Stratasys High Yield PA11 Material Properties

Preliminary information, subject to change

Processed with SAF™ technology on the Stratasys H350 3D printer, Stratasys High Yield PA11 delivers production-grade plastic parts for high-volume demands — driving new areas of business growth. Stratasys High Yield PA11 enables a high nesting density while maintaining high part consistency to deliver production-level yields.

In additive manufacturing, PA12 is the go-to material for prototyping. But in traditional high-volume production of end-use parts, PA11 is much more widely used due to its higher ductility and higher impact resistance, as well as its suitability for a wider range of industry applications. PA11 is also eco-friendly and 100 percent bio-based from sustainable castor oil.

The mechanical data below provides a good characterisation of the entire build volume across multiple printers. It was generated after measuring more than 2000 tensile specimens (972 in X/Y and 1,080 in Z direction), 540 flexural specimens (360 in X/Y and 180 in Z) and 540 impact specimens (360 in X/Y and 180 in Z), all printed in 36 builds from 5 different printers. These specimens were widely and regularly distributed throughout the build volume, in a 12% nesting density build and produced with default printer settings.

Property	Mean	Standard Deviation	Unit	Standard
Tensile Strength (XZ,YX)	51 (7397)	2.2 (319)	MPa (psi)	ASTM D638-14
Tensile Strength (ZX)	47 (6817)	4.4 (638)	MPa (psi)	ASTM D638-14
Elongation at Break (XZ,YX)	30	5.6	%	ASTM D638-14
Elongation at Break (ZX)	11	4.8	%	ASTM D638-14
0.2% Offset Yield Strength (XZ,YX)	35 (5076)	1.6 (232)	MPa (psi)	ASTM D638-14
0.2% Offset Yield Strength (ZX)	34 (4931)	2.5 (363)	MPa (psi)	ASTM D638-14
Tensile Modulus (XZ,YX)	1529 (222)	76 (11)	MPa (ksi)	ASTM D638-14
Tensile Modulus (ZX)	1609 (233)	99 (14)	MPa (ksi)	ASTM D638-14
Flexural Strength (XZ,YX)	35 (5033)	2.3 (327)	MPa (psi)	ASTM D790-17
Flexural Strength (ZX)	36 (5280)	2.9 (414)	MPa (psi)	ASTM D790-17
Flexural Modulus (XZ,YX)	826 (120)	65 (9.5)	MPa (ksi)	ASTM D790-17
Flexural Modulus (ZX)	885 (128)	79 (11.5)	MPa (ksi)	ASTM D790-17
Notched Impact Strength (XZ,YX)	7.4 (3.5)	0.6 (0.3)	kJ/m^2 ($Ft.lbf/in^2$)	ASTM D256-10
Notched Impact Strength (ZX)	4.5 (2.1)	0.2 (0.1)	kJ/m^2 ($Ft.lbf/in^2$)	ASTM D256-10

General	Value	Unit	Standard
Part Specific Gravity	1.02	-	ASTM D792-13
Virgin Particle Size D50	47 (1.9)	µm (thou)	-
Virgin Powder Melting Point	202 (396)	°C (°F)	-
Surface	**Value**	**Unit**	**Standard**
Surface Roughness, Top Surface (Ra)	8.5 (0.3)	µm (thou)	ISO 4287
Surface Roughness, Bottom Surface (Ra)	7.2 (0.3)	µm (thou)	ISO 4287
Surface Roughness, Sidewall (Ra)	7.9 (0.3)	µm (thou)	ISO 4287
Thermal	**Value**	**Unit**	**Standard**
Heat Deflection Temperature (0.45MPa/65psi)	185 (365)	°C (°F)	ASTM D648
Heat Deflection Temperature (1.82MPa/264psi)	47 (117)	°C (°F)	ASTM D648
Coefficient of Thermal Expansion	171 (0.095)	µm/°C.m (thou/in.°F)	ASTM E831
Specific Heat Capacity (20°C/68°F)	1.72 (0.411)	J/g.°C (BTU/lbm.°F)	ASTM E1952
Thermal Conductivity (20°C/68°F)	0.263 (0.152)	W/°C.m (BTU/hr.ft.°F)	ASTM E1952
Electrical	**Mean**	**Unit**	**Standard**
Surface resistivity	1.9×10^{15}	Ohm	ASTM D257
Volume resistivity	3.6×10^{14}	Ohm-cm	ASTM D257
Bio compatibility	**Result**	**Unit**	**Standard**
Determination of Sensitization - human cell line activation test (h-Clat)	Non-Sensitizer	N/A	OECD 442E 2018-06
Determination of Skin Irritation	Non-irritant	N/A	ISO 10993-10 2014-10 / OECD 439 2015-07
Determination of Cytotoxicity	Material shows no cytotoxic effect	N/A	DIN EN ISO 10993-5, 2009, Annex D
Flammability		**Unit**	**Standard**
UL94 HB	Pass*	Not Applicable	UL94 (2013)
Reusability	**Value**	**Unit**	**Standard**
Typical Powder Mix Ratio (Virgin)	30	%	-

* Product is not currently UL Blue Card Registered.

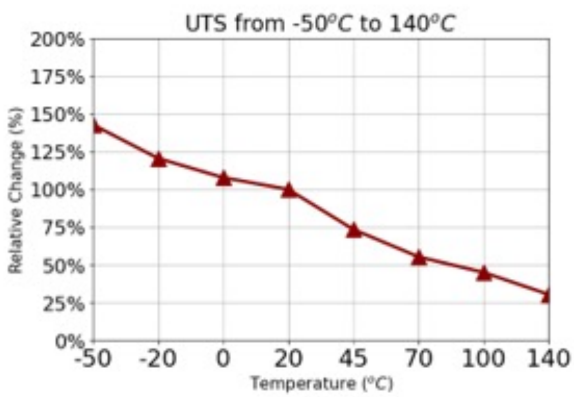
Testing Varying Temperatures

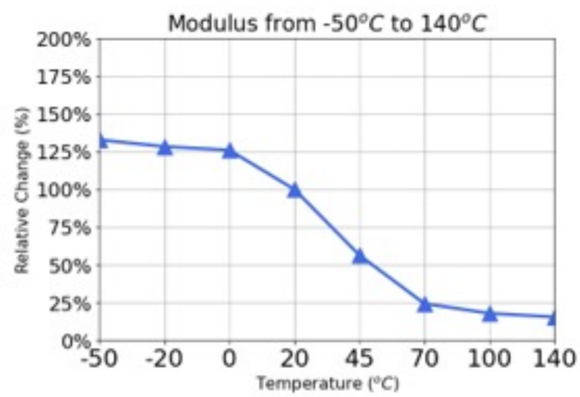
The following results give an indication of the tensile properties of the material across a range of temperatures. Tensile testing was conducted between -50°C (-58°F) and 140°C (284°F) with all coupons and testing in accordance with ASTM D638-22. Coupons were manufactured in both XZ and ZX directions with 5 coupons per direction. The results are presented as a percentage of room temperature properties.

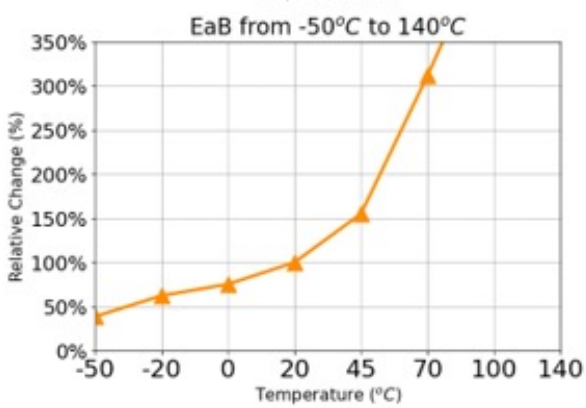
XZ

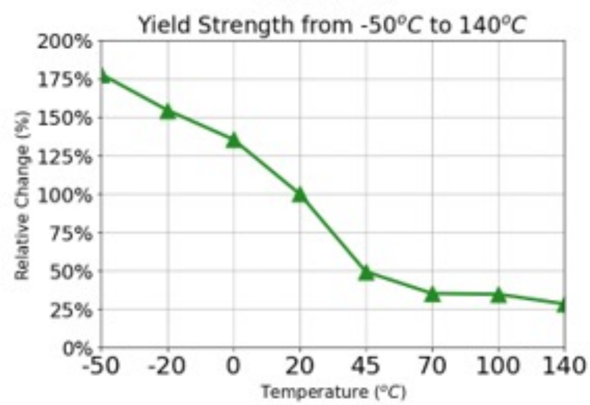
When testing samples at high temperatures, ductility is significantly increased. This can lead to samples stretching beyond the capability of the test equipment rather than having a definitive failure point. With no failure point, the elongation at break and ultimate strength of the sample cannot be accurately measured. Values affected by this are highlighted in **blue**. Where necessary, these values are excluded from the plots below to keep the scales legible.

Material	Direction	Temp (F)	(C)	Ultimate Tensile Strength	Elongation at Break	Tensile Modulus	Yield Strength
High Yield PA11	XZ	-58	-50	143%	39%	133%	178%
		-4	-20	121%	62%	128%	155%
		32	0	108%	75%	126%	135%
		113	45	74%	155%	56%	49%
		158	70	55%	311%	24%	35%
		212	100	45%	479%	18%	35%
		284	140	31%	485%	16%	28%



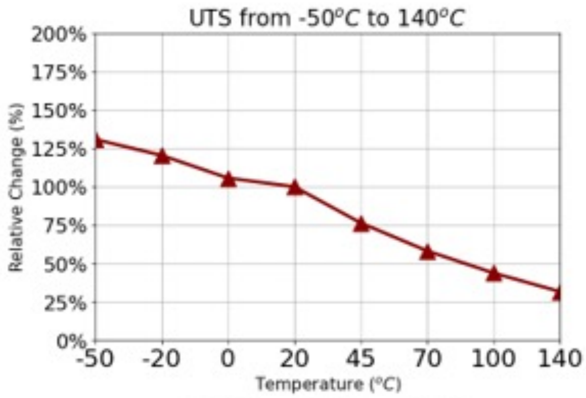


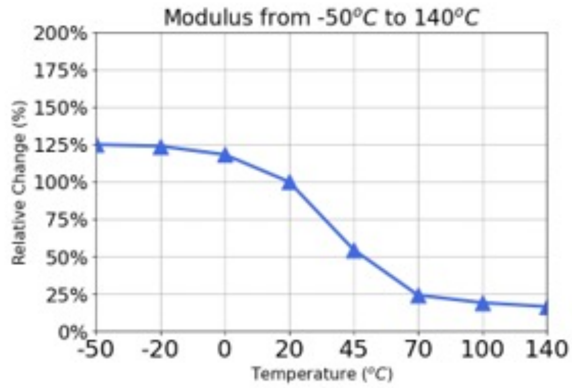


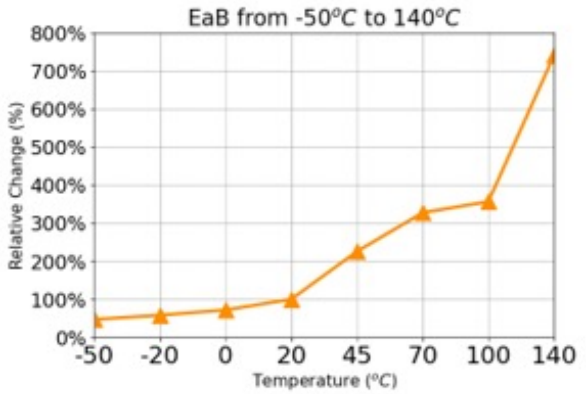


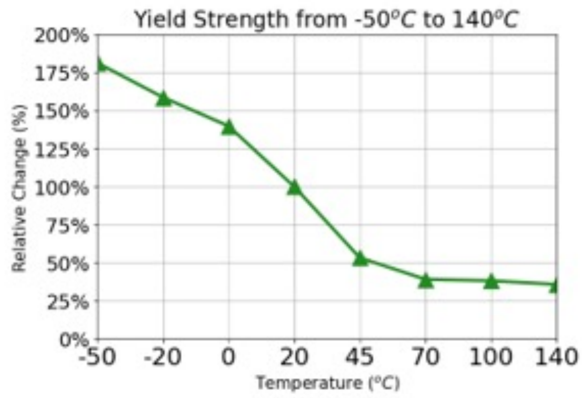
ZX

Material	Direction	Temp (F)	(C)	Ultimate Tensile Strength	Elongation at Break	Tensile Modulus	Yield Strength
High Yield PA11	ZX	-58	-50	131%	47%	125%	181%
		-4	-20	120%	58%	124%	159%
		32	0	106%	72%	118%	140%
		113	45	76%	225%	55%	53%
		158	70	58%	327%	24%	39%
		212	100	44%	356%	19%	38%
		284	140	32%	741%	17%	36%









Tests were performed on parts produced on the H350 using a Full Standard Test Build (FSTB), with 12% nesting density, on multiple machines after a standard installation process, using the default machine settings with 70/30 reused/virgin mix throughout the testing process. H350 installation includes a standard calibration process. Post processing of parts followed H350 recommended guidelines including 24 hours cooling after removal from the machine, manual breaking out, and powder removal via automatized bead blasting with no further post processing. All testing was to ASTM or ISO standards where applicable. All mechanical parts were preconditioned according to ASTM D618-13.

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[3] The information presented are typical values intended for reference and comparison purposes only. They should not be used for design specifications or quality control purposes. End-use material performance can be impacted (+/-) by, but not limited to, part design, end-use conditions, test conditions, etc. Actual values will vary with build conditions. Tested parts were built on the Stratasys H350 3D printer. Product specifications are subject to change without notice. The performance characteristics of these materials may vary according to application, operating conditions, or end use. Each user is responsible for determining that the Stratasys material is safe, lawful, and technically suitable for the intended application, as well as for identifying the proper disposal (or recycling) method consistent with applicable environmental laws and regulations. Stratasys makes no warranties of any kind, express or implied, including, but not limited to, the warranties of merchantability, fitness for a particular use, or warranty against patent infringement.

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SAF™ PA12 technology
Datasheet

SAF™ PA12 is available for use with the H350, a material offering numerous benefits, most notably in delivering a high level of accuracy. Tight thermal control on the H350 leads to consistent parts and high nesting densities, and thus more parts per build. The following data highlight the capability of SAF™ PA12.

Property	Mean	Unit	Standard*
Tensile Strength (XZ,YX)	47 (6817)	MPa (psi)	ASTM D638-14
Tensile Strength (ZX)	45 (6672))	MPa (psi)	ASTM D638-14
Elongation at Break (XZ,YX)	11	%	ASTM D638-14
Elongation at Break (ZX)	5	%	ASTM D638-14
0.2% Offset Yield Strength (XZ,YX)	33.5 (4859)	MPa (psi)	ASTM D638-14
0.2% Offset Yield Strength (ZX)	32.2 (4670)	MPa (psi)	ASTM D638-14
Tensile Modulus (XZ,YX)	1750 (254)	MPa (ksi)	ASTM D638-14
Tensile Modulus (ZX)	1700 (247)	MPa (ksi)	ASTM D638-14
Flexural Strength (XZ,YX)	40 (5801)	MPa (psi)	ASTM D790-17
Flexural Strength (ZX)	41 (5946)	MPa (psi)	ASTM D790-17
Flexural Modulus (XZ,YX)	900 (131)	MPa (ksi)	ASTM D790-17
Flexural Modulus (ZX)	925 (134)	MPa (ksi)	ASTM D790-17
Notched Impact Strength (XZ,YX)	4.17 (1.98)	kJ/m2 (Ft.lbf/in^2)	ASTM D256-10
Notched Impact Strength (ZX)	3.36 (1.60)	kJ/m2 (Ft.lbf/in^2)	ASTM D256-10

*testing based on stated ASTM standards with the following exceptions: tests performed at ambient laboratory conditions (approximately 21 °C and ambient humidity). Samples not conditioned as per stated methods prior to testing.

General	Mean	Unit	Standard
Part Specific Gravity	0.98		ASTM D792-13
Virgin Particle Size D50	56 (2.2)	μm (thou)	
Virgin Powder Melting Point	185 (365)	°C (°F)	

Thermal	Mean	Unit	Standard
Heat Deflection Temperature (0.45MPa/65psi)	173 (343)	°C (°F)	ASTM D648
Heat Deflection Temperature (1.82MPa/264psi)	77 (171)	°C (°F)	ASTM D648
Coefficient of Thermal Expansion	160 (0.089)	µm/°C.m (thou/in.°F)	ASTM E831
Specific Heat Capacity (20°C/68°F)	1.69 (0.4)	J/g.°C (BTU/lb.°F)	ASTM E1952
Thermal Conductivity (23°C/73°F)	0.192 (1.34)	W/m K (BTU (th) inch/hr.ft.°F)	ASTM E1952
Electrical	**Mean**	**Unit**	**Standard**
Surface resistivity	5.53 x10^{13}	Ohm	ASTM D257
Volume resistivity	4.19 x10^{14}	Ohm-cm	ASTM D257
Bio compatibility	**Result**	**Unit**	**Standard**
Determination of Sensitization - human cell line activation test (h-Clat)	Non-Sensitizer	N/A	OECD 442E 2018-06
Determination of Skin Irritation	Non-irritant	N/A	ISO 10993-10 2014-10 / OECD 439 2015-07
Determination of Cytotoxicity	Material shows no cytotoxic effect	N/A	DIN EN ISO 10993-5, 2009, Annex D
Flammability	**Mean**	**Unit**	**Standard**
UL94 HB	Pass*	Not Applicable	UL94 (April 2022)

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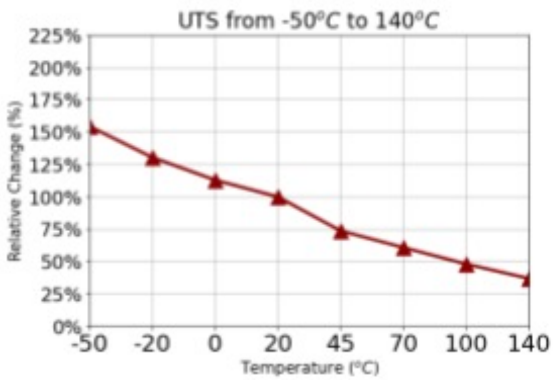
Testing Varying Temperatures

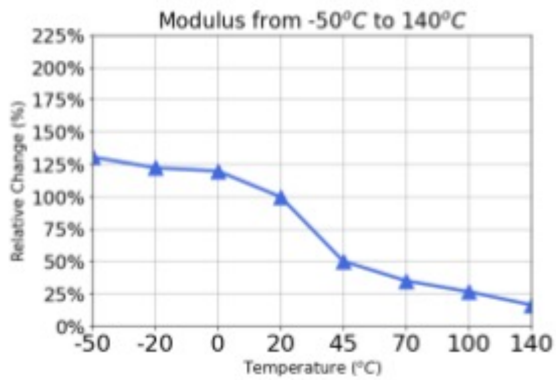
The following results give an indication of the tensile properties of the material across a range of temperatures. Tensile testing was conducted between -50°C (-58°F) and 140°C (284°F) with all coupons and testing in accordance with ASTM D638-22. Coupons were manufactured in both XZ and ZX directions with 5 coupons per direction. The results are presented as a percentage of room temperature properties.

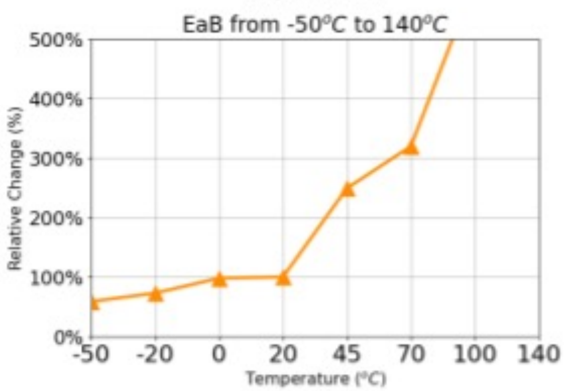
XZ

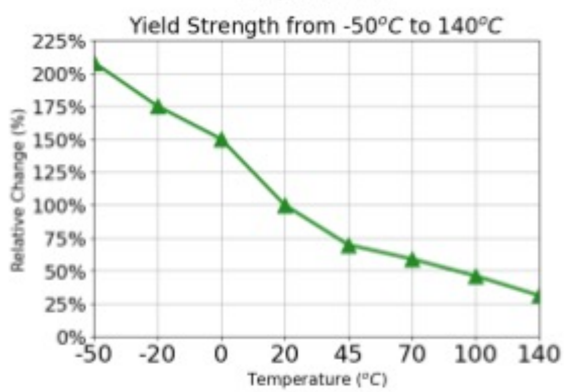
When testing samples at high temperatures, ductility is significantly increased. This can lead to samples stretching beyond the capability of the test equipment rather than having a definitive failure point. With no failure point, the elongation at break and ultimate strength of the sample cannot be accurately measured. Values affected by this are highlighted in **blue**. Where necessary, these values are excluded from the plots below to keep the scales legible.

Material	Direction	Temp (F)	Temp (C)	Ultimate Tensile Strength	Elongation at Break	Tensile Modulus	Yield Strength
High Yield PA12	XZ	-58	-50	154%	58%	130%	208%
		-4	-20	130%	73%	122%	175%
		32	0	113%	98%	120%	150%
		113	45	74%	249%	50%	70%
		158	70	61%	320%	35%	59%
		212	100	48%	396%	27%	46%
		284	140	37%	1373%	16%	31%





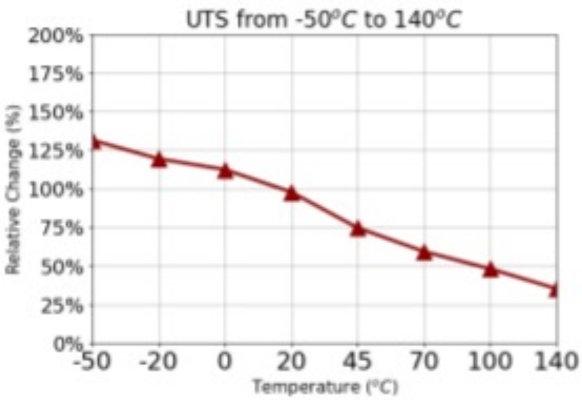


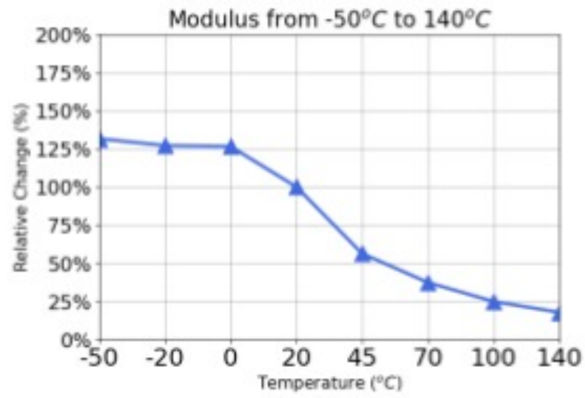


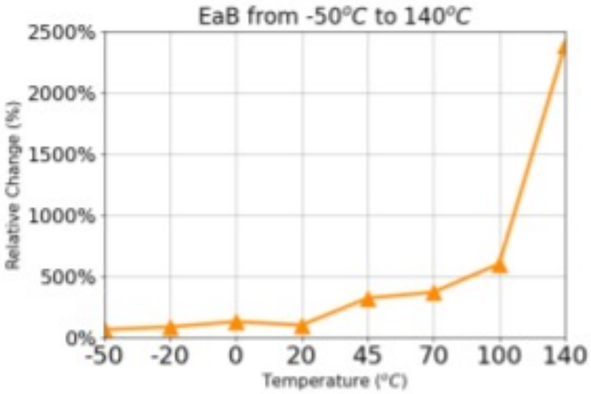
ZX

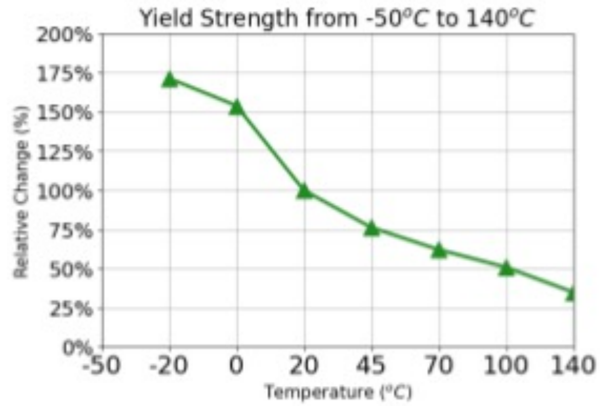
Material	Direction	Temp (F)	Temp (C)	Ultimate Tensile Strength	Elongation at Break	Tensile Modulus	Yield Strength
High Yield PA12	ZX	-58	-50	131%	64%	131%[1]	NA[1]
		-4	-20	119%	85%	127%	171%
		32	0	112%	128%[2]	126%	154%
		113	45	75%	320%	56%	76%
		158	70	59%	368%	37%	62%
		212	100	48%	600%	25%	51%
		284	140	35%	2384%	18%	35%

[1] Samples underwent brittle fracture with no yield or plastic deformation. No yield strength could be determined. Tensile modulus may also be inaccurate as a result.
[2] Elongation at break is expected to improve as temperature increases. Temperature testing was conducted with fewer test coupons than the room temperature. Smaller sample sizes are more likely to yield extreme results which may not conform to the expected trend.









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