

# Space-grade silicones



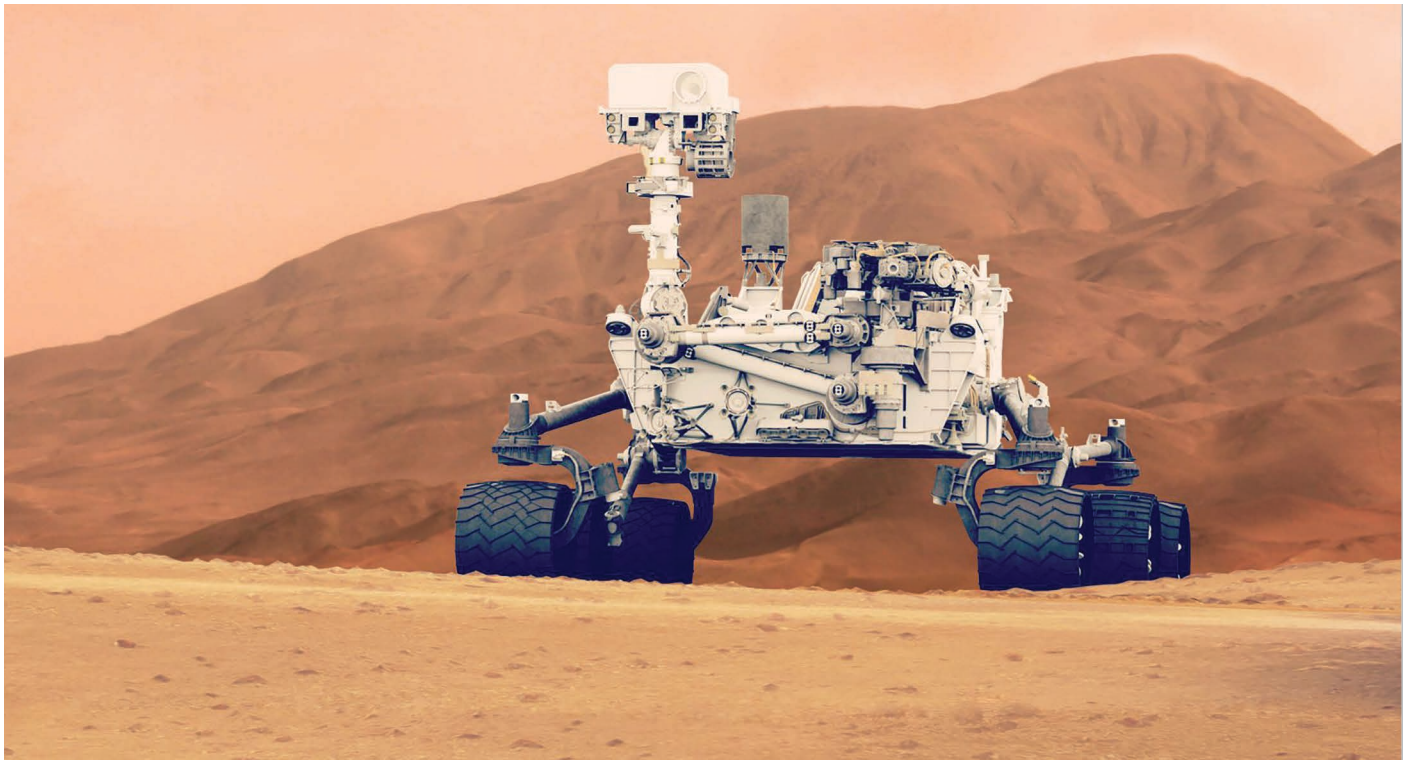
# Silicones for the most demanding missions

## UNMATCHED PERFORMANCE FOR EXTREME ENVIRONMENTS

For more than 40 years, the NuSil® brand has delivered ultra-high-purity silicones to leading aerospace manufacturers to fulfill their missions across the universe. In our early days, NuSil supported solar arrays on the space station. Today, we've grown to become the leading brand of silicones for space exploration. Our unparalleled expertise in low outgassing and ultra-low outgassing allows us to meet the critical demands of the aerospace industry.

## SILICONES FOR SPACE

The extreme temperatures and vacuum conditions of space present unique environmental challenges. NuSil space-grade silicones provide reliable performance in these harsh conditions. Silicones remain elastic at temperatures as low as  $-120^{\circ}\text{C}$  and resist breakdown at elevated temperatures up to  $300^{\circ}\text{C}$ . They can compensate for coefficient of thermal expansion (CTE) mismatch and remain stable during thermal cycling as the spacecraft travels through space. Optically clear silicone transmits light to important components for applications such as sensors and cameras. Our silicone also offers weight reduction solutions to address launch concerns and protect against atomic oxygen while in orbit.

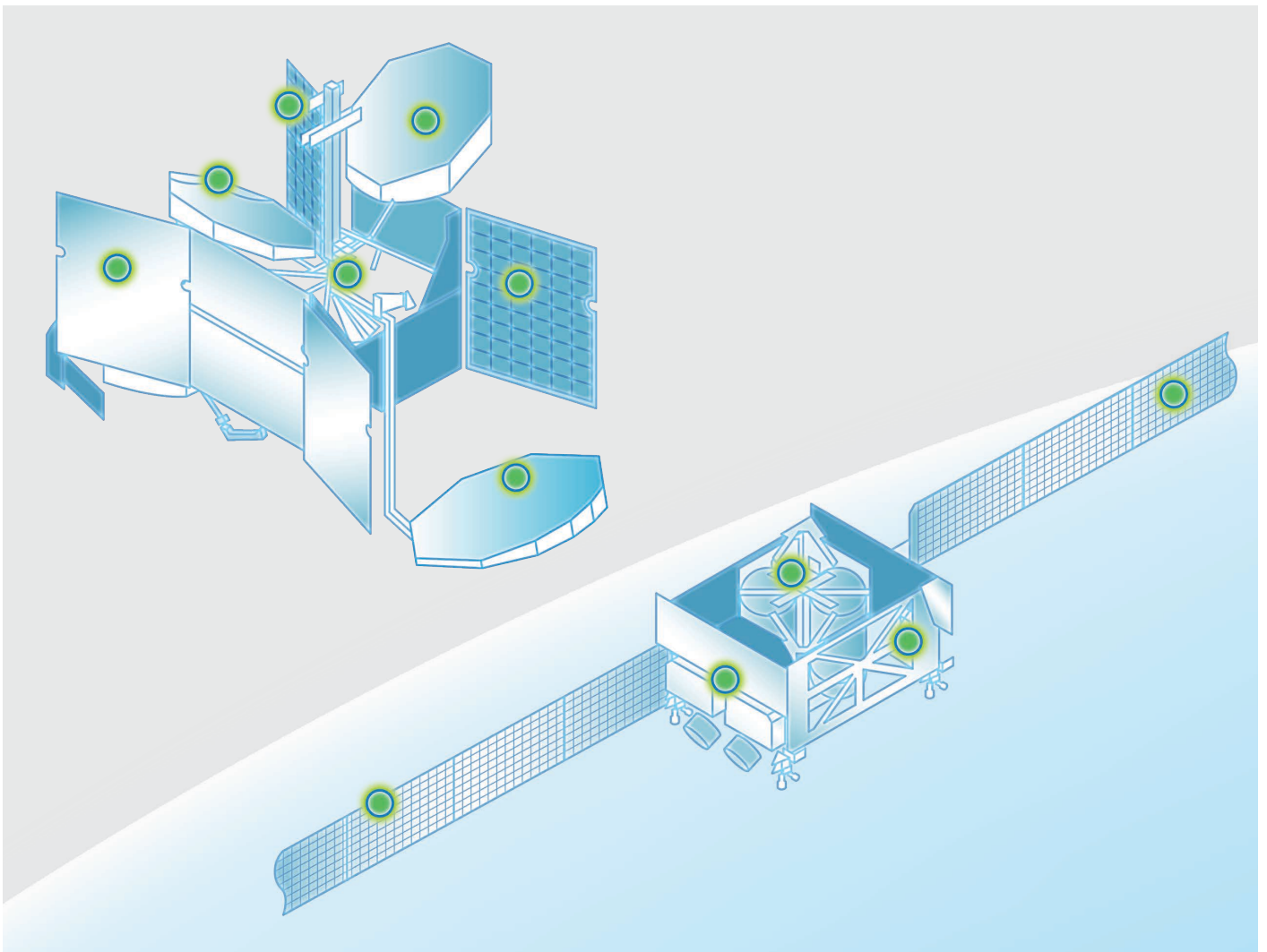


# Applications

With decades of flight heritage in outer space, geosynchronous earth orbit (GEO) and lower earth orbit (LEO), NuSil space-grade silicones are a proven solution in the industry.

Silicones are used in a wide variety of applications on spacecrafts, from CubeSats to crew capsules to deep space exploration vehicles to traditional satellites and constellation systems. Leading applications for NuSil space-grade silicones include:

- Antennas
- Cameras
- Sensors
- Solar panels
- General assembly



# Space-grade silicones

## RIGOROUS LOW OUTGASSING STANDARDS

Our commitment to this industry goes beyond the standard level of testing and support. We understand that it is mission critical for our products to stand up against the rigor of outer space, which is why NuSil space-grade silicones are tested on a lot-to-lot basis against the standards set forth by NASA and the European Space Agency (ESA) to ensure reliable performance. These agencies require materials to be tested per ASTM E595 prior to use in space, with a total mass loss (TML) of  $\leq 1.00\%$  and collected volatile condensable material (CVCM) of  $\leq 0.10\%$ .

## NUSIL SPACE-GRADE SILICONES ARE OFFERED IN TWO PRODUCT LINES:

- Low outgassing materials demonstrate  $\leq 1.00\%$  TML and  $\leq 0.10\%$  CVCM
- Ultra-low outgassing silicones exceed these standards by an order of magnitude:  $\leq 0.10\%$  TML and  $\leq 0.010\%$  CVCM

Our highly purified silicones are used by leading space programs to avoid contamination and material desegregation as well as mitigate condensation of volatiles, all of which could result in catastrophic failure. The NuSil space-grade product line provides the most diverse range of solutions in the industry.



## ADHESIVES

NuSil silicone adhesives range from traditional liquid adhesives to novel peel-and-stick tapes or films to pressure-sensitive adhesives. Primers are also available to improve adhesion.



## THERMALLY & ELECTRICALLY CONDUCTIVE MATERIALS

NuSil thermally conductive silicones aid in the transfer of heat from electronic devices without adding stress to the systems. Our electrically conductive silicones can carry a current, while our dissipative silicones enable static to dissipate continuously rather than accumulate and discharge rapidly.



## COATINGS

Our coatings protect against atomic oxygen (AO) and provide radiation or thermal stress resistance. They are used on a variety of spacecraft surfaces as well as small components in electronic devices.



## POTTING & ENCAPSULATING MATERIALS

NuSil potting and encapsulating silicones provide excellent protection against thermal cycling, shock and contaminants, such as moisture and debris.



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### CUSTOMIZATION MASTERED

We know that standard solutions don't always fit. That's why we customize our silicones from formulation to packaging based on our customers' unique applications. With over four decades of serving the most demanding industries, we've honed our processes and proprietary equipment to take customization to a mass scale.



### NUSIL SUPPORT

We maintain a comprehensive quality system, including AS9100 and ISO 9001 certifications, requiring complete documentation and ensuring the highest quality and reliability.

NuSil collaborates with our customers to develop revision-controlled material specifications and drawings. Customer specifications facilitate certification of each material lot to their specific properties and specification ranges. NuSil supports and controls the inclusion of customer part numbers, customer drawing numbers, and unique labeling of products.

# Adhesives

## Description

NuSil adhesives offer excellent bonding to a wide variety of substrates like metals, plastics and glass, including Kovar® and polyimide. Our silicone adhesives range from liquid to tape or film that form a permanent bond to pressure-sensitive adhesives (PSA) for temporary bonding. Primers are also available to improve adhesion.

## Applications

Our silicones are specifically designed to increase manufacturing throughput for speed to market. Many of these adhesives cure at room temperature faster than traditional room temperature vulcanizing (RTV) adhesives or can be heat accelerated to accommodate processing procedures. NuSil tapes have also been known to function as a particle getter to avoid contamination on surfaces.

## ADHESIVES

PRODUCT NUMBER	CURE SYSTEM	MIX RATIO	VISCOSITY (cP/mPa·s) EXTRUSION (g/minute)	LAP SHEAR psi (MPa)	DUROMETER TYPE A	TENSILE psi (MPa)	ELONGATION %	WORK TIME (TACK-FREE TIME)	COLOR	SPECIAL FEATURES
<b>ULTRA-LOW OUTGASSING</b>										
SCV1-2590	Platinum	1:1	3,300	175 (1.2)	50	925 (6.4)	90	4 h	Clear	Formulated for reduced discoloration due to UV exposure
SCV2-2590	Platinum	10:1	4,000	250 (1.7)	45	475 (3.3)	85	2 h	Clear	1.43 refractive index
SCV-2590	Platinum	10:1	7,300	375 (2.6)	45	950 (6.6)	125	2 h (24 h max)	Clear	Available in black
SCV-2585	Platinum	1:1	49,500	475 (3.3)	35	700 (4.8)	300	1 h (24 h max)	Translucent	Tough, thixotropic elastomer
SCV-2586	Platinum	1:1	325,000	175 (1.2)	45	225 (1.6)	150	4 h (24 h max)	Red	Low density
<b>LOW OUTGASSING</b>										
CV-2510	Alkoxy	100:0.5	45,000	-	45	600 (4.1)	200	4 h (24 h max)	White	-
CV1-2566	Alkoxy	100:0.5	45,000	650 (4.5)	50	900 (6.2)	160	3 h (24 h max)	Red	Lower viscosity version of CV-2566
CV-2566	Alkoxy	100:0.5	55,000	500 (3.4)	55	950 (6.6)	150	3 h (24 h max)	Red	-
CV-2568	Alkoxy	100:0.5	125,000	100 (0.7)	50	175 (1.2)	60	4 h (24 h max)	Red	Low density
CV4-2500	Platinum	1:1	1,500	-	28	-	-	(15 h)	Clear	Tack free in 10 minutes at 65°C
CV16-2500	Platinum	10:1	3,600	200 (1.4)	40	650 (4.5)	100	2 h (24 h max)	Clear	1.43 refractive index, broad operating temperature
CV10-2500	Platinum	1:1	5,500	480 (3.3)	50	950 (6.6)	140	4 h (24 h max)	Clear	1:1 (A:B) version of CV-2500
CV-2500	Platinum	10:1	8,000	400 (2.8)	50	1,000 (6.9)	125	2 h (24 h max)	Clear	Available in black and a 1:1 version (CV10-2500)
CV2-2289-1	Platinum	1:1	12,250	300 (2.1)	30	450 (3.1)	250	(24 h max)	White	Tack free in 15 minutes at 65°C, broad operating temperature
CV-2289	Platinum	1:1	50,000	400 (2.8)	30	750 (5.2)	350	30 m (8 h max)	Translucent	Available in white and black, broad operating temperature
CV10-2568	Platinum	1:1	102,500	175 (1.2)	40	235 (1.6)	170	3 h	Red	Low density, broad operating temperature
CV7-2289-1	Platinum	1:1	228,750	350 (2.4)	30	700 (4.8)	375	9 h (25 h)	White	Improved primerless adhesion, broad operating temperature
CV4-2289-1	Platinum	1:1	1,150,000	325 (2.2)	30	650 (4.5)	400	30 m (11 h)	White	Non-slump, broad operating temperature
CV-1142	Oxime	1 Part	35 g/minute	375 (2.6)	45	700 (4.8)	300	(20 m)	Translucent	Spot bonding, also available in black & white, broad operating temperature
CV1-1142	Oxime	1 Part	13,000	-	30	400 (2.8)	200	-	Translucent	Self-leveling, also available in black & white and with UV tracer, broad operating temperature

### Next Generation Adhesives

Our curable silicone film adhesives are alternate solutions to traditional liquid adhesives. These offer reliable bond-line control in an easy-to-use peel and stick format. No mixing is needed.

### Customization

With NuSil film adhesives and tapes, the options are endless. These solutions can be customized to the size and thickness needed for the application. The degree of adhesion can be tuned to a specific substrate. Structural support systems, such as mesh or carrier, are available options to improve the integrity of the adhesive.

### TAPES, FILM ADHESIVES & PSAs

PRODUCT NUMBER	LAP SHEAR psi (MPa) PEEL STRENGTH ppi (kN/m)	THICKNESS (INCHES)	CURE SYSTEM	SPECIAL FEATURES
<b>TAPES</b>				
CV4-1161-5	Peel: 2.5 (0.4)	0.005	Cured	Double-sided tape, Kapton® carrier
<b>TWO-PART CURABLE FILM ADHESIVES</b>				
CV-2688-12	Lap Shear: 250 (1.7)	0.013	Platinum	Versatile bond over a variety of substrates
CV-2686-12	Lap Shear: 60 (0.4)	0.013	Platinum	Volume resistivity, 150 ohm-cm
<b>LIQUID PRESSURE-SENSITIVE ADHESIVES</b>				
CV3-1161	Peel: 1.5 (0.3)	-	Peroxide	Non-VOC solvent, tert butyl acetate, 37% solids

NuSil offers custom tapes and films to further optimize manufacturing and product performance. Contact a NuSil representative for more details.

### PRIMERS

PRODUCT NUMBER	% SOLIDS	SPECIAL FEATURES
CF1-136	3.7	Red primer
SP-120	4.0	Available in red
CF1-135	4.0	Recommended for addition cure silicones where there is slight cure inhibition
SP-126	6.3	In IPA
CF2-137	7.0	Contains UV Light detectable dye for inspections
CF6-135	8.7	Available in red and IPA
SP-270	15.0	Available in red
SP-142	15.0	Recommended for increasing adhesion to plastic
SP-271	20.0	Recommended for adhering to gold substrates

### Processing tips

For the best bond, ensure the substrate is thoroughly clean. Activating and/or priming the surface can also improve adhesion. When working with silicone adhesives, it is important to consider the solvents, chemicals or substrates they may contact in their uncured state. Certain chemical elements and compounds can retard or inhibit the adhesive's curing process.

# Thermally conductive materials

## Description

Thermally conductive silicones aid in the transfer of heat from electronic devices without adding stress to the systems. Unlike thermal pads, NuSil thermally conductive silicone adhesives and encapsulants conform to complex geometries, making them ideal for use in a wide array of electronic assemblies.

## Applications

NuSil thermally conductive silicones provide heat transfer between electronic components or adhere integrated circuit boards and base plates. With both flowable and non-flowable options, these thermally conductive silicones can be used to seal grooves or adhere openings in modules or housings.

## THERMALLY CONDUCTIVE MATERIALS

PRODUCT NUMBER	THERMAL CONDUCTIVITY W/(mK)	MIX RATIO	VISCOSITY (cP/mPa-s) EXTRUSION (g/minute)	CURE SYSTEM	DUROMETER TYPE A	TENSILE psi (MPa)	ELONGATION %	WORK TIME	SPECIAL FEATURES
<b>ULTRA-LOW OUTGASSING</b>									
SCV1-2599	1.6	15:1	4,150,000	Platinum	75	200 (1.4)	30	2 h	-
SCV2-2599	0.6	20:1	140 g/minute	Platinum	55	400 (2.8)	225	3 h	Syringe-dispensable
<b>LOW OUTGASSING</b>									
CV-2948	2.0	100:0.2	Thixotropic	Alkoxy	80	250 (1.7)	30	2.5 h	Broad operating temperature
CV-2943	1.2	100:0.2	Thixotropic	Alkoxy	90	750 (5.2)	35	2 h	High adhesion, broad operating temperature
CV-2946	1.5	15:1	Thixotropic	Platinum	75	200 (1.4)	30	2 h	-
CV1-2960	1.1	10:1	900,000	Platinum	75	250 (1.7)	60	2 h	-
CV-2942	1.0	20:1	Thixotropic	Platinum	85	650 (4.5)	15	2.5 h	High adhesion, broad operating temperature
CV1-2964	1.0	1:1	50,000	Platinum	65	180 (1.2)	50	-	Self-leveling
CV4-2946	1.0	20:1	122 g/minute	Platinum	36 '00'	-	-	5.5 h	Low modulus gel for sensitive components
CV-2960	0.8	10:1	130,000	Platinum	60	200 (1.4)	110	1.5 h	-
CV-2961	0.8	10:1	300,000	Platinum	75	275 (1.9)	40	2 h	Broad operating temperature
CV-2963	0.6	20:1	Thixotropic	Platinum	60	425 (2.9)	250	2 h	For bond-line applications ≥ 10 micron
CV2-2946	0.6	20:1	140 g/minute	Platinum	55	400 (2.8)	225	3 h	For bond-line applications ≥ 10 micron
CV-2900	0.6	1 Part	40 g/minute	Oxime	65	400 (2.8)	150	-	Broad operating temperature

## Processing tips

To ensure a homogenous blend, individually mix part A and B prior to combining. De-airing may be required to assure a bubble-free product. Thinner bond lines will result in lower thermal resistance.

For optimum adhesion, it is recommended to use NuSil brand primers prior to applying thermally conductive coatings.





# Electrically conductive materials

## Description

NuSil electrically conductive space-grade silicones enable static to dissipate continuously rather than accumulate and discharge rapidly. This is a critical requirement for space applications: Static accumulation and discharge can damage sensitive electronic components, disabling orbital equipment.

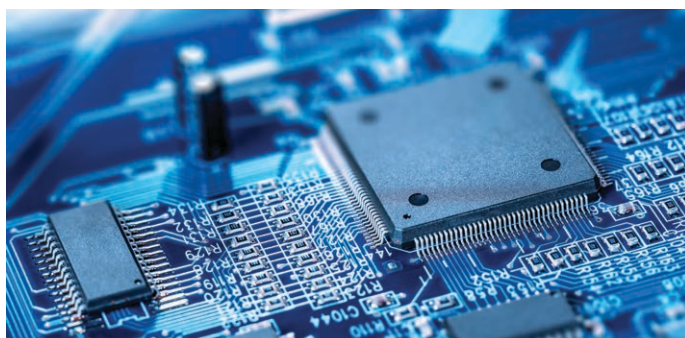
The electrical conductivity is measured by volume resistivity ( $\Omega \cdot \text{cm}$ ) and is used to gauge the EMI shielding effectiveness of the material.

## Applications

NuSil electrically conductive silicones are often used for RFI and EMI shielding in electronics that control vital components of a spacecraft such as control panels, sensors and antennas. They are also well suited for form-in-place conductive gaskets.

## ELECTRICALLY CONDUCTIVE MATERIALS

PRODUCT NUMBER	VOLUME RESISTIVITY (ohm.cm)	MIX RATIO	VISCOSITY (cP/mPa-s) EXTRUSION (g/minute) FLOW (inches)	CURE SYSTEM	DUROMETER TYPE A	TENSILE psi (MPa)	ELONGATION %	WORK TIME (TACK-FREE TIME)	FILLER TYPE	SPECIAL FEATURES
<b>ULTRA-LOW OUTGASSING</b>										
SCV1-2596	0.005	20:1	Thixotropic	Platinum	85	450 (3.1)	-	2.5 h	Metallic	-
SCV-2596	2.5	10:1	Thixotropic	Platinum	75	475 (3.3)	90	2 h	Carbon	Broad operating temperature
<b>LOW OUTGASSING</b>										
CV2-2646	0.003	100:0.5	4 inches	Alkoxy	75	300 (2.1)	70	2 h	Metallic	Certified conductivity at 200° C
CV2-2644	0.004	20:1	Thixotropic	Platinum	85	500 (3.4)	100	2.5 h	Metallic	Conductive at 80° C
CV-2644	0.005	20:1	Thixotropic	Platinum	85	525 (3.6)	-	2.75 h	Metallic	-
CV1-2646	0.005	100:0.5	Thixotropic	Alkoxy	90	-	-	2.5 h	Metallic	Broad operating temperature
CV-2646	0.007	100:0.5	Thixotropic	Alkoxy	80	400 (2.8)	90	3.5 h	Metallic	Broad operating temperature
CV2-2640	1 minimum	1:1	675,000	Platinum	30	500 (3.4)	350	1 h	Carbon	Broad operating temperature
CV-2640	2.5	10:1	Thixotropic	Platinum	75	475 (3.3)	90	2 h	Carbon	Broad operating temperature
CV-1500	3.0	1 Part	Thixotropic	Oxime	80	650 (4.5)	20	(10 m)	Carbon	Broad operating temperature
CV1-2640	25	10:1	300 g/minute	Platinum	40	525 (3.6)	225	4 h	Carbon	Broad operating temperature
CV3-2640	$2.2 \times 10^6$	1:1	10,000	Platinum	25	70 (0.5)	120	(7 h)	Carbon	Low viscosity, low specific gravity, broad operating temperature
CV1-1148	$9 \times 10^9$	1 Part	5,000	Oxime	-	-	-	(50 m)	Carbon	Dispersed for spraying, broad operating temperature
CV2-1148	$9 \times 10^9$	1 Part	36 g/minute	Oxime	44	-	-	-	Carbon	Flows easily at low pressure, broad operating temperature



## Processing tips

To ensure a homogenous blend, individually mix part A and B prior to combining. De-airing may be required to assure a bubble-free product.

For optimum adhesion, it is recommended to use NuSil brand primers prior to applying electrically conductive coatings.

# Coatings

## Description

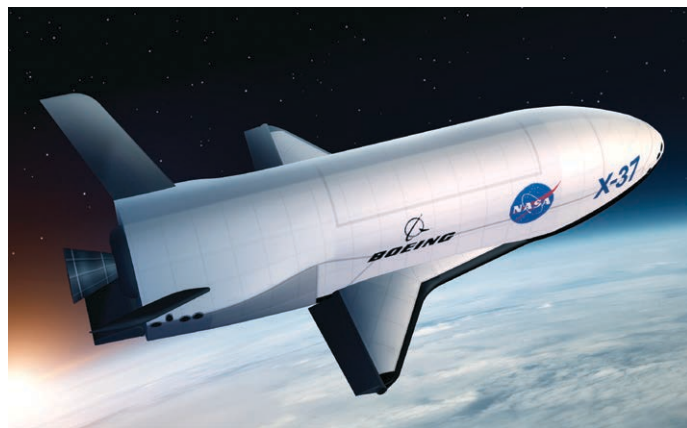
NuSil silicone coatings protect against atomic oxygen (AO) and provide radiation resistance. They are used on a variety of spacecraft surfaces as well as small components used in electronic devices. Solvent-based coatings are ideal for processes where the silicone is applied as a thin film coating. Solvent-less coatings are non-flammable and can cure faster than solvent-based.

## Applications

NuSil silicone coatings can be used as an overcoating for a variety of surfaces and components to protect against the harsh environment of space. Due to their noncorrosive nature, they are ideal for coating electronic components, such as connectors or switches as well as flexible or rigid circuit boards.

## COATINGS

PRODUCT NUMBER	VISCOSITY (cP/mPa·s)	% SOLIDS	COLOR	TACK-FREE TIME	SPECIAL FEATURES
<b>SOLVENT-BASED (NAPHTHA)</b>					
CV-1144-0	240	60	Translucent	50 m	Available with UV tracer
CV4-2500	1,500	100	Clear	15 h	Tack free in 10 minutes at 65°C
CV2-1147	2,000	60	Translucent	2 h	Non-blocking overcoat
CV-1146-2	2,400	72	Black	-	Non-glossy black coating
<b>SOLVENTLESS</b>					
CV3-1144-1	900	60	White	-	-
CV16-2500	3,600	100	Clear	24 h max	Broad operating temperature
CV-1152	7,300	100	Translucent	50 m	-
CV-2500	8,000	100	Clear	24 h max	Available in black and a 1:1 version



## Processing tips

Individually premix part A and B prior to combining the components. De-airing may be required to assure a bubble-free product. It is recommended to increase the cure temperature slowly or utilize a multistep curing process, which allows the solvent to evaporate prior to the silicone curing.

# Potting and encapsulating materials

## Description

Our potting and encapsulating silicones provide excellent protection against thermal cycling, shock, vibration and outside contaminants. For complex geometries, NuSil low modulus gels offer flexibility to protect delicate wire bonds from shearing and components from warping. While our elastomers offer a tougher, more rigid solution for stability and surface protection, NuSil space-grade foams can also be used for shock and vibration dampening in applications requiring a lightweight, flexible material.

## Applications

NuSil potting and encapsulating compounds are found on nearly all solar module assemblies or power electronics that operate or assist in the functionality of the spacecraft and space vehicles.

## GELS

PRODUCT NUMBER	VISCOSITY (cP/mPa-s)	PENETRATION (mm)	WORK TIME	COLOR	SPECIAL FEATURES
CV-8251	1,800	3.0	24 h	Clear	Broad operating temperature
CV-8151	2,500	4.0	> 30 h	Clear	Versatile gel

All materials are Platinum cure

## ELASTOMERS

PRODUCT NUMBER	VISCOSITY (cP/mPa-s)	MIX RATIO	LAP SHEAR (psi (MPa))	DUROMETER TYPE A	TENSILE (psi (MPa))	ELONGATION (%)	WORK TIME (TACK-FREE TIME)	COLOR	SPECIAL FEATURES
<b>ULTRA-LOW OUTGASSING</b>									
SCV1-2590	3,300	1:1	175 (1.2)	50	925 (6.4)	90	4 h	Clear	Formulated for reduced discoloration due to UV exposure
SCV2-2590	4,000	10:1	250 (1.7)	45	475 (3.3)	85	2 h	Clear	1.43 refractive index
SCV-2590	7,300	10:1	375 (2.6)	45	950 (6.6)	125	2 h (24 h max)	Clear	Available in black
<b>LOW OUTGASSING</b>									
CV4-2500	1,500	1:1	-	28	-	-	(15 h)	Clear	Tack free in 10 minutes at 65°C
CV16-2500	3,600	10:1	200 (1.4)	40	650 (4.5)	100	2 h (24 h max)	Clear	1.43 refractive index, broad operating temperature
CV10-2500	7,000	1:1	400 (2.8)	50	1,000 (6.9)	130	3 h (24 h max)	Clear	1:1 (A:B) version of CV-2500
CV-2500	8,000	10:1	400 (2.8)	50	1,000 (6.9)	125	2 h (24 h max)	Clear	Available in black (CV-2500-2) and a 1:1 version (CV10-2500)
CV-2960	130,000	10:1	205 (1.4)	60	200 (1.4)	110	1.5 h	White	-

## FOAMS

PRODUCT NUMBER	FOAM DENSITY (lbs/ft <sup>3</sup> )	VISCOSITY (cP/mPa-s)	APPLICATION LIFE (MINUTES)	COLOR	CURE SYSTEM
CV-2391	14	3,000	6	White	Platinum

## Processing tips

Blend both components of the material into a homogenous mixture and de-air if necessary to remove bubbles. Foams do not require a de-airing process. Gels may need to be mixed longer and more aggressively compared to other silicone systems due to their low viscosity. Note: Heat can easily be generated during the mixing process which can cause an adverse effect on pot life.



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