formlabs

ENGINEERING RESIN

# Tough 1500 Resin V2

Stiff but compliant material with toughness that rivals polypropylene

**Prototypes requiring the toughness, compliance and resilience of polypropylene.**

**Impact resistant jigs and fixtures that survive long term use on the factory floor.**

**Tough and rugged enclosures with functional elements like self-tapping screw bosses and snap fits.**

**Parts that need a combination of stiffness and ductility to create compliant mechanisms like latches, flexures, and dampers.**

V2 **FLTO1502**

Prepared 18/03/2025

Rev. 03 22/04/2025

Tough 1500 Resin V2 is a resilient material with strength, stiffness, and toughness comparable to polypropylene (PP), offering exceptional resistance to fractures, impacts, and shattering.

Create parts that balance stiffness and ductility, whether for compliant mechanisms like rugged enclosures with self-tapping screws and snap fits. Tough 1500 Resin V2 enables a wide range of applications, from functional prototypes to end-use jigs and fixtures.

Tough 1500 Resin V2 is a new material formulation that leverages the Form 4 Series to deliver 10 times higher fracture toughness than the previous version.

| **Material Properties** | METRIC [1] | | IMPERIAL [1] | | METHOD |
|---|---|---|---|---|---|
| | **Green [2]** | **Post-Cured [3]** | **Green [2]** | **Post-Cured [3]** | |
| **Tensile Properties** | METRIC [1] | | IMPERIAL [1] | | METHOD |
| Ultimate Tensile Strength | 30 MPa | 34 MPa | 4350 psi | 4930 psi | ASTM D638-14 |
| Tensile Modulus | 1250 MPa | 1460 MPa | 181 ksi | 212 ksi | ASTM D638-14 |
| Tensile Strength at Yield | 30 MPa | 34 MPa | 4350 psi | 4930 psi | ASTM D638-14 |
| Elongation at Yield | 5.6% | 6.1% | 5.6% | 6.1 % | ASTM D638-14 |
| Elongation at Break | 210% | 155% | 210% | 155% | ASTM D638-14 |
| **Flexural Properties** | METRIC [1] | | IMPERIAL [1] | | METHOD |
| Flexural Strength | 26 MPa | 41 MPa | 3770 psi | 5950 psi | ASTM D790-17 |
| Flexural Modulus | 900 MPa | 1370 MPa | 130 ksi | 199 ksi | ASTM D790-17 |
| **Toughness Properties** | METRIC [1] | | IMPERIAL [1] | | METHOD |
| Notched Izod | 45 J/m | 42 J/m | 0.84 ft-lb/in | 0.79 ft-lb/in | ASTM D256-10 |
| Unnotched Izod | 1080 J/m | 910 J/m | 20.2 ft-lb/in | 17.0 ft-lb/in | ASTM D4812-11 |
| Notched Charpy | 8.9 $kJ/m^2$ | 7.5 $kJ/m^2$ | 4.2 $ft\text{-}lb/in^2$ | 3.6 $ft\text{-}lb/in^2$ | ISO 179-1 |
| Unnotched Charpy | 63 $kJ/m^2$ | 57 $kJ/m^2$ | 30 $ft\text{-}lb/in^2$ | 27 $ft\text{-}lb/in^2$ | ISO 179-1 |
| Gardner Impact Strength at 1/32" (0.79 mm) thickness | 7.0 J | 5.9 J | 62 in-lb | 52 in-lb | ASTM D5420-21 |
| Gardner Impact Strength at 1/16" (1.6 mm) thickness | 12.4 J | 11.1 J | 110 in-lb | 98 in-lb | ASTM D5420-21 |
| Ross Flex Fatigue at 23°C | 11000 cycles | 8000 cycles | 11000 cycles | 8000 cycles | Internal (23°C, 60 Degree deflection at 1 hz) |
| **Fracture Properties** | METRIC [1] | | IMPERIAL [1] | | METHOD |
| Maximum Stress Intensity Factor (Kmax) | 1.7 $MPa \cdot m^{1/2}$ | 1.7 $MPa \cdot m^{1/2}$ | 1550 $psi \cdot in^{1/2}$ | 1550 $psi \cdot in^{1/2}$ | ASTM D5045-14 |
| Work of Fracture ($W_f$) | 1090 $J/m^2$ | 1011 $J/m^2$ | 74.7 $ft\text{-}lb/ft^2$ | 69.3 $ft\text{-}lb/ft^2$ | ASTM D5045-14 |

[1] Material properties can vary with part geometry, print orientation, print settings, and temperature.

[2] Data was obtained from green parts, printed using Form 4, 100 µm, Tough 1500 V2 settings, without additional treatments.

[3] Data for post-cured samples were measured on Type I tensile bars printed on a Form 4 printer with 100 µm Tough 1500 Resin V2 settings, washed in a Form Wash for 10 minutes in ≥99% Isopropyl Alcohol, and post-cured at 70°C for 12 minutes in a Form Cure (2nd generation).

| Material Properties | METRIC [1] | | IMPERIAL [1] | | METHOD |
|---|---|---|---|---|---|
| | Green [2] | Post-Cured [3] | Green [2] | Post-Cured [3] | |
| **Thermal Properties** | METRIC [1] | | IMPERIAL [1] | | METHOD |
| Heat Deflection Temp. @ 1.8 MPa | 42 °C | 53 °C | 107 °F | 127 °F | ASTM D648-16 |
| Heat Deflection Temp. @ 0.45 MPa | 54 °C | 66 °C | 129 °F | 151 °F | ASTM D648-16 |
| Thermal Expansion (0-150 °C) | 116 µm/m/°C | 99 µm/m/°C | 64 µin/in/°F | 55 µin/in/°F | ASTM E 831-19 |
| Flammability | Not Tested | HB | Not Tested | HB | UL 94 |
| **Electric Properties** | METRIC [1] | | | | METHOD |
| | Green [2] | | Post-Cured [3] | | |
| Dielectric Strength | Not Tested | | 23.4 kV/mm | | ASTM D149-20 |
| Dielectric Constant (50 Hz) | Not Tested | | 4.5 | | ASTM D150 (50 Hz) |
| Dielectric Constant (1 kHz) | Not Tested | | 3.9 | | ASTM D150 (1 kHz) |
| Dissipation Factor (50 Hz) | Not Tested | | 0.018 | | ASTM D150 (50 Hz) |
| Dissipation Factor (1 kHz) | Not Tested | | 0.013 | | ASTM D150 (1 kHz) |
| Volume Resistivity | Not Tested | | $2.91 * 10^{15}$ Ω · cm | | ASTM D257-14 |
| **Other Properties** | METRIC [1] | | | | METHOD |
| Shore D Hardness | 70D | | 76D | | ASTM D2240 |
| Bulk Density | 1.12 g/mL | | | | ASTM D792-20 |
| Viscosity at 25 °C | 1000 cP | | | | ASTM D792-20 |
| Liquid Density | 1.02 g/mL | | | | ASTM D792-20 |

[1] Material properties can vary with part geometry, print orientation, print settings, and temperature.

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[3] Data for post-cured samples were measured on Type I tensile bars printed on a Form 4 printer with 100 µm Tough 1500 Resin V2 settings, washed in a Form Wash for 10 minutes in ≥99% Isopropyl Alcohol, and post-cured at 70°C for 12 minutes in a Form Cure (2nd generation).

## CHEMICAL COMPATIBILITY

Percent weight gain over 24 hours for a printed 1 x 1 x 1 cm cube immersed in respective solvent:

| Solvent | 24 hr weight gain, % | Solvent | 24 hr weight gain, % |
|---|---|---|---|
| Acetic Acid (5%) | 0.5 | Mineral Oil (Heavy) | 0.3 |
| Acetone | 37.3 | Mineral Oil (Light) | 0.3 |
| Bleach (5% NaOCl) | 0.4 | Salt water (3.5% NaCl) | 0.9 |
| Butyl Acetate | 4.5 | Skydrol 5 | 6.9 |
| Diesel | 6.9 | Sodium Hydroxide Solution (0.025% pH = 10) | 0.6 |
| Diethyl Glycol Monomethyl Ether | 6.2 | Strong Acid (HCl Conc) | 0.4 |
| Hydraulic Oil | 0.3 | TPM | 0.9 |
| Hydrogen Peroxide (3%) | 0.6 | Water | 0.8 |
| Isooctane | 3.4 | Xylene | 4.1 |
| Isopropyl Alcohol | 15.6 | | |

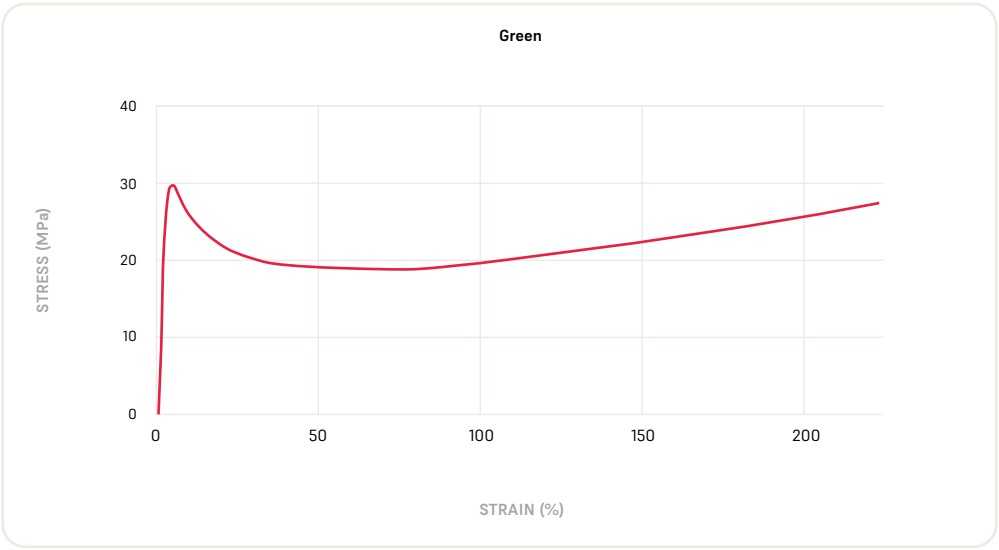
## Chemical Compatibility (ASTM D543)

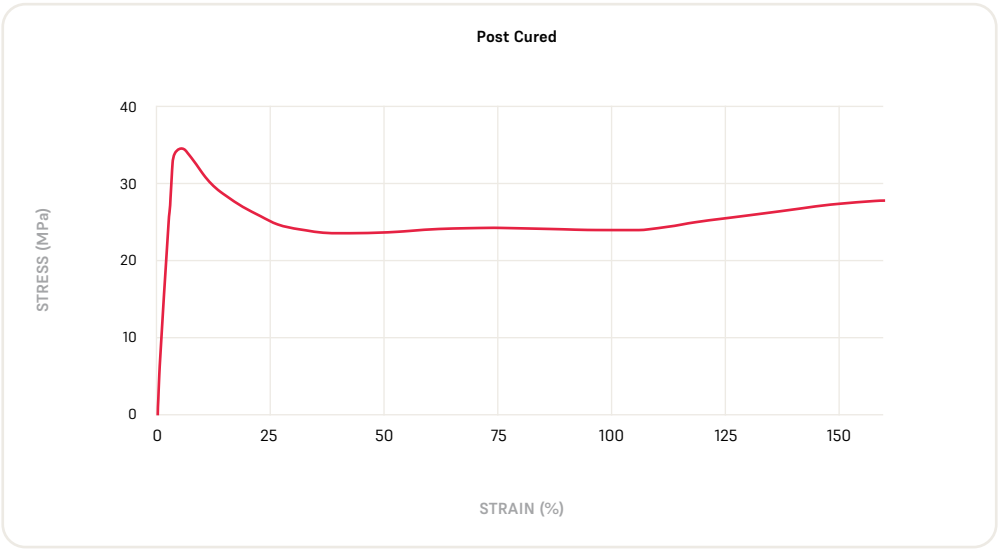
Tough 1500 Resin V2 was tested for chemical compatibility according to ASTM D543. The influence of various chemicals was tested by measuring flexural modulus and strength after different exposure times. Exposed samples were stored in containers and fully immersed in the test chemicals for 1 day and 1 week. After removal, exposed samples were washed and conditioned for 24 hours at 22°C before mechanical testing. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C). Results are reported as a % difference from the measured values of non-exposed samples.

| Chemical | Exposure Time | Relative Change in Flexural Modulus (%) | Relative Change in Flexural Strength (%) | Relative Change in Mass (%) |
|---|---|---|---|---|
| Isopropanol | 1 day | -41% | -47% | 8.7% |
| | 1 week | -69% | -77% | 23.6% |
| Acetone | 1 day | -51% | -59% | 42.0% |
| | 1 week | -46% | -54% | 42.0% |
| NaOH (10%) | 1 day | 0% | -1% | 0.3% |
| | 1 week | 1% | 2% | 0.5% |
| HCl (10%) | 1 day | 0% | 1% | 0.3% |
| | 1 week | 3% | 0% | 0.4% |
| Deionized Water | 1 day | 2% | 0% | 0.3% |
| | 1 week | 0% | -2% | 0.7% |
| Hydrogen Peroxide (3%) | 1 day | -1% | -2% | 0.4% |
| | 1 week | 0% | 0% | 0.7% |
| Bleach (6%) | 1 day | 1% | 1% | 0.4% |
| | 1 week | 3% | 3% | 0.5% |
| Diesel Fuel | 1 day | -16% | -15% | 2.6% |
| | 1 week | -54% | -55% | 7.9% |
| Motor Oil (5W-30) | 1 day | 1% | -1% | -1.8% |
| | 1 week | 2% | 1% | 0.1% |
| Skydrol 5 | 1 day | -25% | -24% | 3.9% |
| | 1 week | -44% | -41% | 6.6% |

## Representative Tensile Curve (ASTM D638-14)

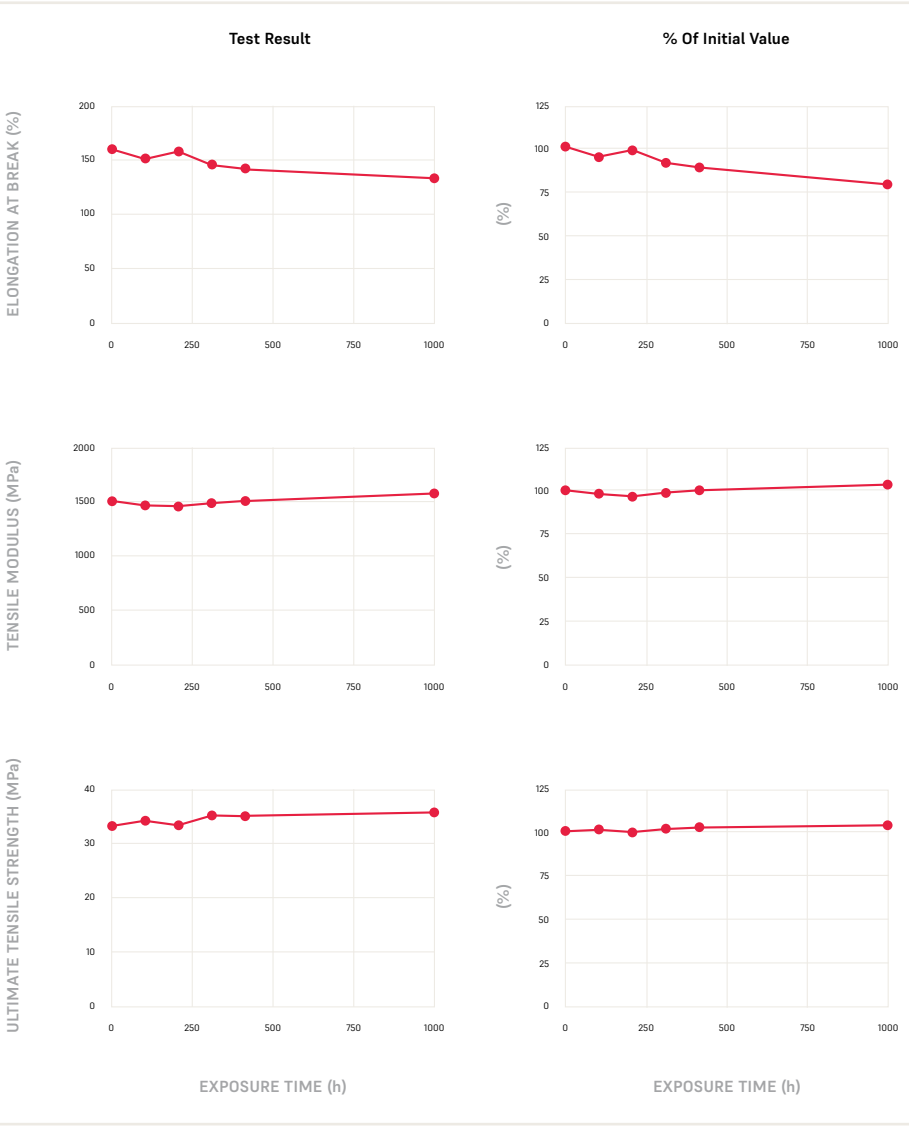
Type I, 5 mm/min



## Heat Aging (ASTM D3045)

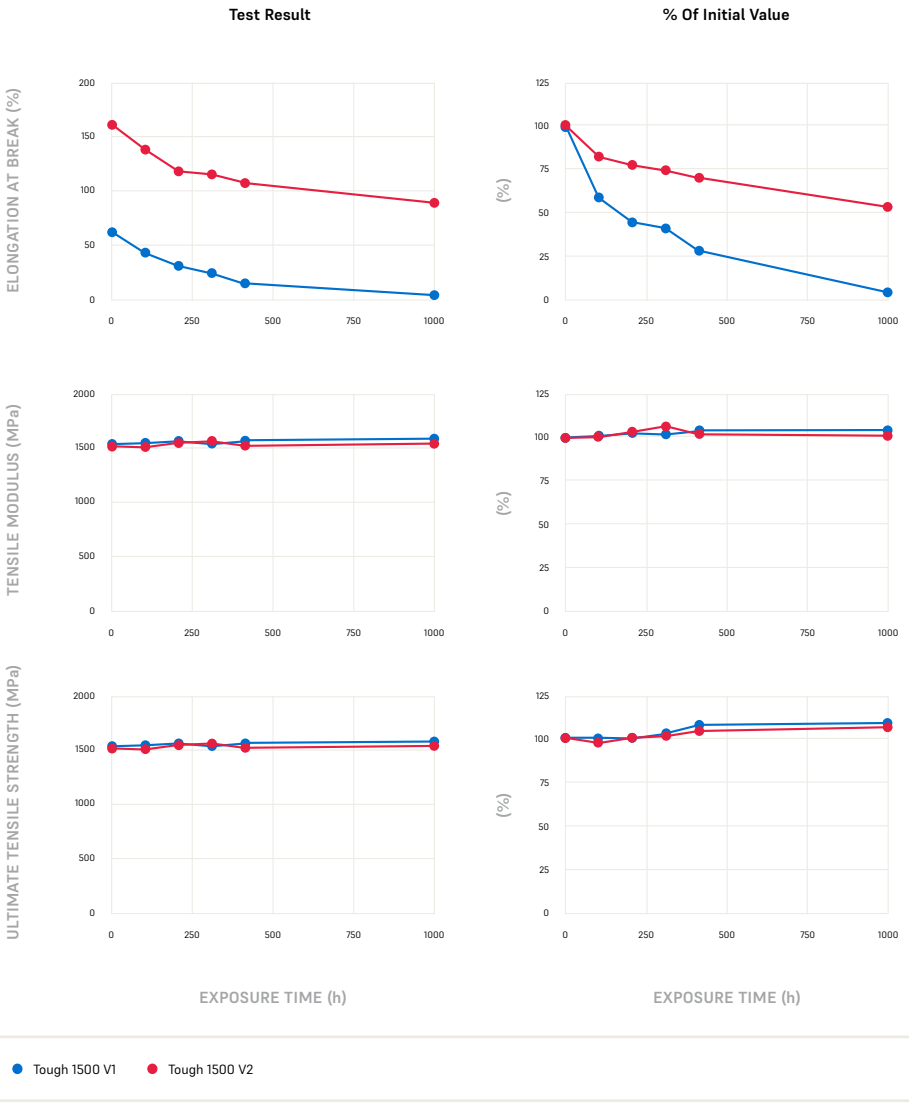
Formlabs evaluated the heat aging performance of Tough 1500 Resin V2 using ASTM D3045, a test method for evaluating heat aging of plastics without load. In this test, mechanical properties of samples placed at 50 °C environments are measured at different durations of time for up to 6 weeks.



## Indoor Aging (ASTM D4459)

Formlabs evaluated the UV aging performance of Tough 1500 Resin V2 using ASTM D4459, a test standard for xenon-arc exposure of plastics for indoor applications. This test simulates polymer aging due to solar radiation exposure through glass. Exposed samples were conditioned for 24 hours at 22 °C before mechanical testing. Control samples were stored at a constant 22 °C. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22 °C). "0 hrs" represents non-aged samples stored at 22 °C and tested 24 hours after post-processing.

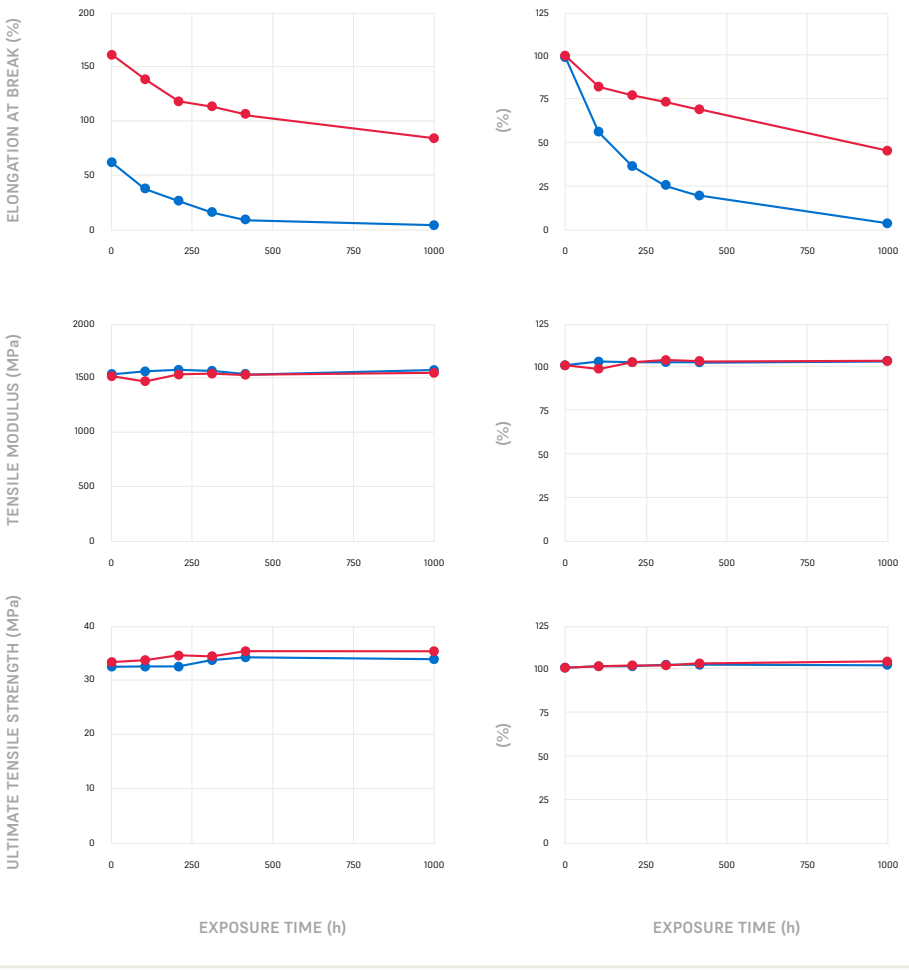
Please note, accelerated weathering testing cannot fully represent all aging conditions.
Formlabs recommends conducting additional outdoor testing relevant for your specific application needs.



## Outdoor Aging (ASTM D4329)

Tough 1500 Resin V2 was tested in accelerated outdoor weathering conditions according to ASTM D4329 (Cycle A). Test samples were exposed to defined conditions of heat, water condensation and UV light. Exposed samples were conditioned for 24 hours at 22°C before mechanical testing. Control samples were stored at a constant 22°C. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C). "0 hrs" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.

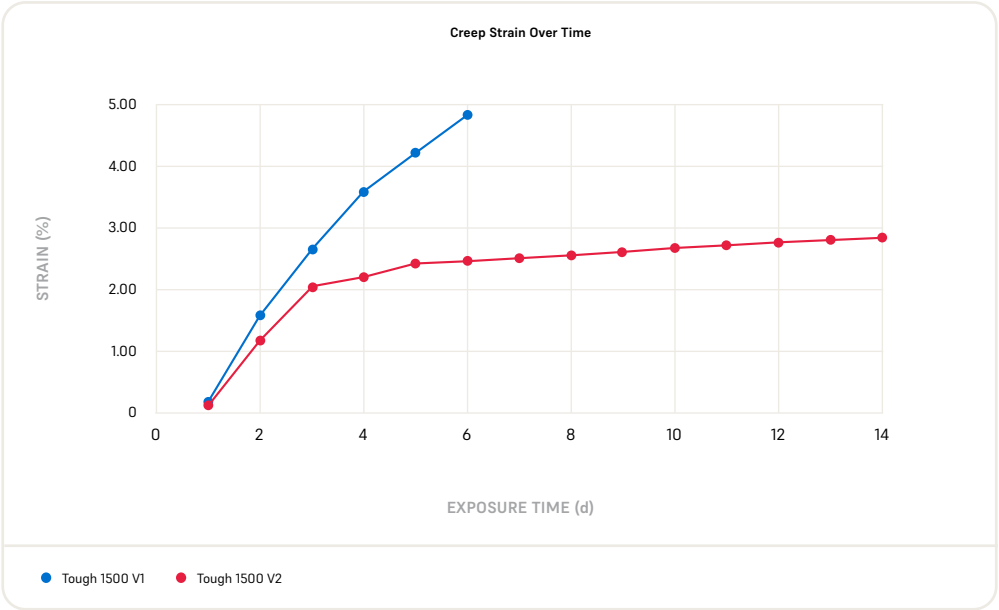
Please note, accelerated weathering testing cannot fully represent all aging conditions.
Formlabs recommends conducting additional outdoor testing relevant for your specific application needs.




ASTM D4329: Cycle A for general applications, QUV/se, UVA 340 nm, 0.89 W/m2-nm, 8 hours UV light at 60°C followed by 4 hours at 50°C condensation in the dark. To reduce any sample warpage during test time samples were placed in tailor-made holders without any fixation clamps or mechanical load. Exposed samples were always removed from QUV before next condensation cycle to avoid samples that are soaked excessively with water before testing.

## Flexural Creep ISO 6602

Formlabs evaluated the creep resistance of Tough 1500 Resin V2 using ISO 6602. This test measures a materials rate of deformation at a constant temperature under a fixed load. Speciments were tested at 22 °C under a 4.0 MPa load. Deflection was measured once a day over the course of 14 days.




## Dynamic Mechanical Analysis (DMA)

A DMA curve of Tough 1500 Resin v2 from 0 °C to 140 °C at 3 °C/min is shown. A glass transition is observed at 109.6 °C, and an inflection of the storage (elastic) modulus is observed at 60.8 °C.