STEREOLITHOGRAPHY

PP-LIKE TRANSLUCENT WHITE

Product Description

PP-Like Translucent White is translucent in appearance. It's also the most flexible stereolithography material available with a flexural modulus of 1,600 MPa. Its mechanical properties are similar to the average values of injection-molded polypropylene except for a slightly lower elongation at break.

Applications

PP-Like Natural is often used for medical device prototypes, electrical casings, fluid flow analysis parts, and automotive components.

Key Product Benefits

- Translucent
- Semi-flexible
- Enhanced feature details

Tolerances

For well-designed parts, tolerances in the X/Y dimension of ±0.002 in. (0.05mm) for the first inch plus ±0.001 in./in., and Z-dimension tolerances of ±0.005 in. (0.127mm) for the first inch plus ±0.001 in./in. (0.001mm/mm), can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	White
Density in solid state*	@ 25 °C (77 °F)	1.13 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	-
E-module (x-y plane)	ASTM D638, test speed 10mm/min	1,600 ± 300 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	35 ± 5 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	25 ± 5%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	61 °C (142 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	52 °C (126 °F)

* From supplier data sheet

All of the figures contained on this data sheet are approximate and dependent on a number of factors, including but not limited to, machine and process parameters. The information provided is therefore not binding and not deemed to be certified.

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FPU 50

FPU 50 is an impact, abrasion, and fatigue resistant semi-rigid material that is a good choice for parts that must withstand repetitive stresses, such as living hinges or friction fits.

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Tensile Properties ASTM D638, Type I, 50 mm/min	**Metric**	**US**
Tensile Modulus	700 MPa	100 ksi
Yield Strength	15 MPa	2 ksi
Strain at Yield	7%	7%
Ultimate Tensile Strength	25 MPa	4 ksi
Elongation at Break	200%	200%

Tensile Properties ASTM D638, Type V, 10 mm/min	**Metric**	**US**
Tensile Modulus	700 MPa	100 ksi
Yield Strength	15 MPa	2 ksi
Strain at Yield	7%	7%
Ultimate Tensile Strength	25 MPa	4 ksi
Elongation at Break	200%	200%

Flexural Properties ASTM D790-B	**Metric**	**US**
Flexural Stress at 5% strain	30 MPa	4 ksi
Flexural Modulus (Chord, 0.5-1%)	800 MPa	120 ksi

Impact Properties	**Metric**	**US**
Notched Charpy (Machined Notch), ISO 179-1/1eA	2.5 kJ/m^2	1.2 ft-lb/in^2
Notched Izod (Machined Notch), 23 °C, ASTM D256	40 J/m	0.7 ft-lb/in
Notched Izod (Machined Notch), -30 °C, ASTM D256	30 J/m	0.5 ft-lb/in

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Parts were processed using an M series printer and a Smart Part Washer with VF 1 as the solvent.

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Thermal Properties	Metric	US
Heat Deflection Temperature at 0.455 MPa/66 psi, ASTM D648	70 °C	155 °F
Heat Deflection Temperature at 1.82 MPa/264 psi, ASTM D648	45 °C	110 °F
Coefficient of Thermal Expansion (-40, 40 °C), ASTM E831	130 ppm/°C	70 ppm/°F
Heat Capacity, 23 °C, ASTM E1269	1.5 J/g-°C	0.35 BTU/lb-°F
Thermal Conductivity, ASTM C518	0.14 W/m-K	0.08 BTU/h-ft-°F

Dielectric/Electric Properties	Metric
Dielectric Strength, ASTM D149	13 kV/mm
Dielectric Constant, ASTM D150	3.2
Dissipation Factor, ASTM D150	0.013
Volume Resistivity, ASTM D257	1. E+13 ohm-cm

General Properties	
Hardness, ASTM D2240	71, Shore D
Density, ASTM D792	1.05 g/cm^3
Density (liquid resin)	1.06 g/cm^3
Taber Abrasion, ASTM D4060, CS-10, 1 kg, 100% vacuum	6.5 mg / 1000 cycles
Water Absorption, 23 °C, 24 hours ASTM D570	< 1%
Water Absorption, 23 °C, 7 days, ASTM D570	< 1%

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FPU 50

Extended TDS

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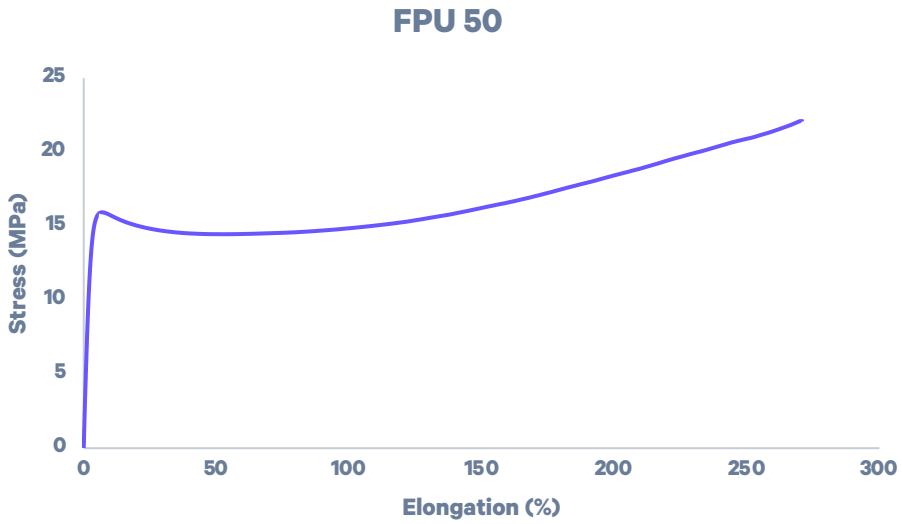
FPU 50 Mechanical Properties

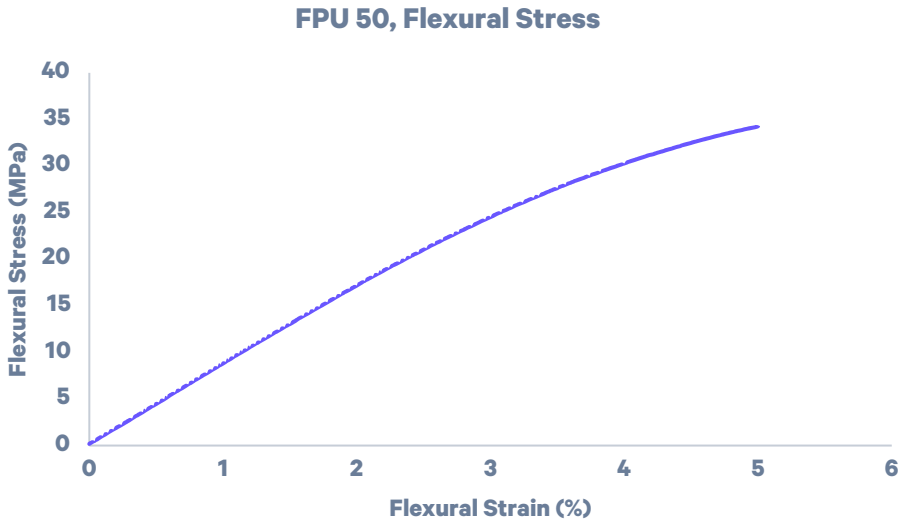
Representative Tensile Curve

ASTM D638, Type I, 50 mm/min



Representative Flexural Curve

ASTM D790-B
Samples are tested to 5% extension.



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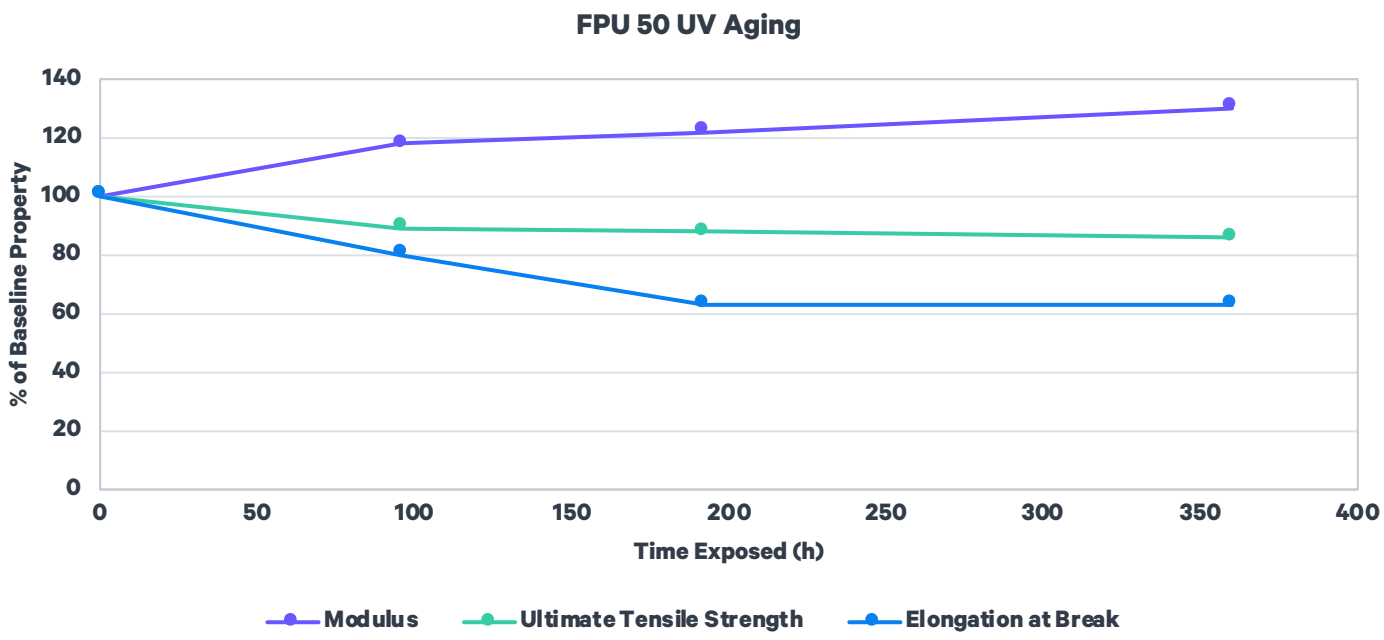
FPU 50 UV Aging

Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of FPU 50 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 at 420 nm, 55 °C
ASTM D638: Type V, 10 mm/min, average values represented

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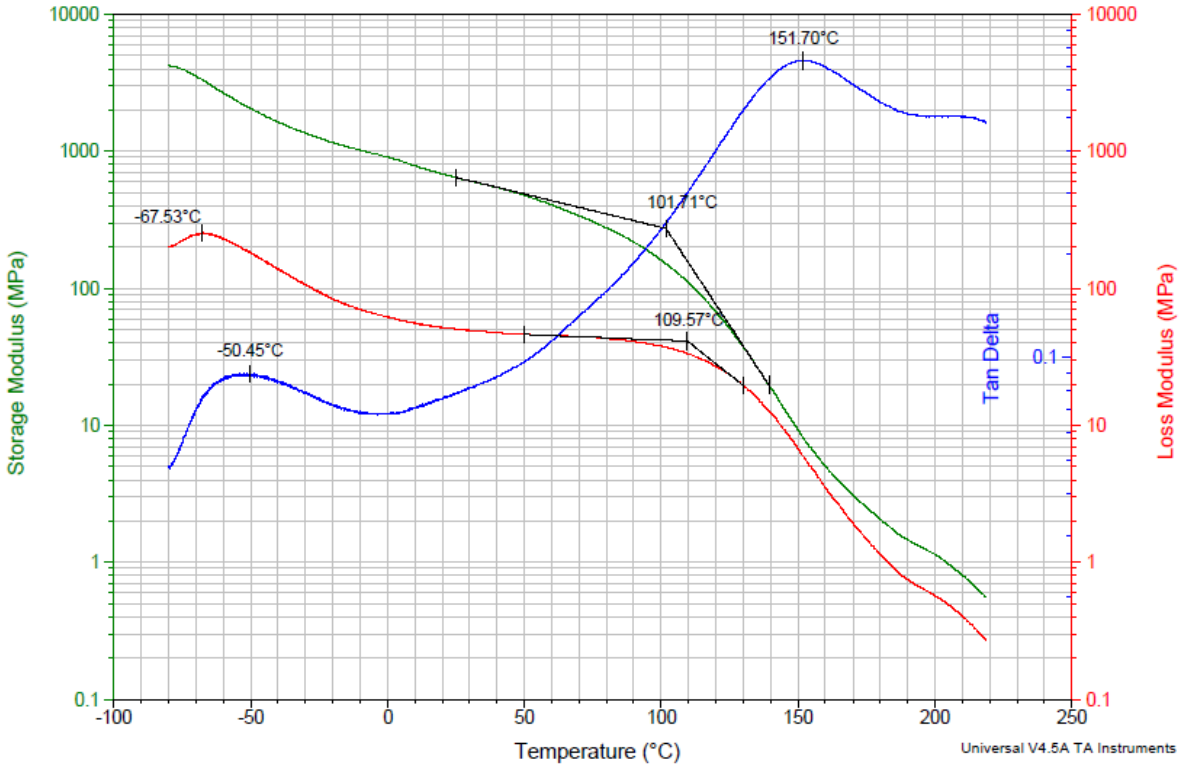
FPU 50 Dynamic Mechanical Analysis (DMA)

Dynamic mechanical analysis provides insight into the resin's viscoelastic properties across a range of temperatures. The figure below shows a temperature ramp of FPU 50. This material exhibits a storage modulus softening temperature near 100 °C. The peak in the tan(d) curves indicates that the glass transition temperature of FPU 50 is approximately 150 °C.



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: -80 °C to 220 °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.

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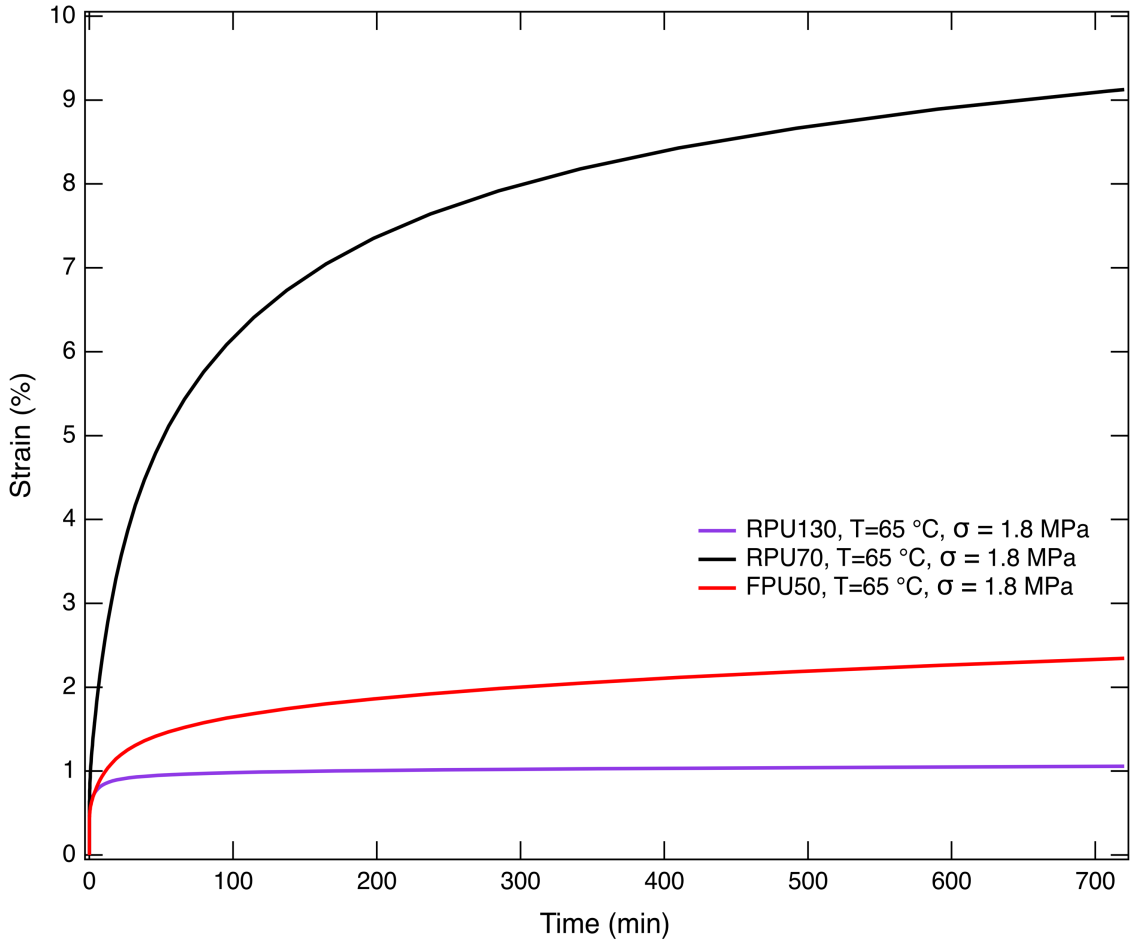
FPU 50 Creep Behavior

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 shows FPU 50 creeps approximately 2% strain over 12 hours at 65 °C and 1.8 MPa applied load. Low creep behavior is necessary for dimensional stability over time and loads.



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FPU 50 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*. Parts were processed using an M series printer and a Smart Part Washer with VF 1 as the solvent. The results indicated that FPU 50 passed the requirements for biocompatibility according to the above test. **Carbon has not conducted ISO 10993-10, *Biological evaluation of medical devices - Part 10: Tests for irritation and skin sensitization (GPMT)* testing. Carbon makes no representation and is not responsible for the results of any biocompatibility tests other than those specified above.**

Disclaimer

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

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DIRECT METAL LASER SINTERING

Stainless Steel 17-4PH

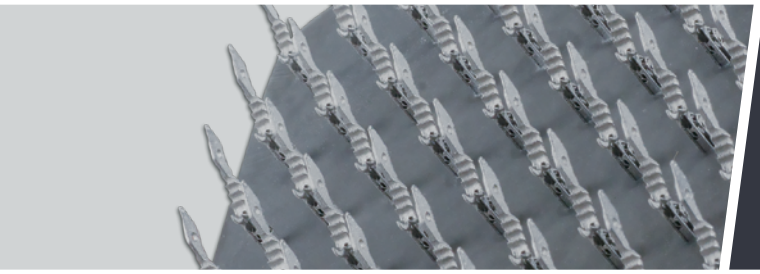
Product Specifications

Product Description

Stainless Steel 17-4 PH is a precipitation hardened stainless steel that is known for its hardness and corrosion resistance. If needing a stainless steel option, select 17-4 PH for its significantly higher tensile strength and yield strength, but recognize that it has far less elongation at break than 316L. Final parts built 17-4 PH receive vacuum solution heat treatment as well as H900 aging.

Applications

17-4PH is a martensitic precipitation hardening stainless steel that is known for its hardness and corrosion resistance. Applications include medical, aerospace, and mechanical components.



Key Product Benefits

- Heat treated for full hardness and strength
- Corrosion resistance

Properties

Resolution	Condition	Ultimate Tensile Strength (ksi)	Yield Stress (ksi)	Elongation (%)	Hardness
20 µm	Solution & Aged (H900)	199	178	10	42 HRC
30 µm	Solution & Aged (H900)	198	179	13	42 HRC

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DIRECT METAL LASER SINTERING

Stainless Steel 316L

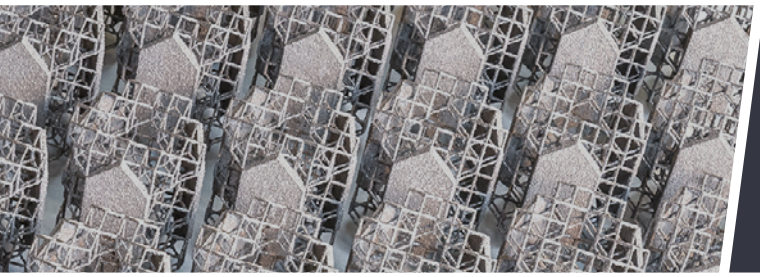
Product Specifications

Product Description

Stainless steel 316L is a workhorse material used for manufacturing acid and corrosion resistant parts. Select 316L when stainless steel flexibility is needed; 316L is a more malleable material compared to 17-4 PH. Final parts built in 316L receive stress relief application.

Applications

The material is used for manufacturing acid and corrosion resistant prototypes and unique or series production parts in the following fields: Medical technology, plant engineering, automotive industry, jewelry and components for molds.



Key Product Benefits

- Acid and corrosion resistance
- High ductility

Properties

Resolution	Condition	Ultimate Tensile Strength (ksi)	Yield Stress (ksi)	Elongation (%)	Hardness
20 µm	Stress Relieved	89	73	55	94 HRB
30 µm	Stress Relieved	92	72	58	94 HRB

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DIRECT METAL LASER SINTERING

Titanium (Ti-6Al-4V)

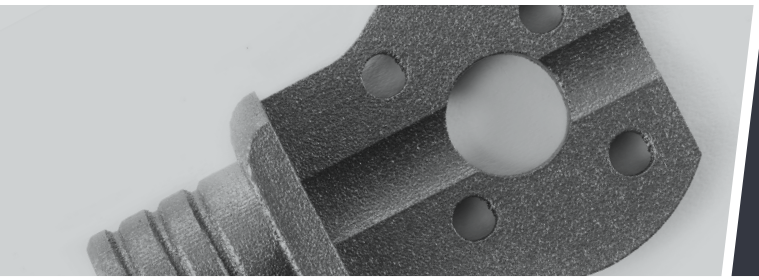
Product Specifications

Product Description

Titanium (Ti6Al4V) is a workhorse alloy. The mechanical properties of Ti6Al4V are comparable to wrought titanium for tensile strength, elongation, and hardness. Final parts built in Ti6Al4V receive vacuum stress relief application.

Applications

Due to its light weight, high strength, and high temperature and corrosion resistance, titanium is often used for aerospace applications. This alloy is commonly used in a variety of medical applications which require high strength.



Key Product Benefits

- High stiffness and strength relative to weight
- High temperature and corrosion resistance

Properties

Resolution	Condition	Ultimate Tensile Strength (ksi)	Yield Stress (ksi)	Elongation (%)	Hardness
20 µm	Stress Relieved	153	138	15	35 HRC
30 µm	Stress Relieved	144	124	18	33 HRC

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SELECTIVE LASER SINTERING

TPU-70A

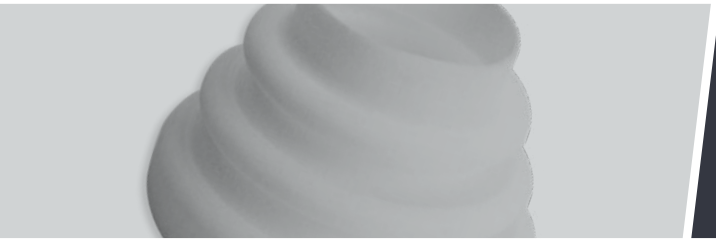
Current Supplier's Material: TPU-70A

Product Description

This thermoplastic polyurethane (TPU) combines rubber-like elasticity and elongation with good abrasion and impact resistance. It can be leveraged to produce both prototypes and functional parts.

Applications

The material's rubber-like quality is ideal for seals, gaskets, grips, hoses, or any other application where excellent resistance under dynamic loading is required.



Key Product Benefits

- Flexibility
- Tear and abrasion resistance
- Durability

Tolerances

For well-designed parts, tolerances of ±0.050 in. can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	White
E-module (x-y plane)	ASTM D412, test speed 500mm/min	40.5 MPa
E-module (z plane)	ASTM D412, test speed 500mm/min	33 MPa
Tensile strength (x-y plane)	ASTM D412, test speed 500mm/min	6.5 MPa
Tensile strength (z plane)	ASTM D412, test speed 500mm/min	4.1 MPa
Elongation at break (x-y plane)	ASTM D412, test speed 500mm/min	355%
Elongation at break (z plane)	ASTM D412, test speed 500mm/min	250%

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STEREOLITHOGRAPHY

ABS-LIKE WHITE

Product Description

ABS-Like White is a widely used, all-purpose material that provides flexibility relative to other SLA resins. It is an ideal stereolithography material for durability. Compared to the average value for injection-molded ABS, it will have a slightly higher tensile strength but lower elongation at break. ABS-Like White's heat deflection is the lowest of all SLA materials.

Applications

ABS-Like White's well-rounded mechanical properties make it suitable for form-and-fit prototypes, snap-fit assemblies, consumer electronic components, and medical device prototypes.

Key Product Benefits

- Good strength and flexibility
- Durability
- Dimensional Stability

Tolerances

For well-designed parts, tolerances in the X/Y dimension of ±0.002 in. (0.05mm) for the first inch plus ±0.001 in./in., and Z-dimension tolerances of ±0.005 in. (0.127mm) for the first inch plus ±0.001 in./in. (0.001mm/mm), can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	White
Density in solid state*	@ 25 °C (77 °F)	1.18 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.65 ± 0.15%
E-module (x-y plane)	ASTM D638, test speed 10mm/min	3,300 ± 400 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	55 ± 10 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	9 ± 5%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	47 °C (117 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	42 °C (108 °F)

* From supplier data sheet

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STEREOLITHOGRAPHY

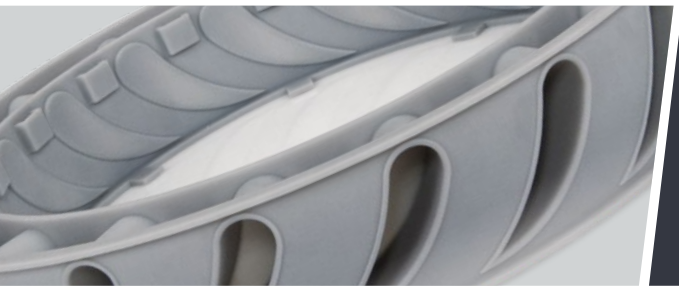
ABS-LIKE GRAY

Product Description

ABS-Like Gray is a widely used, all-purpose material that provides flexibility relative to other SLA resins. It is an ideal sterolithography material for durability and heat tolerance. Parts built with ABS-Like Gray will have a look and feel similar to a molded plastic.

Applications

ABS-Like Gray's well-rounded mechanical properties make it suitable for form-and-fit prototypes, snap-fit assemblies, consumer electronic components, and medical device prototypes.



Key Product Benefits

- Good strength and flexibility
- Durability
- Gray color

Tolerances

For well-designed parts, tolerances in the X/Y dimension of ±0.002 in. (0.05mm) for the first inch plus ±0.001 in./in., and Z-dimension tolerances of ±0.005 in. (0.127mm) for the first inch plus ±0.001 in./in. (0.001mm/mm), can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	Gray
Density in solid state*	@ 25 °C (77 °F)	1.19 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.65 ± 0.15%
E-module (x-y plane)	ASTM D638, test speed 10mm/min	2,000 ± 400 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	40 ± 8 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	9 ± 5%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	62 °C (144 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	54 °C (129 °F)

* From supplier data sheet

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STEREOLITHOGRAPHY

ABS-LIKE Black

Product Description

ABS-Like Black is a durable material for general purpose prototyping. Its deep black color and glossy, cosmetic up-facing surfaces in a top profile offer the appearance of a molded part. Part sidewalls and down-facing surfaces will have a matte finish. The material has good dimensional stability and moisture resistance.

Applications

ABS-Like Black is a good general purpose material for a variety of prototypes that mimic molded prototypes as well as functional assemblies. Common uses include housings for electronics and consumer goods.

Key Product Benefits

- Glossy, cosmetic up-facing surface
- Moisture resistance
- Dimensional stability

Tolerances

For well-designed parts, tolerances in the X/Y dimension of ±0.002 in. (0.05mm) for the first inch plus ±0.001 in./in., and Z-dimension tolerances of ±0.005 in. (0.127mm) for the first inch plus ±0.001 in./in. (0.001mm/mm), can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	Black
Density in solid state*	@ 25 °C (77 °F)	1.16 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.25 ± 0.15%
E-module (x-y plane)	ASTM D638, test speed 10mm/min	3,000 ± 400 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	55 ± 10 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	5 ± 3%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	51 °C (124 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	-

* From supplier data sheet

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MicroFine™ Resin
PRODUCT SPECIFICATIONS

PRODUCT DESCRIPTION

Protolabs' MicroFine material is available in opaque green and gray. This ABS-like material has been custom formulated by DSM for micro-resolution stereolithography.

APPLICATIONS

MicroFine enables the production of parts with the finest features and tightest tolerances in the industry. Color options allow for good part and feature visibility, and its mechanical properties make it a durable choice for small part applications.

PHYSICAL PROPERTY DATA

The following mechanical, electrical, and thermal property data was gathered from the base material used in the formulation of MicroFine material. Properties of the final formulated material may differ from those published below.

KEY PRODUCT BENEFITS

- Custom formulated for micro-sized parts
- Can produce features as small as 0.0025 in.
- ABS-like stiffness

PROPERTIES

ASTM Method	Property Description	Metric	Imperial
D638	Tensile Modulus	2,600 ± 400 MPa	377 ± 58 ksi
D638	Tensile Strength	60 ± 10 MPa	8.7 ± 1.45 ksi
D638	Elongation to Break	8% ± 4%	8% ± 4%
D790	Flexural Strength	74.3 MPa	10,770 psi
D790	Flexural Modulus	2,200 MPa	329,000 psi
D2240	Hardness (Shore D)	85	85
D256A	Izod Impact (Notched)	0.23 J/cm	0.46 ft lb/in
D570	Water Absorption	0.85% ± 0.15%	0.85% ± 0.15%
D648	HDT @ 0.46 MPa (66 psi)	59° C	138° F
D648	HDT @ 1.82 MPa (264 psi)	50° C	122° F

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STEREOLITHOGRAPHY

ABS-LIKE TRANSLUCENT/CLEAR

CUSTOM STANDARD NATURAL

Product Description

ABS-Like Translucent/Clear offers a unique combination of low moisture absorption and near-colorless transparency. Custom finishing is required to achieve functional clarity. Its tensile strength and elongation at break are among the highest of 3D-printed, thermoset material.

Applications

ABS-Like Translucent/Clear can be used for general-purpose applications but is ideal for flow-visualization models, microfluidics, and light pipes.

Key Product Benefits

- Functional clarity
- Water resistant

Tolerances

For well-designed parts, tolerances in the X/Y dimension of ±0.002 in. (0.05mm) for the first inch plus ±0.001 in./in., and Z-dimension tolerances of ±0.005 in. (0.127mm) for the first inch plus ±0.001 in./in. (0.001mm/mm), can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	Translucent with Standard Finish / Clear with Custom Finish
Density in solid state*	@ 25 °C (77 °F)	1.12 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.35 ± 0.15%
E-module (x-y plane)	ASTM D638, test speed 10mm/min	2,900 ± 400 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	55 ± 10 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	6 ± 3%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	45.9 – 54.5 °C (115 – 130 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	49.0 – 49.7 °C (120 °F)

* From supplier data sheet

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Doc #103213-02 Rev B
January 11, 2021

RPU 70

RPU 70 is a tough, rigid material that is a good choice for parts requiring strength, toughness, and moderate heat-resistance.

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Tensile Properties ASTM D638, Type I, 50 mm/min	**Metric**	**US**
Tensile Modulus	1700 MPa	245 ksi
Yield Strength	40 MPa	6 ksi
Strain at Yield	5%	5%
Ultimate Tensile Strength	40 MPa	6 ksi
Elongation at Break	30%	30%

Tensile Properties ASTM D638, Type V, 10 mm/min	**Metric**	**US**
Tensile Modulus	1700 MPa	245 ksi
Yield Strength	40 MPa	6 ksi
Strain at Yield	5%	5%
Ultimate Tensile Strength	40 MPa	6 ksi
Elongation at Break	100%	100%

Flexural Properties ASTM D790-B	**Metric**	**US**
Flexural Stress at 5% strain	55 MPa	8 ksi
Flexural Modulus (Chord, 0.5-1%)	1500 MPa	220 ksi

Impact Properties	**Metric**	**US**
Unnotched Charpy, ISO 179-1/1eA	35 kJ/m^2	17 ft-lb/in^2
Notched Charpy (Machined Notch), ISO 179-1/1eA	1.5 kJ/m^2	0.7 ft-lb/in^2
Unnotched Izod, ASTM D4812	300 J/m	6 ft-lb/in
Notched Izod (Machined Notch), ASTM D256	15 J/m	0.3 ft-lb/in

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Parts were processed using an M series printer and a Smart Part Washer with VF 1 as the solvent.

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Thermal Properties	Metric	US
Heat Deflection Temperature at 0.455 MPa/66 psi, ASTM D648	60 °C	140 °F
Heat Deflection Temperature at 1.82 MPa/264 psi, ASTM D648	45 °C	110 °F
Coefficient of Thermal Expansion (-40, 40 °C), ASTM E831	100 ppm/°C	50 ppm/°F
Heat Capacity, 23 °C, ASTM E1269	1.8 J/g-°C	0.5 BTU/lb-°F
Flammability, UL 94 (1.5mm,)	HB	HB

Dielectric/Electric Properties	
Dielectric Strength, ASTM D149	15.5 kV/mm
Dielectric Constant, ASTM D150	3.3
Dissipation Factor, ASTM D150	0.017
Volume Resistivity, ASTM D257	8.0 E+14 ohm-cm

General Properties	
Hardness, ASTM D2240	80, Shore D
Density, ASTM D792	1.08 g/cm^3
Density (liquid resin)	1.01 g/cm^3
Taber Abrasion, ASTM D4060, CS-17, 1 kg, 100% vacuum	70 mg / 1000 cycles
Water Absorption, Short Term (24 hours) ASTM D570	< 0.5%
Water Absorption, Long Term (14 days) ASTM D570	< 1.5%

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Parts were processed using an M series printer and a Smart Part Washer with VF 1 as the solvent.

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RPU 70

Extended TDS

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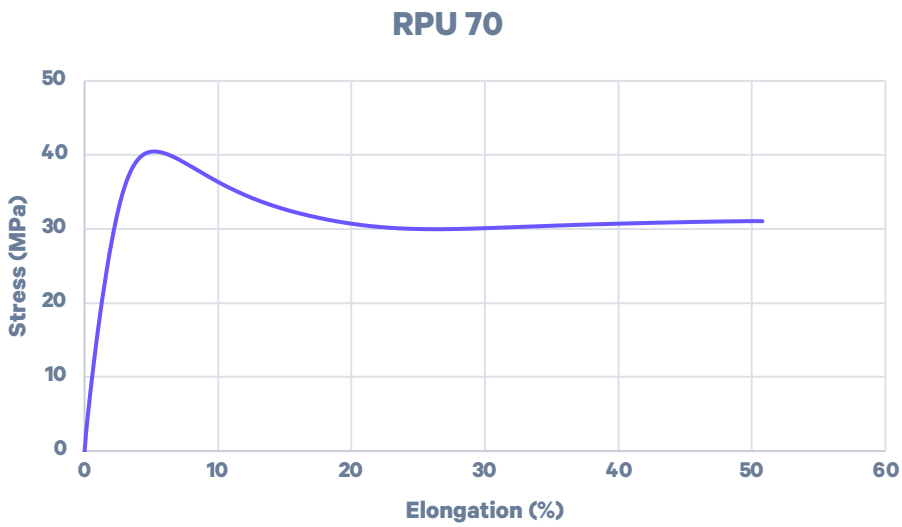
RPU 70 Mechanical Properties

Representative Tensile Curve

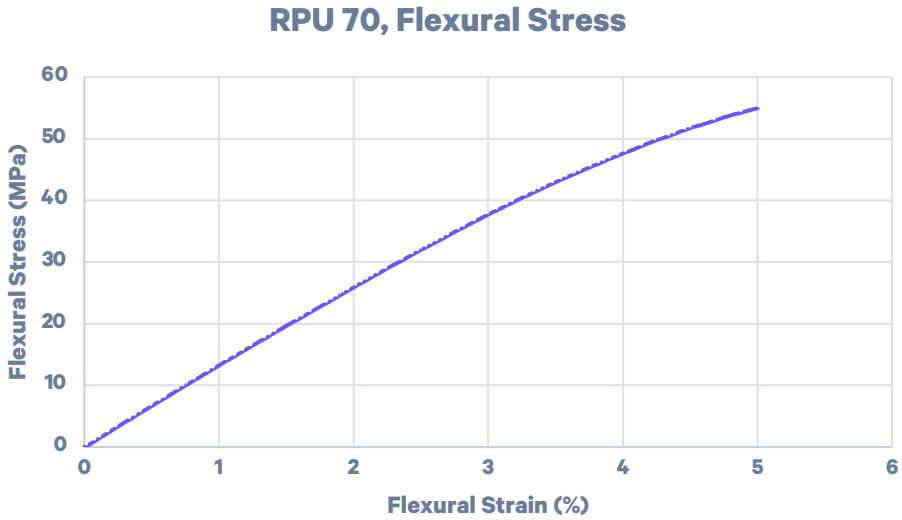
ASTM D638, Type I, 50 mm/min



Representative Flexural Curve

ASTM D790-B

Samples are tested to 5% extension.



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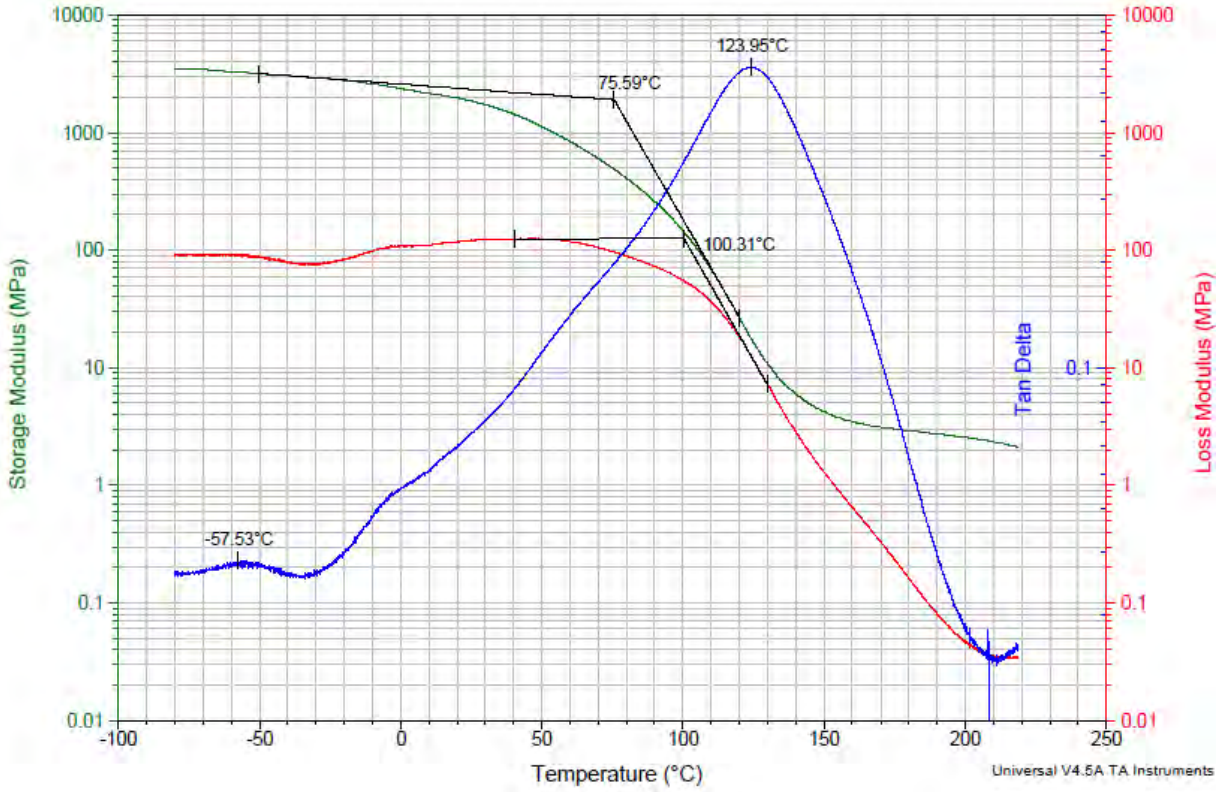
RPU 70 Dynamic Mechanical Analysis (DMA)

Dynamic mechanical analysis provides insight into the resin's viscoelastic properties across a range of temperatures. The figure below shows a temperature ramp of RPU 70. RPU 70 exhibits a storage modulus softening temperature at 75 °C. The peak in the tan(d) curves indicates that the glass transition temperature of RPU 70 is approximately 125 °C.



Standard: ASTM D4065
Instrument: TA DMA Q800
DMA Mode: Tension
Sample Dimensions: L=20mm, W=10mm, t=1mm (rectangular block)
Strain Amplitude: 0.1% (linear regime of viscoelasticity)
Oscillation frequency: 1 Hz
Temperature Range: -100ºC to 200ºC
Ramp Rate: 1.5 ºC/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.

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RPU 70 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%)	15 – 30%
Industrial Fluids	
Engine Oil (Havoline SAE 5W-30)	< 5%
Brake Fluid (Castrol DOT-4)	< 5%
Airplane Deicing Fluid (Type I Ethylene Glycol)	< 5%
Airplane Deicing Fluid (Type I Propylene Glycol)	< 5%
Airplane Deicing Fluid (Type IV Ethylene Glycol)	< 5%
Airplane Deicing Fluid (Type IV Propylene Glycol)	< 5%
Transmission Fluid (Havoline Synthetic ATF)	< 5%
Engine Coolant (Havoline XLC, 50%/50% premixed)	< 5%
Diesel (Chevron #2)	< 5%
Gasoline (Chevron #91)	> 30%
Skydrol 500B-4	5 – 15%
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.

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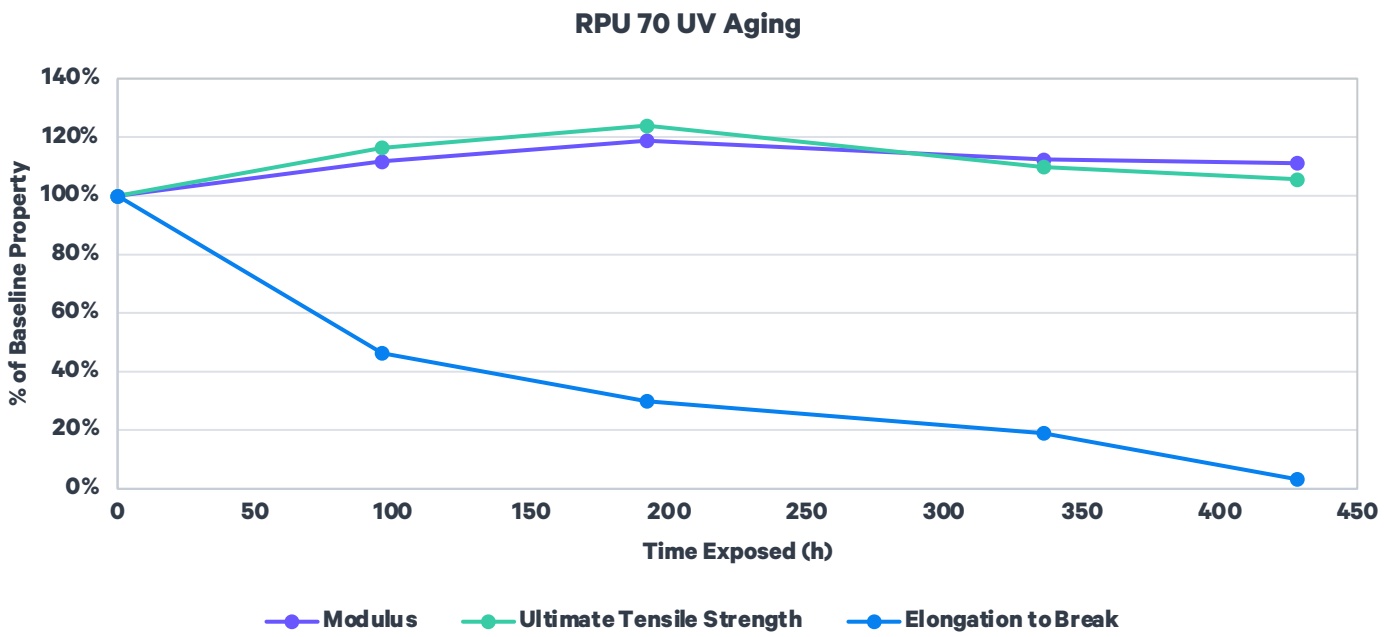
RPU 70 UV Aging

Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of RPU 70 using ASTM D4459, which is intended to simulate indoor exposure of solar radiation through glass. RPU 70 retained up to 46% of the original elongation at break after 96 hours of exposure.



ASTM 4459: 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

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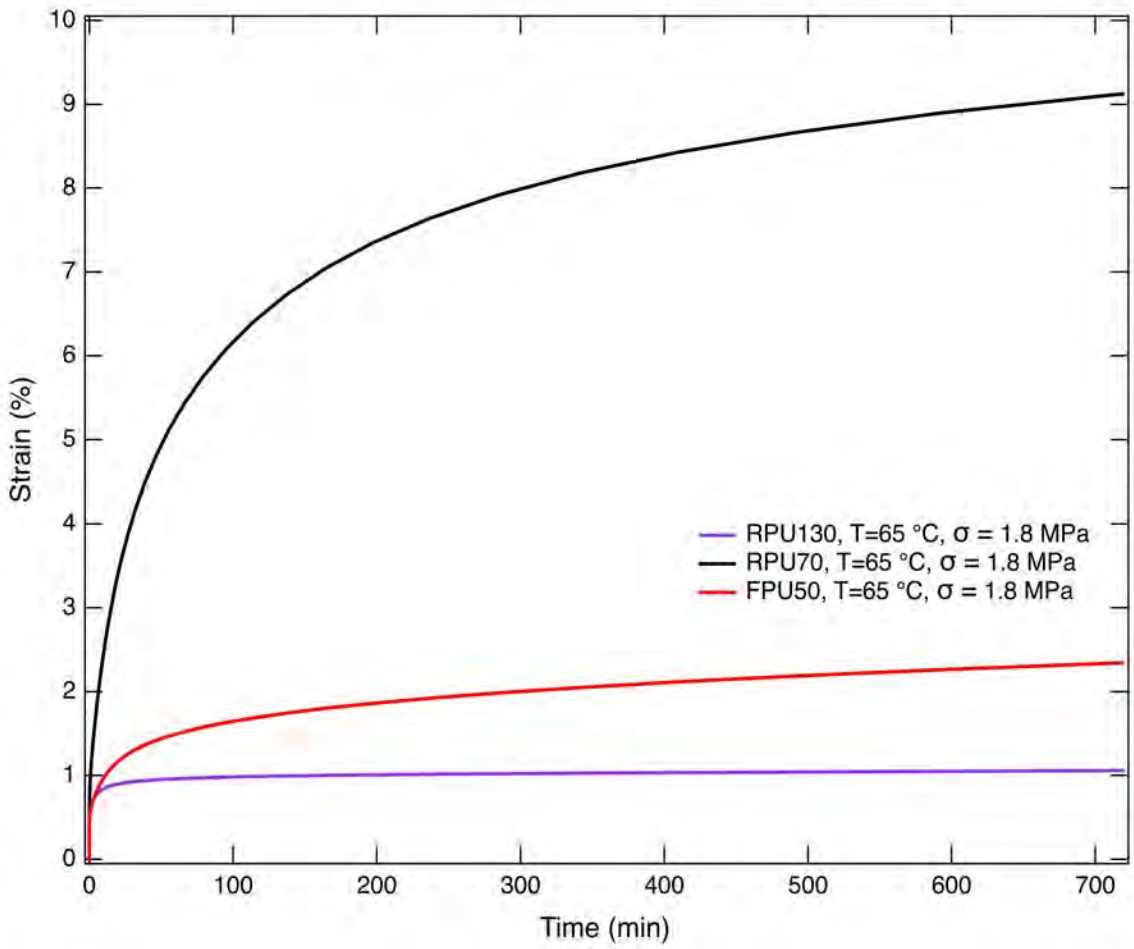
RPU 70 Creep Behavior

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 shows RPU 70 creeps up to 10% strain over 12 hours at 65 °C and 1.8 MPa applied load. Low creep behavior is necessary for dimensional stability over time and loads.



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RPU 70 Biocompatibility

Biocompatibility Testing

Printed parts were provided to NAMSA and Pacific BioLabs 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 VF 1 as the solvent. **The results for all tests indicated that RPU 70 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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DIRECT METAL LASER SINTERING

Cobalt Chrome (Co28Cr6Mo)

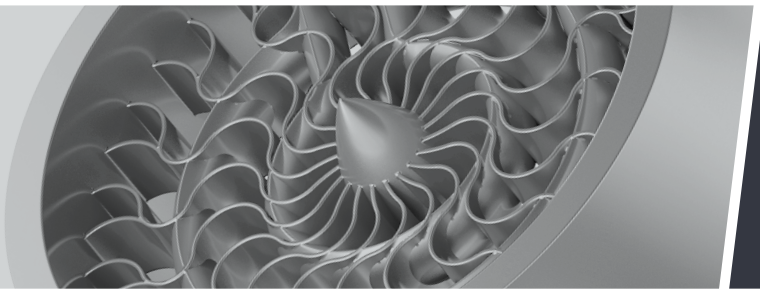
Product Specifications

Product Description

Cobalt-Chrome (Co28Cr6Mo) material is used in our DMLS process. It is a superalloy comprised primarily of cobalt and chromium, and is known for its high strength-to-weight ratio, excellent creep and corrosion resistance.

Applications

Cobalt-Chrome is a superalloy that is used for specialty applications within the aerospace and medical industries.



Key Product Benefits

- High performance tensile and creep
- Creep and corrosion resistance

Properties

Resolution	Condition	Ultimate Tensile Strength (ksi)	Yield Stress (ksi)	Elongation (%)	Hardness
20 µm	As Built	182	112	17	39 HRC
30 µm	As Built	176	119	14	38 HRC

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DIGITAL PHOTOPOLYMER

PRODUCT SPECIFICATIONS

PRODUCT DESCRIPTION:

Protolabs' PolyJet process builds parts comprised of digital photopolymer. The material is available in multiple Shore A hardnesses and colors: clear/translucent, white, and black. It supports complex geometries and can take on a range of mechanical properties.

APPLICATIONS:

Digital photopolymer can be leveraged in a variety of 3D printing applications that incorporate flexible features. It's routinely used to prototype overmolded and liquid silicone rubber parts such as: gaskets, seals, covers, and straps.

KEY PRODUCT BENEFITS

- Two-toned coloring aesthetics
- Soft touch and flexible features
- Improved grip and impact resistance

PROPERTIES:

			Shore A							
Digital Material Properties	ASTM Standard	Unit of Measure	30	40	50	60	70	85	95	Rigid
Tensile Tear Strength	D-624	Kg/cm	5.0-7.0	6.0-8.0	7.0-9.0	7.0-10.0	12.0-14.0	22.0-26.0	26.0-30.0	-
Elongation at Break	D-412	%	220-270	190-210	170-210	150-170	120-140	70-90	50-70	10.0-25.0
Shore Hardness	D-2240	Scale A	30-35	40-50	50-55	55-60	60-70	80-85	85-90	83-86 (D)
Tensile Strengnth	D-412	MPa	2.4-3.1	3.0-4.0	3.0-4.0	3.5-4.5	4.0-6.0	6.0-10.0	10.0-14.0	50-65

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DIRECT METAL LASER SINTERING

Inconel 718

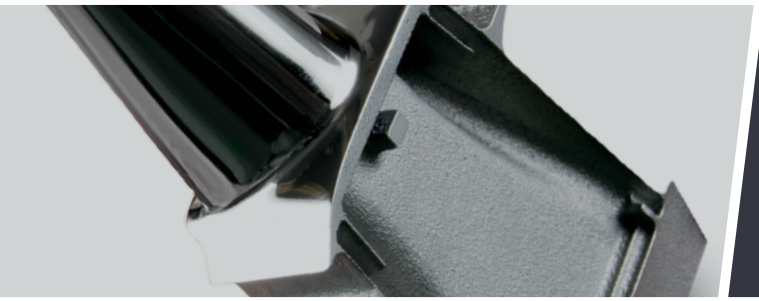
Product Specifications

Product Description

Inconel is a high strength, corrosion resistant nickel chromium superalloy ideal for parts that will experience extreme temperatures and mechanical loading. Final parts built in Inconel 718 receive stress relief application. Solution and aging per AMS 5663 is also available to increase tensile strength and hardness. It is available in both high and normal resolution and can be used for parts as large as 31.5 in. x 15.7 in. x 19.7 in. in size.

Applications

Inconel is an excellent choice for rocket engine components and related equipment exposed to extreme environments.



Key Product Benefits

- Oxidation and corrosion resistance
- High performance tensile, fatigue, creep, and rupture strength

Properties

Resolution	Condition	Ultimate Tensile Strength (ksi)	Yield Stress (ksi)	Elongation (%)	Hardness
20 µm	Stress Relieved	143	98	36	33 HRC
30 µm	Stress Relieved	144	91	39	30 HRC
30 µm	Solution & Aged per AMS 5663	208	175	18	46 HRC
60 µm	Stress Relieved	139	83	40	27 HRC
60 µm	Solution & Aged per AMS 5663	201	174	19	45 HRC

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SELECTIVE LASER SINTERING

PA 12 WHITE

Product Description

PA 12 White is an economical material choice for functional prototypes and end-use parts. It offers high impact and temperature resistance, is very durable, and remains stable under a range of environmental conditions. The nylon material exhibits a white finish with a slightly rougher surface texture compared to other nylons.

Applications

The material's high strength is ideal for jigs and fixtures, housings, and other functional parts. It also has a low coefficient of friction, making it suitable for many types of gears and bearings.

Key Product Benefits

- Strength and stiffness
- Well-balanced material properties

Tolerances

For well-designed parts, tolerances of ±0.012 in. plus ±0.002 in./in. for each additional inch can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	White
Sintered Density	ASTM D792	1.02 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.5 ± 0.2%
Water absorption, 24 hrs. in boiling water	ASTM D570	2.0 ± 0.3%
E-Module (x-y plane)	ASTM D638, test speed 10mm/min	2,000 ± 200 MPa
E-Module (z plane)	ASTM D638, test speed 10mm/min	1,900 ± 200 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	50 ± 4 MPa
Tensile strength (z plane)	ASTM D638, test speed 10mm/min	42 ± 5 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	11 ± 4%
Elongation at break (z plane)	ASTM D638, test speed 10mm/min	4 ± 2%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	177 °C (350 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	86 °C (186 °F)

* From supplier data sheet

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SELECTIVE LASER SINTERING

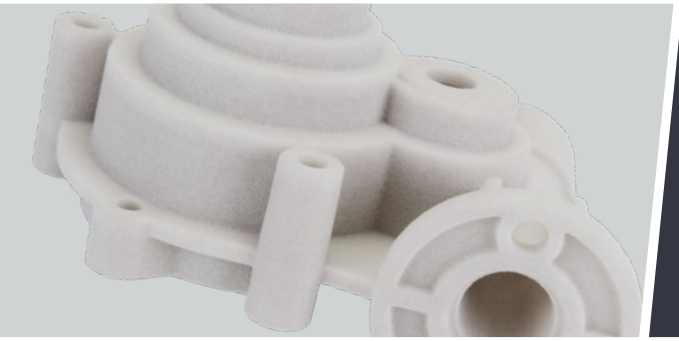
PA 12 MINERAL-FILLED

Product Description

This 25% mineral-filled nylon offers the highest stiffness among Protolabs' selective laser sintering materials. It's an excellent choice when stiffness and high temperature resistance are the most important requirements.

Applications

The material's stiffness and temperature resistance makes it suited for components like armatures and mounting plates.



Key Product Benefits

- Excellent strength to weight performance
- High temperature resistance
- Parts can be oriented to achieve maximum strength in X-build direction

Tolerances

For well-designed parts, tolerances of ±0.010 in. plus ±0.0015 in./in. for each additional inch can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	Light Gray
Sintered Density	ASTM D792	1.20 g/cm³
E-Module (x-y plane)	ASTM D638, test speed 10mm/min	3,100 ± 400 MPa
E-Module (z plane)	ASTM D638, test speed 10mm/min	2,500 ± 200 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	38 ± 5 MPa
Tensile strength (z plane)	ASTM D638, test speed 10mm/min	32 ± 7 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	3 ± 1%
Elongation at break (z plane)	ASTM D638, test speed 10mm/min	2 ± 1.5%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	184 °C (363 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	179 °C (354 °F)

* From supplier data sheet

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MULTI JET FUSION

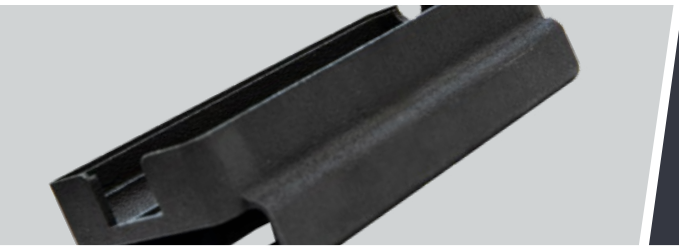
PA 12 BLACK

Product Description

PA 12 Black is a high tensile strength nylon suitable for prototypes and end-use production parts. Final parts exhibit quality surface finishes, fine feature resolution, and more consistent mechanical properties when compared to processes like selective laser sintering.

Applications

Multi Jet Fusion's PA 12 black is often used to build housings, enclosures, and fixtures, and can work well for snap fits and hinges.



Key Product Benefits

- Near isotropic mechanical properties
- Water- and airproof without further treatment

Tolerances

For well-designed parts, tolerances of ±0.012 in. plus ±0.002 in./in. for each additional inch can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	Black
Sintered Density	ASTM D792	1.01 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.5 ± 0.2%
Water absorption, 24 hrs. in boiling water	ASTM D570	2.0 ± 0.3%
E-Module (x-y plane)	ASTM D638, test speed 10mm/min	1,900 ± 200 MPa
E-Module (z plane)	ASTM D638, test speed 10mm/min	1,900 ± 200 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	49 ± 4 MPa
Tensile strength (z plane)	ASTM D638, test speed 10mm/min	47 ± 4 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	12 ± 4%
Elongation at break (z plane)	ASTM D638, test speed 10mm/min	9 ± 4%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	175 °C (374 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	95 °C (203 °F)

* From supplier data sheet

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SELECTIVE LASER SINTERING

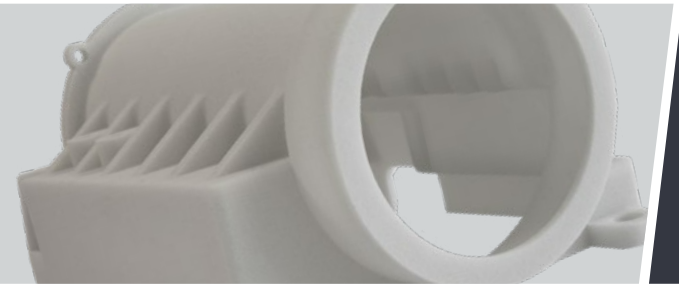
PA 40% GLASS-FILLED

Product Description

PA 12 40% Glass-Filled is a polyamide powder loaded with glass spheres that add stiffness and dimensional stability. The material possesses higher thermal resistance than unfilled polyamides and exhibits excellent long-term wear resistance. Due to the glass additive, it has decreased impact and tensile strengths compared to other nylons.

Applications

The material's stiffness and temperature resistance makes it suited for components like armatures and mounting plates.



Key Product Benefits

- Stiffness and dimensional stability
- Long-term wear resistance
- High temperature resistance

Tolerances

For well-designed parts, tolerances of ±0.012 in. plus ±0.002 in./in. for each additional inch can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	White
Sintered Density	ASTM D792	1.22 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.5 ± 0.2%
Water absorption, 24 hrs. in boiling water	ASTM D570	2.0 ± 0.3%
E-Module (x-y plane)	ASTM D638, test speed 10mm/min	3,600 ± 400 MPa
E-Module (z plane)	ASTM D638, test speed 10mm/min	3,600 ± 400 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	50 ± 4 MPa
Tensile strength (z plane)	ASTM D638, test speed 10mm/min	46 ± 4 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	5 ± 2%
Elongation at break (z plane)	ASTM D638, test speed 10mm/min	3 ± 2%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	157 °C (314 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	96 °C (204 °F)

* From supplier data sheet

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SELECTIVE LASER SINTERING

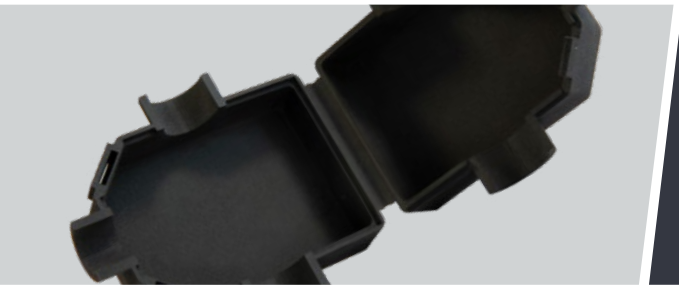
PA 11 BLACK

Product Description

PA 11 Black provides excellent ductility and temperature resistance without sacrificing tensile strength. It offers one of the highest elongation break thresholds in the nylon family.

Applications

The material is suited for functional, moving parts with features like snap fits and living hinges. Its black color makes it desirable for optical applications due to low reflectivity.



Key Product Benefits

- High elongation at break
- Flexibility
- Uniform black color

Tolerances

For well-designed parts, tolerances of ±0.012 in. plus ±0.002 in./in. for each additional inch can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	Black
Sintered Density	ASTM D792	1.03 g/cm³
Water absorption (20 °C, 50% relative humidity)	ASTM D570	0.3 ± 0.2%
Water absorption, 24 hrs. in boiling water	ASTM D570	1.5 ± 0.2%
E-Module (x-y plane)	ASTM D638, test speed 10mm/min	1,800 ± 200 MPa
E-Module (z plane)	ASTM D638, test speed 10mm/min	1,800 ± 200 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 10mm/min	52 ± 4 MPa
Tensile strength (z plane)	ASTM D638, test speed 10mm/min	49 ± 4 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 10mm/min	30 ± 7%
Elongation at break (z plane)	ASTM D638, test speed 10mm/min	18 ± 7%
Heat deflection temperature @ 0.46 MPa*	ASTM D648	188 °C (370 °F)
Heat deflection temperature @ 1.82 MPa*	ASTM D648	48 °C (118 °F)

* From supplier data sheet

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MULTI JET FUSION

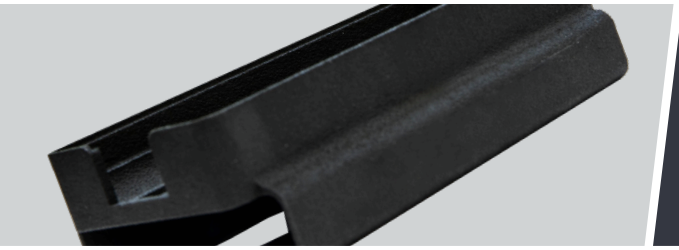
PA 12 40% Glass-Filled Black

Product Description

PA 12 40% Glass-Filled Black is a 40% glass-filled nylon. Final parts are dyed black. The biggest advantage offered by this material is the heat deflection temperature of 248°F when measured at 264 psi, ranking 2nd best after PA 12 Mineral-Filled.

Applications

Multi Jet Fusion's PA 12 40% Glass-Filled Black is often used to build housings, enclosures, and fixtures, and can work well for snap fits and hinges.



Key Product Benefits

- Economical material choice
- Heat deflection

Tolerances

For well-designed parts, tolerances of ±0.012 in. plus ±0.002 in./in. for each additional inch can typically be achieved. Note that tolerances may change depending on part geometry.

Properties

Property	Test Method	Value
Color	-	Black
Sintered Density*	ASTM D792	1.3 g/cm³
E-module (x-y plane)	ASTM D638, test speed 5mm/min	2900 +/- 400 MPa
E-module (z plane)	ASTM D638, test speed 5mm/min	3500 +/- 275 MPa
Tensile strength (x-y plane)	ASTM D638, test speed 5mm/min	27.5 ± 2 MPa
Tensile strength (z plane)	ASTM D638, test speed 5mm/min	30 ± 2 MPa
Elongation at break (x-y plane)	ASTM D638, test speed 5mm/min	8.5 ± 3%
Elongation at break (z plane)	ASTM D638, test speed 5mm/min	6.8 ± 3%
Heat Defelction Temperature @ 0.46 MPa*	ASTM D648	175 ˚C
Heat Defelction Temperature @ 1.82 MPa*	ASTM D648	120 ˚C

*From supplier data sheet

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