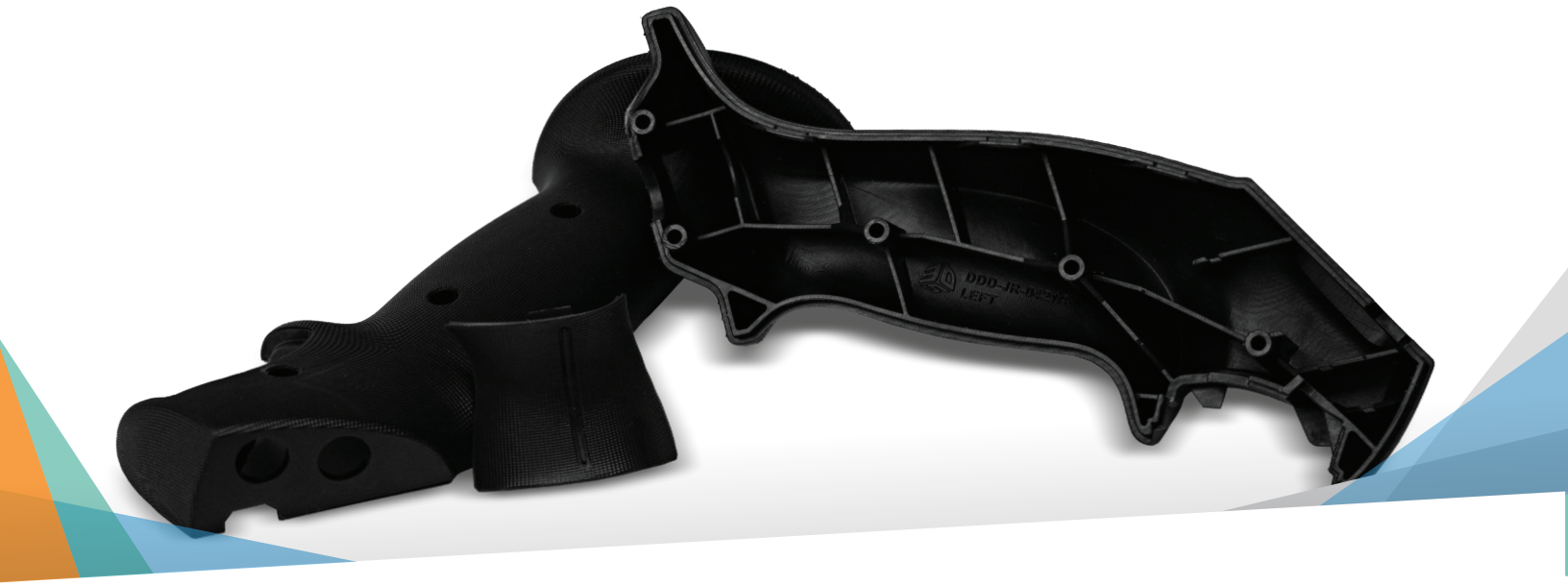


Figure 4® Tough 65C Black

Production Rigid

Figure 4

Black plastic for long-term use parts with a good combination of impact strength, elongation, and tensile strength

SAVE ON TOOLING COSTS AND TIME WITH DIRECT PRODUCTION PLASTIC PARTS

Figure 4® Tough 65C Black is a versatile production-grade black material with good impact strength, elongation, and tensile strength. It provides long-term environmental stability with an injection molded-like surface quality. This material is recommended for high mechanical load-bearing batch production parts, jigs and fixtures, and prototypes that remain stable for years.

This resin features a 70˚C heat deflection temperature and 35% elongation at break, and is excellent for buckles, snaps, and clips due to a 6.6% elongation at yield. Simplified post-processing speeds enable high end-to-end throughput.

HANDLING AND POST-PROCESSING GUIDELINES

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

Figure 4 Standalone:
http://infocenter.3dsystems.com/figure4standalone/node/1546

Figure 4 Modular:
http://infocenter.3dsystems.com/figure4modular/node/1741

APPLICATIONS

- Load-bearing parts such as handles, cranks, knobs, and levers Structural parts like brackets, snap-fits, and custom fasteners
- Small parts requiring detail and accuracy for consumer products, sporting goods, and general use
- Latching and board connectors for data devices and white goods
- Sensor holders and guides

BENEFITS

- Long-term use parts for indoor and outdoor applications
- High elongation at yield for ABS-like material; good for better snaps and clips
- Excellent surface quality, accuracy, repeatability
- Fast throughput to finished part; no secondary thermal cure required

FEATURES

- Long-term indoor and outdoor environmental stability of mechanical properties; tested out to 8 and 1.5 years (respectively) per ASTM methods
- 70°C HDT at 0.455MPa
- 35% elongation at break
- 6.6% elongation at yield
- 31 J/m notched impact strength
- 41 MPa tensile strength
- Biocompatible-capable per ISO 10993-5
- UL94 HB flammability

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

3D SYSTEMS®

Figure 4 Tough 65C 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)	1900 cPs	4596 lb/ft·h
Color		Black	
Liquid Density	Kruss K11 Force Tensiometer @ 25 °C (77 °F)	1.13 g/cm³	0.04 lb/in³
Default Print Layer Thickness	Internal	50 µm	0.002 in
Speed - Standard Mode	Internal	mm/hr	30
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	1.22 g/cm³	0.044 lb/in³	ISO 1183	1.22 g/cm³	0.044 lb/in³
24 Hour Water Absorption	ASTM D570	0.62 %	0.62 %	ISO 62	0.62 %	0.62 %
	MECHANICAL				**MECHANICAL**	
Tensile Strength Ultimate	ASTM D638	41 MPa	6000 psi	ISO 527 -1/2	41 MPa	5900 psi
Tensile Strength at Yield	ASTM D638	40 MPa	5800 psi	ISO 527 -1/2	39 MPa	5700 psi
Tensile Modulus	ASTM D638	1700 MPa	250 ksi	ISO 527 -1/2	1800 MPa	260 ksi
Elongation at Break	ASTM D638	35 %	35 %	ISO 527 -1/2	31 %	31 %
Elongation at Yield	ASTM D638	6.6 %	6.6 %	ISO 527 -1/2	6.9 %	6.9 %
Flex Strength	ASTM D790	60 MPa	8600 psi	ISO 178	60 MPa	8200 psi
Flex Modulus	ASTM D790	1600 MPa	240 ksi	ISO 178	1800 MPa	257 ksi
Izod Notched Impact	ASTM D256	31 J/m	0.6 ft-lb/in	ISO 180-A	N/A	N/A
Izod Unnotched Impact	ASTM D4812	100 J/m	2 ft-lb/in	ISO 180-U	8.4 kJ/m²	4 ft-lb/in²
Shore Hardness	ASTM D2240	81 D	81 D	ISO 7619	81 D	81 D
	THERMAL				**THERMAL**	
Tg (DMA, E")	ASTM E1640 (E"at 1C/min)	50 C	123 F	ISO 6721-1/11 (E"at 1C/min)	50 C	123 F
HDT @ 0.455 MPa/66 PSI	ASTM D648	70 C	159 F	ISO 75- 1/2 B	70 C	158 F
HDT @ 1.82 MPa/264 PSI	ASTM D648	51 C	124 F	ISO 75-1/2 A	51 C	125 F
CTE below Tg	ASTM E831	92 ppm/C	51 ppm/F	ISO 11359-2	92 ppm/K	51 ppm/F
CTE above Tg	ASTM E831	163 ppm/C	90 ppm/F	ISO 11359-2	163 ppm/K	90 ppm/F
UL Flammability	UL94	HB	HB			
	ELECTRICAL				**ELECTRICAL**	
Dielectric Strength (kV/mm) @ 3.0 mm thickness	ASTM D149	13				
Dielectric Constant @ 1 MHz	ASTM D150	3.75				
Dissipation Factor @ 1 MHz	ASTM D150	0.037				
Volume Resistivity (ohm-cm)	ASTM D257	3.37×10^{15}				

Figure 4 Tough 65C Black

ISOTROPIC PROPERTIES

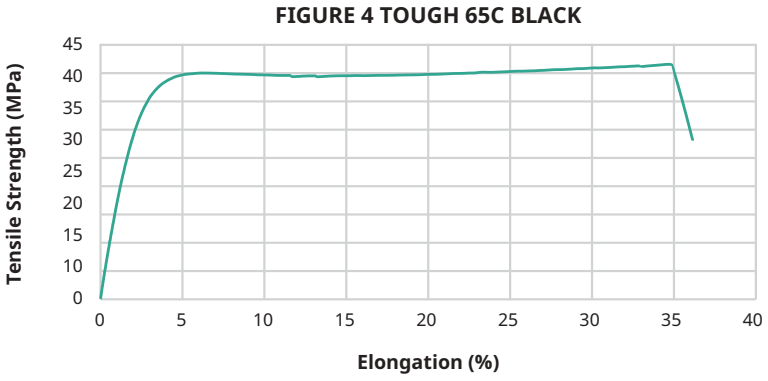
Figure 4 technology prints parts that are generally isotropic in mechanical properties meaning the parts printed along either the XYZ axis will give similar results.

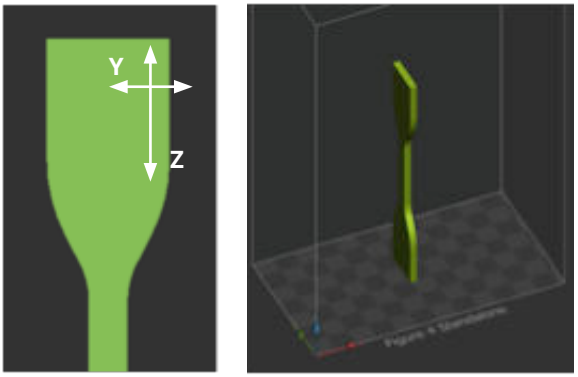
Parts do not need to be oriented to get the highest mechanical properties, further improving the degree of freedom for part orientation for mechanical properties.

SOLID MATERIAL					
METRIC	METHOD	METRIC			
MECHANICAL					
		ZY	XZ	XY	Z45
Tensile Strength Ultimate	ASTM D638	41 MPa	39 MPa	38 MPa	40 MPa
Tensile Strength at Yield	ASTM D639	40 MPa	38 MPa	38 MPa	40 MPa
Tensile Modulus	ASTM D640	1700 MPa	1600 MPa	1500 MPa	1700 MPa
Elongation at Break	ASTM D641	35%	15%	27%	25%
Elongation at Yield	ASTM D642	6.6%	6.6%	6.5%	6.7%
Flex Strength	ASTM D790	60 MPa	49 MPa	44 MPa	52 MPa
Flex Modulus	ASTM D790	1600 MPa	1300 MPa	1100 MPa	1400 MPa
Izod Notched Impact	ASTM D256	31 J/m	30 J/m	41 J/m	40 J/m
Shore Hardness	ASTM D2240	81 D	N/A	N/A	N/A

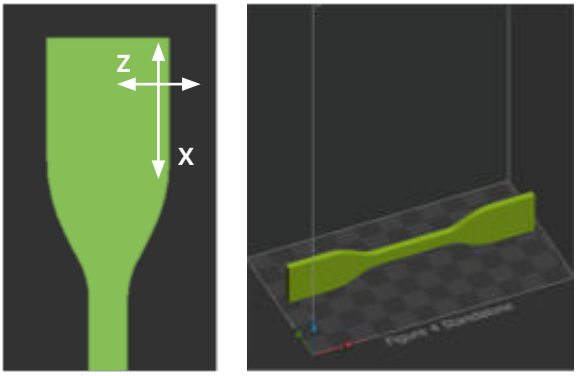
STRESS-STRAIN CURVE

The graph represents the Stress-Strain curve for Figure 4 Tough 65C Black per ASTM D638 testing.

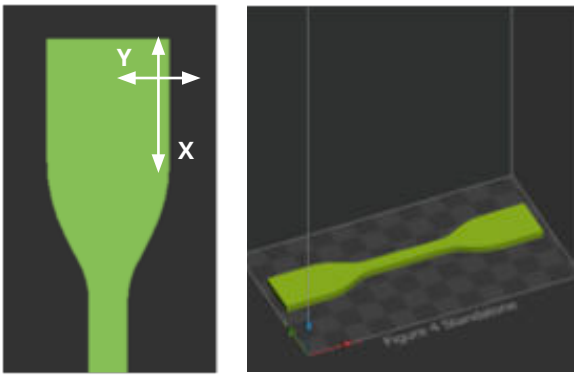




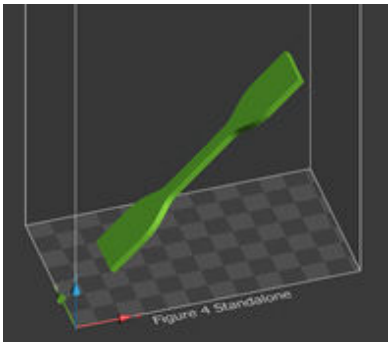
ZY - orientation



XZ - orientation



XY - orientation



Z45-Degree - orientation

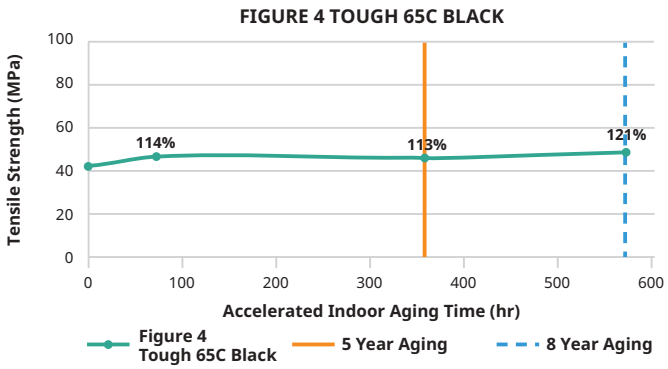
Figure 4 Tough 65C Black

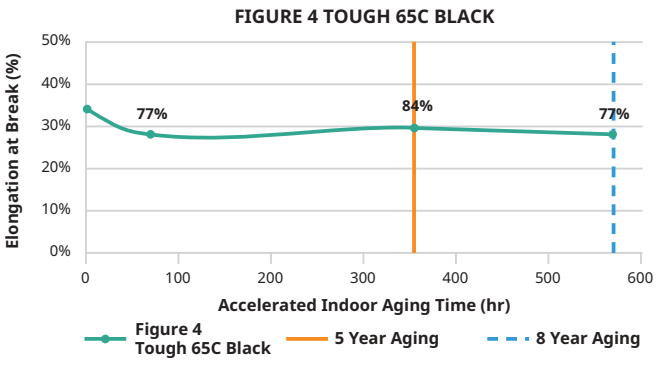
LONG TERM ENVIRONMENTAL STABILITY

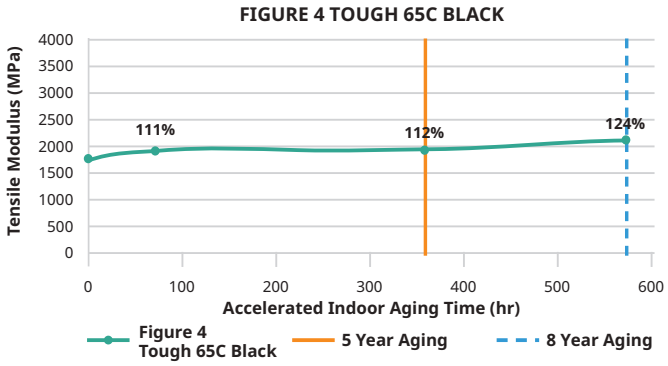
Figure 4 Tough 65C Black is engineered to give long term environmental UV and humidity stability. This means the material is tested for the ability to retain a high percent of the initial mechanical properties over a given period of time. This provides real design conditions to consider for the application or part. **Actual data value is on Y-axis, and data points are % of initial value.**

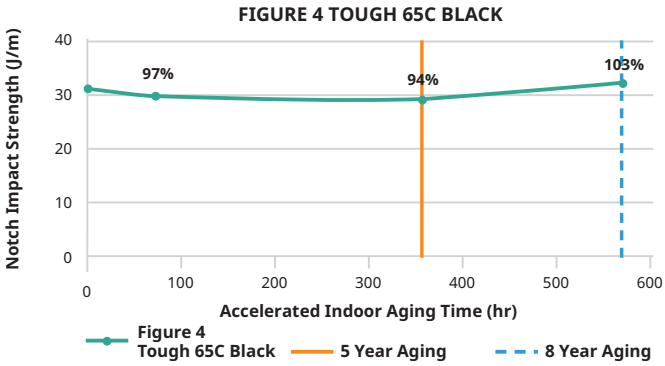
INDOOR STABILITY

INDOOR STABILITY: Tested per ASTM D4329 standard method.



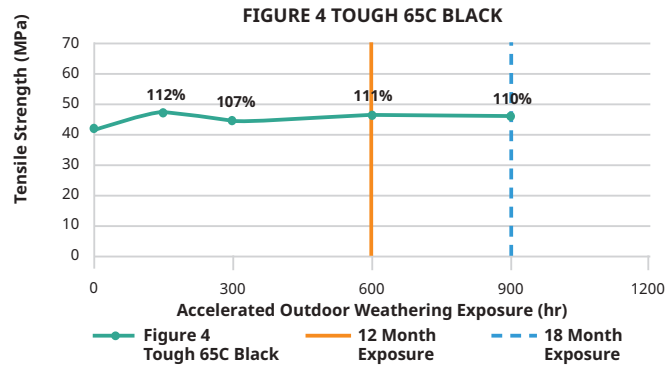


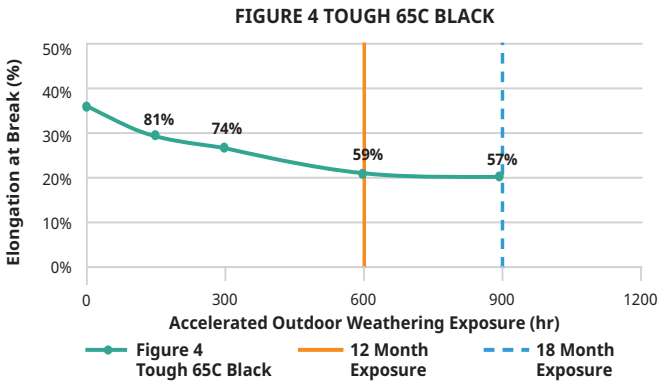


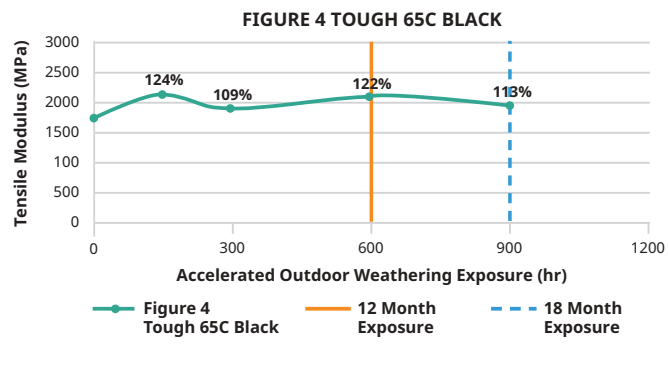


OUTDOOR STABILITY

OUTDOOR STABILITY: Tested per ASTM G154 standard method.







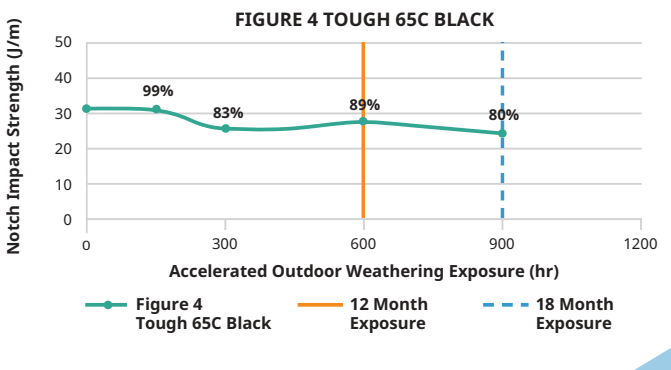


Figure 4 Tough 65C Black

AUTOMOTIVE FLUID COMPATIBILITY

The compatibility of a material with hydrocarbons and cleaning chemicals is critical to part application. Figure 4 Tough 65C 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 TOUGH 65C BLACK

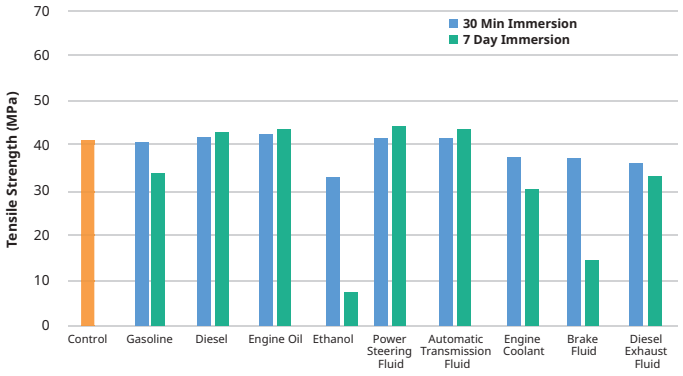


FIGURE 4 TOUGH 65C BLACK

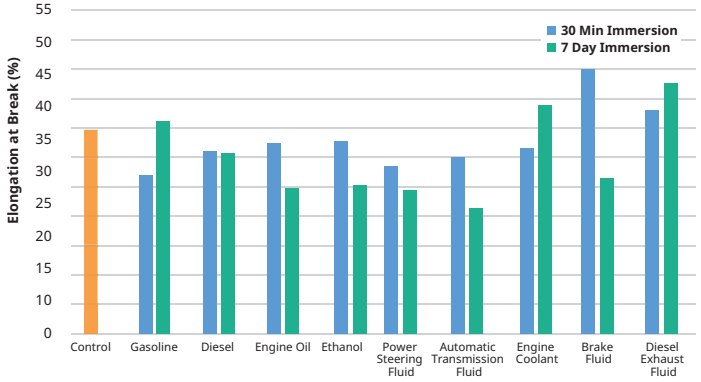


FIGURE 4 TOUGH 65C BLACK

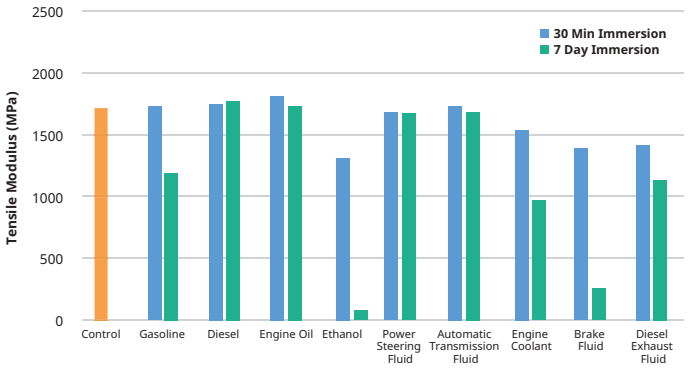


FIGURE 4 TOUGH 65C BLACK

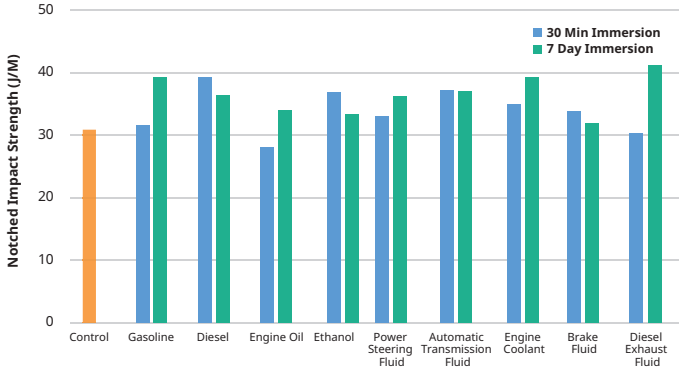


Figure 4 Tough 65C Black

CHEMICAL COMPATIBILITY

The compatibility of a material with cleaning chemicals is critical to part application. Figure 4 Tough 65C 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 thru 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 TOUGH 65C BLACK

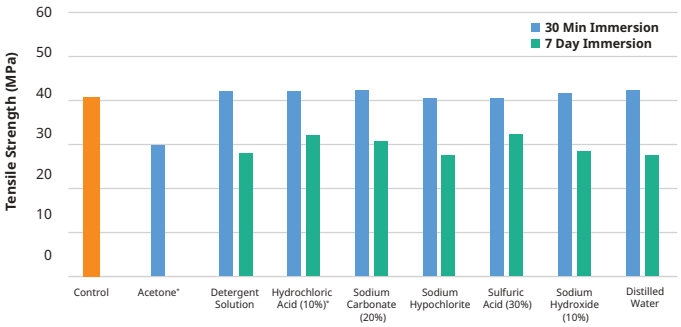


FIGURE 4 TOUGH 65C BLACK

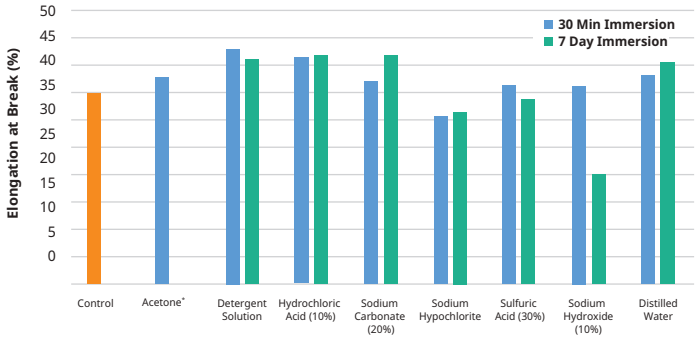


FIGURE 4 TOUGH 65C BLACK

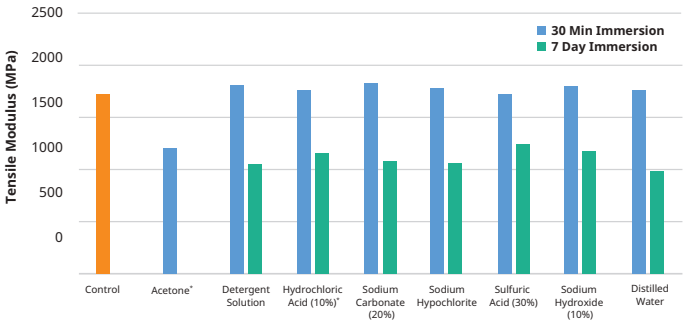
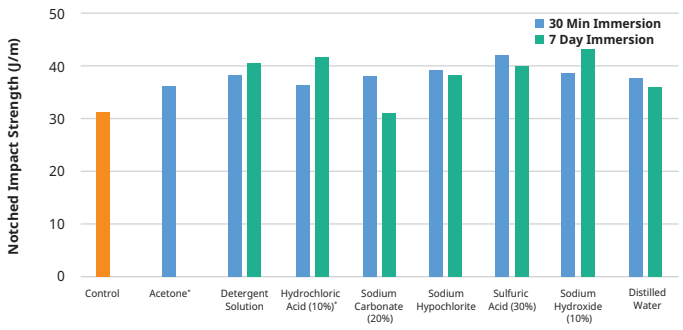


FIGURE 4 TOUGH 65C BLACK



BIOCOMPATIBILITY STATEMENT

Figure 4® Tough 65C 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® Tough 65C 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® Tough 65C 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 Tough 65C Black

POST-PROCESSING INSTRUCTIONS REQUIRED TO PASS ISO 10993-5

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

- Roll bottle for 1 hour on 3D Systems LC-3D Mixer for first use
- Roll for 10 minutes before subsequent uses

2.5 kg cartridge for Figure 4 Modular

- Vigorously shake the bottle for 2 minutes before installing cartridge

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

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

Figure 4 Modular: http://infocenter.3dsystems.com/figure4modular/node/1741