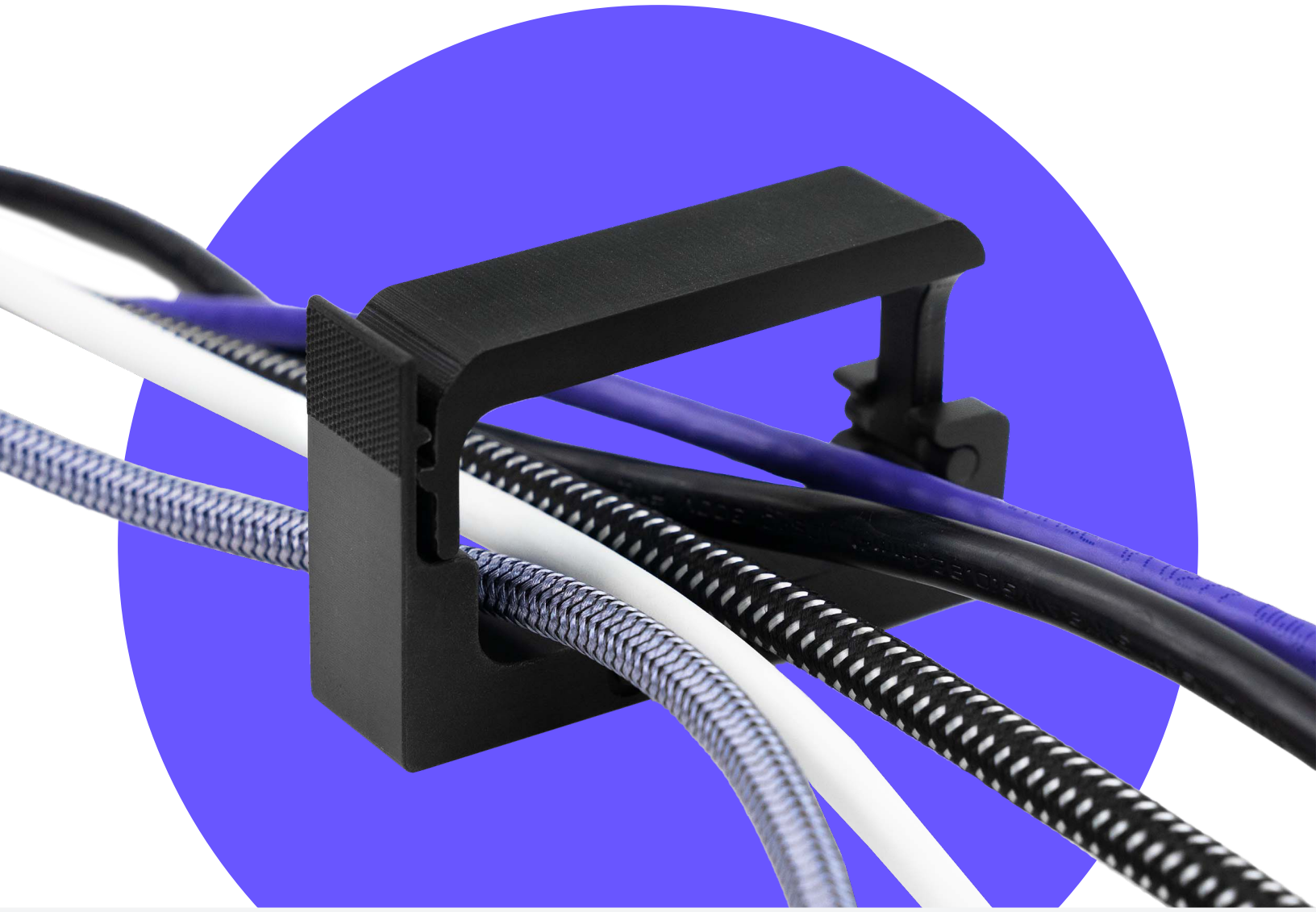

EPX 86FR

Flame-retardant, functional tough, high-strength, and long-term stability

Table of Contents

EPX 86FR offers an unmatched combination of flame-retardance, functional toughness, high strength, and long-term stability. It suits well for consumer, automotive and industrial applications that require UL 94 V-0 or 25.853(a) ratings with flame-retardant and self-extinguishing features.

Tensile Properties*	Test Standard	Metric	English
Tensile Modulus	ISO 527-2 Type 1A 5 mm/min	3300 MPa	480 ksi
Ultimate Tensile Strength		90 MPa	13 ksi
Elongation at Break		5%	5%

Tensile Properties*	Test Standard	Metric	English
Tensile Modulus	ASTM D638 Type V 1 mm/min	3300 MPa	480 ksi
Tensile Yield Strain		5%	5%
Ultimate Tensile Strength		90 MPa	13 ksi
Elongation at Break		10%	10%

Flexural Properties*	Test Standard	Metric	English
Flexural Stress at 5% strain	ASTM D790-B	140 MPa	20 ksi
Flexural Modulus (Chord, 0.5-1%)		3500 MPa	510 ksi

Impact Properties*	Test Standard	Metric	English
Unnotched Charpy	ISO 179-1/1eU	30 kJ/m^2	14.3 ft-lb/in^2
Notched Charpy (Machined Notch)	ISO 179-1/1eA	2.7 kJ/m^2	1.3 ft-lb/in^2
Unnotched Izod, (23 °C, -40 °C)	ASTM D4812	490 J/m, 393 J/m	9.2 ft-lb/in, 7.4 ft-lb/in
Notched Izod (Machined Notch), (23 °C, -40 °C)	ASTM D256	30 J/m, 30 J/m	0.6 ft-lb/in, 0.6 ft-lb/in

Flammability	Metric
Flammability, UL 94	V-0 (2.0 mm) V-1 (1.5 mm)
FAR 25.853(a) 12 seconds Vertical Burn	Pass (1.0 mm)

The information in this document includes typical values from printing various parts and is intended for reference and comparison purposes only. This information should not be used for testing, design specification or quality control purposes. End-use material performance can be impacted by, but not limited to, design, processing, color treatment, operating and end-use conditions, test conditions, etc. Actual values will vary with build conditions. In addition, product specifications are subject to change without notice.

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Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent.

*Samples were kept in dry conditions and tested within 24 hours.

Thermal Properties	Test Standard	Metric	English
Heat Deflection Temperature* at 0.455 MPa/66 psi	ASTM D648	135 °C	275 °F
Heat Deflection Temperature* at 1.82 MPa/264 psi		130 °C	266 °F
Coefficient of Thermal Expansion (-60, 100 °C)	ASTM E831	70 ppm/°C	40 ppm/°F
Heat Capacity, 23 °C	ASTM E1269	1.6 J/g-°C	0.4 BTU/lb-°F
Thermal Conductivity	ASTM C518	0.2 W/m-k	0.1 BTU/hr-ft-°F

Dielectric/Electric Properties	Test Standard	Metric
Dielectric Strength	ASTM D149	15. kV/mm
Dielectric Constant	ASTM D150	2.9
Dissipation Factor		0.006
Volume Resistivity	ASTM D257	2.4 x 10^{16} ohm-cm
Comparative Tracking Index	ASTM D3638	600 V

General Properties	Test Standard	Metric
Hardness*	ASTM D2240	88 (instant), 87 (5 sec), Shore D
Bulk Density	ASTM D792	1.30 g/mL
Poisson's Ratio	ASTM D638	0.35
Taber Abrasion, CS-17, 1 kg, 100% vacuum	ASTM D4060	23 mg/ 1000 cycles
Water Absorption, Short Term (24 hours)	ASTM D570	1%
Water Absorption, Long Term (14 days)		4%
Material Color		Black

Liquid Properties	Metric
Liquid Density (Part A)	1.25 g/mL
Liquid Density (Part B)	1.18 g/mL
Liquid Density (Part A+B)	1.23 g/mL
Part A:B Volume Ratio (Mass Ratio)	2.00 (2.12)
25 °C Viscosity (Part A)	3200 cP
25 °C Viscosity (Part B)	220 cP
25°C Viscosity (Part A+B)	1200 cP

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Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent.

*Samples were kept in dry conditions and tested within 24 hours.

EPX 86FR

Extended TDS

EPX 86FR Flammability Testing

UL 94 Flammability Rating

Test Summary

LIMS Master Sample	
Master Sample Number:	4153291
Sample Label ID(s):	4153291-1,4153291-2
LIMS Project Number:	1001284141

Material Designation:	EPX 86FR [XY plane]
Color:	Black
Expected Thickness:	2.0 mm
Flame Rating:	V-0

50W (20MM) VERTICAL BURNING TEST; V-0, V-1, V-2						UL94 Paragraph 8
>48hrs@23±2C/50±10%RH						
Sample #: 4153291-1						
#	Thk. (mm)	t1 (s)	Comments - t1	t2 (s)	t2 + t3 (s)	Comments - t2
1	2.066	1.0	Specimen did NOT drip	8.0	8.0	Specimen did NOT drip
2	2.092	1.0	Specimen did NOT drip	1.0	1.0	Specimen did NOT drip
3	2.063	1.0	Specimen did NOT drip	3.0	3.0	Specimen did NOT drip
4	2.039	1.0	Specimen did NOT drip	0.0	0.0	Specimen did NOT drip
5	2.079	1.0	Specimen did NOT drip	0.0	0.0	Specimen did NOT drip
					Total Flame Time, t1+t2 (s):	17.0
					Vertical Flame Result:	V-0
Note:			t1 = Afterflame Time t2 = Afterflame Time t2+t3 = Afterflame + Afterglow Time			

50W (20MM) VERTICAL BURNING TEST; V-0, V-1, V-2						UL94 Paragraph 8
168±2hrs@70±2C|>4hrs@23±2C/<20%RH						
Sample #: 4153291-2						
#	Thk. (mm)	t1 (s)	Comments - t1	t2 (s)	t2 + t3 (s)	Comments - t2
1	2.006	1.0	Specimen did NOT drip	1.0	1.0	Specimen did NOT drip
2	2.015	1.0	Specimen did NOT drip	1.0	1.0	Specimen did NOT drip
3	2.031	1.0	Specimen did NOT drip	5.0	5.0	Specimen did NOT drip
4	2.024	2.0	Specimen did NOT drip	7.0	7.0	Specimen did NOT drip
5	2.038	2.0	Specimen did NOT drip	4.0	4.0	Specimen did NOT drip
					Total Flame Time, t1+t2 (s):	25.0
					Vertical Flame Result:	V-0
Note:			t1 = Afterflame Time t2 = Afterflame Time t2+t3 = Afterflame + Afterglow Time			

EPX 86FR Flammability Testing

UL 94 Flammability Rating

Test Summary

LIMS Master Sample	
Master Sample Number:	4153288
Sample Label ID(s):	4153288-1,4153288-2
LIMS Project Number:	1001284141

Material Designation:	EPX 86FR [XY plane]
Color:	Black
Expected Thickness:	1.5 mm
Flame Rating:	V-1

50W (20MM) VERTICAL BURNING TEST; V-0, V-1, V-2						UL94 Paragraph 8
>48hrs@23±2C/50±10%RH						
Sample #: 4153288-1						
#	Thk. (mm)	t1 (s)	Comments - t1	t2 (s)	t2 + t3 (s)	Comments - t2
1	1.509	1.0	Specimen did NOT drip	12.0	12.0	Specimen did NOT drip
2	1.528	1.0	Specimen did NOT drip	5.0	5.0	Specimen did NOT drip
3	1.525	1.0	Specimen did NOT drip	2.0	2.0	Specimen did NOT drip
4	1.531	1.0	Specimen did NOT drip	2.0	2.0	Specimen did NOT drip
5	1.516	2.0	Specimen did NOT drip	3.0	3.0	Specimen did NOT drip
					Total Flame Time, t1+t2 (s):	30.0
					Vertical Flame Result:	See Retest
Note:			t1 = Afterflame Time t2 = Afterflame Time t2+t3 = Afterflame + Afterglow Time			

50W (20MM) VERTICAL BURNING TEST; V-0, V-1, V-2						UL94 Paragraph 8
>48hrs@23±2C/50±10%RH						
Sample #:						
#	Thk. (mm)	t1 (s)	Comments - t1	t2 (s)	t2 + t3 (s)	Comments - t2
6	1.564	1.0	Specimen did NOT drip	4.0	4.0	Specimen did NOT drip
7	1.536	2.0	Specimen did NOT drip	5.0	5.0	Specimen did NOT drip
8	1.570	2.0	Specimen did NOT drip	2.0	2.0	Specimen did NOT drip
9	1.521	1.0	Specimen did NOT drip	3.0	3.0	Specimen did NOT drip
10	1.525	1.0	Specimen did NOT drip	2.0	2.0	Specimen did NOT drip
					Total Flame Time, t1+t2 (s):	23.0
					Vertical Flame Result:	V-0
Note:			t1 = Afterflame Time t2 = Afterflame Time t2+t3 = Afterflame + Afterglow Time			

50W (20MM) VERTICAL BURNING TEST; V-0, V-1, V-2						UL94 Paragraph 8
168±2hrs@70±2C|>4hrs@23±2C/<20%RH						
Sample #: 4153288-2						
#	Thk. (mm)	t1 (s)	Comments - t1	t2 (s)	t2 + t3 (s)	Comments - t2
1	1.523	1.0	Specimen did NOT drip	2.0	2.0	Specimen did NOT drip
2	1.552	2.0	Specimen did NOT drip	14.0	14.0	Specimen did NOT drip
3	1.524	1.0	Specimen did NOT drip	22.0	22.0	Specimen did NOT drip
4	1.517	1.0	Specimen did NOT drip	9.0	9.0	Specimen did NOT drip
5	1.525	2.0	Specimen did NOT drip	25.0	26.0	Specimen did NOT drip
					Total Flame Time, t1+t2 (s):	79.0
					Vertical Flame Result:	V-1
Note:			t1 = Afterflame Time t2 = Afterflame Time t2+t3 = Afterflame + Afterglow Time			

EPX 86FR Flammability Testing

FAR 25.853(a)

T E S T R E C O R D N O 1

FAR 25.853-VERTICAL Test:

The tests were conducted in accordance with the test method outlined in Federal Aviation Administration, DOT; FAR 25.853-Vertical Test-1–1–12 Edition.

SAMPLES

Carbon Inc. supplied the test material to UL LLC for the investigation reported in this document.

The sample identifications are given in Table 1.

Table 1 - Sample Identification

System
Three Thicknesses (1.0, 2.0, and 3.0 mm), color-black EPX 86FR

Tests were conducted in accordance with the requirements of test method outlined in the report. UL LLC did not witness the production of the test samples nor were we provided with information relative to the formulation or identification of component materials used in the manufacture of the test samples.

RESULTS:

Sample conditioned at 70 +/- 5 °F and 50 +/- 5% Relative humidity to equilibrium weight or 24 hours.

Table 1: Test result of 1 mm thickness

Test [Number]	Flame Time [Seconds]	Flame Time [Seconds]	Burn Length [Inches]	Drip Flame Time [Seconds]
1	12	7	0.2760	No Dripping
2	12	5	0.100	No Dripping
3	12	2	0.0805	No Dripping
Average:		4.66	0.152	0
Vertical [12 Second] Burn Test: Average Self Extinguish time may not exceed 15 Seconds. Average Burn Length may not exceed 8 inches. Average Dripping may not exceed 5 seconds after failing.				

Test Result: Complied

EPX 86FR Flammability Testing

FAR 25.853(a)

Table 2: Test result of 2 mm thickness

Test [Number]	Flame Application Time [Seconds]	Flame Time [Seconds]	Burn Length [Inches]	Drip Flame Time [Seconds]
1	12	DNI*	0.0	No Dripping
2	12	DNI*	0.0	No Dripping
3	12	DNI*	0.0	No Dripping
Average:		Not applicable	0.0	Not applicable
Vertical [12 Second] Burn Test: Average Self Extinguish time may not exceed 15 Seconds. Average Burn Length may not exceed 8 inches. Average Dripping may not exceed 5 seconds after failing.				

DNI*- Did not ignite

Test Result: Complied

Table 3: Test result of 3 mm thickness

Test [Number]	Flame Application Time [Seconds]	Flame Time [Seconds]	Burn Length [Inches]	Drip Flame Time [Seconds]
1	12	DNI*	0.0	No Dripping
2	12	DNI*	0.0	No Dripping
3	12	DNI*	0.0	No Dripping
Average:		Not applicable	0.0	Not applicable
Vertical [12 Second] Burn Test: Average Self Extinguish time may not exceed 15 Seconds. Average Burn Length may not exceed 8 inches. Average Dripping may not exceed 5 seconds after failing.				

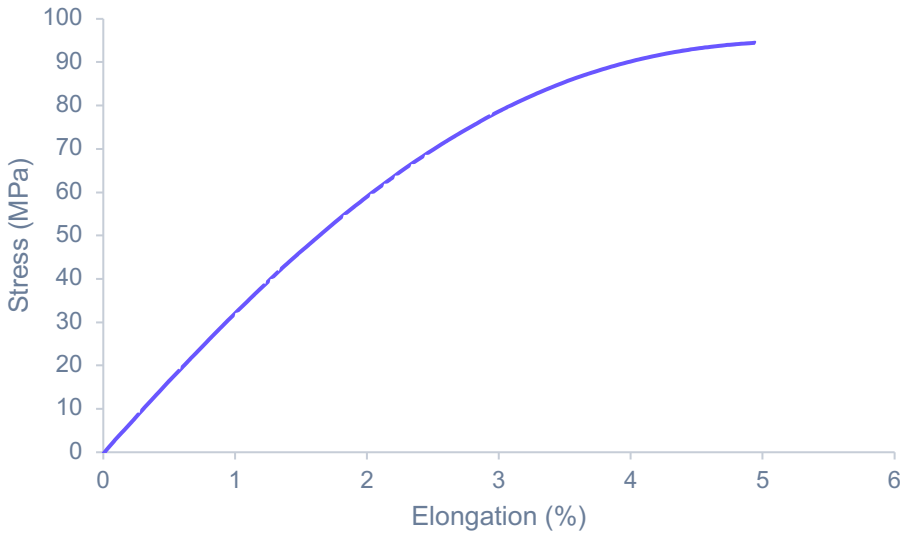
DNI*- Did not ignite

Test Result: Complied

EPX 86FR Mechanical Properties

Representative Tensile Curve

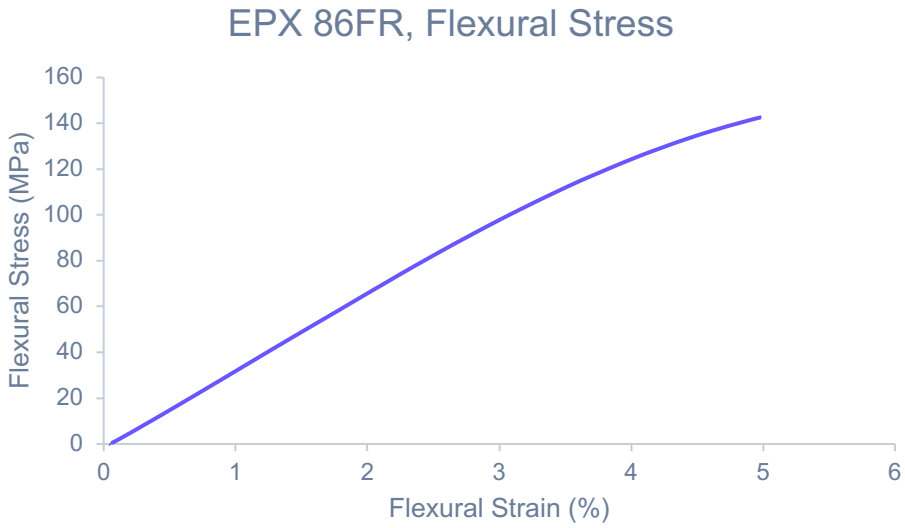
ISO 527-2, Type 1A, 5 mm/min



Representative Flexural Curve

ASTM D790-B

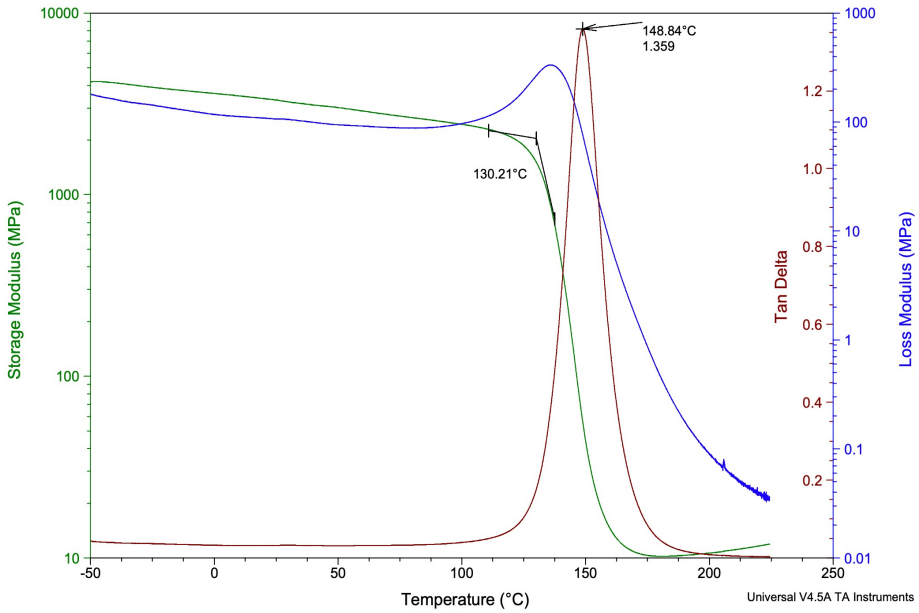
Samples are tested to 5% extension.



EPX 86FR Thermal Properties

DMA

The figure below shows the thermomechanical behavior of EPX 86FR. The storage modulus remains relatively glassy until the softening onset temperature at 130 °C. The glass transition temperature, derived as the temperature of maximum tan delta, is approximately 150 °C. The low loss modulus and damping coefficient (tanD) correlate to excellent dimensional stability at elevated temperature.



EPX 86FR Thermal Properties

Creep Recovery

EPX 86FR has excellent heat resistance, with a heat deflection temperature (0.455 MPa) of 130 °C (exact value depends on sample conditioning). This is further demonstrated in tests of EPX 86FR's creep recovery profile. Figure 1 below shows the creep-recovery of EPX 86FR (dry) at 65, 100, and 125 °C. EPX 86FR shows less than 0.5% creep (1.8 MPa load) at or below 100 °C operating temperatures. As the sample approaches the storage modulus softening temperature of 130 °C (see DMA in extended TDS), the creep recovery is reduced, as expected. Figure 2 presents the creep-recovery comparisons for EPX 86FR, FPU 50, RPU 70, and RPU 130 tested at similar conditions of 1.8 MPa load and 65 °C. The results show that EPX 86FR offers the best creep recovery.

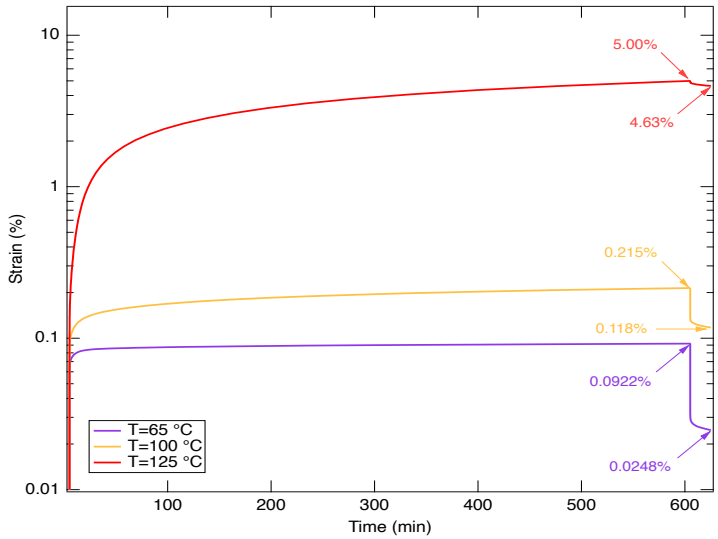


Figure 1. Ten-hour isothermal creep-recovery experiments conducted at 65 °C, 100 °C, and 125 °C respectively, for a stress of 1.8 MPa.

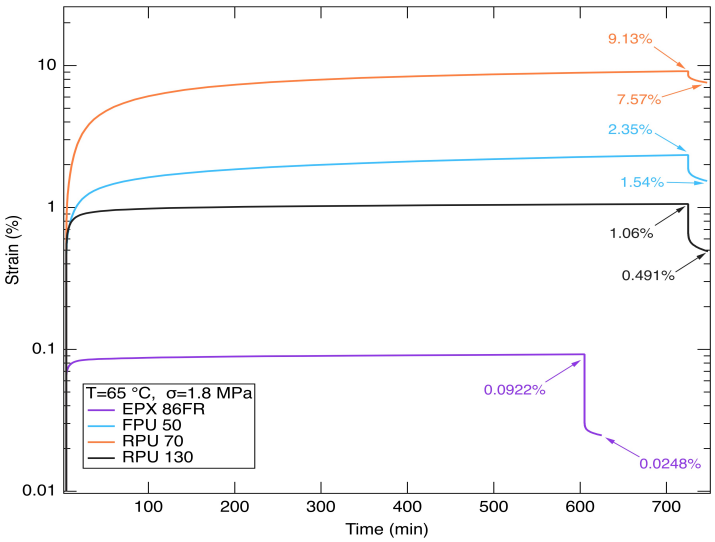
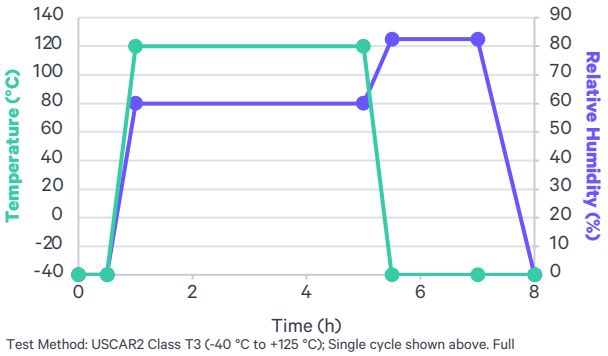


Figure 2. Isothermal creep-recovery experiments for EPX 86FR conducted at 65 °C and stress of 1.8 MPa under single cantilever deformation mode.

EPX 86FR Material Endurance

Automotive USCAR2 Class T3

EPX 86FR is a cross-linked aromatic epoxy/amine, which leads to excellent retention of material properties during high-temperature aging, temperature/humidity cycling, and thermal shock. EPX 86FR is able to retain function with minimal property degradation after heat and humidity aging tests required for automotive and industrial brackets/mounts/housings. Class T3: -40 °C to +125 °C; typically suitable for use in engine compartments.



Test Method: USCAR2 Class T3 (-40 °C to +125 °C); Single cycle shown above. Full testing is 40 cycles.

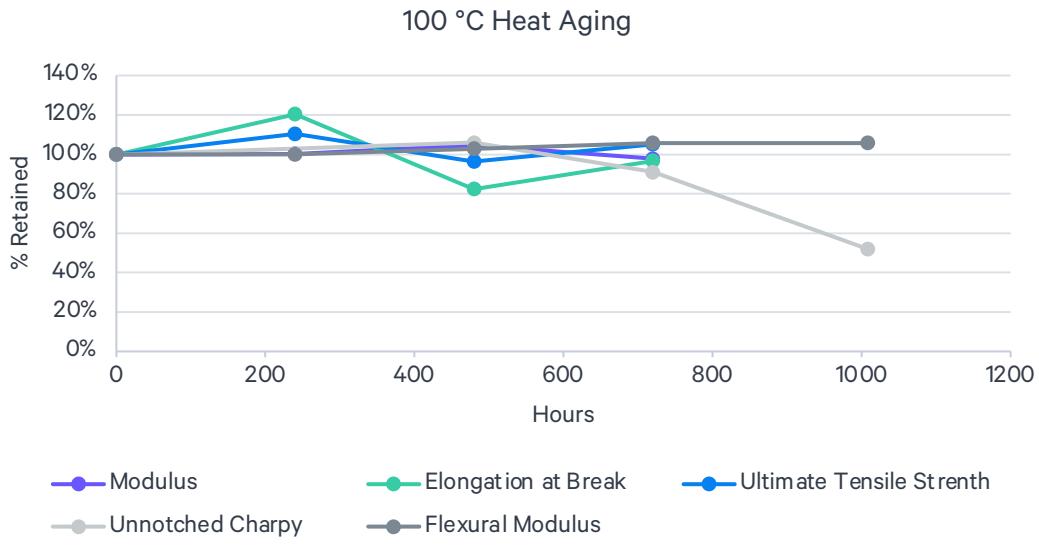
	Initial Tensile Properties	% Retained after USCAR2 T3 cycling (320 h, 40 cycles)
Tensile Modulus	3300 MPa	100%
Yield strength	90 MPa	100%
Elongation at Break	4%	100%

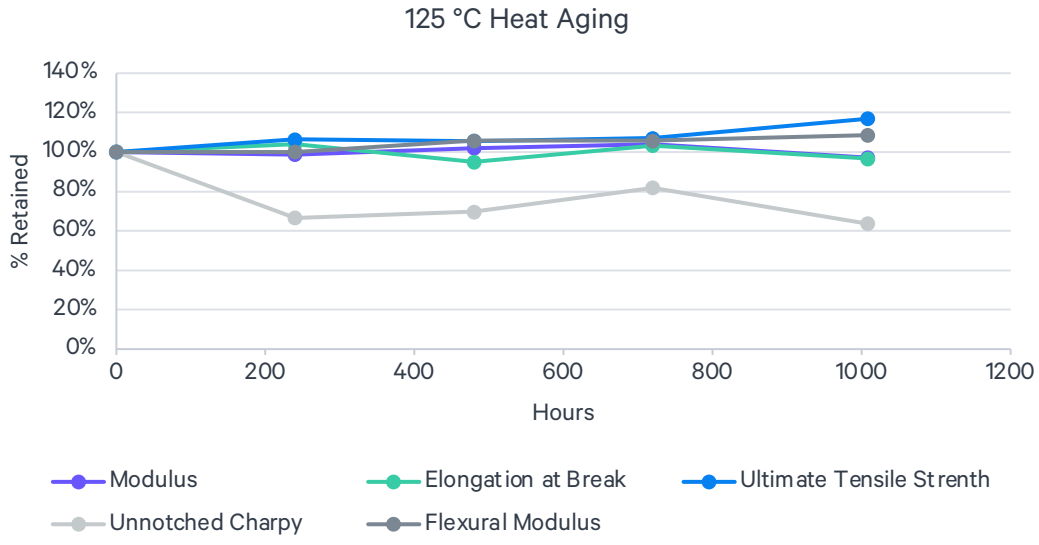
ISO 527-2: Type 1A, 5 mm/min, average values represented

EPX 86FR Material Endurance

Heat Aging

EPX 86FR is a cross-linked aromatic epoxy/amine, which leads to excellent retention of material properties during high-temperature aging, temperature/humidity cycling, and thermal shock. EPX 86FR retains function with minimal tensile and flexural property degradation after 720–1000+ hours of heat aging at 100 °C and 125 °C. Unnotched charpy results aged at 100 °C showed retention of impact properties until 30 days of aging; however, samples aged at 125 °C presented a steeper decline in impact properties after 10 days of aging.





ISO 179-1eU Charpy
ISO 527-2: Type 1A, 5 mm/min, average values represented

EPX 86FR Chemical Compatibility

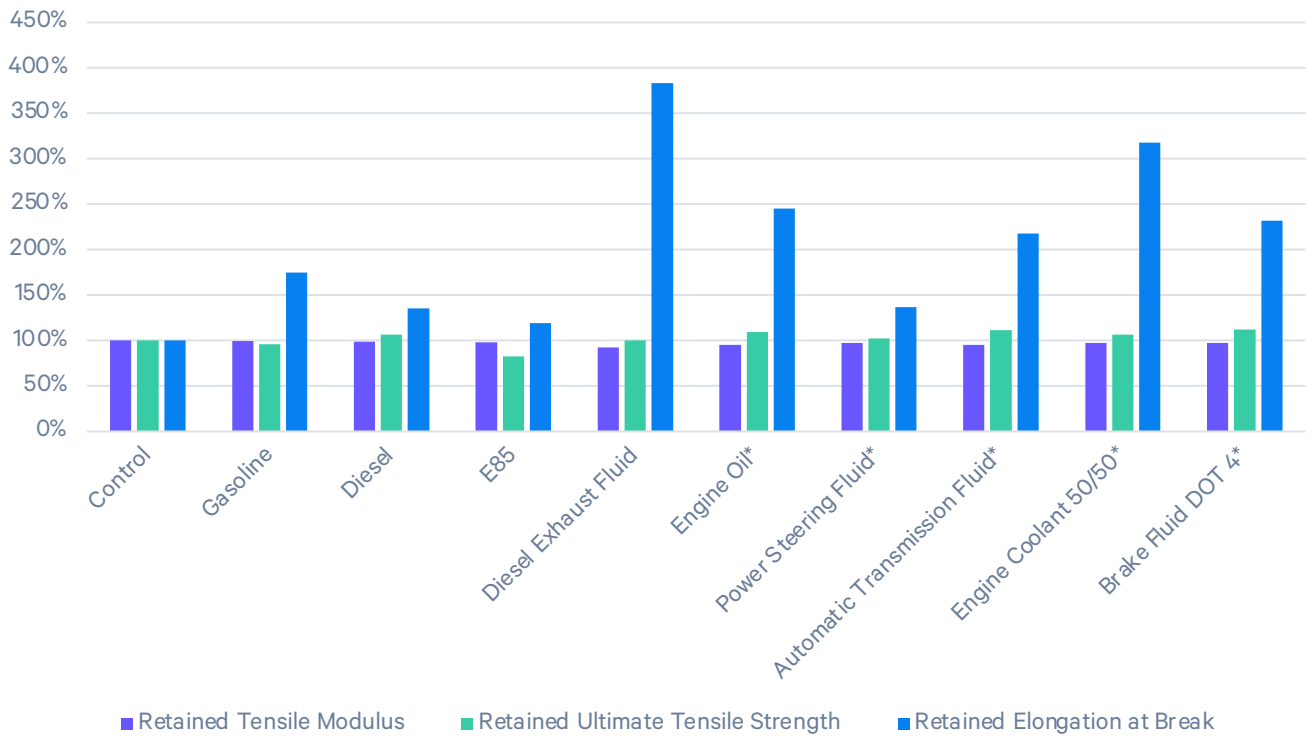
	Mass Gain* (%)
Household Chemicals	
Bleach (NaClO, 5%)	< 5%
Sanitizer (NH_4Cl, 10%)	< 5%
Distilled Water	< 5%
Sunscreen (Banana Boat, SPF 50)	< 5%
Detergent (Tide, Original)	< 5%
Windex Powerized Formula	< 5%
Hydrogen Peroxide (30%)	< 5%
Ethanol (95%)	< 5%
Industrial Fluids	
Engine Oil (Havoline SAE 5W-30)	< 5%
Brake Fluid (Castrol DOT-4)	< 5%
Airplane Deicing Fluid (Type I Ethylene Glycol)	-
Airplane Deicing Fluid (Type I Propylene Glycol)	-
Airplane Deicing Fluid (Type IV Ethylene Glycol)	-
Airplane Deicing Fluid (Type IV Propylene Glycol)	-
Transmission Fluid (Havoline Synthetic ATF)	< 5%
Engine Coolant (Havoline XLC, 50%/50% premixed)	< 5%
Diesel (Chevron #2)	< 5%
Gasoline (Chevron #91)	-
Skydrol 500B-4	< 5%
Strong Acid/Alcohol/Base	
Sulfuric Acid (30%)	< 5%
Sodium Hydroxide (10%)	< 5%

**Percent weight gained after one week submersion following ASTM D543. Values do not represent changes in dimension or mechanical properties.*

EPX 86FR Chemical Compatibility, cont.

USCAR2 Fluid Resistance

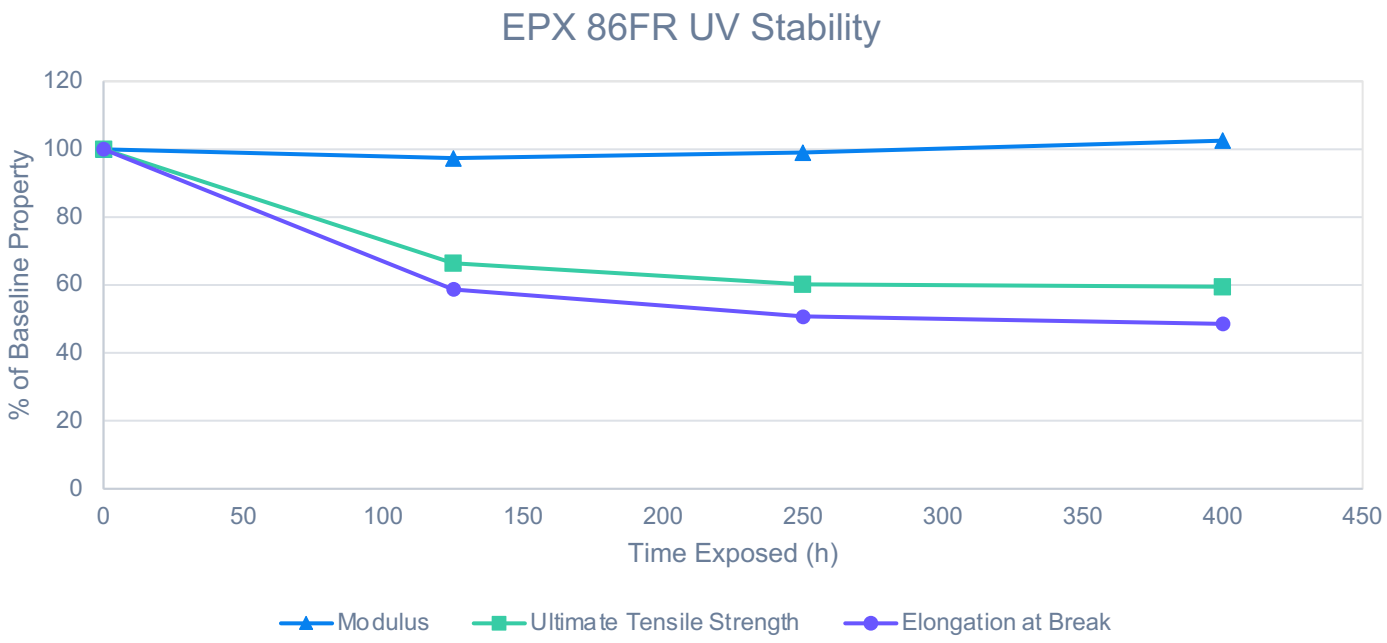
Epoxies as a chemical family exhibit excellent chemical resistance. EPX 86FR shows similar performance, showing no surface blemishes and minimal change in tensile properties after chemical exposure simulating splash contact per USCAR2 conditions.



Treatment Method: Samples submerged in test liquid for 30 minutes at 23 °C or 50 °C (starred) then removed from test liquid and allowed to sit at ambient room temperature conditions for 1 week (samples were not wiped).
Test Method: ISO 527-2, Type I, 5 mm/min

EPX 86FR UV Stability

Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of EPX 86FR using ASTM D4459, which is intended to simulate indoor exposure of solar radiation through glass.

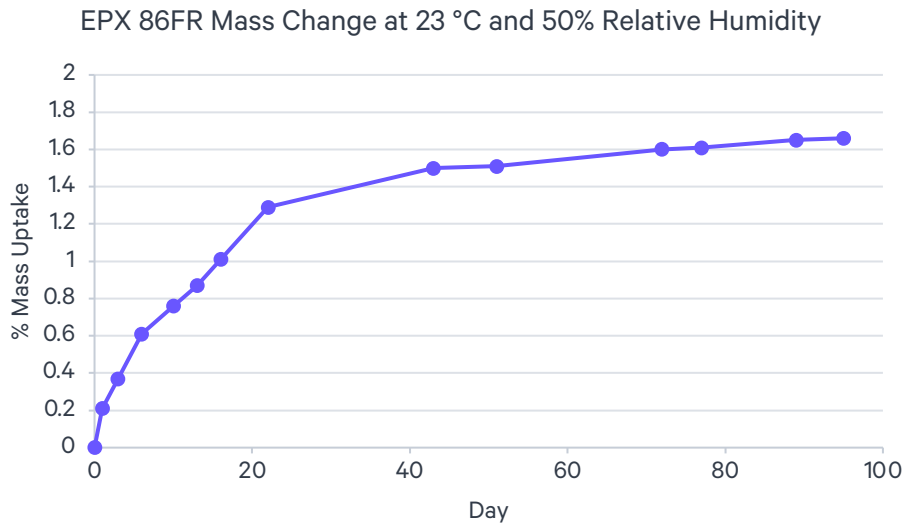


ASTM D4459: Q-Sun XE-1, 0.8 W/m^2/nm at 420 nm, 55 °C
ISO 527-2: Type 1A, 5 mm/min, average values represented

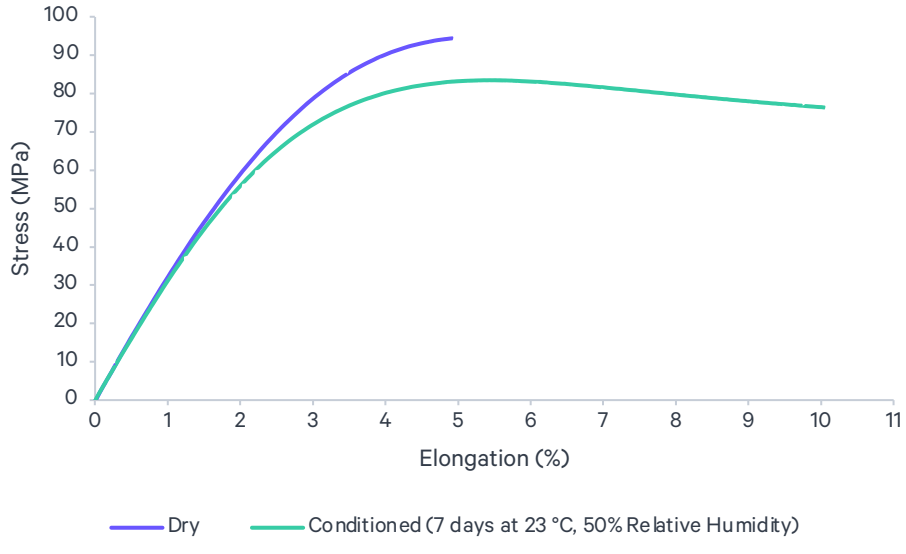
EPX 86FR Water Uptake

Connectors

Like the polyamide family of polymers (nylons), EPX 86FR absorbs and releases water from the atmosphere based on ambient humidity. EPX 86FR absorbs less than 2% by weight of water after 90 days of conditioning at 23 °C and 50% relative humidity. This water leads to a small decrease in yield strength, an increase in elongation at break, and a decrease in heat deflection temperature.



Test Method: ASTM D570 specimens conditioned at 23 °C, 50% relative humidity



Test Method: ISO 527-2, Type 1A, 5mm/min

EPX 86FR

Conditioned Mechanical Properties

Tensile Properties	Test Standard	Metric	US
Tensile Modulus	ISO 527-2 Type 1A 5 mm/min	3300 MPa	480 ksi
Ultimate Tensile Strength		80 MPa	12 ksi
Elongation at Break		10%	10%

Tensile Properties	Test Standard	Metric	US
Tensile Modulus	ASTM D638 Type V 1 mm/min	3400 MPa	490 ksi
Tensile Yield Strain		6%	6%
Ultimate Tensile Strength		80 MPa	12 ksi
Elongation at Break		13%	13%

Flexural Properties	Test Standard	Metric	US
Flexural Stress at 5% strain	ASTM D790-B	140 MPa	22 ksi
Flexural Modulus (Chord, 0.5-1%)		3300 MPa	480 ksi

Impact Properties	Test Standard	Metric	US
Unnotched Charpy	ISO 179-1/1eU	24 kJ/m^2	1.1 ft-lb/in^2
Notched Charpy (Machined Notch)	ISO 179-1/1eA	2 kJ/m^2	1 ft-lb/in^2
Unnotched Izod	ASTM D4812	310 J/m	5.8 ft-lb/in
Notched Izod (Machined Notch)	ASTM D256	30 J/m	0.6 ft-lb/in

Thermal Properties	Test Standard	Metric	US
Heat Deflection Temperature at 0.455 MPa/66 psi	ASTM D648	120 °C	240 °F
Heat Deflection Temperature at 1.82 MPa/264 psi		110 °C	220 °F

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Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent. Conditioned values were measured after 1 week at 23 °C and 50% relative humidity.