



Teflon™ and Tefzel™

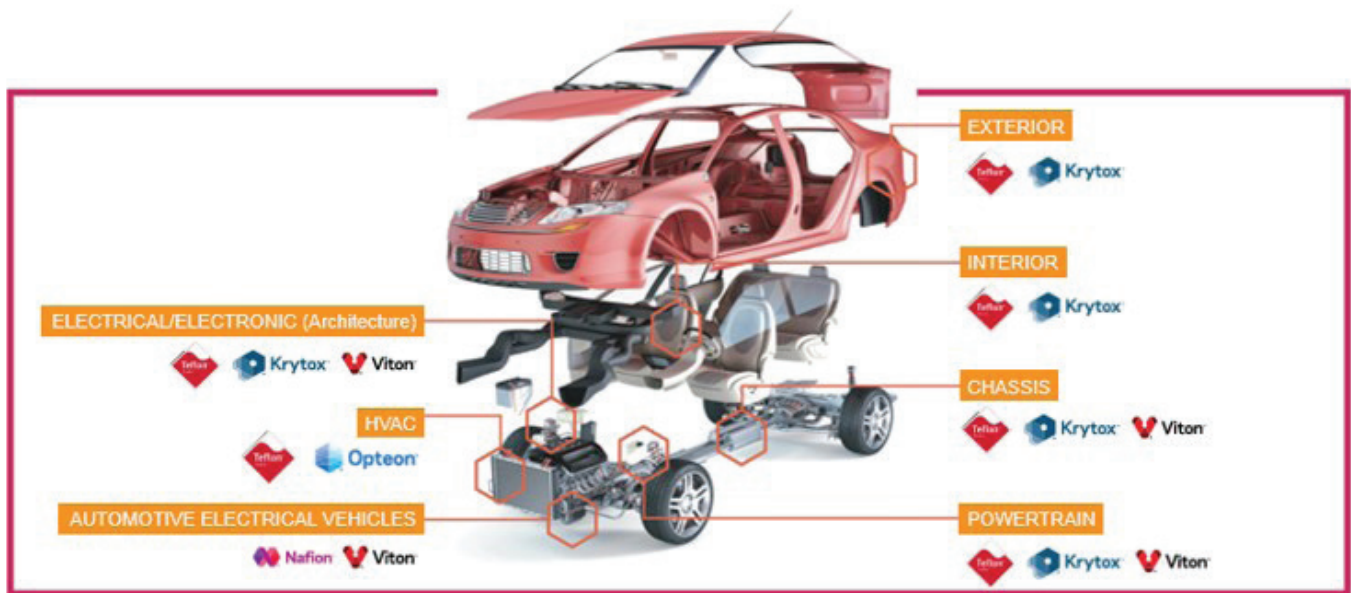
Fluoropolymer Resins

Integrating Innovation Throughout the Vehicle



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Materials and More

In 1938, Roy Plunkett invented Teflon™ PTFE at what is now the Chemours Chambers Works facility, and since then, the Chemours Power Brands, including Teflon™, have been synonymous with reliability, safety, and performance. Today, Chemours offers the broadest range of fluoropolymer resins to meet the most challenging requirements of the automotive industry. In addition to this broad fluoropolymer offering, Chemours provides a wide range of expert resources to help you maximize product quality and reduce your product cost.

These fluoropolymers include:

- Teflon™ PTFE fine powders
- Teflon™ PTFE granular molding powders
- Teflon™ aqueous dispersions
- Teflon™ FEP
- Teflon™ PFA
- Teflon™ AF amorphous fluoropolymers
- Tefzel™ ETFE
- Zonyl™ fluoroadditives

Quality: The Essential Part of the Process

In the manufacturing environment, quality is very important. The properties of your finished product can vary, depending on:

- **Microporosity:** Microscopically visible voids, created by imperfect particle fusion
- **Crystallinity:** The closeness and arrangement of polymer chains
- **Molecular weight:** The average length of polymer chains
- **Macroscopic flaws:** Internal bubbles, tears, foreign impurities, shear planes or poor charge-to-charge bonds
- **Orientation:** The alignment of polymer chains in a given direction

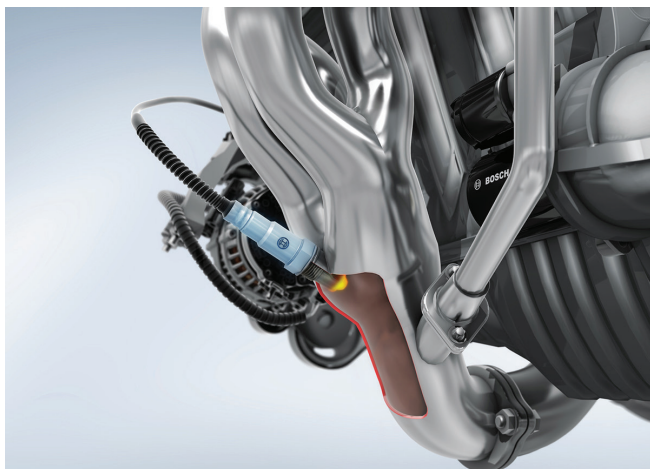
For every application, a different combination of the above factors is acceptable and ideal. To ensure you get the best possible quality for your intended application, Chemours offers the expertise needed to utilize our fluoropolymer resins to their full potential. It's also important to remember that only Chemours makes Teflon™ and Tefzel™. We are the experts. We'll help you make the most of our materials. So what do you get when you buy Chemours? Not just resin, but meticulous quality control and superior technical service as well.

The World's Greatest Electrical Insulator

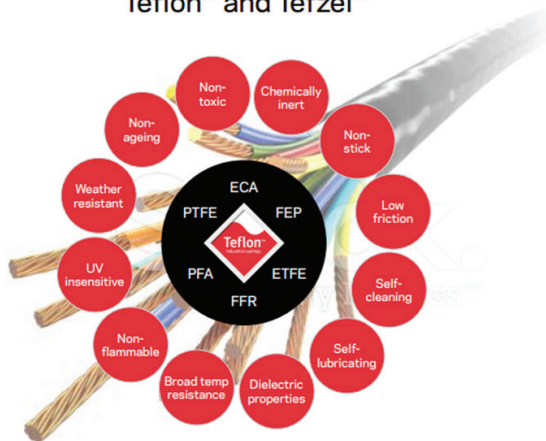
When your application requires world-class electrical insulating properties, Chemours fluoropolymers can meet your needs. With low dielectric constants and high volume resistivity, Chemours fluoropolymers provide unmatched insulating capabilities under harsh environmental conditions.



Oxygen exhaust sensor wire insulation



The unique properties of Teflon™ and Tefzel™



Temperature Class Ratings for Wire Insulation According to ISO 6722

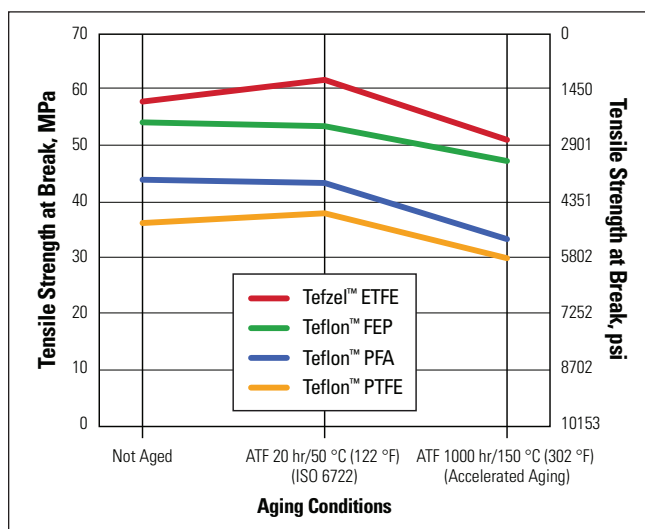
Teflon™ PTFE	Class H	-40 to 250 °C (-40 to 482 °F)
Teflon™ PFA	Class H	-40 to 250 °C (-40 to 482 °F)
Teflon™ FEP	Class G	-40 to 225 °C (-40 to 437 °F)
Tefzel™ ETFE	Class F	-40 to 200 °C (-40 to 392 °F)

Note: Class H (250 °C [482 °F]) is the highest temperature class in ISO 6722. Both Teflon™ PTFE and PFA are capable of operating at higher temperatures.

Tensile Properties of Wire Insulation* Aged in ATF** 20 hr at 50 °C (122 °F) and 1000 hr at 150 °C (302 °F)

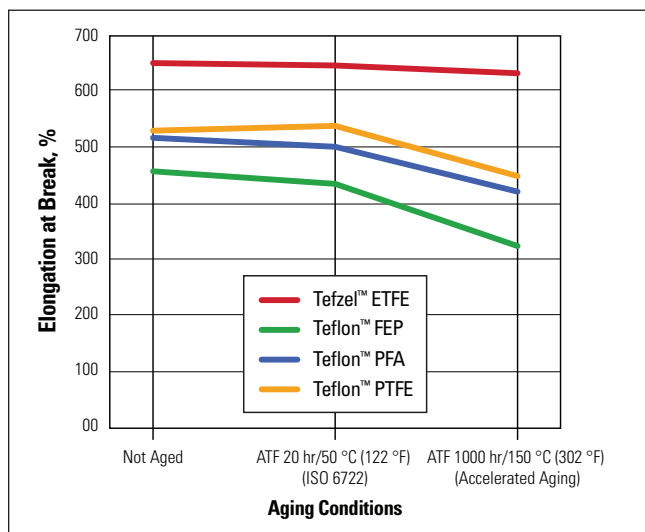
Tensile strength at break on wire insulation

Wire insulated with Teflon™ and Tefzel™ fluoropolymer resins aged in ATF



Elongation at break on wire insulation

Wire insulated with Teflon™ and Tefzel™ fluoropolymer resins aged in ATF

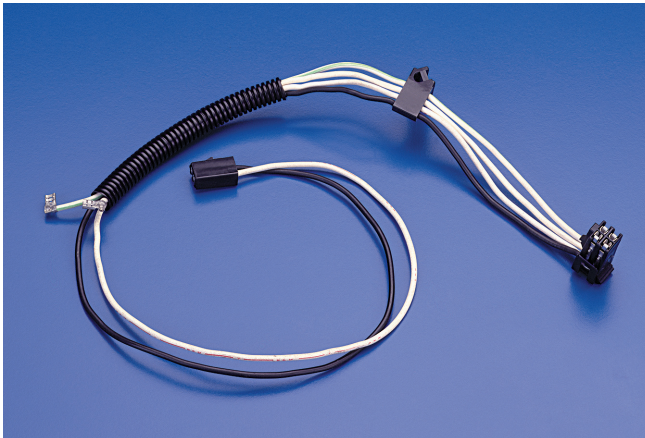


* Wire construction AWG 22 (0.34 mm²), 7 strands copper conductor, coated with 0.25 mm thick insulation.

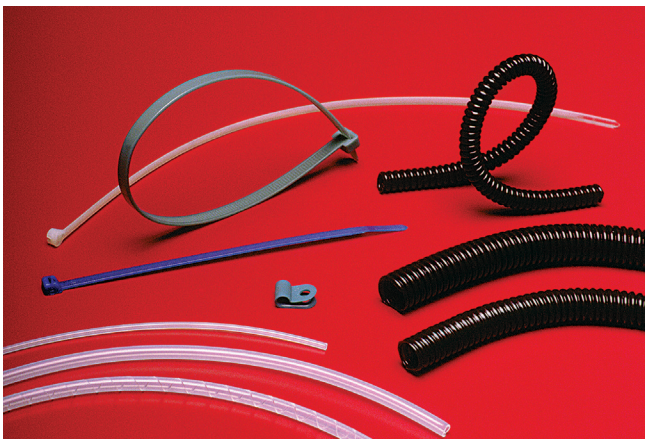
**ATF: Automatic Transmission Fluid Citro #33123 (Dexron III).

Going to Extremes

For applications that demand maximum durability in cases of extreme temperatures, harsh chemicals, and abrasion, Teflon™ and Tefzel™ fluoropolymers provide unparalleled tenacity. They set the standard for toughness in wire and cable applications by not only maintaining ductility and other key properties well below -40 °C (-40 °F), but also providing a cost-effective solution for high-temperature needs between 150-300 °C (302-572 °F). In particular, Tefzel™ ETFE allows the automotive industry to save weight, space, and cost by converting to ultra-thin wire insulation. Tefzel™ ETFE fluoropolymer resin is also well suited for many additional wire management components, including cable ties, electrical conduits, harness covers, and clips. You can rest assured that with Chemours fluoropolymers, your electrical system will never fail due to extreme conditions.



Ultra-thin wire insulation



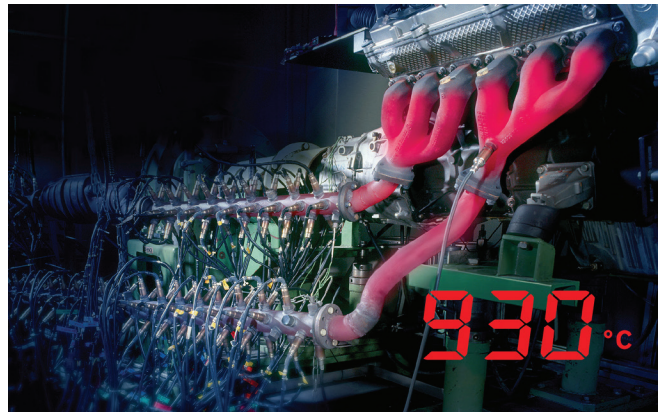
Wire management components

Engines: Hot and Getting Hotter

Inside the engine and out, Chemours fluoropolymers can take the heat. Both Teflon™ and Tefzel™ fluoropolymer resins retain their properties, even after exposure to temperatures that destroy nearly all other thermoplastics and elastomers. These fluoropolymers also excel in resisting polymer degradation caused by the chemical attack that occurs under such high temperatures. We are available to advise you on how best to use our fluoropolymer resins in applications that require high-temperature tolerance as well as chemical resistance.



Cummins 6.7 liter turbo diesel engine

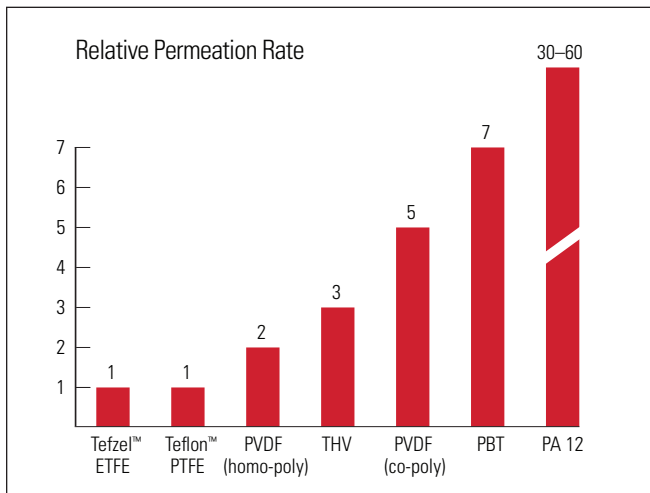


Oxygen sensor test rack, Bosch GmbH. The 930 °C represents the testing temperature of the engines. The oxygen sensor wire conduits, made with Teflon™ PTFE 62 X, are very close to the hot spot and can reach temperature peaks up to 300 °C (572 °F).

Emissions: Meet (and Beat) New Environmental Regulations

Using Teflon™ and Tefzel™ fluoropolymers in your fuel system will help you curb evaporative emissions. Our fluoropolymers provide outstanding chemical resistance and extremely low permeability. They resist even the most aggressive biodiesel and sour gas fuel compositions. With outstanding low-temperature toughness and lack of any measurable oligomer migration, these fluoropolymers provide near-zero permeation and are well suited for direct contact with current and future fuel and oil compositions. Let us show you how our fluoropolymers will help you meet new regulations on evaporative emissions.

Fuel Permeability M15 at 60 °C (140 °F)*

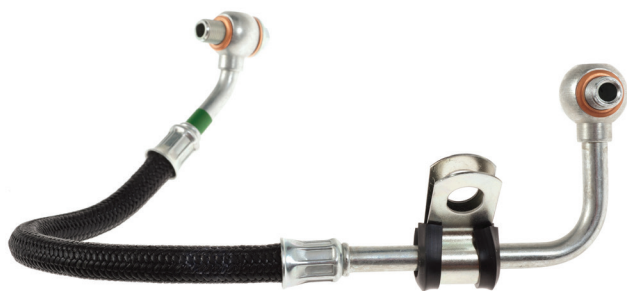
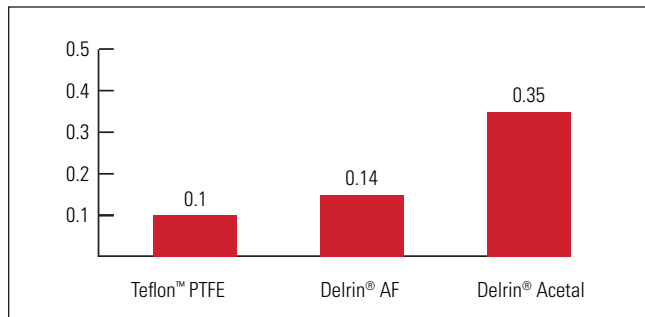


*15% methanol and 85% reference fuel C.

The Smooth Solution

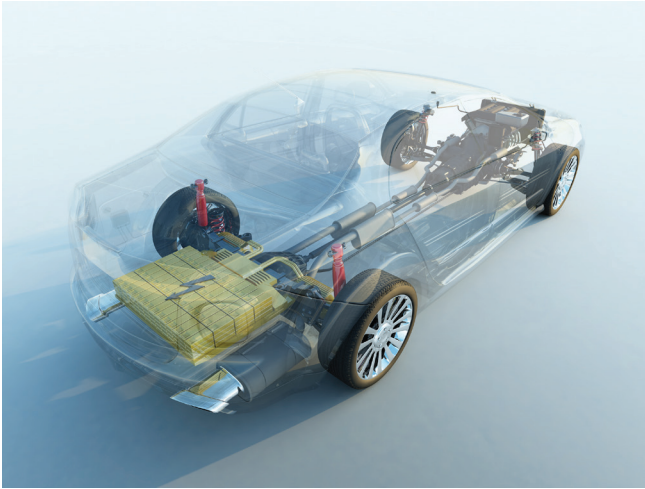
If friction is your problem, let Chemours provide the smooth solution. Teflon™ fluoropolymer resins have one of the lowest coefficient of friction of any solid material. Graphite, glass, or a variety of other inorganic fillers can be in used in combination with Teflon™ resins for adaptable abrasion resistance. Teflon™ fluoropolymer resin has been used successfully in many practical, non- and minimally lubricated mechanical systems.

Kinetic Coefficient of Friction ASTM D1894



Kongsberg Fluoro-comp® fuel hose

Typical Automotive Applications of Teflon™ and Tefzel™



Alternative energy vehicle

Fuel System

- Fuel lines: feed, return, vapor
- Diaphragm-pressure regulator
- Interconnect hoses
- Fuel rail crossover (fuel tubing/hose)
- Gas injection bushing
- Filler-neck hose
- Anti-expulsion tank valve
- Multi-port fuel rail distribution tubes
- OBD sensor seals

Powertrain

- Transmissions and trans-axles
 - Internal shift seal rings
 - Hydraulic clutch piston rings
- Engine
 - Head gasket
 - Oxygen sensor hermetic seal
 - Crankshaft rotary lip seals
 - Valve stem seals
 - A/C piston rings
- Control cable liners
 - Accelerator
 - Brake
 - Shifter
 - Cruise control
 - Clutch

Electrical System

- Oxygen sensor wire
- Throttle body injection (TBI) wire
- Catalytic converter control wire
- Heated seat wire
- Convoluted wire harness
- Diesel engine wire
- ABS wire
- Transmission wire
- Brake sensor wire
- High tension ignition cable
- Battery terminal binder
- Wire harness conduit
- Cable tie wraps

Interior/Body

- Power window vents
- Headlight vents
- Door hinge sleeves
- Clutch and brake pedal pivots
- Coated weather stripping
- Power seat and motor bushing
- Lumbar support air pump bushing
- Interior fabric protector

Brake System

- ABS interconnect hose
- Impulse hose at wheel
- Brake pad wear indicator

Chassis

- Shock absorber piston seals
- Stabilizer bar bushing
- Steering ball joint insert
- Steering assist pump piston rings

Miscellaneous

- Elastomers components—Zonyl™ PTFE additive
- Grommets coating—throttle body and carburetor parts, screw fastener
- Additives for grease and oil
- Seat belt control mechanism

Typical Properties of Teflon™ and Tefzel™ Fluoropolymers

Typical Properties ¹	Test Method	Unit	Teflon™ PTFE	Teflon™ FEP	Teflon™ PFA	Tefzel™ 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 ² 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 ³	UL94		94 V-0	94 V-0	94 V-0	94 V-0
Oxygen Index	ISO 4589	%	>95	>95	>95	30–32
Temperature Index	NES 715	°C (°F)	>400 (>752)	>400 (>752)	>400 (>752)	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

continued

Typical Properties of Teflon™ and Tefzel™ Fluoropolymers (continued)

Typical Properties ¹	Test Method	Unit	Teflon™ PTFE	Teflon™ FEP	Teflon™ PFA	Tefzel™ ETFE
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

¹Typical measured values based on grades representative for each product family, these properties are not suitable for specification purposes.

²Values for folding endurance cannot be directly compared between the different products; range indicates different types.

³These results are based on laboratory tests under controlled conditions and do not reflect performance under actual conditions.

Vital Products and Sound Advice

One of Chemours' greatest strengths is our technical expertise. As our offering of excellent materials continues to grow, so does our commitment to helping you succeed. Our technical services laboratories can provide the right solution for applications that involve new materials or processes among many others. Our business personnel can offer sales and marketing support. If you have a problem, we'll see you through to the solution. Chemours is continually developing new products and practices to meet your evolving needs.

Global Research and Technical Service Centers

Technical Services Laboratories (TSL)— Delaware, USA

As Chemours' main center of competency for fluoropolymer technical service, TSL focuses on material, process, and application development as well as technical and customer support. The Teflon™ technical service group facilitates communication and information sharing across various internal functions, such as R&D, manufacturing, sales, and product stewardship, to meet the needs of our external customers. The TSL facility has commercial-scale processing equipment that enables customer problem solving and rapid prototyping. Our expert scientists and engineers have access to equipment for wire and cable processing, foaming, tube extrusion, rotomolding, cable testing, and PTFE dispersion coating and testing.

The Teflon™ technical service strategy includes these five points:

Best-in-class technical service

- Product selection and process support
- Yield improvement/scrap reduction

Market-driven innovation

- New product/application development
- Differentiated product performance

Customer intimacy

- Detailed customer process knowledge
- Market VOC and demand forecasting

Manufacturing/operations support

- Process optimization and capacity release
- Quality improvement

Technical marketing

- Targeted value propositions
- Literature and publications

China Technology Center—Shanghai, China

Our center for research, product development, customer support, and materials testing for customers across Asia since 2007. Over 30 scientists and engineers at the center provide in-market application expertise for customers and connections to knowledge from around the world.

They support materials research for customers involved in automotive, bio-based materials, chemical production, coatings, communications, computers, consumer electronics, packaging, protection, and safety applications.

The center provides process optimization for advanced manufacturing, part fabrication, and polymer blending. It also provides analytical capability for materials characterization, failure analysis, and performance properties.

European Technical Center (ETC)—Meyrin, Switzerland

Our European research and development center focuses on both evolving our core chemistries and creating specialized applications for customers. Nearly 200 scientists and engineers support markets in Europe, the Middle East, and Africa. Since its inception in 1989, ETC has been at the forefront of applied research and dynamic product development. ETC's activities are fully aligned with market needs and driven by sustainable growth objectives.

The products and applications developed and tested at ETC serve several thriving markets and industries, mainly automotive, aerospace, transportation, cosmetics, and oil and gas. Capabilities extend from early-stage research through commercialization, supported by processing, prototyping, and testing expertise.

Many customers and end users come to this Center of Excellence for training, product demonstrations, scientific seminars, joint developments, marketing and technical expertise, as well as industry standardization (ISO, ASTM, DIN, AFNOR, BSI) and product stewardship support (FDA, UL, REACH). Through ETC, clients can benefit from the global network of Chemours' expertise.

MDF—Shimizu, Japan

MDF is a joint venture started between Mitsui and DuPont in 1963, and it is the only location with R&D, analytical, technical service, and production all in one site. Each function collaborates for quick scale-up and commercialization by sharing technical data, knowledge, and analytical/processing equipment.

MDF is able to not only produce material, but also mold, extrude, and compound articles. MDF has state of the art testing equipment for rheology, tribology, and other physical property testing. The Shimizu site's assets allow MDF to develop new products, characterize products and molding processability, and access products for applications important to global leading strategic customers.



Chemours Global Research and Technical Service Centers

HOW TO USE THE TEFLON™ BRAND NAME WITH YOUR PRODUCT

Teflon™ is a registered trademark of Chemours for its brand of fluoropolymer resins, coatings, films, and dispersions. The Teflon™ brand name is licensed by Chemours in association with approved applications. Without a trademark license, customers may not identify their product with the Teflon™ brand name, as Chemours does not sell such offerings with the Teflon™ trademark. Unlicensed customers may refer to the Chemours product offering with only the Chemours name and product code number descriptor as Chemours sells its product offerings. There are no fair use rights or exhaustion of rights to use the Teflon™ trademark from buying from Chemours, a Chemours customer, or a distributor without a trademark license from Chemours.

If you are interested in applying for a trademark licensing agreement for the Teflon™ brand, please visit www.teflon.com/license

For more information, visit Teflon.com

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