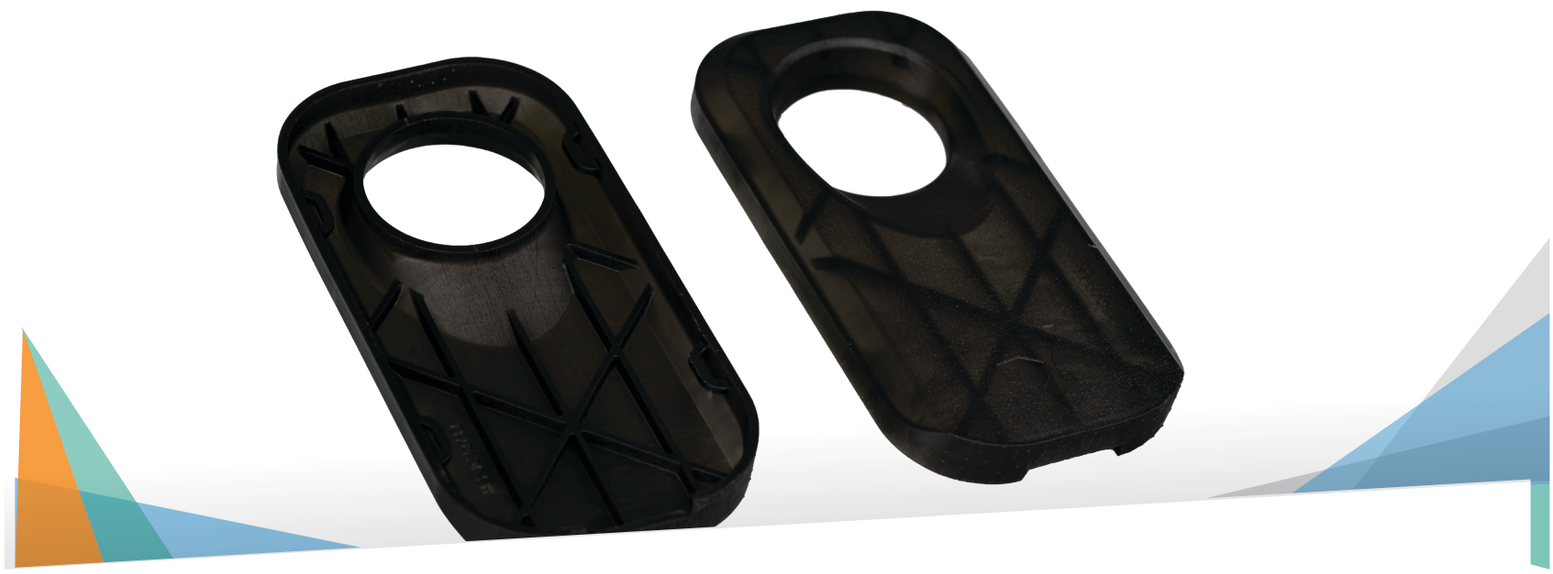


Figure 4® Tough FR V0 Black

Production Tough

A tough, production-grade flame-retardant additive manufacturing material that passes UL94 V0 test standards.

Figure 4
PSLA

PROVEN PERFORMANCE IN EXTREME CONDITIONS

Figure 4 Tough FR V0 Black delivers exceptional results in many key performance areas including fire resistance, fluid compatibility, UV stability, paint adhesion, and mechanical properties. It distinguishes itself from other flame-retardant materials for being a tough material and possessing an astounding elongation at break as high as 45%. Figure 4 Tough FR V0 Black easily achieves parts with high degrees of accuracy and detail without requiring a thermal cure.

This material is recommended for a variety of industries including aerospace, automotive, transportation, and consumer products.

Figure 4 Tough FR V0 Black is tested to 8 years of indoor and 1 year outdoor mechanical performance per ASTM D4329 and ASTM G154 methods, ensuring that printed parts remain functional and stable for long periods in real-world conditions.

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 User Guides and Best Practices Documentation available at https://support.3dsystems.com/

APPLICATIONS

- Aircraft electrical connectors, knobs, grommets, and spacers
- End-use manufacturing of high-volume, small plastic parts
- Printed circuit board covers
- Electrical and under-hood housings
- Tough covers, hangers, and brackets
- Flame retardant parts for trains and buses

BENEFITS

- Passes UL94 V0 above 3mm wall thickness and FAR25.853(a) above 2mm wall thickness
- Self-extinguishing, flame-retardant material
- Capable of plating and painting
- No secondary thermal cure required
- Outstanding fluid compatibility with fuel turbine oil, hydraulic fluid, and IPA
- Achieve production efficiencies due to a shared base chemistry with SLA version of Tough FR V0 Black

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

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	**METHOD**	**METRIC**	**ENGLISH**
Viscosity (@25C)	Brookfield Viscometer	1140 cPs	2758 lb/ft·h
Color		Black	
Liquid Density (@25C)	Kruss K11 Force Tensiometer	1.23 g/cm³	0.043 lb/in³
Default print layer thickness	Internal	50 µm	0.002 in
Speed - Standard mode	Internal	48 mm/hr	1.89 in/hr
Speed - Draft mode	Internal	70 m mm/hr	2.76 in/hr

SOLID MATERIAL						
METRIC	**ASTM METHOD**	**METRIC**	**US**	**ISO METHOD**	**METRIC**	**US**
	PHYSICAL				**PHYSICAL**	
Solid Density	ASTM D792	1.31 g/cm³	0.047 lb/in³	ISO 1183	1.31 g/cm³	0.047 lb/in³
24 Hour Water Absorption	ASTM D570	1.03 %	1.03 %	ISO 62	1.03 %	1.03 %
	MECHANICAL				**MECHANICAL**	
Tensile Strength Ultimate	ASTM D638 Type IV	38 MPa	5500 psi	ISO 527 -1/2	35 MPa	5100 psi
Tensile Strength at Yield	ASTM D638 Type IV	35 MPa	5100 psi	ISO 527 -1/2	35 MPa	5100 psi
Tensile Modulus	ASTM D638 Type IV	1400 MPa	210 ksi	ISO 527 -1/2	1500 MPa	220 ksi
Elongation at Break	ASTM D638 Type IV	44.6 %	44.6 %	ISO 527 -1/2	27.4 %	27.4 %
Elongation at Yield	ASTM D638 Type IV	5.6 %	5.6 %	ISO 527 -1/2	5.3 %	5.3 %
Flex Strength	ASTM D790	48 MPa	7000 psi	ISO 178	45 MPa	6500 psi
Flex Modulus	ASTM D790	1300 MPa	190 ksi	ISO 178	1400 MPa	209 ksi
Izod Notched Impact	ASTM D256	35 J/m	0.7 ft-lb/in	ISO 180-A	4 J/m²	0.0018 ft-lb/in²
Izod Unnotched Impact	ASTM D4812	770 J/m	15 ft-lb/in	ISO 180-U	70 J/m²	0.0339 ft-lb/in²
Shore Hardness	ASTM D2240	78 D	78 D	ISO 7619	78 D	78 D
	THERMAL				**THERMAL**	
Tg (DMA E")	ASTM E1640 (E"Peak)	6 °C	42 °F	ISO 6721-1/11 (E" Peak)	6 °C	42 °F
HDT 0.455MPa/66PSI	ASTM D648	66 °C	150 °F	ISO 75- 1/2 B	58 °C	136 °F
HDT 1.82MPa/264 PSI	ASTM D648	51 °C	124 °F	ISO 75-1/2 A	46 °C	114 °F
CTE -20 TO 50C	ASTM E831	108 ppm/°C	60 ppm/°F	ISO 11359-2	108 ppm/°C	60 ppm/°F
CTE 75 TO 180C	ASTM E831	158 ppm/°C	88 ppm/°F	ISO 11359-2	158 ppm/°C	88 ppm/°F
UL Flammability	UL94	V0 @ 3mm				
	ELECTRICAL				**ELECTRICAL**	
Dielectric Strength (kV/mm) @ 3 mm thickness	ASTM D149	14.69				
Dielectric Constant @ 1kHz	ASTM D150	3.465				
Dissipation Factor @ 1kHz	ASTM D150	0.034				
Volume Resistivity (ohm-cm)	ASTM D257	2.26e14				

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.

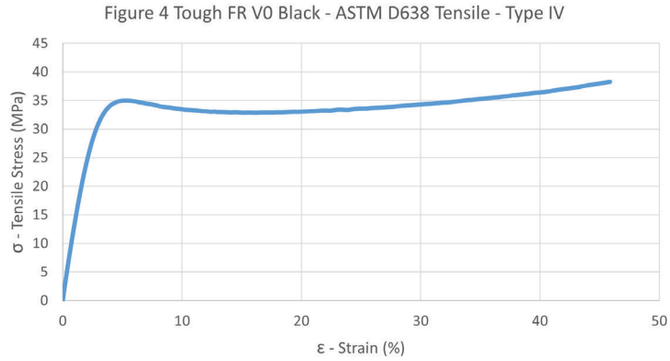
Parts do not need to be oriented to get the highest mechanical properties, further improving the degree of freedom for part orientation for mechanical properties.

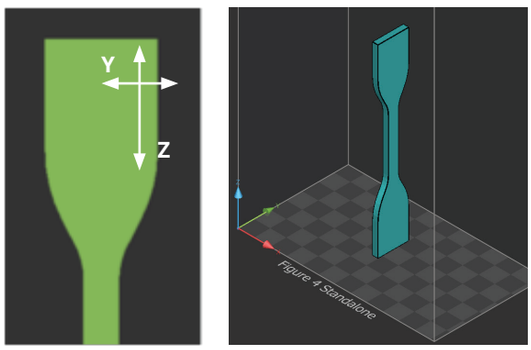
SOLID MATERIAL					
METRIC	METHOD	METRIC			
MECHANICAL					
		ZY	XZ	XY	Z45
Tensile Strength Ultimate	ASTM D638 Type IV	38 MPa	32 MPa	34 MPa	33 MPa
Tensile Strength at Yield	ASTM D638 Type IV	35 MPa	32 MPa	34 MPa	31 MPa
Tensile Modulus	ASTM D638 Type IV	1400 MPa	1300 MPa	1600 MPa	1300 MPa
Elongation at Break	ASTM D638 Type IV	44.6 %	30 %	27 %	37 %
Elongation at Yield	ASTM D638 Type IV	5.6 %	5.7 %	5.3 %	6 %
Flex Strength	ASTM D790	48 MPa	41 MPa	44 MPa	42 MPa
Flex Modulus	ASTM D790	1300 MPa	1200 MPa	1100 MPa	1100 MPa
Izod Notched Impact	ASTM D256	35 J/m	33 J/m	34 J/m	35 J/m
Izod unnotched impact	ASTM D4812	770 J/m	224 J/m	218 J/m	637 J/m
Shore D Hardness	ASTM D2240	78 D	76 D	74 D	75 D

STRESS-STRAIN CURVE

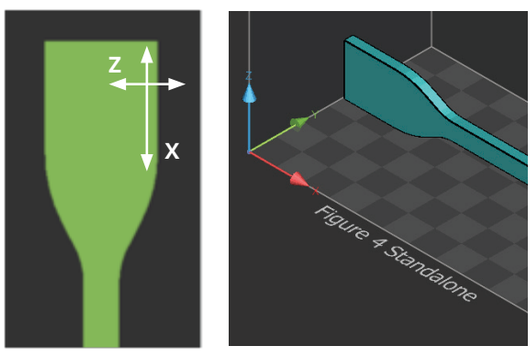
The graph represents the Stress-Strain curve for Figure 4 Tough FR V0 Black per ASTM D638 testing.

Figure 4 Tough FR V0 Black - ASTM D638 Tensile - Type IV

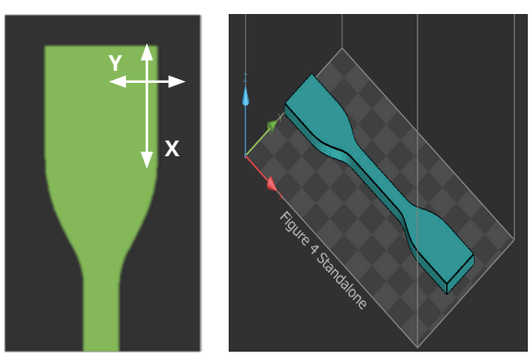




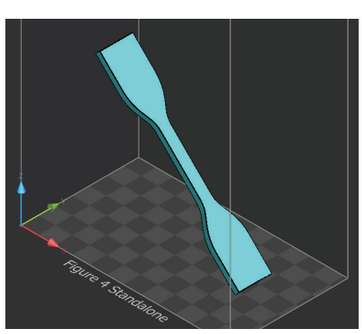
ZY - orientation



XZ - orientation



XY - orientation



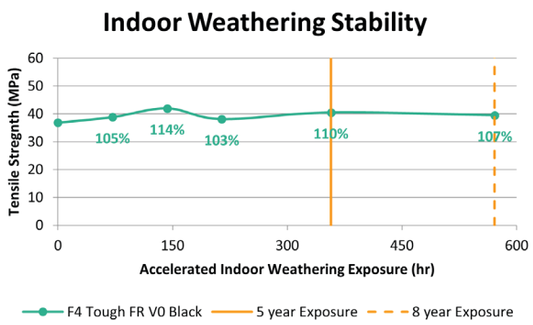
Z45-Degree - orientation

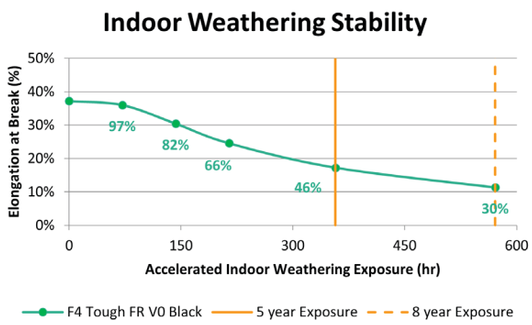
LONG TERM ENVIRONMENTAL STABILITY

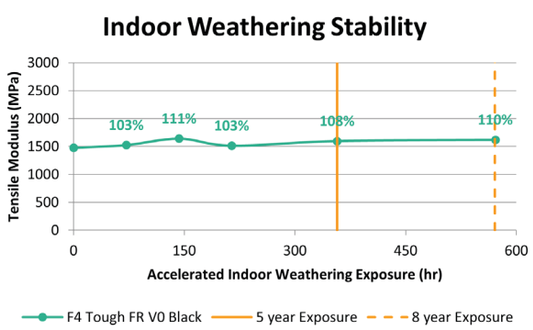
Figure 4 Tough FR V0 Black is engineered to give long term environmental UV and humidity stability. This means the material is tested for the ability to retain a high percent of the initial mechanical properties over a given period of time. This provides real design conditions to consider for the application or part. **Actual data value is on Y-axis, and data points are % of initial value.**

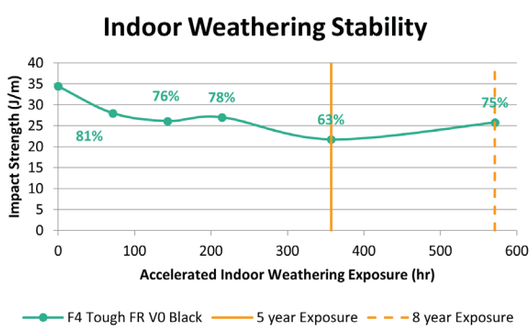
INDOOR STABILITY

INDOOR STABILITY: Tested per ASTM D4329 standard method.



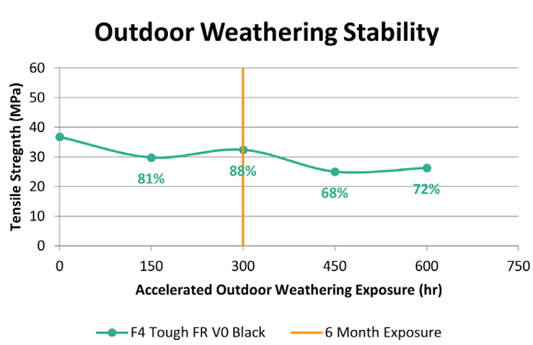


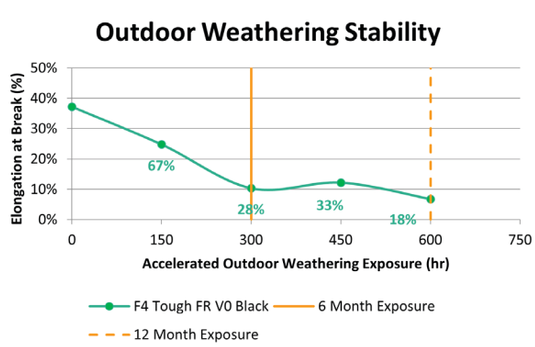


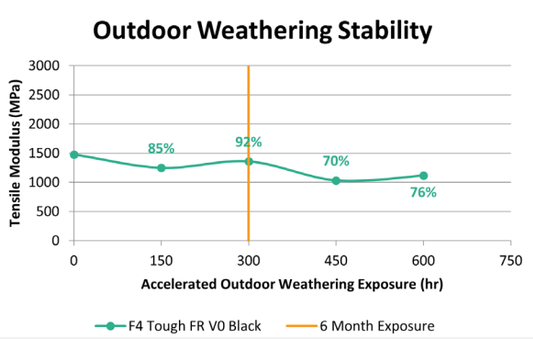


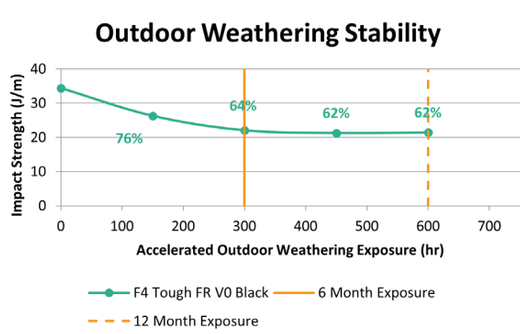
OUTDOOR STABILITY

OUTDOOR STABILITY: Tested per ASTM G154 standard method.









AUTOMOTIVE FLUID COMPATIBILITY

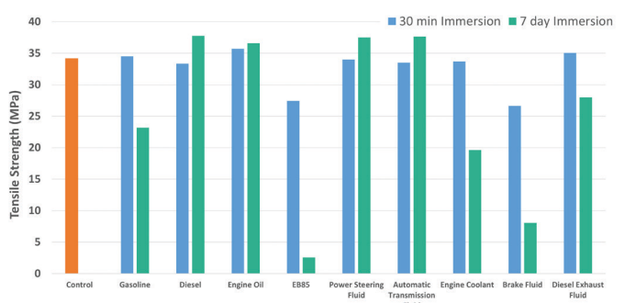
The compatibility of a material with hydrocarbons and cleaning chemicals is critical to part application. Figure 4 Tough FR V0 Black parts were tested for sealed and surface contact compatibility per USCAR2 test conditions. The fluids below were tested in two different ways per the specs.

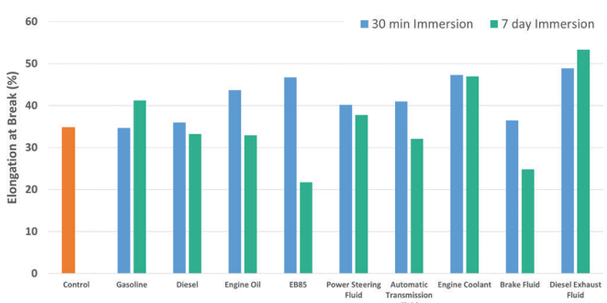
- Immerse for 7-days, then take mechanical property data for comparison.
- Immerse for 30-minutes, remove, and take mechanical property data for comparison in 7-days

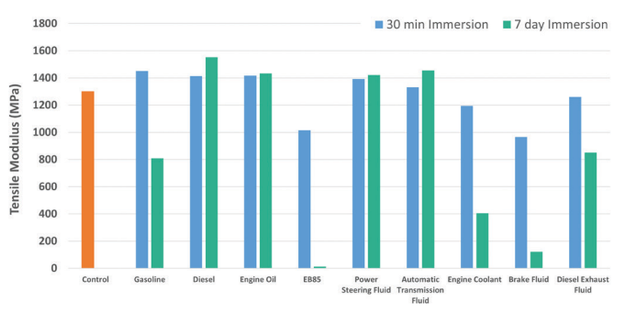
Data reflects the measured value of properties over that period of time.

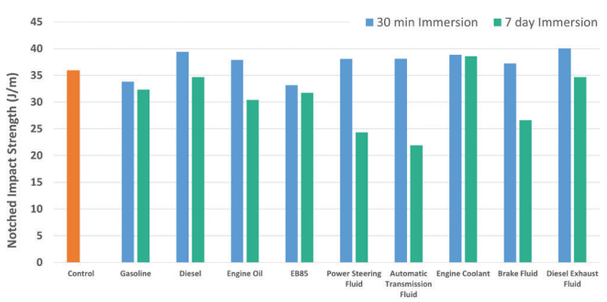
AUTOMOTIVE FLUIDS		
FLUID	**SPECIFICATION**	**TEST TEMP °C**
Gasoline	ISO 1817, liquid C	23 ± 5
Diesel Fuel	905 ISO 1817, Oil No. 3 + 10% p-xylene*	23 ± 5
Engine Oil	ISO 1817, Oil No. 2	50 ± 3
Ethanol	85% Ethanol + 15% ISO 1817 liquid C*	23 ± 5
Power Steering Fluid	ISO 1917, Oil No. 3	50 ± 3
Automative 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









CHEMICAL COMPATIBILITY

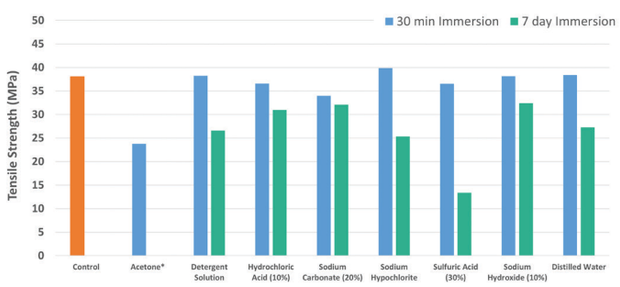
The compatibility of a material with cleaning chemicals is critical to part application. Figure 4 parts were tested for sealed and surface contact compatibility per ASTM D543 test conditions. The fluids below were tested in two different ways per the specs.

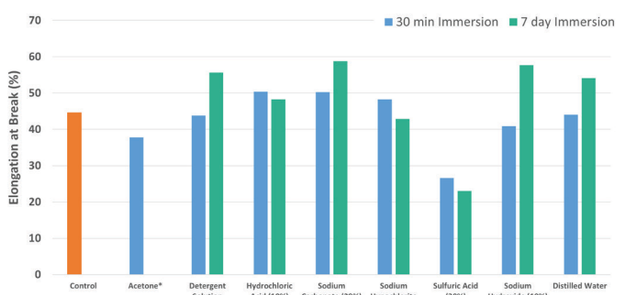
- Immerse for 7-days, then take mechanical property data for comparison.
- Immerse for 30-minutes, remove, and take mechanical property data

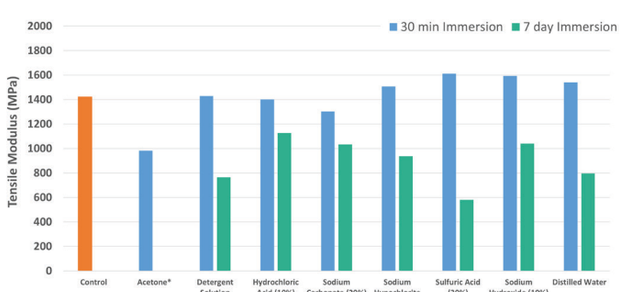
Data reflects the measured value of properties over that period of time.

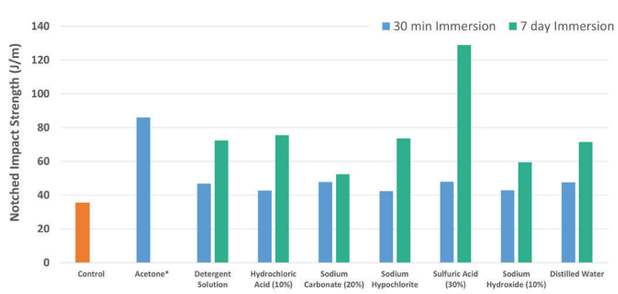
*Denotes materials did not go through 7-day soak conditioning.

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









POST-PROCESSING INSTRUCTIONS

ULTRASONIC CLEANING INSTRUCTIONS

- Sonicate parts in IPA for no longer than 5 minutes
- Inspect parts for any uncured resin
- Use a spray bottle with IPA to rinse parts ensuring uncured resin is removed
- Manual agitation and/or a soft brush can be used to aid cleaning
- If desired, blow the part off with low-pressure compressed air

MANUAL CLEANING INSTRUCTIONS

- Manual cleaning with 2 containers of IPA (dirty and clean)
- Wash manually in dirty IPA for 5 minutes
- Wash manually in clean IPA for 5 minutes
    - 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

- Let dry at 35° C for 25 minutes or at ambient temperature on a mesh wire drying rack in a ventilated area for at least 60 minutes

UV CURE TIME

- Recommended Cure Time is 90 minutes

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

More details can be found in the User Guides and Best Practices Documentation available at https://support.3dsystems.com/

ALSO CERTIFIED TO IEC REQUIREMENTS

We worked with UL Solutions to obtain third-party, science-backed flammability certification for our Figure 4 Tough FR V0 Black in accordance with IEC 60695-11-10, Fire Hazard Testing-Part 11-10: Test Flames-50 W Horizontal and Vertical Flame Test Methods.