



# Figure 4<sup>®</sup> PRO-BLK 10

## Production Rigid

Production-grade additive manufacturing material with game-changing thermoplastic-like mechanical properties and long-term environmental stability

Figure 4

### VERSATILE RIGID HEAT-RESISTANT MATERIAL COMBINES SPEED, STRENGTH, EXCELLENT MECHANICAL PROPERTIES FOR TOOL-LESS, DIRECT PRODUCTION OF PLASTIC PARTS

Figure 4<sup>®</sup> PRO-BLK 10 delivers on the promise of additive manufacturing with true direct digital production of plastic parts. Go from CAD to manufacturing line in one day with tool-less, same day part production. With a fast print speed and simplified post-processing that includes a single curing cycle and single solvent cleaning, this material delivers exceptional throughput. It is a high precision resin producing parts with a smooth surface finish and sidewall quality, and has excellent mechanical properties and long-term environmental stability that brings a new level of assurance to 3D production.

### 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>

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

### APPLICATIONS

- Tool-less, same day production
- Direct production of small black plastic parts; examples include: motor housings, connectors, snap-fits, automotive interior and other general-use parts
- Digital production to replace injection molding or soft tooling processes

### BENEFITS

- Improved environmental stability of mechanical and performance properties over time
- Fast throughput for part-in-hand with no secondary thermal cure required
- Simple, single solvent cleaning
- Excellent surface quality and repeatability
- Accurate, low distortion material for fast first article print success

### FEATURES

- Fast print speed up to 62 mm/hr at 50 micron layer thickness
- 70 °C heat deflection temperature, 12% elongation at break
- Durability and strength
- UL94 HB flammability
- Biocompatible capable per ISO10993-5 and ISO10993-10
- Exhibits thermoplastic behavior in necking at tensile break point

## Figure 4 PRO-BLK 10

### 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)       | 293 cps  |                          | 709 lb/ft-hr                 |                        |                              |
| Color  |   | Black  |                          |                              |                        |                              |
| Liquid Density                                 | Kruss K11 Force Tensiometer @ 25 °C (77 °F) | 1.07 g/cm <sup>3</sup>   |                          | 0.039 lb/in <sup>3</sup>     |                        |                              |
| Default Print Layer Thickness (Standard Mode)  |   | 0.05 mm  |                          | 0.002 in                     |                        |                              |
| Speed - Standard Mode                          |   | 62 mm/hr   |                          | 2.4 in/hr                    |                        |                              |
| Speed - Draft Mode                             |   | 81 mm/hr   |                          | 3.2 in/hr                    |                        |                              |
| Package Volume                                 |   | 1 kg bottle - Figure 4 Standalone<br>2.5 kg cartridge - Figure 4 Modular<br>9 kg container - Figure 4 Production |                          |                              |                        |                              |
| SOLID MATERIAL                                 |   |  |                          |                              |                        |                              |
| METRIC   | ASTM METHOD                                 | METRIC   | ENGLISH                  | ISO METHOD                   | METRIC                 | ENGLISH                      |
| PHYSICAL                                       |   |  |                          | PHYSICAL                     |                        |                              |
| Solid Density                                  | ASTM D792                                   | 1.16 g/cm <sup>3</sup>   | 0.042 lb/in <sup>3</sup> | ISO 1183                     | 1.16 g/cm <sup>3</sup> | 0.042 lb/in <sup>3</sup>     |
| 24 Hour Water Absorption                       | ASTM D570                                   | 1.16%  | 1.16%                    | ISO 62                       | 1.16%                  | 1.16%                        |
| MECHANICAL                                     |   |  |                          | MECHANICAL                   |                        |                              |
| Tensile Strength Ultimate                      | ASTM D638 *                                 | 63 MPa   | 9140 psi                 | ISO 527 -1/2                 | 58 MPa                 | 8348 psi                     |
| Tensile Strength at Yield                      | ASTM D638                                   | 63 MPa   | 9140 psi                 | ISO 527 -1/2                 | 58 MPa                 | 8348 psi                     |
| Tensile Modulus                                | ASTM D638                                   | 2320 MPa   | 336 ksi                  | ISO 527 -1/2                 | 2275 MPa               | 330 ksi                      |
| Elongation at Break                            | ASTM D638                                   | 12%  | 12%                      | ISO 527 -1/2                 | 15 %                   | 15 %                         |
| Elongation at Yield                            | ASTM D638                                   | 4.7%   | 4.7%                     | ISO 527 -1/2                 | 4.3 %                  | 4.3 %                        |
| Flex Strength                                  | ASTM D790                                   | 92 MPa   | 13340 psi                | ISO 178                      | 89 MPa                 | 12940 psi                    |
| Flex Modulus                                   | ASTM D790                                   | 2290 MPa   | 332 ksi                  | ISO 178                      | 2783 MPa               | 404 ksi                      |
| Izod Notched Impact                            | ASTM D256                                   | 24 J/m   | 0.5 ft-lb/in             | ISO 180-A                    | 2 J/m <sup>2</sup>     | 0.0009 ft-lb/in <sup>2</sup> |
| Izod Unnotched Impact                          | ASTM D4812                                  | 614 J/m  | 11.5 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)                   | 62 °C  | 144 °F                   | ISO 6721-1/11 (E''at 1C/min) | 62 °C                  | 144 °F                       |
| HDT @ 0.455 MPa/66 PSI                         | ASTM D648                                   | 70 °C  | 158 °F                   | ISO 75- 1/2 B                | 67 °C                  | 153 °F                       |
| HDT @ 1.82 MPa/264 PSI                         | ASTM D648                                   | 56 °C  | 133 °F                   | ISO 75-1/2 A                 | 55 °C                  | 132 °F                       |
| CTE below Tg                                   | ASTM E831                                   | 71 ppm/°C  | 39 ppm/°F                | ISO 11359-2                  | 71 ppm/°C              | 39 ppm/°F                    |
| CTE above Tg                                   | ASTM E831                                   | 188 ppm/°C   | 104 ppm/°F               | ISO 11359-2                  | 188 ppm/°C             | 104 ppm/°F                   |
| UL Flammability                                | UL94  | HB   | HB                       |                              |                        |                              |
| ELECTRICAL                                     |   |  |                          | ELECTRICAL                   |                        |                              |
| Dielectric Strength (V/mil) @ 3.0 mm thickness | ASTM D149                                   | 19.3   |                          |                              |                        |                              |
| Dielectric Constant @ 1 MHz                    | ASTM D150                                   | 3.17   |                          |                              |                        |                              |
| Dissipation Factor @ 1 MHz                     | ASTM D150                                   | 0.012  |                          |                              |                        |                              |
| Volume Resistivity (ohm-cm)                    | ASTM D257                                   | 2.6x10 <sup>15</sup>   |                          |                              |                        |                              |

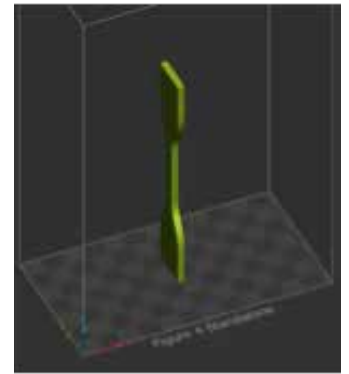
# Figure 4 PRO-BLK 10

## ISOTROPIC PROPERTIES

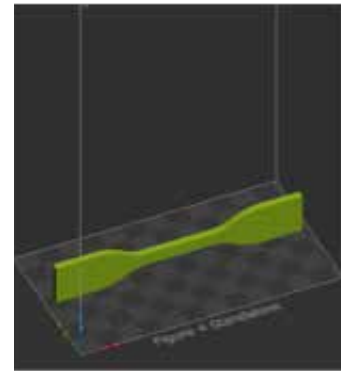
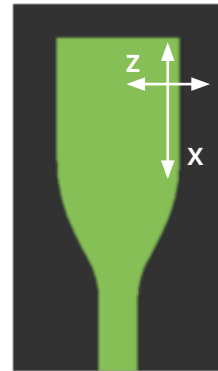
Figure 4 technology prints parts that are isotropic in mechanical properties meaning the parts printed along either the XYZ axis will give similar results.

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.

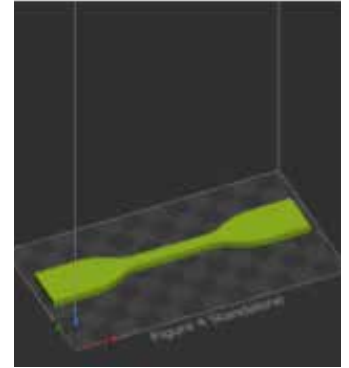
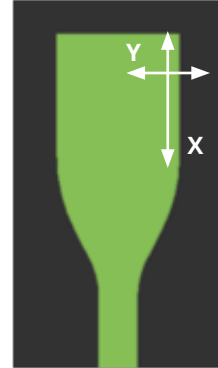
| SOLID MATERIAL            |            |          |          |          |          |
|---------------------------|------------|----------|----------|----------|----------|
| METRIC                    | METHOD     | METRIC   |          |          |          |
| MECHANICAL                |            |          |          |          |          |
|                           |            | ZY       | XZ       | XY       | Z45      |
| Tensile Strength Ultimate | ASTM D638  | 63 MPa   | 56 MPa   | 60 MPa   | 57 MPa   |
| Tensile Strength at Yield | ASTM D639  | 63 MPa   | 56 MPa   | 60 MPa   | 57 MPa   |
| Tensile Modulus           | ASTM D640  | 2320 MPa | 2315 MPa | 2330 MPa | 2300 MPa |
| Elongation at Break       | ASTM D641  | 12%      | 12%      | 13%      | 11%      |
| Elongation at Yield       | ASTM D642  | 4.7%     | 4.7%     | 4.7%     | 4.4%     |
| Flex Strength             | ASTM D790  | 92 MPa   | 91 MPa   | 90 MPa   | 85 MPa   |
| Flex Modulus              | ASTM D790  | 2320 MPa | 2280 MPa | 2742 MPa | 2339 MPa |
| Izod Notched Impact       | ASTM D256  | 24 J/m   | 22 J/m   | 23 J/m   | 23 J/m   |
| Shore Hardness            | ASTM D2240 | 79D      | 80D      | 79D      | 80D      |



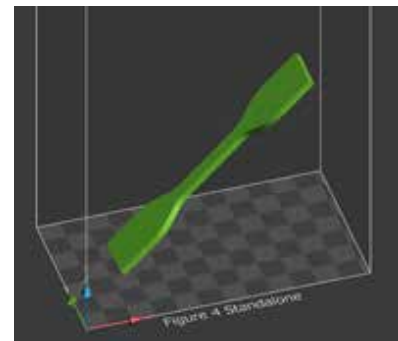
YZ - orientation



XZ - orientation



XY - orientation



Z45-Degree - orientation

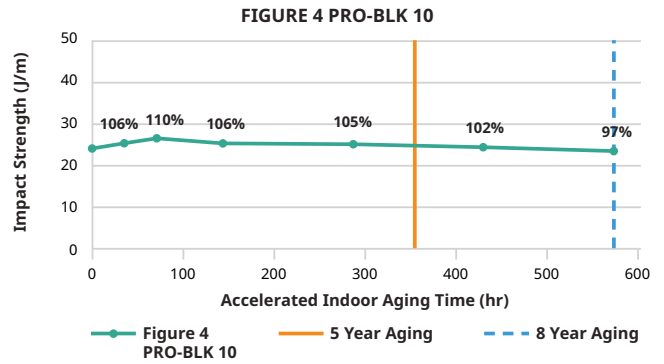
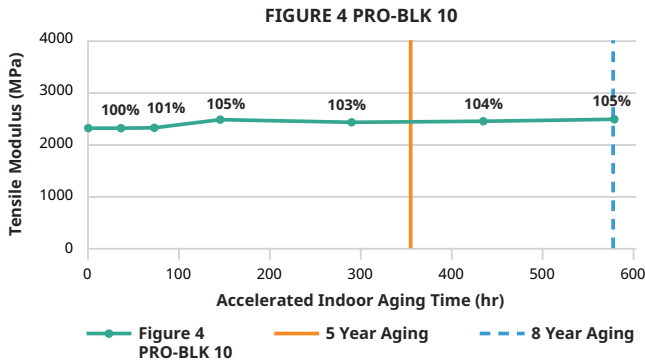
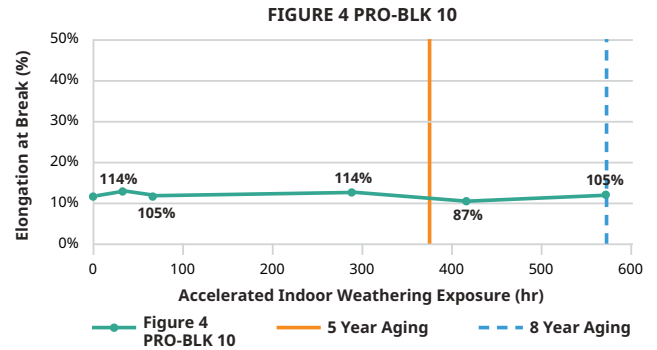
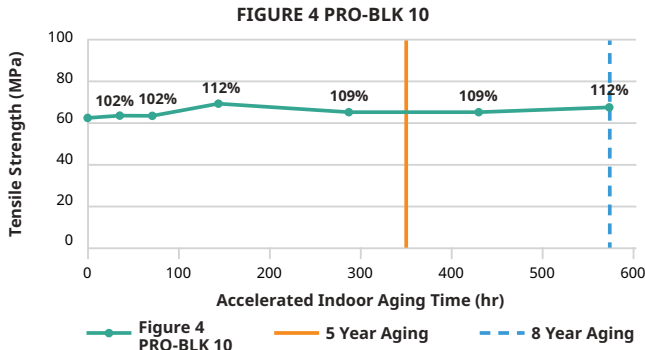
# Figure 4 PRO-BLK 10

## LONG TERM ENVIRONMENTAL STABILITY

Figure 4 PRO-BLK 10 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.**

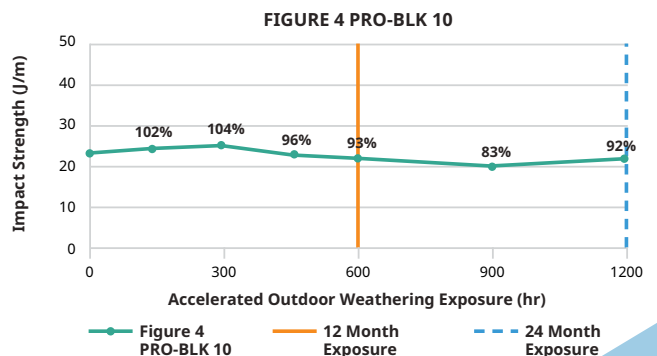
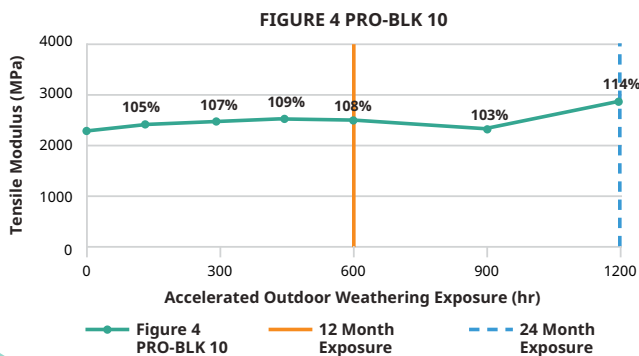
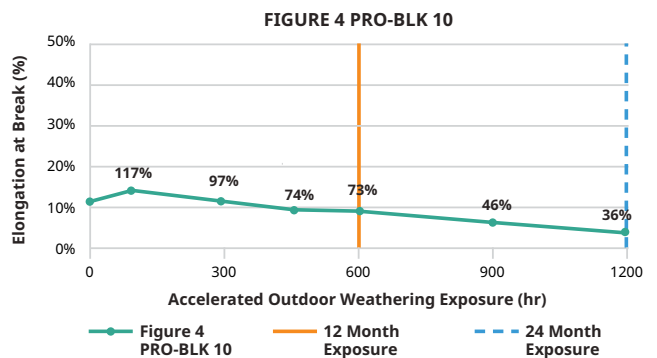
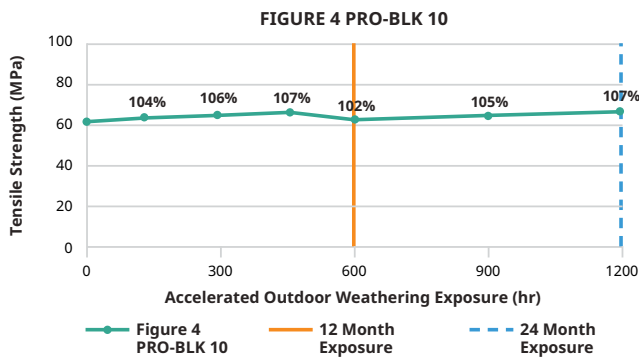
**INDOOR STABILITY:** Tested per ASTM D4329 standard method.

INDOOR STABILITY



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

OUTDOOR STABILITY



# Figure 4 PRO-BLK 10

## AUTOMOTIVE FLUID COMPATIBILITY

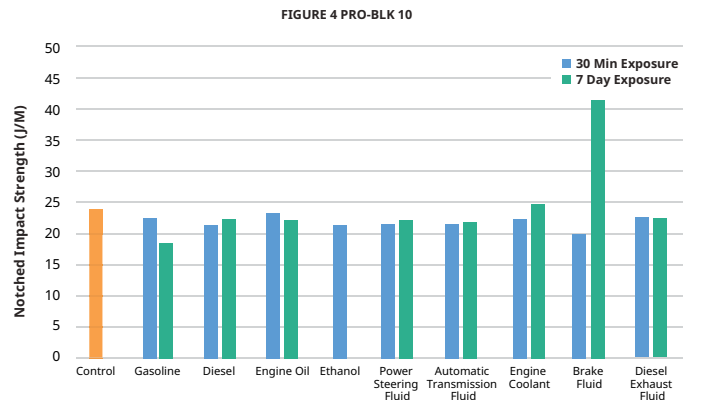
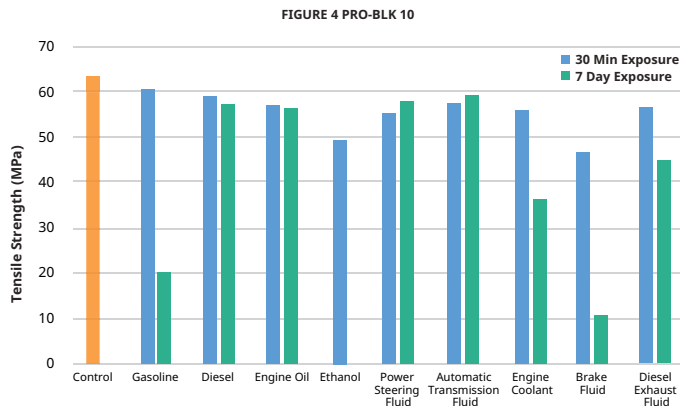
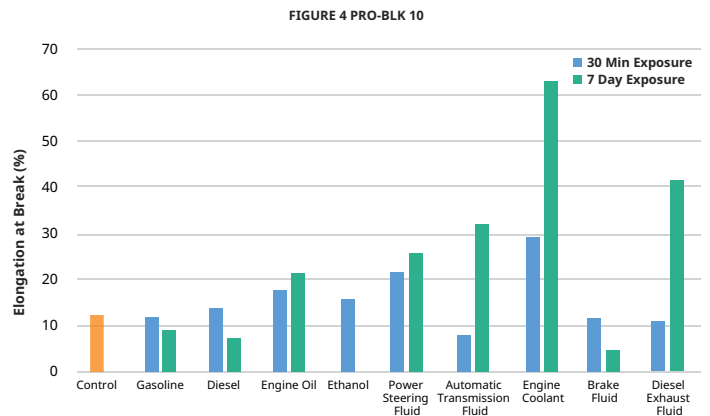
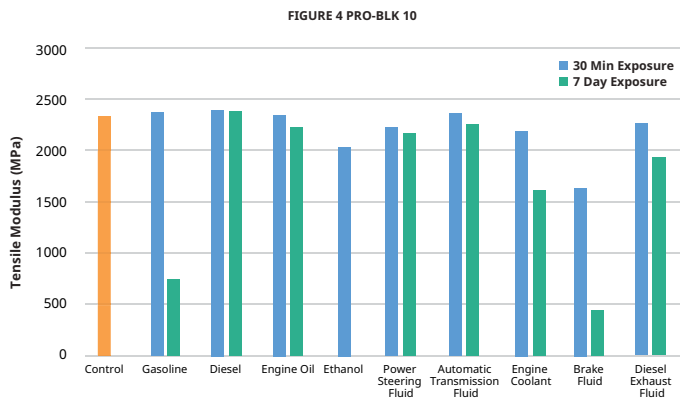
The compatibility of a material with hydrocarbons and cleaning chemicals is critical to part application. Figure 4 PRO-BLK 10 parts were tested for sealed and surface contact compatibility per USCAR2 test conditions. The fluids below were tested in two different ways per the specs.

- 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

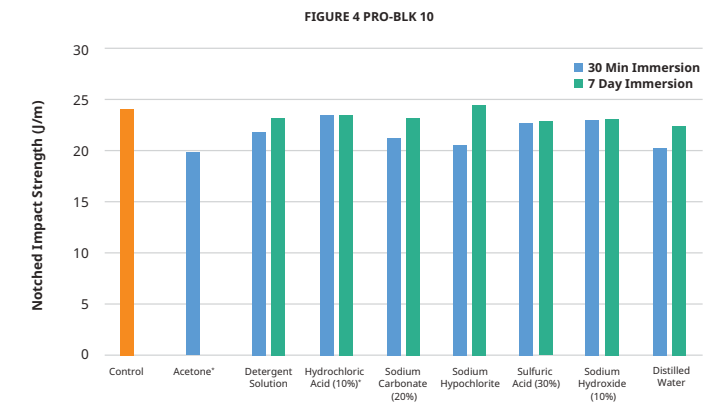
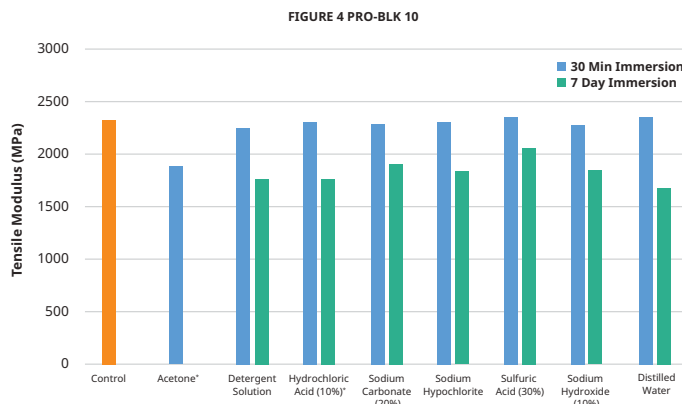
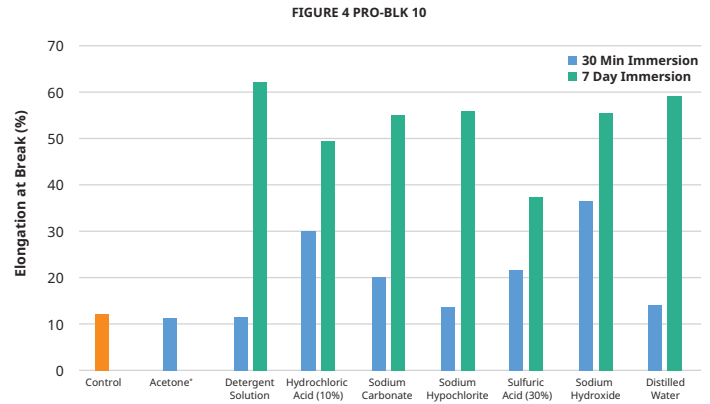
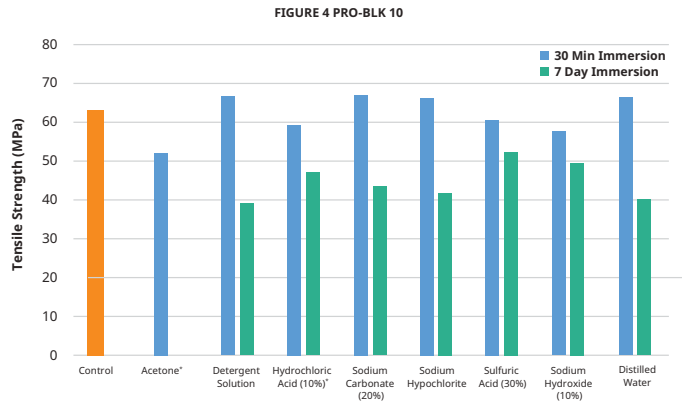
The compatibility of a material with cleaning chemicals is critical to part application. Figure 4 PRO-BLK 10 parts were tested for sealed and surface contact compatibility per ASTM D543 test conditions. The fluids below were tested in two different ways per the specs.

- 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                        |



### BIOCOMPATIBILITY STATEMENT

Figure 4® PRO-BLK 10 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*, and *ISO 10993-10, Biological evaluation of medical devices - Part 10: Tests for irritation and skin sensitization (GPMT)*. The test results indicate that Figure 4® PRO-BLK 10 has passed the requirements for biocompatibility according to the above tests.

It is the responsibility of each customer to determine that its use of Figure 4® PRO-BLK 10 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.

### POST-PROCESSING INSTRUCTIONS REQUIRED TO PASS ISO 10993-5 AND ISO 10993-10

#### 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>

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

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

