Information About *Dow Corning*® brand Thermally Conductive Adhesives

Silicones and Electronics

Long-term, reliable protection of sensitive circuits and components is important in today's delicate and demanding electronic applications. Silicones function as durable dielectric insulation, as barriers against environmental contaminants and as stress relieving shock and vibration absorbers over a wide temperature and humidity range.

In addition to sustaining their physical and electrical properties over a broad range of operating conditions, silicones are resistant to ozone and ultraviolet degradation, have good chemical stability and are available in a variety of useful forms such as conformal coatings, encapsulants and adhesives.

Dow Corning offers a variety of noncorrosive, thermally conductive silicone adhesives that are ideally suited for use in bonding hybrid integrated circuit substrates, components and devices to heat sinks, as well as for use in other bonding applications where flexibility and thermal conductivity are major concerns. The flowable products are also ideal for use as thermally conductive potting materials for transformers, power supplies, coils, relays and other electronic devices that require improved thermal dissipation.

These thermally conductive adhesives all cure with heat to produce a durable, relatively low stress elastomer. No byproduct is produced in the cure process allowing use in deep section and complete confinement. These adhesives will develop good, primerless adhesion to a variety of common substrates including ceramics, epoxy laminate boards, reactive metals and filled plastics.

Heat Cure Thermally Conductive Adhesives
Type One- and two-part silicone elastomer
Physical Form Nonflowing and flowable options; cures to flexible elastomer
Special Properties Fast thermal cure; resists humidity and other harsh environments; good dielectric properties; self priming adhesion; low stress; noncorrosive
Potential Uses Bonding hybrid integrated circuit substrates; heat sink attach; potting power supplies

Dow Corning® brand Product	Description	Features
Heat Cure Thermally Conductive Adhesives		
3-6605 Primerless Silicone Adhesive	Two-part (1:1) mix; gray; medium viscosity	Heat cure; good flow
3-6642 Primerless Silicone Adhesive	Two-part (1:1 to 5:1); low viscosity; excellent flow; gray; can increase amount of part A for softer elastomer	Rapid heat cure; contains 7 mil glass beads for minimum bond line
1-4173 Primerless Silicone Adhesive	One-part; low flow; gray	Rapid heat cure; very high thermal conductivity
1-4174 Primerless Silicone Adhesive	One-part; low flow; gray	Rapid heat cure; contains 7 mil glass beads for minimum bond line; very high thermal conductivity

Dow Corning® brand Product	Potential Uses	Application Methods
3-6605 Primerless Silicone Adhesive	Bonding integrated circuit substrates; adhering lids and housings; base plate attach; heat sink attach	Automated, two-part airless mix equipment; manual mixing and de-airing
3-6642 Primerless Silicone Adhesive	Potting/encapsulating electronic modules, power supplies, transformers, coils, relays, etc. where heat dissipation is needed	Automated or manual dispense
1-4173 Primerless Silicone Adhesive	Bonding integrated circuit substrates; adhering lids and housings; base plate attach; heat sink attach	
1-4174 Primerless Silicone Adhesive	Glob top	

TYPICAL PROPERTIES
These values are not intended for use in preparing specifications.

Dow Corning® brand Product	Product Form	Color	Viscosity/Flowabilty, centipoise or mPa•s	Durometer	Specific Gravity	Working Time[1] at RT, hours	Heat Cure[2] Time, minutes			Unprimed Adhesion, Lap Shear,			Thermal Conductivity	
							at 100°C (212°F)	at 125°C (257°F)	at 150°C (302°F)	psi	MPa	kgf/cm^2	Watt/m-°K	cal/cm•sec•°C
Heat Cure Thermally Conductive Adhesives														
3-6605 Primerless Silicone Adhesive	Two-part	Gray	47,000	78 A	2.14	>24	90	45	<15	350	2.4	24.6	0.85	2.03 x 10^{-3}
3-6642 Primerless Silicone Adhesive	Two-part	Gray	5,100	82 A	2.21	0.5	90	30	10	470	3.2	33.0	1.00	2.39 x 10^{-3}
1-4173 Primerless Silicone Adhesive	One-part	Gray	58,000	92 A	2.70	NA	90	30	20	640	4.4	45.0	1.90	4.54 x 10^{-3}
1-4174 Primerless Silicone Adhesive	One-part	Gray	58,000	92 A	2.71	NA	90	30	20	590	4.1	41.5	1.90	4.54 x 10^{-3}

[1]Time to double initial mixed viscosity.
[2]Time to develop durometer hardness and adhesion strength.

Specification Writers: Please obtain copies of the Dow Corning Sales Specifications for these products and use them as a basis for your specifications. They may be obtained from any Dow Corning Sales Office, or from Dow Corning Customer Service in Midland, MI. Call (517) 496-6000.

Dow Corning® brand Product	Tensile Strength			Elongation, percent	Tear Strength			Linear CTE, micron/m-°C or ppm	Dielectric Strength		Dielectric Constant at 100Hz	Dielectric Constant at 100 kHz	Dissipation Factor at 100 Hz	Dissipation Factor at 100 kHz	Volume Resistivity, ohm-cm	Shelf Life from Date of Manufacture, months
	psi	MPa	kgf/cm^2		ppi	kN/m	kgf/cm		volts/mil	kV/mm						
Heat Cure Thermally Conductive Adhesives																
3-6605 Primerless Silicone Adhesive	850	5.9	59.8	90	34	6.0	6.07	225	455	17.9	4.51	4.50	0.0058	<0.001	1 x 10^{14}	12 @ RT
3-6642 Primerless Silicone Adhesive	–	–	–	–	50	8.8	8.92	180	440	17.3	–	4.20	–	0.001	1.1 X 10^{13}	8 @ <5°C (41°F)
1-4173 Primerless Silicone Adhesive	900	6.2	63.3	20	–	–	–	–	425	16.7	4.98	4.86	0.008	<0.003	2.2 X 10^{14}	6 @ <5°C (41°F)
1-4174 Primerless Silicone Adhesive	900	6.2	63.3	22	–	–	–	–	425	16.7	–	4.63	–	0.0021	1.9 X10^{14}	6 @ <5°C (41°F)

CURE CONDITIONS

All of these addition curing adhesives should be cured at 100°C (212°F) or above. The cure rate is rapidly accelerated with heat (see cure schedules in Typical Properties table). Thin sections of less than 2 mils may be cured in 15 minutes at 150°C (302°F). For thicker sections, a pre-cure at 70°C (158°F) may be necessary to reduce voids in the elastomer. Length of pre-cure will depend on section thickness and confinement of adhesive. It is recommended that 30 minutes at 70°C (158°F) be used as a starting point for determining necessary pre-cure time. Addition curing materials contain all the ingredients needed for cure with no byproducts from the cure mechanism. Deep section or confined cures are possible. Cure progresses evenly throughout the material. These adhesives have generally long working times.

MIXING AND DE-AIRING
(Two-part materials only)

Upon standing, some filler may settle to the bottom of the liquid containers after several weeks. To ensure a uniform product mix, the material in each container should be thoroughly mixed prior to use.

Two-part materials should be mixed in the proper ratio either by weight or volume. The presence of light-colored streaks or marbling indicates inadequate mixing.

Automated airless dispense equipment can be used to reduce or avoid the need to de-air. If de-airing is required to reduce voids in the cured elastomer, consider a vacuum de-air schedule of >28 inches Hg for 10 minutes or until bubbling subsides.

PREPARING SURFACES

All surfaces should be thoroughly cleaned and/or degreased with a solvent such as *Dow Corning*® brand OS Fluids, naphtha, mineral spirits, or methyl ethyl ketone (MEK). Solvents such as acetone or isopropyl alcohol (IPA) do not tend to remove oils well, and any oils remaining on the surface will interfere with adhesion. Light surface abrasion is recommended whenever possible, because it promotes good cleaning and increases the surface area for bonding. A final surface wipe with acetone or IPA is also useful. On some surfaces, different cleaning techniques will give better results than others. Users should determine the best techniques for their applications.

ADHESION

Dow Corning silicone adhesives are specially formulated to provide unprimed adhesion to many reactive metals, ceramics and glass, as well as to selected laminates, resins and plastics. However, good adhesion cannot be expected on nonreactive metal substrates or non-reactive plastic surfaces such as *Teflon*®, polyethylene or polypropylene. Special surface treatments such as chemical etching or plasma treatment can sometimes provide a reactive surface and promote adhesion to these types of substrates. *Dow Corning*® primers (see Selection Guide) can be used to increase the chemical activity on difficult substrates.

Poor adhesion can be experienced on plastic or rubber substrates that are highly plasticized, since the mobile plasticizers act as release agents. Small scale laboratory

PRIMER SELECTION GUIDE

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Dow Corning® brand Primer or Adhesion Promoter	Flash Point, °C (°F)	Volatile Organic Content (VOC), grams/liter[4]	Special Properties	For Use On	For Use With	Silicone Product Examples
P5200 Clear[1]	32 (90)	110/705		Most metals, glass, ceramics and some plastics	Pigmented two-part addition cure	160, 165, 170
1200 Clear	17 (63)	748				
1200 Red	17 (63)	774	Colored for easier identification			
P5200 Red[2]	32 (90)	110/705				
1204	15 (59)	774		Most metals, glass and ceramics	All one-part alcohol cure	3140, 3145, 838, 3-1753
P5204[3]	18 (64)	205/591				
1205	5 (41)	861	Film-forming	Most plastics	All	
3-6060	37 (99)	780	Improves inhibition resistance	Most plastics and metals	All two-part addition cure	182, 184, 186
92-023	-4 (25)	678		Most metals, glass and ceramics		
Sylgard® Prime Coat	-3 (27)	687				

[1]P5200 Clear is a low-VOC alternative to 1200 Clear.
[2]P5200 Red is a low-VOC alternative to 1200 Red.
[3]P5204 is a low-VOC alternative to 1204.
[4]The lower VOC value is for states and air quality management districts that have recognized volatile methylsiloxanes as VOC exempt.

evaluation of all substrates is recommended before production trials are made.

In general, increasing the cure temperature and/or cure time will improve the ultimate adhesion.

SUBSTRATE TESTING

Due to the wide variety of substrate types and differences in substrate surface conditions, general statements on adhesion and bond strength are impossible. To ensure maximum bond strength on a particular substrate, 100 percent cohesive failure of the adhesive in a lap shear or similar adhesive strength test is needed. This ensures compatibility of the adhesive with the substrate being considered. Also, this test can be used to determine minimum cure time or can detect the presence of surface contaminants such as mold release agents, oils, greases and oxide films.

SOLVENT EXPOSURE

Although highly filled silicones such as those discussed in this data sheet are generally more resistant to solvent or fuel exposure, silicone adhesives are only intended to survive splash or intermittent exposures. They are typically not suited for continuous solvent or fuel exposure. Testing should be done to confirm performance of the adhesives under these conditions.

USEFUL TEMPERATURE RANGES

For most uses, silicone elastomers should be operational over a temperature range of -45 to 200°C (-49 to 392°F) for long periods of time. However, at both the low and high temperature ends of the spectrum, behavior of the materials and performance in particular applications can become more complex and require additional considerations.

For low-temperature performance, thermal cycling to conditions such as -55°C (-67°F) may be possible, but performance should be verified for your parts or assemblies. Factors that may influence performance are configuration and stress sensitivity of components, cooling rates and hold times, and prior temperature history.

At the high-temperture end, the durability of the cured silicone elastomer is time and temperature dependent. As expected, the higher the temperature, the shorter the time the material will remain useable.

COMPATIBILITY

Certain materials, chemicals, curing agents and plasticizers can inhibit the cure of addition cure adhesives. Most notable of these include:

- Organotin and other organometallic compounds
- Silicone rubber containing organotin catalyst
- Sulfur, polysulfides, polysulfones or other sulfur-containing materials
- Amines, urethanes or amine-containing materials
- Unsaturated hydrocarbon plasticizers
- Some solder flux residues

If a substrate or material is questionable with respect to potentially causing inhibition of cure, it is recommended that a small scale compatibility test be run to ascertain suitability in a given application. The presence of liquid or uncured product at the interface between the questionable substrate and the cured gel indicates incompatibility and inhibition of cure.

STORAGE AND SHELF LIFE

Shelf life is indicated by the "Use By" date found on the product label.

LIMITATIONS

These products are neither tested nor represented as suitable for medical or pharmaceutical uses.

PACKAGING

In general, *Dow Corning* thermally conductive adhesives are available in nominal 0.45-, 3.6-, 18- and 200-kg (1-, 8-, 40- and 440-lb) containers, net weight. Not all adhesives may be available in all packages and some additional packages and package sizes may be available.

SAFE HANDLING INFORMATION

PRODUCT SAFETY INFORMATION REQUIRED FOR SAFE USE IS NOT INCLUDED. BEFORE HANDLING, READ PRODUCT AND MATERIAL SAFETY DATA SHEETS AND CONTAINER LABELS FOR SAFE USE, PHYSICAL AND HEALTH HAZARD INFORMATION. THE MATERIAL SAFETY DATA SHEET IS AVAILABLE FROM YOUR DOW CORNING REPRESENTATIVE, OR DISTRIBUTOR, OR BY WRITING TO DOW CORNING CUSTOMER SERVICE, OR BY CALLING (517) 496-6000.

WARRANTY INFORMATION – PLEASE READ CAREFULLY

The information contained herein is offered in good faith and is believed to be accurate. However, because conditions and methods of use of our products are beyond our control, this information should not be used in substitution for customer's tests to ensure that Dow Corning's products are safe, effective, and fully satisfactory for the intended end use. Dow Corning's sole warranty is that the product will meet the Dow Corning sales specifications in effect at the time of shipment. Your exclusive remedy for breach of such warranty is limited to refund of purchase price or replacement of any product shown to be other than as warranted. Dow Corning specifically disclaims any other express or implied warranty of fitness for a particular purpose or merchantability. Unless Dow Corning provides you with a specific, duly signed endorsement of fitness for use, Dow Corning disclaims liability for any incidental or consequential damages. Suggestions of uses should not be taken as inducements to infringe any particular patent.

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