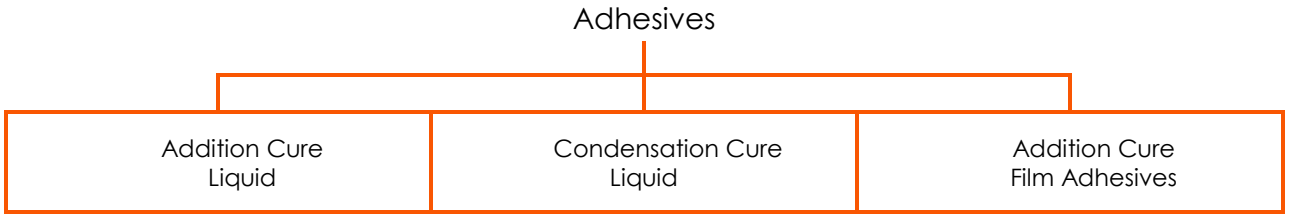
THE CHEMISTRY OF CARE

Bonding with NuSil Technology

NuSil understands that choosing the right silicone structural adhesive is challenging when creating new designs for complex systems and components. Balancing competing factors of higher operating temperatures, longer product lifecycle, reducing weight and energy consumption and cost requires utilizing novel materials for processing. NuSil Technology, with its diverse line of silicone adhesives offers the right material choice for your application.

NuSil Specialty Adhesives offers Diversity



- Variety with over 30 products
- Room Temperature cure available
- Heat reduces cure time
- Excellent adhesion

- Excellent adhesion
- No mixing required
- Easy to dispense
- Variety of packaging

- Controlled bond line thickness
- Eliminates cure staging and clean-up
- Eliminates liquid contamination

Why Silicones? Because they offer:

- High Dielectric Strength >400 V/mil (16 kV/mm)
- Dielectric Constant typically 2.8 at 100 Hz
- Low Young's Modulus from 0-60% Elongation <150 psi (1 MPa)
- Elastic at low temperatures with Tg from -60˚C down to -120˚C
- NuSil provides solutions
    - Customize new and existing formulations
    - Excellent technical support and testing capabilities

NuSil Purity

NuSil Technology, the global leader in space-grade silicones, brings over 30 years of success developing products for the most extreme environments, from deep inside the human body to the harsh conditions of outer space. With each facility being ISO 9001 and AS 9100 certified, we ensure consistent process and standards around the globe. NuSil understands markets and industries require different purity standards. NuSil is capable to test and meet standards for a variety of chemical species related to purity.

- Na, K, and Cl content (<20 ppm per ion)
- Low volatility (1%maximum volatile content on cured material when heated 1 hour at 275˚C)
- D4-D22 cyclics
- Metal content
- Clarity
- ROHS compliant
- See our Space Grade Guide for low outgassing and Ultra Low Outgassing silicones

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Addition Cure Liquid Adhesives

Two part (2K) platinum catalyzed addition cure silicones offer several benefits and come in a variety of working times and cure temperatures to allow almost limitless cure conditions. These features and benefits include:

- Can be used for thick bond lines
- Adjustable Cure Schedules
- Minimal shrinkage
- No cure by-products

Product	Appearance	Durometer (Type A)	Mixed Rheology	Work Time	*Lap Shear (psi/MPa)	UL 94 Test Results	Applications
R-2141	Translucent	40	~ 80,000 cPs	1.5 hrs	350/2.4	V-1 (4.8 mm)	Excellent for damming
R31-2186	Translucent	20	~ 80,000 cPs	15 minutes	110/0.8	V-0 (4.7 mm)	General, non-slump, fast cure. Available in black
R32-2186	Translucent	15	~ 80,000 cPs	> 8 hrs	150/1	NT	General, non-slump, requires heat to cure
R33-2186	Translucent	20	~ 80,000 cPs	2 hrs	100/0.7	NT	General, non-slump, RTV cure with longer pot life. Available in white
R34-2186	Translucent	50	9 g/min (90 psi, 0.32 cm orifice)	> 8 hrs	150/1	V-1 (4.7 mm)	Excellent for PET. Requires 40°C minimum to cure.
R1-2145	Dark Gray	45	290 g/min (90 psi, 0.32 cm orifice)	1 hr	145/1	V-1 (4.6 mm)	Excellent for damming
LS2-6140	Clear	50	~3,000 cPs	> 8 hrs	390/2.7	V-0 (3.7 mm)	Low volatility, self-leveling adhesive
EPM1-2412	Translucent	40	0.1 g/min (90 psi, 1.3 mm orifice)	10 minutes	185/1.3	V-1 (~5 mm)	Low volatility, non-slump adhesive
EPM-2411-2	Black	20	300,000 cPs	> 8 hrs	125/0.8	NT	Low Volatility Glob Top. Requires heat to cure. 1 Part and ships frozen.

Data is not to be used for writing specifications. See Data Sheets for test parameter details. .*Aluminum

Tin Cure Replacements

One part condensation cures have a long and respected history as silicone adhesives. The use of these types of silicones are becoming limited as regulatory concerns over tin increases, and production costs and speed are a critical part of the total cost of the part. Addition cure silicones can be an alternate choice and have the advantage of reducing risk of volatile components during and after cure while having comparable primerless adhesion.

*Adhesion measured 24 hours after cure

Fig 1: Adhesive strength of R-2141 versus similar 1 part tin catalyzed competitor silicone

	R-2141	Tin Adhesive	% Lower Volatiles
Cure loss %	*1	^2.9	-66
Weight loss at 275°C (%)	0.3	1.6	-81

*Tested 3 hrs at 150°C

^ Tested 72 hrs at ambient

Table 1: Volatility upon cure and after cure of R-2141 versus similar 1 part tin catalyzed competitor silicone

Condensation Cure Liquid Adhesives

Condensation cure silicones are typically one part (1K) and do not require mixing and have excellent adhesion to variety of organic and metallic substrates. They are tin catalyzed and require moisture to cure. The feature and benefits

- Typically 1 parts
- No mixing
- Robust adhesion

Product	Cure Type	Appearance	Durometer (Type A)	Flow	Tack Free Time	*Lap Shear (psi/MPa)	Applications
R-1130	Tin/ Oxime	Translucent	35	~0.3 in/min	15 minutes	485 (3.3)	Recommended for Polycarbonate and Polyimide
R-1140	Tin/ Acetoxy	Translucent	30	1.5 in/ 5 min	15 minutes	Not Tested	Robust adhesion to multiple substrates. Corrosive cure by-products
EPM-2840	Tin/ Oxime	Translucent	35	<2 in/ 5 min	25 minutes	280/1.9	Low volatility. Recommended for Polycarbonate and Polyimide
FS3-3730	Tin/ Acetoxy	Translucent	35	230 g/min	15 minutes	200/1.4	Solvent and Fuel Resistant. Robust adhesion to multiple substrates. Corrosive cure by-products

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Addition Cure Films Adhesives

Film Adhesives are 100% solids, do not flow and will maintain their shape when uncured. This allows for better bond line thickness control and the component can be moved immediately to next stage. They are designed to have excellent bonding to a wide variety of substrates including glass, ceramics, metals and plastics. Other benefits include:

- Control bond line thickness
- RTV cure or can be accelerated with heat
- Cure in place and long work time
- Sheet size customization possible and can be die and laser cut
- Can be stored at room temperature
- Does not require freezing to prevent cure
- Low Outgassing grade available

Product	Cure System	Type	Thickness In (mm)	*Lap Shear Psi (MPa)	Applications
R-2682-12	Platinum	Film Adhesive	0.014 (0.36)	100 (0.7)	2 part Film Adhesive for wire staking and general adhesive Also available in 4 mil/0.1 mm (R1-2680-4)

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Utilized in Harsh Environments

- Aerospace applications
- Electronics

Primers

NuSil Technology understands the benefits of primers are required at times to overcome cure inhibition, issues with surface wetting, or to increase the adhesive strength. NuSil technology has over 50 primers formulated to increase adhesion based on substrate, cure environment, chemical compatibility and the silicone cure chemistry. For more information please reference "Choosing a silicone primer/adhesive system".

Product	Adhesive Cure System	Recommend Substrates	Benefits
SP-120	Pt or Tin	PPA, PU, PC, PPSU, PEEK, PI, PET, epoxy, butyl rubber	Available in red (SP-121)
CF1-135	Pt	PU, PVC, PC, PSU, PPSU, PMMA, PEEK, PI, PET, epoxy	Available in red (CF1-136). Use with platinum cure silicones.
CF2-135	Pt	Same as above but needed for slight cure inhibition	Available with UV Tracer for backlight inspection (CF2-137). Use with platinum cure silicones.
CF6-135	Pt	Same as above but needed for persistent cure inhibition	Available in IPA (SP-126) and red and IPA (CF6-136). Recommended where Platinum Inhibition is of concern.
SP-142	Pt	PU, PVC, PC, PSU, PPSU, PEEK, PI, PET, epoxy, butyl rubber	Versatile. Recommended where Platinum Inhibition is of concern.
SP-270	Pt	PU, PVC, PC, PSU, PPSU, PEEK, PI, PET, epoxy, butyl rubber	Versatile. Available in red and low VOC solvent (SP-272) and low VOC solvent, without red, (SP1-270). Recommended where Platinum Inhibition is of concern.

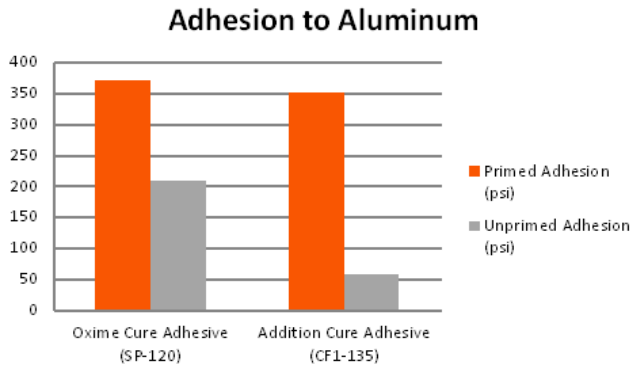
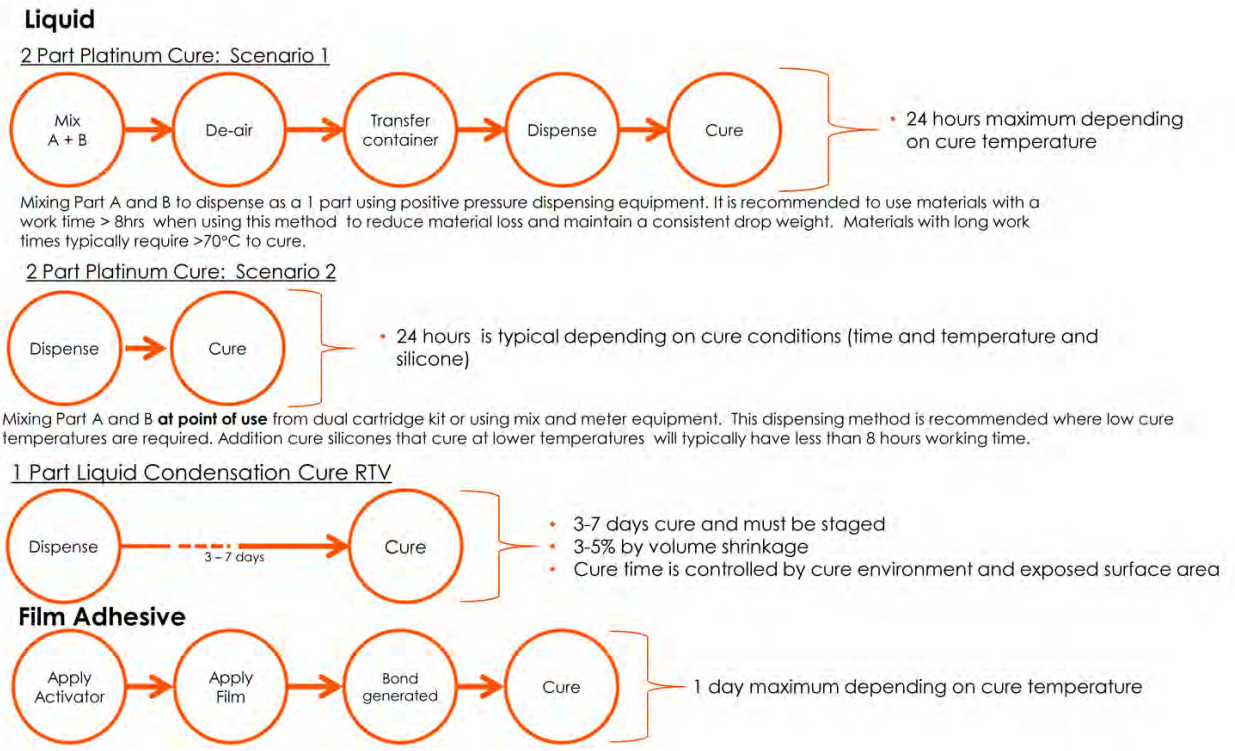


Fig 2: Lap Shear of primed versus unprimed aluminum panels of oxime versus addition cure silicone on aluminum. Note the addition cure silicone does not contain adhesion promoters.

Processing Adhesives

Below are guidelines on the general number of steps needed for applying liquid versus film adhesives. The overall cure time is dependent on the cure temperature for addition cure silicones. We understand that developing a process is much more complex than the outline below, however we believe this will help in choosing the right silicone and process for the application. Please reference "Mixing and De-airing Addition Cure Silicones" for more details on equipment and techniques.



Recommended Cure Times for Select Addition Cure Silicones

Product	Cure at Ambient	T90 at 40°C Minutes	T90 at 60°C Minutes	T90 at 80°C Minutes	T90 at 100°C Minutes	T90 at 120°C Minutes
R-2141	24 hrs	200/4 hrs	50	25	4	2
R31-2186	24 hrs	20	4	1.5	1	0.50
R32-2186	NA	N/A	N/A	15	3	1.5
R33-2186	24 hrs	150/2.5 hr	95	3	1.25	0.80
R34-2186	NA	700/12hrs	80	13	6	3
Product	**Cure at Ambient**	**T90 at 50°C Minutes**	**T90 at 65°C Minutes**	**T90 at 80°C Minutes**	**T90 at 100°C Minutes**	**T90 at 120°C Minutes**
R1-2145	3 days	70	17	6	NT	0.6

**Recommended cure times are based on the testing performed via ODR (Oscillating Disk Rheometer) where T90 is considered 90% of full cure. These tests are not performed on a lot to lot basis. These values are intended to be guidelines to assist in developing a cure process and selecting the correct product that will best fit into the process and application. These are not to be used as specifications.

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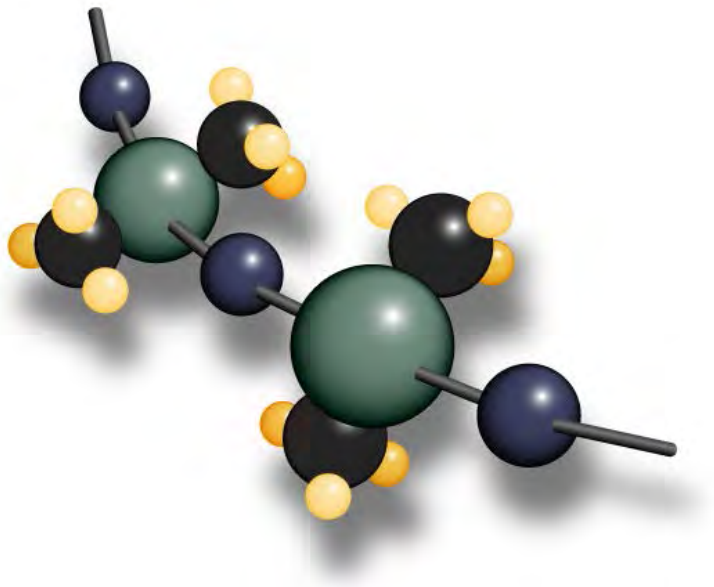

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