and dimensional stability remain unchanged, even after year-long immersion in water.
Light Instability	One of the lowest refractive indexes. Visual appearance does not change after expoure to light ranging from ultraviolet to infrared.
Low Temperature	Excellent property retention, even at cryogenic temperatures. In addition, resistance at these temperatures exceeds that of most other polymers.
Service Life	Outstanding retention of properties after aging, even at high temperatures and in the presence of solvents, oils, oxidizing agents, ultraviolet light, and other environmental agents. Because they do not use any leachable or degradable stabilizing additives, Everflon fluoropolymers offer an important safety advantage when designing products for long service life.

Properties of Everflon™ Fluoropolymers

Chemical Inertness/Solvent Resistance

Fully fluorinated fluoropolymers (PTFE, FEP, and PFA) are virtually inert to the most aggressive organic and inorganic chemicals and solvents over a wide temperature range.

Chemical inertness means that Everflon™ fully fluorinated fluoropolymers can be in continuous contact with another substance with no detectable chemical reaction or degradation taking place. Among others, they are resistant to fuming sulfuric and nitric acids, bases, aggressive peroxides, antioxidants (as used in high temperature oils), and methanol (as used in fuel).

This nearly universal chemical compatibility stems from three causes:

- Very strong interatomic bonds between carbon-carbon and carbon-fluorine atoms
- Almost perfect shielding of the polymer's carbon backbone by fluorine atoms
- Very high molecular weight (or long polymer chain length) compared to many other polymers

Within normal use temperatures, Everflon™ resins are chemically attacked by so few chemicals, that it is more practical to describe the exceptions rather than to tabulate the chemicals with which they are compatible.

The only materials known to react with fluoropolymers are:

- Elemental alkali metals like sodium, potassium, and lithium (molten or in solution)
- Intimate blends of finely divided metal powders (e.g., aluminum or magnesium) with powdered fluoropolymers can react violently when ignited, but ignition temperatures are far above the published recommended maximum service temperature for fluoropolymers
- Extremely potent oxidizers, fluorine (F2) and related compounds like chlorine trifluoride (ClF3)
- 80% NaOH or KOH solutions at or near the upper service temperature

Organic solvents do not attack or dissolve fluoropolymers, although some permeation may occur as a result of both absorption and diffusion.

Similar to the fully fluorinated polymers, Everflon™ ETFE has outstanding resistance to attack by chemicals and solvents that often cause rapid deterioration of other plastic materials. Strong oxidizing acids, organic bases, and sulfonic acids at high concentrations and near their boiling point may affect Everflon ™ ETFE resin.

Mechanical Properties

Tensile strength properties over a wide temperature range are shown in Figure measured on grades representative of the different fluoropolymer families.

Everflon™ ETFE is tougher than fully fluorinated fluoropolymer grades at low and ambient temperatures. At higher temperatures, the lines converge and above 120 °C (248 °F), PTFE and PFA have higher tensile strength than both ETFE and FEP.

Flex fatigue resistance is an important property for parts subjected to repeated stress. It correlates well with the stress-crack resistance of a material. Fatigue resistance and, therefore, stress-crack resistance of a part can vary by magnitudes depending on the resin grade used, processing conditions, and in-use stress level. Molecular weight, composition, crystallinity, and void content are the main parameters influencing flex fatigue resistance. PTFE in general and Everflon™ fluoropolymer in particular have the highest flex fatigue life among all fluoropolymers and are, therefore, very well suited for applications with alternating and/or long-term stresses.

Creep and cold flow occurs when a material is subjected to a continuous load. With most plastics, however, deformation can be significant even at room temperature or below; thus, the name “cold flow”.

Everflon™ ETFE, being a tougher material than Everflon™ PTFE, FEP or PFA, is more creep resistant than Everflon™ fluoropolymers.

The modified grades of granular PTFE have been developed among others to improve the deformation under load. Also the use of a small percentage of filler reduces the deformation under load substantially. For instance, glass fiber reinforced with Everflon™ resin has only 1/5 of the deformation under load of an unreinforced ETFE.

Friction and Anti-Stick Properties

PTFE has an extremely low coefficient of friction. Values of 0.02 have been reported.The lowest values are obtained under condition of high pressure (>3 MPa) and low velocity (<0.1 m/min).
Due to its very low surface energy (18.5 mN/m), PTFE has excellent anti-stick properties.

Dielectric Properties

Everflon™ PTFE, FEP, and PFA fluoropolymers have unique electrical properties: a very low dielectric constant (relative permittivity) of 2.1 over a wide frequency range from 100 Hz to 50 GHz. It is important to note that the velocity of propagation of a signal down the length of cable is directly influenced by the dielectric constant and dissipation factor of the insulation material. The lower the dielectric constant, the higher the velocity. The dielectric constant can be decreased by reducing the density of the insulation. Techniques have been developed to lower the dielectric constant and dissipation factor of the dielectric material by creating voids; thereby, allowing data cables to have lower capacitance, lower attenuation, lower dielectric heating, and higher velocity of propagation.

The dissipation factor is affected by signal frequency, operating temperature, and chemical composition, crystallinity, and void content of the insulation. At room temperature, the dissipation factor of Everflon™ PTFE remains very low at less than 0.0002 for a frequency range of 100 Hz to 10 MHz; the dissipation factor makes a peak between 100 MHz and 20 GHz(108 – 20 x 109 Hz) when tested at room temperature. The peak dissipation factor is around 0.0003. PFA peaks at 0.0010 between 1 GHz and 20 GHz. For FEP, the dissipation factor increases slowly from less than 0.0001 at 1 kHz to 0.0006 at 30 MHz and peaks out at 0.0010 between 1 GHz and 5 GHz.

Everflon™ ETFE has a dielectric constant of 2.6 and dissipation factor of 0.0006 at low frequency (<100 Hz) increasing to 0.0200 at 100 MHz. There is no measurable effect of humidity on the dielectric constant and dissipation factor of ETFE.

The dielectric strength (tested in oil) of Everflon™ is high and unaffected by thermal aging at temperatures up to 200 °C (392 °F). Service life at high dielectric stress is dependent on corona discharge.

Volume resistivity is above 1016 Ω.m (for ETFE, above 1014 Ω.m). Resistivity is not affected by heat aging nor temperatures up to recommended service limits. For applications where tribocharging (electrostatic charge) may occur, special grades exist that dissipate static electricity.

Surface arc resistance of Everflon™ resins is high and is not affected by heat aging. When Everflon™ resins are subjected to a surface arc in air, they do not track or form a carbonized conducting path. When tested by the procedure of ASTM D495, Everflon™ PTFE and FEP resins pass the maximum time of 300 sec without failure.

No tracking was observed with PFA for the duration of the test (test was stopped after 180 sec without any sign of tracking).

Everflon™ ETFE has a dry arc resistance of about 70 sec.

Weather/UV Resistance

Everflon™ fluoropolymers are extremely hydrophobic and shed water almost totally. A moisture absorption of <0.03% has been reported after 24 hr in water at room temperature, followed by 2 hr in boiling water. They are also virtually unaffected by oxygen, ozone, and visible or UV light.

Test samples, exposed for many years to practically all climatic conditions, have shown that Everflon™ PTFE, FEP, and PFA and ETFE fluoropolymers are fully weather-resistant. Results show neither aging nor embrittlement. Because no plasticizers, anti-oxidants or other additives are used during its processing, there is no leaching out of substances.

Temperature Resistance (–200 °C [–328 °F] Up to260 °C [500 °F])

Everflon™ fluoropolymers are extremely stable at high temperatures; PTFE and PFA can be used continuously at 260 °C (500 °F), FEP at 205 °C (401 °F), and ETFE at 155 °C (311 °F).

At those temperatures, at least 50% of their respective and original mechanical properties are retained after 20,000 hr (according to ISO 2578 and IEC 60216). At cryogenic temperatures, these products retain a measure of toughness and strength. PTFE has been used safely in outer space at temperatures approaching absolute zero.

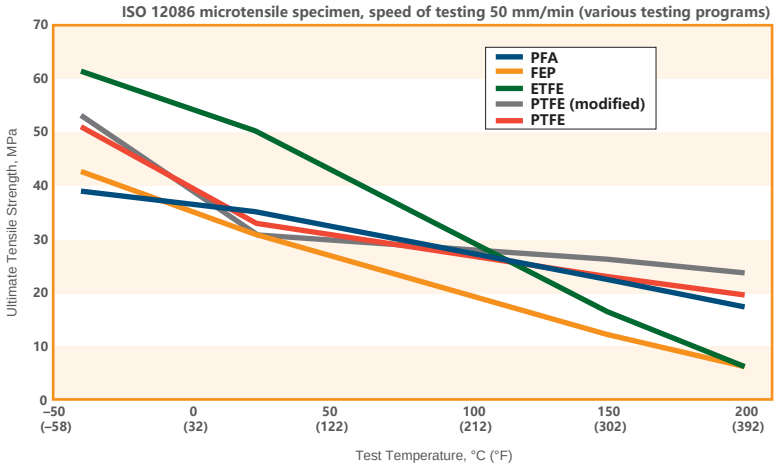
Flammability

Everflon™ PTFE, FEP, and PFA are essentially nonflammable. They will sustain combustion only in an environment containing >95% oxygen (oxygen index). The flash point is 530 °C (986 °F). Everrflon™ ETFE has an oxygen index of 30. PTFE, FEP, PFA, and ETFE are rated by UL. as Flame Class UL 94V-0.Heat of combustion is extremely low at 5 kJ/g (for ETFE 12.5 kJ/g); this provides an additional safety advantage as the “fuel-load” or the energy contained in the material that could be released in a fire event is very low. For comparison, the heat of combustion of polyethylene is 46 kJ/g; therefore, PE will generate more heat in a fire situation and will propagate a fire contrary to fluoropolymers (which are self-extinguishing).

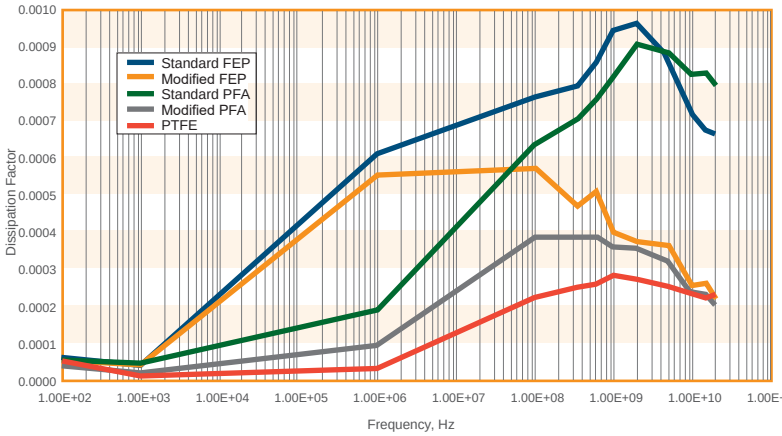
Flame propagation and rate of heat release of fluoropolymers are low. When exposed to flame, they burn but do not continue to burn when the flame is removed.Flame rating according to ASTM D635 is average time of burning (ATB) <5 sec and average extent of burning (AEB) <10 mm.

These properties make fluoropolymers in particular useful in applications where fire hazards must be kept to a minimum.

Tensile Strength as a Function of Temperature



Dielectric Properties of Fluoropolymers



Everflon™ PTFE Granular Molding Resins

Everflon™ Granular PTFE molding resin is made by polymerizing TFE in an aqueous medium (so-called suspension polymerization). In the case of Modified Granular PTFE, trace amounts of fluorinated comonomers are incorporated. The Modified Granular PTFE resins offer the superior properties typical of the fluoropolymer resins; but, in addition, these resins offer weldability, improved resistance to deformation under load, increased permeation resistance, and a higher dielectric breakdown voltage.

After polymerization, the high molecular weight raw polymer is then ground to small particle sizes. These finely divided particles allow for molding of parts essentially free of voids with high properties and are most appropriate for uniform mixing with fillers. On the other hand, the small particles have more tendency to stick together, resulting in poor handleability. A balance between handleability and moldability is achieved by agglomerating (pelletizing) the finely divided resin. Various resin grades with different degrees of pelletization are available, each with its specific set of flow, fill density, and physical properties.

Grades of Everflon™ PTFE Granular Molding Resins

Basic Grades	Main Characteristics	Major Uses
Finely divided resin (fine cut) Everflon PTFE M40	Non-free flowing, medium fill density, high property resin, low preform pressure	Compounding, high quality skived tape billets
Mildly pelletized resin Everflon PTFE M120	Moderate flow, high fill density, high property resin, medium preform pressure	High quality skived tape billets, compression and isostatic molding sheet molding, bearing pads
Free-flowing resin (pelletized) Everflon PTFE G401	Free-flowing, very high fill density, high preform pressure	Automatic molding, compression molding, ram extrusion at low back-pressure
Modified Grades	**Main Characteristics**	**Major Uses**
Modified, finely divided resin Everflon+ PTFE Compound	Non-free flowing, medium fill density, high property resin, low preform pressure	Compounding, high quality skived tape billets, sheet, molding
Modified, free-flowing resin (pelletized) Everflon+ PTFE Compound	Free-flowing, high fill density, high perform pressure	Compression and isostatic molding sheet molding, bearing pads

Processing

Due to the extremely high viscosity above its melting point, PTFE can not be processed using normal thermoplastic techniques. PTFE granular molding resins are processed by modified powder metallurgy techniques.

In this technique, commonly known as compression molding, the dry powder is compressed into a handleable form (preform) at ambient temperature. Depending on the grade, different preforming pressures are recommended to achieve optimum properties. After compression, the preform is then removed from the mold and heated above the melting point (sintering). This coalesces the PTFE particles into a strong homogeneous structure; cooling at a controlled rate achieves the desired degree of crystallinity.

Compression molding can be divided into:

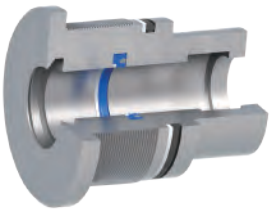
- General compression molding
- Sheet molding
- Big billet molding
- Automatic molding
- Isostatic molding

Ram extrusion is a way of manufacturing continuous length of rods, tubes or profile by feeding successive charges of PTFE powder to a die tube, where a reciprocating ram compacts the powder. Subsequent charges are then compressed onto each other and forced by the ram through the die tube that is heated above the melting point of PTFE, where the PTFE particles and the individual charges are sintered together.

Typical Applications

- Gaskets, seals, valve seats, bellows, diaphragms
- Piston rings, hydraulic seals

- Corrosion resistant linings
- Bearing pads
- Brake pad sensors, oxygen sensor seals
- High-tension circuit breakers, commutator rings



- Printed wiring boards
- Laboratory equipment, beakers

- Iron sole plates
- Ski binders

Everflon™ PTFE Fine Powders

Everflon™ PTFE fine powders are made by polymerizing TFE in an aqueous medium (sometimes called emulsion polymerization). The primary PTFE dispersion particles thus formed have an average particle size of 0.2 µm.This raw dispersion is coagulated into 350–650 µm agglomerates. The agglomerates are then dried gently, avoiding any shearing.

This “spongy” agglomerate has a very high specific surface area (>10 m2/g) and can absorb low surface tension liquids (lubricants). A unique property of PTFE fine powders is that under the effect of shearing, the particles become oriented in the shearing direction and are drawn into long thin fibers. This effect, called fibrillation, is used in the “paste extrusion” process; whereby, the coherent fibrous matrix thus formed gives structural integrity to the extrudate (green strength) before it is sintered.

The various grades of fine powders differ in molecular weight and molecular structure, extrusion pressure, and reduction ratio capability and are chosen primarily on the basis of available processing equipment and end-use requirements.

Grades of Everflon™ PTFE Fine Powders

Final Product	Processing Capability	Major Uses
Wire and Cable	High reduction ratio (1500:1–5000:1) Everflon PTFE F2000	Hook-up wire, automotive wiring
	Medium reduction ratio (300:1–2000:1) Everflon PTFE F1000	Heating cable, appliance wiring
	Low reduction ratio (<100:1–300:1) Everflon PTFE F500	Coaxial cables, electrical grade tape
Hose and Tubing	High reduction ratio (>1000:1) Everflon PTFE F1000	Spaghetti tubing, catheter
	Low/medium reduction ratio (<100:1–1000:1) Everflon PTFE F500	Unsupported industrial tubing, catheter, convoluted tubing,heat-shrinkable tubing
	High performance, high flex. life Everflon PTFE F500S	Aircraft hose, generator hose, automotive tubing, bellows
Lined Pipe and Fittings	Large diameter (>250 mm), low reduction ratio Everflon PTFE 500	Pipe liners, column liners
	Small to medium diameter (<250 mm) Everflon PTFE F1000	Pipe liners, fittings, bellows
Unsintered Products	Low reduction ratio (20:1–100:1) Everflon PTFE 100	Thread seal tape, cords, gaskets

Processing

Everflon™ Fine powders are processed by the so-called paste extrusion process. In this process, the powder is firstmixed with a lubricant (typically a liquid hydrocarbon) under controlled temperature conditions; pigments and/ or fillers can also be incorporated at this stage. After mixing, the blend is conditioned for some time to allow for complete and uniform absorption of the lubricant by the resin particles. This mixture is then compacted at low pressure into a preform that is afterwards loaded into the cylinder of a paste extruder. The lubricated resin is then pressed with a piston through a tooling or shaped orifice to form a coating on a wire, tubing, beading, or ribbon.

The shear stress exerted on the lubricated resin during extrusion confers strength to the extrudate by fibrillation. After extrusion, the lubricant is completely removed (green strength) by evaporation, and the extrudate is sintered—sometimes followed by further post-forming operations. Note that in some applications, the extrudate is left unsintered (e.g., thread sealant tape, sealing cord).

Typical Applications

- Automotive sensor wires
- Coaxial cables for radio frequency
- Seat heating wiring
- Appliance wiring
- Aircraft wiring
- Wire conduits
- Chemical transfer hose and tubing
- Convoluted tubing
- Tubing, small diameter tubing,

chromatography tubing,

heat shrinkable tubing

- Lined pipe and fittings
- Heat exchanger tubing
- Hydraulic hose
- Fuel tubing—aircraft, automotive
- Push-pull cable liner
- Gaskets, sealants
- Filters, membranes
- Monofilaments, fibers
- Profiles

Everflon™ PTFE Aqueous Dispersions

Everflon™ PTFE aqueous dispersions are milky white liquids consisting of hydrophobic, negatively charged submicrometer particles of PTFE resin suspended in water. The most common dispersion has an average particle size of 0.2 µm (200 nanometer), the optimum particle size for most applications. The raw dispersion is typically stabilized, neutralized, and concentrated.

Stabilization with a nonionic or anionic surfactant improves shear stability, wetting of substrate, and helps film formation in coating operations.The high utility of these dispersions is due to their fluid form. This property is especially useful because Everflon™ PTFE resins are not suitable for processing in molten or dissolved form.

Everflon™ PTFE aqueous dispersions are available in different grades designed according to the application, each with a specific molecular weight and molecular structure, dispersion particle size and shape, added surfactant type and quantity, pH and solids content.

Aqueous dispersions of Everflon™ FEP and PFA meltprocessable fluoropolymers as well as Everflon™ PTFE fluoroadditives are also available.

Grades of Everflon™ PTFE Aqueous Dispersions

Grades	Main Characteristics	Major Uses
General-Purpose Everflon™PTFE D60P	Ease of handling, good wetting	Impregnation of yarns for gaskets and packing
Fabric Coating Everflon™ PTFE D60F	High buildup, surface smoothness, weldability, good wetting, low foam, shear stable	Coated architectural fabrics, coated glass fabric for belting, flexible wiring boards, cast film
Metal Coating Everflon™ PTFE D60C	Film forming, good properties at high temperature, impermeable, high critical cracking thickness (CCT)	Coatings for industrial and cookware applications
Specialties Everflon™ PTFE D60P	Wetting, good fixation, high temperature, long-lasting	Compounding, high quality skived tape billets, sheet, molding
Additive Everflon™ PTFE D60A	Homogeneous, ease of handling	Compression and isostatic molding sheet molding, bearing pads

Processing

Uses for Everflon™ PTFE dispersions fall into general categories of coating, impregnation, finishing, and blending. In the case of coating of glass fabric, PTFE aqueous dispersion is applied by dipping the glass fabric in a bath with dispersion. In a typical coating process, the glass fabric is continuously unwound from a roll and fed into a dip bath, where it is submerged in a Everflon™ PTFE aqueous dispersion. The impregnated fabric emerges from the bath, excessive dispersion is wiped off the fabric, the fabric enters the drying zone to remove water, followed by “baking” to remove organic wetting agent(s), and finally a sintering zone. Finished or semi-finished product is wound up on a receiving roll. The same fabric is passed through the equipment a number of times until the desired weight and thickness are achieved.

A variety of porous structures can be impregnated with Everflon™ PTFE dispersion. The dispersion is well-suited for impregnation because of its low viscosity, extremely small particles, and the effect of the surfactant that aids in wetting the surfaces and promotes capillary action.

Typical Applications

- Architectural membranes (flexible coating)
- Electrical insulation in motors, generators
- Top-coat for aerospace wiring
- Flexible wiring boards
- Non-stick conveyor belting
- Non-stick film for heat sealers
- Impregnated yarns for gaskets and packing
- Coated filter bags
- Bearings
- Fibers
- Binders for disposable or recharge-able batteries

Everflon™ PTFE Fluoroadditives

Everflon™ fluoroadditives are part of the C&F Chemicals family of fluoropolymers. They are white, free-flowing, low molecular weight PTFE powders designed for use as additives in other materials or systems. They differ from PTFE granular resins and fine powders because of their very small particle size, typically in the range of 2 to 20 µm, low molecular weight, and the way they are handled and processed. Everflon™ MV fluoroadditives can be used over a wide range of temperatures from -190 to 250 °C (374 to 482 °F) and, depending on the application, may provide non-stick properties, improved lubricity, and better wear resistance and reinforcing properties.

Depending on the material, Everflon™ fluoroadditives can enhance abrasion resistance, reduce coefficient of friction and mechanical wear, reduce surface contamination, and modify appearance of the host material. Everflon™ fluoroadditives also provide specific benefits to specialized products. For example, thermoplastic parts,such as gears, benefit from improved wear resistance and reduced friction. Stick-slip behavior can be eliminated. Elastomeric seals for diverse environments improve in tear and abrasion resistance. Lithographic, flexographic, and gravure inks can be formulated for better image protection and higher productivity.

When used alone as a powder or in a paste or spray, Everflon™ fluoroadditives can be made into all-purpose solid lubricants. As a paste, for example, they can be used as high-performance sealants or as lubricants for wear surfaces in hostile environments. The powder can be dispersed in water or an organic solvent to provide another option for direct use or as an additive.

Because of their inherent low molecular weight, Everflon™ fluoroadditives are not to be used as molding or extrusion powders. Unlike some other micropowders on the market that are based on reprocessed PTFE, Everflon™ fluoroadditives are manufactured from virgin PTFE or are directly polymerized; hence, a better uniformity and inherent cleanliness.

Grades of Everflon™ PTFE Additives

Grades	Main Characteristics	Major Uses
Granular PTFE-Based Everflon PTFE MV	Low specific surface area (2.3–4.5 m2/g), non-agglomerated powder	Thermoplastics, printing inks, coatings
Fine Powder PTFE-Based Everflon PTFE FV	High specific surface area (5–11 m2/g), friable agglomerates of small (0.2 µm) primary particles	Thermoplastics, elastomers, coatings, lubricants and greases
As Polymerized PTFE Everflon PTFE TV	High specific surface area (8–12 m2/g), friable agglomerates of small (0.2 µm) primary particles. Low level of active end groups.	Elastomers, printing inks, coatings, coil coating, greases
Aqueous Dispersion Everflon PTFE D60A	Milky, white, 59–61% solids dispersion of 0.2 µm PTFE particles,stabilized with nonionic wetting agent	Additive for paints, coatings, mold release

Processing

Everflon™ fluoroadditive powders are popular because they can contribute some of their unique properties to the host material to which they are added. However, the suitability of an additive powder for mixing with and enhancing a given host is determined by many other factors, including:

• Size, distribution, and form of the particles

• Lot-to-lot uniformity

• Dispersibility

• Surface area

• Color retention

• Contamination

• FDA compliance/EEC Food Approval

For example, particle characteristics of an additive powder can affect both the process and the performance of products made from the additive. If the particles are too small or too large, surface defects may appear in molded thermoplastic parts. Ink formulations favor a narrow distribution of relatively small particles that remain stable and uniformly distributed during processing.

Because of the careful selection of base materials, uniformity is a major feature of Everflon™ fluoroadditives. Other powders, even with ideal particle size, distribution, and other powder characteristics, can cause problems if they are either not uniform from lot to lot or are contaminated.

Typical Applications

• In modifying thermoplastics for reduced friction and stick-slip, improved wear resistance, increased PV limits

• In elastomers for improved abrasion resistance, coefficient of friction, tear strength, and mold release

• In lithographic, flexographic, and gravure inks for better rub and scuff resistance, slip, and surface smoothness

• In coatings (both water- and hydrocarbon-based) for better water repellency, stain and scrub resistance, enhanced anti-stick, and low friction behavior

• In modifying sealant and lubricants for reduced wear and friction

• In extrusion process as a processing aid

Everflon™FEP Resins

Everflon™ FEP is a fluorinated ethylene propylene resin that meets the requirements of ASTM D2116 “Standard Specification for FEP-Fluorocarbon Molding and Extrusion Materials”. It is available as pellets or stabilized aqueous dispersions. Applications for this family of resins include melt extrusion, injection molding, transfer molding, coating, and impregnating. Products made from Everflonflon™ FEP are known for their excellent chemical resistance, superior electrical properties, and high service temperatures of up to 205 °C (401 °F) based on the 20,000 hr criterion and meet the requirements of International Standard ISO 6722 class G (–40 to 225 °C [–40 to 437 °F]) – Road vehicles – 60 V and 600 V singlecore cables. In addition, Everflon™ FEP provides outstanding low-temperature toughness and unique flame resistance.

FEP compounds are available with proprietary and patented foam nucleants added for physical foaming, e.g., for foamed coaxial cable dielectrics (to achieve low attenuation, low dielectric heating, and high speed of propagation).

Grades of Everflon™ FEP Resin

Grades	Main Characteristics	Major Uses
General-Purpose	High productivity, MFR 5–7 g/10 min Everflon FEP T4608	Wire insulation, tubing (≤2 mm diameter), injection molded parts
Optimum Output-Performance	Optimized productivity and stress-crack resistance balance MFR 4–10 g/10 min Everflon FEP 4610	Wire and cable insulation and jackets
High Productivity	Highest stress-crack resistance, MFR ≤5 g/10 min Everflon FEP 4603	Tubing (≥2 mm diameter)
High Output	Maximum productivity, MFR >30 g/10 min Everflon FEP4630 Low dissipation factor, MFR >20 g/10 min Everfon FEP 4622	Films, chemical linings, high stress applications, wire and cable applications Small wire and cable insulation (≤1.0 mm diameter), injection molded parts
Foam Resins	Physical and chemical system compound resins Everflon FEP CF&PF	Foamed cable insulations, high-frequency data cable with minimum distortion
Colored Resins	Pre-colored and color masterbatch resins Everflon FEP CC&PC	Colored cable and Jackets, tubings
Aqueous Dispersion	Ease of handling, wetting Everflon FEP D50	Top coat on wiring or architectural fabric

Processing

Everflon™ FEP fluoropolymer resins are processed by conventional melt-extrusion techniques and injection, compression, transfer, and blow-molding processes.

The high melt strength and draw-down capability of these resins facilitate the use of large dies and draw-down tooling to increase production rates. Equipment in contact with molten resin should be made of corrosionresistant metals. Larger length-over-diameter extruder barrels are used to provide enough residence time at high production rates to melt these high-temperature polymers. For injection molding, reciprocating screw designs are recommended.

Typical Applications

- Data communication cable jackets and primaries
- Appliance wiring
- Heating cables
- Automotive engine wiring
- Aerospace wiring
- Electric submersible pump motor insulation
- Electrical motor sleeves
- Chemical lining
- Lined valves
- Heat shrinkable tubing
- Tubing, small diameter tubing, chromatography tubing
- Shatterproof lamp covering
- Architectural fabrics (top coat)

Everflon™ PFA Resins

Everflon™ PFA is a perfluoroalkoxy copolymer resin that meets the requirements of ASTM D3307 “Standard Specification for Perfluoroalkoxy (PFA)-Fluorocarbon Resin Molding and Extrusion Materials”. It is available as pellets, powder, or aqueous dispersion.

Everflon™ PFA combines the processing ease of conventional thermoplastic resins with the excellent properties of Everflon™ PTFE. Products manufactured from Everflon™ PFA can offer continuous service temperatures up to 260 °C (500 °F). Everflon™ PFA provides superior creep resistance at high temperatures, excellent lowtemperature toughness, and exceptional flame resistance

Grades of Everflon™ PFA Resin

Grades	Main Characteristics	Major Uses
Everflon™ PFA 403	Highest resistance to stress cracking, high molecular weight, MFR 1.6–2.3 g/10 min	Lining of components for chemical processing industry,transfer molded articles, tubing extrusion
Everflon™ PFA 410	Extrusion and injection molding resin, intermediate molecular weight,MFR 6–12 g/10 min	Wire and cable insulation and jacketing, injection or blowmolded articles, tubing extrusion
Everflon™ PFA 420	High speed extrusion, high productivity, low molecular weight,MFR 20–30 g/10 min	Small gauge wire coating, injection molding
Everflon™ PFA JP04	Premium resin in powder form with the lowest level of extractables,improved flex life and stress crack resistance	Pump housing, containers, fittings with unusual shapes for handling of high purity chemicals
Everflon™ PFA CP	Static dissipating semi-conductive resin	Lined components for CPI
Everflon™ PFA D450 Dispersion	Ease of handling, wetting	Top coat on wiring and architectural fabric

Processing

Everflon™ PFA fluoropolymer resins are processed by conventional melt-extrusion techniques and injection, compression, rotational, transfer, and blow-molding processes. The high melt strength and heat stability of these resins permit the use of relatively large die openings and high-temperature draw-down techniques that increase processing rates. For injection molding, reciprocating screw designs are recommended.

Corrosion-resistant metals should be used in contact with the molten resin. Long extruder barrels, relative to diameter, are used to provide residence time for heating the resin to required processing temperatures.

Typical Applications

- Lined valves, fittings, and pumps
- Chemical linings
- Vessels, containers
- Wafer carriers
- Lab ware
- Heating cables
- Appliance wiring
- Logging cables
- Connectors
- Wire conduits
- Tubing
- Corrugated and convoluted tubing
- Heat shrinkable tubing
- Architectural fabrics

Everflon™ ETFE Resins

Everflon™ is a modified ethylene-tetrafluoroethylene (ETFE) fluoropolymer that meets the requirements of ASTM D3159 “Standard Specification for Modified ETFEFluoropolymer Molding and Extrusion Materials”. Available as pellets or as powder for rotational molding, Everflon™ fluoropolymer or ETFE combines superior mechanical toughness with an outstanding chemical inertness that approaches that of Everflon™ fluoropolymer resins.

Everflon™ features easy processibility, a specific gravity of 1.7, and high-energy radiation resistance. Most grades are rated for continuous exposure at 150 °C (302 °F), based on the 20,000 hr criterion and meet the requirements of International Standard ISO 6722 class F (–40 to 200 °C [–40 to 392 °F]) – Road vehicles – 60 V and 600 V singlecore cables.

Everflon™ ETFE is also available in 25% glass-fiber reinforced composition and as an anti-static grade, as well as functionalized grades for applications that require bonding to other polymers.

Grades of Everflon™ ETFE Resin

Grades	Main Characteristics	Major Uses
Everflon™ ETFE 4003	General-purpose resin of intermediate molecular weight.MFR 2-5 g/10 min	Wire and cable insulation and jacketing, injection-molded components, films, tubing
Everflon ETFE 4010	General-purpose resin of intermediate molecular weight with improved stress crack resistance, MFR6-12g/10 min	Films, tubing, injection-molded articles, wire and cablein-sulation and jacketing, down-hole logging cable,
Everflon™ ETFE 4020	Maximum productivity, MFR >25 g/10 min	Small wire and cable insulation (0.5 mm and smaller), thinwall extrusion, injection-molded parts
Everflon ETFE JP40	Premium grade resin in powder form, designed for use in rotational molding, MFR 20 g/10 min	Pump housing, containers, fittings, pipe sections with unusual shapes for handling of chemicals
Everflon™ ETFE CP	Static dissipating, semi-conductive resin	Lined components for CPI, extruded tubing, hose, and pipe

Processing

Everflon™ ETFE fluoropolymer resins are processed by conventional melt-extrusion techniques and injection, compression, transfer, rotational, and blow molding processes. The relatively high flow rate of these resins provides higher rates with less draw-down, as compared to those required for Everflon™ FEP and PFA.

Reciprocating screw injection molding machines are preferred. For longterm use, corrosion-resistant metals should be used in contact with the molten resin. Long extruder barrels, relative to diameter, should be used to provide residence time for melting these hightemperature resins.

Typical Applications

- Automotive wiring
- Aerospace wiring
- Heating cable
- Appliance wiring
- Down-hole cables and tubing
- Valves, valve seats
- Seals
- Pumps
- Column packing
- Flow meters
- Tubing
- Architectural films
- Release films

Major End-Use Industry Segments

- Chemical processing industry (CPI)
- Pharmaceutical/biotechnology
- Food processing
- Oil and gas
- Automotive
- Aerospace
- Semiconductor
- Cabling solutions
- Electronics/electrical
- Construction
- General industry
- Additives

Chemical Processing Industry

Benefits

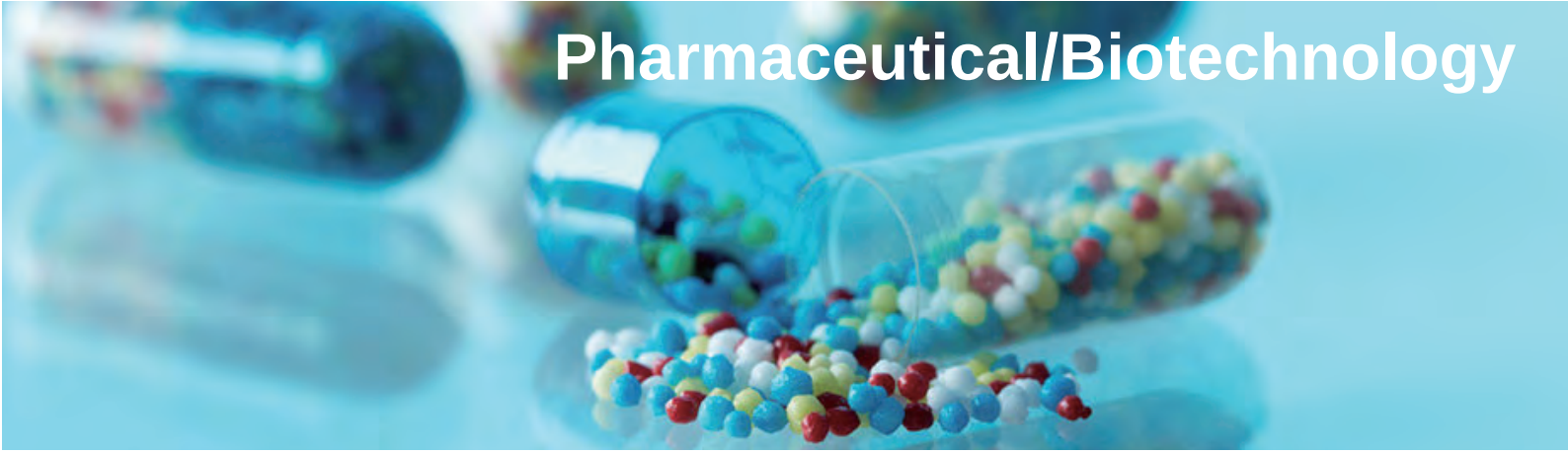
Sustainable solutions against equipment failures due to corrosion cause leakages, emissions, reduced processing efficiencies, increased equipment costs, and production delays in chemical production and processing operations.

Components made of Everflon™ fluoropolymer resins offer outstanding corrosion resistance over a wide temperature range, more universal and more economical than exotic metals or metal alloys. Corrosion protection of equipment results in longer life, less unscheduled downtime, and reduced risk of uncontrolled emission—allowing for longer maintenance intervals.

Fluoropolymers are non-brittle and resistant to mechanical- and thermal-shocks. Low coefficient of friction ensures ease of operation in moving parts, such as ball and plug valves. The inherent anti-stick properties of fluoropolymers resist residue buildup and make cleanup easy.

Typical Applications

- Seals, O-rings, gaskets, braided packing
- Mechanical seals
- Valve seats, valve stem packing
- Lined valve, fittings, pumps
- Sight glasses, flow meters
- Lined pipes, dip pipes, columns, tanks
- Expansion joints, bellows
- Hose, tubing, convoluted tubing
- Filters, de-misters, strainers
- Column packing
- Heat exchanger tubing and lining
- Trace heating cables



Pharmaceutical/Biotechnology

Benefits

The broad chemical compatibility and resistance to biofilm buildup of Everflon™ PTFE allows the protection of product quality and higher productivity to meet demands for increased product purity, easier cleanability, improved durability, and low maintenance costs by offering the following:

• Corrosion resistance over a wide temperature range, more universal and more economical than exotic metal alloys—allowing equipment to make a wider range of products

• No byproducts of corrosion to contaminate products or processes

• No need for passivation or electro-polishing

• Non-stick, smooth surface, resistance to bio-film buildup

• Faster, easier cleaning, in-place cleaning and steaming

• Minimize drug adhesion

• Negligible absorption of chemicals

• Seamless weldability

• Non-brittle, resistant to mechanical- and thermalshocks, flexible, and long-term resistant to vibrations

• Biocompatible (USP Class VI)

• Compliant with FDA and EU requirements

• High purity, extremely low extractable level, prevents contamination of critical chemicals and biological fluids

• Meets drinking water requirements

• UV resistance

Typical Applications

• Pipes, fittings, couplings, expansion joints, bellows

• Labware, trace analyzers, dispensers, bottles, screwcaps

• Seals, O-rings, gaskets, valve seats

• Sight glasses, flow meters

• Tanks, containers

• Transfer hose, tubing, convoluted tubing

• Small diameter tubing, multi-lumen tubing

• Filters, strainers

,• Valves, pumps

beakers, chromatography tubing

• Sterilization units, virus inactivation systems

Food Processing

Benefits

The non-stick performance, chemical inertness, and exceptional purity of fluoropolymers are the best ways to keep food processing equipment running smoothly and profitably.

Components and linings made with Everflon™ PTFE help to cut maintenance costs, increase uptime, increase throughput, safeguard product purity, and allow use of same equipment over a wide range of food products (multipurpose plant operation). The key properties of fluoropolymers in the food processing industry are:

• Corrosion resistance over a wide temperature range, more universal, and more economical than exotic metal alloys

• No chemical interaction or corrosion with foods to compromise taste or create contamination. No absorption of common food preservatives

• Extremely low extractables and reactivity plus high purity

• FDA/European Directive compliant

• Approved for potable drinking water applications

• Non-stick, easy release. Equipment surfaces are easy to clean and remain clean longer.

• Faster, easier cleaning (meets EHEDG Cleanability requirements), cuts downtime for cleaning

• Resists onset of biological film formation

• Reduces chemical usage for cleaning

• Excellent steam and chemical sterilization performance

• The use of fluoropolymers in shatterproof coatings for fluorescent light tubes reduces the risk of glass contamination in food chain.

Typical Applications

• Conveyor belts

• Baking liners

• Industrial bakeware

• Non-stick metal coatings

• Seals, gaskets, packing, valve seats

• Valves, fittings, pumps

• Sight glasses, flow meters

• Pipes, columns, tanks, vessels

• Expansion joints, bellows

• Hose, tubing

• Filters, strainers

• Dispensers, containers

• Shatterproof lamps

Oil and Gas

Benefits

Working in oil and gas refineries, pipelines, and downhole environments can prove environmentally challenging. Products made with Everflon™ fluoropolymers have exceptional resistance to high temperatures, chemical reaction, corrosion, and stress-cracking that results in higher mean time between failures (MTBF). Chemical resistance offered by fluoropolymers is more universal and economical than most exotic metal alloys.• Non-stick, easy cleaning. Very few solid substances will permanently adhere to surfaces of Everflon™ coatings, reducing significantly buildup of asphaltenes, paraffins, and scale— thus yielding enhanced flow of liquids and gases. Although tacky materials may show some adhesion, almost all substances release easily.

• Low coefficient of friction. The coefficient of friction of Everflon™ PTFE is among the lowest of any solid material. This combined with chemical and temperature resistance makes it the product of choice for slide bearings, seals, and gaskets.

• Unique electrical properties over a wide service temperature range allow for downsizing of cables used under extreme conditions (e.g., down-hole).

Based on these properties, fluoropolymers bring solutions to the oil and gas industry that allow maximizing productivity by minimizing production interruptions due to shutdowns for cleanup or for repair or replacement.

Typical Applications

• Electric submersible pump insulation

• ESP power cable

• Data logging cable

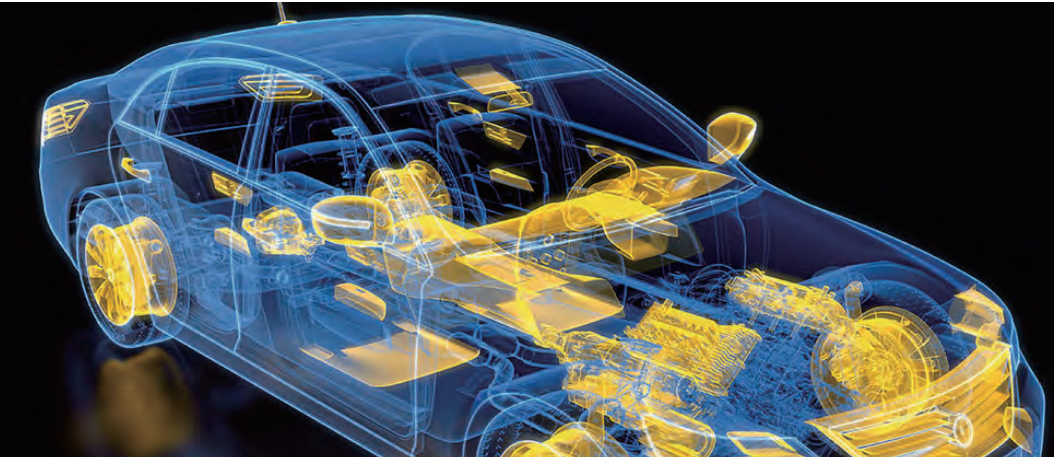
• Trace heating cables

• Gaskets, seals, packing, valve seats

• Slide bearings

• Bellows, expansion joints

• Hose, tubing, down-hole tubing



Automotive

Benefits

The automotive industry has to deliver better performance against ever increasing and sometimes conflicting requirements, such as:

• Lower emissions (including evaporative emissions)

• Better fuel economy

• Increased warranty period

• Lower maintenance costs

• Higher comfort level

Fluoropolymers play an important role in meeting these requirements by offering:

• Maximum durability under extreme temperatures and harsh chemicals. Everflon™ PTFE and PFA meet ISO 6722 Class H (–40 to 250 °C [–40 to 482 °F]), FEP meets Class G (–40 to 225 °C [–40 to 437 °F]), and ETFE meets Class F (–40 to 200 °C [–40 to 392 °F]).

• Extremely low permeability and outstanding resistance to chemicals like biofuels, flex fuels, hydraulic oils, etc.

• Lowest coefficient of friction of any solid material for use in non- and minimally lubricated mechanical systems (to improve wear resistance special technologies are available, such as the incorporation of fillers).

Typical Applications

• Lambda oxygen sensor wiring, seal, and conduit

• Engine wiring

• Seat heating wires

• Headlight wiring

• Wire conduits, harness covers, cable ties

• Static and dynamic seals, O-rings, head gaskets

• Valve stem seals

• Crank shaft rotary lip seals

• Fuel hose and tubing

• ABS interconnect hose

• Hydraulics hose

• Brake pad wear indicator

• Push-pull cable liner

Aerospace

Benefits

The aerospace industry requires products with a complex combination of properties: strength and durability, lightweight, resistance to harsh environments, and ease of use in manufacturing. Safety considerations, such as flame resistance, are also of paramount importance.

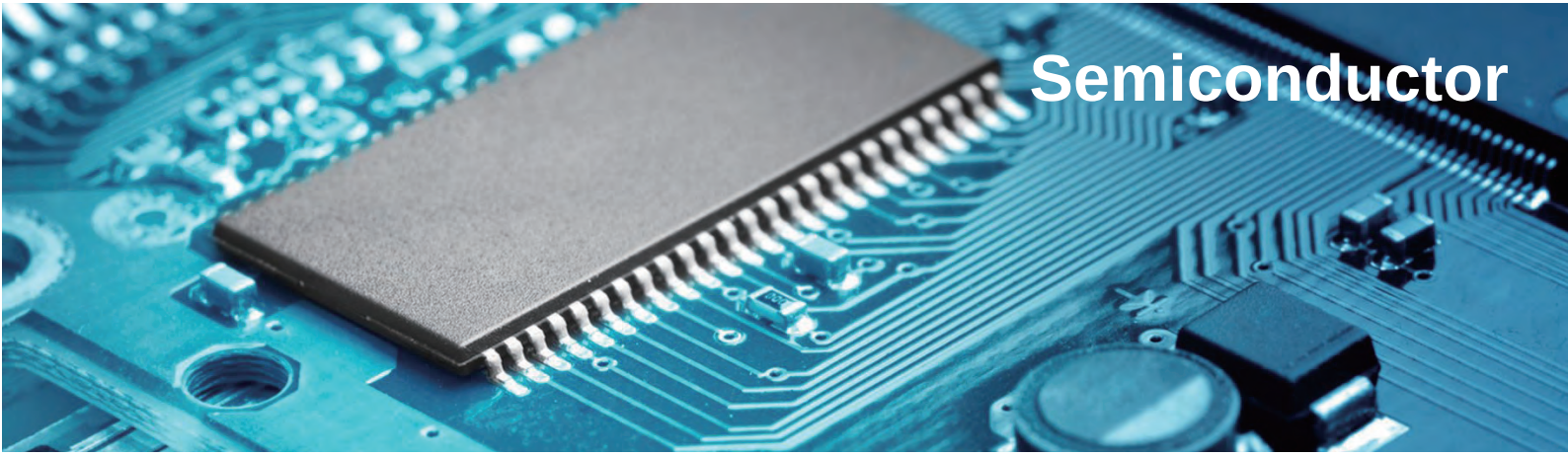
Fluoropolymers have played a key role in the space programs, development of new defense systems, and creation of commercial jet aircraft and engines.

Reasons for the use of fluoropolymers in the aerospace industry are:

- Low smoke and flame
- Weight and space savings
- Operability over broad temperature range and good aging resistance
- Self-lubricating, low friction
- Flexibility, high fatigue resistance
- Excellent dielectric properties over a wide frequency range
- Withstands exposure to hydraulic fluids, solvent, and cleaning solutions
- Resistance to high soldering temperatures
- Good release properties for epoxy resins
- UV resistance
- No degasing of any byproducts

Typical Applications

- Rings, seals, gaskets for hydraulic systems
- Satellite propulsion systems
- Hose, tubing for hydraulic and fuel systems
- Electrical insulation for high frequency cables
- Airframe wire insulation
- Insulation for internal wire and cable in avionics
- Engine wire insulation and jacketing
- Heating cable
- Circuit boards for microwave equipment
- Wire conduits
- Wire and cable sleeves, heat-shrinkable tubing
- Release film in fabrication of composite aerospace parts



Semiconductor

Benefits

• Corrosion resistance over a wide temperature range, more universal and more economical than exotic metal alloys

• High purity, extremely low extractable level, no leaching out of substances that could contaminate ultrahigh purity process fluids

• Everflon™ PFA offers improved system reliability and reduced cost of ownership (longer lifetime, less maintenance), while maintaining the same level of purity

– Longer life under dynamic loads (flex life)

– More resistance to stress cracking by specialty fluorosurfactants, such as aggressive developers

– Smoother surfaces for resistance to microbial contamination

– Inert non-polar polymer chain end groups for unsurpassed protection against ionic and metallic contamination, even from ozonated fluids

– Unmatched HCl permeation resistance

Typical Applications

• Shipping containers

• Pipes, fittings

• Tubing

• Filters

• Wet bench tanks, sinks

• Valves, pumps

• Level indicators

• Wafer carriers

Cabling Solutions

Benefits

Everflon™ PTFE, PFA, FEP, and ETFE fluoropolymer resins are ideal choices for insulation and jacketing applications where low flammability, exceptional dielectric properties over a wide frequency range, high stress-crack resistance, chemical inertness, high service temperature, and thermal cycling capabilities are required.

C&F fluoropolymers offer remarkable resistance to high temperature and flames because they have very high melting points and auto-ignition temperatures, as well as exceptional thermal degradation thresholds.

Moreover, their flame characteristics, such as rate of propagation, heat release, and smoke generation, are very low—enhancing the fire protection for instance in high-speed data communication cables used in concealed spaces (plenum).

Everflonflon™ fluoropolymers offer:

• Low dielectric constant for high speed signal transmission

• Low dissipation factor over a broad range of frequencies gives reduced capacitance and attenuation

• Resistance to high soldering temperatures

Typical Applications

• Insulation and jacketing data communication cable

• Coaxial cables for high frequency antenna systems

• Automotive cable

• Oil well data logging cable

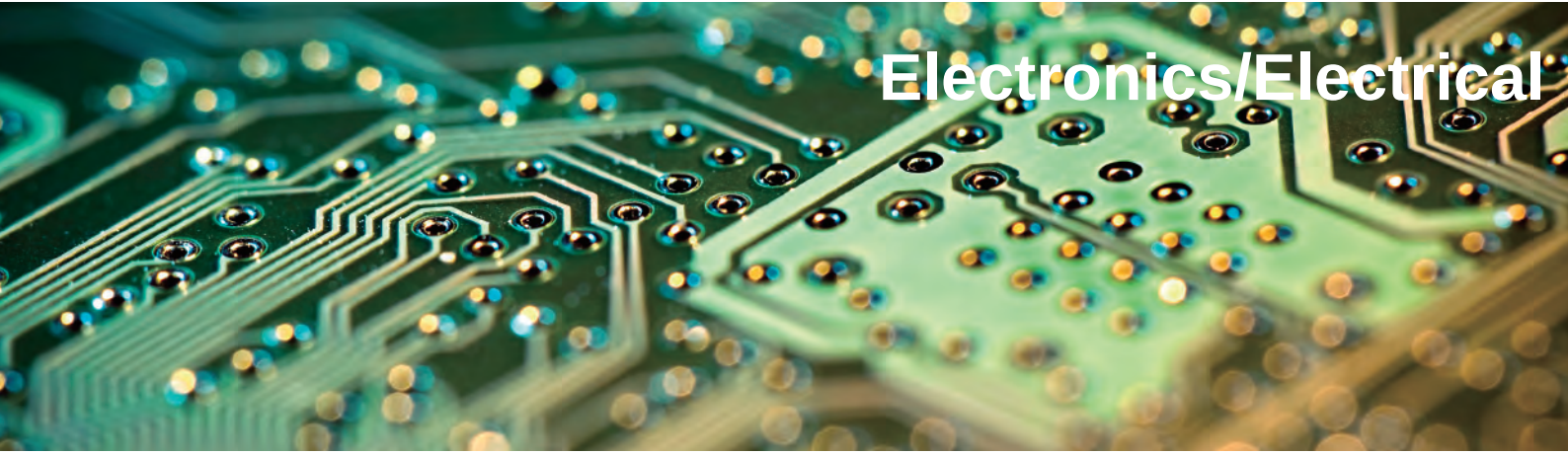
• Heating cable

• Motor lead wire

• Appliance wiring

• Aircraft wiring

• Security system cabling



Electronics/Electrical

Benefits

Everflonn™ PTFE, PFA,FEP, and ETFE fluoropolymer resins offer a unique combination of properties under extreme ambient conditions where most other polymers or elastomers would fail. Those properties that are most important for the electronics/electrical industry are:

• Superior insulation properties, especially at high frequencies. Dielectric constant of Everflon™ is lower than any other solid polymer and changes little with frequency and humidity. Low dissipation factor at radio frequencies

• High volume and surface resistivity unaffected by heat-aging or temperatures

• High dielectric strength

• High surface arc-resistance

• Thermal stability at high temperatures (no cracking or embrittlement)

• Low coefficient of friction

• Solder-iron resistant

Typical Applications

• Wire connectors, insulators

• Printed wiring boards, flexible circuits

• High voltage circuit breakers

• Appliances, consumer electronics

• Battery binder, separator, caps

• Fuel cells

• Generator cooling hose

• Electrical motor sleeving, electrical conduits

• Electrical grade tape

• Heat shrinkable tubing

• Cable ties, protective conduits

Construction

Benefits

Architectural films and membranes made of glassfiber woven fabric coated with Everflon™ fluoropolymers offer many advantages as a construction material over traditional materials:

•**Aesthetics.** Architectural membranes allow structures with graceful, complex curves. Wide-span possibilities with obstruction-free view

•**Safety.** Fluoropolymers are exceptionally resistant to ignition, flame spread, and heat and smoke release. Classifies as “non-combustible” roofing material

•**Non-stick**. Architectural membranes coated with Everfflon™ PTFE are self-cleaning.

•**Durability.** Over 30 years of proven performance, chemically inert Everflon™ PTFE endows architectural fabric with UV resistance and resistance to moisture and microorganisms.

•**Economics.** Multi-functional, translucent. Full spectrum light transmission (except for harmful infrared and UV rays) allows for natural illumination during daylight hours.

This helps reduce lighting costs and promote grass and plant growth. Acts as barrier to external heat and noise, while enhancing internal acoustics and preserving desired level of temperature and humidity

•**Cost-effective.** Fabric structures offer attractive cost saving and energy efficient alternatives to traditional buildings. An architectural membrane roof can be a fraction of the weight of conventional roof structures, allowing substantial savings in floor assemblies, walls, and foundations.

Typical Applications

• Architectural membranes of fiberglass coated with Everflon™

• Architectural fabric woven of PTFE fibers

• Transparent architectural film

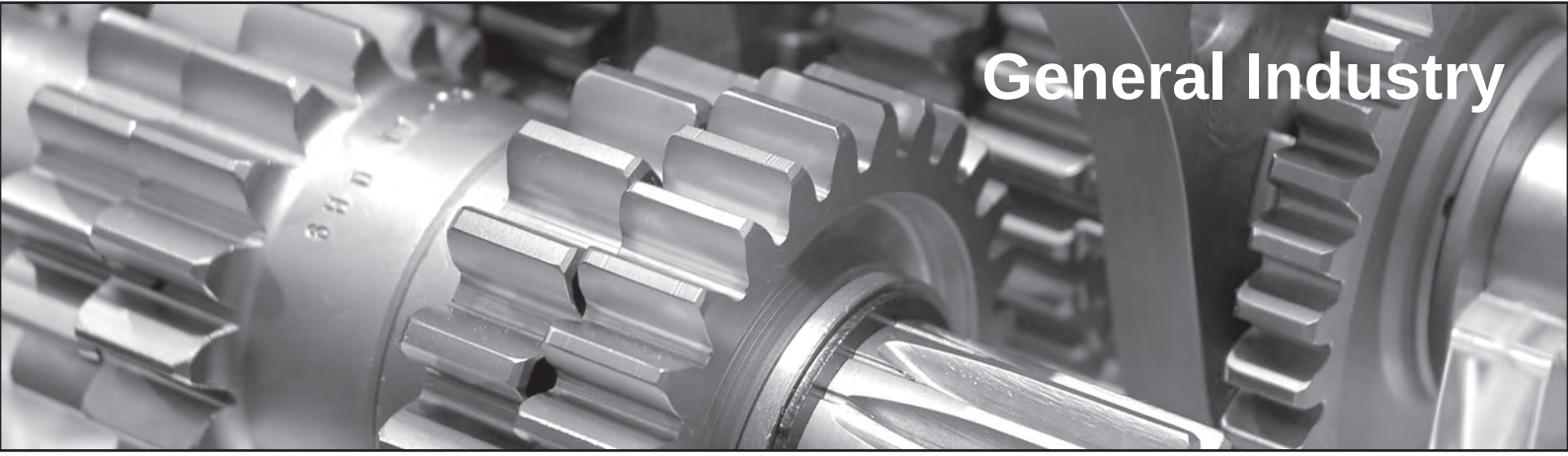
• Enhanced fire performance data cables

• Under-tile heating cables

• Shatterproof lamps

• Slide bearings

• Valve seats for central heating systems



General Industry

Benefits

Industrial products made with Everflon™ fluoropolymer resins have exceptional resistance to low as well as high temperatures, chemical reaction, corrosion, and stresscracking.

The properties of fluoropolymer make it the preferred plastic for a host of industrial applications for the following reasons:

• Lowest coefficient of friction of any solid material

• Static coefficient of friction is lower than dynamic coefficient of friction (no stick-slip effect)

• Ability to operate without lubrication or in marginally lubricated conditions

• Long-term thermal stability at high temperatures (no cracking or embrittlement)

• Avoiding sticking, buildup, or corrosion

• Fragment retention

• Approved for use in pure oxygen, gaseous and liquid

Typical Applications

• Roll covers, heat-shrinkable tubing

• Shatterproof lamps

• Piston rings/shaft seals for non-lubricated compressors, hydraulics, and seal rings for construction machinery

• Hydraulics hose

• Tubing, hose: Hose for high pressure gases, oxygen hose, hose for breathing apparatus, generator hose, paint hose

• Consumer products: Sliding pads for furniture, sporting equipment, iron sole plates, textile treatment, and car care products

Additives

Benefits

Everflon™ fluoroadditives are designed to impart the unique properties of fluoropolymers to a base material, such as a thermoplastic, elastomer, lubricant or coating.

Depending on the host material, Everflon™ fluoroadditives:

- Enhance abrasion and wear resistance
- Lower maintenance costs
- Enhance surface and bulk properties
- Reduce friction and stick-slip response
- Reduce mechanical wear
- Reduce surface contamination
- Improve rub and scuff resistance and surface smoothness

Typical Applications

- Additive to thermoplastic hosts, such as acetals, polycarbonates, polyamides, and other highperformance engineering resins
- High gloss inks
- Self-polishing anti-fouling marine paint
- Lubricating oils, greases, and sealants

Main Typical Properties of Everflon™ Fluoropolymers

Typical Properties	Test Method	Unit	Everflon PTFE	Everflon FEP	Everflon PFA	Everflon ETFE
Mechanical						
Specific Gravity	ISO 1183		2.16	2.15	2.15	1.71
Tensile Strength	ISO 12086	MPa				
−40 °C (−40 °F)			52	43	39	61
23 °C (73 °F)			26–36	20–34	25–35	45–51
150 °C (302 °F)			25	12	23	17
200 °C (392 °F)			22	6.3	17	6.5
Elongation	ISO 12086	%				
−40 °C (−40 °F)			115	235	250	180
23 °C (73 °F)			325	325	350	200–375
150 °C (302 °F)			540	375	515	740
200 °C (392 °F)			560	395	535	630
Tensile Strength at Yield	ISO 12086	MPa				
−40 °C (−40 °F)			28.2	26.4	26.5	41.7
23 °C (73 °F)			13.7	13.1	14.5	22.9
150 °C (302 °F)			6.2	5.5	8.3	6.0
200 °C (392 °F)			4.6	3.4	5.9	3.8
Tensile Modulus	ISO 12086	MPa				
−40 °C (−40 °F)			795	465	520	880
23 °C (73 °F)			480	520	435	840
150 °C (302 °F)			60	34	57	53
200 °C (392 °F)			60	20	46	30
Flexural Modulus, 23 °C (73 °F)	ISO 178	MPa	490	550–655	520–690	1,000–1,380
Folding Endurance MIT (0.2 mm, 270° flex)	ASTM D2176	Cycles	885,000–>90 x 10^6	5,000–1 x 10^6	7,000–2 x 10^6	1,500–60,000
Impact Strength	ASTM D256	J/m				
23 °C (73 °F)			185	No break	No break	No break
−54 °C (−65 °F)			107	158	155	>1,100
Hardness	ISO 868	Shore	D-55	D-55	D-56	D-67
Coefficient of Friction (dyn) 3 m/min, 0.7 MPa	ASTM D3702		0.1	0.3	0.2	0.4
Thermal						
Peak Melting Temperature	ASTM D4591	°C (°F)	327 (621)	260 (500)	305 (581)	265 (509)
Service Temperature (20,000 hr)	ISO 2578	°C (°F)	260 (500)	205 (401)	260 (500)	155 (311)
Flame Class	UL94		94V-0	94V-0	94V-0	94V-0
Oxygen Index	ISO 4589	%	>95	>95	>95	30–32
Temperature Index	NES 715	°C (°F)	>400 (>752)	>400 (>752)	>400 (>752)	ca 290 (554)
Heat of Combustion	ISO 1716 (NFPA-259)	kJ/g	4.9–5.0	4.8–5.1	4.7–4.9	12.4–12.6
Electrical						
Dielectric Strength	IEC 60243	kV/mm				
Film 0.25 mm			85	78	74	62
Film 1.00 mm			35	35	33	30
Relative Permittivity (Dielectric Constant)	ASTM D150	1 MHz 1 GHz	2.05 1.99	2.03 2.02	2.03 2.02	2.47 2.29
Dissipation Factor	ASTM D150	1 MHz 1 GHz	0.00003 0.00028	0.00061 0.00094	0.00019 0.00082	0,00550 0,01430
Arc Resistance	ASTM D495	sec	>300	>300	>180	>72
Volume Resistivity	ASTM D257	Ω.m	>10^{16}	>10^{16}	>10^{16}	>10^{14}
Surface Resistivity	ASTM D257		>10^{16}	>10^{16}	>10^{17}	>10^{14}
General						
Weather Resistance	“Weather-O-Meter” (2,000 hr)		No effect	No effect	No effect	No effect
Solvent Resistance	ASTM D543		Excellent	Excellent	Excellent	Very good
Chemical Resistance	ASTM D543		Excellent	Excellent	Excellent	Very good
Water Absorption	ASTM D570	%	0.00	0.01	0.03	0.03

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