EPX 82

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

Tensile Properties* ISO 527-2, Type 1A, 5 mm/min	**Metric**	**US**
Tensile Modulus	2800 MPa	410 ksi
Yield Strength	80 MPa	10 ksi
Ultimate Tensile Strength	80 MPa	10 ksi
Elongation at Break	5%	5%

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

Impact Properties*	**Metric**	**US**
Gardner, ASTM D5420	0.5 J	0.4 ft-lb
Unnotched Charpy, ISO 179-1/1eA	25 kJ/m^2	12 $ft\text{-}lb/in^2$
Notched Charpy (Machined Notch), ISO 179-1/1eA	4.4 kJ/m^2	2 $ft\text{-}lb/in^2$
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	**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 D64	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	1.3 BTU/hr-ft-°F
Flammability, UL 94 (1.5 mm, 3.0 mm)	HB	HB

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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.

Dielectric/Electric Properties	
Dielectric Strength, ASTM D149	18 kV/mm
Dielectric Constant, ASTM D150	3.4
Dissipation Factor, ASTM D150	0.007
Volume Resistivity, ASTM D257	5.0 E+15 ohm-cm
Comparative Tracking Index, ASTM D3638	600 V

General Properties	
Hardness, ASTM D2240	89 (instant), 88 (5 sec), Shore D
Density, ASTM D792	1.16 g/cm^3
Density (liquid resin)	1.12 g/cm^3
Poisson's Ratio	0.37
Taber Abrasion, ASTM D4060, CS-17, 1 kg, 100% vacuum	40 mg/ 1000 cycles

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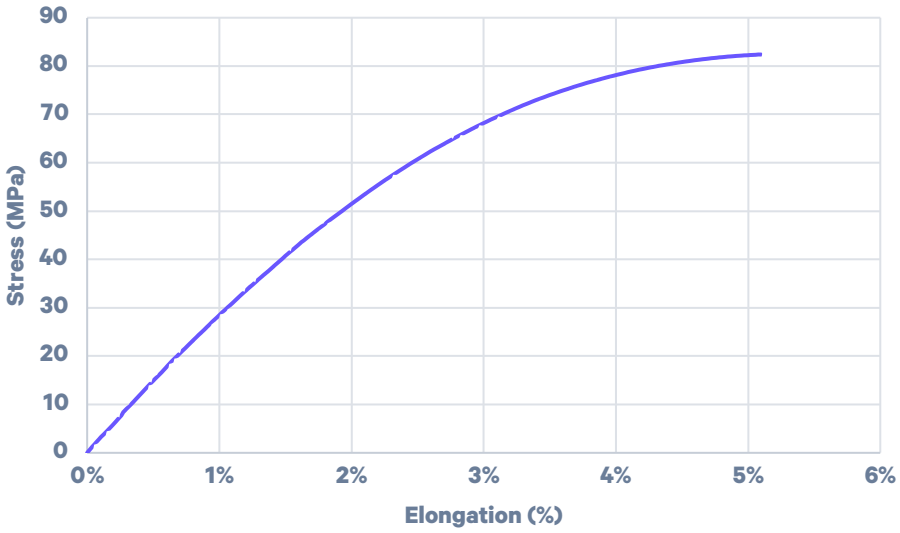
EPX 82

Extended TDS

EPX 82 Mechanical Properties

Representative Tensile Curve

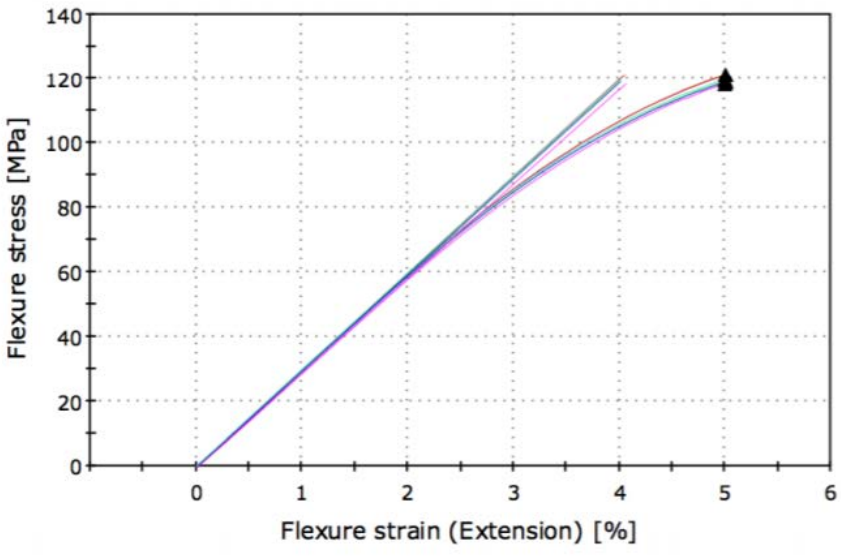
ISO 527-2, Type 1A, 5 mm/min



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 Chemical Compatibility

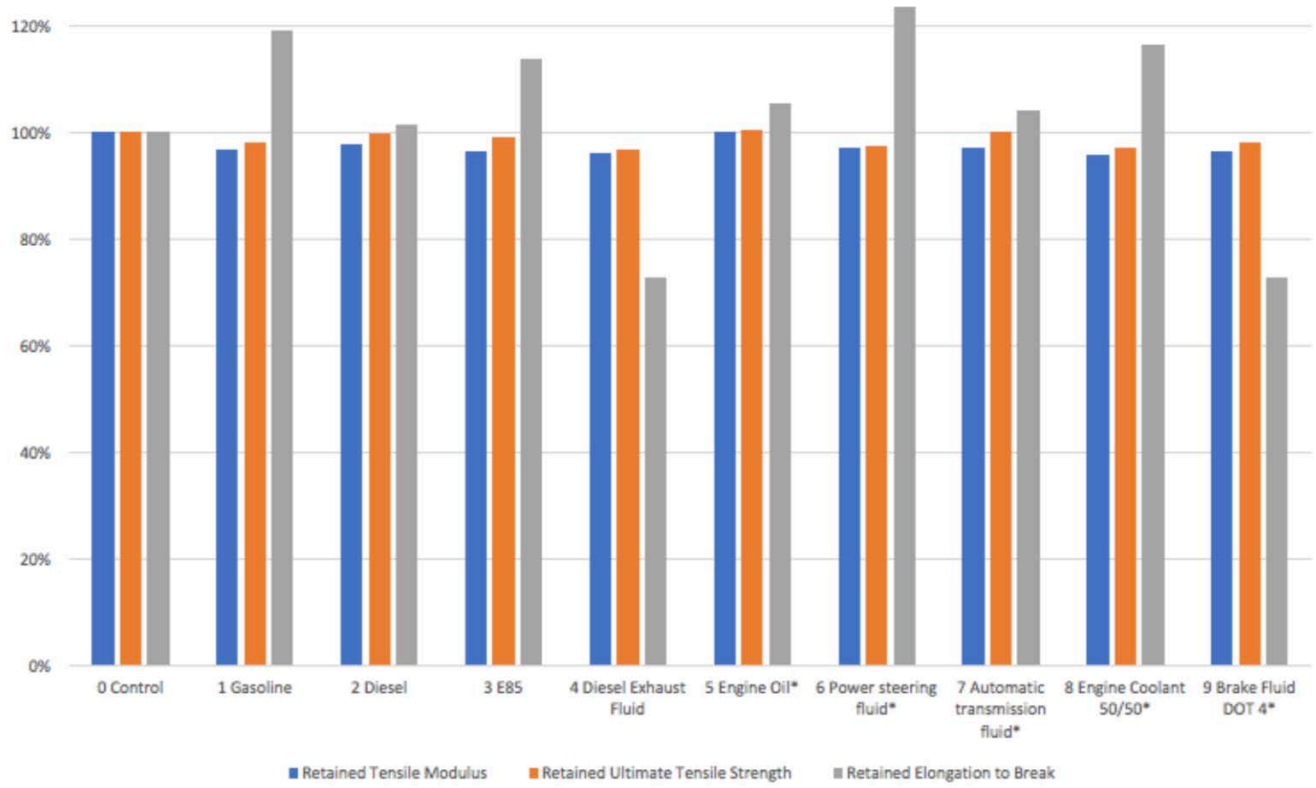
	Mass Gain* (%)
Household Chemicals	
Bleach (NaClO, 5%)	< 5%
Sanitizer (NH_4Cl, 10%)	< 5%
Distilled Water	< 5%
Sunscreen (Banana Boat, SPF 50)	< 5%
Detergent (Tide, Original)	< 5%
Windex Powerized Formula	< 5%
Hydrogen Peroxide (30%)	< 5%
Ethanol (95%)	5 - 15%
Industrial Fluids	
Engine Oil (Havoline SAE 5W-30)	< 5%
Brake Fluid (Castrol DOT-4)	< 5%
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 82 Chemical Compatibility cont.

USCAR2

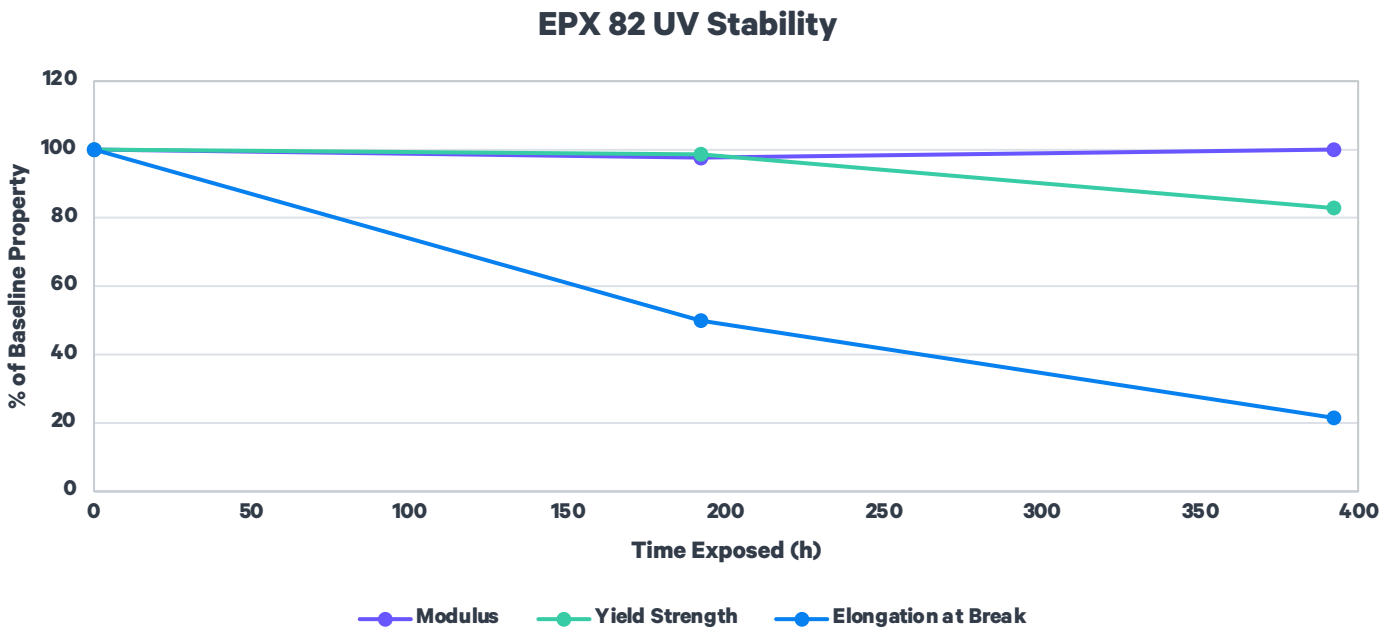
Epoxies as a chemical family exhibit excellent chemical resistance. EPX 82 shows similar performance, showing no surface blemishes and minimal change in tensile properties after chemical exposure simulating splash contact per USCAR2 conditions.



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 I, 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.



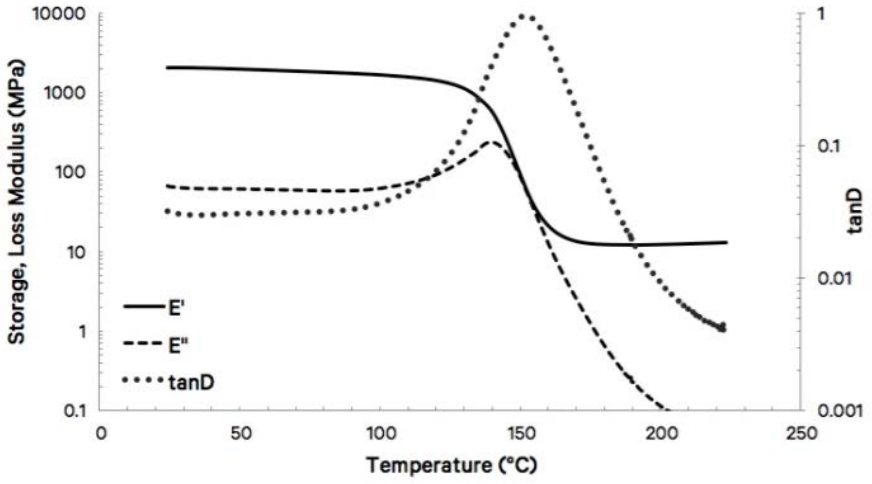
ASTM 4459: Q-Sun XE-1, 0.8 W/m^2/nm at 420 nm, 55 °C
ASTM D638: Type V, 500 mm/min, average values represented

EPX 82 Thermal Properties

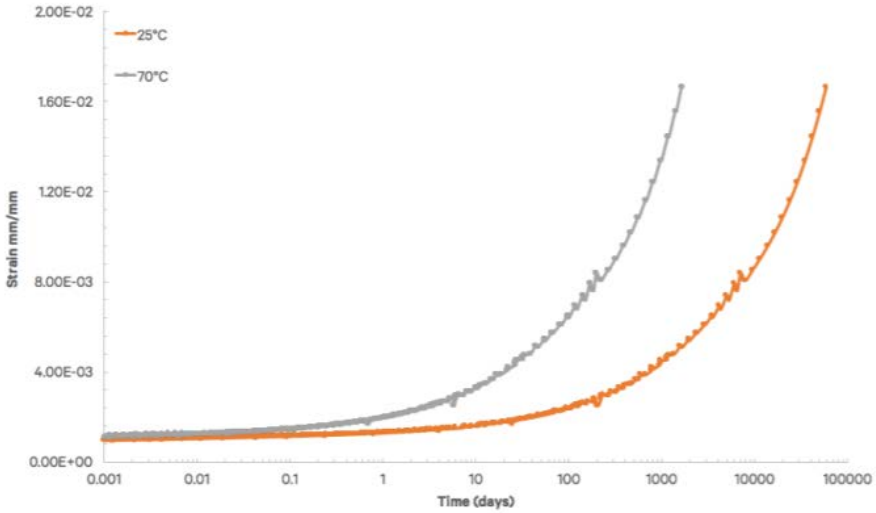
DMA and Creep

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

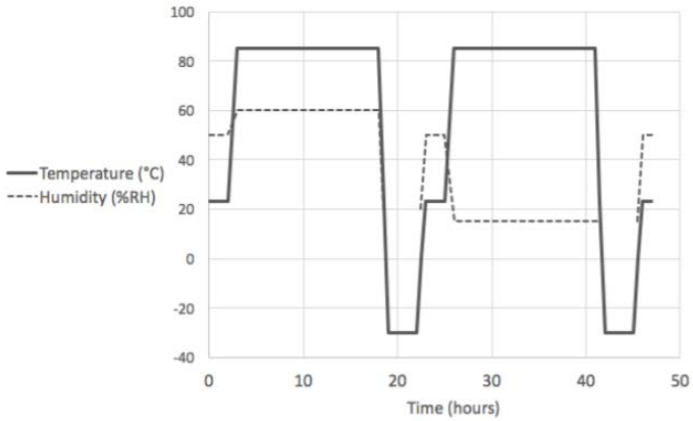


Creep TTS test method: TA Q800 DMA, single cantilever mode, 30x15x3.2 mm sample, 0-125°C sweep at 5°C increments with 5 minute isothermal and 10 minute deformation, 2 MPa applied load, dry

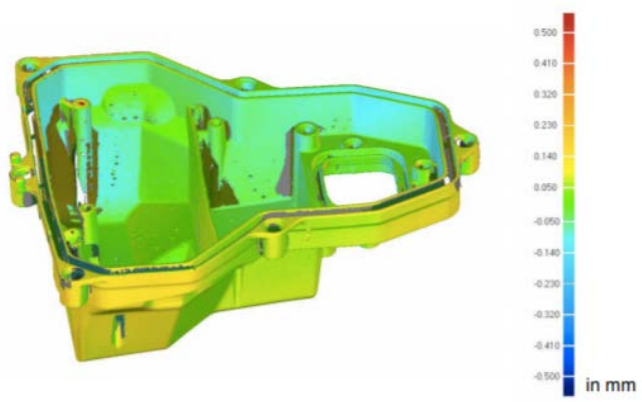
EPX 82 Material Endurance

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

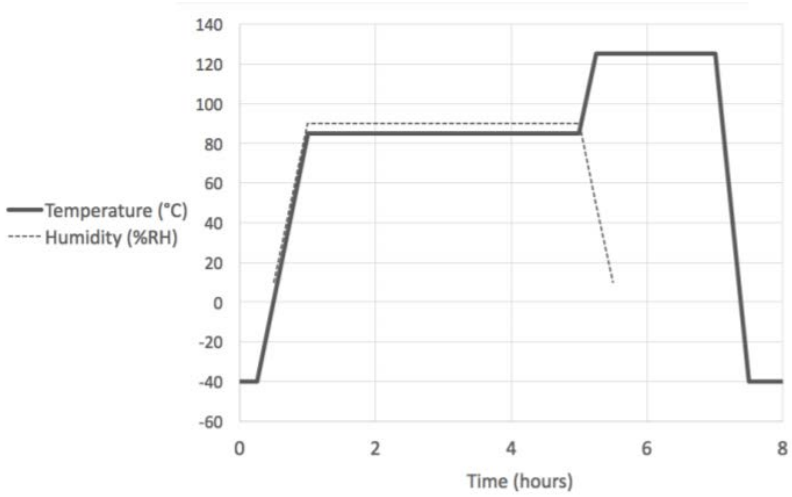
	Initial*	Retained after heat aging (168 h at 100 °C)	Retained after temp/ humidity cycling (240 h, cycle shown above)
Tensile Modulus	**3000 MPa**	**100%**	**95%**
Yield strength	**70 MPa**	**100%**	**100%**
Elongation at Yield	**5%**	**100%**	**95%**
Elongation at Break	**10%**	**100%**	**90%**
Notched Izod Impact (23°C)	**50 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.



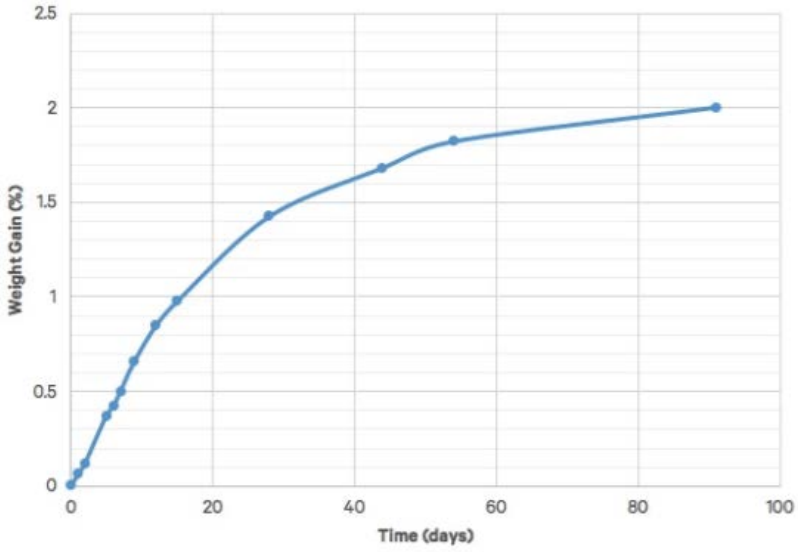
Electrical connector testing		% Retained		
	Initial*	Heat aging: 1008 hours, 125 °C	Temp/humidity cycling: 40 cycles, shown above	Thermal shock: 100 cycles, -40-125 °C
Tensile Modulus	3000 MPa	100%	95%	100%
Yield strength	70 MPa	110%	100%	105%
Elongation at Yield	5%	105%	95%	95%
Elongation at Break	10%	75%	90%	80%
Notched Izod Impact (23 °C)	50 J/m	100%	95%	95%

*Conditioned ASTM D638 Type V dogbones and Izod bars

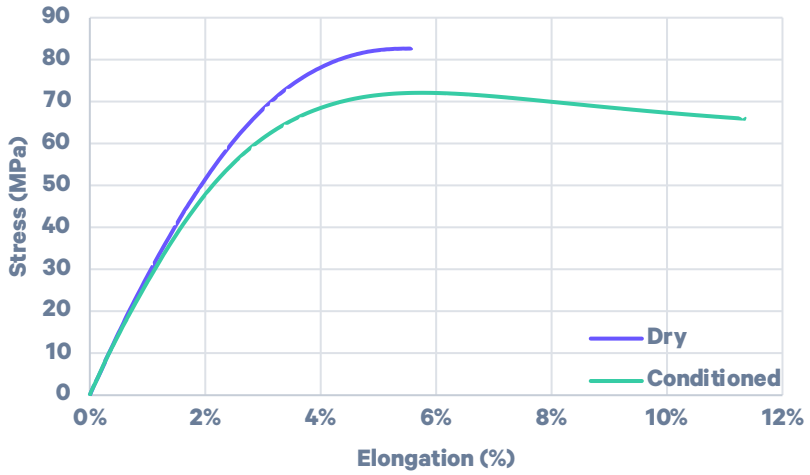
EPX 82 Water Uptake

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 increases in elongation 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

Conditioned Mechanical Properties

Tensile Properties ISO 527-2, Type 1A, 5 mm/min	**Metric**	**US**
Tensile Modulus	2800 MPa	410 ksi
Yield Strength	72 MPa	10 ksi
Ultimate Tensile Strength	67 MPa	10 ksi
Elongation at Break	> 5%	> 5%

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

Impact Properties	**Metric**	**US**
Gardner, ASTM D5420, GC, 3.2 mm	0.56 J	0.41 ft-lb
Unnotched Charpy , ISO 179-1/1eA	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 D256	350 J/m	7 ft-lb/in
Notched Izod (Machined Notch), ASTM D256	42 J/m	0.8 ft-lb/in

Thermal Properties	**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 D64	90 °C	200 °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.

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_0 in mg	G_1 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

Printed parts were provided to NAMSA for evaluation in accordance with ISO 10993-5, *Biological evaluation of medical devices - Part 5: Tests for in vitro cytotoxicity*, and ISO 10993-10, *Biological evaluation of medical devices - Part 10: Tests for irritation and skin sensitization (GPMT).* Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent. The results for all tests indicated that EPX 82 passed the requirements for biocompatibility according to the above tests. **Carbon makes no representation and is not responsible for the results of any biocompatibility tests other than those specified above.**

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Biocompatibility results may vary based on printing and/or post-processing procedures.

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