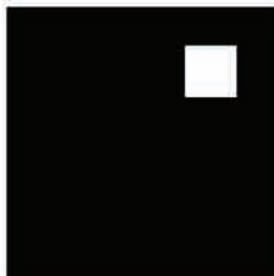
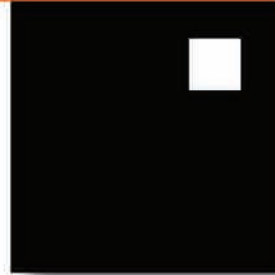
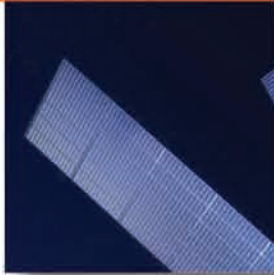




Creative Partners in a Material World

## Controlled Volatility Materials Selection Guide



**NuSil Technology** offers the most extensive line of aerospace-applicable silicone materials in the industry, from adhesives and sealants to coatings. ISO 9001-certified since 1994, NuSil operates state-of-the-art laboratories and processing facilities in North America and Europe and provides on-site, in-person application engineering support worldwide.

## Controlled Volatility (CV) Silicone Materials

Silicone's ability to remain elastic at low temperatures and resistant to breakdown at high temperatures offer excellent utility in extraterrestrial environments where materials are repeatedly exposed to extreme temperatures. NuSil's **Controlled Volatility (CV)** and **Ultra Low Outgassing™** (SCV) silicone products are used by leading space programs to provide the much-needed resilient protection they require against contamination and material degradation.

## Benefits of Silicone Materials for Space

- Broad Operating Temperature
- Compensation for CTE Mismatch
- Protection Against Atomic Oxygen
- Optically Clear Formulations
- Flight Legacy

## Outgassing in Extraterrestrial Environments

Silicones are used on spacecrafts for a wide variety of applications such as: adhesives, sealants, gaskets, and protective coatings. The contamination of components from the use of silicone products on Low Earth Orbit (LEO) spacecrafts is a major concern in the aerospace industry. When silicone is bombarded with Atomic Oxygen (AO) in LEO, it results in the oxidation of methyl groups and the gradual conversion of silicone to silica. This reaction can have detrimental consequences that result in contamination of spacecraft surfaces when low molecular weight, highly volatile, silicone molecules can outgas from the silicone matrix and then recondense on spacecraft surfaces. The deposited silicone may be attacked by AO and converted to silica before re-evaporation is able to occur. The non-volatile silica deposits gradually accumulate over time into low stress crack free coatings. Silica deposits that accumulate on optical surfaces can darken from UV radiation exposure and thicken enough to eventually reduce optical transmittance, diffuse reflectance, and increase absorptance.<sup>1</sup>

The contaminating volatile silicone species are a product of the initial polymerization reaction used to produce a silicone polymer. In a basic Ring Opening Polymerization reaction, the product is a mixture of various molecular weights of cyclics, short chained linear molecules, and higher molecular weight polymers where the concentrations of each species is based on its thermodynamic equilibrium. The low molecular weight linear and cyclic silicones that are not cured into the silicone network easily outgas in low vacuum and high temperature environments. These species must be removed to prevent contamination for low outgassing applications. NuSil's commitment to making advances in formulating, processing and testing have created a new generation of silicone products. The **Ultra Low Outgassing™** line of products, in addition to our current **Controlled Volatility** materials, have excellent performance and low outgassing characteristics in vacuum environments.

## Operating Temperature

The operating temperature range of a silicone in any application is dependent on many variables, including but not limited to: temperature, time of exposure, type of atmosphere, exposure of the material's surface to the atmosphere, and mechanical stress. In addition, a material's physical properties will vary at both the high and low end of the operating temperature range. Silicone typically remains flexible at extremely low temperatures and has been known to perform at -140 °C as well as resist breakdown at elevated temperatures up to 315 °C. The user is responsible to verify performance of a material in a specific application.

## Testing of Low Outgassing Silicones

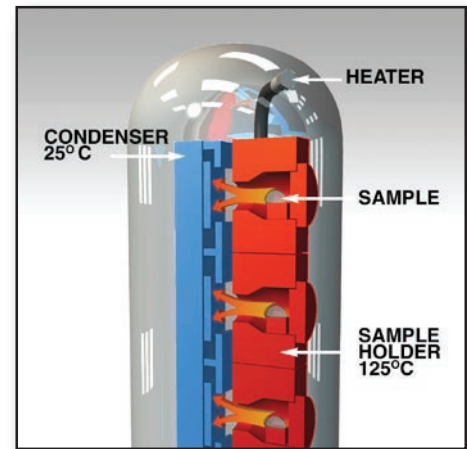
NASA and the European Space Agency (ESA) require materials to be tested per ASTM E-595<sup>3</sup> prior to use in space. These materials must meet the specifications outlined in NASA SP-R-0022A and ESA PSS-014-702, with a maximum Total Mass Loss (TML) of 1% and Collected Volatile Condensable Material (CVCM) of less than 0.1%.<sup>4,5</sup>

**NuSil's Controlled Volatility (CV) materials meet or exceed the  $\leq 1\%$  TML and  $\leq 0.1\%$  CVCM requirements. In addition, our Ultra Low Outgassing™ (SCV) materials exceed the current ASTM E 595 by an order of magnitude,  $\leq 0.1\%$  TMLs and  $\leq 0.01\%$  CVCM.**

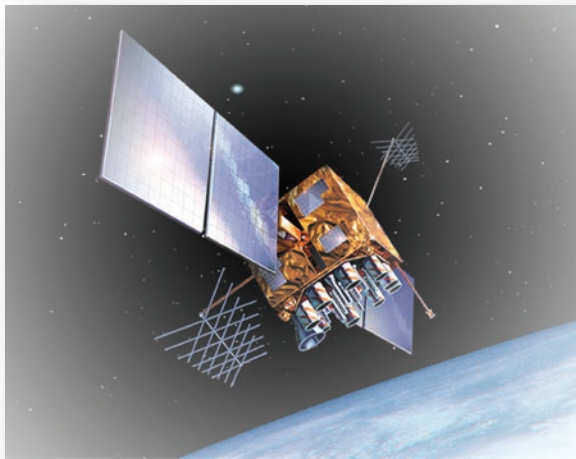
	SCV-2590	SCV-2590-2	SCV1-2590	SCV2-2590	SCV-2596	SCV1-2596	SCV1-2599
% TML	0.07%	0.07%	0.06%	0.07%	0.09%	0.06%	0.08%
% CVCM	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%

\* These properties do not provide a basis for customer specifications. Please contact NuSil Technology prior to drafting any specifications for NuSil Technology Products.

NuSil Technology performs ASTM E 595 testing to certify all CV and SCV silicones on a lot-to-lot basis. First, the sample material is exposed to 23°C and 50% relative humidity for 24 hours, and then it is weighed and loaded into a test chamber. The sample is then heated to 125°C at less than  $5 \times 10^{-5}$  torr. Any volatile components of the sample that outgas under these conditions escape through an exit port and condense on a collector plate that is maintained at 25°C. After 24 hours the chamber is cooled and depressurized with dry inert gas. The collector plate and samples are then weighed to determine the percentage of weight change, determining % TML and % CVCM.



**ASTM E 595 Test Chamber  
of CV-24 Test Stand**



### Additional Resources

All of NuSil's low outgassing materials are tested by NASA and the ESA. The testing data is available at <http://outgassing.nasa.gov>.

To view more information and review white papers on NuSil's low outgassing products visit our website [www.NuSil.com](http://www.NuSil.com).

<sup>1</sup> Banks, BA. Et al., *Consequences of Atomic Oxygen Interaction with Silicone and Silicone Contamination on Surfaces in Low Earth Orbit*. SPIE, 1999, 3784, 62-71.

<sup>2</sup> De Groh, et al, *Low Earth Orbital Durability of Protected Silicones for Refractive Photovoltaic Concentrator Arrays*, J. Spacecraft & Rockets, 1995. 32, 1.

<sup>3</sup> ASTM E 595, "Standard Test Method for Total Mass Loss and Collected Condensable Materials from Outgassing in a Vacuum Environment."

<sup>4</sup> NASA SP-R-0022A

<sup>5</sup> ESA PSS-014-702



# CONTROLLED VOLATILITY MATERIALS

General Purpose	NuSil Product Number	Comments	Cure System	Work Time	Tack Free Time	Cure Time / Temp °C	Specific Gravity	Durometer Type A	Tensile psi (mPa)	Elongation %	Tear ppi (kN/m)	CTE ppm/°C	Dielectric Strength V/mil	Flow (Inches) Viscosity (cP/mPa-sec) Extrusion (g/min)	Mix Ratio	Color	
Materials are tested in accordance with ASTM E 595 Total Mass Loss (TML) of ≤ 1.0% and Collected Volatile Condensable Materials (CVCM) of ≤ 0.10%																	
Properties listed are typical - Do not use as a basis for preparing specifications. Please contact NuSil Technology for assistance and recommendations.																	
ELECTRICALLY CONDUCTIVE / STATIC DISSIPATIVE	CV-1500	3.0 ohm·cm, Primed Lap Shear 325 psi (2.2 MPa), 0.32 W/m·K, Broad Operating Temperature	Oxime	-	10 m	7 d / R.T., H	1.25	80	650 (4.5)	20	-	435	-	Thixotropic	-	Black	
	CV-2640	2.5 ohm·cm, <sup>4)</sup> Primed Lap Shear 250 psi (1.7 MPa), Carbon Fiber Filled, Broad Operating Temp	Platinum	2 h	-	30 m / 150	1.19	75	475 (3.3)	90	-	580	-	-	10:1	Black	
	CV1-2640	25 ohm·cm, Pumpable	Platinum	-	-	2 h / 65	1.07	40	525 (3.62)	225	-	-	-	A:300 g/min / B:150 g/min	10:1	Black	
	CV2-2640	Carbon Black Filled, Broad Operating Temperature	Platinum	60 m	-	24 h / R.T.	1.06	30	515 (3.6)	365	30 (0.05)	-	-	A:1,250,000 / B:100,000	1:1	Black	
	CV3-2640	2.2 x 10 <sup>6</sup> ohm·cm, Broad Operating Temperature	Platinum	-	10 h	7 d / R.T.	1.01	25	70 (0.48)	120	-	-	-	A:10,000 / B:10,000	1:1	Black	
	CV-2644	0.005 ohm·cm, <sup>25)</sup> 1.2 W/m·K	Platinum	3 h	-	30 m / 150	3.39	85	525 (3.6)	-	-	215	-	Paste	20:1	Tan	
	CV2-2644	0.004 ohm·cm	Platinum	2.5 h	-	30 m / 150	3.04	85	500 (3.4)	100	-	-	-	Paste	20:1	Tan	
	CV-2646	0.007 ohm·cm, <sup>25)</sup> 1.0 W/m·K, Broad Operating Temperature	Alcoxy	3.5 h	-	10 d / R.T., H	3.86	80	400 (2.8)	90	60 (10.5)	185	-	Paste	100:0.5	Tan	
	CV1-2646	0.005 ohm·cm, Broad Operating Temperature	Alcoxy	2.5 h	-	7 d / R.T., H	2.20	90	-	-	-	-	-	0 inches	100:0.5	Tan	
	CV2-2646	0.003 ohm·cm, <sup>21, 22)</sup> 1.5 W/m·K, Remains Conductive at High Temperature	Alcoxy	2 h	-	7 d / R.T., H	3.23	75	300 (2.06)	70	55 (9.7)	-	-	4 inches	100:0.5	Gray/Green	
THERMALLY CONDUCTIVE	CV-2900	<sup>25)</sup> 0.6 W/m·K, Broad Operating Temperature	Oxime	-	35 m	72 h / R.T., H	2.34	65	400 (2.8)	150	-	-	-	40 g/min	-	White	
	CV-2942	<sup>25)</sup> 0.999 W/m·K, <sup>4)</sup> Primed Lap Shear 375 psi (2.6 MPa)	Platinum	2.5 h	4 h	24 h / R.T.**	2.40	85	650 (4.5)	15	55 (9.7)	185	430	Paste	20:1	Gray	
	CV-2943	<sup>25)</sup> 1.22 W/m·K, <sup>3)</sup> Primed Lap Shear 475 psi (3.3 MPa), Broad Operating Temperature	Alcoxy	2 h	-	7 d / R.T., H	2.55	90	750 (5.17)	35	90 (15.9)	130	-	Paste	100:0.2	Gray	
	CV-2946	<sup>25)</sup> 1.49 W/m·K, <sup>4)</sup> Primed Lap Shear 165 psi (1.0 MPa), Conductive at Elevated Temps	Platinum	2 h	4.5 h	7 d / R.T.	1.53	75	200 (1.38)	30	50 (8.8)	-	540	Paste	15:1	White	
	CV2-2946	<sup>22)</sup> 0.644 W/m·K, Thin Bond Line	Platinum	3 h	-	30 m / 150	-	55	400 (2.75)	225	55 (9.7)	-	-	140 g/min	20:1	White	
	CV-2948	<sup>25)</sup> 1.95 W/m·K, <sup>3)</sup> Primed Lap Shear 150 psi (1.0 MPa), Broad Operating Temperature	Alcoxy	2.5 h	-	7 d / R.T., H	1.57	80	250 (1.20)	30	45 (7.9)	-	-	Paste	100:0.2	White	
	CV-2960	<sup>25)</sup> 0.828 W/m·K, <sup>4)</sup> Primed Lap Shear 205 psi (1.4 MPa), Low Viscosity	Platinum	1.5 h	3 h	7 d / R.T.	1.34	60	205 (1.4)	110	45 (7.1)	275	-	A:130,000	10:1	White	
	CV1-2960	<sup>22)</sup> 1.11 W/m·K	Platinum	2 h	4 h	4 h / 65	1.45	75	250 (1.38)	60	55 (9.7)	-	-	A:900,000	10:1	White	
	CV1-2964	<sup>25)</sup> 0.95 W/m·K, <sup>5)</sup> Primed Lap Shear 120 psi (0.8 Mpa)	Platinum	-	13 h	15 m / 150	2.34	65	180 (1.2)	50	-	-	-	52,000	1:1	White	
	CV-2961	<sup>25)</sup> 0.791 W/m·K Low Viscosity, <sup>3)</sup> Primed Lap Shear 205 psi (1.4 MPa), Broad Operating Temperature	Platinum	2 h	-	30 m / 150	1.38	75	275 (1.9)	40	45 (7.9)	275	-	A:300,000	10:1	White	
	CV-2963	<sup>22)</sup> 0.64 W/m·K, <sup>4)</sup> Primed Lap Shear 275 psi (1.9 MPa)	Platinum	2 h	-	4 h / 65	1.27	60	425 (2.9)	250	50 (8.8)	-	-	Paste	20:1	White	
	DAMPENING FLUIDS, LUBRICANTS & GREASES	CV-7300	Refractive Index 1.40	-	-	-	-	0.97	-	-	-	-	-	-	1,000 to 100,000	-	Clear
CV-9042		Thermally Conductive	-	-	-	-	1.61	-	-	-	-	-	-	Medium Grease	-	White	
CV-9052		Volume Resistivity 1x10 <sup>15</sup> ohm·cm	-	-	-	-	1.10	-	-	-	-	-	-	Medium Grease	-	Grey	
CV-9341		Thermally Conductive	-	-	-	-	2.30	-	-	-	-	-	-	Medium Grease	-	White	
FILM ADHESIVES	FILMS	CV-2680-12	0.012 inches (12 microns) Thick, 2-Part Film, Lap Shear 250 psi (1.7 MPa)	Platinum	4 h	-	4 h / 65	-	-	-	-	465	-	-	-	Trans	
		CV-2681-12	Volume Resistivity, 125 ohm·cm. Lap Shear 70 psi (0.48 MPa)	Platinum	4 h	-	4 h / 65	-	-	-	-	-	-	-	-	Black	
	PRESSURE SENSITIVE TAPES	CV-1161	50% Solids, 7.5 ppi Release Force	-	-	-	-	-	-	-	-	-	-	-	3,000	-	Clear
		CV2-1161	High Temp, 35% Solids, 2.5ppi Release Force	Peroxide	-	-	1 h / 60 + 1 h / 175	-	-	-	-	-	-	-	770	100:1	White
		CV3-1161	Non-Voc Solvent, Tert Butyl Acetate	Peroxide	-	-	-	-	-	-	-	-	-	-	1,200	100:1	Trans
CV4-1161-5	0.005 inches (5 microns) Double Side Tape, Kapton® Center, 2.5 ppi	-	-	-	-	-	-	-	-	-	-	-	-	-	Trans		
GELS	CV-8151	Low Viscosity, Penetration 4.0 mm	Platinum	>30 h	-	30 m / 150	-	-	-	-	-	-	-	2,500	1:1	Clear	
	CV1-8151	Penetration 0.4 mm	Platinum	> 30 h	-	30 m / 150	-	-	-	-	-	-	-	2,500	1:1	Clear	
	CV-8251	Broad Operating Temperature, Penetration 3 mm	Platinum	24 h	-	40 m / 150	-	-	-	-	-	-	-	1,800	1:1	Clear	
FOAMS	CV-2391	Low density, Soft, 14lb/ft <sup>3</sup> (0.224g/mL)	Platinum	-	-	1 h / R.T.	-	-	-	-	-	-	-	3,000	1:10	White	
PRIMERS	SP1-204	1 and Part RTV System, 3.3% S.	Hydrolysis	-	-	1 h / R.T., H	0.79	-	-	-	-	-	-	-	-	Clear	
	SP-120	General Purpose, 4.1% Solids	Hydrolysis	-	-	1 h / R.T., H	0.77	-	-	-	-	-	-	1.0	-	Clear	
	SP-121	General Purpose, 3.5% Solids	Hydrolysis	-	-	1 h / R.T., H	0.77	-	-	-	-	-	-	1.0	-	Red	
	CF2-135	Addition Cure Systems, 4.7% Solids	Hydrolysis	-	-	1 h / R.T., H	0.77	-	-	-	-	-	-	1.0	-	Clear	
	CF1-141	Addition Cure Systems, IPA Based, 6% Solids	Hydrolysis	-	-	1 h / R.T., H	0.80	-	-	-	-	-	-	1.0	-	Red	
	SP-270	Addition Cure Systems, Difficult Substrates, 15% Solids	Hydrolysis	-	-	1 h / R.T., H	0.77	-	-	-	-	-	-	1.0	-	Trans	
	SP-271	Addition Cure Systems, Difficult Substrates, 20% Solids	Hydrolysis	-	-	1 h / R.T., H	0.80	-	-	-	-	-	-	1.0	-	Trans	

<sup>1)</sup> Primed with SP-120  
<sup>3)</sup> Primed with SP-130  
<sup>4)</sup> Primed with CF1-135

<sup>5)</sup> Primed with SP-270  
<sup>21)</sup> Tested per ASTM C1045  
<sup>22)</sup> Tested per ASTM C177

d = days  
h = hours  
m = minutes  
R.T. = Room Temperature  
H = Humidity  
\*\* Post-cure 15 m / 150  
Version uploaded 11/06/2014

Trans = Translucent  
Clear = Clear to Transparent

**Corporate Headquarters**  
**NuSil Technology - USA**  
**1050 Cindy lane**  
**Carpinteria, CA 93013**  
**+1 (805) 684-8780**  
**+1 (805) 566-9905 Fax**  
**Silicone@NuSil.com**  
**www.NuSil.com**

**NuSil Technology Europe**  
Parc d' Activités de Sophia Antipolis  
Le Natura Bt2  
1198, avenue Maurice Donat  
06250 MOUGINS France  
+33 4 92 96 93 31  
+33 4 92 96 06 37 Fax  
NuSil.Sophia@NuSil.com  
www.NuSil.com

# Polymer Systems Technology Limited

UK & Ireland Distributor



© 2014 - Polymer Systems Technology Limited  
™ Unit 2. Network 4. Cressex Business Park,  
Lincoln Road, High Wycombe, Bucks. HP12 3RF  
Phone +44 (0) 1494 446610  
Fax: +44 (0) 1494 528611  
Web: <http://www.siliconepolymers.co.uk>  
Email: [sales@silicone-polymers.co.uk](mailto:sales@silicone-polymers.co.uk)

