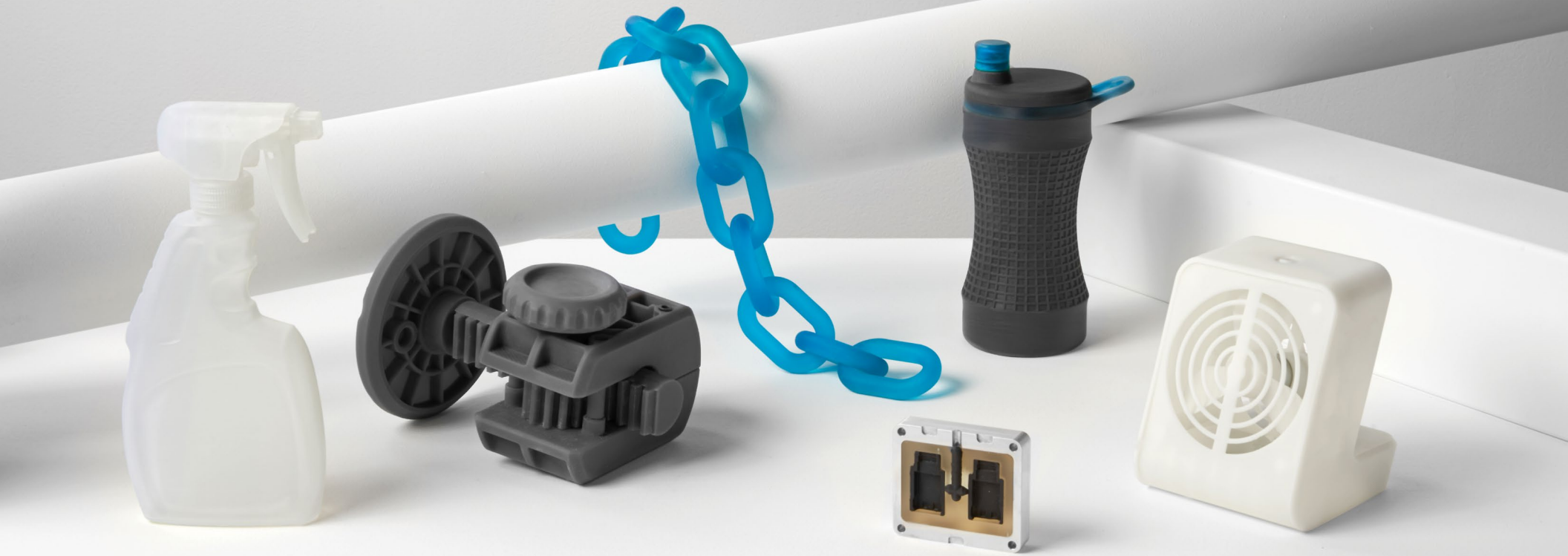
Materials Data Sheet

Photopolymer Resin for Form 1+ and Form 2



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formlabs

STANDARD RESINS

CLEAR FLGPCL04 | WHITE FLGPWH04 | GREY FLGPGR04 | BLACK FLGPBK04 | COLOR BASE FLGPCB01

	METRIC[1]		IMPERIAL[1]		METHOD
	Green[2]	Post-Cured[3]	Green[2]	Post-Cured[3]	
Tensile Properties					
Ultimate Tensile Strength	38 MPa	65 MPa	5510 psi	9380 psi	ASTM D 638-10
Tensile Modulus	1.6 GPa	2.8 GPa	234 ksi	402 ksi	ASTM D 638-10
Elongation at Failure	12 %	6.2 %	12 %	6.2 %	ASTM D 638-10
Flexural Properties					
Flexural Modulus	1.25 GPa	2.2 GPa	181 ksi	320 ksi	ASTM C 790-10
Impact Properties					
Notched IZOD	16 J/m	25 J/m	0.3 ft-lbf/in	0.46 ft-lbf/in	ASTM D 256-10
Temperature Properties					
Heat Deflection Temp. @ 264 psi	42.7 °C	58.4 °C	108.9 °F	137.1 °F	ASTM D 648-07
Heat Deflection Temp. @ 66 psi	49.7 °C	73.1 °C	121.5 °F	163.6 °F	ASTM D 648-07

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

[2] Data was obtained from green parts, printed using Form 2, 100 µm, Clear settings, washed and air dried without post cure.

[3] Data was obtained from parts printed using Form 2, 100 µm, Clear settings, and post-cured with 1.25 mW/cm^2 of 405 nm LED light for 60 minutes at 60 °C.

GREY PRO RESIN

FLPRGR01

	METRIC[1]		IMPERIAL[1]		METHOD
	Green[2]	Post-Cured[3]	Green[2]	Post-Cured[3]	
Tensile Properties					
Ultimate Tensile Strength	35 MPa	61 MPa	5076 psi	8876 psi	ASTM D 638-14
Tensile Modulus	1.4 GPa	2.6 GPa	203 ksi	377 ksi	ASTM D 638-14
Elongation	32.5 %	13 %	32.5 %	13 %	ASTM D 638-14
Flexural Properties					
Flexural Stress at 5% Strain	39 MPa	86 MPa	5598 psi	12400 psi	ASTM D 790-15
Flexural Modulus	0.94 GPa	2.2 GPa	136 ksi	319 ksi	ASTM D 790-15
Impact Properties					
Notched IZOD	not tested	18.7 J/m	not tested	0.351 ft-lbf/in	ASTM D256-10
Temperature Properties					
Heat Deflection Temp. @ 1.8 MPa	not tested	62.4 C	not tested	144.3 °F	ASTM D 648-16
Heat Deflection Temp. @ 0.45 MPa	not tested	77.5 C	not tested	171.5 °F	ASTM D 648-16
Thermal Expansion (-30 to 30° C)	not tested	78.5 um/m/C	not tested	43.4 µin/in/°F	ASTM E 831-13

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

[2] Data was obtained from green parts, printed using Form 2, 100 µm, Grey Pro settings, washed and air dried without post cure.

[3] Data was obtained from parts printed using Form 2, 100 µm, Grey Pro settings, and post-cured with a Form Cure for 120 minutes at 80 °C.

TOUGH RESIN

FLTOTL05

	METRIC[1]		IMPERIAL[1]		METHOD
	Green[2]	Post-Cured[3]	Green[2]	Post-Cured[3]	
Mechanical Properties					
Ultimate Tensile Strength	34.7 MPa	55.7 MPa	5040 psi	8080 psi	ASTM D 638-14
Tensile Modulus	1.7 GPa	2.7 GPa	239 ksi	387 ksi	ASTM D 638-14
Elongation at Break	42 %	24 %	42 %	24 %	ASTM D 638-14
Flexural Strength at 5% Strain	20.8 MPa	60.6 MPa	3020 psi	8790 psi	ASTM D 790-15
Flexural Modulus	0.6 GPa	1.6 GPa	90.3 ksi	241 ksi	ASTM D 790-15
Notched IZOD	32.6 J/m	38 J/m	0.61 ft-lbf/in	0.71 ft-lbf/in	ASTM D256-10
Thermal Properties					
Heat Deflection Temp. @ 1.8 MPa	32.8 °C	45.9 °C	91.1 °F	114.6 °F	ASTM D 648-16
Heat Deflection Temp. @ 0.45 MPa	40.4 °C	48.5 °C	104.7 °F	119.3 °F	ASTM D 648-16
Thermal Expansion (23 – 50 °C)	159.7 µm/m/°C	119.4 µm/m/°C	88.7 µin/in/°F	66.3 µin/in/°F	ASTM E 831-13

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

[2] Data was obtained from green parts, printed using Form 2, 100 µm, Tough settings, washed and air dried without post cure.

[3] Data was obtained from parts printed using Form 2, 100 µm, Tough settings, and post-cured with 2.5 mW/cm^2 of 405 nm LED light for 120 minutes at 60 °C.

RIGID RESIN

FLRGWH01

	METRIC[1]		IMPERIAL[1]		METHOD
	Green[2]	Post-Cured[3]	Green[2]	Post-Cured[3]	
Tensile Properties					
Ultimate Tensile Strength	40 MPa	75 MPa	5801 psi	10907 psi	ASTM D 638-14
Tensile Modulus	2.2 GPa	4.1 GPa	319 ksi	594 ksi	ASTM D 638-14
Elongation	13.3 %	5.6 %	13.3 %	5.6 %	ASTM D 638-14
Flexural Properties					
Flexural Stress at 5% Strain	49 MPa	121 MPa	7135 psi	17593 psi	ASTM D 790-15
Flexural Modulus	1.37 GPa	3.7 GPa	198 ksi	537 ksi	ASTM D 790-15
Impact Properties					
Notched IZOD	not tested	18.8 J/m	not tested	0.37 ft-lbf/in	ASTM D256-10
Temperature Properties					
Heat Deflection Temp. @ 1.8 MPa	not tested	74 °C	not tested	165.2 °F	ASTM D 648-16
Heat Deflection Temp. @ 0.45 MPa	not tested	88 °C	not tested	190.4 °F	ASTM D 648-16
Thermal Expansion (-30 to 30° C)	not tested	53 µm/m/°C	not tested	29.5 µin/in/°F	ASTM E 831-13

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

[2] Data was obtained from green parts, printed using Form 2, 100 µm, Rigid settings, washed and air dried without post cure.

[3] Data was obtained from parts printed using Form 2, 100 µm, Rigid settings, and post-cured with a Form Cure for 120 minutes at 80 °C.

DURABLE RESIN

FLDUCL02

	METRIC[1]		IMPERIAL[1]		METHOD
	Green[2]	Post-Cured[3]	Green[2]	Post-Cured[3]	
Tensile Properties					
Ultimate Tensile Strength	18.6 MPa	31.8 MPa	2.7 ksi	4.61 ksi	ASTM D 638-10
Tensile Modulus	0.45 GPa	1.26 GPa	65.7 ksi	183 ksi	ASTM D 638-10
Elongation	67 %	49 %	67 %	49 %	ASTM D 638-10
Flexural Properties					
Flexural Stress at 5% Strain	4.06 MPa	27.2 MPa	0.59 ksi	3.95 ksi	ASTM D 790-10, Procedure A
Flexural Modulus	0.16 GPa	0.82 GPa	23.4 ksi	119 ksi	ASTM D 790-10, Procedure A
Impact Properties					
Notched IZOD	130.8 J/m	109 J/m	2.46 ft-lbf/in	2.05 ft-lbf/in	ASTM D 256-10, Test Method A
Temperature Properties					
Heat Deflection Temp. @ 0.45 MPa	< 30 °C	43.3 °C	< 86 °F	110 °F	ASTM D 648-07, Method B
Thermal Expansion (23 to 50° C)	117.0 µm/m/°C	145.1 µm/m/°C	65.0 µin/in/°F	80.6 µin/in/°F	ASTM E831-14

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

[2] Data was obtained from green parts, printed using Form 2, 100 µm, Durable settings, washed and air dried without post cure.

[3] Data was obtained from parts printed using Form 2, 100 µm, Durable settings, and post-cured with 2.5 mW/cm^2 of 405 nm LED light for 120 minutes at 60 °C.

HIGH TEMP RESIN

FLHTAM01

	METRIC[1]		IMPERIAL[1]		METHOD
	Green[2]	Post-Cured[3]	Green[2]	Post-Cured[3]	
Mechanical Properties					
Ultimate Tensile Strength	33 MPa	51.1 MPa	4790 psi	7410 psi	ASTM D 638-14
Tensile Modulus	1.5 GPa	3.6 GPa	222 ksi	525 ksi	ASTM D 638-14
Elongation at Break	9 %	2 %	9 %	2 %	ASTM D 638-14
Flexural Strength at Break	41.2 MPa	106.9 MPa	5980 psi	15500 psi	ASTM D 790-15
Flexural Modulus	1.1 GPa	3.3 GPa	158 ksi	478 ksi	ASTM D 790-15
Notched IZOD	12.3 J/m	14 J/m	0.23 ft-lbf/in	0.26 ft-lbf/in	ASTM D 256-10
Water Absorption	N/A	0.21 %	N/A	0.21 %	ASTM D 570-98
Thermal Properties					
Heat Deflection Temp. @ 1.8 MPa	42.3 °C	130 °C	108.1 °F	266 °F	ASTM D 648-16
Heat Deflection Temp. @ 0.45 MPa	55.9 °C	289 °C	132.6 °F	552.2 °F	ASTM D 648-16
Thermal Expansion (0 – 150 °C)	120.9 µm/m/°C	87.5 µm/m/°C	67.2 µin/in/°F	48.6 µin/in/°F	ASTM E 831-13

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

[2] Data was obtained from green parts, printed using Form 2, 100 µm, High Temp settings, washed and air dried without post cure.

[3] Data was obtained from parts printed using Form 2, 100 µm, High Temp settings, and post-cured with 80.5 mW/cm^2 of 365 nm fluorescent light for 60 minutes, plus additional thermal post cure at 130 °C for 1 hour.

FLEXIBLE RESIN

FLFLGR02

	METRIC[1]		IMPERIAL[1]		METHOD
	Green	Post-Cured[2]	Green	Post-Cured[2]	
Mechanical Properties					
Ultimate Tensile Strength[3]	3.3 - 3.4 MPa	7.7 - 8.5 MPa	483 - 494 psi	1100 - 1230 psi	ASTM D 412-06 (A)
Elongation at Failure[3]	60 %	75 - 85 %	60 %	75 - 85 %	ASTM D 412-06 (A)
Compression Set[4]	0.40 %	0.40 %	0.40 %	0.40 %	ASTM D 395-03 (B)
Tear Strength[5]	9.5 - 9.6 kN/m	13.3 - 14.1 kN/m	54 - 55 lbf/in	76 - 80 lbf/in	ASTM D 624-00
Shore Hardness	70 - 75 A	80 - 85 A	70 - 75 A	80 - 85 A	ASTM 2240
Thermal Properties					
Vicat Softening Point[6]	231 °C	230 °C	448 °F	446 °F	ASTM D 1525-09

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

[2] Data was obtained from parts printed using Form 2, 100 µm, Flexible settings, and post-cured with 80.5 mW/cm2 of 365 nm fluorescent light for 60 minutes.

[3] Tensile testing was performed after 3+ hours at 23 °C, using a Die C dumbbell and 20 in/min cross head speed.

[4] Compression testing was performed at 23 °C after aging at 23 °C for 22 hours.

[5] Tear testing was performed after 3+ hours at 23 °C, using a Die C tear specimen and a 20 in/min cross head speed.

[6] Thermal testing was performed after 40+ hours with a 10 N loading at 50 °C/hour. Cracks formed in samples during testing.

CASTABLE WAX RESIN

FLCWPU01

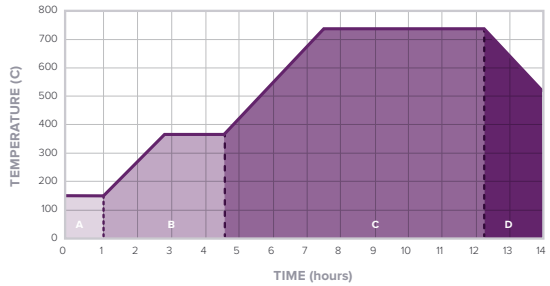
	METRIC[1]	IMPERIAL[1]	METHOD
Tensile Properties [2]			
Ultimate Tensile Strength	11.6 MPa	1680 psi	ASTM D 638-10
Tensile Modulus	220 MPa	32 ksi	ASTM D 638-10
Elongation at Break	13 %	13 %	ASTM D 638-10
Burnout Properties [2]			
Temp @ 5% Mass Loss	249 °C	480 °F	ASTM E 1131
Ash content (TGA)	0.0-0.1%	0.0-0.1%	ASTM E 1131

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

[2] Data was obtained from parts printed using Form 2, Castable 50 µm Fine Detail settings and washed without post-cure.

The Standard Burnout Schedule is designed to provide the maximum possible investment strength and complete burnout of the finest details using R&R Plasticast or similar investment materials. Use this schedule as a starting point and make adjustments as needed.

JEWELRY CASTING BURNOUT SCHEDULE – CASTABLE WAX RESIN



	PHASE	TIME	SCHEDULE °C	SCHEDULE °F
A	Insert Flasks	0 min	150 °C	302 °F
	Hold	60 min	150 °C	302 °F
B	Ramp	100 min	2.2 °C / min	4 °F / min
	Hold	120 min	371 °C	700 °F
C	Ramp	180 min	2.0 °C / min	3.6 °F / min
	Hold	280 min	732 °C	1350 °F
D	Ramp	100 min	- 2.2 °C / min	- 4 °F / min
	Hold (casting window)	Up to 2 hours	512 °C or casting temp	954 °F or casting temp

Post-Curing Info:

No post-cure required.

CASTABLE RESIN

FLCABL02

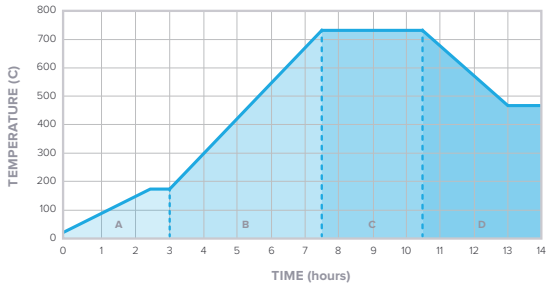
	METRIC[1]	IMPERIAL[1]	METHOD
Mechanical Properties [2]			
Tensile Strength at Break	11.6 MPa	1680 psi	ASTM D 638-10
Tensile Modulus	220 MPa	32 ksi	ASTM D 638-10
Elongation at Failure	13 %	13 %	ASTM D 638-10

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

[2] Data was obtained from parts printed using Form 2, Castable 50 µm Fine Detail settings, and post-cured with 2.5 mW/cm² of fluorescent bulb UV light, centered at 405 mm.

We specifically recommend Plasticast with BANDUST. If seeking alternatives, look for investments advertised to work with photopolymers. Customers have reported success with Kerr SatinCast and Omega+ by Goldstar Powders. You can also experiment with bonded investments, like those typically used for dental applications. Some casting houses have also developed proprietary investments.

JEWELRY CASTING BURNOUT SCHEDULE – CASTABLE RESIN



	PHASE	TIME	SCHEDULE °C	SCHEDULE °F
A	Insert Flasks	0 min	Room temp	Room temp
	Ramp	150 min	1.0 °C / min	1.9 °F / min
	Hold	30 min	177 °C	350 °F
B	Ramp	270 min	2.1 °C / min	3.7 °F / min
C	Hold	180 min	732 °C	1350 °F
D	Ramp	150 min	- 1.7 °C / min	- 3.0 °F / min
	Hold (casting window)	Up to 2 hours	482 °C or desired casting temp	900 °F or desired casting temp

Post-Curing Info:

Formlabs recommends post-curing Castable Resin parts for 280 minutes at 45 °C.

DENTAL LT CLEAR

FLDLCL01

	METRIC[1]	METHOD[1]
	Post-cured[2]	
Flexural Properties		
Ultimate Flexural Strength	≥ 50 MPa (no break)	ISO 20795-2:2013
Flexural Modulus	≥ 1300 Mpa	ISO 20795-2:2013
Hardness Properties		
Hardness Shore D	80 - 90D	ISO 868:2003
Impact Properties		
Maximum stress intensity factor	≥ 1.1 MPa•m^{½}	ISO 179:2010
Total fracture work	≥ 250 J/m²	ISO 20795-2:2013

Dental LT Clear is tested at NAMSA, Chasse sur Rhône in France, and is certified biocompatible per EN-ISO 10993-1:2009/AC:2010. Further details are available upon request.

The product is in compliance with ISO Standards:

- EEN ISO 1641:2009
- EN-ISO 10993-1:2009/AC:2010
- EN-ISO 10993-3:2009
- EN-ISO 10993-5:2009
- EN 908:2008

NOTES:

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

[2]Data refers to post-cured properties obtained after exposing green parts to 108 watts each of Blue UV-A (315 – 400 nm) and UV-Blue (400 – 550 nm) light, in a heated environment at 80 °C (176 °F), with six (6) 18W/71 lamps (Dulux L Blue) and six (6) 18W/78 lamps (Dulux blue UV-A) for 20 minutes.

DENTAL MODEL

FLDMBE02

	METRIC[1]		IMPERIAL[1]		METHOD
	Green[2]	Post-Cured[3]	Green[2]	Post-Cured[3]	
Mechanical Properties					
Tensile Strength at Yield	33 MPa	61 MPa	4800 psi	8820 psi	ASTM D 638-14
Tensile Modulus	1.6 GPa	2.7 GPa	230 ksi	397 ksi	ASTM D 638-14
Elongation at Failure	25 %	5 %	25 %	5 %	ASTM D 638-14
Flexural Properties					
Flexural Modulus	0.95 GPa	2.5 GPa	138 ksi	365 ksi	ASTM D 790-15
Flexural Strength at 5% Strain	33.9 MPa	95.8 MPa	4910 psi	13900 psi	ASTM D 790-15
Impact Properties					
Notched IZOD	27 J/m	33 J/m	0.5 ft-lbf/in	0.6 ft-lbf/in	ASTM D256-10
Thermal Properties					
Heat Deflection Temp. @ 264 psi	32.8 °C	45.9 °C	91.1 °F	114.6 °F	ASTM D 648-16
Heat Deflection Temp. @ 66 psi	40.4 °C	48.5 °C	104.7 °F	119.3 °F	ASTM D 648-16

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

[2] Data was obtained from green parts, printed using Form 2, 100 µm, Dental Model settings, washed and air dried without post cure.

[3] Data was obtained from parts printed using Form 2, 100 µm, Dental Model settings, and post-cured with 1.25 mW/cm² of 405 nm LED light for 60 minutes.

DENTAL SG

FLDGOR01

	METRIC[1]	METHOD[1]
	Post-Cured[2]	
Flexural Properties		
Flexural Strength	≥ 50 MPa	ISO 20795-1:2013
Flexural Modulus	≥ 1500 Mpa	ISO 20795-1:2013
Hardness Properties		
Hardness Shore D	≥ 80 D	per ISO 868:2003
Impact Properties		
Charpy Impact Strength Unnotched	12 - 14 kJ/m²	ISO 179:2010

Dental SG is tested at NAMSA, Chasse sur Rhône in France, and is certified biocompatible per EN-ISO 10993-1:2009/AC:2010:

- Non-mutagenic.
- Non-cytotoxic.
- Not induce any erythema or edema reactions.
- Not a sensitizer.
- Not cause systemic toxicity.

The product is in compliance with ISO Standards:

- EN-ISO 20795-1:2013 (Dentistry – Base Polymers – Part 1: Denture Base Polymers)
- EN-ISO 7405:2009/A1:2013 (Dentistry – Evaluation of biocompatibility of medical devices used in dentistry)
- EN-ISO 10993-1:2009/AC:2010 (Biological evaluation of medical devices – Part 1 – Evaluation and testing)

NOTES:

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

[2]Data refers to post-cured properties obtained after exposing green parts to 108 watts each of Blue UV-A (315 – 400 nm) and UV-Blue (400 – 550 nm) light, in a heated environment at 60 °C (140 °F), with six (6) 18W/71 lamps (Dulux L Blue) and six (6) 18W/78 lamps (Dulux blue UV-A).

SOLVENT COMPATIBILITY

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

	24 HR WEIGHT GAIN (%)							DENTAL MODEL	
Solvent	**STANDARD** (tested with clear)	**GREY PRO**	**RIGID**	**TOUGH**	**DURABLE**	**FLEXIBLE**	**HIGH TEMP**	**GREEN**	**POST CURED**
Acetic Acid, 5 %	< 1	<1	<1	2.8	1.3	1.3	< 1	G *	G
Acetone	sample cracked	10.8	3.3	sample cracked	sample cracked	33	< 1	X	X *
Isopropyl Alcohol	< 1	1.6	<1	2.1	5.1	9.8	< 1	X	G
Bleach, ~5 % NaOCl	< 1	<1	<1	1.7	< 1	1.1	< 1	G	G
Butyl Acetate	< 1	<1	<1	1.6	7.9	16	< 1	X	G
Diesel	< 1	<1	<1	< 1	< 1	not tested	< 1	not tested	not tested
Diethyl glycol monomethyl ether	1.7	2.4	1.4	6.6	7.8	30	< 1	X	G
Hydrolic Oil	< 1	<1	<1	< 1	< 1	not tested	< 1	not tested	not tested
Skydrol 5	1	<1	1.1	1.2	1.3	not tested	not tested	not tested	not tested
Hydrogen Peroxide (3 %)	< 1	<1	<1	2.1	1	1.3	< 1	G	G
Isooctane	< 1	<1	<1	< 1	< 1	< 1	< 1	G	G
Mineral Oil, light	< 1	<1	<1	< 1	< 1	not tested	< 1	not tested	not tested
Mineral Oil, heavy	< 1	<1	<1	< 1	< 1	not tested	< 1	not tested	not tested
Salt Water (3.5 % NaCl)	< 1	<1	<1	1.5	< 1	< 1	< 1	G	G
Sodium hydroxide (0.025 %, pH = 10)	< 1	<1	<1	1.5	< 1	1	< 1	G	G
Water	< 1	<1	<1	1.6	< 1	not tested	not tested	G	G
Xylene	< 1	<1	<1	< 1	6.5	29	not tested	X	G
Strong Acid (HCl Conc)	distorted	8.2	5.3	distorted	distorted	not tested	not tested	not tested	not tested

* **G = Good resistance.** Parts exposed to this solvent should not experience a decrease in mechanical properties. (≤ 1% weight gain, ≤ 1% width increase over 24 hours for a 1 x 1 x 1 cm cube)

* **X = Unacceptable resistance.** Parts exposed to this solvent will experience a significant decrease in mechanical properties as well as visible degradation. (> 2% weight gain, > 2% width increase over 24 hours for a 1 x 1 x 1 cm cube)