GE
Advanced Materials

Thermal Management Silicones for Electronics

GE imagination at work

Thermal Management Solutions from GE Advanced Materials

Long-term, reliable protection of sensitive electronic components is essential to many electronic applications today. Increasingly small systems and rising circuit densities have resulted in hotter operating temperatures, and driven demand for high-performance solutions for heat dissipation.

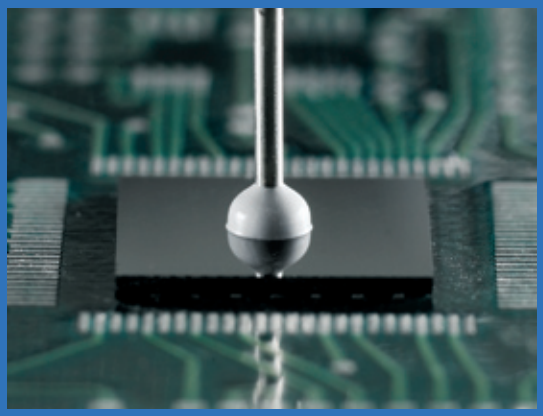
Designers confronting these challenges will find a range of solutions from GE Advanced Materials, Silicones. Our SilCool* family of adhesives and compounds deliver the high-thermal conductivity, thin bond lines, and low thermal resistance required for high-performance components. For applications requiring moderate level thermal management, GE offers a selection of standard-grade silicone adhesives, encapsulants, and potting materials.

Thermally Conductive Silicone Grease Compounds

GE's thermally conductive SilCool grease compounds offer excellent thermal conductivity, as well as excellent stability, penetration, temperature resistance, and low bleed. These properties enable SilCool grease compounds to draw heat away from devices, contributing to improved reliability and operational efficiency of electronic components. The combination of processing performance and thermal conductivity that these grease compounds offer makes them good candidates for thermal interface applications in high-performance devices and packages, such as TIM2 applications in CPUs and MPUs.

Thermally Conductive Silicone Adhesives

GE Advanced Materials developed its family of SilCool thermally conductive adhesives to help deliver thin bond lines, which contribute to low thermal resistance while providing excellent adhesion and reliability. This series of heat-cured, 1-Part adhesives excel in thermal interface applications that demand good structural adhesion. Examples include spreaders and heat generators, and thermal interfaces to heat sinks in TIM2 applications.
Additional thermal adhesives from GE offer the process convenience of 1-Part condensation cure with moderate heat dissipation. Target applications include board assemblies and sealants in power modules and sensors.



Thermally Conductive Potting & Encapsulation

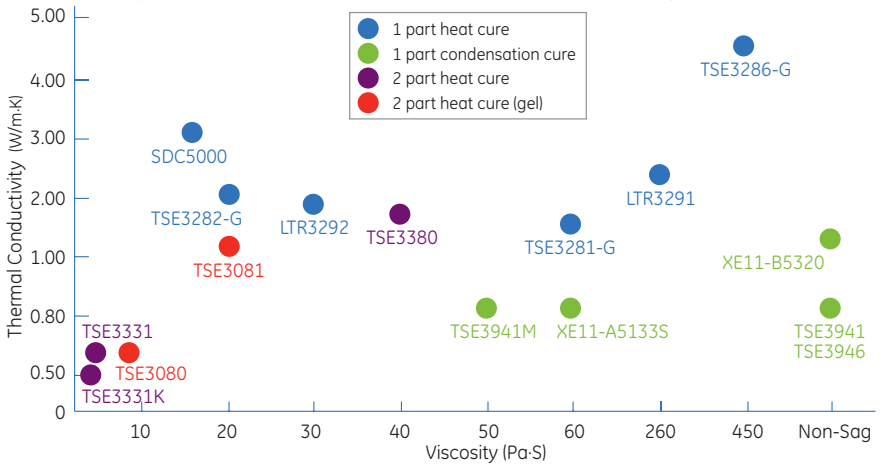
GE Advanced Materials offers a variety of condensation cure and 2-Part heat cure elastomeric rubber grades, as well as 2-Part heat cure gels. This selection of materials combines good thermal conductivity with low-viscosity to pot in deep, intricate cavities of electronic components. After cure, these materials provide excellent electric insulation, environmental protection, and resistance to vibration and shock for sensitive components. Common applications include power modules, sensors, converters, IGBT units, and connectors. Several grades also offer UL recognition for flame retardant performance.

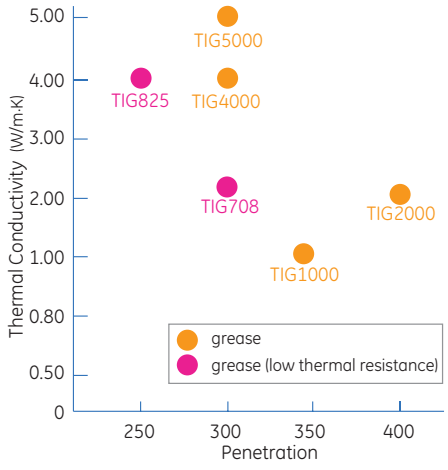
Product Selector Guide

The task of component design challenges materials suppliers to address an array of thermal management applications that impose a variety of performance and process profiles. GE brings to this challenge a broad and versatile range of thermally conductive materials. Whether an application requires superior performance in thermal interfaces, general heat dissipation in assemblies, thermal performance in board-level assembly, or potting and encapsulation, we offer a solution to help match the application's parameters.

Application	Performance Characteristics	Solutions
Thermal interface in high-performance devices / semiconductor packages such as TIM1 applications, in MPUs & CPUs	• High thermal conductivity • Low separation • Wide operating temperatures • Low thermal resistance • Minimal ionic impurities	· TIG5000 5.0 W/m·K · TIG4000 4.0 W/m·K · TIG2000 2.0 W/m·K · TIG825 8 mm^2K/W · TIG708 7 mm^2K/W
	• High thermal conductivity • Structural adhesion • Minimal ionic impurities • Low thermal resistance • Thin bond lines • Low modulus & stress	· TSE3286-G 4.5 W/m·K · SDC5000 3.1 W/m·K · LTR3291 2.5 W/m·K · LTR3292 1.9 W/m·K
Thermal interface between high performance devices, (MPUs, CPUs) & heat dissipation devices (heat sinks) in TIM2 applications	• High thermal conductivity • Low separation • Wide operating temperatures • Low thermal resistance • Minimal ionic impurities	· TIG5000 5.0 W/m·K · TIG4000 4.0 W/m·K · TIG2000 2.0 W/m·K · TIG825 8 mm^2K/W · TIG708 7 mm^2K/W
	• High thermal conductivity • Structural adhesion • Minimal ionic impurities • Low thermal resistance • Thin bond lines • Low modulus & stress	· TSE3286-G 4.5 W/m·K · SDC5000 3.1 W/m·K · LTR3291 2.5 W/m·K · LTR3292 1.9 W/m·K
General heat dissipation in board assemblies and various electronic sensors	• Moderate thermal conductivity • Wide operating temperatures	· TIG1000 1.0 W/m·K
	• Moderate thermal conductivity • Structural adhesion • Low thermal resistance	· TSE3282-G 2.0 W/m·K · TSE3281-G 1.7 W/m·K
Thermal interface with heat dissipation devices in control units, medium-performance CPUs, etc.	• Moderate thermal conductivity • Structural adhesion • Low thermal resistance	· TSE3282-G 2.0 W/m·K · TSE3281-G 1.7 W/m·K
Board level assembly and component sealing /fixing, Switching Power Supply component assembly / sealing	• Moderate thermal conductivity • Structural adhesion • Ease of use • Low thermal resistance • Room temperature cure	· XE11-B5320 1.3 W/m·K · TSE3941 0.83 W/m·K · TSE3941M 0.83 W/m·K · TSE3946 0.83 W/m·K
Rubber and Gel potting / encapsulation in power modules, converters, IGBT units	• Moderate thermal conductivity • Low viscosity • Ease of use • Low thermal resistance • Flame retardancy	· XE11-A5133S 0.83 W/m·K · TSE3331 0.63 W/m·K · TSE3331K 0.53 W/m·K · TSE3380 1.68 W/m·K · TSE3080 (gel) 0.63 W/m·K · TSE3081 (gel) 1.26 W/m·K

Thermally Conductive Silicone Portfolio Map





SilCool* Silicone Grease Compounds

GE's family of SilCool series silicone grease compounds feature outstanding thermal conductive and dielectric properties, excellent workability, virtually no oil separation, and minimal weight loss at elevated temperatures. These high-performance grease products were formulated to help address heat management challenges resulting from higher frequencies, higer power, and miniaturization in the development of electric and electronic devices.

Key features:
- Highly workable – excels in automated dispensing, screen printing, and stamping applications
- High thermal conductivity
- Wide operating temperature range from -50°C to +170°C
- Low oil separation and minimal weight loss at elevated temperatures
- Minimal ionic impurities & excellent dielectric properties

Product Details

SilCool Series

		TIG5000	TIG4000	TIG2000	TIG1000
Property / Color		Gray Paste	Gray Paste	Pale Blue Paste	White Paste
Thermal Conductivity[1]	W/m·K	5.0	4.0	2.0	1.0
Thermal Resistance[2] (BLT)	mm²·K / W	14 (50µm)	15 (50µm)	24 (50µm)	33 (50µm)
Specific Gravity @23°C		2.60	2.80	2.80	2.50
Penetration[3] @23°C		300	300	400	340
Bleed[3] @150°C/24h	wt%	<0.1	<0.1	<0.1	0.1
Evaporation[3] @150°C/24h	wt%	<0.1	<0.1	<0.1	0.1
Volume Resistivity[4]	MΩ·m	2	$2x10^6$	$1x10^6$	$3x10^6$
Dielectric Strength	kV/0.25mm	5	5	5	-
Volatile Siloxane (D_3-D_{10})	ppm	30	20	<100	30
Ionic Content*[5] (Na/K, Cl)	ppm	each <2	each <2	-	-

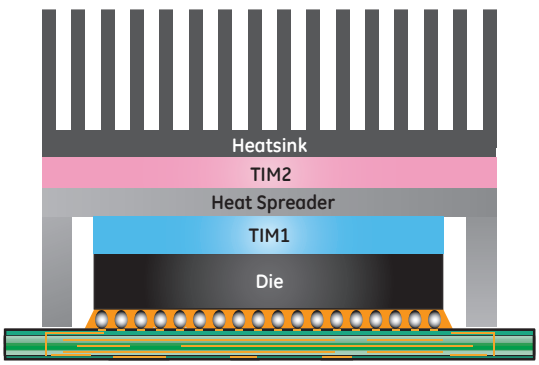
SilCool
Low Thermal Resistance Series

		TIG825	TIG708
Property / Color		Gray Paste	Gray Paste
Thermal Conductivity[1]	W/m·K	4.0	2.1
Thermal Resistance[2] (BLT)	mm²·K / W	8 (25µm)	7 (8µm)
Specific Gravity @23°C		2.80	2.30
Penetration[3] @23°C		250	300
Bleed[3] @150°C/24h	wt%	<0.1	<0.1
Evaporation[3] @150°C/24h	wt%	<0.1	<0.1
Volume Resistivity[4]	MΩ·m	$1x10^7$	$1x10^7$
Dielectric Strength	kV/0.25mm	5	5
Volatile Siloxane (D_4-D_{10})	ppm	20	20
Ionic Content*[5] (Na/K, Cl)	ppm	each <2	each <2

[1]Bulk sample measurement (hot wire method), [2]Laser flash analysis on a Si-Si sandwiched material
[3]JIS K 2220, [4]MIL-S-8660B, [5]Ion chromotography analysis on water extracts
Typical property values should not be used as specifications

Packaging

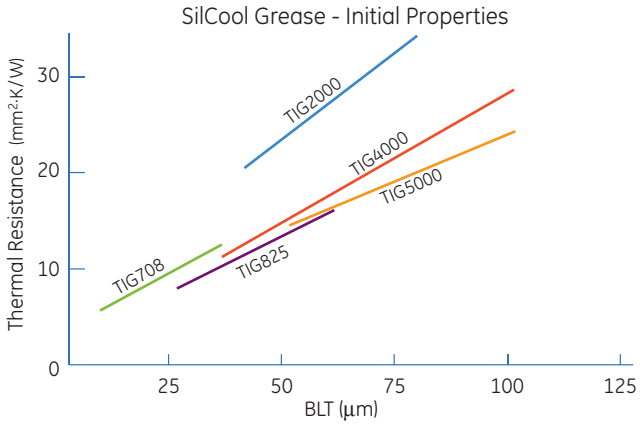
	30ml syringe	250gr tube	2kg can	2kg bottle
TIG5000	●	●		●
TIG4000	●	●		●
TIG2000			●	
TIG1000			●	
TIG825	●	●		●
TIG708	●	●		●

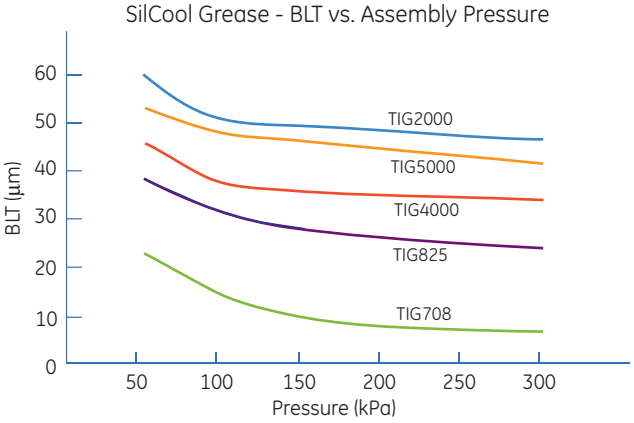


SilCool grease in TIM1 and TIM2 semiconductor applications.

Initial Performance Data

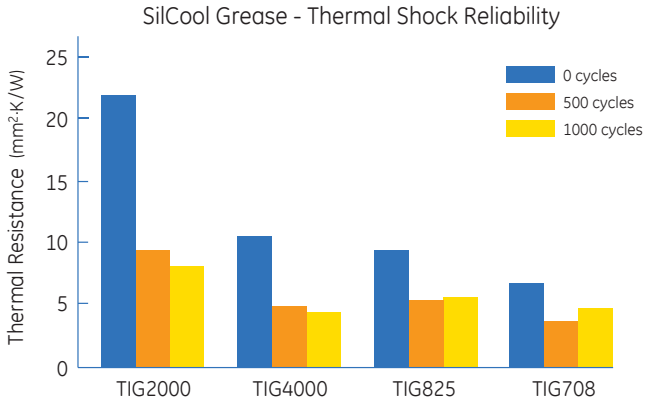
Thermal Resistance is proportional to the thickness of the material through which the heat must travel. The ability to control and reduce thickness (BLT) of the thermal interface is a key factor in the component assembly process. Increases in assembly pressures are known to contribute to reductions in BLT, and subsequently, reduced thermal resistance.



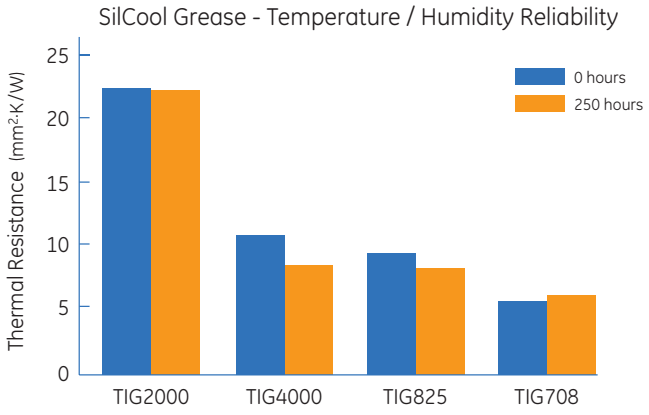


Test Conditions:
· 0.02ml of material dispensed on 10mm x 10mm Silicon coupon
· Place silicon die on top
· Apply pressure for 1 minute

Reliability Data



Test Conditions:
· 10mm x 10mm AL-TIM-Si sandwiches
· Assembled at 130 kPa



Test Conditions:
· 10mm x 10mm AL-TIM-Si sandwiches
· Assembled at 130 kPa

Handling & Storage

· Wear eye protection and protective gloves as required when handling.
· Use in a well ventilated area.
· Store in a dark, cool place out of direct sunlight.

SilCool* Silicone Adhesive - Addition Cure

The SilCool series silicone adhesives from GE Advanced Materials offer 1-Part, heat curable materials that bond well to a wide variety of substrates without the need for primers. They help deliver outstanding thermal conductivity, low thermal resistance, excellent dielectric properties, and low stress.
SilCool adhesives are excellent candidates for addressing the heat management challenges arising from the higher frequencies, power, and miniaturization in today's electronic devices. Designed to efficiently conduct heat, these materials are valuable additions to semiconductor packages that incorporate heat-generating chips, heat spreaders, and heat sinks (TIM1 & TIM2).

Key features:
- Ready to use - one component
- Highly workable – excels in automated dispensing, screen printing, and stamping applications
- Fast cure & good adhesion
- High thermal conductivity
- Low thermal resistance
- Low modulus & stress
- Reliable in a wide temperature range
- Compatible with high-temperature lead-free processing
- Minimal ionic impurities & excellent dielectric properties

Product Details

SilCool Series

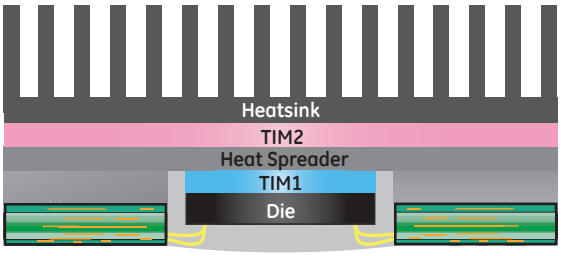
		TSE3286-G[7]	SDC5000	LTR3291	LTR3292	TSE3282-G	TSE3281-G
Type		1 Part	1 Part	1 Part	1 Part	1 Part	1 Part
Property (uncured)		Paste	Paste	Semi-Flowable	Flowable	Flowable	Flowable
Color		Gray	Yellow	Gray	Gray	Gray	Gray
Viscosity @23°C	Pa·s	450	16	260	30	20	60
Curing Condition	°C/h	150/1	150/1	150/1	150/1	150/1	150/1
Thermal Conductivity[1]	W/m·K	4.5	3.1	2.5	1.9	2.0	1.7
Thermal Resistance[2] (BLT)	mm²·K / W	12 (40µm)	10 (20µm)	22 (40µm)	25 (40µm)	33 (50µm)	35 (50µm)
Specific Gravity @23°C		3.20	3.77	2.80	2.62	2.70	2.70
Hardness (Type A)		95	65	92	83	80	84
Tensile Strength	MPa	2.0	1.2	2.3	2.6	4.0	4.5
Elongation	%	10	200	15	49	50	50
Adhesion (Lap Shear)[4]	MPa	1.0	0.9	0.7	0.97	2.5	2.5
Adhesion (Die Shear)[5]	MPa	-	-	-	-	-	3.0
CTE	ppm/K	95	150	113	-	140	140
Glass Transition Temp	°C	-120	-120	-120	-120	-120	-120
Volume Resistivity[3]	MΩ·m	5.0×10^{6}	2.0×10^{-4}*	1.63×10^{8}	4.6×10^{7}	4.8×10^{6}	4.8×10^{6}
Dielectric Strength	kV/mm	15	-	17	17	23	15
Ionic Content[6] (Na/K, Cl)	ppm	each <5	each <5	each <5	each <5	each <10	each <10
Moisture Absorption	wt%	<0.6	<0.2	<0.1	<0.1	<0.6	<0.6

[1]Bulk sample measurement (hot wire method), [2]Laser flash analysis on a Si-Si sandwiched material, [3]ASTM E 14561, [4]Aluminum lap shear, [5]Si die to aluminum shear, [6]Ion chromatography analysis, [7]Experimental grade, *Ω·cm

Typical property values should not be used as specifications

Packaging

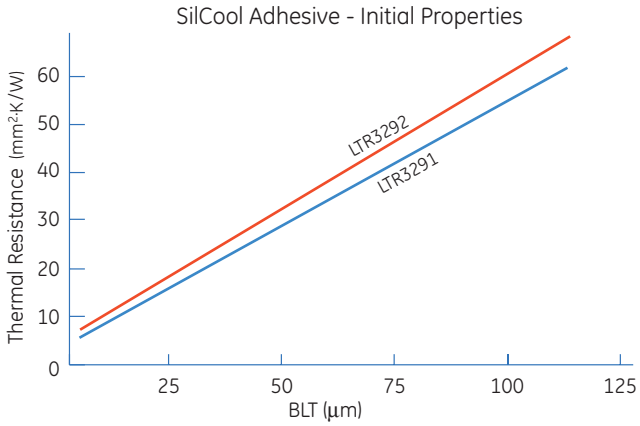
	5ml syringe	10ml syringe	30ml syringe	200gr tube	500gr bottle	1kg can	2kg can
TSE3286-G		●	●			●	
SDC5000	●	●	●		●		
LTR3291			●			●	
LTR3292			●			●	●
TSE3282-G				●		●	
TSE3281-G						●	

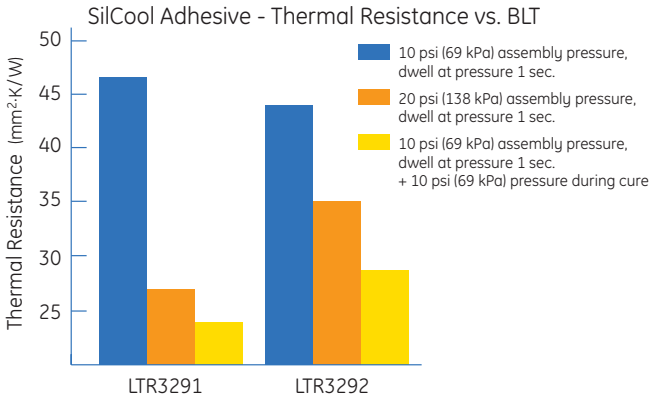


SilCool adhesive in TIM1 and TIM2 semiconductor applications.

Initial Performance Data

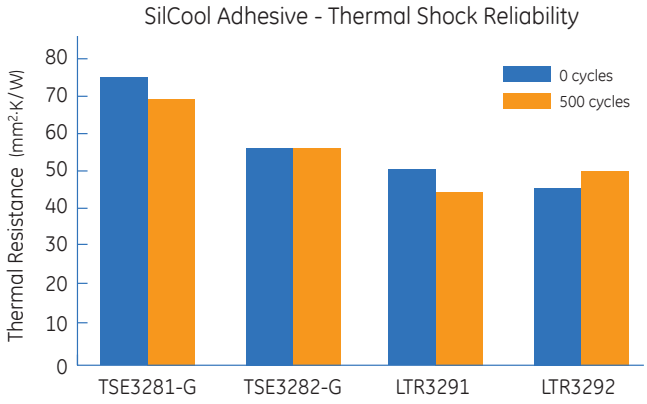
Thermal Resistance is proportional to the thickness of the material through which the heat must travel. Increases in pressure during the component assembly process are known to contribute to reductions in thickness of the thermal interface (BLT), and subsequently, reduced thermal resistance.



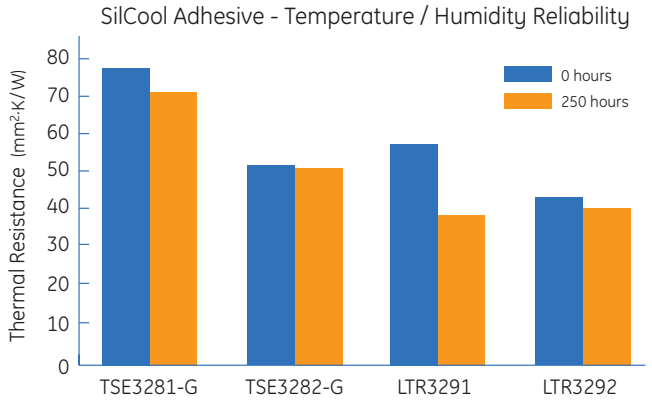


Test Conditions:
· 8mm x 8mm AL (Cr finish) -TIM-Silicone die sandwiches
· Cured for 2 hours at 150°C
· Laser Flash Diffusivity Instrument - Netzsch Microflash™

Reliability Data



Test Conditions:
· 8mm x 8mm AL-TIM-Silicone die sandwiches
· Assembled at 10psi (2-3 sec) and cured for 2 hours at 150°C
· AATS-500 cycles, -55 to 125°C, 20 minute cycles, dwell time of 10 minutes at each extreme



Test Conditions:
· 8mm x 8mm AL-TIM-Silicone die sandwiches
· Assembled at 10psi (2-3 sec) and cured for 2 hours at 150°C
· 85°C and 85% Relative Humidity, 250 hours

Handling & Storage

Upon receipt, immediately transfer the material to a suitable storage environment. Refer to individual product data sheets for required storage conditions.

To avoid formation of voids, always maintain syringes in an upright position - with the syringe tip facing down. Do not lay syringes on their sides under any circumstances.

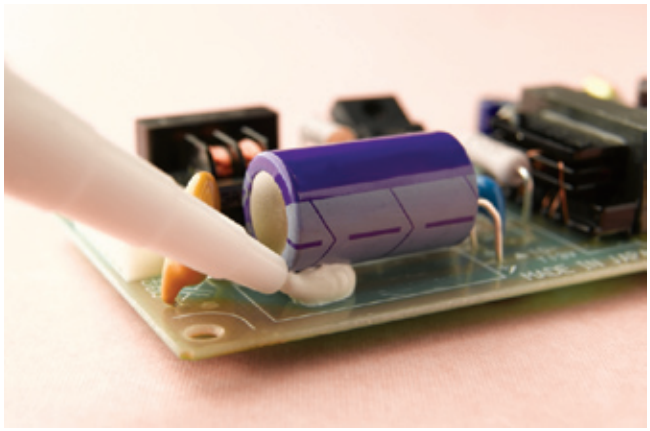
Prior to application, allow the material to warm to room temperature. Refer to individual product data sheets for approximate time intervals for achieving room temperatures. Do not use the syringes or open the cans before contents reach ambient temperature. Wipe all condensation from the syringes or the cans prior to use.

Wear protective goggles and gloves, and maintain adequate ventilation in the work place when working with these materials. Please refer to the Material Safety Data Sheet for preventing and controlling hazardous accidents.

Substrates containing water, sulfur, nitrogen compounds, organic metallic salts, phosphorus compounds, etc. can inhibit curing. A sample test should always be conducted to determine compatibility.

Silicone Adhesive - Condensation Cure

GE Advanced Materials offers a wide range of condensation cure adhesives & sealants that deliver thermal conductive performance. These materials cure to form an elastic rubber when exposed to atmospheric moisture at room temperatures, eliminating the need for heat ovens. The result is a unique combination of process efficiency and excellent thermal conductivity.
Our condensation-cure adhesives and sealants are commonly applied in board assembly and sensor applications that require moderate thermal management performance and ease of use.



Product Details

		XE11-B5320	TSE3941	TSE3941M	TSE3946
Type		1 Part	1 Part	1 Part	1 Part
Property (uncured)		Non-Flowable	Non-Flowable	Flowable	Non-Flowable
Color		White	White	White	White
Viscosity @23°C	Pa·s	-	-	50	-
Tack Free Time	Min	5	5	5	5
Thermal Conductivity	W/m·K	1.3	0.83	0.83	0.83
Specific Gravity @23°C		2.59	1.65	1.64	1.70
Hardness (Type A)		80	65	63	68
Tensile Strength	MPa	3.6	2.9	3.2	3.9
Elongation	%	40	100	70	100
Adhesive Strength	MPa	1.3	1.4	1.4	1.6
CTE	ppm/K	120	160	-	-
Volume Resistivity	MΩ·m	2.0×10^7	4.0×10^6	4.0×10^6	4.0×10^6
Dielectric Strength	kV/mm	17	22	21	23
Volatile Siloxane (D_3-D_{10})	wt%	0.020	-	-	0.025
Flame Retardancy		-	UL94 V-1	-	UL94 V-1

Typical property values should not be used as specifications

Packaging

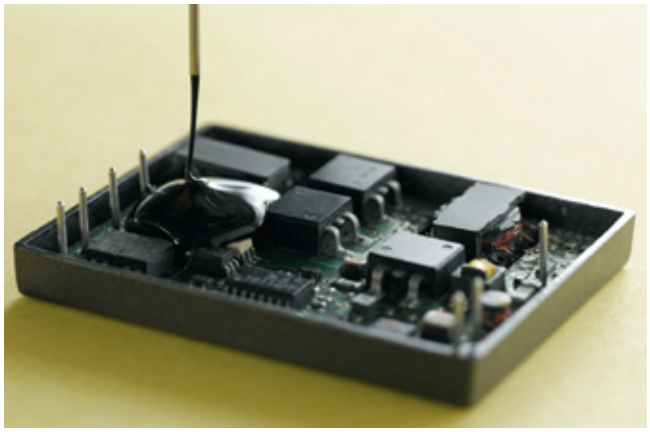
	150gr tube	333ml crt.	20kg pail can
XE11-B5320		●	
TSE3941	●	●	●
TSE3941M	●	●	●
TSE3946	●	●	

Handling & Storage

· Wear eye protection and protective gloves as required while handling.
· Use in a well ventilated area.
· Store in a dark, cool place out of direct sunlight.

Silicone Potting / Encapsulants

GE Advanced Materials' silicone potting materials deliver thermal conductive performance, contributing to the long-term reliability of heat-generating electronic components. These low viscosity rubbers and gels provide moisture and vibration protection in power modules, converters, IGBTs, and other sensitive devices. Many also offer flame retardant properties and are UL recognized.



Product Details

		Potting Rubber				Potting Gel	
		TSE3380	XE11-A5133S	TSE3331	TSE3331K	TSE3081	TSE3080
Type		2 Part Heat Cure	1 Part Alkoxy Cure	2 Part Heat Cure	2 Part Heat Cure	2 Part Heat Cure	2 Part Heat Cure
Property (uncured)		Flowable	Flowable	Flowable	Flowable	Flowable	Flowable
Mixing Ratio	(A:B)	100:100	-	100:100	100:100	100:100	100:100
Viscosity @23°C	Pa·s	40	60	3.5	2.6	20	7.0
Tack Free Time	Min	-	10	-	-	-	-
Pot Life @23°C	h	8	-	8	8	3	3
Color		Gray	White	Gray	Dark Gray	Black	Black
Curing Condition	°C/h	150/0.5	-	120/1	120/1	100/1	100/1
Thermal Conductivity	W/m·K	1.68	0.83	0.63	0.53	1.26	0.63
Specific Gravity @23°C		2.70	1.64	1.51	1.43	2.50	1.53
Hardness (Type A)		70	63	60	45	10 (penetration)	25 (penetration)
Tensile Strength	MPa	2.5	3.9	2.9	3.1	-	-
Elongation	%	100	100	70	120	-	-
Adhesive Strength	MPa	1.5	1.3	1.3	1.6	-	-
CTE	ppm/K	140	-	170	190	-	-
Volume Resistivity	MΩ·m	$2.1x10^6$	$4.0x10^6$	$2.0x10^6$	$6.0x10^6$	$1.0x10^7$	$1.0x10^7$
Dielectric Strength	kV/mm	15	20	26	22	22	22
Flame Retardancy		-	UL94 V-1	UL94 V-0	UL94 V-0	-	-

Typical property values should not be used as specifications

Packaging

	150gr tube	333ml crt.	1kg can	1.5kg can	5kg can	6kg can	20kg can	25kg pail can
TSE3380 (A)			●					
TSE3380 (B)			●					
XE11-5133S	●	●						
TSE3331 (A)			●	●		●		●
TSE3331 (B)			●	●		●		●
TSE3331K (A)			●		●			
TSE3331K (B)			●		●			
TSE3081 (A)			●				●	
TSE3081 (B)			●				●	
TSE3080 (A)			●				●	
TSE3080 (B)			●				●	

Handling & Storage

- For 2 Part grades, mix both parts thoroughly before use, as filler sedimentation may occur during storage.
- Wear eye protection and protective gloves at all times.
- Maintain adequate ventilation in the work place at all times.
- Store in a dark, cool place out of direct sunlight.

Thermal Management Fundamentals

Thermal Conductivity

Thermal Conductivity is a property that describes the intrinsic ability of a material to conduct heat. It is commonly represented by the unit W/m·K (watt per meter Kelvin), which measures the rate (watt) at which heat travels through a material where there is a temperature difference between two points (T1 - T2) over a specific distance (d).

k = thermal conductivity (W/m·K)
q = rate of heat flow (W)
T = temperature
d = distance
A = contact area

$$q = kA\frac{(T_1 - T_2)}{d}$$

Thermal Conductivity can be further derived from this formula as follows: A higher k value (W/m·K) indicates that the material is more efficient at conducting heat.

$$k = \frac{q}{A} \cdot \frac{d}{(T_1 - T_2)}$$

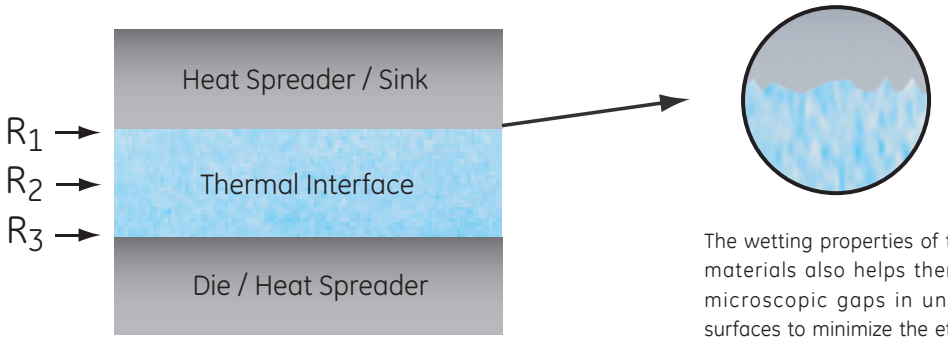
Thermal Resistance

Thermal Resistance also describes the thermal properties of a material and how it resists heat at a specific thickness.

$$R_m = A\frac{(T_1 - T_2)}{q}$$

Thermal resistance is proportional to the thickness of the material, but it can be affected by gaps that occur between contact surfaces. These gaps create *Contact Resistance*, contributing to additional thermal resistance not represented in the above formula. Therefore, total thermal resistance in an application is represented by:

$$R = R_m + R_C$$



GE Advanced Materials designs its thermal silicones to maximize thermal conductivity of the interface material (R2), and minimize the resistance between R1 and R3 through minimized bond lines.

The wetting properties of these materials also helps them fill microscopic gaps in uneven surfaces to minimize the effects of contact resistance.

Thermal Conductivity Unit Conversion Guide

There are several commonly used measurements of Thermal Conductivity. In addition to W/m·K, other potential units of measurement include cal/cm·s°C and BTU-in/hr·ft²°F.

Original Unit	Conversion Multiplier	Final Unit
W/m·K	2.4×10^{-3}	cal/cm·s°C
	6.94	BTU-in/hr·ft²°F
cal/cm·s°C	4.2×10^{2}	W/m·K
BTU-in/hr·ft²°F	0.14	W/m·K

Product Availability by Region[1]

	Japan	Korea	China	US	Europe
TIG5000	●	●	●	●	●
TIG4000	●	●	●	●	●
TIG2000	●	●	●	●	●
TIG1000	●	●	●	●	●
TIG825	●	●	●	●	●
TIG708	●	●	●	●	●
TSE3286-G	●				●
SDC5000	●	●	●	●	●
LTR3291	●	●	●	●	●
LTR3292	●	●	●	●	●
TSE3282-G	●	●	●		●
TSE3281-G	●	●	●	●	●
XE11-B5320	●	●	●	●	●
TSE3941	●	●	●	●	●
TSE3941M	●	●	●		●
TSE3946	●	●	●	●	●
TSE3380	●		●	●	●
XE11-A5133S	●	●	●	●	●
TSE3331	●	●	●	●	●
TSE3331K	●	●	●	●[2]	●[2]
TSE3081	●	●	●	●	●
TSE3080	●	●	●	●	●

[1] Contact a GE Advanced Materials sales representative for availability in countries and regions not listed

[2] Product code TSE3331K-EX

Principal Locations

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		RTV Products - Elastomers 800.332.3390	304.746.1623
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