

Estane[®] TPU

Pushing the Boundaries of High-Performance

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Topics

Intro to Lubrizol

TPU – a Unique Polymer

Pushing Boundaries of Performance

TPU Capabilities

Bringing Value to Power & Fluid Systems



Lubrizol is a global specialty chemical company

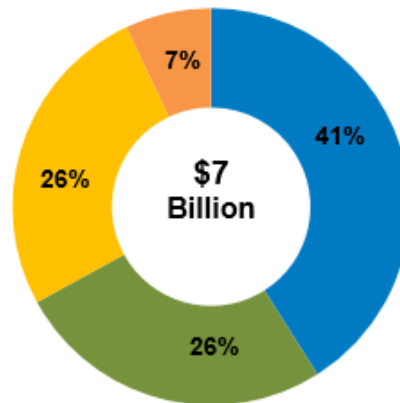
We combine complex, specialty chemicals to optimize the quality, performance and value of our customers' products while reducing their environmental impact.

The Lubrizol Corporation: A Berkshire Hathaway Company

- Berkshire Hathaway is ranked # 4 on the Fortune 500
- One of the world's largest public companies
 - 2015: revenues \$211 billion, net income \$24 billion
 - Headquarters: Omaha, Nebraska
 - Chairman & CEO: Warren E. Buffett

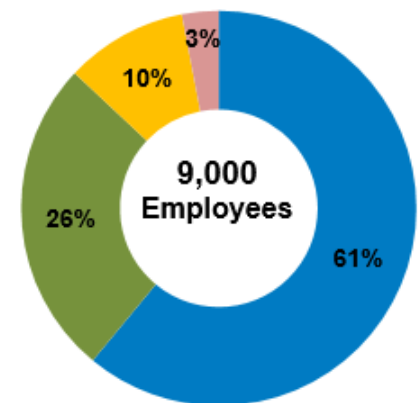


Consolidated Revenues



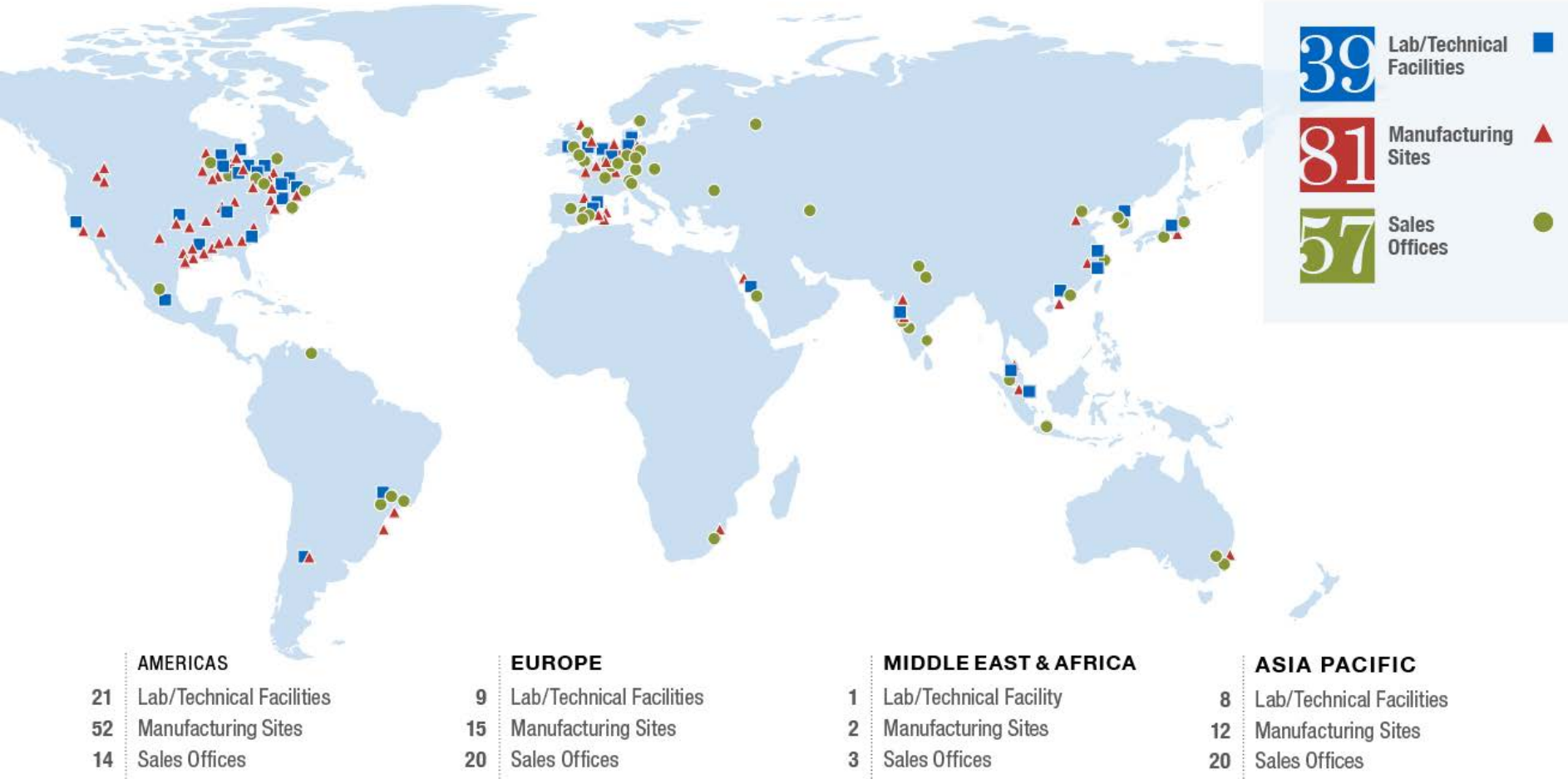
■ North America ■ Europe ■ Asia/ME ■ Latin America

Worldwide Employees



*Revenue and employee information - 2015

Global Presence



Business Segments

Lubrizol

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graph TD; Lubrizol --> Additives; Lubrizol --> Materials; Lubrizol --> Solutions;
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LUBRIZOL ADDITIVES

A pioneering global supplier of chemical additive technologies including additives for engine oils, driveline and transportation-related fluids, industrial lubricants, gasoline and diesel fuel

LUBRIZOL ADVANCED MATERIALS

A leading global producer of advanced specialty polymers, polymer-based additives and chemical additives used in everyday consumer and industrial applications

LUBRIZOL OILFIELD SOLUTIONS

An advanced technology solutions provider to all phases of oilfield activity including exploration, production and transportation

Lubrizol Additives

Product lines

- Engine Additives
- Driveline Additives
- Industrial Additives
- Fuel Additives

- Develop products that play an essential part in the proven performance of the finished lubricant
- Test additives extensively in the lab and in the field under real-world conditions
- Help customers differentiate and succeed through trusted expertise, testing confidence, global supply and independent strength



Our products keep the world moving...

Lubrizol Oilfield Solutions

Product lines

- Oilfield Chemistry
- Pipeline Flow Improvers

- Offering industry-leading quality, technology and supply chain reliability
- Striving to exceed our customers' expectations for performance and service
- Leveraging expertise and numerous technologies to deliver targeted chemical solutions for customers



Creating essential chemistry to meet industry needs and reduce environmental impact...

Lubrizol Advanced Materials

Product lines

- **Engineered Polymers**
- Personal and Home Care
- Performance Coatings
- CPVC Piping Systems
- Life Sciences

- **The inventor and one of the largest manufacturers of thermoplastic polyurethanes in the world**
- Leverage core polymer and surface active chemistries and formulations
- Create proprietary, high-performance materials for our customers in a wide range of industries
- Innovation leader, and industry partner

At work...and at home... Anywhere you are!



The Estane[®] TPU Advantage

Bringing high performance to Power & Fluid Systems

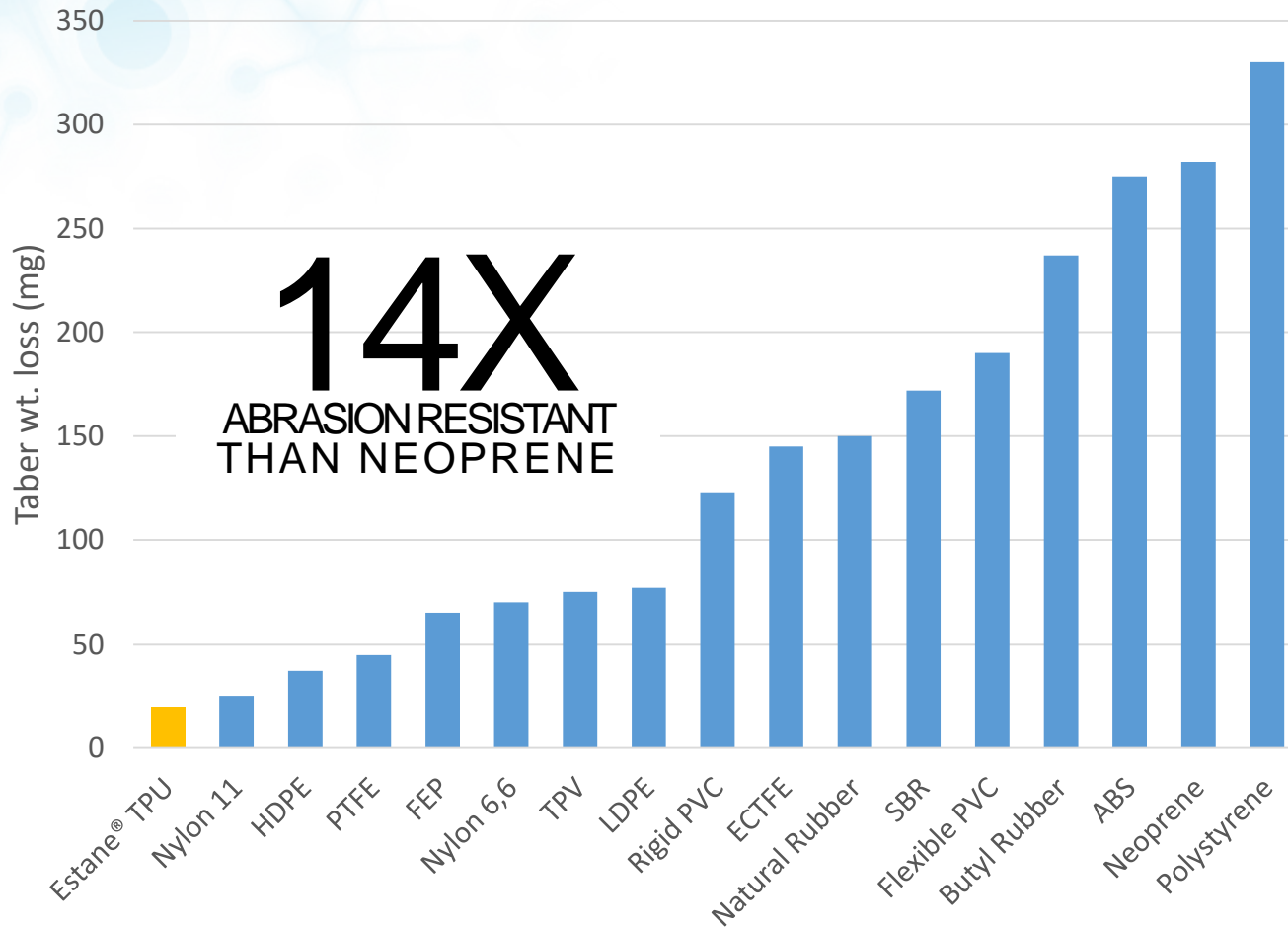
Abrasion Resistance

Chemical Resistance

Low Temperature
Flexibility

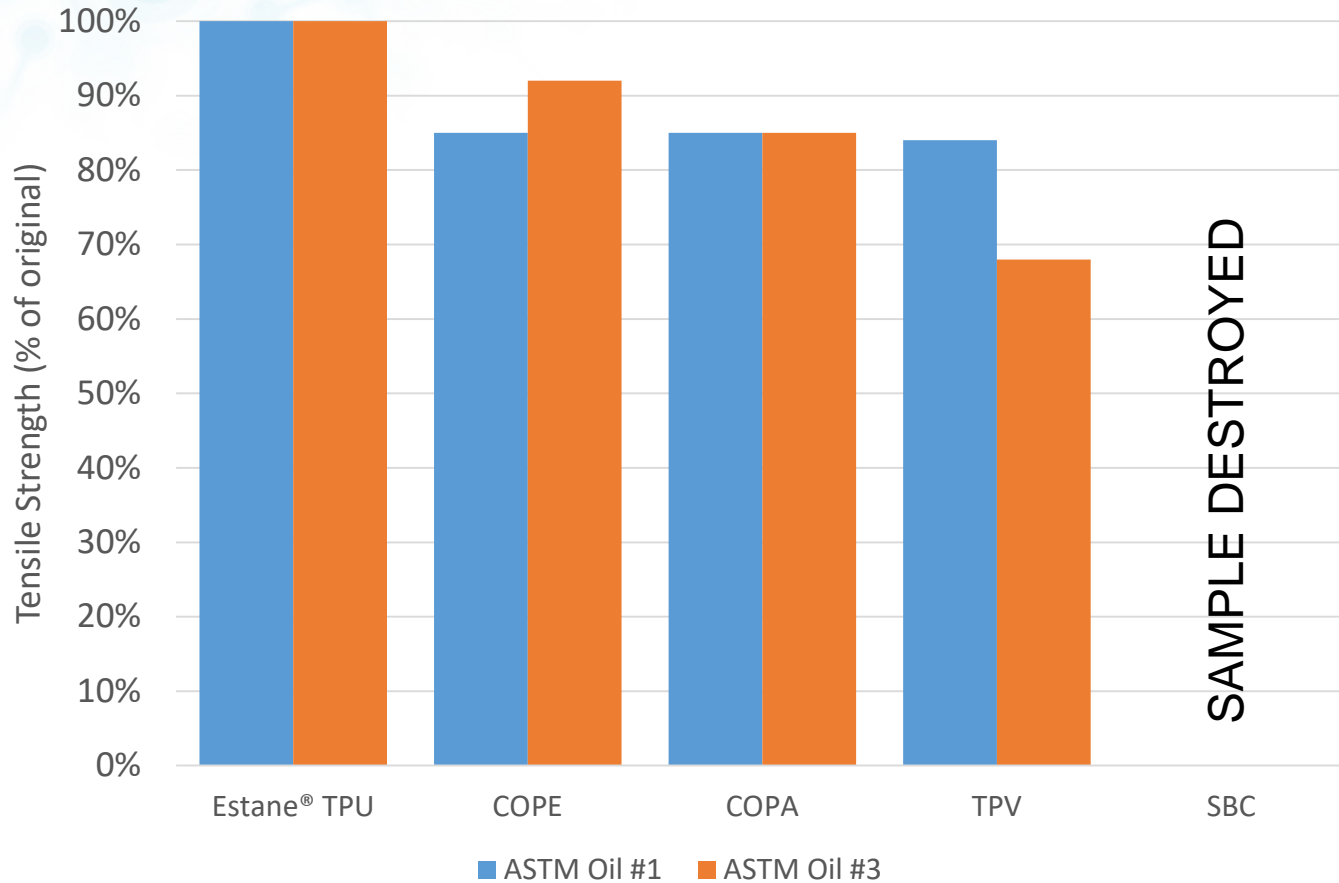


TPU Abrasion Resistance

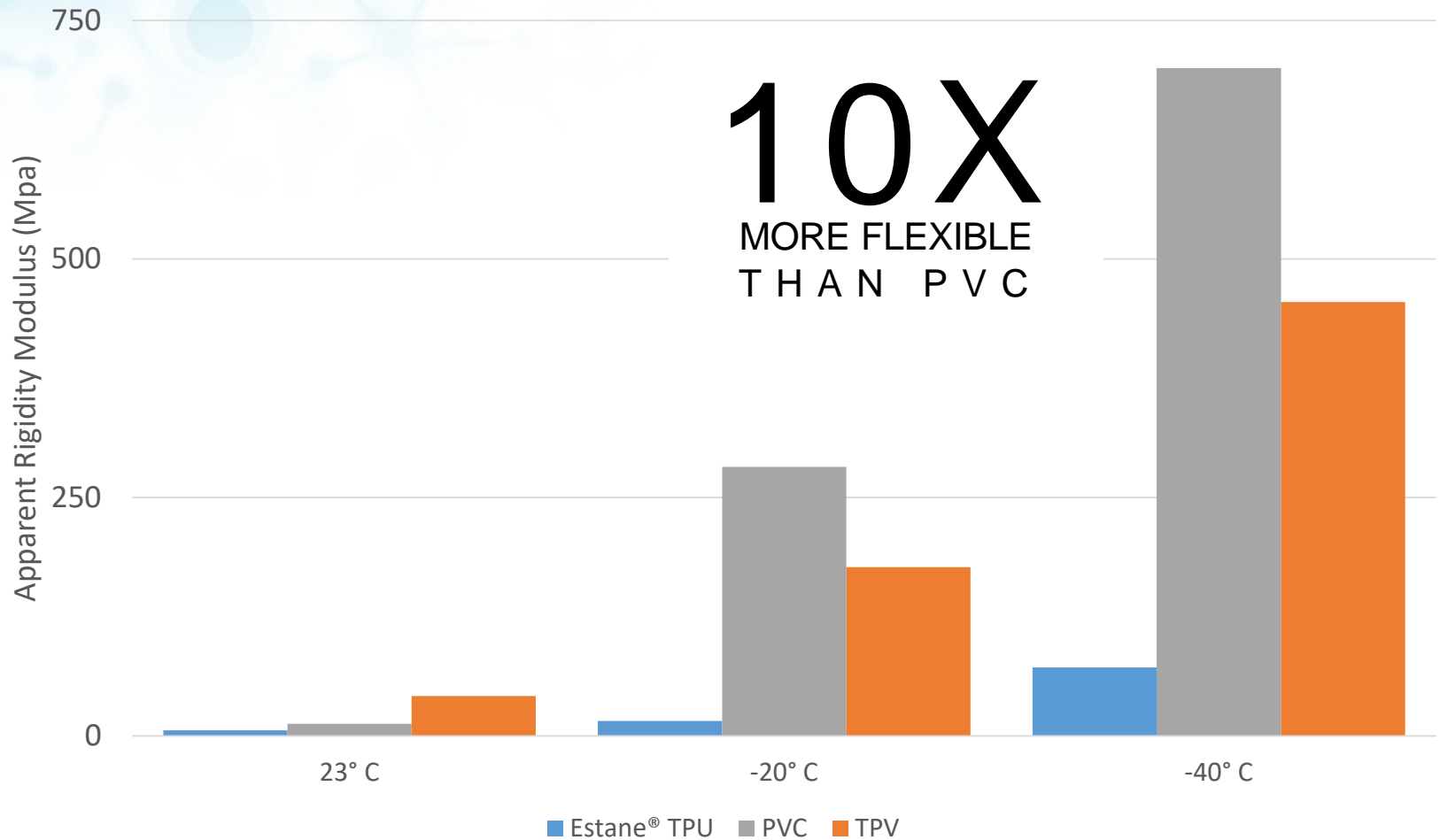


TPU Chemical Resistance

Oil Aging Strength Retention



TPU Low Temp Flexibility (ASTM D1053)



Pushing the Boundaries

Estane® High Performance Series

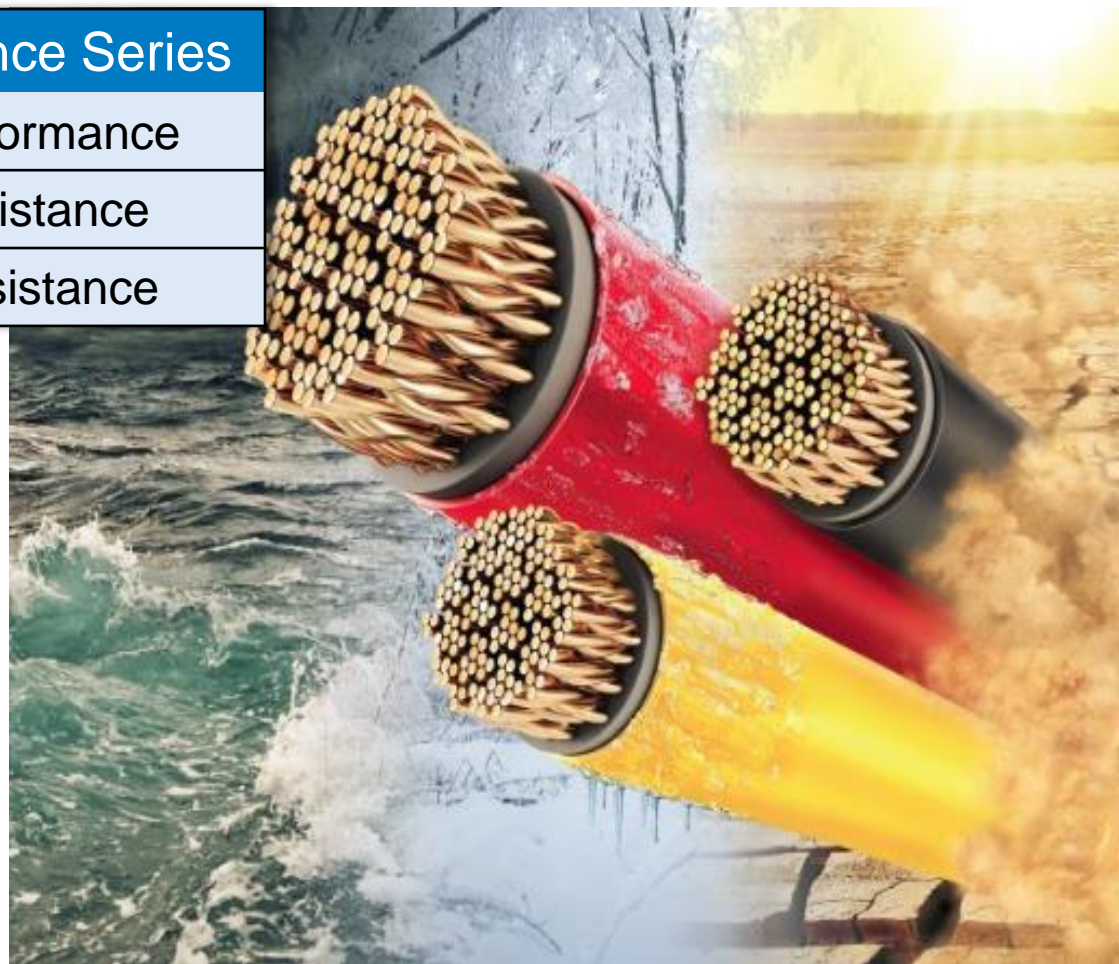
Higher temperature performance

Improved chemical resistance

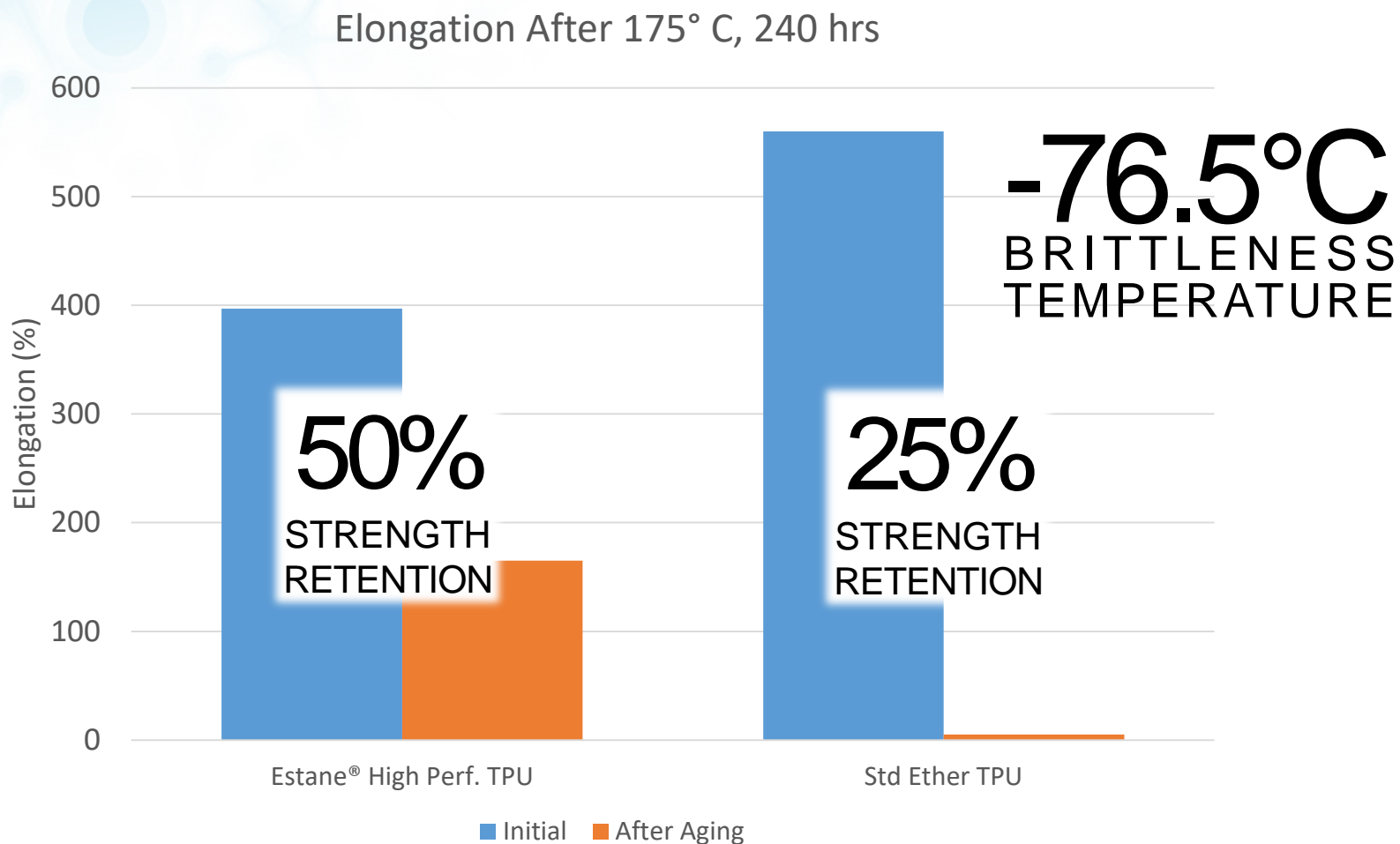
Excellent hydrolysis resistance

Applications in:

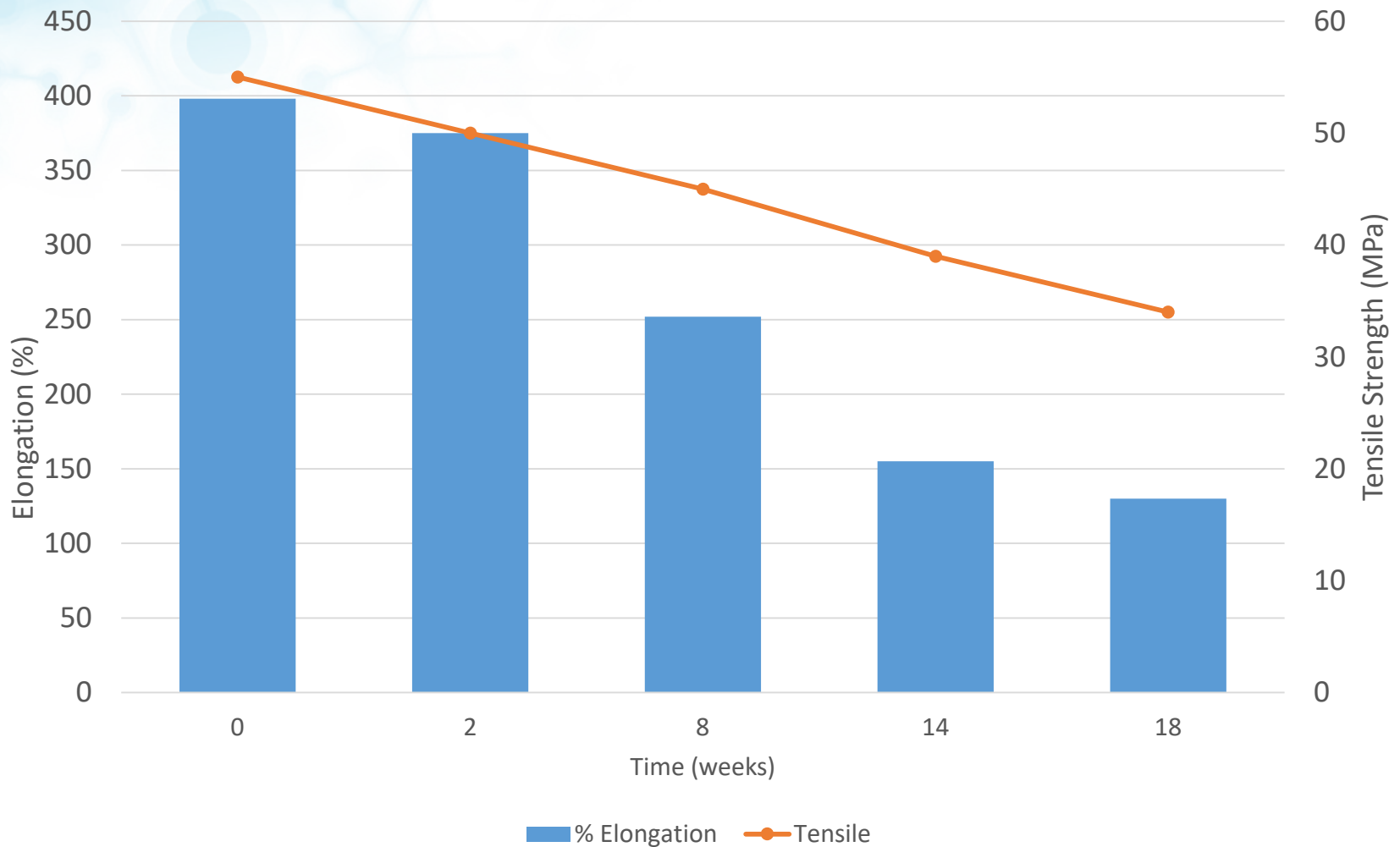
- Transportation
- Communications
- Oil & Gas
- Marine
- Mining
- Military



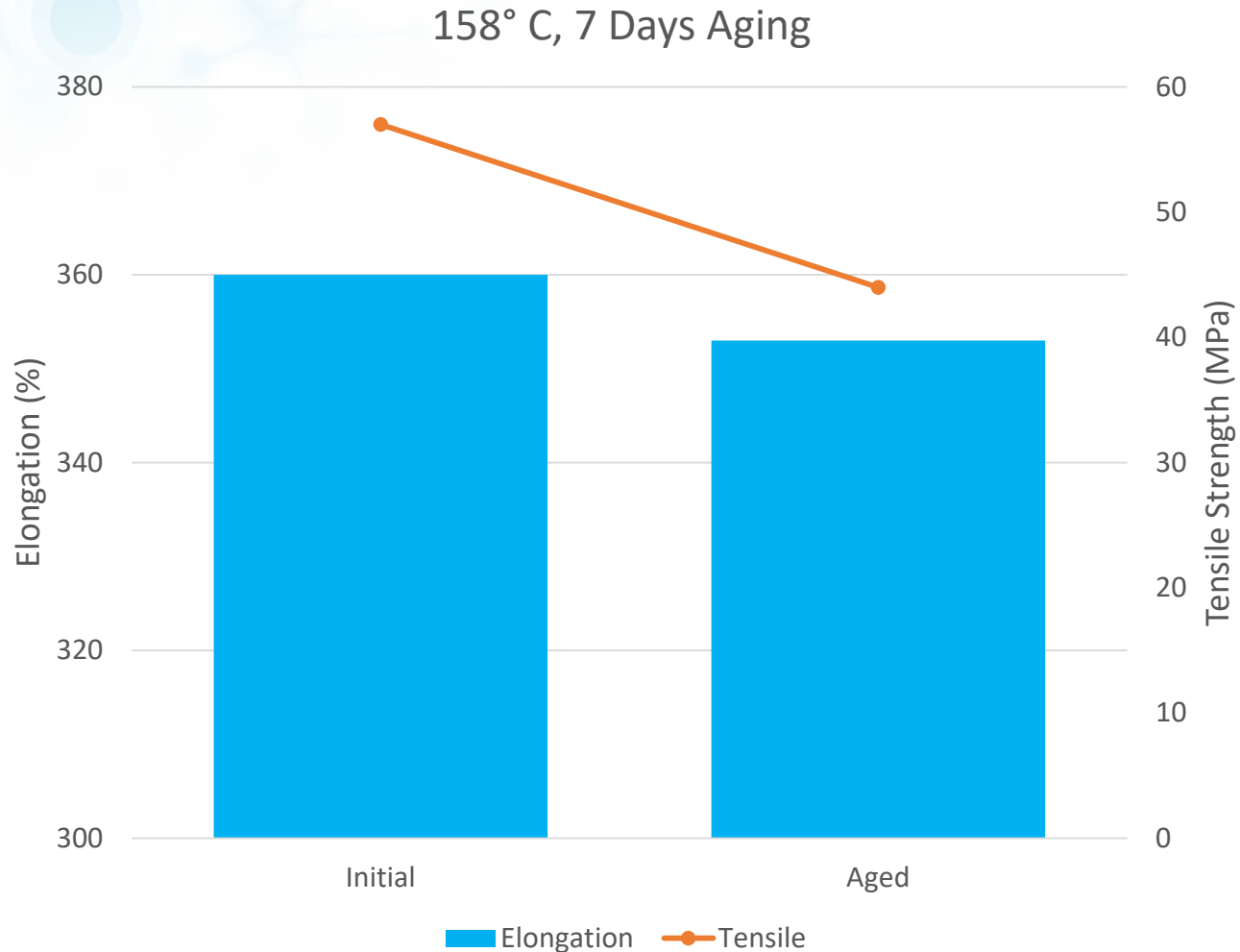
Extreme Temperature (ISO 6722, ASTM D746)



150°C Performance!

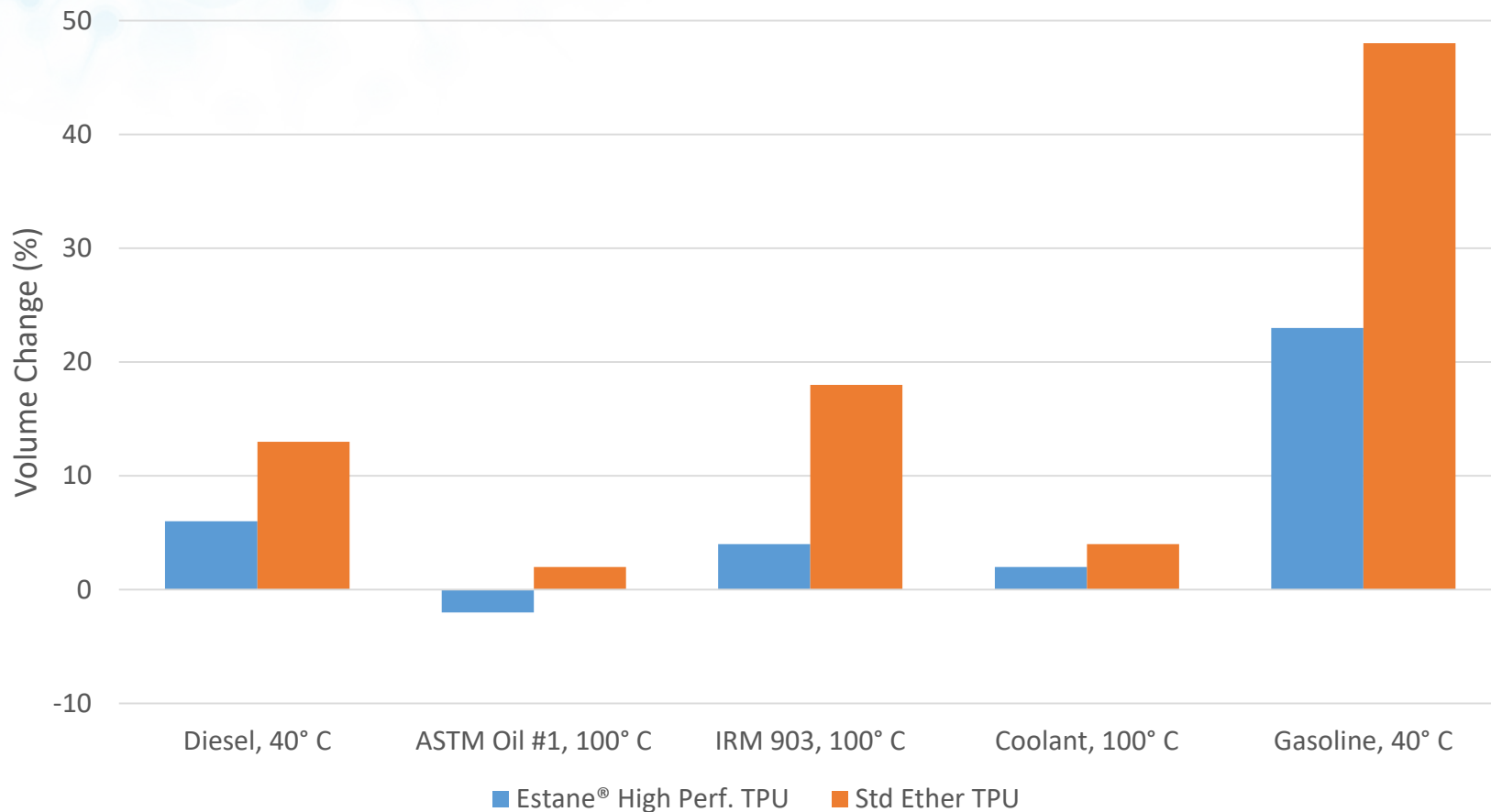


UL 125°C Performance (UL 1581)

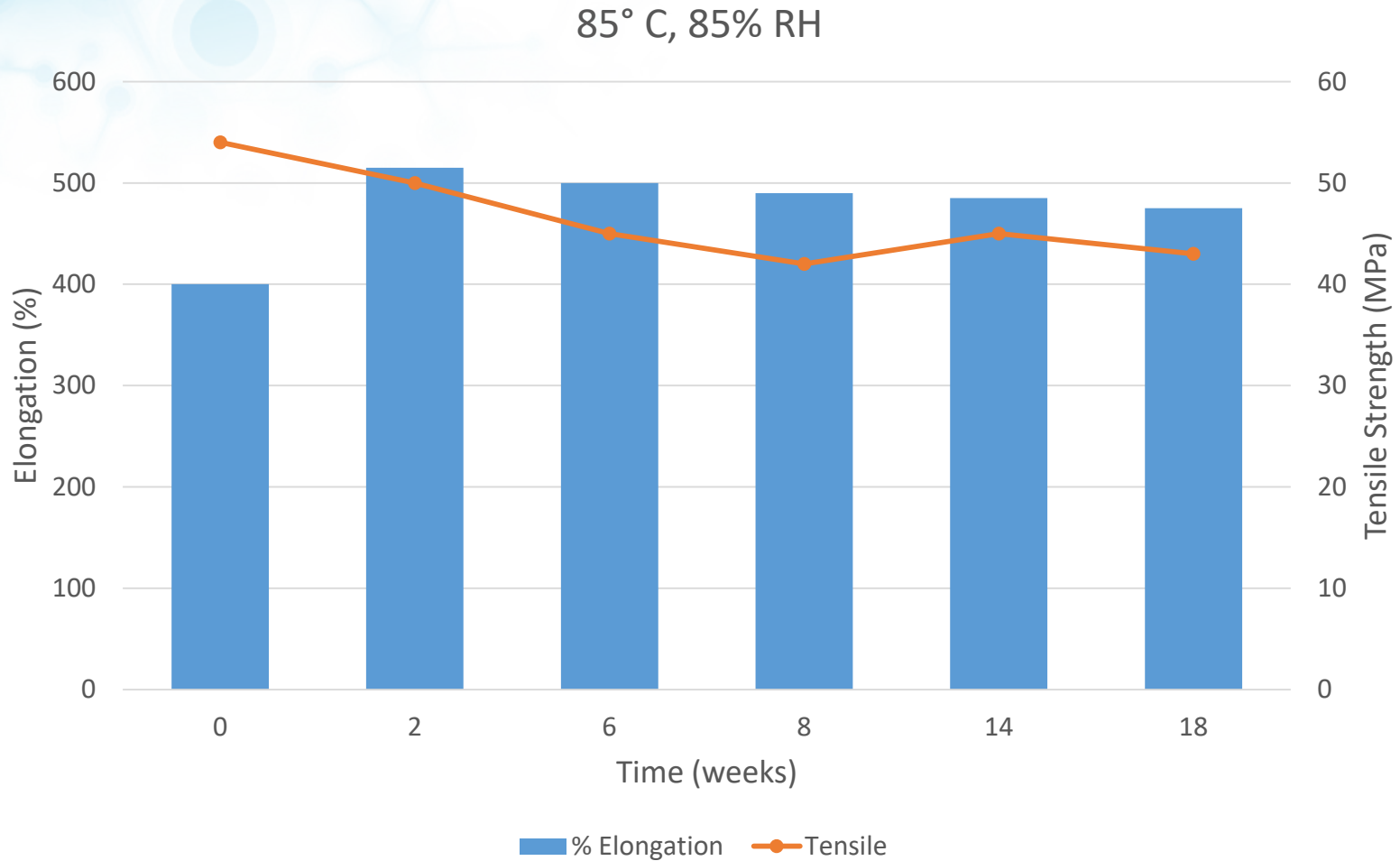


Improved Chemical Resistance

Volume Change After 7 Days Exposure



Excellent Hydrolysis Resistance



Technologies

Chemical Resistant



Easy-to-Extrude (ETE)



Flame Retardant



Bio-Based*



Polymer
Compatibility



Glass Reinforced



Static Dissipative



Soft Elastic



* Bio-based content as certified in accordance with ASTM D-6866

Processes

Blow Molding



Calendaring



Extrusion



Fabric Coating



Film & Sheet



Injection Molding



Overmolding



Solution Process



Flame Retardants

Ethane[®] FR TPU

- Halogenated
- Non-Halogenated (NHFR)
- Low Smoke, Zero Halogen (LSZH)

Alternative to PVC solutions

- Abrasion
- Chemical
- Flexibility
- Antimicrobial Resistance



Flame Retardant Product Offerings

Product Family	Product	Hardness	Finish	UL Vertical Burn Rating	Mechanical (Tensile)	Low Smoke (Yes or No)	Comment
Halogen	58370	80A	Matte	V2 / LOI 25	High	No	Low-Temperature Flexibility
	58202	85A	Matte	V0 / LOI 30	High	No	Industry Standard
	58211	90A	Matte	V0 / LOI 32	High	No	Standard Grade
Non-Halogen	ZHF 80AT3	80A	Gloss	V2 / LOI 25	High	No	Softest NHFR / Clear
	58244	90A	Matte	V0 / LOI 28	Average	Yes	Low Smoke
	ZHF 90AT0	90A	Gloss	V2 / LOI 24	High	No	Clear Version
	ZHF 90AT2	90A	Matte	V2 / LOI 25	High	Yes	Higher Mechanicals
	ZHF 95AT3	95A	Matte	V0 / LOI 39	Average	No	High LOI

New Flame Retardant sales sheet available at: <https://www.lubrizol.com/Engineered-Polymers/Literature/Brochures.html>

Bio-based TPU

Produced of renewable-sourced ingredients

- 30%-70% bio content
- 82A-55D shore hardness

No performance compromise!

- Superior abrasion resistance
- Very good chemical resistance
- Cold temperature flexibility
- UV and hydrolysis resistance
- Transparency
- Outstanding mechanical properties
- Processed via injection molding extrusion



Bio-based Product Offerings

TPU for injection molding and extrusion:

Product	Percentage of bio-based content*	Hardness	Comment
Pearlthane® ECO D12T80	42%	82 Shore A	Food-contact grades may be available upon request.
Pearlthane® ECO D12T85	46%	85 Shore A	
Pearlthane® ECO D12T90	38%	91 Shore A	Food-contact grades may be available upon request.
Pearlthane® ECO 12T95	32%	95 Shore A	UV-stabilized.
Pearlthane® ECO D12T55D	29%	55 Shore D	

Polymer Compatibility

Deliver unique properties in alloys with polar polymers

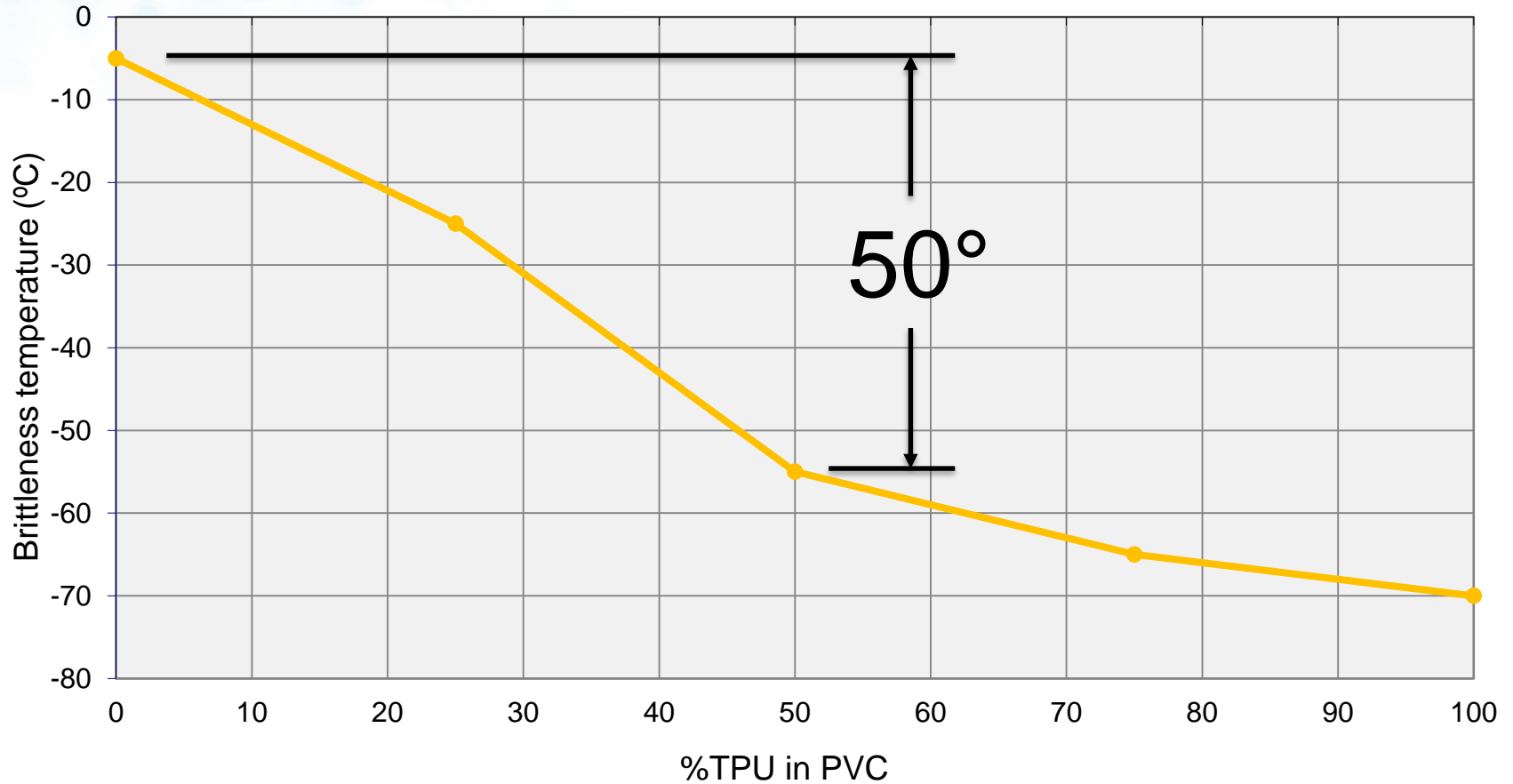
- ABS, SAN
- Acrylic
- PBT
- PET, PETG
- Polycarbonate
- Polyesters
- PVC
- SEBS, SIBS



TPU / PVC Compounds

- A number of unique benefits over plasticized PVC
 - None or less plasticizer for extended or permanent flexibility
 - Less migration of plasticizer if partly used
 - Lower temperature brittleness point
 - Enhanced oil and chemical resistance
 - Improved mechanical and thermal properties
 - Outstanding abrasion resistance
 - Better melt adhesion to PC and ABS
 - Better RF weldability
- Use as little as 5% to recognize modified properties
- Suitable for demanding FR requirements
- Possible to blend during melt process
 - Pre-compound if desired

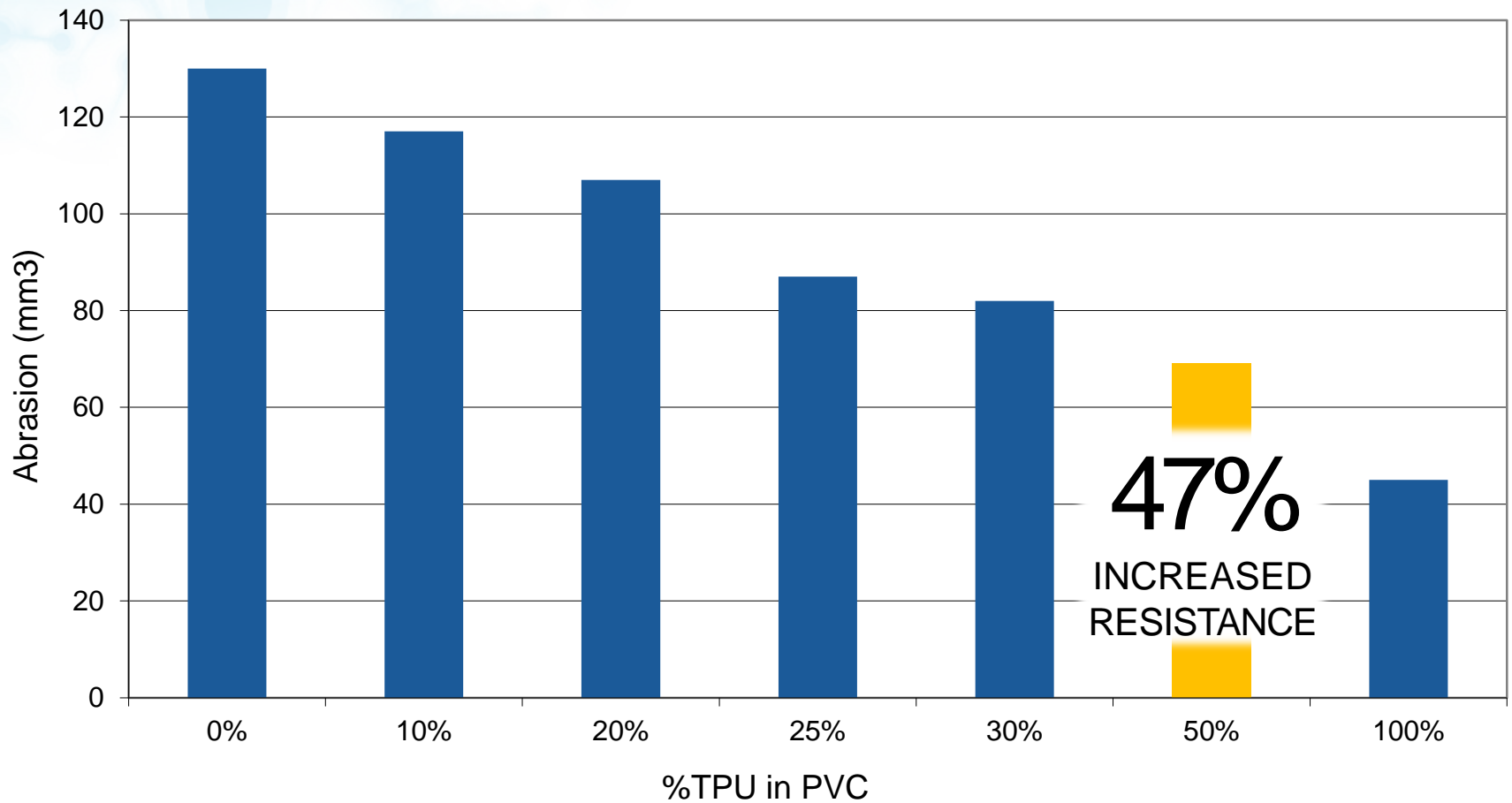
TPU / PVC Compounds – Brittleness Temp



TPU / PVC Compounds – Enhanced Chemical Resistance

Olive Oil	PVC		PVC / Estane 58213	
(24 h @ 70 °C)	(reference)		(80/20)	
	TS (MPa)	EL (%)	TS (MPa)	EL (%)
Initial	14.5	415	16.1	515
After 24 hours	12.9	350	15.6	500
	89%	84%	97%	97%

TPU / PVC Compounds – Abrasion Resistance



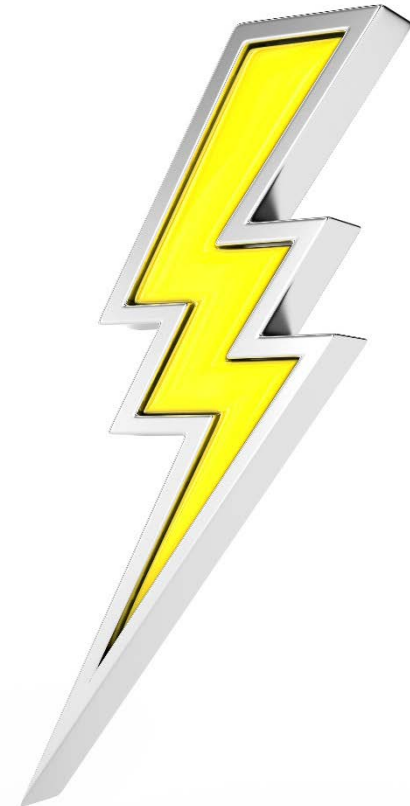
Static Dissipative

Permanent ESD

- Non-Carbon Containing
- Colorable
- Consistent Properties, as low as 4.8×10^{-7}
- Alloy compatibility (masterbatch available)

Typical uses:

- Clean rooms
- Explosive environments
- Sensitive electronics
- Pneumatic Conveying
- Around Powders



Stat-Rite® TPU Based IDP Compounds

Product Name	Surface Resistance (ohms)*	Volume Resistance (ohms)	Durometer	FDA Status	Applications
E-1140 Ester	3 x 10 ¹⁰	5 x 10 ¹⁰	82A	21CFR175.105 21CFR177.2600	Hose, Tubing, Belting & Film
E-1150 Ether	5 x 10 ¹⁰	5 x 10 ¹⁰	88A	21CFR17.105	Hose, Tubing, Belting & Film
S-1100 Ether	5 x 10 ⁹ Better ESD	5 x 10 ⁹	90A / 47D	None	Hose, Tube, Belting, Film & Softwall Curtains
S-1107 S-1107L **	4.8 x 10⁷ Best ESD	2.3 x 10⁷	83A	None	Mats, Tubing, Hose, Belting & Film

- * Ohms x 10 yields resistivity property,
- ** - L grade for ionic extractable cleanliness applications.
- E series TPU IDP grades not great ESD but FDA compliant
- S Series TPU IDP grades – excellent ESD performance but not FDA compliance

Compliance & Certifications

REACH

UL

ISO

Flame Resistance

Food & Beverage

- EU
- FDA
- 3A
- NSF 51 & 61

Fuel/Oil Resistance

Mil-Spec

Mud Resistance

UV



Applications | Hose & Tube

Multilayer or single layers spiral hoses, braided hoses and TPU tubing are used in:

Sewer cleaning hoses

Oil and Gas - lay flat hose and material transfer hoses

- Chemicals, fuels, solids

Air powered tools

Dental equipment

Fire Hose

Pneumatic tubing

Garden hoses

Fuel hoses

Vacuum cleaner hoses

Material Transfer:

- Chemical liquids – paint spray hose
- Abrasive substances
- Food & beverages
- Potable water



Applications | Wire & Cable

Extruded jacketing, molded connectors, overmolded encapsulants and strain reliefs:

Power/Energy

- building/construction, mining, coiled/spiral cables, alternative energy

Telecommunication

- telephone/data, military, fiber optics

Geophysical

- land/marine, ocean bottom/off-shore, umbilical

Automotive

- anti-lock braking systems-ABS harnesses sensor battery

Oil & Gas

- multi-layer, single layer, MUX, downhole and seismic cable

Industrial

- robot, chain, signal

Mass Transit

- train/boat/airplane and subway/airport/public buildings

Miscellaneous

- spiral/retractable, video/audio



Applications | Belting

Belts produced as Cleated, Modular, Reinforced, and Monolithic:

Power Transmission Belting

Timing Belts

Conveyor Belting

- Airports
- Metal Processing
- Sand & Gravel
- Food Processing
- Paper Pulp



Applications | Seals & Gaskets

Produced by injection molding or extrusion:

Actuator Seals:

- Pneumatic
- Hydraulic

Rod Wipers

Gaskets:

- Food & Beverage
- Pharmaceutical
- Industrial



TPU – Meeting Demands of P&FS Requirements!

Estane[®] - Bringing Higher Performance to TPU

- Increased **temperature** resistance
- Improved **chemical** resistance
- Excellent **hydrolysis** resistance

New Innovations in Development

- Higher Temperature!
 - >150°C
- Enhanced Hydrolysis!
 - High pressure steam
- More Chemicals!

Let us be your partner!



Thank You

www.lubrizol.com/engineeredpolymers

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