LOCTITE®

LOCTITE® 3D IND406™

High Temperature
Black

LOCTITE®
Henkel Corporation
loctite3dp@henkel.com

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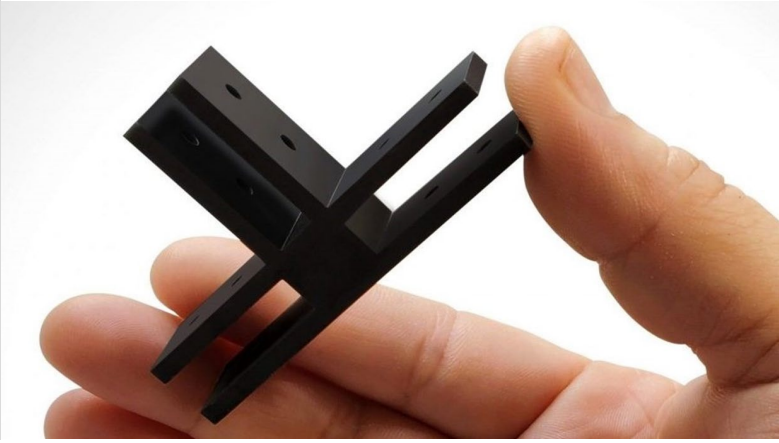


LOCTITE 3D IND406™

Our toughest High Temperature Resin

LOCTITE 3D IND406 is a high-strength, high elongation engineering plastic with good impact and high temperature resistance.

Stiffness, toughness and thermal durability make this material ideal for a wide variety of tools in the production floor and for final parts production in Automotive interior and manufacturing. The product is ideal for fixtures, interior and machinery parts.

LOCTITE 3D IND406 can be printed in various DLP printers and parts can be machined, tapped, or polished for final finish.

Benefits:

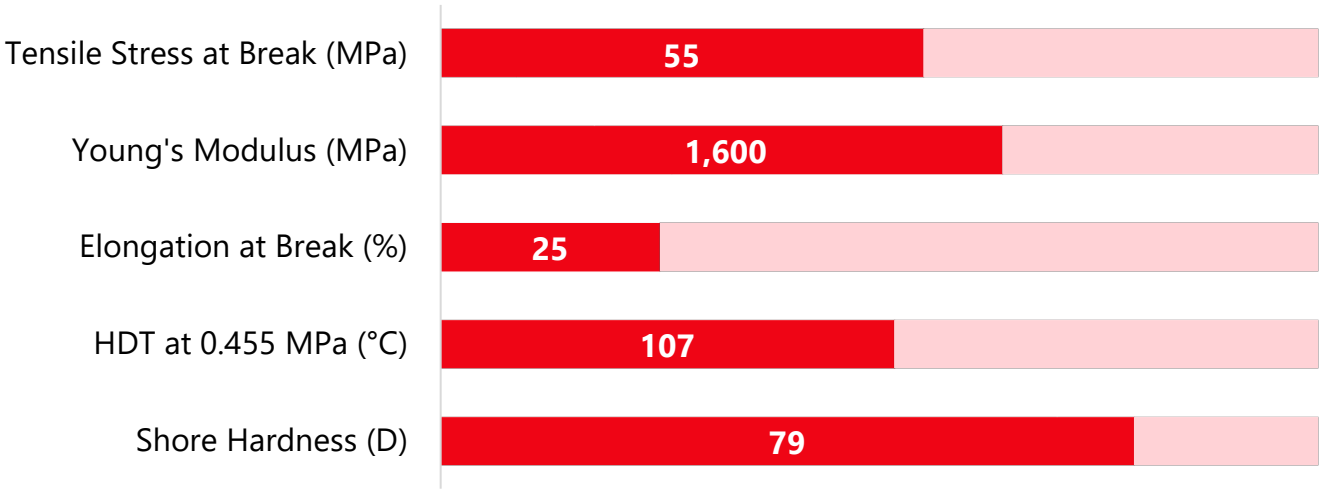
- High heat deflection temperature
- Tough and durable
- Good surface finish

Ideal for:

- Interior applications in automotive
- Tooling and fixtures
- Machinery components

Markets:

Industry | Automotive | Consumer Goods



**Values shown are linked to LOCTITE IND406 Black as reference, please refer to the specific mechanical properties for each of the colors shown in this document*

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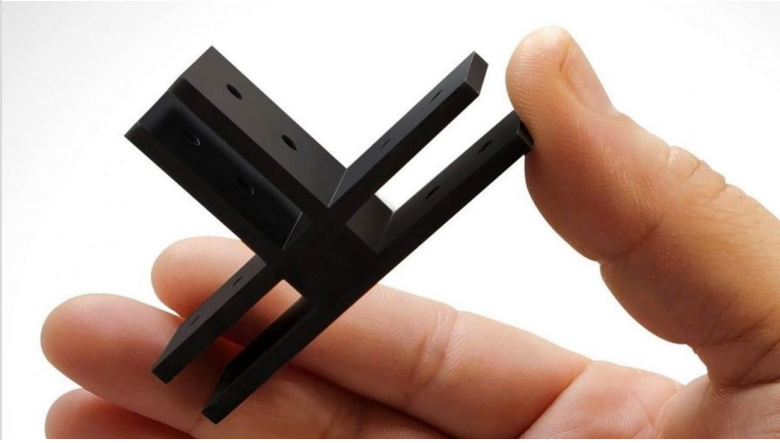

PROPERTIES

Mechanical Properties	Measure	Method	Green	Post Processed
Young's Modulus	MPa	ASTM D638	360 ± 50 [1]	1610 ± 40 [16]
Tensile Stress at Break	MPa	ASTM D638	17 ± 3 [1]	55 ± 1 [16]
Elongation at Break	%	ASTM D638	40 ± 6 [1]	25 ± 4 [2]
Flexural Modulus	MPa	ASTM D790	391 ± 28 [21]	1880 ± 25 [21]
Flexural Stress at Break	MPa	ASTM D790	-	-
Flexural Strain at Break	%	ASTM D790	>5 [21]	>5 [21]
IZOD Impact (Notched)	J/m	ASTM D256	75 ± 4 [3]	35 ± 8 [4]
Shore Hardness (3s)	D	ASTM D2240	57 ± 1 [6]	79 ± 1 [7]
Other Properties				
HDT at 0.455 MPa	°C	ASTM D648	-	107 ± 1 [5,17]
HDT at 1.82 MPa	°C	ASTM D648	-	81 ± 2 [5,17]
Water Absorption (24 h)	%	ASTM D570	-	1.4 [8]
Water Absorption (72 h)	%	ASTM D570	-	2.6 [9]
Solid Density	g/cm^3	ASTM D792		1.19 [18]
Thermal Conductivity	mW/m·K	ASTM D5930	-	206 ± 3 [14]
Heat Capacity	J/(g·K)	ASTM D5930	-	1.46 ± 0.04 [14]
Horizontal flame spread speed (1.4 mm thickness)	mm/min	DIN 75200	-	28 (Pass) [15]
Biocompatibility				
Cytotoxicity		ISO10993-5		Comply [19]
Irritation		ISO10993-23*		Comply [20]

Test parameters:
"All specimen are printed unless otherwise noted. All specimen were conditioned in ambient lab conditions at 19-23C / 40-60% RH for at least 24 hours." ASTM Methods: D638 Type IV, 5 mm/min; D790-B, D256 Notched IZOD (Machine Notched), D648; D2240, Type "D" (0, 3 seconds); D570, 0.125" x 2" Disc, samples were dried at 50 °C for 24h; D7867 at 25°C (77°F) *The biological assessment has been performed based on the in vitro method according to ISO10993-23

Internal Data Sources:
[1] FOR34521, [2] FOR34437, [3] FOR20571, [4] FOR20572, [5] FOR33203, [6] FOR20367, [7] FOR20368, [8] FOR22529, [9] FOR22668, [10] FOR20806, [11] FOR25882, [12] FOR25880, [13] FOR25881, [14] FOR26105, [15] FOR30899, [16] FOR33166, [17] FOR33204, [18] FOR47937, [19] FOR27757, [20] FOR52821, [21] FOR235051

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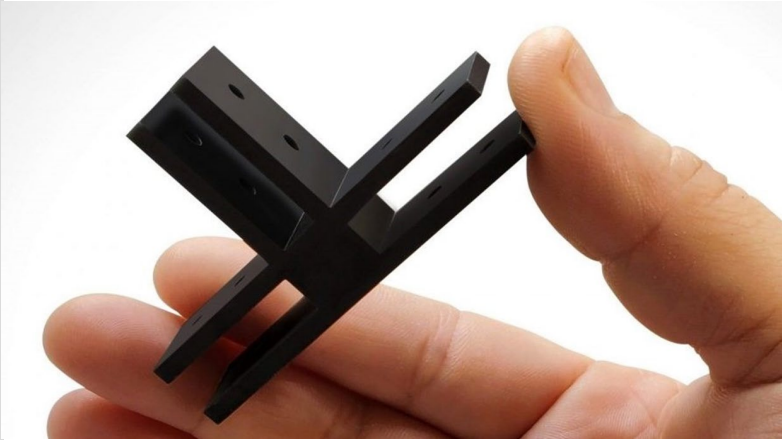

PROPERTIES

Liquid Properties	Measure	Method	Green	Post Processed
Viscosity at 25°C (77°F)	cP	ASTM D7867	-	1060 [10]
Liquid Density	g/cm^3	ISO 1675	-	1.10 [18]

Electrical Properties	Measure	Method	Green	Post Processed
Dielectric Strength	kV/mm	ASTM D149	-	26.0 ± 0.3 [13]
Volume Resistance	Ω·cm	ASTM D257	-	4.5 ± 0.6 E+15 [12]
Surface Resistance	Ω	ASTM D257	-	1.1 ± 0.6 E+15 [12]
AC Relative Permittivity (Dielectric Constant) [11]				
at 50 Hz (XY)	none	ASTM D150	-	3.6
at 1 kHz (XY)	none	ASTM D150	-	3.4
at 1 MHz (XY)	none	ASTM D150	-	3.1
AC Loss Characteristics (Dissipation Factor) [11]				
at 50 Hz (XY)	none	ASTM D150	-	0.014
at 1 kHz (XY)	none	ASTM D150	-	0.019
at 1 MHz (XY)	none	ASTM D150	-	0.022

Test parameters:
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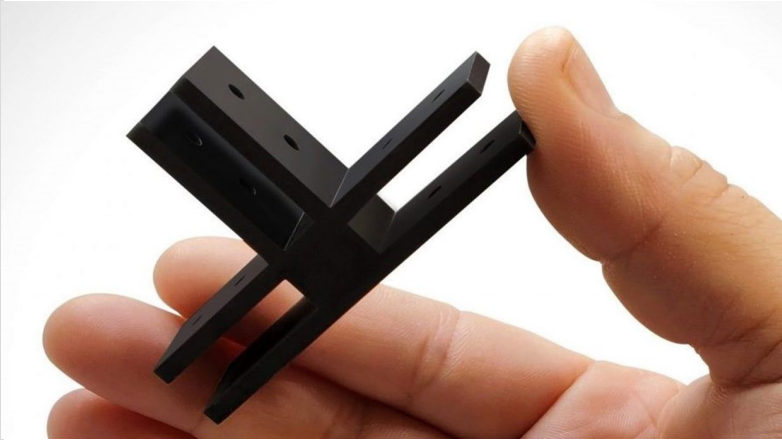

WORKFLOW

Validated workflows need to be followed to achieve properties as provided in the TDS. Examples of validated workflow steps are listed below. Users should defer to the most current workflow information for best results which can be found at https://www.loctiteam.com/printer-validation-settings

PRINTER SETTINGS

LOCTITE 3D IND406 BK is formulated to print optimally on industrial DLP printer. Read the safety data sheet carefully to get details about health and safety instructions. Recommended print parameters:

- Shake resin bottle well before usage
- Temperature: 20°C to 35°C
- Intensity: 3 mW/cm² to 7 mW/cm²

Exposure time for an intensity of 4-7 mW/cm²

Layer Thickness (µm)	100	E_C (mJ/cm²)	6.45
Burn-in Region (s)	40	D_P (mm)	0.28
Model Region (s)	6		

CLEANING

LOCTITE 3D IND406 BK requires post processing to achieve specified properties. Prior to post curing, support structures should be removed from the printed part, and the part should then be washed. Use compressed air to remove residual solvent from the surface of the material between intervals.

Post Process Step	Agent	Method	Duration	Intervals	Additional Info
Cleaning	IPA	Ultra sonic bath	3 min	1	Allow parts to dry between intervals
Dry	n.a.	Compressed air	10 to 60 s	1	Air pressure (50 psi)
Wait before post curing	n.a.	Ambient condition	60 min	1	Room temperature

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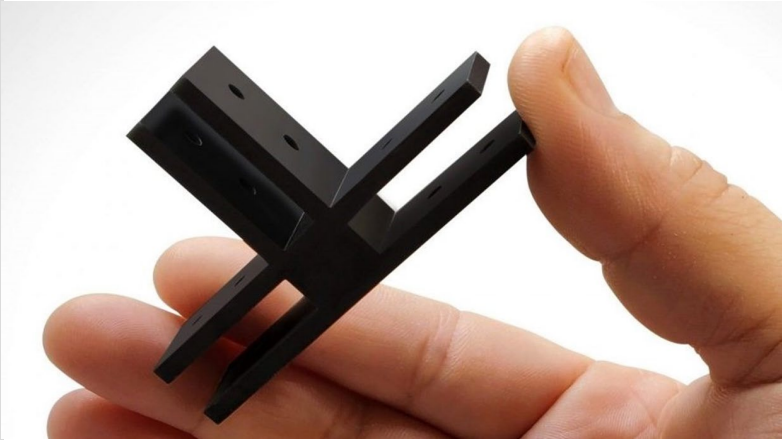

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POST CURING

LOCTITE 3D IND406 BK requires a two-step post curing to achieve specified properties. In the first step it is recommended that either an LED or wide spectrum lamp be used to UV post cure parts. In the second step the UV post cured parts require an additional Heat post cure to achieve final properties.

STEP 1: UV post cure

UV Curing Unit	UV Source	Intensity	Cure time per side	Additional Settings (Shelf, Output Energy)
Loctite UVALOC 1000	Mercury Arc Bulb (broad spectrum)	30 mW/cm^2 at 365 nm	10 min	500 W, lowest shelf
Rapidshape RS Cure XL	Multiple LEDs	150%	30 min	Third shelf from bottom, Vacuum: 50 mbar

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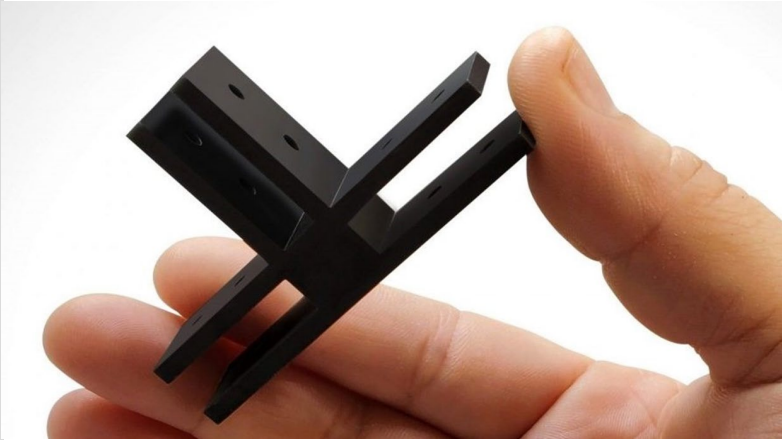

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POST CURING

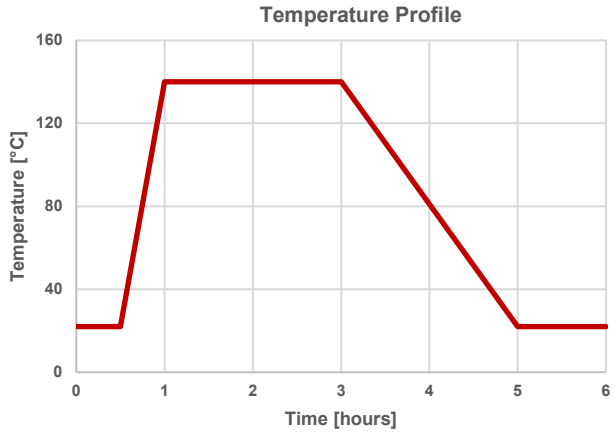
LOCTITE 3D IND406 BK requires a two-step post curing to achieve specified properties.

STEP 2: Heat post cure

After UV post curing, an additional Heat post cure at 140°C for 2 hours is required to reach final properties. Let parts rest one hour between UV post cure and Heat post cure.

To minimize risk of warpage place parts in the oven at standard lab conditions with T_{start} = 22°C before ramping temperature with are rate of $R_T \leq 4$°C/min to target value of T_{cure} = 140°C.

After 2 hours at T_{cure} = 140°C cool down parts slowly in the switched off oven to standard lab conditions with T_{end} = 22°C . Do not remove the parts from the oven before they reached lab temperature to prevent thermal stress and warpage.



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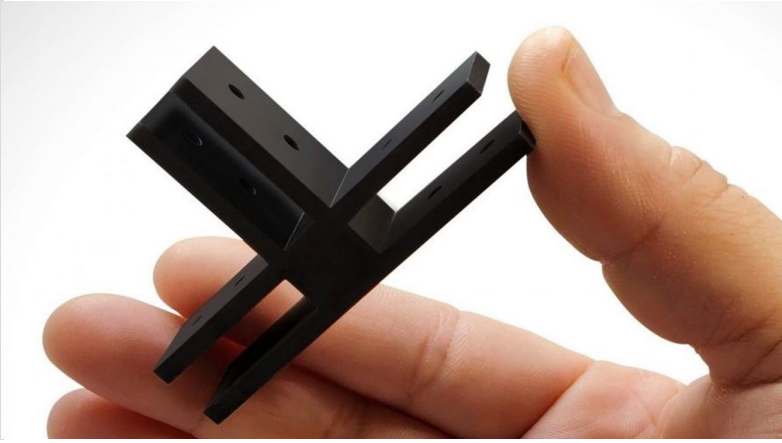

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STORAGE

Store LOCTITE 3D IND406 BK in the unopened container in a dry location. Optimal Storage: 8°C to 30°. Storage below 8°C or above 30°C can adversely affect product properties. Material removed from containers may be contaminated during use. For this reason, filter used resin with 190µm mesh filter before placing back into proper storage container.

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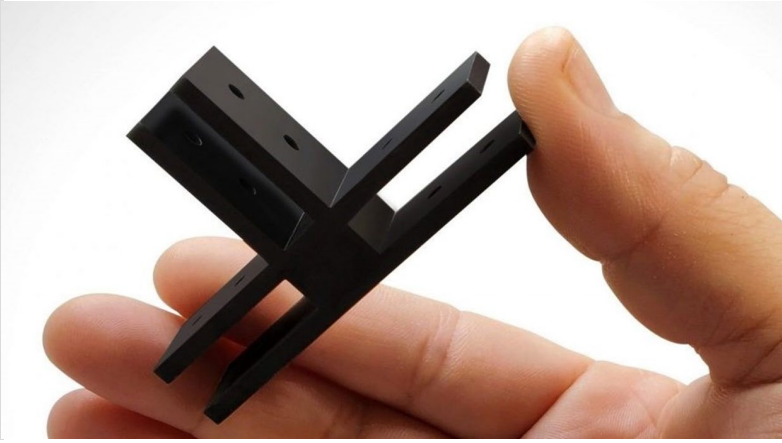
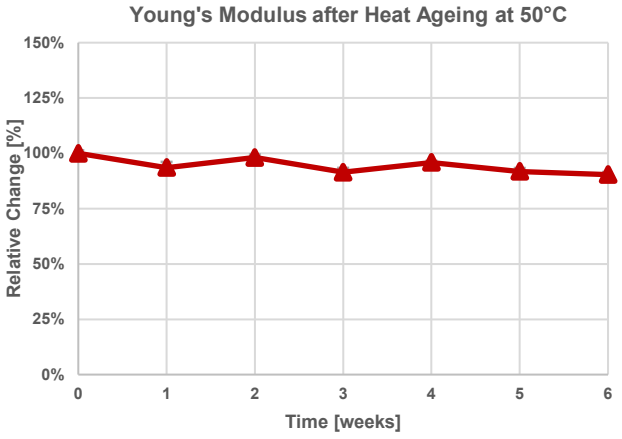


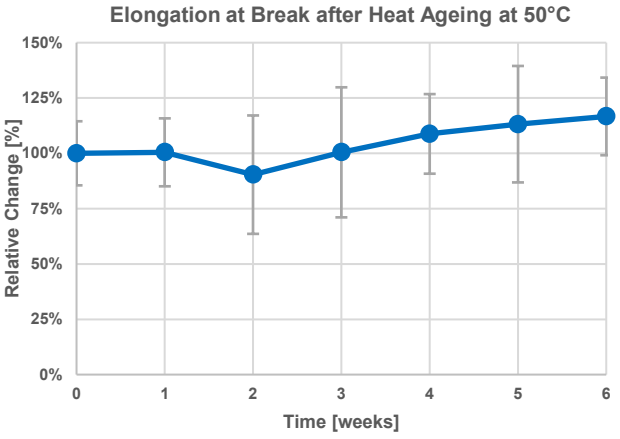
AGEING AND ENVIRONMENTAL EFFECTS – HEAT AGEING

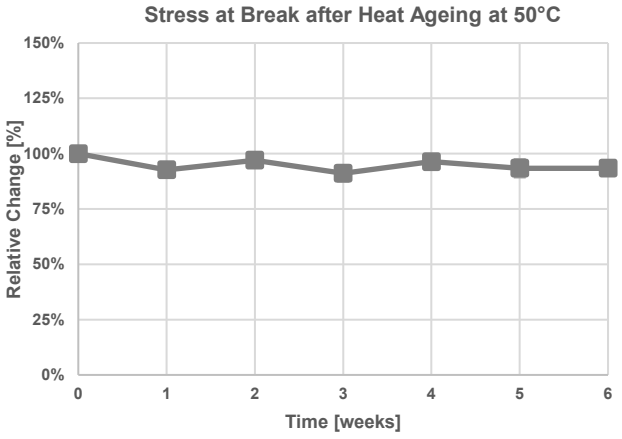
LOCTITE 3D 406 BK was heat aged without load according to ASTM D3045. Test samples were exposed for a defined time at 50°C and conditioned for 24 hours at 22°C before mechanical testing. Control samples were stored at a constant 22°C. All samples were printed in the same print job using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C).

"0 weeks" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.

Based on temperature dependence of reaction rates a test time of 6 weeks at 50°C can be interpreted as approximately 12 months at ambient temperature.







Test parameters:
ASTM D638: Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1.0% (regression), 22°C

Internal Data Sources:
FOR163707, FOR163721

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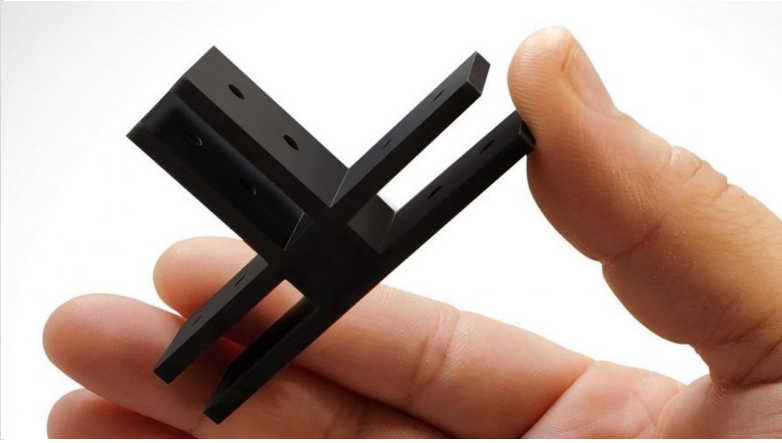
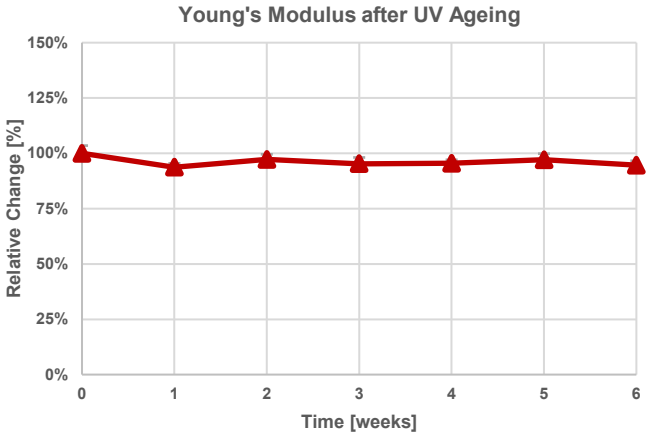
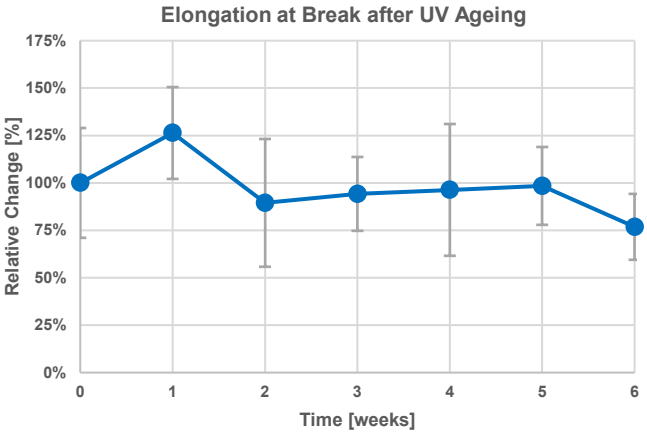


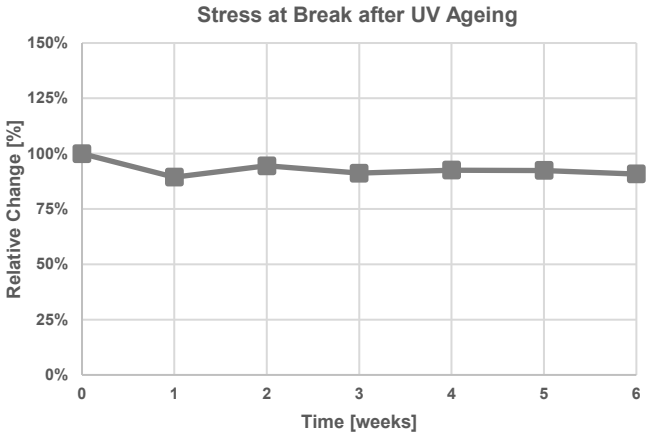
AGEING AND ENVIRONMENTAL EFFECTS – ACCELERATED WEATHERING (UV AGEING)

LOCTITE 3D IND406 BK has been tested after accelerated outdoor weathering 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. All samples were printed in the same print job using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C). "0 weeks" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.

Please note, accelerated weathering testing can never fully represent real outdoor conditions and complexity. It is therefore recommended to conduct additional (outdoor) testing relevant for your specific application needs.







Test parameters:
ASTM D638: Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1% (regression), 22 °C
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.

Internal Data Sources:
FOR590829

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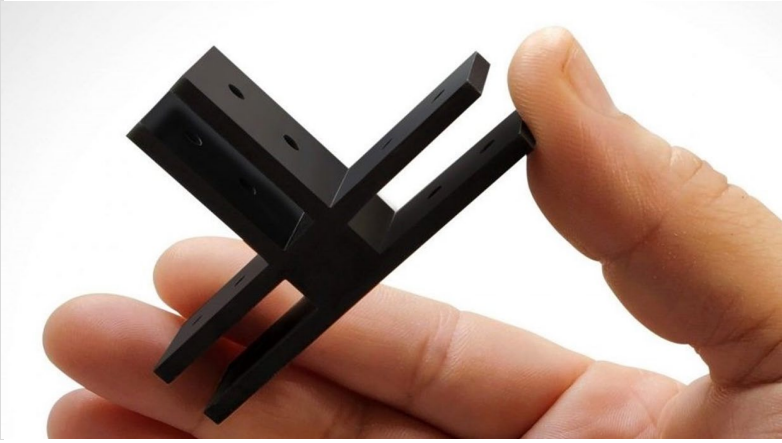
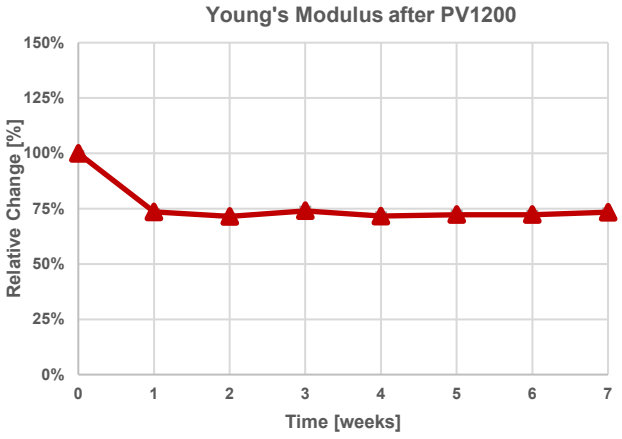


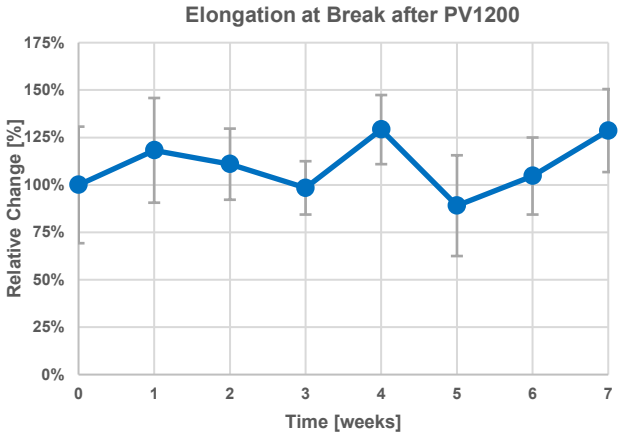
AGEING AND ENVIRONMENTAL EFFECTS – CLIMATE CYCLING TEST (PV1200)

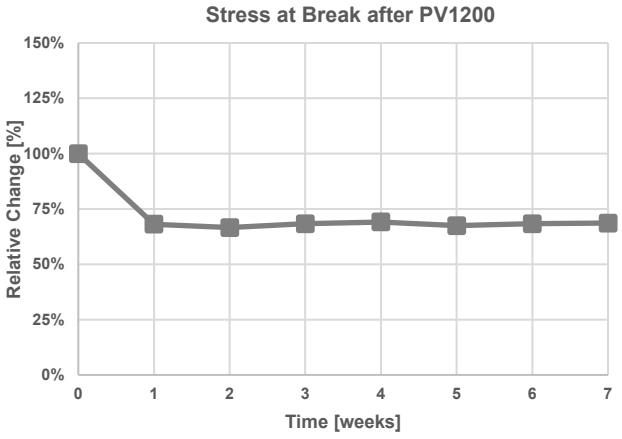
LOCTITE 3D IND406 BK was tested in an environmental climate cycling test according to PV1200 specification. This specification was developed by Volkswagen AG to evaluate material durability and cycles between -40°C (4 hours) and 80°C (4 hours at 80 % rel. humidity) during a repeating 12-hour cycle. Test samples were exposed to this temperature cycle for a total duration of 7 weeks (100 cycles).

Before mechanical testing samples were conditioned for 24 hours at 22°C. Control samples were stored at a constant 22°C. All samples were printed in the same print job using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C).

"0 weeks" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.







Test parameters:
ASTM D638: Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1.0% (regression), 22°C
PV1200: Samples were removed from climate chamber during heating phase (Cycle time: 240-300 minutes) and then conditioned for 24 hours at 22°C. 1 Test cycle is equal to 12 hours of test time. "7 weeks" of test time represent 100 test cycles or 1200 hours of test time.

Internal Data Sources:
FOR283110, FOR283128

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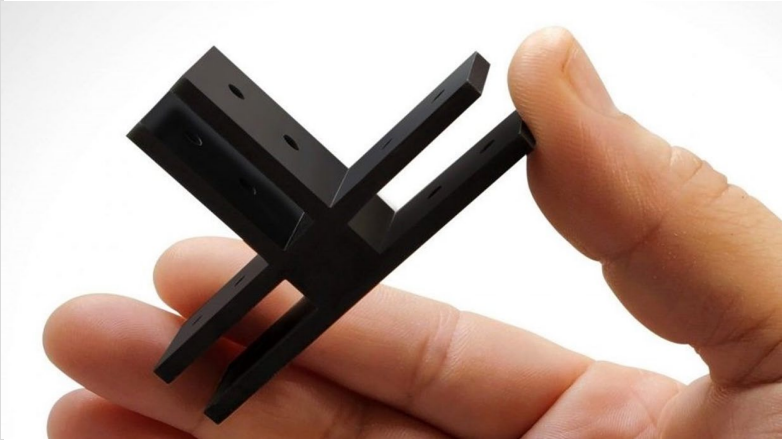
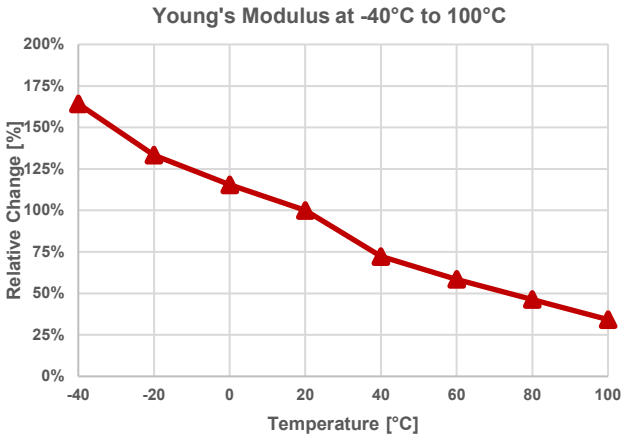
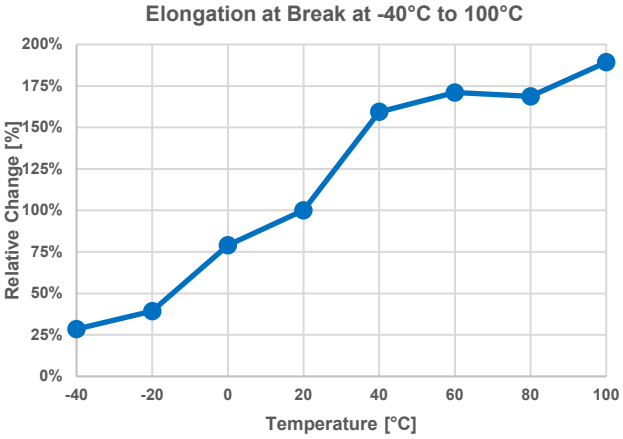
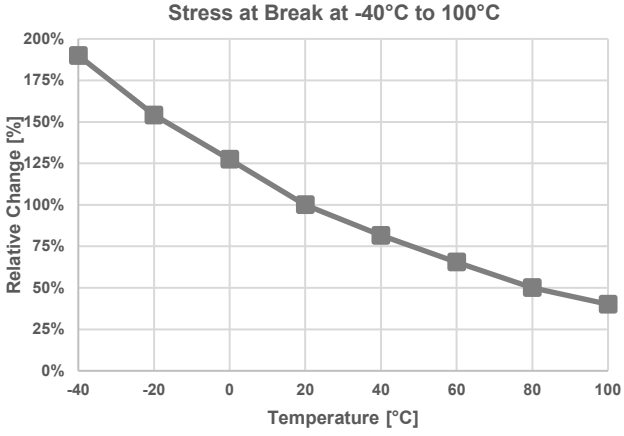


THERMAL INFLUENCE ON MECHANICAL PROPERTIES

LOCTITE 3D IND406 BK has been tested according to ASTM D638 at varied environmental temperatures, from -40°C to 100°C. All samples were printed in the same print job using a validated workflow. Mechanical testing was conducted according to ASTM D638. Before each test series samples were conditioned for 60 minutes at the specific test temperature.







Test parameters:
ASTM D638, Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1% (regression),

Internal Data Sources:
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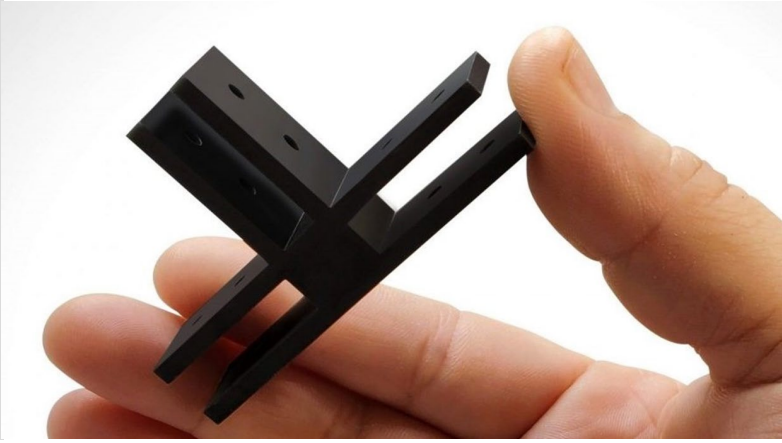
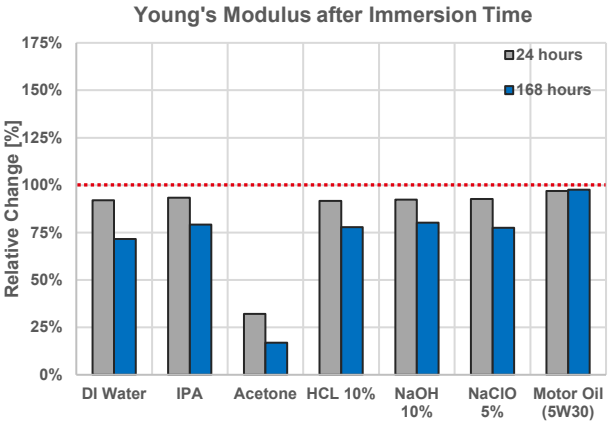
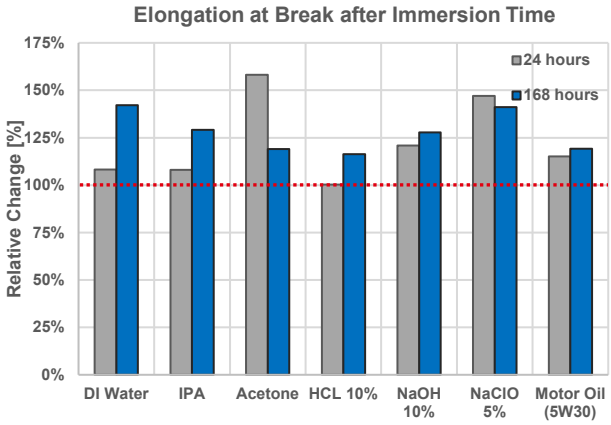
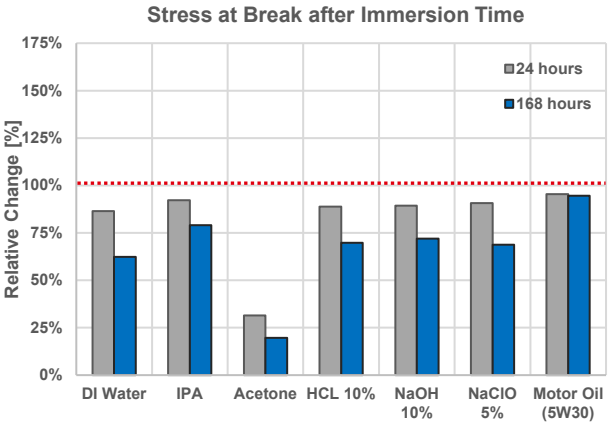


AGEING AND ENVIRONMENTAL EFFECTS – CHEMICAL RESISTANCE (1/2)

LOCTITE 3D IND406 BK has been tested after chemical ageing according to ASTM D543. The influence of chemicals was tested by measuring mechanical properties after different test times (Immersion test for 24 and 168 hours). Exposed samples were stored in containers and fully immersed in different chemicals. Samples were stirred every 24 hours using a shaker. After removal, exposed samples were washed and conditioned for 24 hours at 22°C before mechanical testing. All samples were printed using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C). "100%" represents non-aged samples stored at 22°C and tested 24 hours after post-processing.







Test parameters:
ASTM D638: Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1.0% (regression), 22°C
ASTM D543: Samples immersed in different chemicals were stored at 22°C. Samples immersed in Motor Oil were stored at 50°C.
Properties of media used: pH(HCl, 10%) = 1; pH(NaOH, 10%) = 14; pH(NaClO, 5%) = 13

Internal Data Sources:
[DI water] FOR322675, [IPA] FOR322677, [Acetone] FOR322678, [HCl 10 %] FOR322679, [NaOH 10 %] FOR314425, [NaClO 5 %] FOR314429, [5W30] FOR314430,

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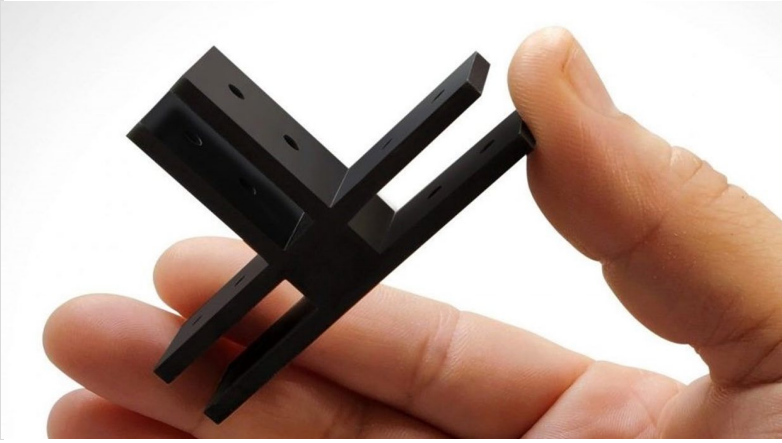
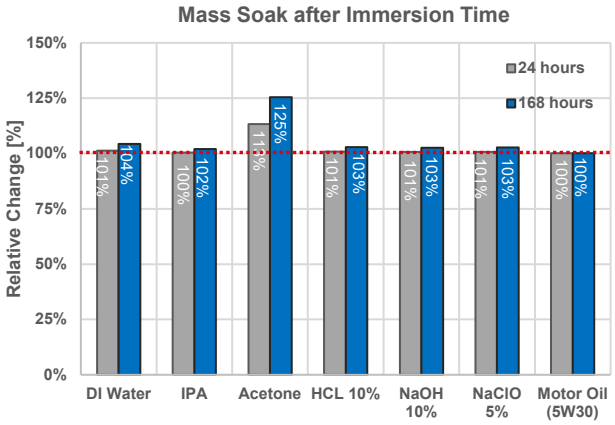
LOCTITE®

IND406™
HIGH TEMPERATURE
BLACK



AGEING AND ENVIRONMENTAL EFFECTS – CHEMICAL RESISTANCE (2/2)

LOCTITE 3D IND406 BK has been tested after chemical ageing according to ASTM D543. The influence of chemicals was tested by measuring the mass change after different test times (Immersion test for 24 and 168 hours). Exposed samples were stored in containers and fully immersed in different chemicals. Samples were stirred every 24 hours using a shaker. After removal exposed samples were washed, dried and immediately weighed. All samples were printed using a validated workflow. "100%" represents the initial weight 24 hours after post-processing.



Test parameters:
ASTM D543: Samples immersed in different chemicals were stored at 22°C. Samples immersed in Motor Oil were stored at 50°C.
Properties of media used: pH(HCl, 10%) = 1; pH(NaOH, 10%) = 14; pH(NaClO, 5%) = 13

Internal Data Sources:
[DI water] FOR322682, [IPA] FOR322687, [Acetone] FOR322694, [HCl 10 %] FOR322695, [NaOH 10%] FOR314434, [NaClO 5 %] FOR314437, [5W30] FOR314439,

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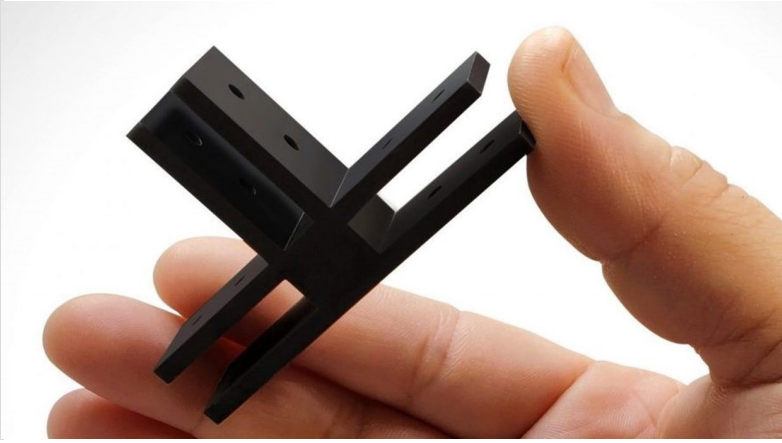

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