RPU 130

RPU 130 is a strong and tough engineering polyurethane offering a unique combination of durability, impact resistance, and performance at elevated temperatures.

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RPU 130

Tensile Properties	Test Standard	Metric	US
Tensile Modulus	ASTM D638 Type I 50 mm/min	1000 MPa	145 ksi
Yield Strength		25 MPa	4 ksi
Strain at Yield		10%	10%
Ultimate Tensile Strength		35 MPa	5 ksi
Elongation at Break		100%	100%
Tensile Modulus	ASTM D638 Type V 10 mm/min	900 MPa	130 ksi
Yield Strength		25 MPa	4 ksi
Strain at Yield		10%	10%
Ultimate Tensile Strength		35 MPa	5 ksi
Elongation at Break		100%	100%

Flexural Properties	Test Standard	Metric	US
Flexural Stress at 5% strain	ASTM D790-B	35 MPa	5 ksi
Flexural Modulus (Chord, 0.5-1%)		900 MPa	130 ksi

Impact Properties	Test Standard	Metric	US
Gardner Impact	ASTM D5420	> 36 J	> 26 ft-lb
Gardner Impact (-30 °C)		35 J (ductile)	> 26 ft-lb
Notched Charpy (Machined Notch)	ISO 179-1/1eA	10 kJ/m^2	4.8 ft-lb/in^2
Notched Izod (Machined Notch)	ASTM D256	75 J/m	1.4 ft-lb/in
Notched Izod (Machined Notch) (-30 °C)		50 J/m	0.9 ft-lb/in
Unnotched Izod (-30 °C)	ASTM D4812	1600 J/m	30 ft-lb/in

Thermal Properties	Test Standard	Metric	US
Heat Deflection Temperature at 0.455 MPa/66 psi	ASTM D648	120 °C	250 °F
Heat Deflection Temperature at 1.82 MPa/264 psi		55 °C	130 °F
Coefficient of Thermal Expansion (-60, 100 °C)	ASTM E831	150 ppm/°C	82 ppm/°F

Dielectric/Electric Properties	Test Standard	Metric
Dielectric Strength	ASTM D149	17 kV/mm

Flammability	
FMVSS 302	Pass

Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent, followed by isopropanol dunk. The test articles were baked following the standard baking schedule for RPU 130.

General Properties	Test Standard	
Shore D Hardness	ASTM D2240	77
Bulk Density	ASTM D792	1.07 g/mL
Poisson's Ratio	ASTM D638 Type I 5 mm/min	0.47
Taber Abrasion	ASTM D4060 CS-17, 1 kg, 100% vacuum	10 mg / 1000 cycles
Water Absorption, Short Term (24 hours)	ASTM D570	< 2%
Water Absorption, Long Term (14 days)		5%

Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent, followed by isopropanol dunk. The test articles were baked following the standard baking schedule for RPU 130.

Liquid Properties	
Liquid Density (Part A)	1.05 g/mL
Liquid Density (Part B)	0.95 g/mL
Liquid Density (Part A+B)	1.03 g/mL
Part A:B Volume Ratio (Mass Ratio)	4.00 (4.43)
25 °C Viscosity (Part A)	30000 cP
25 °C Viscosity (Part B)	90 cP
25 °C Viscosity (Part A+B)	11000 cP

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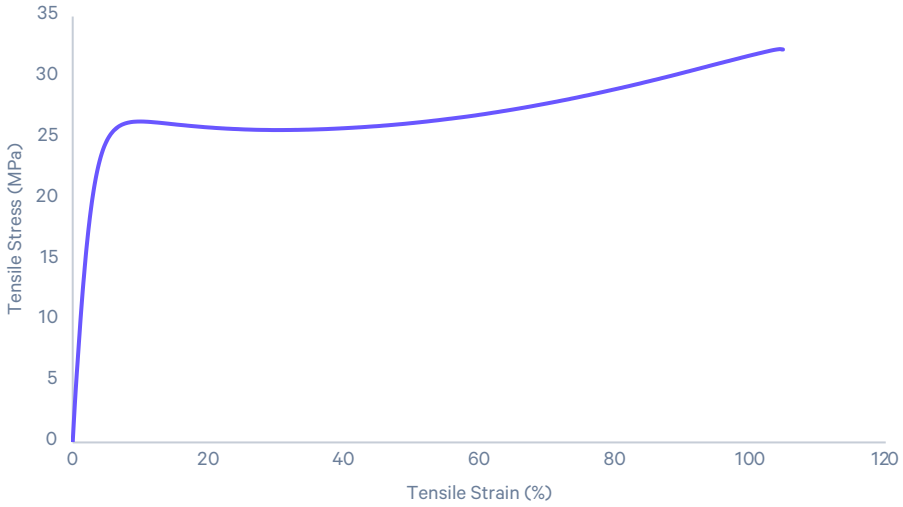
RPU 130

Extended TDS

RPU 130 Mechanical Properties

Representative Tensile Curve

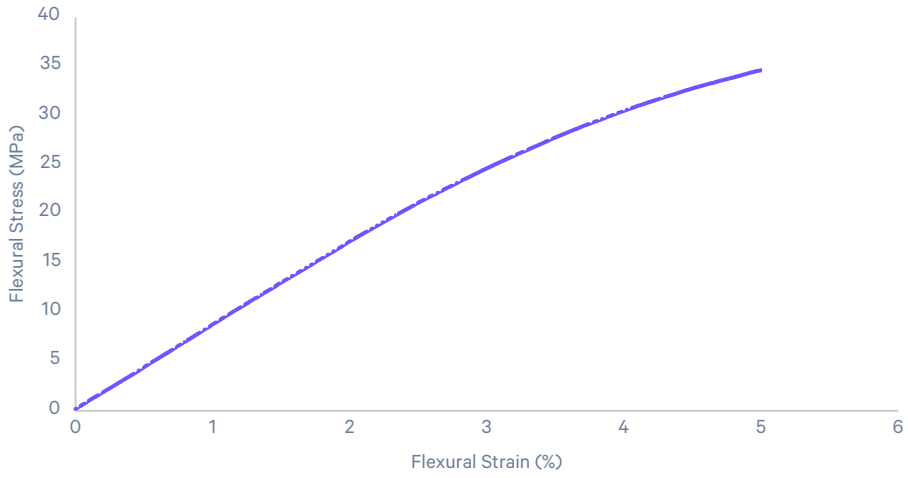
ASTM D638, Type V, 10 mm/min



Typical Flexural Curve

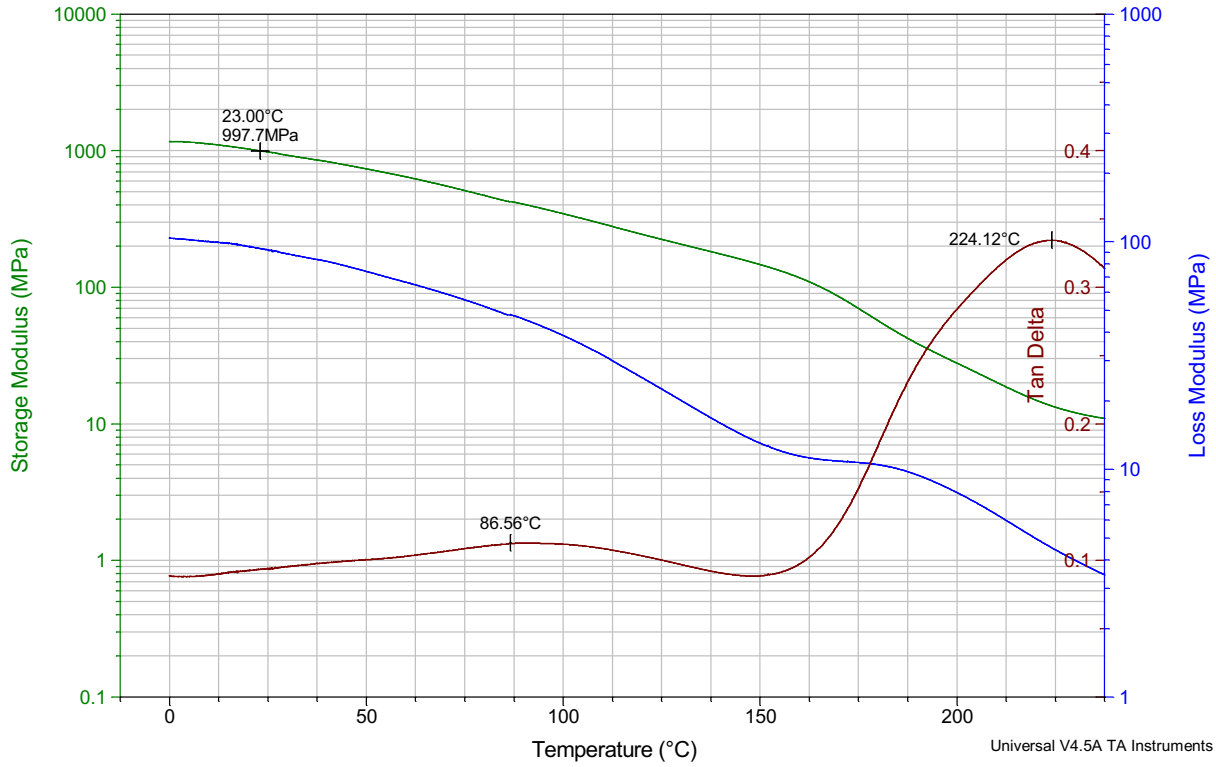
ASTM D790-B

Samples are tested to 5% extension.



RPU 130 Dynamic Mechanical Analysis (DMA)

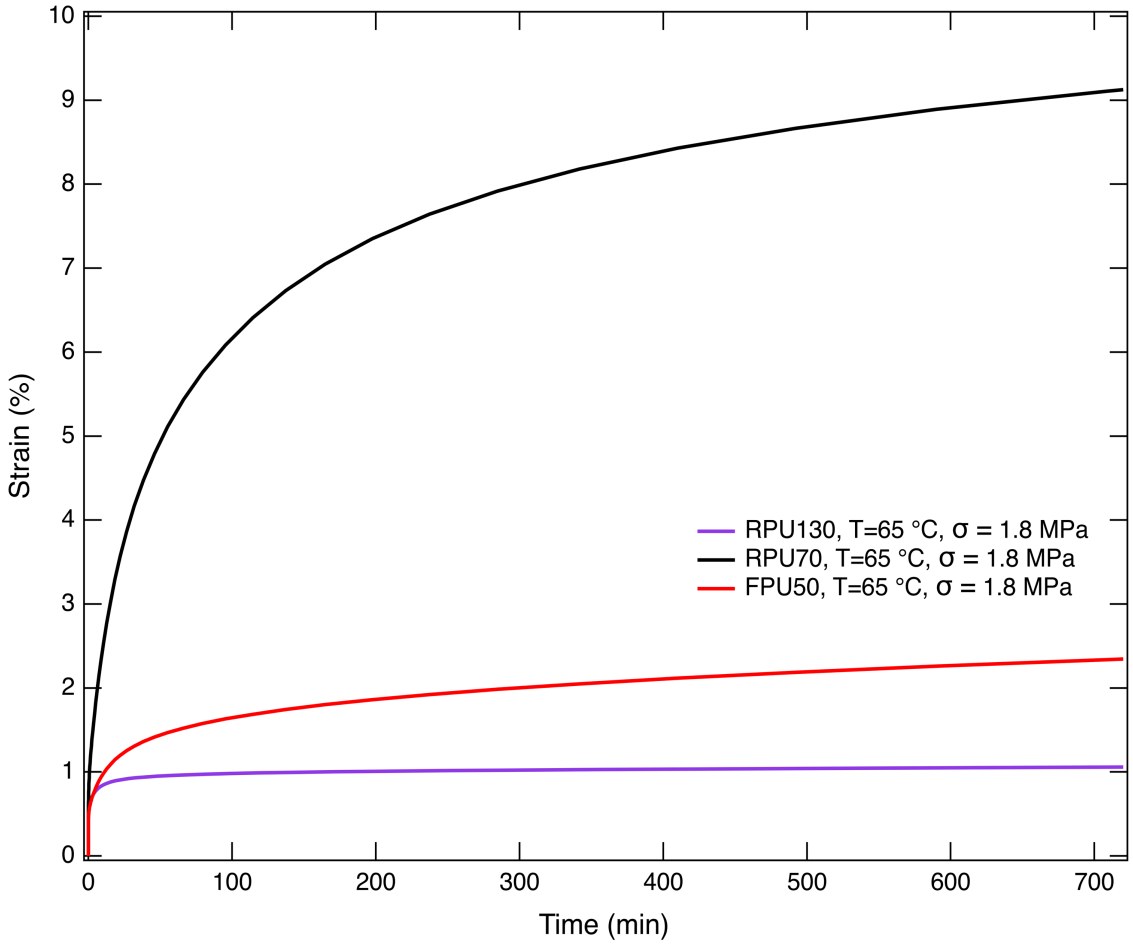
Dynamic mechanical analysis provides insight into a material's viscoelastic properties across a range of temperatures. The figure below shows a temperature ramp of RPU 130. This material exhibits two transition temperatures at 90 °C and 225 °C as indicated by the two peaks in the tan(d) curve.



Standard: ASTM D4065
Instrument: TA DMA Q800
DMA Mode: Tension
Sample Dimensions: L=20 mm, W=10 mm, t=1 mm (rectangular block)
Strain Amplitude: 0.1% (linear regime of viscoelasticity)
Oscillation frequency: 1 Hz
Temperature Range: 0 °C to 250 °C
Ramp Rate: 1.5 °C/min
Print Conditions: Samples were hand-wiped and not washed with solvent. The thermal cure for all materials complies with the Carbon user manual. Values may differ based on post processing conditions.

RPU 130 Creep Behavior

A creep test measures a polymer's rate of deformation under constant load at a fixed temperature and is a fundamental property for materials that need to operate under load. The figure below highlights RPU 130's ability to withstand 1.8 MPa of applied load compared to RPU 70 and FPU 50 at elevated temperatures. Low creep behavior is necessary for performance and dimensional stability over time.



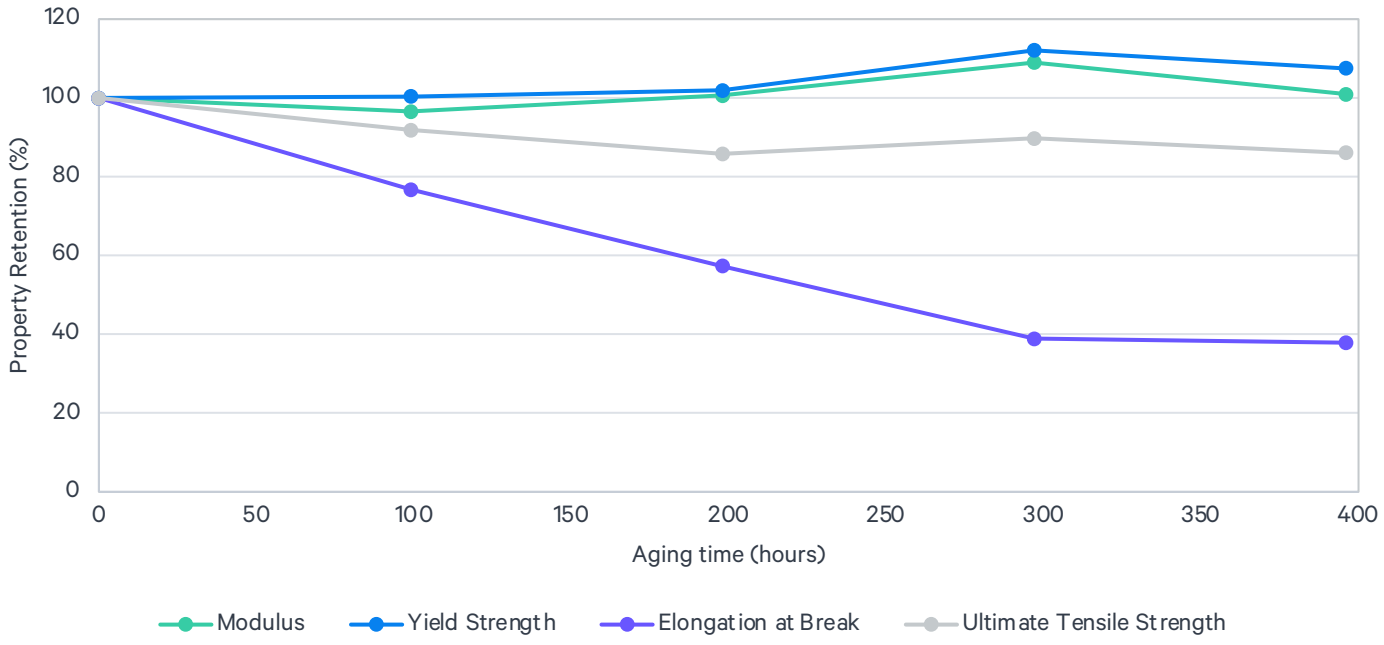
RPU 130 Chemical Compatibility

	Mass Gain* (%)
Household Chemicals	
Sunscreen (Banana Boat, SPF 50)	5 - 15%
Industrial Fluids	
Engine Oil (Havoline SAE 5W-30)	< 5%
Transmission Fluid (Havoline Synthetic ATF)	< 5%
Diesel (Chevron #2)	15 - 30%

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

RPU 130 UV Aging

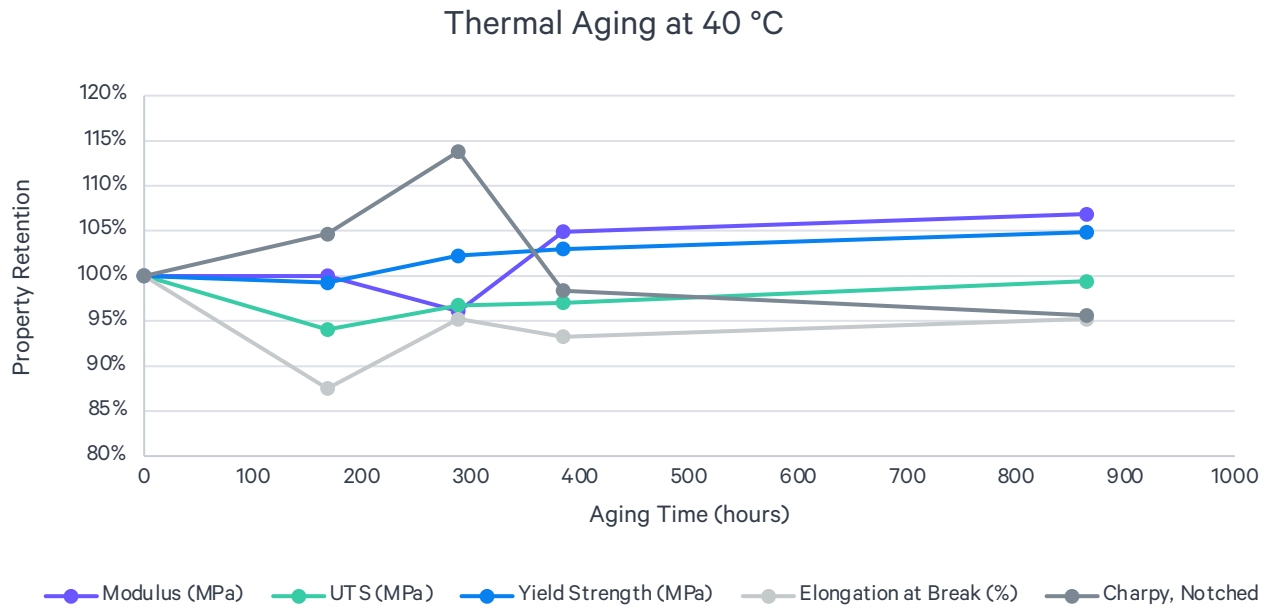
Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of RPU 130 using ASTM D4459, which is intended to simulate indoor exposure of solar radiation through glass.



ASTM D4459: Q-Sun XE-1, 0.8 W/m^2/nm at 420 nm, 55 °C
ASTM D638: Type V, 10 mm/min, average values represented

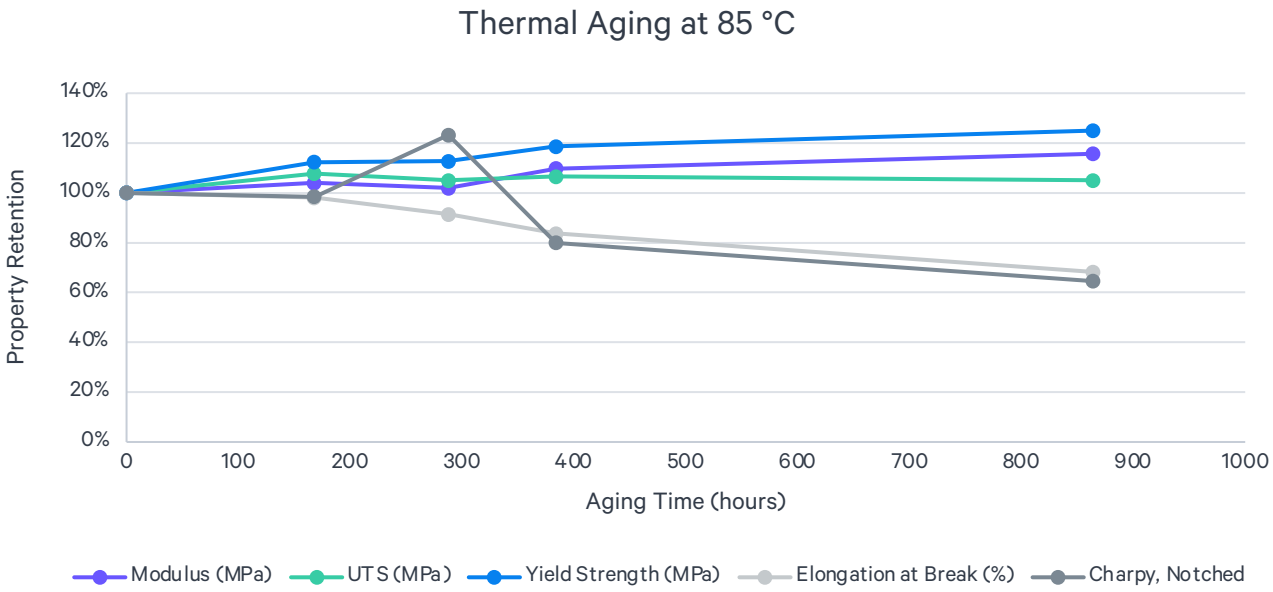
RPU 130 Thermal Aging

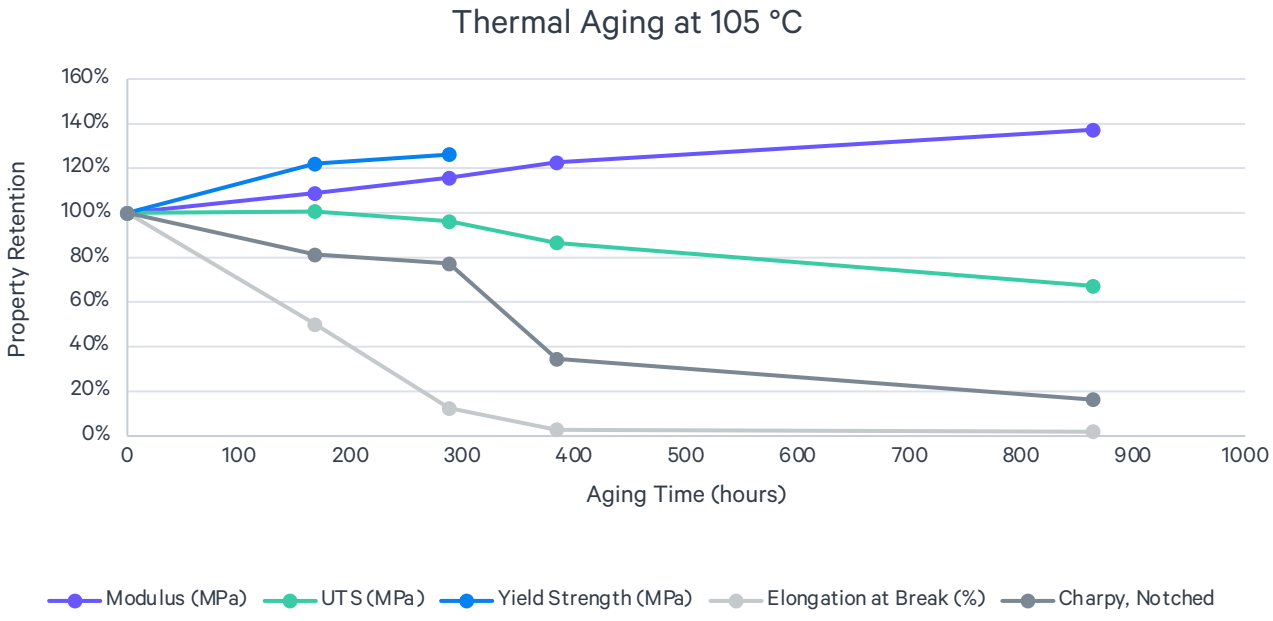
High thermal stability is an important property for high performance rigid polymers. RPU 130 offers better thermal stability compared to previous polyurethane offerings. The figures below illustrate the change in mechanical properties after thermal aging at 40 °C, 85 °C, and 105 °C.



ASTM D638: Type I, 50 mm/min
ISO 179-1/1eA: Notched Charpy (Machined Notch)

RPU 130 Thermal Aging cont.





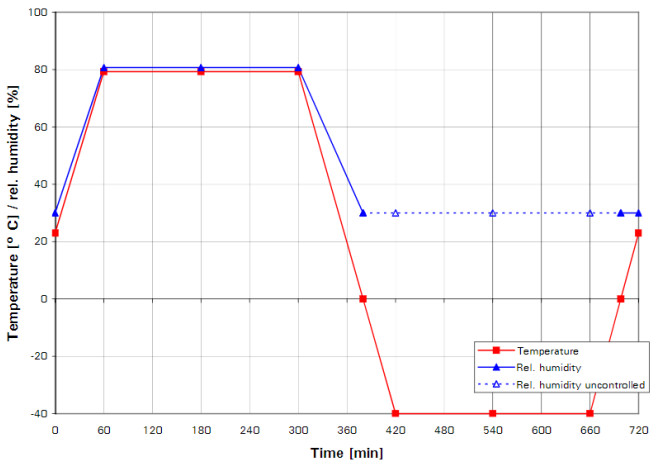
ASTM D638: Type I, 50 mm/min
ISO 179-1/1eA: Notched Charpy (Machined Notch)

RPU 130 Environmental Aging

PV 1200

Stability to environmental factors, such as temperature and humidity, is a key performance aspect for plastic materials. PV 1200, a standard developed by the Volkswagen Group to evaluate material durability, is used as a representative climate cycling test. This standard designates one cycle to be a 720 minute period in which both temperature and humidity are varied from 80 °C/80% RH to -40 °C, shown on the figure to the right.

Test cycle for PV 1200



Carbon evaluated RPU 130 after 20 cycles per PV 1200 with the results reported in the table below. RPU 130 shows > 75% retention in tensile and impact properties after this exposure.

Further testing is recommended for applications that require performance under differing environmental conditions.

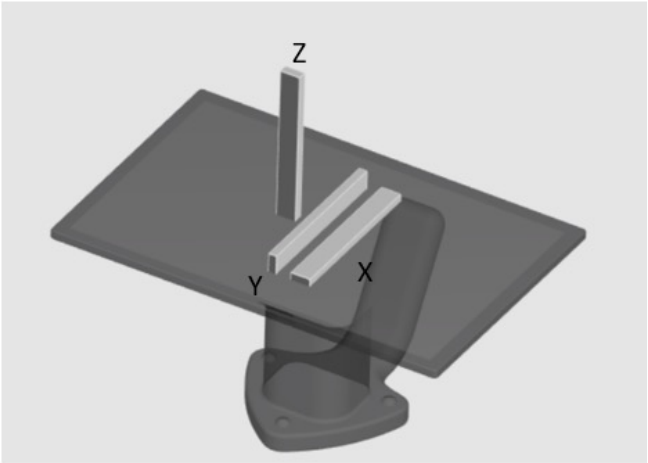
Properties	Test	Baseline	20 Cycles, PV1200
Modulus	ASTM D638 Type I 50 mm/min	1000 MPa	1000 MPa
Yield Strength		25 MPa	25 MPa
Ultimate Tensile Strength		30 MPa	30 MPa
Elongation at Break		100%	110%
Notched Charpy (Machined Notch)	ISO 179-1/1eA	10 kJ/m^2	10 kJ/m^2

The samples sizes for ASTM D638 and ISO-179-1/1eA are 6 and 8, respectively.

RPU 130 Mechanical Isotropy

Type I and Charpy bars

Carbon's dual cure materials yield parts that have a higher degree of isotropy than other additive manufacturing materials. To highlight this, Carbon evaluated the tensile and impact properties of RPU 130 printed in three orientations: flat on the platform (X), on edge lengthwise (Y), and on end (Z). The tensile specimens printed in the Y orientation required additional supports in the gage area to be properly printed. The table below shows the results of the tested samples.



		Orientation		
Properties	**Test**	**X**	**Y**	**Z (Baseline)**
Modulus	ASTM D638 Type I	1000 MPa	1000 MPa	1000 MPa
Yield Strength		25 MPa	25 MPa	25 MPa
Ultimate Tensile Strength		30 MPa	35 MPa	35 MPa
Elongation at Break		105%	110%	100%
Notched Charpy (Machined Notch)	ISO 179-1/1eA	20 kJ/m^2	30 kJ/m^2	10 kJ/m^2

RPU 130 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 (Closed patch sensitization study in guinea pigs)
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 DPM as the wash solvent, followed by isopropanol dunk. The test articles were baked following the standard baking schedule for RPU 130 (see below). Additional details about the tests are available upon request.

Baking schedule: Ramp from room temperature to 140 °C over 2 hours; Hold at 140 °C for 12 hours; Ramp from 140°C to 50 °C over 5 minutes; Hold at 50°C for 1 minute.

Disclaimer

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