GORE AEROSPACE & DEFENSE DEROGATION SUPPORT MATERIALS

DRAFT FOR COMMENT

NEMA – AEROSPACE Cable

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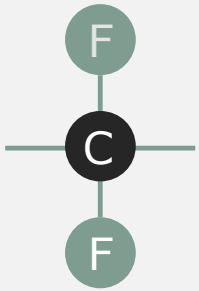
Together, improving life

Overview

Per- and Polyfluoroalkyl Substances (PFAS)

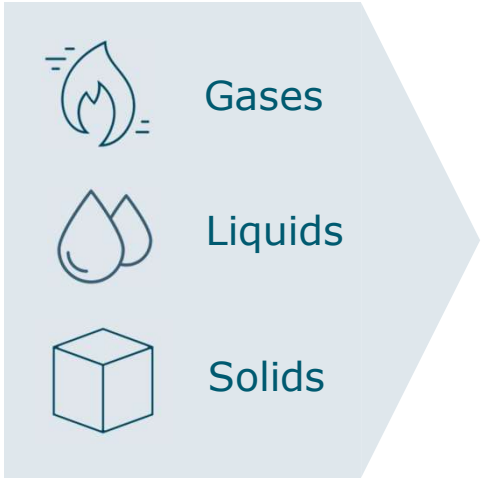
Thousands of PFAS **with a wide variety of properties**

Similarities

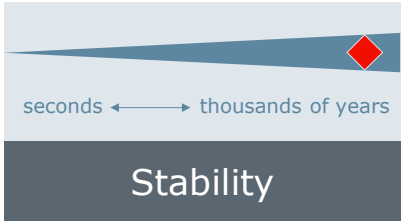


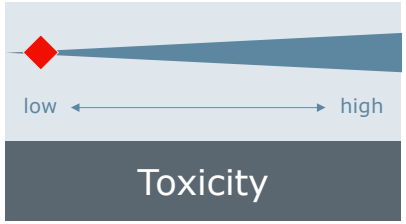
1 fully fluorinated carbon

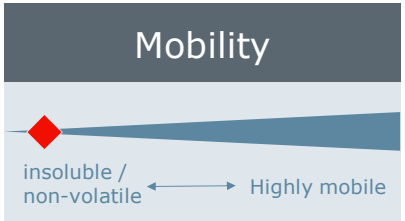
Differences

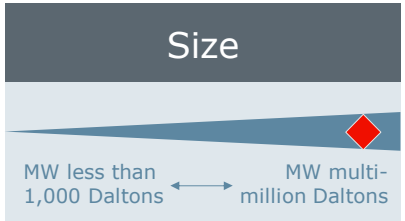


PTFE on the spectrum





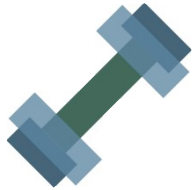




Fluoropolymers – Key properties

Durability

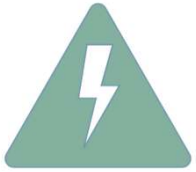
Inertness



Mechanical strength

Thermal stability

Resistance to degradation



Low Dielectric Constant

Benefits of Fluoropolymers in Aerospace & Defense – Wire, Cable, Sealants

Unique Material Characteristics Deliver Superior Platform Performance

Base Material Properties

- Broad temperature range
- Chemical inertness
- Stable in harsh environments
- Non-flammable
- Flexible
- High mechanical strength
- Low dielectric constant
- High dielectric strength
- UV resistant
- Low coefficient of friction
- Hydrophobic
- "Engineer-able"
- Radiation resistance (cross-linked ETFE)

Engineered Characteristics

- Superior mechanical durability
- Superior signal integrity
- Durable in harsh environments
- Lighter weight
- Greater flexibility
- Smaller size
- Configurable material properties
- Expandable (ePTFE)
- Fillable (Dopants)
- Lower electrical loss
- Increased phase stability

System Impact

- Superior power transmission
- Superior signal transmission
- Higher electrical density
- Less fuel consumption
- Less arc tracking
- Better sealing
- Faster installation
- More consistent installation
- Reduction of voids/air
- Longer lifetime
- Lower launch cost

Platform Impact

- Superior safety
- Improved reliability
- Increased mission assurance
- Longer operational range
- Greater sustainability
- Improved energy efficiency
- Improved maintainability
- Reduced unscheduled maintenance
- Reduced down time
- Increased payload

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Relative Performance of Fluoropolymers in Aerospace and Defense

Draft: Wire & Cable Property Comparison for Broader Customer/Market Input and Support Feedback Desired

Disclaimer: Material Family Properties are Approximations Across Broad Material Sets.
Gore has created this table based on a collection of internal data, external data, and experience

	Characteristic	Typical Aerospace requirements	Fluoropolymers	Polyimide	Polyester	Polyethylene	Polyurethane	Silicones	PVC	Foamed Polyethylene
	Max Temperature[1,2]	200 C								
	Min Temperature	-65 C; Cold Bend EN3475-406								
	Flammability, Toxicity	EN3475-407, EN3475-602								
	Chemical Resistance[3]	EN3475-411								
	Arc Tracking	MIL-STD-2223				?	?	?		?
	Hydrolitic stability	EN3475-412								
	Long term Thermal stability[1]	EN3475-416								
	Dielectric Constant[4]	low Er for smaller lighter weight cables								
	Cut through resistance /Abrasion resistance	EN3475-503/EN3475-501								
	Flexibility (stiffness, and springback force)	AS4373-707 (Gore experience)								
SPACE FOCUSED	Combination of low loss over broad temperature range[5]	See Dielectric Constant Over Temperature Range								
	Outgassing	ASTM E595 TML ≤ 1% (Gore experience)								
	Radiation Resistance	Cross-linked ETFE performance unique	Cross-linked ETFE Specific							

Sources of Information

(1) - "Max Temperature - Thermal Index. The thermal index is computed usin the projected 15,000 hour life based on the ASTM D3032, Section 14. The minimum thermal index shall be 200 C" (Ron Solomon, June 1991, *New Insulation Constructions for Aerospace Wiring Application* s (WL-TR-91-4066 Volume 1). St. Louis, Missouri,: McDonnel Douglas Corporation, p. 15), (Lectromec,2016)

(2) Use of Cables on Aircraft - Lectromec (Link: https://lectromec.com/use-of-cables-on-aircraft-part-1/)

(3) rating for Chemical Resistance taken from Chemical Resistance Chart PN 41-6018/rev. C (Emerson Process Management, 2010; Link: https://studylib.net/doc/18540781/chemical-resistance-chart---emerson-process-management: https://studylib.net/doc/18540781/chemical-resistance-chart---emerson-process-management)

(4) Dielectric constant: for microwave cable assemblies' dielectric material, smaller dielectric constant values are more desirable because it concurrently enables ultra-low attenuation of microwave/RF signal over distance, smaller phase/amplitude change over temperature, shorter time delay of microwave/RF signal over distance, and lower capacitance over distance to enable precise and accuurate microwave/RF transmission

(5) The sustainable use of PTFE in Wire and Cable, Gore Internal White Paper, Amadeus Wiesemann, November 2022.

←Data on next slide

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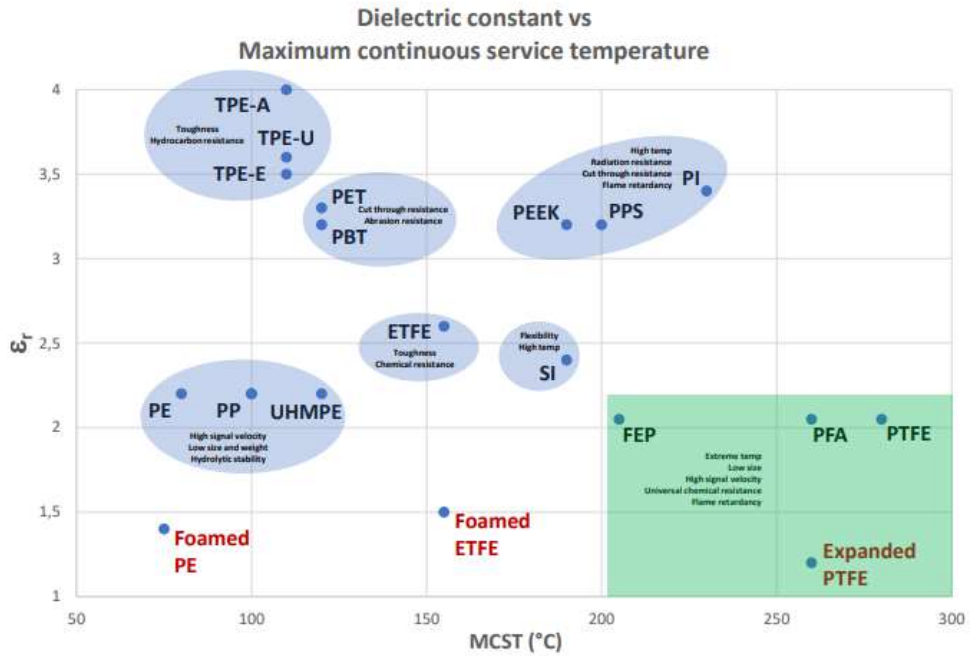
Dielectric Constant vs Maximum Continuous Service Temperature

Combined view of dielectric performance and thermal resistance

A graphical representation of dielectric constant versus MCST exemplifies some of the capabilities of dielectric and insulating thermoplastic materials. In addition to their environmental stability and ε_r derived properties, a selection of general material attributes are added to visualize property combinations which correlate with the application areas of the materials.



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THANK YOU

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