EPX 82

EPX 82 combines functional toughness, stiffness, and temperature resistance, making it useful for a variety of automotive, industrial, and consumer applications.

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EPX 82

Tensile Properties*	Test Standard	Metric	US
Tensile Modulus	ISO 527-2 Type IA 5 mm/min	2800 MPa	410 ksi
Yield Strength		80 MPa	10 ksi
Ultimate Tensile Strength		80 MPa	10 ksi
Elongation at Break		5%	5%

Flexural Properties*	Test Standard	Metric	US
Flexural Stress at 5% strain	ASTM D790-B	130 MPa	19 ksi
Flexural Modulus (Chord, 0.5-1%)		3000 MPa	430 ksi

Impact Properties*	Test Standard	Metric	US
Gardner Impact	ASTM D5420	0.5 J	0.4 ft-lb
Unnotched Charpy	ISO 179-1/1eU	25 kJ/m^2	12 ft-lb/in^2
Notched Charpy (Machined Notch)	ISO 179-1/1eA	4.4 kJ/m^2	2 ft-lb/in^2
Unnotched Izod	ASTM D4812	370 J/m	7 ft-lb/in
Notched Izod (Machined Notch)	ASTM D256	45 J/m	0.8 ft-lb/in

Thermal Properties	Test Standard	Metric	US
Heat Deflection Temperature* at 0.455 MPa/66 psi	ASTM D648	130 °C	270 °F
Heat Deflection Temperature* at 1.82 MPa/264 psi		120 °C	250 °F
Coefficient of Thermal Expansion (-60, 100 °C)	ASTM E831	90 ppm/°C	50 ppm/°F
Heat Capacity, 23 °C	ASTM E1269	1.3 J/g-°C	0.3 BTU/lb-°F
Thermal Conductivity	ASTM C518	0.2 W/m-k	0.1 BTU/hr-ft-°F
Flammability	UL 94	HB (1.5 mm) HB (3.0 mm)	

Dielectric/Electric Properties	Test Standard	
Dielectric Strength	ASTM D149	18 kV/mm
Dielectric Constant	ASTM D150	3.4
Dissipation Factor		0.007
Volume Resistivity	ASTM D257	5.0 x 10^{15} ohm-cm
Comparative Tracking Index	ASTM D3638	600 V

Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent, followed by isopropanol dunk. The washed test articles were baked following the standard baking schedule for EPX 82 in an air oven.

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

EPX 82

General Properties	Test Standard	
Shore D Hardness	ASTM D2240	89 (instant), 88 (5 sec)
Bulk Density	ASTM D792	1.16 g/mL
Poisson's Ratio	ASTM D638 Type I 5 mm/min	0.37
Taber Abrasion	ASTM D4060 CS-17, 1 kg, 100% vacuum	40 mg/ 1000 cycles

Liquid Properties	
Liquid Density (Part A)	1.08 g/mL
Liquid Density (Part B)	1.10 g/mL
Liquid Density (Part A+B)	1.09 g/mL
Part A:B Volume Ratio (Mass Ratio)	1.00 (0.98)
25 °C Viscosity (Part A)	13000 cP
25 °C Viscosity (Part B)	390 cP
25 °C Viscosity (Part A+B)	1300 cP

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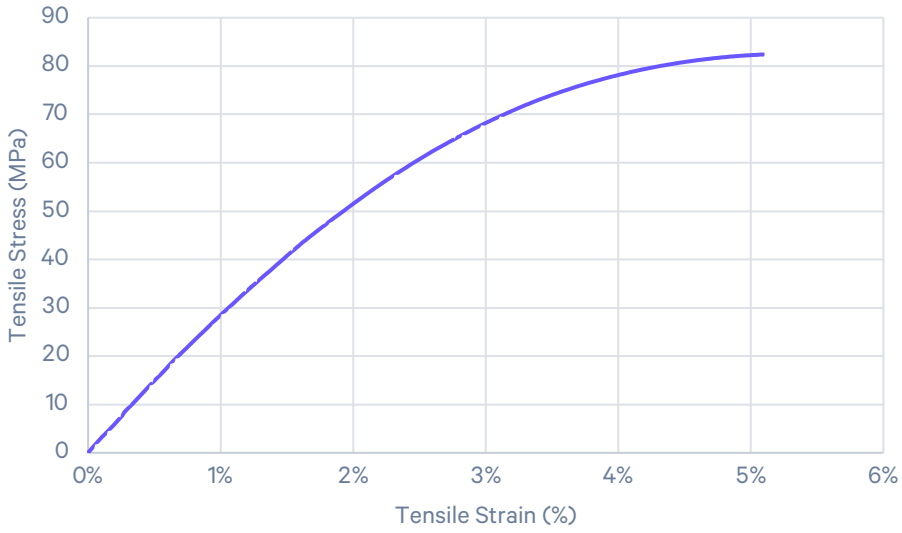
EPX 82

Extended TDS

EPX 82 Mechanical Properties

Representative Tensile Curve

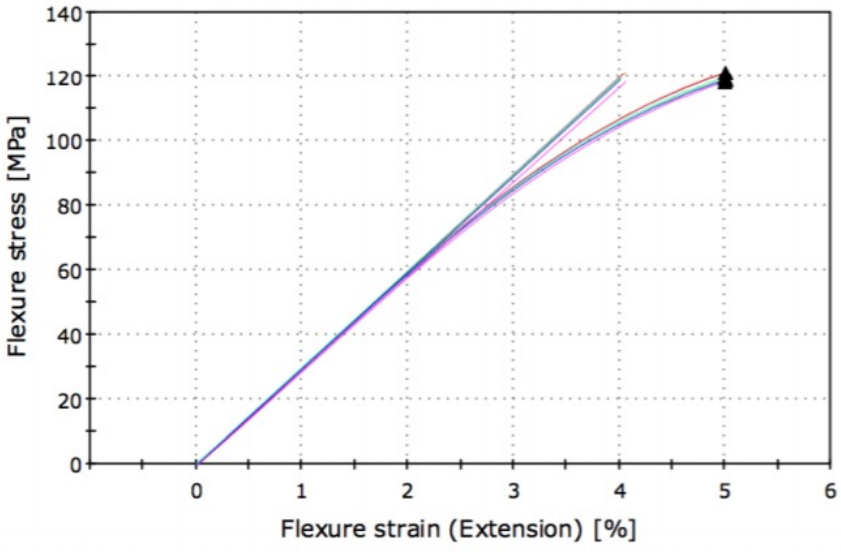
ISO 527-2, Type 1A, 5 mm/min



Representative Flexural Curve

ASTM D790-B

Samples are tested to 5% extension.



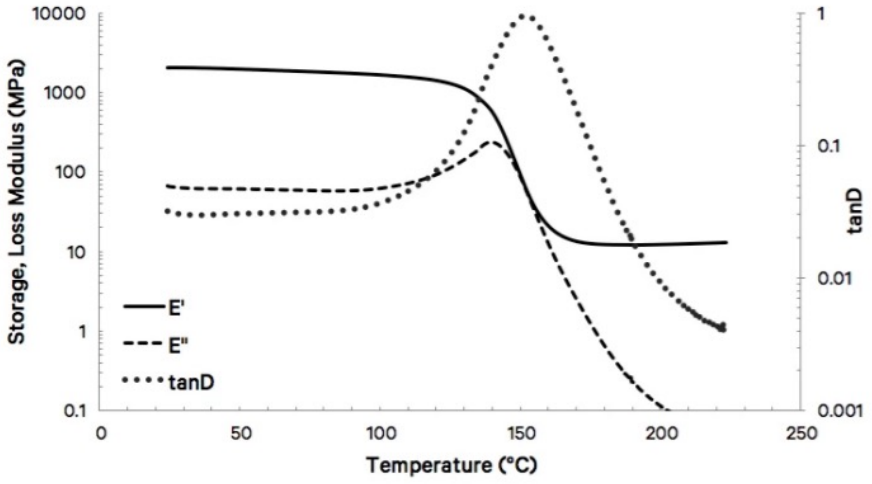
Flexural test method: ASTM D790-B, 40mm span, sample thickness: 3.18mm, dry

EPX 82 Thermomechanical Properties

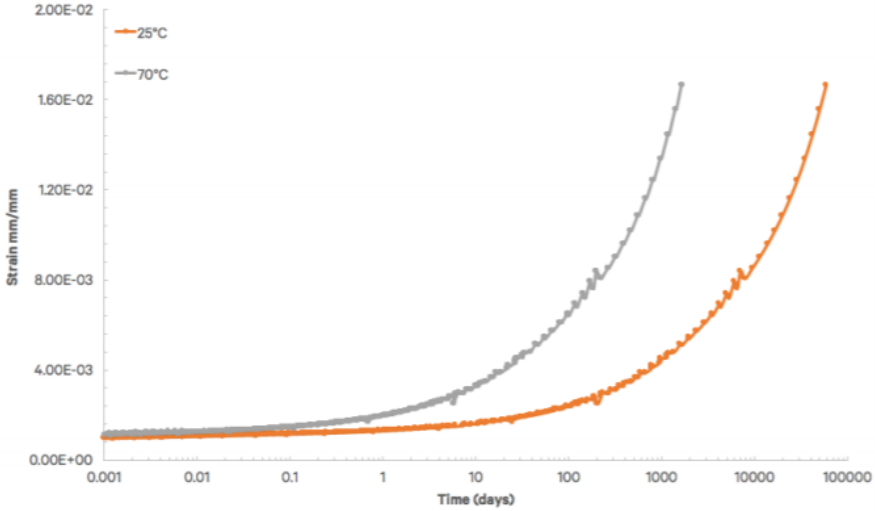
Dynamic Mechanical Analysis (DMA) and Creep

EPX 82 has excellent heat resistance, with a heat deflection temperature (0.455 MPa) greater than 100 °C (exact value depends on sample conditioning - see Water Uptake section). EPX 82 exhibits a sharp transition in dynamic mechanical analysis. The low loss modulus and damping coefficient (tanD) correlate to excellent dimensional stability at elevated temperatures.

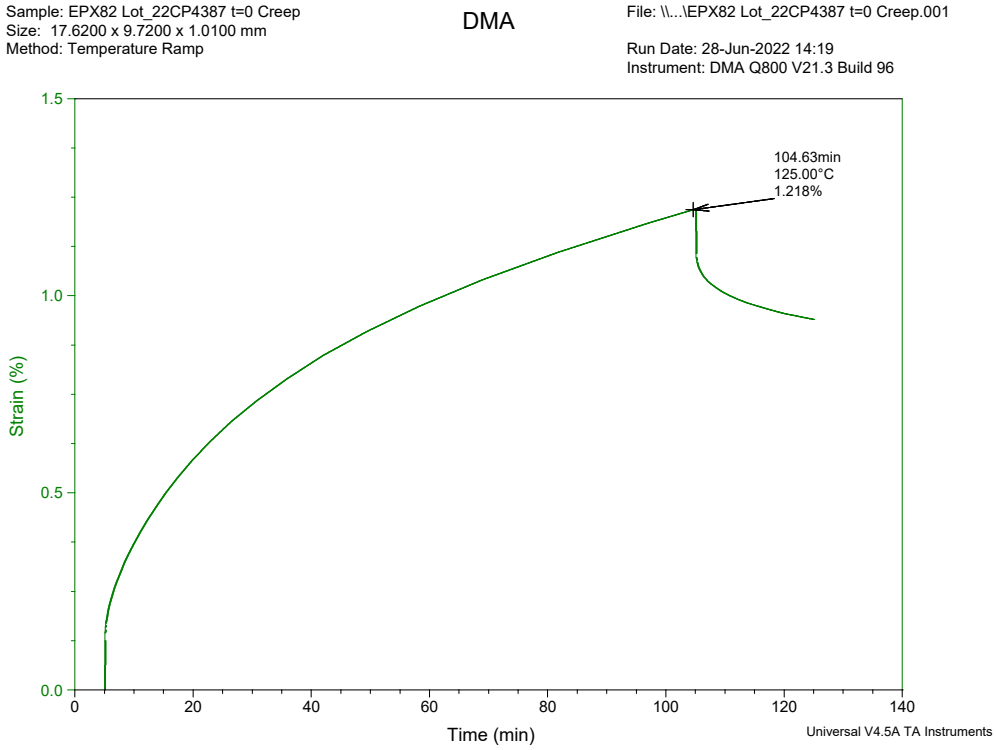
This is further reflected in tests of EPX 82's creep resistance. Creep time-temperature superposition is used to simulate long-term creep behavior.

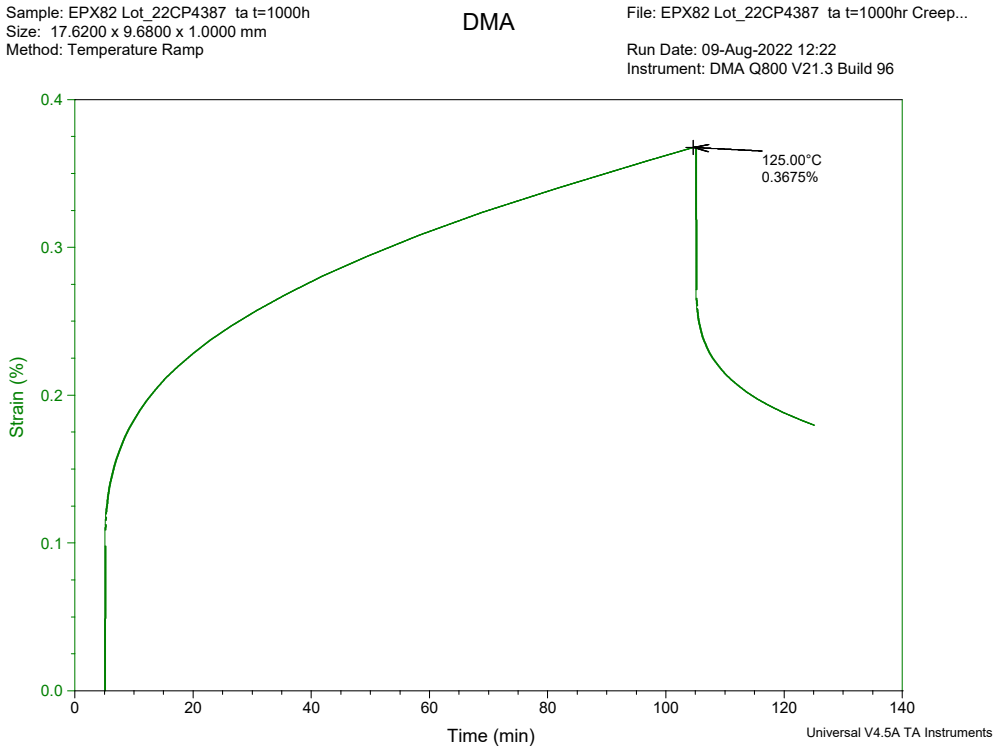


Test method: TA Q800 DMA, single cantilever mode, 25-225°C sweep, 1°C/min, 1 Hz, 1mm sample, dry-as-printed



Creep TTS test method: TA Q800 DMA, single cantilever mode, 30x15x3.2 mm sample, 0-125°C sweep at 5°C increments with 5 minute isothermal and 10 minute deformation, 2 MPa applied load, dry





EPX 82 Chemical Compatibility

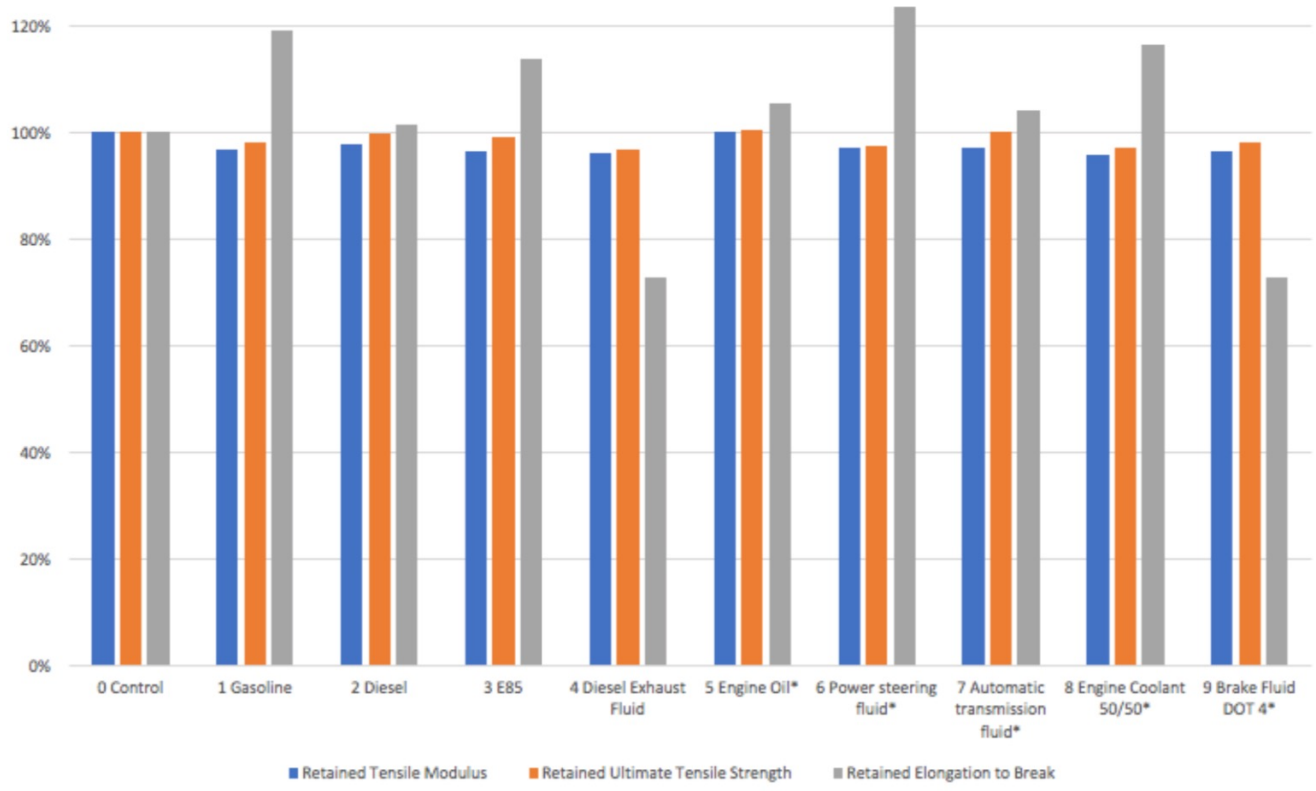
	Mass Gain* (%)
Household Chemicals	
Bleach (NaClO, 5%)	< 5%
Sanitizer (NH_4Cl, 10%)	< 5%
Distilled Water	< 5%
Sunscreen (Banana Boat, SPF 50)	< 5%
Detergent (Tide, Original)	< 5%
Windex Powerized Formula	< 5%
Hydrogen Peroxide (30%)	< 5%
Ethanol (95%)	5 - 15%
Industrial Fluids	
Engine Oil (Havoline SAE 5W-30)	< 5%
Brake Fluid (Castrol DOT-4)	< 5%
Transmission Fluid (Havoline Synthetic ATF)	< 5%
Engine Coolant (Havoline XLC, 50%/50% premixed)	< 5%
Diesel (Chevron #2)	< 5%
Skydrol 500B-4	< 5%
Strong Acid/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 82 Chemical Compatibility cont.

USCAR2

Epoxies as a chemical family exhibit excellent chemical resistance. EPX 82 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 IA, 5 mm/min

EPX 82 UV Aging

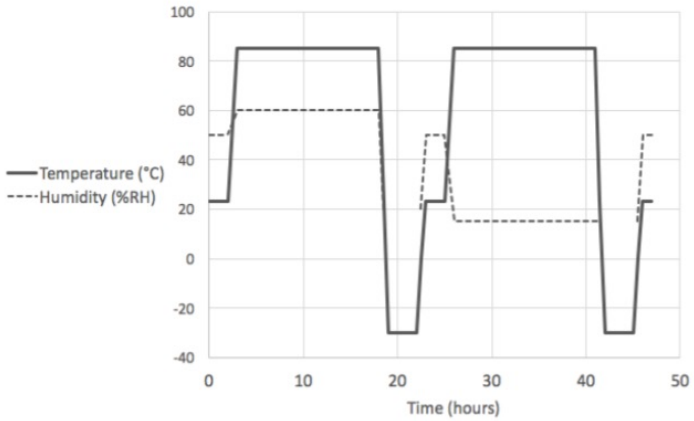
Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of EPX 82 using ASTM D4459, which is intended to simulate indoor exposure of solar radiation through glass.

ASTM 4459: Q-Sun XE-1, 0.8 W/m^2/nm at 420 nm, 55 °C
ASTM D638: Type V, 500 mm/min, average values represented

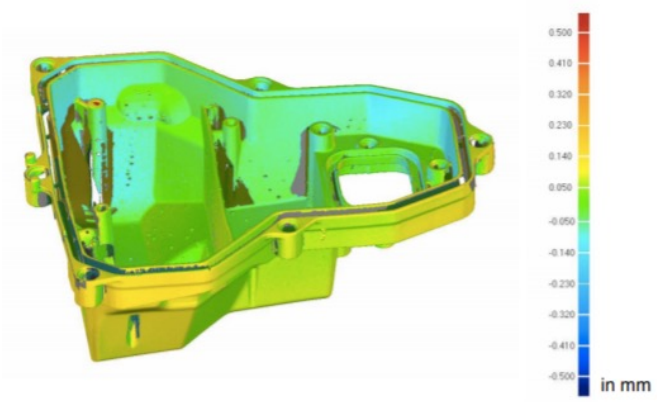
EPX 82 Material Endurance

Automotive

EPX 82 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 82 can retain function with minimal property degradation after aging tests required for automotive and industrial brackets/mounts/housings.



Temp/humidity cycling schedule: cycle repeated 4x, 240 hours total



DC charger housing shows minimal dimensional change after automotive thermal/humidity cycling, with 95% of points within ±150um of initial

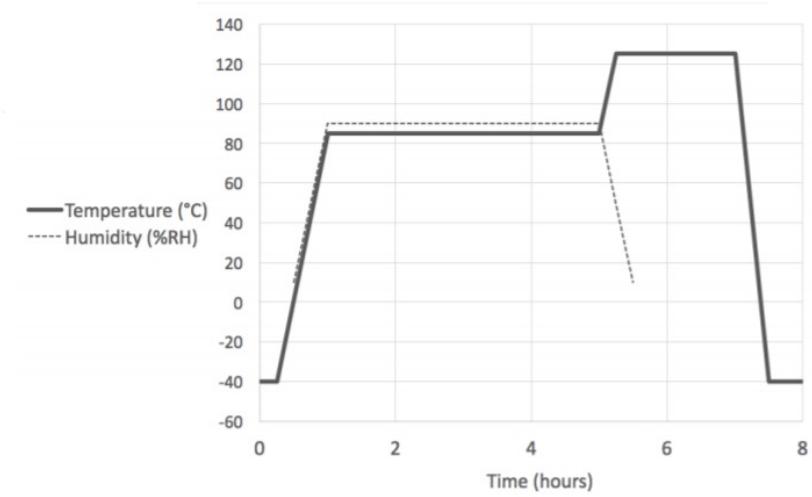
	Initial*	Retained after heat aging: 168 h at 100 °C	Retained after temp/humidity cycling: 240 h, cycle shown above
Tensile Modulus	3000 MPa	100%	95%
Yield strength	70 MPa	100%	100%
Elongation at Yield	5%	100%	95%
Elongation at Break	10%	100%	90%
Notched Izod Impact (23 °C)	45 J/m	100%	95%

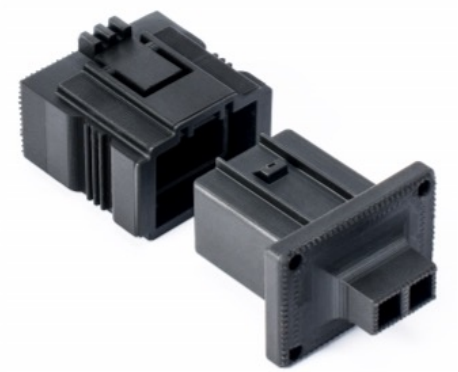
*Conditioned ASTM D638 Type V dogbones and Izod bars

EPX 82 Material Endurance cont.

Connectors

EPX 82 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 82 can retain function with minimal property degradation after aging tests required for automotive and industrial brackets/mounts/housings.





Electrical connector testing		% Retained		
	Initial*	**Heat aging: 1008 h at 125 °C**	**Temp/humidity cycling: 40 cycles, shown above**	**Thermal shock: 100 cycles, -40-125 °C**
Tensile Modulus	3000 MPa	100%	95%	100%
Yield strength	70 MPa	110%	100%	105%
Elongation at Yield	5%	105%	95%	95%
Elongation at Break	10%	75%	90%	80%
Notched Izod Impact (23 °C)	45 J/m	100%	95%	95%

*Conditioned ASTM D638 Type V dogbones and Izod bars

EPX 82

Conditioned Mechanical Properties

Tensile Properties	Test Standard	Metric	US
Tensile Modulus	ISO 527-2 Type IA 5 mm/min	2800 MPa	410 ksi
Yield Strength		72 MPa	10 ksi
Ultimate Tensile Strength		72 MPa	10 ksi
Elongation at Break		> 5%	> 5%

Flexural Properties	Test Standard	Metric	US
Flexural Stress at 5% strain	ASTM D790-B	110 MPa	16 ksi
Flexural Modulus (Chord, 0.5-1%)		2900 MPa	420 ksi

Impact Properties	Test Standard	Metric	US
Gardner Impact	ASTM D5420 GC, 3.2 mm	0.56 J	0.41 ft-lb
Unnotched Charpy	ISO 179-1/1eU	26 kJ/m^2	12 ft-lb/in^2
Notched Charpy (Machined Notch)	ISO 179-1/1eA	4.2 kJ/m^2	2 ft-lb/in^2
Unnotched Izod	ASTM D4812	350 J/m	7 ft-lb/in
Notched Izod (Machined Notch)	ASTM D256	42 J/m	0.8 ft-lb/in

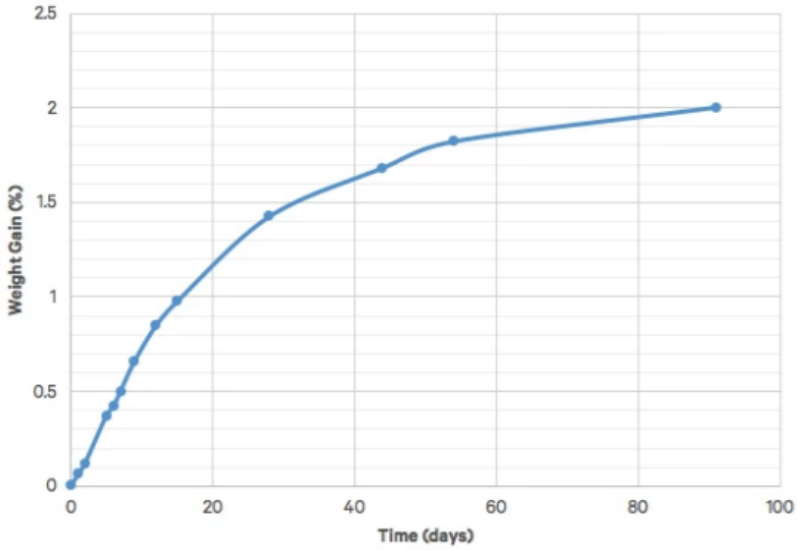
Thermal Properties	Test Standard	Metric	US
Heat Deflection Temperature at 0.455 MPa/66 psi	ASTM D648	105 °C	220 °F
Heat Deflection Temperature at 1.82 MPa/264 psi	ASTM D648	90 °C	200 °F

Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent, followed by isopropanol dunk. The washed test articles were baked following the standard baking schedule for EPX 82 in an air oven. Properties were measured after 1 week conditioning at 23 °C and 50% relative humidity.

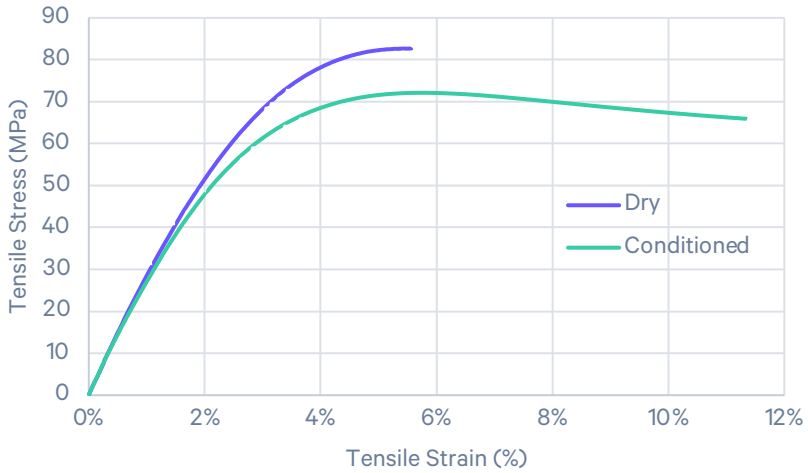
EPX 82 Water Uptake

Connectors

Like the polyamide family of polymers (Nylons), EPX 82 absorbs and releases water from the atmosphere based on ambient humidity. This process is reversible, and the impact of this moisture uptake on mechanical properties is relatively low due to the highly crosslinked nature of EPX 82. EPX 82 takes up approximately 2% by weight of water at 23 °C and 50% relative humidity in equilibrium conditions. This water leads to small decreases in modulus and yield strength, with accompanying increase in tensile strain and a decrease in heat deflection temperature (0.455 MPa) to approximately 105°C at equilibrium conditions.



Test method: ASTM D570 coupons (3" x 1" x 1/8"), conditioned at 23°C/50%RH



Conditioning method: Conditioned 2 weeks, 23°C/50%RH. ASTM D638 Type V dogbones

EPX 82 Inert Baked

Inert baking improves toughness and impact resistance (elongation at break, Gardner impact, unnotched Charpy and Izod) while maintaining other properties.

Tensile Properties	Test Standard	Metric	US
Tensile Modulus	ISO 527-2 Type IA 5 mm/min	2800 MPa	410 ksi
Yield Strength		84 MPa	12 ksi
Ultimate Tensile Strength		84 MPa	12 ksi
Elongation at Break		8%	8%
Tensile Modulus	ASTM D638 Type V 1 mm/min	2800 MPa	410 ksi
Yield Strength		75 MPa	11 ksi
Ultimate Tensile Strength		75 MPa	11 ksi
Elongation at Break		12%	12%

Flexural Properties	Test Standard	Metric	US
Flexural Stress at 5% strain	ASTM D790-B	120 MPa	17 ksi
Flexural Modulus (Chord, 0.5-1%)		2700 MPa	390 ksi

Impact Properties	Test Standard	Metric	US
Gardner Impact	ASTM D5420 GC, 3 mm	1.5 J	1.1 ft-lb
Unnotched Charpy	ISO 179-1/1eU	76 kJ/m^2	36 ft-lb/in^2
Notched Charpy (Machined Notch)	ISO 179-1/1eA	4.4 kJ/m^2	2 ft-lb/in^2
Unnotched Izod	ASTM D4812	840 J/m	16 ft-lb/in
Notched Izod (Machined Notch)	ASTM D256	45 J/m	0.8 ft-lb/in

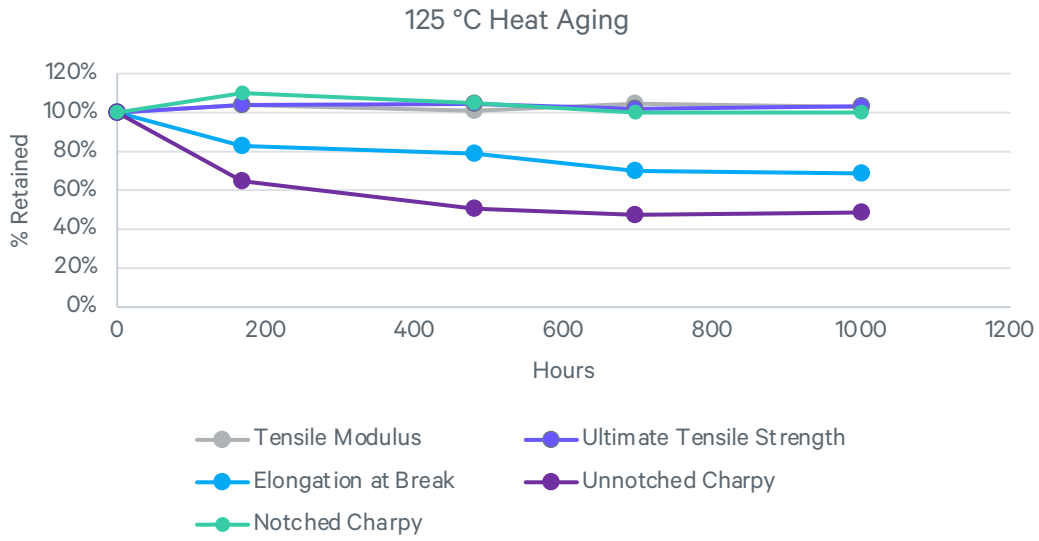
Thermal Properties	Test Standard	Metric	US
Heat Deflection Temperature at 0.455 MPa/66 psi	ASTM D648	130 °C	270 °F
Heat Deflection Temperature at 1.82 MPa/264 psi	ASTM D648	120 °C	250 °F

Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent, followed by isopropanol dunk. The washed test articles were baked following the standard baking schedule for EPX 82 in a nitrogen oven. Samples were kept in dry conditions and tested within 24 hours.

EPX 82 Inert Bake Material Endurance

Heat Aging

Heat aging mechanical properties are often used to evaluate materials performance for automotive applications. EPX 82 inert bake tensile and impact samples were subjected to 125 °C heat aging for 1000 hours. The results show that EPX82 inert bake samples retained mechanical performance with minimal change in tensile modulus, ultimate tensile strength (UTS), and notched Charpy impact after 1000 hours of heat aging at 125 °C. Both the elongation at break and unnotched Charpy impact values show a decrease in performance during heat aging.



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

EPX 82 Vehicle Interior Air Quality (VIAQ)

EPX 82 passes stringent odor, fogging, and emissions standards required for interior automotive applications.

Material Emissions - Automotive			
	Test Method	**Results**	**General Target**
Odor	VDA 270	Grade: 3.5	< 4
Volatile Organics (VOC)	VDA 278	3 ppm	< 100 ppm
Fogging	DIN 75201, Method B, Gravimetric	0.04 mg	< 2 mg
Semi-Volatile Organics (FOG)	VDA 278	0 ppm	< 250 ppm

Test Report No. 4548732/A-01

DIN 75201 B

Client	: Carbon, Inc.
Order	: Test according to DIN 75201 B
Sample received	: 04/05/2018 (sent)
Carried out by	: SGS INSTITUT FRESENIUS GmbH, Am Technologiepark 10, 45699 Herten, TRP Automotive Testhouse
Test period	: May 2018
Conditioning	: 7 days at 23°C
Test method	: Test method DIN 75201B describes the gravimetric fogging test. The test specimen is placed on the bottom of a glass beaker. The beaker is covered with an aluminium foil, where volatile components from the test specimen are able to condense. The foil is cooled to 21 ± 1°C by a cooling-plate. The prepared beaker is held at a temperature of 100 ± 0,3°C for 16 h inside a controlled thermostatic bath. The condensable constituents G condensed on the aluminium foil are determined by weighing the foil before and after the test.
Test equipment	: Lauda master / HAAKE CPA 225D

No.	SGS IF Sample number	G_e in mg	G_f in mg	G in mg
1	180438932	638,45	638,51	0,06
2	180438932	631,17	631,18	0,01

fogging value G (mean)
0,04 mg

DIDP-standard (~ 0,65 mg)	0,67 mg
Blank (< 0,05 mg)	0,05 mg

Test Report No. 4548732/A-01

VDA 270

Client	: Carbon, Inc.
Order	: Odour test acc. to VDA 270
Sample received	: 04/05/2018 (sent)
Conditioning	: 7 days at 23°C
Carried out by	: SGS INSTITUT FRESENIUS GmbH, Am Technologiepark 10, 45699 Herten, TRP Automotive Testhouse
Test period	: May 2018
Test method	: VDA 270 B3 (November 2016)
	Determination of the odour characteristics of materials The sample will be placed on the bottom of three different 1-L-glass beakers with fixed quantities or sizes. All beakers will be closed with a glass plate (air tight). The beaker thus prepared will be positioned in a warming chamber under given environmental parameters: 80 °C / 2 h. After each period the odour characteristics of each sample will be tested by three Testers.
Devices	: Warming chamber/air conditioning with unity to control the temperature

Date of measurement : 25/05/2018

80°C / 2 h	VDA 270	Final Score 3,5

Tester 1	Tester 2	Tester 3	Spec.	Score
3,5	3,5	3,0	B3	3,3

Specification:
A – (10 ± 1) g
B – (20 ± 2) cm³
C – (50 ± 5) cm³
*200 cm²

Benchmark:
1 – imperceptible
2 – perceptible, undisturbing
3 – clear perceptible, undisturbing
4 – disturbing
5 – strong disturbing
6 - intolerable

Test Report No. 4548732/A-01

VDA 278

Client	: Carbon, Inc.
Sample received	: 04/05/2018 (sent)
Conditioning	: 7 days at 23°C
Carried out by	: SGS INSTITUT FRESENIUS GmbH, Am Technologiepark 10, 45699 Herten, TRP Automotive Testhouse
Test period	: May/June 2018
Test method	: VDA 278 (October 2011)

In the test method VDA 278 -Thermodesorption analysis of organic emission for the characterization of non-metallic car materials - of the association of the german automotive industry (VDA) the substances are measured which are emitted at 90°C (VOC) and 120°C (FOG). For this purpose a sample of the test material is heated in a current of inert gas, and the substances released are frozen out in the refrigerated injector of the gas chromatograph. After separation of the mixture of substances, the individual substances are, as far as possible, identified by means of a mass-sensitive detector. The VOC and FOG measurements are carried out with the **same test** samples. Quantification of the gaseous emissions (VOC) is made against an external toluene standard, while the condensable emissions (FOG) are quantified against hexadecane (C16-n-alkane). The individual concentrations are given in ppm (mg/kg) as total emissions in toluene or hexadecane equivalents. The substances which could be identified within the total emission are individually listed in the raw data.
The identified substances have also been examined for the extent to which they are classified in the applicable edition of Regulation (EG) No. 1272/2008 (CLP Regulation) including ATP and Annexe in the Carc., Muta. and Repr. 1A, 1B, 2.

Devices:
- Gerstel TDS incl. Autosampler
- Gerstel Kaltaufgabesystem KAS 4
- GC Hewlett-Packard 6890
- Mass Selective Detector „MS" Hewlett-Packard 5973

SGS IF sample number	: 180438932
Sample identification	: **#4**
Date of measurement	: 05/06/2018
Documentation	-

Test parameter		Measured value in ppm (µg/g)
VOC	**total emission**	**3**
	second value	1
FOG	**total emission**	**0**

EPX 82 Biocompatibility

Biocompatibility Testing

Test articles in the form of printed parts were provided to NAMSA for evaluation and met the requirements of each of the following tests:

Biocompatibility Testing	Test Standard
Cytotoxicity	ISO 10993-5: Biological evaluation of medical devices – Part 5: Tests for *in vitro* cytotoxicity (MEM extract)
Sensitization	ISO 10993-10: Biological evaluation of medical devices – Part 10: Tests for skin sensitization (Guinea Pig Maximization Sensitization Test)
Irritation	ISO 10993-23: Biological evaluation of medical devices – Part 23: Tests for irritation (Intracutaneous study in rabbits)

Test articles were processed using an M series printer and a Smart Part Washer with DPM as the solvent followed by isopropanol dunk. The washed test articles were baked following the standard baking schedule for EPX 82 (see below) in an air oven. Additional details about the tests are available upon request.

Baking schedule: Ramp from room temperature to 70 °C over 1 hour; Ramp from 70 to 100 °C over 2 hours; Hold at 100 °C for 3 hours; Ramp from 100 to 120 °C over 1 hour; Hold at 120°C for 30 minutes; Ramp from 120 to 180°C over 2 hours; Hold at 180 °C for 1 hour; Ramp from 180 to 200°C over 1 hour; Ramp from 200 to 220°C over 1 hour; Cool to room temperature with the door closed (about 2 hours).

Disclaimer

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