Figure 4® Rigid 140C Black

Production Rigid

Figure 4 Standalone

Rigid heat-resistant material combining high strength and high elongation for tool-less, direct plastics production

HIGH PERFORMANCE PHOTOPOLYMER SUITABLE FOR UNDERHOOD AND ELECTRICAL CONNECTOR END-USE COMPONENTS

Figure 4® Rigid 140C Black delivers on the promise of additive manufacturing with true functional durability in plastic parts. A two-part epoxy/acrylate hybrid material, Figure 4 Rigid 140C Black provides production-grade parts with long-term mechanical stability in various environments.

This innovative material, made with patented filler, provides toughness comparable to injection molded polybutylene glass fiber (PBT GF). It is an attractive material for under-the-hood and internal cabin automotive applications with a 124°C @1.82MPa HDT, and ideal for end-use clips, covers, connectors, housings and fasteners, electrical latching, and board connectors.

Under-the-hood components produced with Figure 4 Rigid 140C Black demonstrate excellent reliability when subjected to high temperature operating life (HTOL) testing. These parts also demonstrate good part-to-part friction making this an ideal material for industrial applications such as levers, knobs, and clutches. Figure 4 Rigid 140C Black was tested to the equivalent of eight years indoor and one-and-a-half years in outdoor environments per ASTM D4329 and ASTM G194 methods.

HANDLING AND POST-PROCESSING GUIDELINES

Figure 4 Rigid 140C Black is a two-part material available for the Figure 4 Standalone 3D printer. Proper mixing, cleaning, drying and curing is required for this material. Post-processing information can be found at the end of this document.

Note: all properties are based on using the documented post-processing method. Any deviation from this method could yield a different result.

More details can be found in the **Figure 4 User Guide** available at http://infocenter.3dsystems.com

Note: Not all products and materials are available in all countries — please consult your local sales representative for availability.

APPLICATIONS

- Automotive under-the-hood and in-cabin components
- End-use clips, covers, connectors, housings and fasteners
- Electrical latching and board connectors
- End-use production and functional prototype components

BENEFITS

- Parts can withstand years of indoor UV and humidity exposure with minimal degradation to dimensional stability or functional performance
- Surface finish comparable to injection molding
- Suitable for repeated snap-fit use without deformation

FEATURES

- Versatile with a good combination of elongation, HDT and tensile strength
- Long-term environmental stability of mechanical properties and performance
- Superior part-on-part friction
- Excellent surface quality, accuracy and repeatability
- Biocompatible capable per ISO 10993-5
- UL94 HB flammability
- Short thermal cure at 135C

3D SYSTEMS®

Figure 4 Rigid 140C Black

MATERIAL PROPERTIES

The full suite of mechanical properties is given per ASTM and ISO standards where applicable. Properties like flammability, dielectric properties, and 24-hour water absorption are also provided for better understanding of material capabilities to help design decisions using the material. All parts are conditioned per ASTM recommended standards for a minimum of 40 hrs at 23°C, 50% RH.

Solid material properties reported were printed along the vertical axis (ZX-orientation). As detailed in the Isotropic Properties section, Figure 4 material properties are relatively uniform across print orientations. Parts do not need to be oriented in a particular direction to exhibit these properties.

LIQUID MATERIAL			
MEASUREMENT	**CONDITION/METHOD**	**METRIC**	**ENGLISH**
Viscosity	Brookfield Viscometer @ 25 °C (77 °F)	900 cPs	2177 lb/ft·h
Color		Black	
Liquid Density	Kruss K11 Force Tensiometer @ 25 °C (77 °F)	1.16 g/cm³	0.04 lb/in³
Default Print Layer Thickness	Internal	? µm	? in
Speed - Standard Mode	Internal	N/A	N/A
Package Volume		1 kg bottle - Figure 4 Standalone 2.5 kg cartridge - Figure 4 Modular 9 kg container - Figure 4 Production	

SOLID MATERIAL						
METRIC	**ASTM METHOD**	**METRIC**	**ENGLISH**	**ISO METHOD**	**METRIC**	**ENGLISH**
	PHYSICAL				**PHYSICAL**	
Solid Density	ASTM D792	1.19 g/cm³	0.043 lb/in³	ISO 1183	1.19 g/cm³	0.043 lb/in³
24 Hour Water Absorption	ASTM D570	1.54 %	1.54 %	ISO 62	1.54 %	1.54 %
	MECHANICAL				**MECHANICAL**	
Tensile Strength Ultimate	ASTM D638	80 MPa	11600 psi	ISO 527 -1/2	80 MPa	11500 psi
Tensile Strength at Yield	ASTM D638	N/A	N/A	ISO 527 -1/2	N/A	N/A
Tensile Modulus	ASTM D638	2800 MPa	400 ksi	ISO 527 -1/2	3400 MPa	491 ksi
Elongation at Break	ASTM D638	5.6 %	5.6 %	ISO 527 -1/2	4.5 %	4.5 %
Elongation at Yield	ASTM D638	N/A	N/A	ISO 527 -1/2	N/A	N/A
Flex Strength	ASTM D790	110 MPa	15800 psi	ISO 178	100 MPa	14600 psi
Flex Modulus	ASTM D790	2700 MPa	390 ksi	ISO 178	2700 MPa	398 ksi
Izod Notched Impact	ASTM D256	16 J/m	0.3 ft-lb/in	ISO 180-A	1.9 kJ/m²	.9 ft-lb/in²
Izod Unnotched Impact	ASTM D4812	330 J/m	6 ft-lb/in	ISO 180-U	19 kJ/m²	9.2 ft-lb/in²
Shore Hardness	ASTM D2240	84 D	84 D	ISO 7619	84 D	84 D
	THERMAL				**THERMAL**	
Tg (DMA, E")	ASTM E1640 (E"at 1C/min)	124 °C	256 °F	ISO 6721-1/11 (E"at 1C/min)	124 °C	256 °F
HDT @ 0.455 MPa/66 PSI	ASTM D648	140 °C	281 °F	ISO 75- 1/2 B	121 °C	250 °F
HDT @ 1.82 MPa/264 PSI	ASTM D648	124 °C	255 °F	ISO 75-1/2 A	96 °C	204 °F
CTE below Tg	ASTM E831	89 ppm/°C	49 ppm/°F	ISO 11359-2	89 ppm/K	49 ppm/F
CTE above Tg	ASTM E831	110 ppm/°C	61 ppm/°F	ISO 11359-2	110 ppm/K	61 ppm/F
UL Flammability	UL94	HB	HB			
	ELECTRICAL				**ELECTRICAL**	
Dielectric Strength (kV/mm) @ 3.0 mm thickness	ASTM D149	16				
Dielectric Constant @ 1 MHz	ASTM D150	3.32				
Dissipation Factor @ 1 MHz	ASTM D150	0.027				
Volume Resistivity (ohm-cm)	ASTM D257	5.44×10^{15}				

Figure 4 Rigid 140C Black

ISOTROPIC PROPERTIES

Figure 4 technology prints parts that are generally isotropic in mechanical properties meaning the parts printed along either the XYZ axis will give similar results.

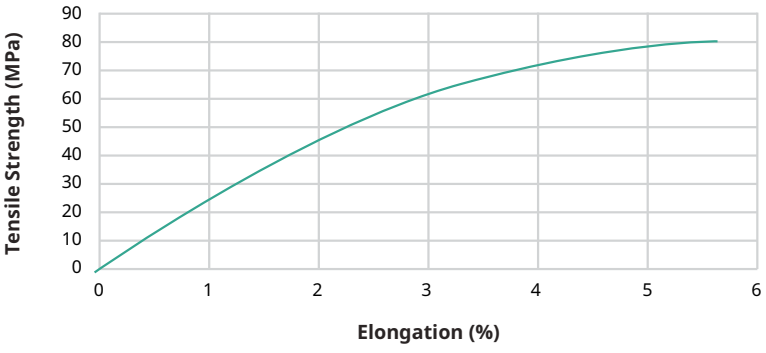
Parts do not need to be oriented to get the highest mechanical properties, further improving the degree of freedom for part orientation for mechanical properties.

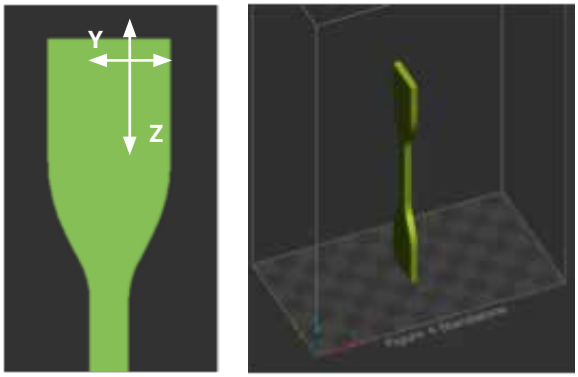
SOLID MATERIAL					
METRIC	METHOD	METRIC			
MECHANICAL					
		ZY	XZ	XY	Z45
Tensile Strength Ultimate	ASTM D638	80 MPa	79 MPa	76 MPa	73 MPa
Tensile Strength at Yield	ASTM D639	N/A	N/A	N/A	N/A
Tensile Modulus	ASTM D640	2800 MPa	2800 MPa	2800 MPa	3000 MPa
Elongation at Break	ASTM D641	5.6 %	6.5 %	5.1 %	6.1 %
Elongation at Yield	ASTM D642	N/A	N/A	N/A	N/A
Flex Strength	ASTM D790	110 MPa	108 MPa	99 MPa	107 MPa
Flex Modulus	ASTM D790	2700 MPa	2700 MPa	2500 MPa	2600 MPa
Izod Notched Impact	ASTM D256	16 J/m	17 J/m	19 J/m	20 J/m
Shore Hardness	ASTM D2240	84 D	84 D	85 D	84 D

STRESS-STRAIN CURVE

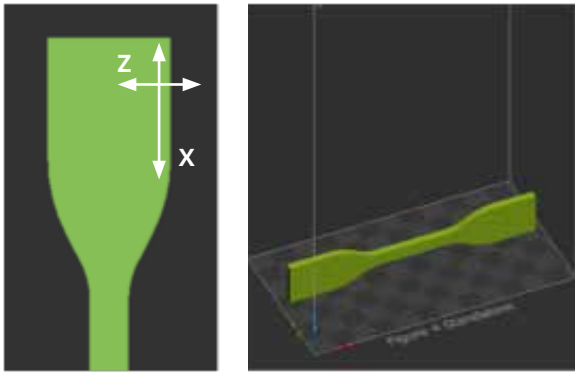
The graph represents the Stress-Strain curve for Figure 4 Rigid 140C Black per ASTM D638 testing.

FIGURE 4 RIGID 140C BLACK

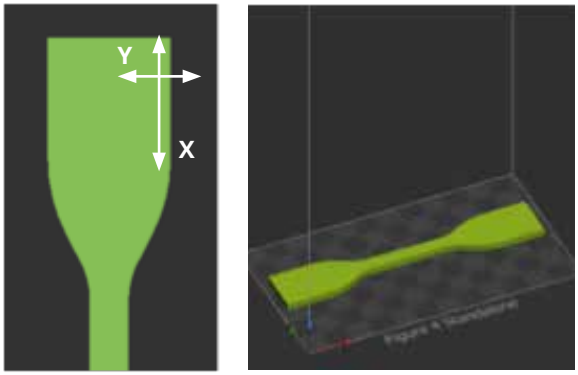




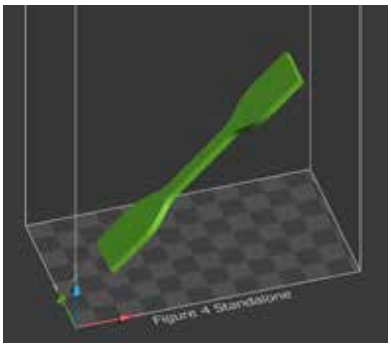
ZY - orientation



XZ - orientation



XY - orientation



Z45-Degree - orientation

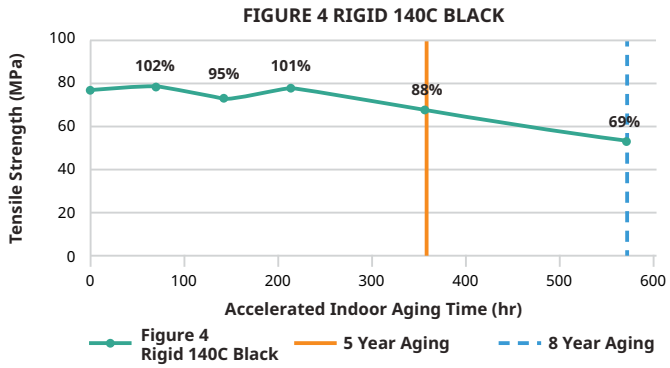
Figure 4 Rigid 140C Black

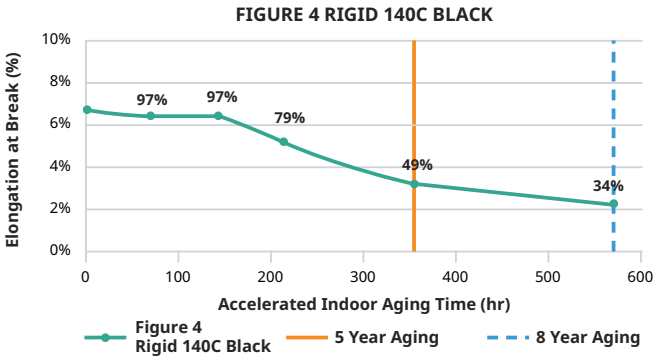
LONG TERM ENVIRONMENTAL STABILITY

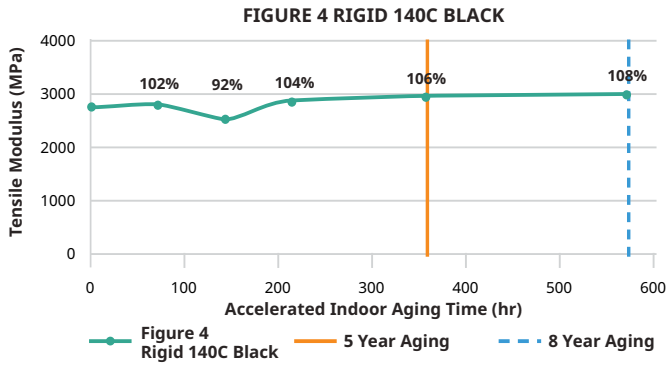
Figure 4 Rigid 140C Black is engineered to give long term environmental UV and humidity stability. This means the material is tested for the ability to retain a high percent of the initial mechanical properties over a given period of time. This provides real design conditions to consider for the application or part. **Actual data value is on Y-axis, and data points are % of initial value.**

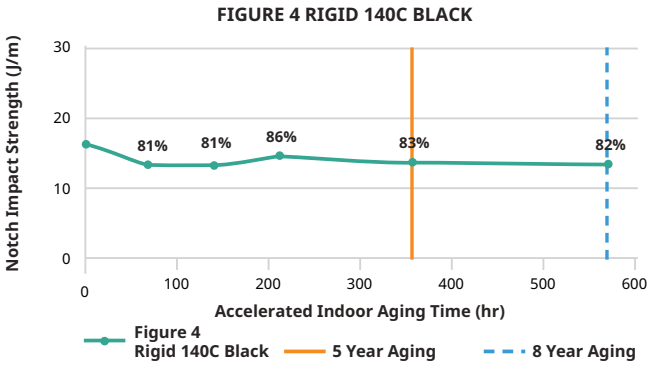
INDOOR STABILITY: Tested per ASTM D4329 standard method.

INDOOR STABILITY



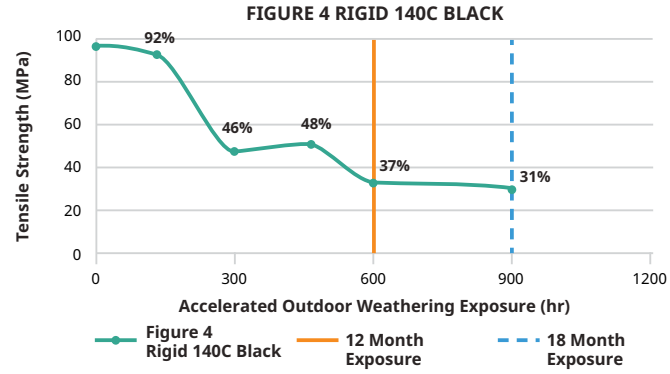


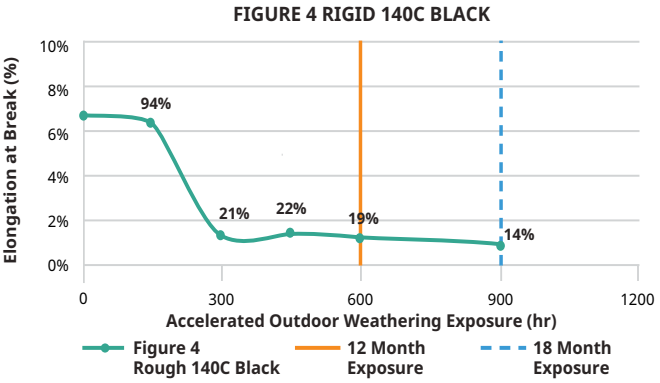


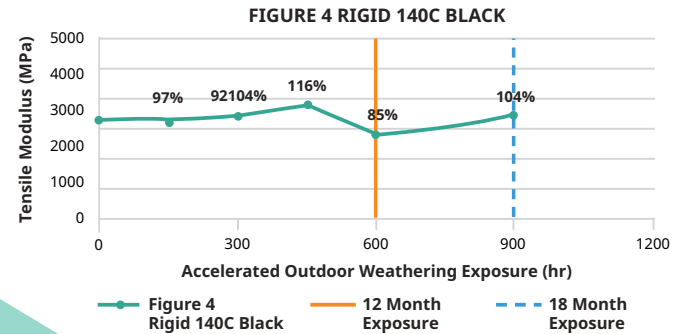


OUTDOOR STABILITY: Tested per ASTM G154 standard method.

OUTDOOR STABILITY







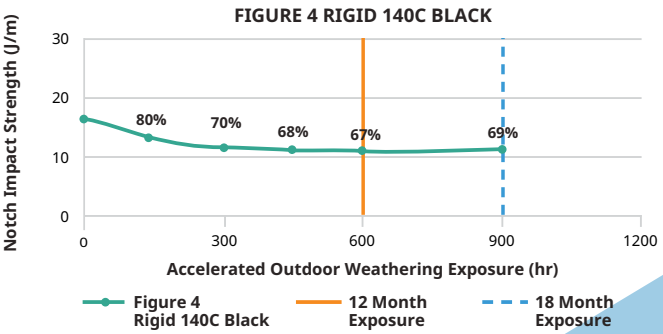


Figure 4 Rigid 140C Black

AUTOMOTIVE FLUID COMPATIBILITY

The compatibility of a material with hydrocarbons and cleaning chemicals is critical to part application. Figure 4 Rigid 140C Black parts were tested for sealed and surface contact compatibility per USCAR2 test conditions. The fluids below were tested in two different ways per the specs.

- Immerse for 7-days, then take mechanical property data for comparison.
- Immerse for 30-minutes, remove, and take mechanical property data for comparison in 7-days.

Data reflects the measured value of properties over that period of time.

AUTOMOTIVE FLUIDS		
FLUID	**SPECIFICATION**	**TEST TEMP °C**
Gasoline	ISO 1817, liquid C	23 ± 5
Diesel Fuel	905 ISO 1817, Oil No. 3 + 10% p-xylene*	23 ± 5
Engine Oil	ISO 1817, Oil No. 2	50 ± 3
Ethanol	85% Ethanol + 15% ISO 1817 liquid C*	23 ± 5
Power Steering Fluid	ISO 1917, Oil No. 3	50 ± 3
Automative Transmission Fluid	Dexron VI (North American specific material)	50 ± 3
Engine Coolant	50% ethylene glycol + 50% distilled water*	50 ± 3
Brake Fluid	SAE RM66xx (Use latest available fluid for xx)	50 ± 3
Diesel Exhaust Fluid (DEF)	API certified per ISO 22241	23 ± 5

*Solutions are determined as percent by volume

FIGURE 4 RIGID 140C BLACK

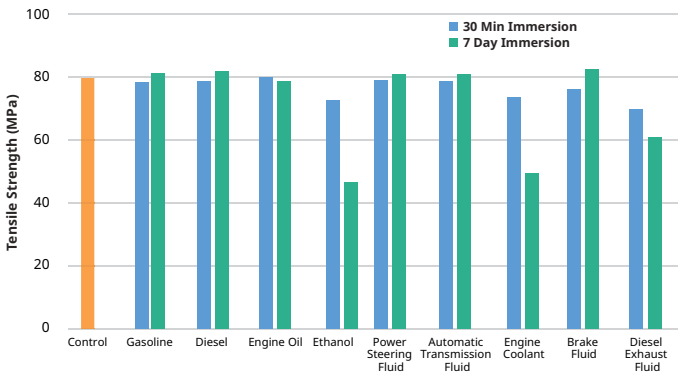


FIGURE 4 RIGID 140C BLACK

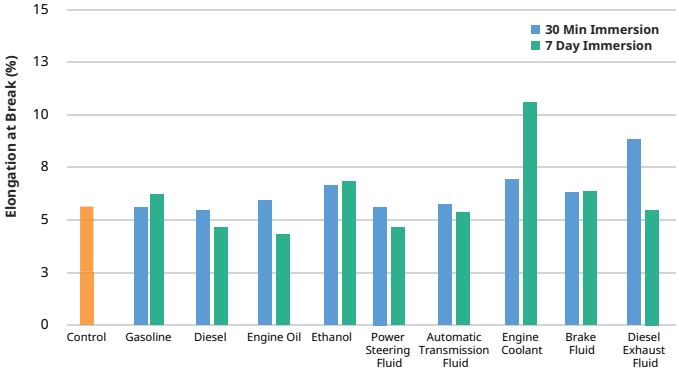


FIGURE 4 RIGID 140C BLACK

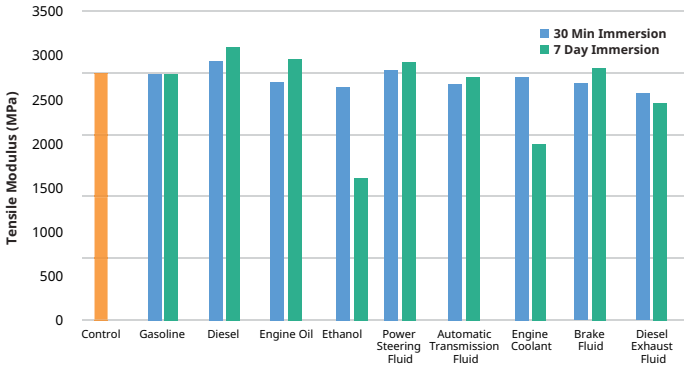


FIGURE 4 RIGID 140C BLACK

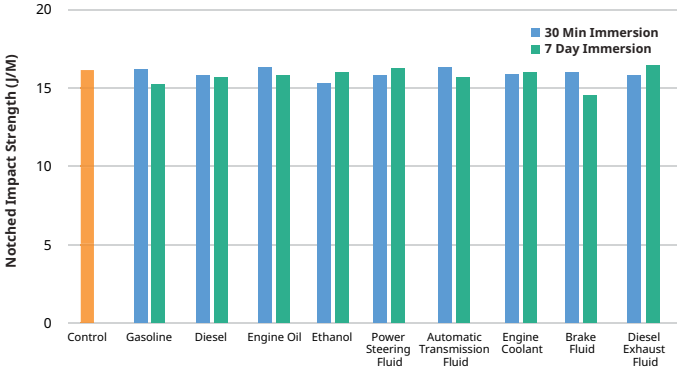


Figure 4 Rigid 140C Black

CHEMICAL COMPATIBILITY

The compatibility of a material with cleaning chemicals is critical to part application. Figure 4 Rigid 140C Black parts were tested for sealed and surface contact compatibility per ASTM D543 test conditions. The fluids below were tested in two different ways per the specs.

- Immerse for 7-days, then take mechanical property data for comparison.
- Immerse for 30-minutes, remove, and take mechanical property data for comparison in 7-days.

Data reflects the measured value of properties over that period of time.

*Denotes materials did not go through 7-day soak conditioning.

CHEMICAL COMPATIBILITY
6.3.3 Acetone
6.3.12 Detergent Solution, Heavy Duty
6.3.23 Hydrochloric Acid (10%)
6.3.38 Sodium Carbonate Solution (20%)
6.3.44 Sodium Hypochlorite Solution
6.3.46 Sulfuric Acid (30%)
6.3.42 Sodium Hydroxide Soln (10%)
6.3.15 Distilled Water

FIGURE 4 RIGID 140C BLACK

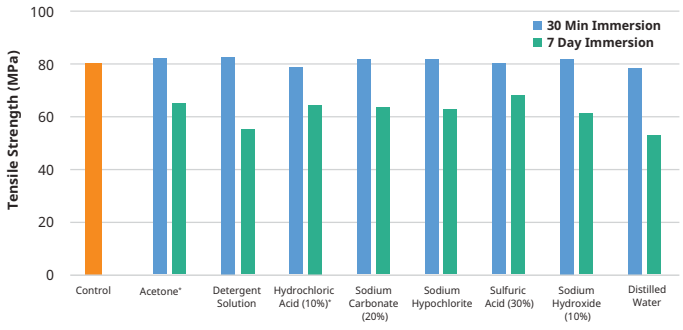


FIGURE 4 RIGID 140C BLACK

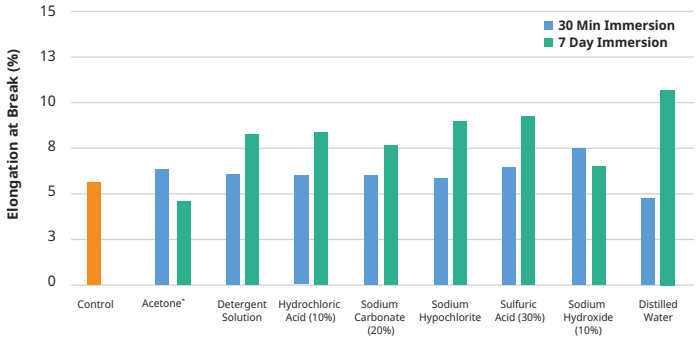


FIGURE 4 RIGID 140C BLACK

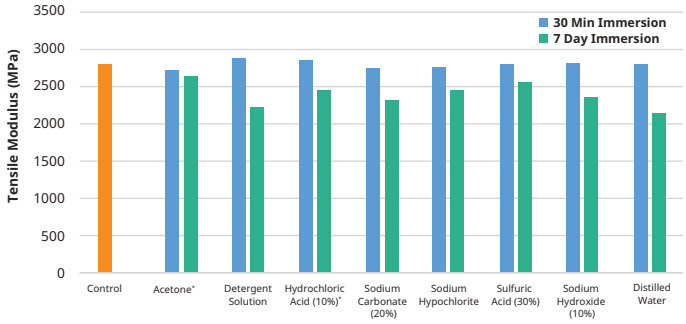
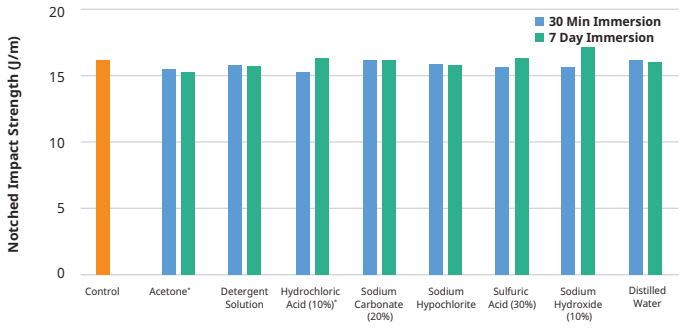


FIGURE 4 RIGID 140C BLACK



EFFICIENT THERMAL POST-CURE PROCESS

Figure 4 Rigid 140C Black creates production parts with excellent surface quality, accuracy and repeatability while reducing the finish time thanks to an efficient thermal post-cure process. Figure 4 Rigid 140C Black requires a three-hour thermal post-cure at 135°C without the need to pack the parts in salt, as is required for other similar materials available on competitive systems. Additionally, the cure time is approximately 75% shorter than the 8 to 12 hours required for similar materials available on competitive systems.

BIOCOMPATIBILITY STATEMENT

Figure 4 Rigid 140C Black test coupons printed and processed according to the post processing instructions below were provided to an external biological testing laboratory for evaluation in accordance with *ISO 10993-5, Biological evaluation of medical devices - Part 5: Tests for in vitro cytotoxicity*. The test results indicate that Figure 4 Rigid 140C Black has passed the requirements for biocompatibility according to the above test.

It is the responsibility of each customer to determine that its use of Figure 4 Rigid 140C Black material is safe, lawful and technically suitable to the customer's intended applications. Customers should conduct their own testing to ensure that this is the case. Because of possible changes in the law and in regulations, as well as possible changes in these materials, 3D Systems cannot guarantee that the status of these materials will remain unchanged or that it will qualify as biocompatible in any particular use. Therefore, 3D Systems recommends that customers continuing to use these materials verify their status on a periodic basis.

FIGURE 4 RIGID 140C BLACK BIOCOMPATIBILITY POST PROCESS

MIXING INSTRUCTIONS

This material has a pigment that settles very slowly over time before printing. For best results mix material in the bottle:

1 kg bottle for Figure 4 Standalone

1. Roll Part A bottle for 1 hour on 3D Systems LC-3D Mixer for first use
2. Roll for 10 minutes before subsequent uses
3. Use 19:1 Mix Ratio Part A to Part B.
4. Shake vigorously in mixing container 2-5 minutes

Use the Resin Mixer to stir material in the tray for 30 seconds between print jobs.

MANUAL CLEANING INSTRUCTIONS

- Manual cleaning with 2 containers of 1-TPM, 1-IPA (wash and rinse)
- Rinse in 'clean' TPM for 5 minutes while agitating part
- Clean in 'wash' IPA for 5 minutes while agitating part
  DO NOT EXCEED more than 10 minutes total exposure to IPA to preserve mechanical properties
- Manual agitation and/or a soft brush can be used to aid cleaning
- Refresh IPA when cleaning becomes ineffective

DRYING INSTRUCTIONS

- Oven dry at 35 °C for 25 minutes

UV CURE TIME

- 3D Systems LC-3DPrint Box UV Post-Curing Unit or Figure 4 UV Cure Unit 350: 90 minutes

THERMAL POST CURE

- Ramp rate of 3 minutes to 130C and hold for 3 hours. Cool before handling parts.

More details can be found in the Figure 4 User Guide available at http://infocenter.3dsystems.com
Figure 4 Standalone: http://infocenter.3dsystems.com/figure4standalone/node/1546