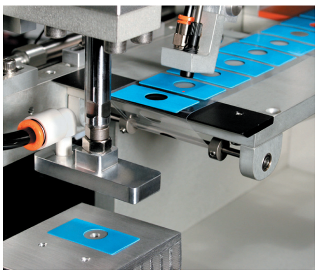
Sil-Pad® Thermally Conductive Insulators

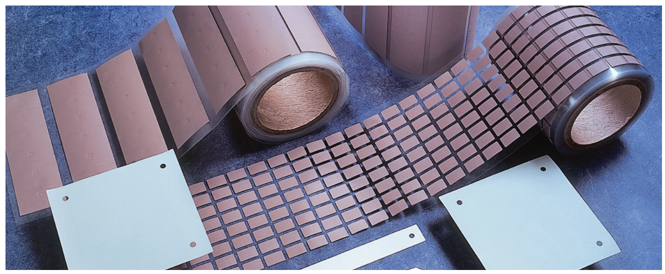
Solutions-Driven Thermal Management Products for Electronic Devices

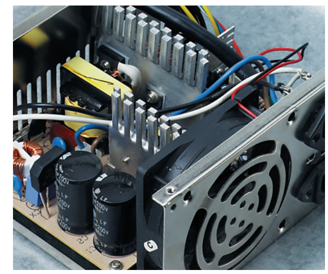
Comprehensive choices for a cleaner and more efficient thermal interface

More than 25 years ago, Bergquist set the standard for elastomeric thermal interface materials with the introduction of Sil-Pad. Today, Bergquist is a world leader with a complete family of Sil-Pad materials to meet the critical needs of a rapidly changing electronics industry.

Sil-Pad thermally conductive insulators, in their many forms, continue to be a clean and efficient alternative to mica, ceramics or grease for a wide range of electronic applications. Bergquist application specialists work closely with customers to specify the proper Sil-Pad material for each unique thermal management requirement.







Features

The Sil-Pad family encompasses dozens of products, each with its own unique construction, properties and performance. Here are some of the important features offered by the Sil-Pad family:

- Proven silicone rubber binders
- Fiberglass, dielectric film or polyester film carriers
- Special fillers to achieve specific performance characteristics
- Flexible and conformable
- Reinforcements to resist cut-through
- Variety of thicknesses
- Wide range of thermal conductivities and dielectric strengths

Benefits

Choosing Sil-Pad thermal products saves time and money while maximizing an assembly's performance and reliability. Specifically:

- Excellent thermal performance
- Eliminates the mess of grease
- More durable than mica
- Less costly than ceramic
- Resistant to electrical shorting
- Easier and cleaner to apply
- Under time and pressure, thermal resistance will decrease
- Better performance for today's high-heat compacted assemblies
- A specific interfacial performance that matches the need
- Efficient "total applied cost" that compares favorably with other alternatives

Options

Some Sil-Pad products have special features for particular applications. Options include:

- Available with or without adhesive
- Some configurations are well suited for automated dispensing and/or placement
- Aluminum foil or imbedded graphite construction for applications not requiring electrical insulation
- Copper shield layer
- Polyester binder material for silicone-sensitive applications
- Polyimide film carrier for increased voltage breakdown
- Materials with reduced moisture sensitivity
- Available in rolls, sheets, tubes and custom die-cut parts
- Custom thicknesses and constructions

We produce thousands of specials. Tooling charges vary depending on the complexity of the part.

Applications

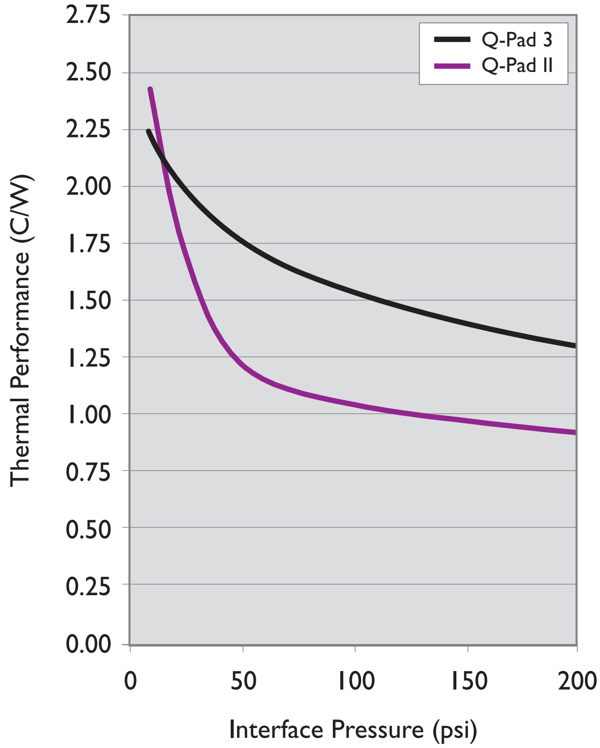
The large family of Sil-Pad thermally conductive insulators is extremely versatile. In today's marketplace, Sil-Pads are used in virtually every component of the electronics industry, including:

- Interface between a power transistor, CPU or other heat-generating component and a heat sink or rail
- Isolate electrical components and power sources from heat sink and/or mounting bracket
- Interface for discrete semiconductors requiring low-pressure spring-clamp mounting
- Consumer electronics
- Automotive systems
- Telecommunications
- Aerospace
- Military
- Medical devices
- Industrial controls

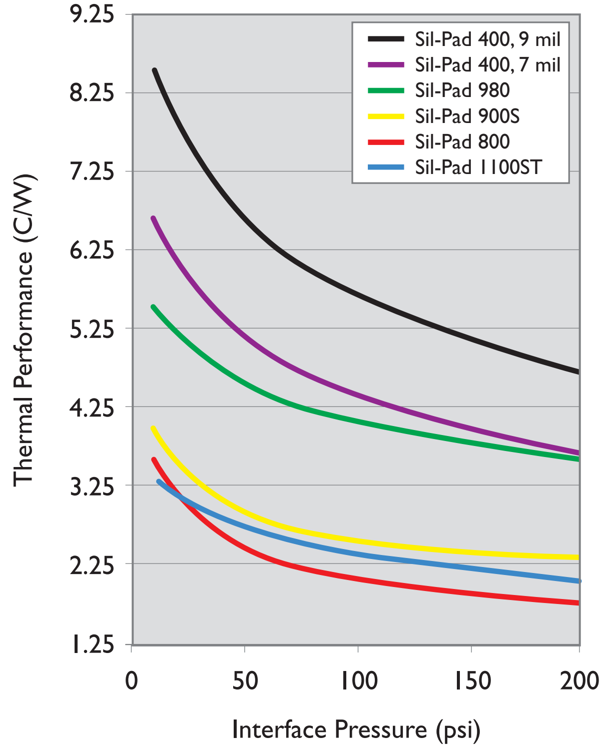
Sil-Pad® Comparison Data

TO-220 Thermal Performance

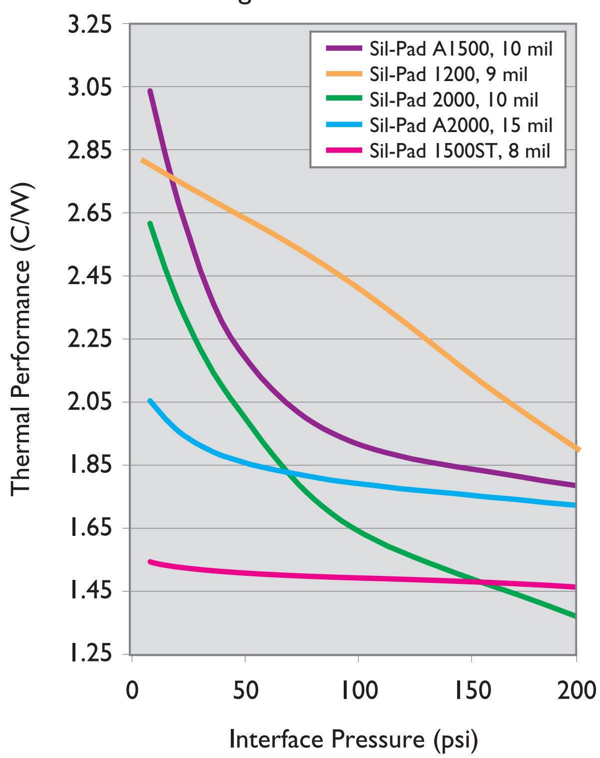
Q-Pad Materials
Non-Electrically Isolating



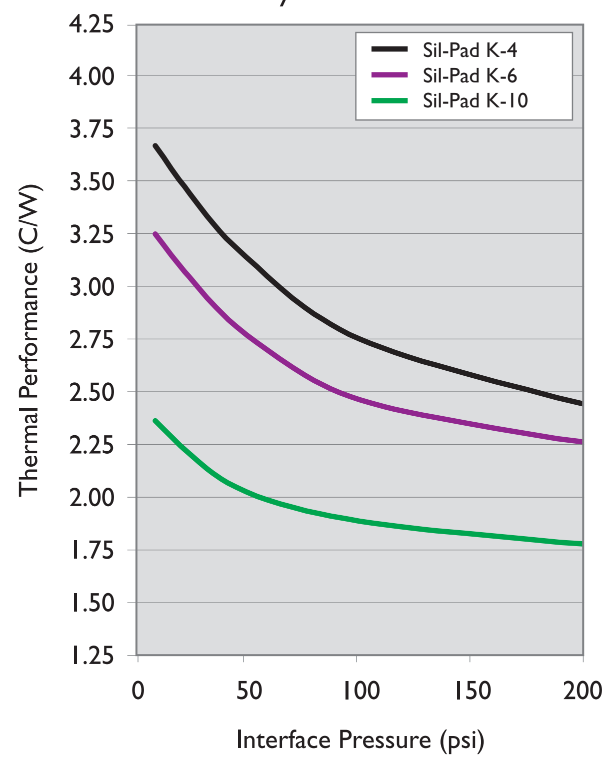
Sil-Pad High Value Materials



Sil-Pad High Performance Materials



Sil-Pad Polyimide-Based Materials



Frequently Asked Questions

Q: What is the primary difference between Sil-Pad A2000 and Sil-Pad 2000 products?

A: Sil-Pad A2000 utilizes a different filler package than Sil-Pad 2000. This change results in a more compliant Sil-Pad A2000 material that inherently lowers interfacial resistance losses. This reduction in interfacial resistance results in improved overall thermal performance when measured at lower pressures in standard ASTM D5470 and TO-220 testing.

Q: When should I choose Sil-Pad A2000 versus Sil-Pad 2000 for my application?

A: The answer is based on the assumption that the primary design intent is to increase thermal performance. If your application utilizes lower clamping pressures (e.g. 10 to 75 psi) you will find the Sil-Pad A2000 to provide excellent thermal performance. In contrast, if you are designing for higher clamping pressures (e.g. 100 psi or greater), it is likely that you will require the thermal performance characteristics of the Sil-Pad 2000.

Q: Are there differences in electrical characteristics between Sil-Pad A2000 and Sil-Pad 2000?

A: Yes. Bergquist evaluates and publishes voltage breakdown, dielectric constant and volume resistivity data per ASTM standards for these materials. Due to differences between ASTM lab testing and actual application performance, for best results, these characteristics should be evaluated within the actual customer system.

Q: Can I get Sil-Pad A2000 in roll form?

A: Yes. With the new environmentally "green" process improvements added with the introduction of Sil-Pad A2000 products, the materials are now available in roll form. The original Sil-Pad 2000 material cannot be produced in continuous roll form.

Q: When should I choose Sil-Pad 800 versus Sil-Pad 900S for my application?

A: Sil-Pad 800 is specifically formulated to provide excellent thermal performance for discrete semiconductor applications that utilize low clamping pressures (e.g. spring clips at 10 to 50 psi). In contrast, if you are designing for higher clamping pressure applications using discrete semi-conductors (e.g. 50 to 100 psi), it is likely that you will prefer the combination of high thermal performance and cut-through resistance inherent in Sil-Pad 900S material.

Q: When should I choose Sil-Pad 980 versus Sil-Pad 900S for my application?

A: Sil-Pad 980 is specifically formulated to provide superior cut-through and crush resistance in combination with excellent heat transfer and dielectric properties. Sil-Pad 980 has a proven history of reliability in high-pressure applications where surface imperfections such as burrs and dents are inherently common. These applications often include heavily machined metal surfaces manufactured from extrusions or castings. Sil-Pad 900S carries a high level of crush resistance and is more likely to be used in burr-free or controlled-surface finish applications.

Q: Is there an adhesive available for Sil-Pad 1500ST and Sil-Pad 1100ST?

A: Sil-Pad 1500ST and Sil-Pad 1100ST have an inherent tack on both sides of the material. This inherent tack is used instead of an adhesive. The tack provides sufficient adhesive for dispensing from the carrier liner and placement on the component. Sil-Pad 1500ST and Sil-Pad 1100ST can be repositioned after the initial placement.

Q: Why is the thermal performance curves of Sil-Pad 1500ST and Sil-Pad 1100ST so flat when compared to other Sil-Pads?

A: Sil-Pad 1500ST and Sil-Pad 1100ST wet-out the application surfaces at a very low pressures. Optimal thermal performance is achieved at pressures as low as 50 psi.

Q: How do I know which Sil-Pad is right for my specific application?

A: Each application has specific characteristics (e.g. surface finish, flatness tolerances, high pressure requirements, potential burrs, etc.) that determine which Sil-Pad will optimize thermal performance. Select a minimum of two pads that best fit the application, then conduct testing to determine which material performs the best.

Q: What is ISO9001:2000?

A: The ISO certification is the adoption of a quality management system that is a strategic decision of the organization. This International Standard specifies requirements for a quality management system where an organization: a) needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements, and b) aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and regulatory requirements.

Why Choose Sil-Pad Thermally Conductive Insulators?

Mica and Grease

Mica insulators have been in use for over 35 years and are still commonly used as an insulator. Mica is inexpensive and has excellent dielectric strength, but it is brittle and is easily cracked or broken. Because mica used by itself has high thermal impedance, thermal grease is commonly applied to it. The grease flows easily and excludes air from the interface to reduce the interfacial thermal resistance. If the mica is also thin (2-3 mils [50-80 µm]), a low thermal impedance can be achieved.

However, thermal grease introduces a number of problems to the assembly process. It is time-consuming to apply, messy and difficult to clean. Once thermal grease has been applied to an electronic assembly, solder processes must be avoided to prevent contamination of the solder. Cleaning baths must also be avoided to prevent wash-out of the interface grease, causing a dry joint and contamination of the bath. Assembly, soldering and cleaning processes must be performed in one process while the greased insulators are installed off-line in a secondary process. If the grease is silicone-based, migration of silicone molecules occurs over time, drying out the grease and contaminating the assembly.

Polyimide Films

Polyimide films can also be used as insulators and are often combined with wax or grease to achieve a low thermal impedance. These polyimide films are especially tough and have high dielectric strength. Sil-Pad K-4, K-6 and K-10 incorporate polyimide film as the carrier material.

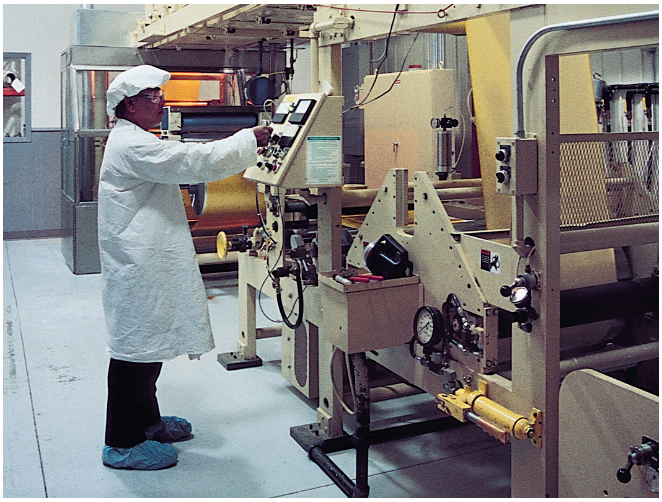
Ceramic Insulators

Other insulation materials include ceramic wafer insulators which have a higher thermal conductivity than mica. They are often used thicker (20-60 mils), (.5 to 1.5 mm) to reduce capacitive coupling while maintaining a low thermal impedance.

Drawbacks to ceramic insulators are their high cost and, like mica, they are rigid and crack easily. Also, ceramic beryllia use requires careful handling since inhalation of beryllia dust can cause lung inflammation (berylliosis).

Sil-Pad Materials

Sil-Pad thermally conductive insulators are designed to be clean, grease-free and flexible. The combination of a tough carrier material such as fiberglass and silicone rubber which is conformable, provides the engineer with a more versatile material than mica or ceramics and grease. Sil-Pad products minimize the thermal resistance from the case of a power semiconductor to the heat sink. Sil-Pad materials electrically isolate the semiconductor from the heat sink and have sufficient dielectric strength to withstand high voltage. They are also strong enough to resist puncture by the facing metal surface.



Binders

Most Sil-Pad products use silicone rubber as the binder. Silicone rubber has a low dielectric constant, high dielectric strength, good chemical resistance and high thermal stability.

Silicone rubber also exhibits cold flow, which excludes air from the interface as it conforms to the mating surfaces. This flow eliminates the need for thermal grease. A rough-surface-textured insulator needs to flow more to exclude air than a smooth one. The smoother pads also need less pressure to wet-out the surfaces and obtain optimum thermal contact.

Carriers

The carrier provides physical reinforcement and contributes to dielectric strength. High dielectric and physical strength are obtained by using a heavy, tight mesh, but thermal resistance will suffer. A light, open mesh reduces thermal resistance, dielectric strength and cut-through resistance. The carrier materials used in Sil-Pad materials include fiberglass and dielectric film.

Fillers

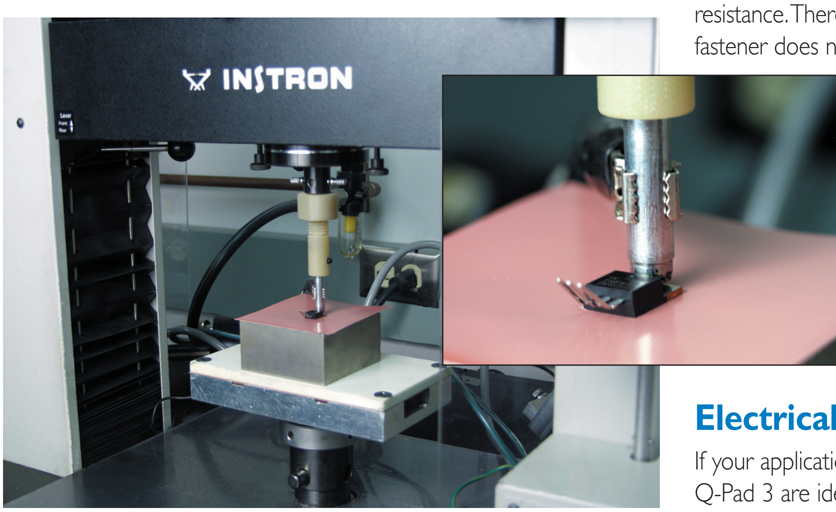
The thermal conductivity of Sil-Pad products is improved by filling them with ingredients of high thermal conductivity. The fillers change the characteristics of the silicone rubber to enhance thermal and/or physical characteristics.

For instance, some fillers make the silicone rubber hard and tough while still retaining the ability to flow under pressure. A harder silicone helps the material resist cut-through. In other applications a filler is used to make the silicone rubber softer and more conformable to rough surfaces. While the range in thermal resistance of greased mica is quite large, the average is comparable to elastomeric insulators filled with a blend of the appropriate ingredients.

Mechanical, Electrical and Thermal Properties

Mechanical Properties

Woven fiberglass and films are used in Sil-Pad products to provide mechanical reinforcement. The most important mechanical property in Sil-Pad applications is resistance to cut-through to avoid electrical shorting from the device to the heat sink.



Cut-Through Resistance *- Bergquist introduced its TO-220 cut-through test to help customers better understand typical application performance.*

Mounting Techniques and Mounting Pressure

Typical mounting techniques include:

- A spring clip, which exerts a centralized clamping force on the body of the transistor. The greater the mounting force of the spring, the lower the thermal resistance of the insulator.
- A screw in the mounting tab. With a screw-mounted TO-220, the force on the transistor is determined by the torque applied to the fastener.

In extremely low-pressure applications, an insulator with pressure sensitive adhesive on each side may give the lowest thermal resistance since the adhesive wets-out the interface easier than the dry rubber. This decreases the interfacial thermal resistance.

Devices with larger surface areas need more pressure to get the insulator to conform to the interface than smaller devices. In most screw-mount applications, the torque required to tighten the fastener is sufficient to generate the pressure needed for optimum thermal resistance. There are exceptions where the specified torque on the fastener does not yield the optimum thermal resistance for the insulator being used and either a different insulator or a different mounting scheme should be used.

Interfacial thermal resistance decreases as time under pressure increases. In applications where high clamping forces cannot be used, time can be substituted for pressure to achieve lower thermal resistance. The only way to know precisely what the thermal resistance of an insulator will be in an application is to measure it in that application.

Electrical Properties

If your application does not require electrical insulation, Q-Pad II or Q-Pad 3 are ideal grease replacement materials. These materials do not provide electrical isolation but have excellent thermal properties. Hi-Flow phase change materials should also be considered for these applications. (Reference pages 32-44 of this guide.)

The most important electrical property in a typical assembly where a Sil-Pad insulator is used is dielectric strength. In many cases the dielectric strength of a Sil-Pad will be the determining factor in the design of the apparatus in which it is to be used.

Here are some general guidelines regarding electrical properties to consider when selecting a Sil-Pad material:

- Q-Pad II and Q-Pad 3 are used when electrical isolation is not required.
- Dielectric breakdown voltage is the total voltage that a dielectric material can withstand. When insulating electrical components from each other and ground, it is desirable to use an insulator with a high breakdown voltage.

SIL-PAD TYPICAL ELECTRICAL PROPERTIES					
	BREAKDOWN VOLTAGE	DIELECTRIC STRENGTH		DIELECTRIC CONSTANT	VOLUME RESISTIVITY
Material	(kV)	(Volts/mil)	(kV/mm)	(1000 Hz)	(Ohm-Meter)
Sil-Pad 400 - 0.007	3.5	500	20	5.5	10^{11}
Sil-Pad 400 - 0.009	4.5	500	20	5.5	10^{11}
Sil-Pad 900S	5.5	600	24	6.0	10^{10}
Sil-Pad 1200 - 0.009	6.0	667	26	7.0	10^{10}
Sil-Pad A1500	6.0	600	24	7.0	10^{11}
Sil-Pad 2000	4.0	400	16	4.0	10^{11}
Sil-Pad K-4	6.0	1000	39	5.0	10^{12}
Sil-Pad K-6	6.0	1000	39	4.0	10^{12}
Sil-Pad K-10	6.0	1000	39	3.7	10^{12}
Test Method	ASTM D149* * Method A, Type 3 Electrodes	ASTM D149* * Method A, Type 3 Electrodes		ASTM D150	ASTM D257

- Breakdown voltage decreases as the area of the electrodes increases. This area effect is more pronounced as the thickness of the insulator decreases.
- Breakdown voltage decreases as temperature increases.
- Breakdown voltage decreases as humidity increases.
- Breakdown voltage decreases in the presence of partial discharge.
- Breakdown voltage decreases as the size of the voltage source (kVA rating) increases.
- Breakdown voltage can be decreased by excessive mechanical stress on the insulator.

Dielectric strength, dielectric constant and volume resistivity should all be taken into consideration when selecting a Sil-Pad material. If your application requires specific electrical performance, please contact a Bergquist Sales Representative for more detailed testing information.

Thermal Properties

The thermal properties of a Sil-Pad material and your requirements for thermal performance probably have more to do with your selection of a Sil-Pad than any other factor.

Discrete semiconductors, under normal operating conditions, dissipate waste power which raises the junction temperature of the device. Unless sufficient heat is conducted out of the device, its electrical performance and parameters are changed. A 10°C rise in junction temperature can reduce the mean-time-to-failure of a device by a factor of two. Also, above 25°C, the semiconductor's total power handling capability will be reduced by a derating factor inherent to the device.

The thermal properties of Sil-Pad products are thermal impedance, thermal conductivity and thermal resistance. The thermal resistance and conductivity of Sil-Pad products are inherent to the material and do not change. Thermal resistance and thermal conductivity are measured per ASTM D5470 and do not include the interfacial thermal resistance effects. Thermal impedance applies to the thermal transfer in an application and includes the effects of interfacial thermal resistance. As the material is applied in different ways, the thermal impedance values will vary from application to application.

- The original Sil-Pad material, Sil-Pad 400, continues to be Bergquist's most popular material for many applications.
- Sil-Pad A1500 is chosen when greater thermal performance is required. Sil-Pad A2000 is ideal for high performance, high reliability applications.

Beyond these standard materials, many things can contribute to the selection of the correct material for a particular application. Questions regarding the amount of torque and clamping pressure are often asked when selecting a Sil-Pad material. Here are some guidelines:

- Interfacial thermal resistance decreases as clamping pressure increases.
- The clamping pressure required to minimize interfacial thermal resistance can vary with each type of insulator.
- Sil-Pad products with smooth surface finishes (Sil-Pad A1500, Sil-Pad A2000, Sil-Pad K-4, Sil-Pad K-6 and Sil-Pad K-10) are less sensitive to clamping pressure than Sil-Pads with rough surface finishes (Sil-Pad 400) or smooth and tacky finishes (Sil-Pad 1500ST).

Sil-Pad Thermal Performance Overview (TO-220 Test @ 50 psi)