

# Tough FR V0 Black

(Matrix FR V0 Black)

## Proven performance in extreme conditions

DLP material 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%. 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.

### 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

### Features

- ▶ 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



**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.

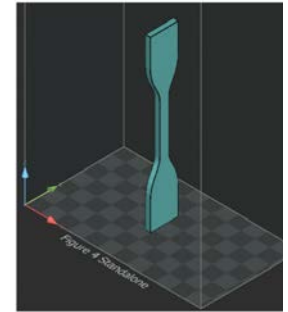
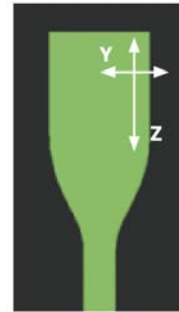
Solid material properties reported were printed along the vertical axis (ZX-orientation). As detailed in the Isotropic Properties section, DLP material properties are relatively uniform across print orientations. Parts do not need to be oriented in a particular direction to exhibit these properties.

LIQUID MATERIAL						
MEASUREMENT	METHOD		METRIC	ENGLISH		
Viscosity	Brookfield viscometer @ 25°C (77°F)		1140 cPs	2758 lb/ft-hr		
Colour			Black			
Liquid Density	Kruss K11 Force Tensiometer @ 25°C (77°F)		1.23 g/cm <sup>3</sup>	0.043 lb/in <sup>3</sup>		
SOLID MATERIAL						
MEASUREMENT	ASTM METHOD	METRIC	ENGLISH	ISO METHOD	METRIC	ENGLISH
PHYSICAL				PHYSICAL		
Solid Density	ASTM D792	1.31 g/cm <sup>3</sup>	0.047 lb/in <sup>3</sup>	ISO 1183	1.31 g/cm <sup>3</sup>	0.047 lb/in <sup>3</sup>
24 hour water absorption	ASTM D570	1.03%	1.03%	ISO 62	1.03%	1.03%
MECHANICAL				MECHANICAL		
Tensile Strength Ultimate	ASTM D638	38 MPa	5500 psi	ISO 527 - 1/2	35 MPa	5100 psi
Tensile Strength at Yield	ASTM D638	35 MPa	5500 psi	ISO 527 - 1/2	35 MPa	5100 psi
Tensile Modulus	ASTM D638	1400 MPa	210 ksi	ISO 527 - 1/2	1500 MPa	220 ksi
Elongation at Break	ASTM D638	44.6%	44.6%	ISO 527 - 1/2	27.4%	27.4%
Elongation at Yield	ASTM D638	5.6%	5.6%	ISO 527 - 1/2	5.3%	5.3%
Flexural Strength	ASTM D790	48 MPa	7000 psi	ISO 178	45 MPa	6500 PSI
Flexural Modulus	ASTM D790	1300 MPa	190 ksi	ISO 178	1400 MPa	209 ksi
Notched Izod Impact	ASTM D256	35 J/m	0.7 ft-lb/in	ISO 180-A	4 kJ/m <sup>2</sup>	0.0018 ft-lb/in <sup>2</sup>
Unnotched Izod Impact	ASTM D4812	770 J/m	15 ft-lb/in	ISO 180-U	70 kJ/m <sup>2</sup>	0.0339 ft-lb/in <sup>2</sup>
Shore Hardness	ASTM D2240	78 D	78 D	ISO 7619	78 D	78 D
THERMAL				THERMAL		
Tg (DMA E'')	ASTM E1640 (E'' at 1C/min)	6°C	42°F	ISO 6721-1/11 (E'' at 1C/min)	6°C	42°F
HDT @ 0.455 MPa (66 PSI)	ASTM D648	66°C	150°F	ISO 75- 1/2 B	58°C	136°F
HDT @ 1.82 MPa (264 PSI)	ASTM D648	51°C	124°F	ISO 76- 1/2 A	46°C	114°F
CTE below Tg	ASTM E831	108 ppm/C	60 ppm/F	ISO 11359-2	108 ppm/K	60 ppm/F
CTE above Tg	ASTM E831	158 ppm/C	88 ppm/F	ISO 11359-2	158 ppm/K	88 ppm/F
UL Flammability	UL94	V0 @ 3mm				
ELECTRICAL				ELECTRICAL		
Dielectric Strength (kV/mm) @ 3.0 mm thickness	ASTM D149	373 V/mil				
Dielectric Constant @ 1 MHz	ASTM D150	3.465				
Dissipation Factor @ 1 MHz	ASTM D150	0.034				
Volume Resistivity (ohm-cm)	ASTM D257	2.26e14				

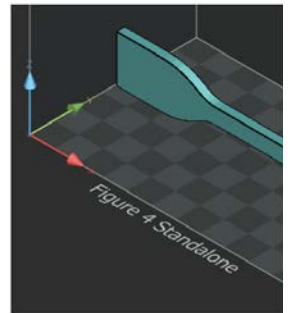
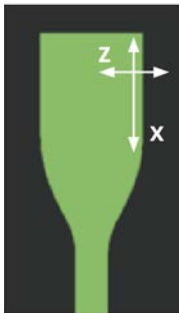
## ISOTROPIC PROPERTIES

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

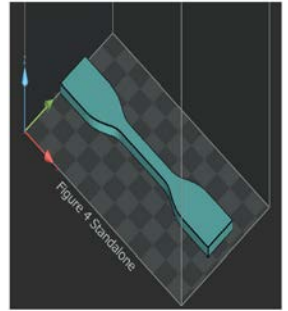
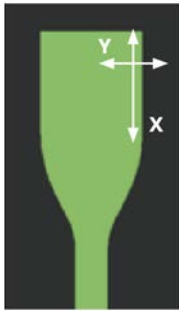
Parts do not need to be oriented to get the highest mechanical properties, further improving the degree of freedom for part orientation for mechanical properties.



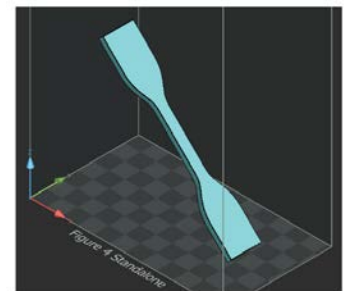
ZY - orientation



XZ - orientation



XY - orientation

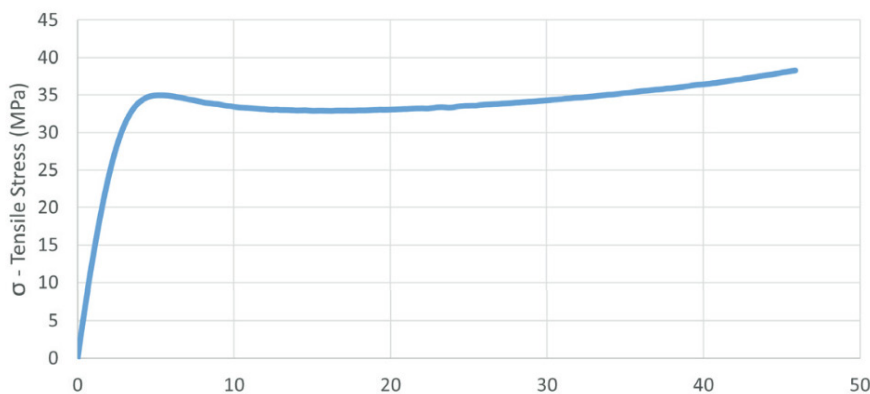


Z45-Degree - orientation

SOLID MATERIAL					
METRIC	METHOD	METRIC			
MECHANICAL					
		ZY	XZ	XY	Z45
Tensile Strength Ultimate	ASTM D638	38 MPa	32 MPa	34 MPa	33 MPa
Tensile Strength at Yield	ASTM D639	35 MPa	32 MPa	34 MPa	31 MPa
Tensile Modulus	ASTM D640	1400 MPa	1300 MPa	1600 MPa	1300 MPa
Elongation at Break	ASTM D641	44.6%	30%	27%	37%
Elongation at Yield	ASTM D642	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 Notched Impact	ASTM D4812	770 J/m	224 J/m	218 J/m	637 J/m
Shore Hardness	ASTM D2240	78 D	76 D	74 D	75 D

## STRESS-STRAIN CURVE

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

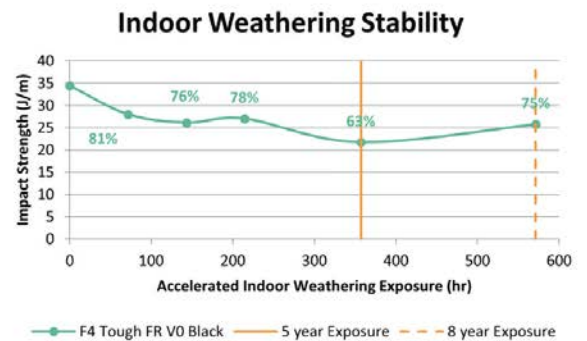
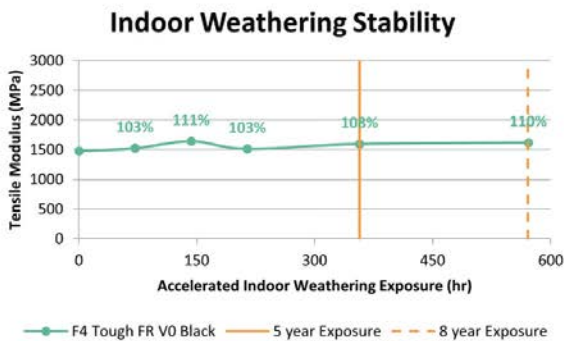
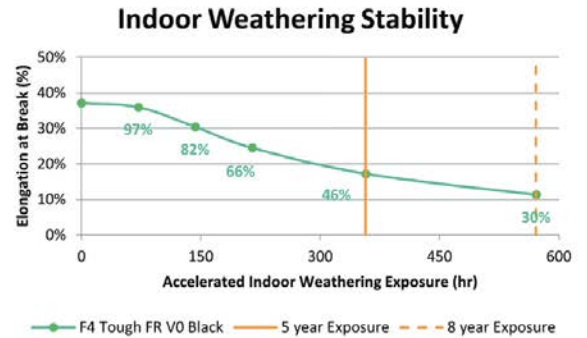
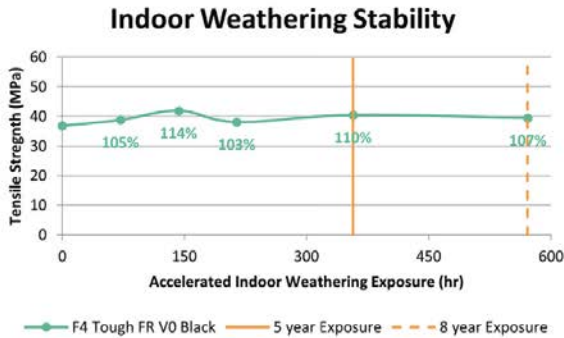


## LONG TERM ENVIRONMENTAL STABILITY

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.**

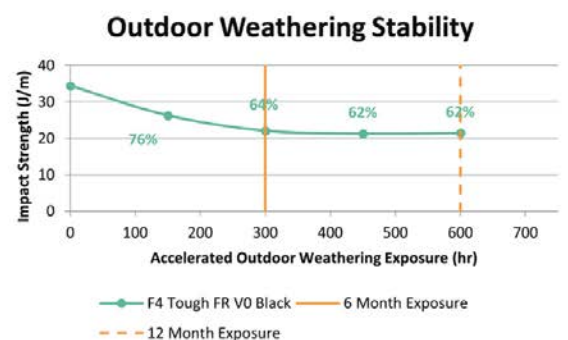
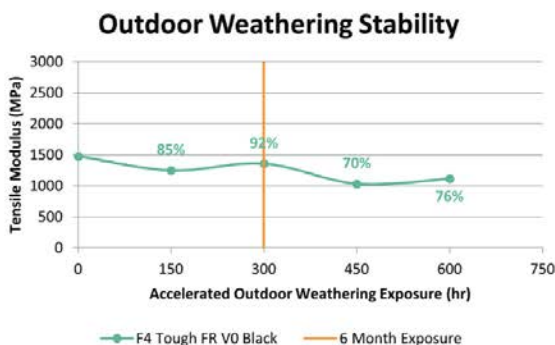
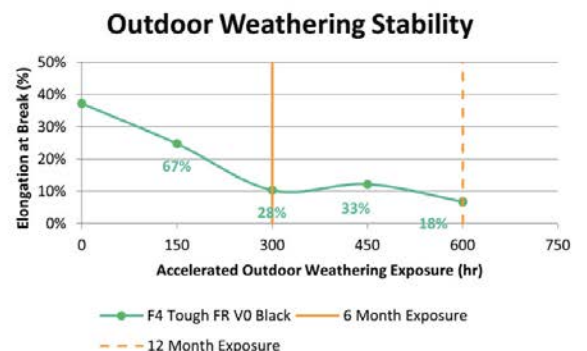
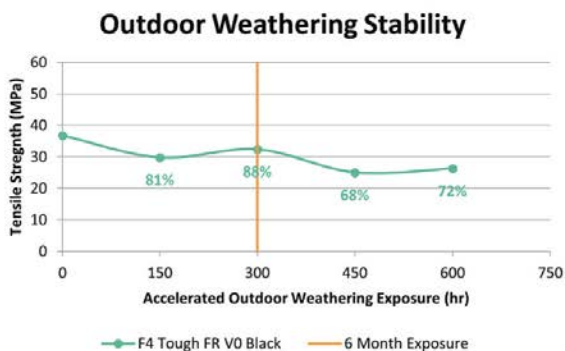
**INDOOR STABILITY:** Tested per ASTM D4329 standard method.

INDOOR STABILITY



**OUTDOOR STABILITY:** Tested per ASTM G154 standard method.

OUTDOOR STABILITY



## AUTOMOTIVE FLUID COMPATIBILITY

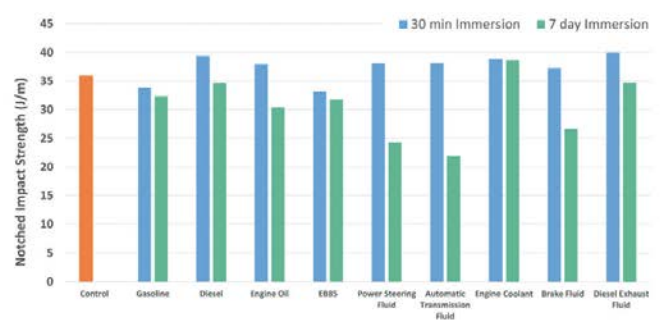
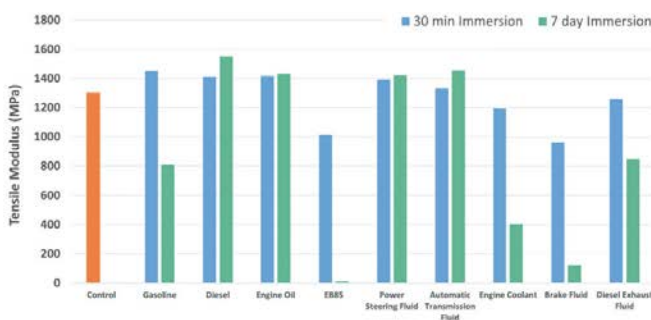
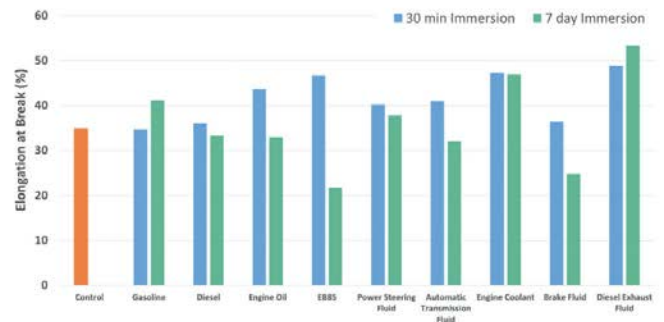
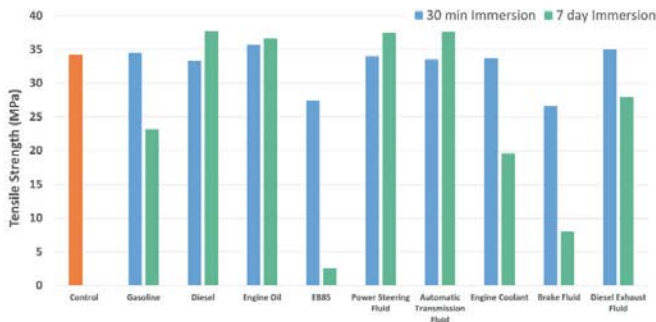
The compatibility of a material with hydrocarbons and cleaning chemicals is critical to part application. Tough FR V0 Black parts were tested for sealed and surface contact compatibility per USCAR2 test conditions. The fluids below were tested in two different ways per the specs.

- 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
Automotive 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

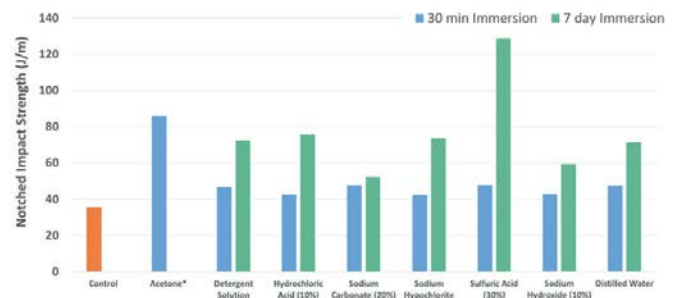
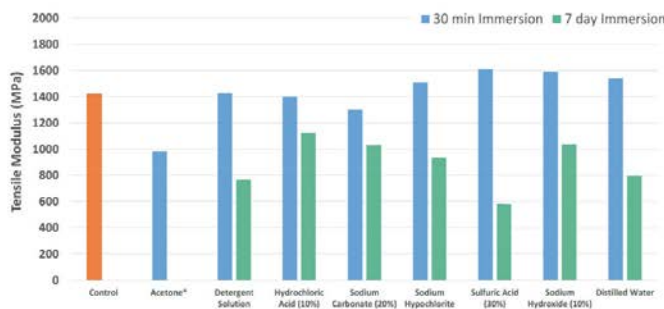
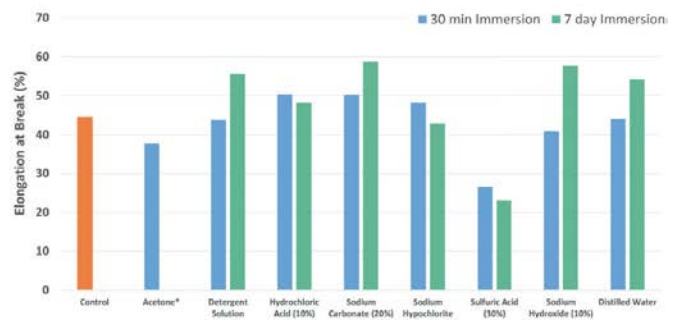
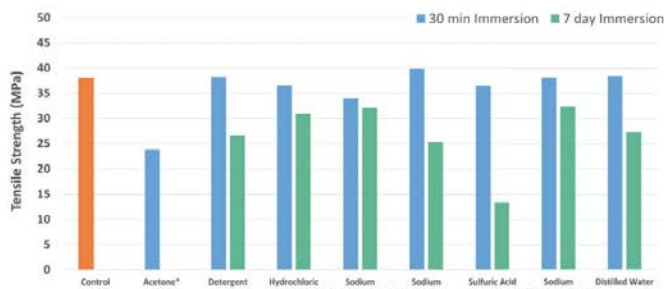
The compatibility of a material with cleaning chemicals is critical to part application. Tough FR V0 Black parts were tested for sealed and surface contact compatibility per ASTM D543 test conditions. The fluids below were tested in two different ways per the specs.

- 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
6.33 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 Hydrochloric Solution
6.3.46 Sulfuric Acid (30%)
6.3.42 Sodium Hydroxide Soln (10%)
6.3.15 Distilled Water



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