



Figure 4® TOUGH-BLK 20

Production Rigid

A strong material with long-term environmental stability for the production of black parts with the look and feel of injection molded ABS

Figure 4

EXCEPTIONAL SURFACE FINISH, DURABILITY AND ENVIRONMENTAL STABILITY FOR HIGH PERFORMANCE PROTOTYPING AND PRODUCTION APPLICATIONS

Figure 4® TOUGH-BLK 20 is a strong black plastic simulating injection molded ABS, with long-term environmental stability for high performance prototyping and production applications where lifecycle stability is critical and mechanical properties fit. It provides high precision, smooth surface finish and exceptional sidewall quality with minimal finishing.

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

- Rapid design iteration
- Strong functional parts for:
 - Automotive styling parts
 - Consumer electronics components
 - Legacy replacement parts
 - Form, fit and function testing
 - Durable assemblies and snap fits
 - Bezels, knobs, brackets, covers, cases
- Master patterns for RTV/silicone molding
- Short-run manufacturing of rigid parts

BENEFITS

- Reliable and robust functional prototypes
- Improved environmental stability of mechanical and performance properties over time
- High precision and exceptional part quality with smooth surfaces and sidewalls
- Beautiful black parts with the look and feel of injection molded ABS

FEATURES

- Long-term indoor and outdoor environmental stability
- Durable and strong
- Excellent humidity/moisture resistance
- Simulating some properties of molded black ABS

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 are given per ASTM and ISO standards where applicable. In addition, properties such as flammability, dielectric properties, and 24 hour water absorption. This allows for better understanding of the material capability to aid in design decisions for the material. All parts are conditioned per ASTM recommended standards for a minimum of 40 hours at 23 °C, 50% RH.

Solid material properties reported were printed along the vertical axis (ZY-orientation). Figure 4 material properties are relatively uniform across print orientations, as detailed in the following section on Isotropic Properties. Because of this, 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) | 2623 cps | 6350 lb/ft-hr | | | |
| Color | | | Black | | | |
| Liquid Density | Kruss K11 Force Tensiometer @ 25 °C (77 °F) | 1.04 g/cm ³ | 0.038 lb/in ³ | | | |
| Default Print Layer Thickness (Standard Mode) | | 0.05 mm | 0.002 in | | | |
| Speed - Standard Mode | | 43 mm/hr | 1.8 in/hr | | | |
| Speed - Draft Mode | | 53 mm/hr | 2.1 in/hr | | | |
| Package Volume | | 1 kg bottle - Figure 4 Standalone 2.5 kg cartridge - Figure 4 Modular 9 kg container - Figure 4 Production | | | | |

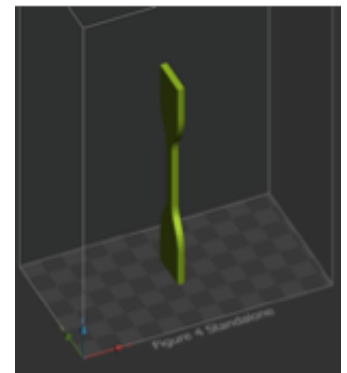
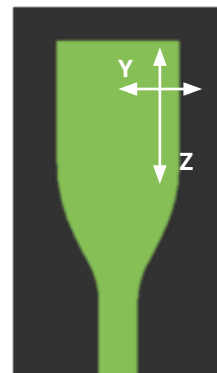
| SOLID MATERIAL | | | | | | |
|--|---------------------------|------------------------|--------------------------|------------------------------|------------------------|------------------------------|
| METRIC | ASTM METHOD | METRIC | ENGLISH | ISO METHOD | METRIC | ENGLISH |
| PHYSICAL | | | | PHYSICAL | | |
| Solid Density | ASTM D792 | 1.11 g/cm ³ | 0.040 lb/in ³ | ISO 1183 | 1.11 g/cm ³ | 0.040 lb/in ³ |
| 24 Hour Water Absorption | ASTM D570 | 0.31% | 0.31% | ISO 62 | 0.31% | 0.31% |
| MECHANICAL | | | | MECHANICAL | | |
| Tensile Strength Ultimate | ASTM D638 * | 40 MPa | 5860 psi | ISO 527 -1/2 | 40 MPa | 5869 psi |
| Tensile Strength at Yield | ASTM D638 | 40 MPa | 5860 psi | ISO 527 -1/2 | 40 MPa | 5869 psi |
| Tensile Modulus | ASTM D638 | 1780 MPa | 260 ksi | ISO 527 -1/2 | 1981 MPa | 287 ksi |
| Elongation at Break | ASTM D638 | 36% | 36% | ISO 527 -1/2 | 25 % | 25 % |
| Elongation at Yield | ASTM D638 | 4.6% | 4.6% | ISO 527 -1/2 | 4.4 % | 4.4 % |
| Flex Strength | ASTM D790 | 61 MPa | 8775 psi | ISO 178 | 64 MPa | 9313 psi |
| Flex Modulus | ASTM D790 | 1650 MPa | 240 ksi | ISO 178 | 2327 MPa | 338 ksi |
| Izod Notched Impact | ASTM D256 | 27 J/m | 0.5 ft-lb/in | ISO 180-A | 2.7 J/m ² | 0.0013 ft-lb/in ² |
| Izod Unnotched Impact | ASTM D4812 | 1008 J/m | 18.9 ft-lb/in | ISO 180-U | | |
| Shore Hardness | ASTM D2240 | 79D | 79D | ISO 7619 | 79D | 79D |
| THERMAL | | | | THERMAL | | |
| Tg (DMA, E'') | ASTM E1640 (E''at 1C/min) | 46 °C | 115 °F | ISO 6721-1/11 (E''at 1C/min) | 46 °C | 115 °F |
| HDT @ 0.455 MPa/66 PSI | ASTM D648 | 55 °C | 131 °F | ISO 75- 1/2 B | 57 °C | 134 °F |
| HDT @ 1.82 MPa/264 PSI | ASTM D648 | 45 °C | 113 °F | ISO 75-1/2 A | 46 °C | 115 °F |
| CTE below Tg | ASTM E831 | 83 ppm/°C | 46 ppm/°F | ISO 11359-2 | 83 ppm/°K | 46 ppm/°F |
| CTE above Tg | ASTM E831 | 173 ppm/°C | 96 ppm/°F | ISO 11359-2 | 173 ppm/°K | 96 ppm/°F |
| ELECTRICAL | | | | ELECTRICAL | | |
| Dielectric Strength (V/mil) @ 3.0 mm thickness | ASTM D149 | | | | | |
| Dielectric Constant @ 1 MHz | ASTM D150 | | | | | |
| Dissipation Factor @ 1 MHz | ASTM D150 | | | | | |
| Volume Resistivity (ohm-cm) | ASTM D257 | | | | | |

Figure 4 TOUGH-BLK 20

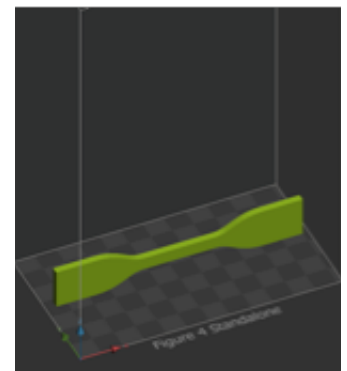
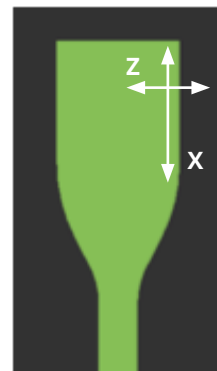
ISOTROPIC PROPERTIES

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

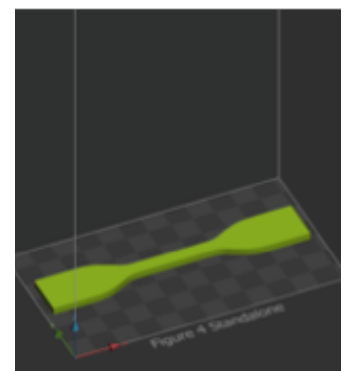
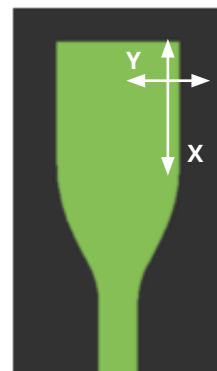
Parts do not need to be oriented to get the highest mechanical properties, further improving the degree of freedom for part orientation for mechanical properties.



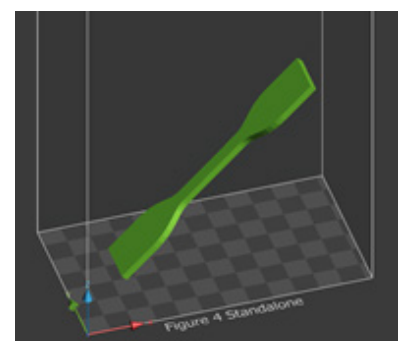
YZ - orientation



XZ - orientation



XY - orientation



Z45-Degree - orientation

| SOLID MATERIAL | | | | | |
|---------------------------|------------|----------|----------|----------|----------|
| METRIC | METHOD | METRIC | | | |
| MECHANICAL | | | | | |
| | | ZY | XZ | XY | Z45 |
| Tensile Strength Ultimate | ASTM D638 | 40 MPa | 42 MPa | 43 MPa | 42 MPa |
| Tensile Strength at Yield | ASTM D639 | 40 MPa | 42 MPa | 43 MPa | 42 MPa |
| Tensile Modulus | ASTM D640 | 1780 MPa | 1625 MPa | 1634 MPa | 1919 MPa |
| Elongation at Break | ASTM D641 | 36% | 27% | 31% | 20% |
| Elongation at Yield | ASTM D642 | 4.6% | 5% | 5.6% | 4.3% |
| Flex Strength | ASTM D790 | 61 MPa | 71 MPa | 62.2 MPa | 65 MPa |
| Flex Modulus | ASTM D790 | 1650 MPa | 2029 MPa | 1599 MPa | 1796 MPa |
| Izod Notched Impact | ASTM D256 | 27 J/m | 35 J/m | 34 J/m | 32 J/m |
| Shore Hardness | ASTM D2240 | 79D | 79D | 72D | 78D |

Figure 4 TOUGH-BLK 20

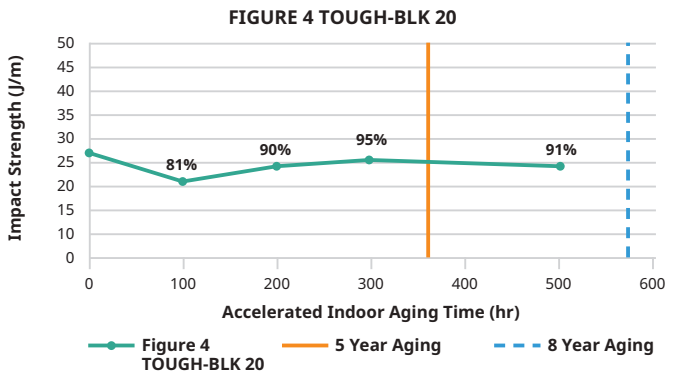
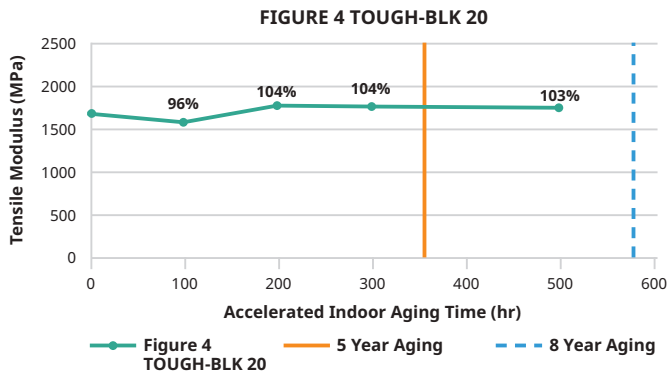
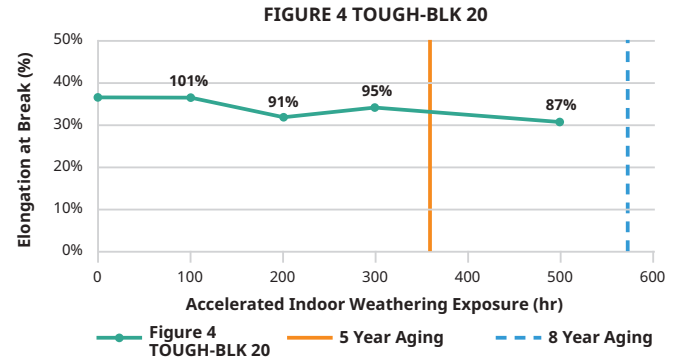
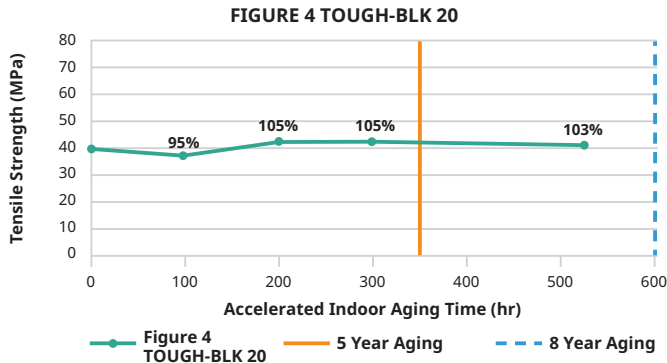


LONG TERM ENVIRONMENTAL STABILITY

Figure 4 TOUGH-BLK 20 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.**

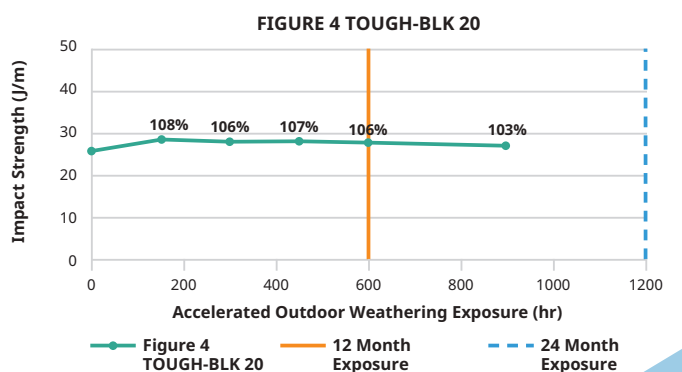
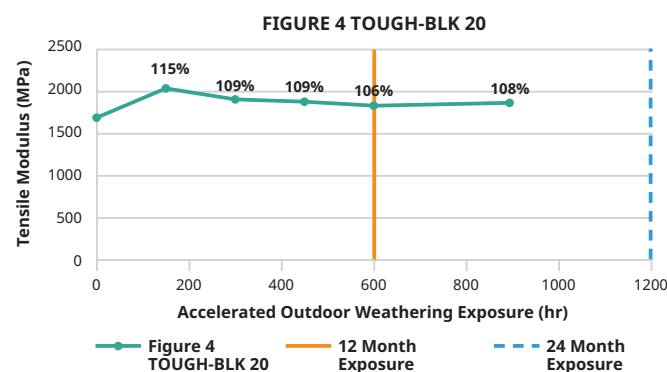
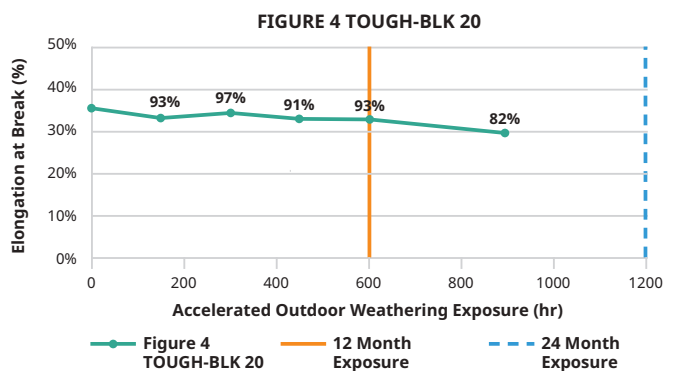
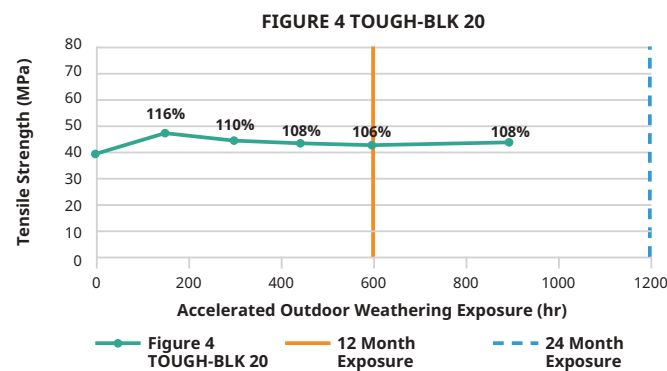
INDOOR STABILITY: Tested per ASTM D4329 standard method.

INDOOR STABILITY



OUTDOOR STABILITY: Tested per ASTM G154 standard method.

OUTDOOR STABILITY



AUTOMOTIVE FLUID COMPATIBILITY

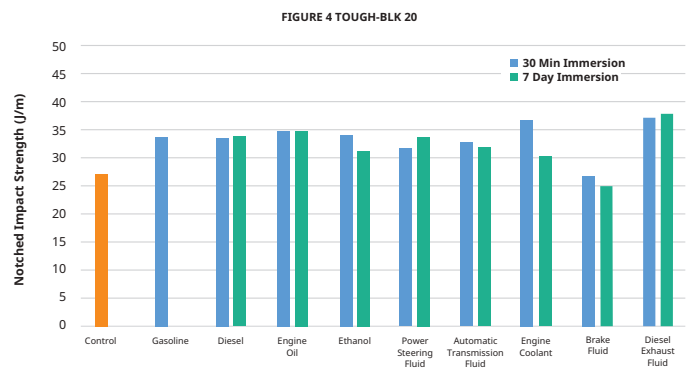
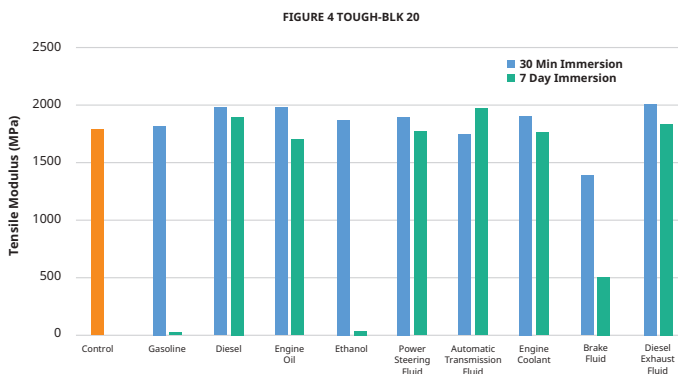
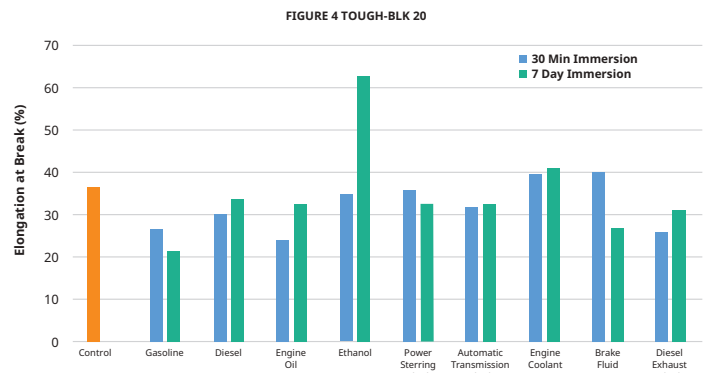
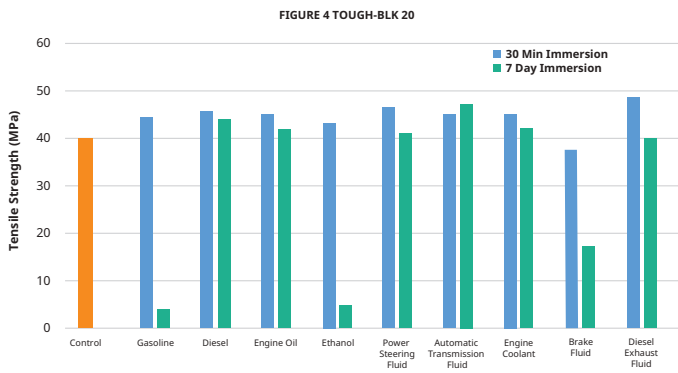
The compatibility of a material with hydrocarbons and cleaning chemicals is critical to part application. Figure 4 TOUGH-BLK 20 parts were tested for sealed and surface contact compatibility per USCAR2 test conditions. The fluids below were tested in two different ways per the specs.

- 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. Figure 4 TOUGH-BLK 20 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%) |
| Distilled Water |

FIGURE 4 TOUGH-BLK 20

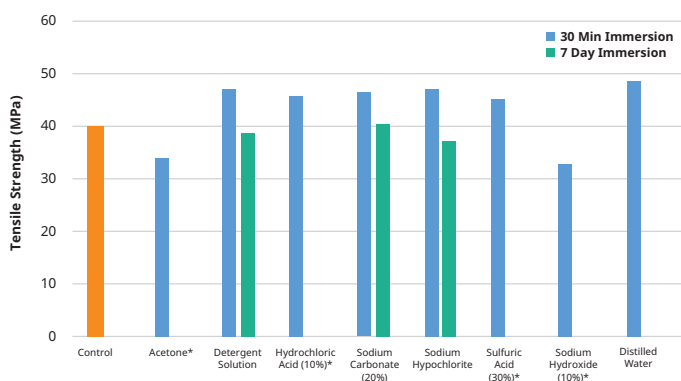


FIGURE 4 TOUGH-BLK 20

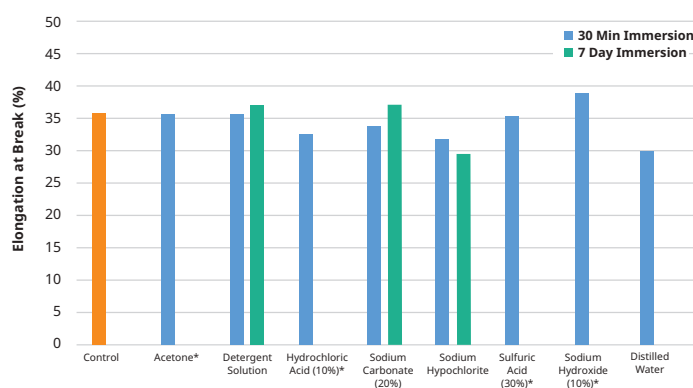


FIGURE 4 TOUGH-BLK 20

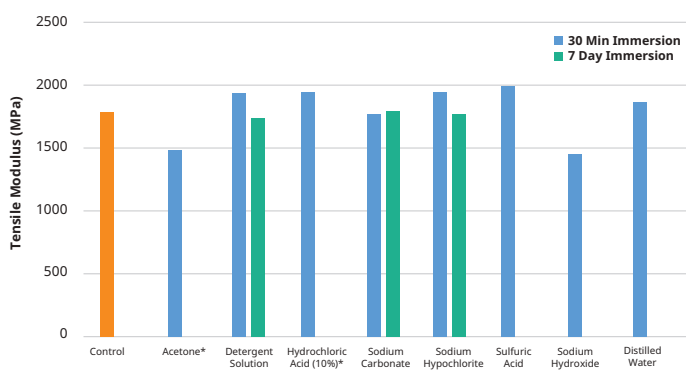
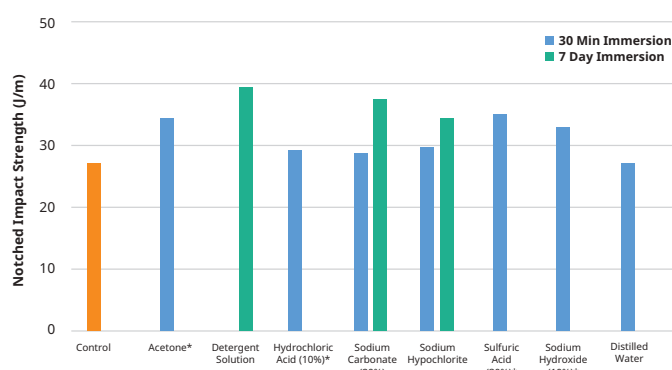


FIGURE 4 TOUGH-BLK 20



POST-PROCESSING INSTRUCTIONS

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 IPA (wash and rinse)
- Clean in 'wash' IPA for 5 minutes while agitating part
- Rinse in 'clean' 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

- Ambient air dry > 1 hour before post cure

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>

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

