LOCTITE®

LOCTITE® 3D IND249™

High Temperature
Black

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Henkel Corporation
loctite3dp@henkel.com

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LOCTITE 3D IND249 BK™

LOCTITE 3D IND249 BK is a high-temperature, high-strength material that prints challenging geometries with fine feature resolution. This low-viscosity material features exceptionally high green strength to enable ease of processing.

Stiffness and thermal durability make LOCTITE 3D IND249 BK ideal for production applications, including mold tooling, manufacturing aids, and other complex geometries. In addition, LOCTITE 3D IND249 BK provides an exceptional chemical resistance.

LOCTITE 3D IND249 BK has validated workflows for printing on various DLP platforms.

Benefits:

- Exceptionally high stiffness
- Low viscosity
- High accuracy
- Good temperature resistance
- Very high chemical resistance

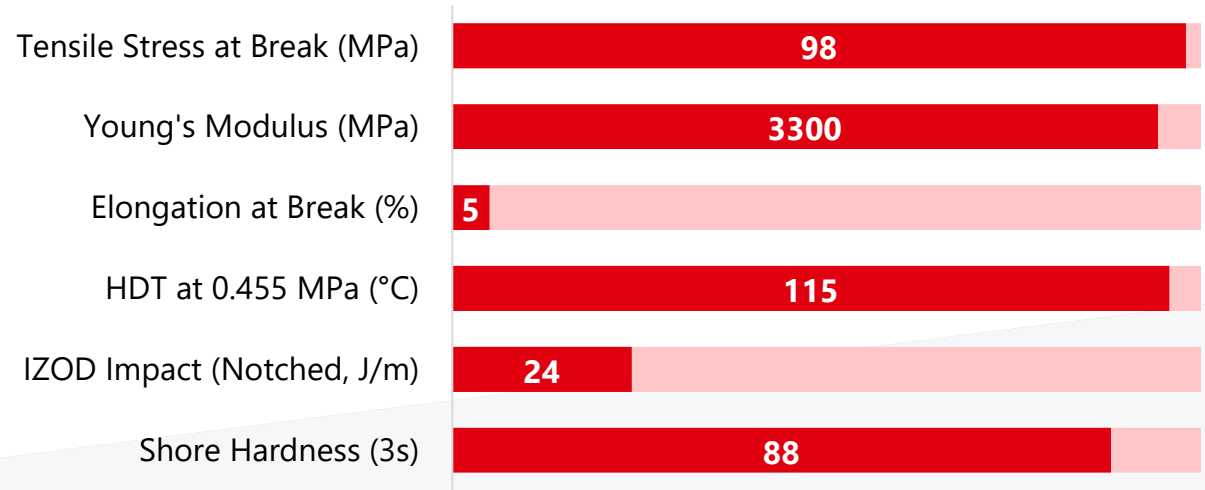
Ideal for:

- Challenge geometries
- Mold tooling
- Manufacturing aids

Markets:

Industry

Consumer Goods



**Values shown are linked to LOCTITE IND249 BK 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	1700 – 1880 [1]	2980 – 3350 [1]
Tensile Stress at Yield	MPa	ASTM D638	43 – 53 [1]	-
Elongation at Yield	MPa	ASTM D638	4.2 – 4.8 [1]	-
Tensile Stress at Break	MPa	ASTM D638	37 – 46 [1]	83 – 98 [1]
Elongation at Break	%	ASTM D638	16 – 24 [1]	4 – 7 [1]
Flexural Modulus	MPa	ASTM D790	2340 – 3330 [2,3]	3170 – 3600 [3,4]
Flexural Stress at Break	MPa	ASTM D790	94 - 130 [2,3]	127 – 153 [3,4]
Flexural Elongation at Break	%	ASTM D790	>5 [2,3]	4 – 5 [3,4]
IZOD Impact (Notched)	J/m	ASTM D256	11 – 24 [8,9]	13 – 24 [10,8]
Shore Hardness (3s)	D	ASTM D2240	74 – 87 [13,14]	81 – 88 [13,15]
Other Properties				
HDT at 0.455 MPa	°C	ASTM D648	-	113 – 117 [5,6]
HDT at 1.82 MPa	°C	ASTM D648	-	96 – 101 [7,6]
Water Absorption (24hr)	%	ASTM D570	-	0.5 – 0.7 [11,12]
Water Absorption (48hr)	%	ASTM D570	-	0.6 – 0.7 [25]
Water Absorption (72hr)	%	ASTM D570	-	0.7 – 0.9 [11,12]
Solid Density	g/cm^3	ASTM D792	1.16 – 1.19 [16,17]	1.17– 1.20 [16,17]
Thermal Conductivity	W/(m·K)	ASTM D5930	-	0.2 – 0.21 [21]
Heat Capacity	J/(g·K)	ASTM D5930	-	1.4 – 1.5 [21]
CTE (< 55°C)	µm/(m·K)	ASTM E831	-	60 – 67 [22]

Test parameters:
"All specimen are printed unless otherwise noted. All specimen were in ambient lab conditions at 19-23°C / 40-60% RH for at least 24 hours." ASTM Methods: D638 Type IV, 5mm/min; D790-B 1.3 mm/min; D256 Notched IZOD (Machine Notched) 6 mm x 12 mm; D2240 Type "D" (3, 5 seconds); D648 127 mm x 13 mm x 6,8 mm; D570 3.2 mm x 51 mm Disc 24hr@ 25°C; D792 solid 8 mm x 10 mm Disc; D5930 80 mm x 40 mm x 10 mm; E831 80 mm x 40 mm x 10 mm; D7867@ 25°C (77°F); D1475; D149 50 mm x 3 mm disc; D257 110 mm x 110 mm x 5 mm; D150 70 mm x 70 mm x 1.2 mm.
*The biological assessment has been performed based on the in vitro method according to ISO10993-23

Internal Data Sources:
[1] GEN329696, [2] FOR317892, [3] FOR317854, [4] FOR317895, [5] FOR338673, [6] FOR338726, [7] FOR332911, [8] FOR332913, [9] FOR331481, [10] FOR317866, [11] FOR332975, [12] FOR316403, [13] FOR332977,[14] FOR317904, [15] FOR317906, [21] FOR377534, [22] FOR377524, [25] FOR539856

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PROPERTIES

Liquid Properties

Viscosity at 25°C (77°F)	cP	ASTM D7867		444 – 461 [18,19]
Liquid Density	g/cm³	ASTM D1475		1.09 – 1.10 [17,16]
Electrical Properties	**Measure**	**Method**	**Green**	**Post Processed**
Volume Resistivity	Ω·cm	ASTM D257	-	$0.9 \cdot 10^{16}$ – $1.4 \cdot 10^{16}$ [23]
Surface Resistivity	Ω	ASTM D257	-	$2.0 \cdot 10^{16}$ – $4.6 \cdot 10^{16}$ [23]
Dielectric Strength	kV/mm	ASTM D149	-	24.0 – 26.4 [24]
AC Relative Permittivity (Dielectric Constant)[25]				
at 50 Hz (XY)	none	ASTM D150	-	3.2 - 3.8
at 1 kHz (XY)	none	ASTM D150	-	3.4 - 3.8
at 1 MHz (XY)	none	ASTM D150	-	2.5 - 3.3
AC Loss Characteristic (Dissipation Factor)[25]				
at 50 Hz (XY)	none	ASTM D150	-	0.11 – 0.15
at 1 kHz (XY)	none	ASTM D150	-	0.05 – 0.09
at 1 MHz (XY)	none	ASTM D150	-	0.21 – 0.35

Test parameters:
"All specimen are printed unless otherwise noted. All specimen were in ambient lab conditions at 19-23°C / 40-60% RH for at least 24 hours." ASTM Methods: D638 Type IV, 5mm/min; D790-B 1.3 mm/min; D256 Notched IZOD (Machine Notched) 6 mm x 12 mm; D2240 Type "D" (3, 5 seconds); D648 127 mm x 13 mm x 6,8 mm; D570 3.2 mm x 51 mm Disc 24hr@ 25°C; D792 solid 8 mm x 10 mm Disc; D5930 80 mm x 40 mm x 10 mm; E831 80 mm x 40 mm x 10 mm; D7867@ 25°C (77°F); D1475; D149 50 mm x 3 mm disc; D257 110 mm x 110 mm x 5 mm; D150 70 mm x 70 mm x 1.2 mm.
*The biological assessment has been performed based on the in vitro method according to ISO10993-23

Internal Data Sources:
[16] FOR332976, [17] FOR316402, [18] FOR323025, [19] FOR316377, [23] FOR402775, [24] FOR402788, [25] FOR402809

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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 IND249 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

Settings: 385 nm at 5 mW/cm²	Measure	Method	Value
Layer Thickness (µm):	µm	Internal	100
Burn-in Region (s)	s	Internal	30
Transition Region (s):	s	Internal	20
Model Region (s):	s	Internal	7

Settings: 385 nm at 5 mW/cm²	Measure	Method	Value
E_C	mJ/cm2	Internal	11.37 [1, 20]
D_P	mm	Internal	0.28 [1, 20]

Settings: 385 nm at 5 mW/cm²	Measure	Method	Exposure time
D_C =100um	s	Internal	1.82 [1, 20, *]
D_C =50um	s	Internal	1.30 [1, 20, *]

Test parameters:
" Exposure times are calculated without a safety factor.

Internal Data Sources:
[1] GEN329696, [20] FOR328621

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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

CLEANING

LOCTITE 3D IND249 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 Step #1	IPA	Ultrasonic	1 min	1	Dry after each interval
Cleaning Step #2	IPA	Ultrasonic	1 min	1	Dry after each interval
Dry	n.a.	Compressed air	10 to 60 s	1	Air pressure (50psi)
Wait before post curing	n.a.	Ambient condition	60 min	1	Room temperature

POST CURING

LOCTITE 3D IND249 BK requires post curing to achieve specified properties. It is recommended that either an LED or wide spectrum lamp be used to post cure parts.

If a lower energy LED or other post cure unit is used, an additional heat cure at 130°C for 2 hours may be required to realize highest HDT performance. Allow the parts to rest one hour between UV cure and heat cure. To minimize risk of warpage place parts in cold oven before ramping up temperature to target value and cool down parts slowly in switched off oven after reaching the heat curing conditions.

UV Curing Unit	UV Source	Intensity	Cure time per side	Additional Settings (Shelf, Output Energy)	Heat Cure
Dymax 5000 EC Flood	Mercury Arc Bulb (broad spectrum)	148 mW/cm² at 380 nm	10 min	400W, Shelf K	-
Loctite CL36	405nm LED	80 mW/cm² at 405 nm	30 min	100% top & side	2 hours at 130°C
PCU 90	Metal halide	100%	20 min	Rotary Table	2 hours at 130°C

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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

STORAGE

Store LOCTITE 3D IND249 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.

TIPS & TRICKS

This section is a collection of useful advices, guides, and recommendations designed to help users of the LOCTITE 3D IND249 BK deal with specific process tasks more efficiently.

RESIN USE

Use LOCTITE 3D IND249 BK within two weeks after having opened the bottle to assure stable mechanical properties.

Please make sure to do the Heat Curing at the same day as the post UV cuing step when using an LED based 405nm post curing device to get best mechanical properties in combination with an HDT of over 113 °C at 0.455 MPa.

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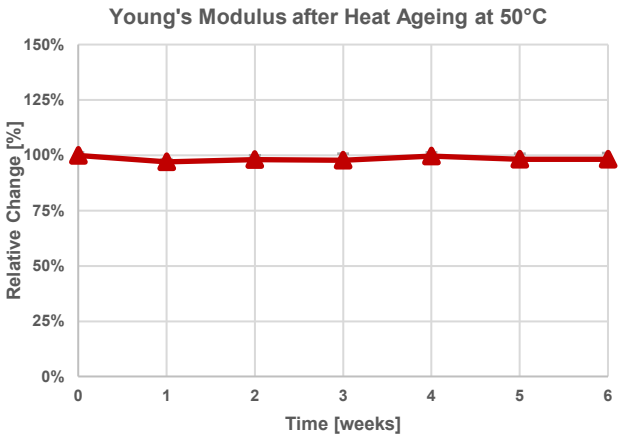
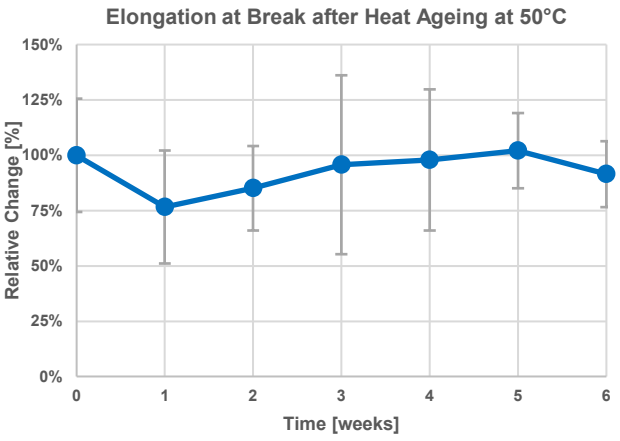
AGEING AND ENVIRONMENTAL EFFECTS – HEAT AGEING

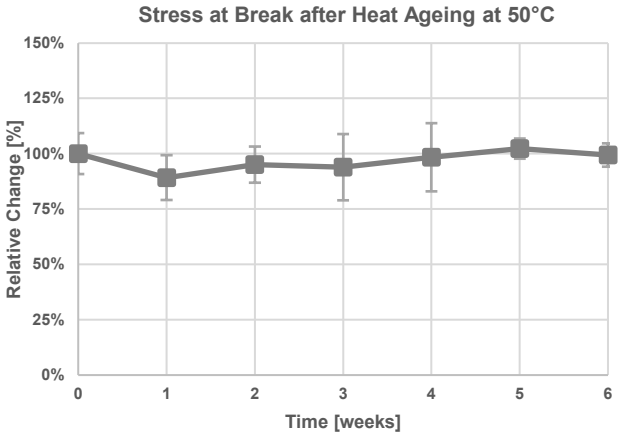
LOCTITE 3D IND249 BK was heat aged without load according to ASTM D3045. Test samples were exposed for a defined time at 50°C and conditioned for 24 hours at 22°C before mechanical testing. Control samples were stored at a constant 22°C. All samples were printed in the same print job using a validated workflow. Mechanical testing was conducted according to ASTM D638 at standard lab conditions (22°C).

Values at '0 weeks' are non-aged samples stored at 22°C and tested after 24 hours of 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:
FOR382546, FOR382551

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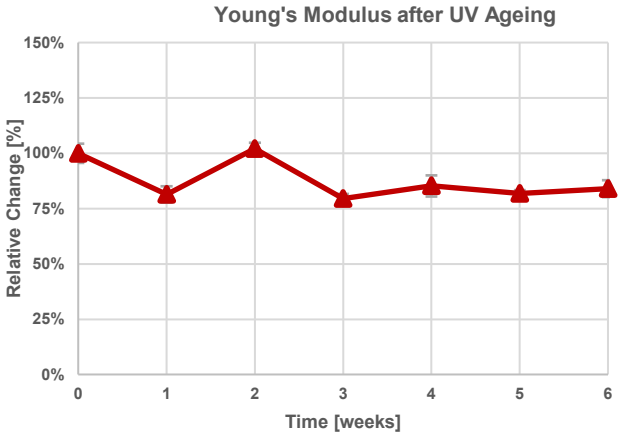
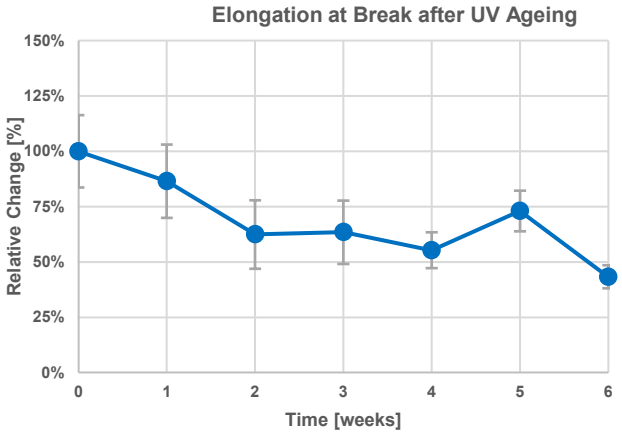
AGEING AND ENVIRONMENTAL EFFECTS – ACCELERATED WEATHERING (UV AGEING)

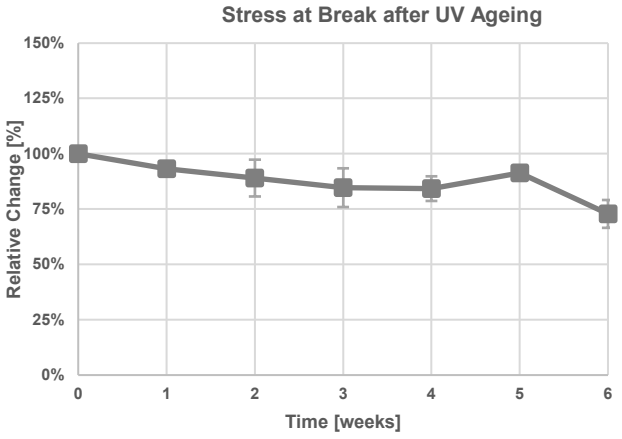
LOCTITE 3D IND249 BK has been tested after accelerated outdoor weathering according to ASTM D4329 (Cycle A). Test samples were exposed to defined conditions of heat, water condensation and UV light. Exposed samples were conditioned for 24 hours at 22°C before mechanical testing. Control samples were 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).

Values at '0 weeks' are non-aged samples stored at 22°C and tested after 24 hours of 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:
FOR390777, FOR390768

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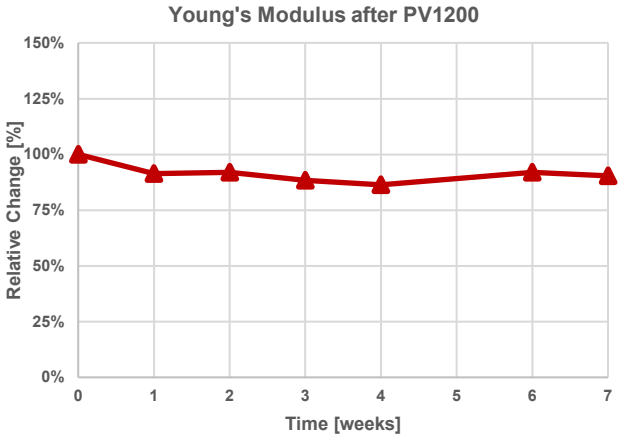
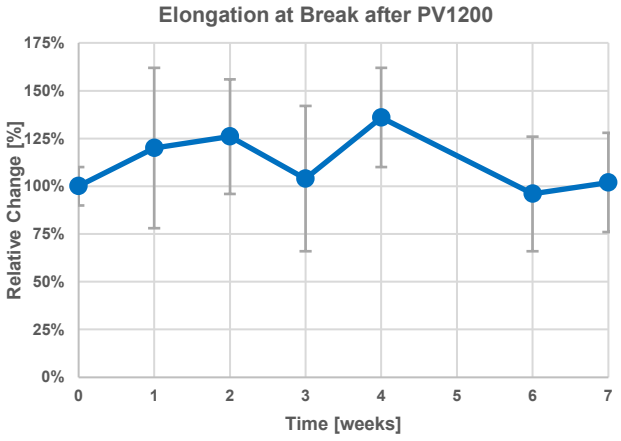
AGEING AND ENVIRONMENTAL EFFECTS – CLIMATE CYCLING TEST (PV1200)

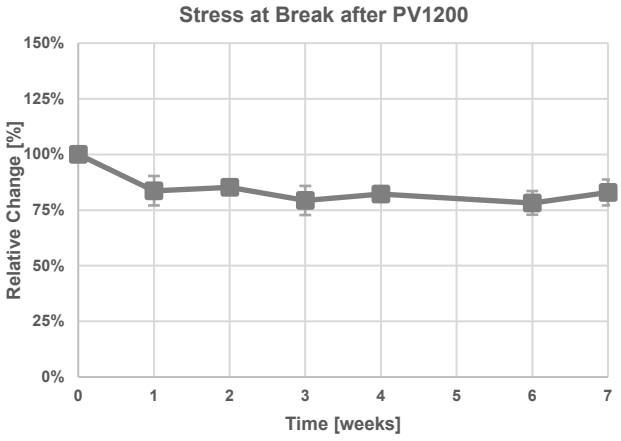
LOCTITE 3D IND249 BK was tested in an environmental climate cycling test according to PV1200 specification. This specification was developed by Volkswagen AG to evaluate material durability and cycles between -40°C (4 hours) and 80°C (4 hours at 80 % rel. humidity) during a repeating 12-hour cycle. Test 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).

Values at '0 weeks' are non-aged samples stored at 22°C and tested after 24 hours of 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. One 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:
FOR604113

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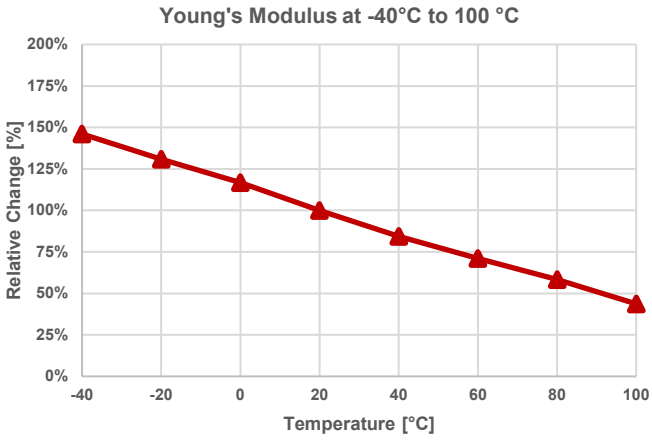
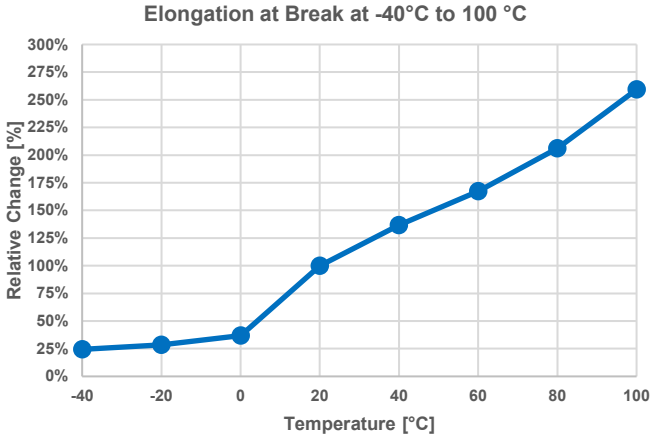
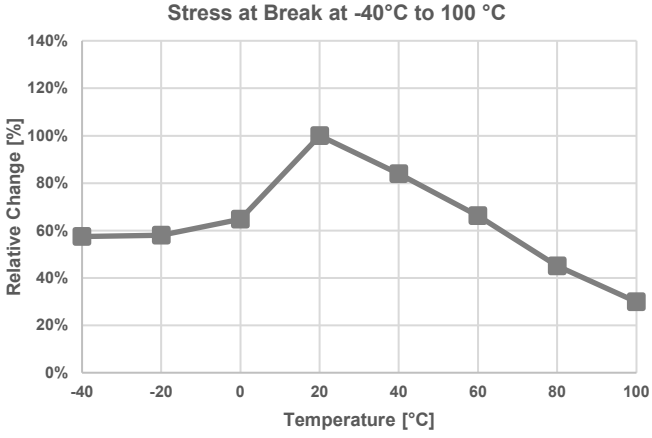
THERMAL INFLUENCE ON MECHANICAL PROPERTIES

LOCTITE 3D IND249 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:
FOR576509, FOR574696

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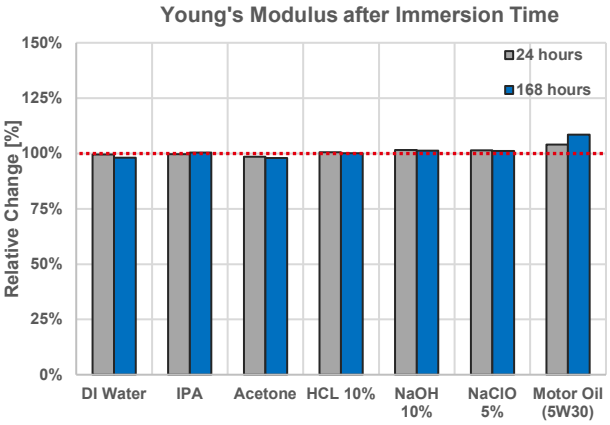
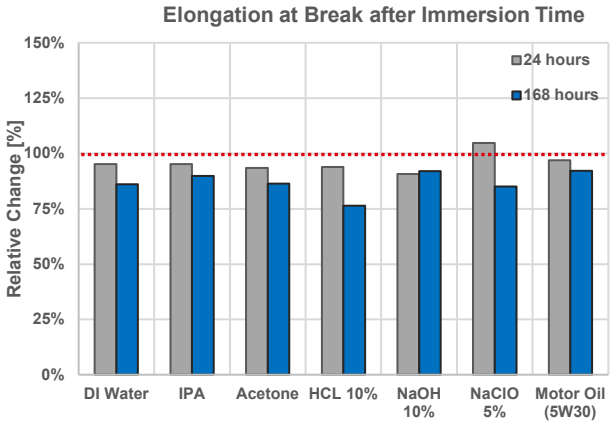
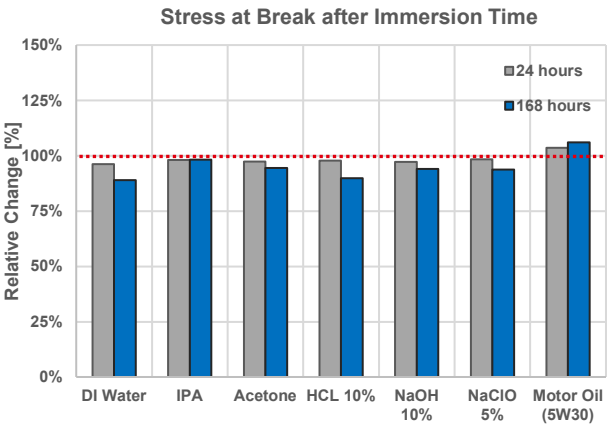
AGEING AND ENVIRONMENTAL EFFECTS – CHEMICAL RESISTANCE INDUSTRIAL

LOCTITE 3D IND249 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).

The 100% value represents the initial weight 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: FOR423057, IPA: FOR423062, Acetone: FOR423064, HCl 10 %: FOR423065, NaOH 10 %: FOR402572, NaClO 5 %: FOR402575, 5W30: FOR402578

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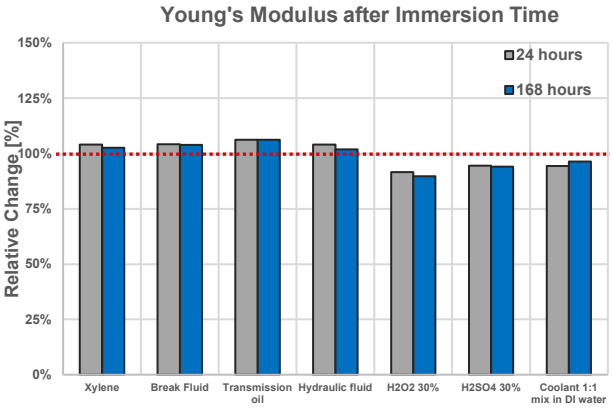
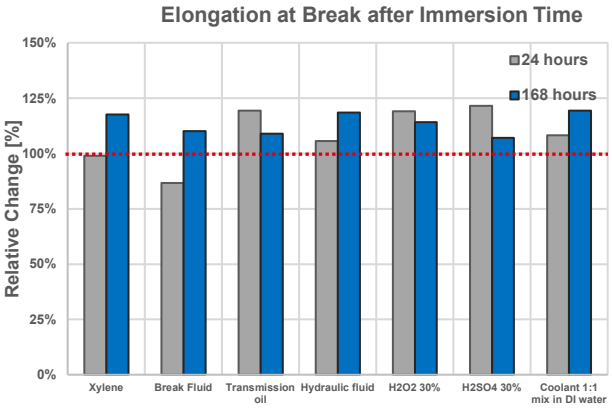
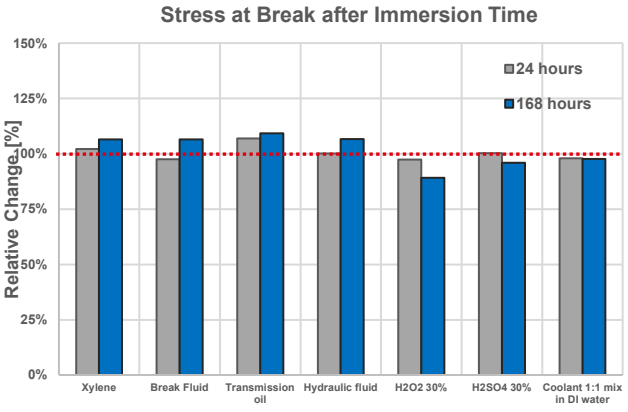
AGEING AND ENVIRONMENTAL EFFECTS – CHEMICAL RESISTANCE AUTOMOTIVE

LOCTITE 3D IND249 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).

The 100% value represents the initial weight 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 Transmission oil and Coolant mix 1:1 were stored at 50°C.

Properties of media used: pH(H_2SO_4 30%) = 0; pH(H_2O_2 30%) = 5; pH (NaCl solution 0.9%) = 5

Viscosity: Hydraulic fluid = 3000 mPas at 40°C; Transmission oil = 8200 mPas at 40°C;

Minimum temperature of coolant mix 1:1 = -40°C

Internal Data Sources:

Xylene: FOR666376, Break Fluid: FOR666380, Transmission oil: FOR666448, Hydraulic Fluid: FOR666450, Sulfuric acid 30%: FOR669883, Hydrogen Peroxide 30%: FOR669886, Coolant 1:1: FOR669911

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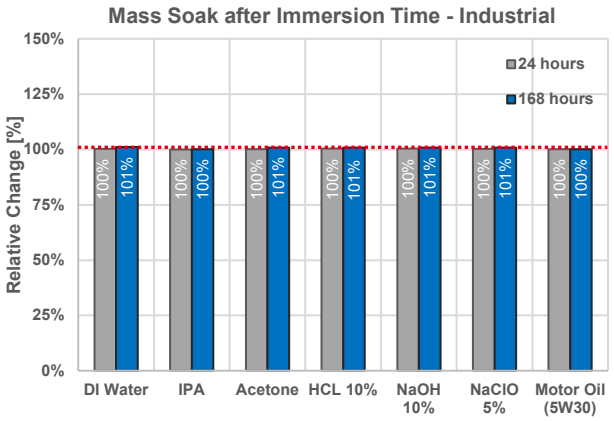
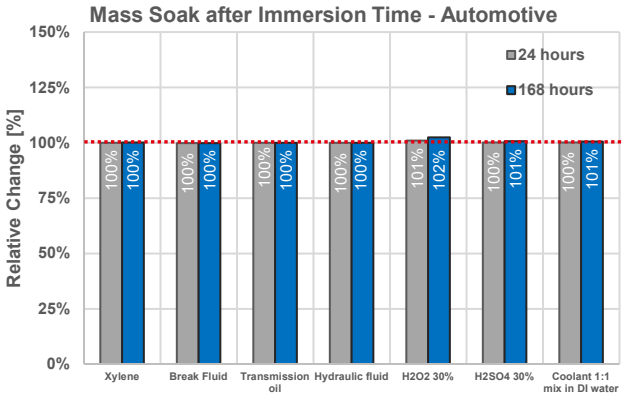
AGEING AND ENVIRONMENTAL EFFECTS – CHEMICAL RESISTANCE MASS SOAK

LOCTITE 3D IND249 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.

The 100% value 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; pH(H_2SO_4 30%) = 0; pH(H_2O_2 30%) = 5; pH (NaCl solution 0.9%) = 5
Viscosity: Hydraulic fluid = 3000 mPas at 40°C; Transmission oil = 8200 mPas at 40°C;
Minimum temperature for coolant mix 1:1 = -40°C

Internal Data Sources:
FOR423067, FOR423069, FOR423073, FOR423076, FOR402584, FOR402585, FOR402586, FOR666376, FOR666380, FOR666448, FOR666450, FOR669883, FOR669886, FOR669911

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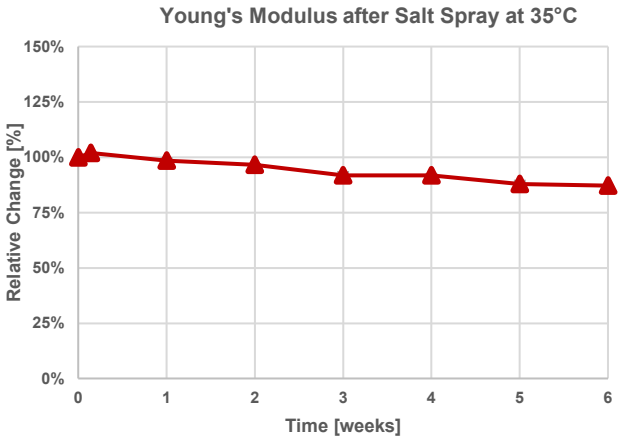
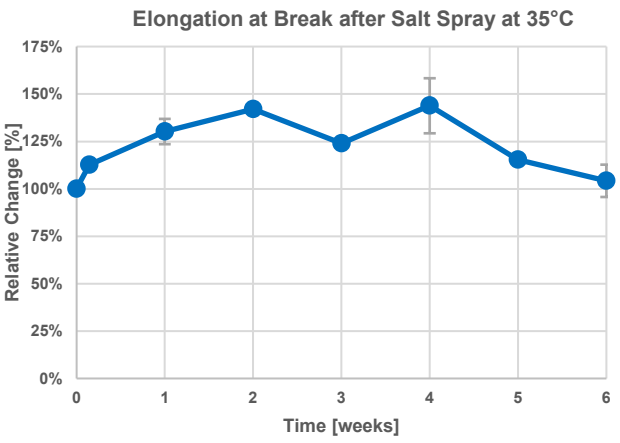
AGEING AND ENVIRONMENTAL EFFECTS – SALT SPRAY EXPOSURE

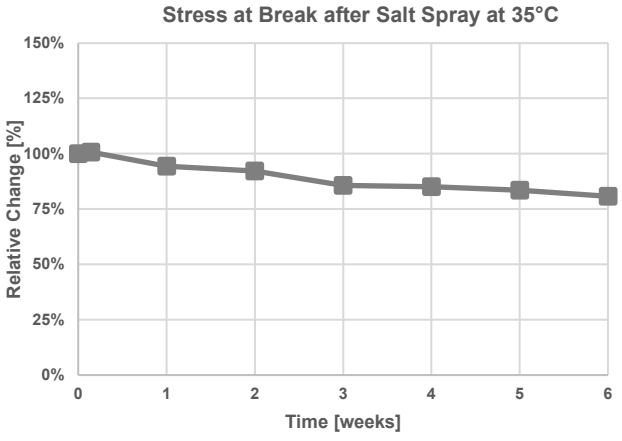
LOCTITE 3D IND249 BK was aged according to ASTM B117-19. During the test samples were exposed to salt spray at 35°C. After removal from the test chamber, exposed samples were dried, inspected, cleaned using water and wiped dry. Before mechanical testing, samples were conditioned for 24 hours at 22°C. 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).

Values at '0 weeks' are non-aged samples stored at 22°C and tested after 24 hours of 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 B117-19: pH = 6.1; Fog collection = 1.3 ml/h
ASTM D638, Type IV, Pull speed: 5 mm/min, Young's modulus measured at 0.1-1% (regression), 22°C

Internal Data Sources:
FOR592531

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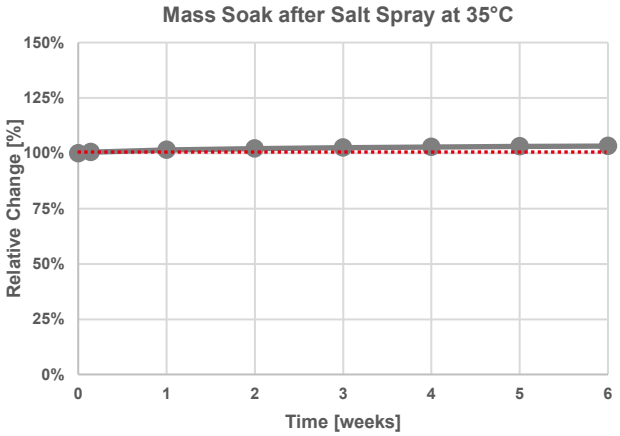
AGEING AND ENVIRONMENTAL EFFECTS – SALT SPRAY EXPOSURE

LOCTITE 3D IND249 BK has been tested after salt spray exposure according to ASTM B117-19. All samples were printed in the same print job using a validated workflow. After removal from the salt spray environment, exposed samples were dried, inspected, cleaned using water, wiped dry and immediately weighed.

The influence of the salt spray was measured by mass change after different exposure times. Samples were weighed after 24 hours and 1 to 6 weeks.

The 100% value represents the initial weight 24 hours after post-processing.



Test parameters:
ASTM B117-19: pH = 6.1; Fog collection = 1.3 ml/h

Internal Data Sources:
FOR592531

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NOTE

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