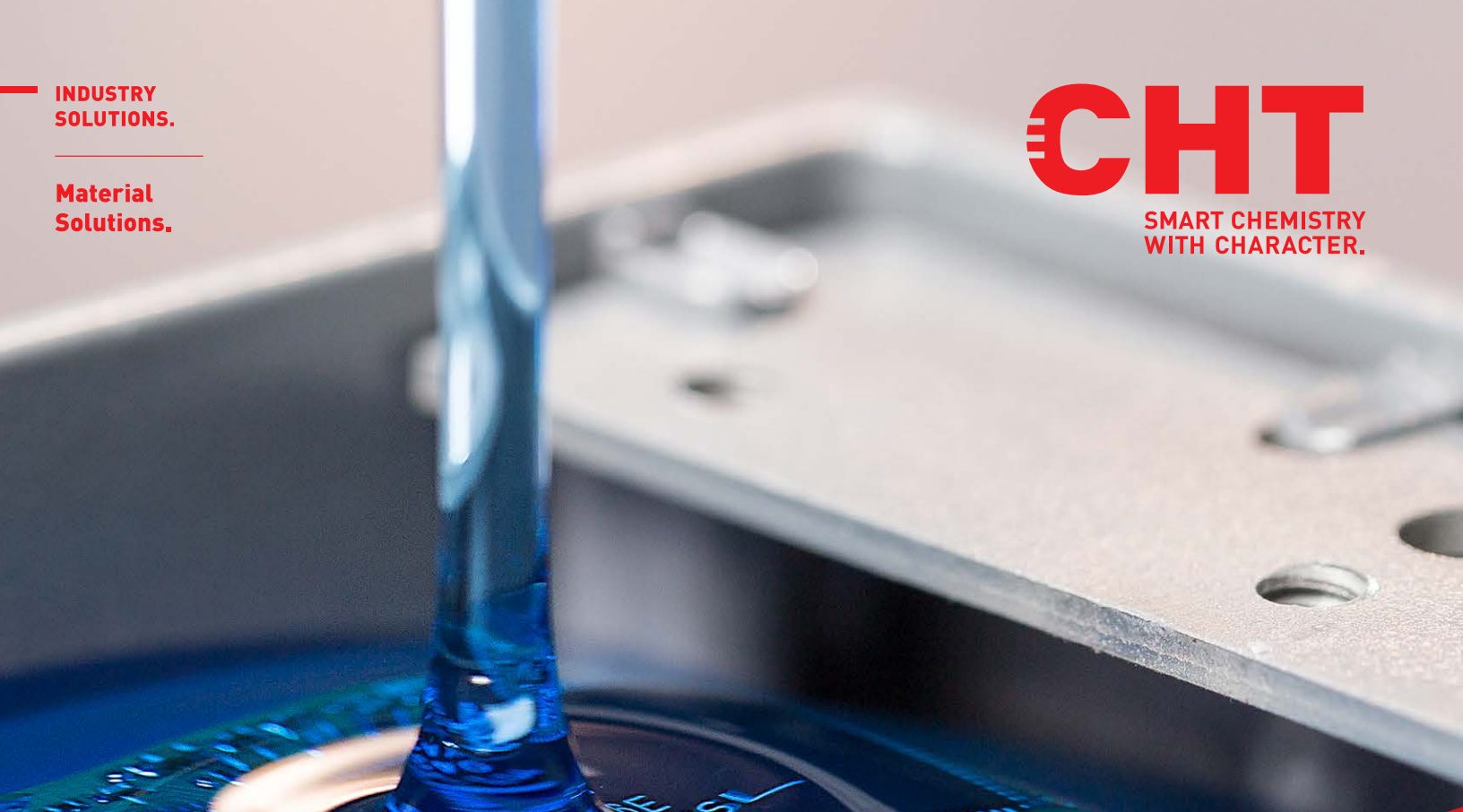
INDUSTRY SOLUTIONS.

Material Solutions.

CHT

SMART CHEMISTRY WITH CHARACTER.



CUSTOMIZED SILICONE TECHNOLOGY

FOR TODAY'S AND NEXT GENERATION ELECTRONIC APPLICATIONS

Electronics are fundamental to products and equipment across nearly every industry. In order to function effectively and reliably, electronics must be protected from harsh environmental conditions such as moisture, temperature fluctuations, and UV exposure. Electronic components may also be affected by impacts, shock, vibrations, and thermal expansion. All these factors can cause dangerous electrical malfunctions and sometimes critical failures.

With the continued miniaturization and expanding population of components that comprise electronic devices, mitigation of generated heat is an ongoing issue. To achieve operational stability and longevity, thermally conductive materials are often incorporated within the device to aid in heat dissipation. With the addition of specialty fillers, silicone formulations can be customized to facilitate the flow of heat to or from electronic components in an assembly.

While other materials such as epoxies, polyurethanes, among others are often used to protect electronic components, silicone elastomers feature increased flexibility, versatility, durability, and longevity as well as maintain their physical properties in a wider operational temperature range compared to alternative materials. Silicone formulations can be further developed to meet specific application requirements and operating environments.

The CHT Group's silicone experts possess extensive experience designing a broad range of silicone technology including potting compounds and encapsulants, thermal interface materials, gels, coatings, and adhesive sealants for large and small companies worldwide.

CUSTOMIZATION OF SILICONE ELASTOMER PROPERTIES

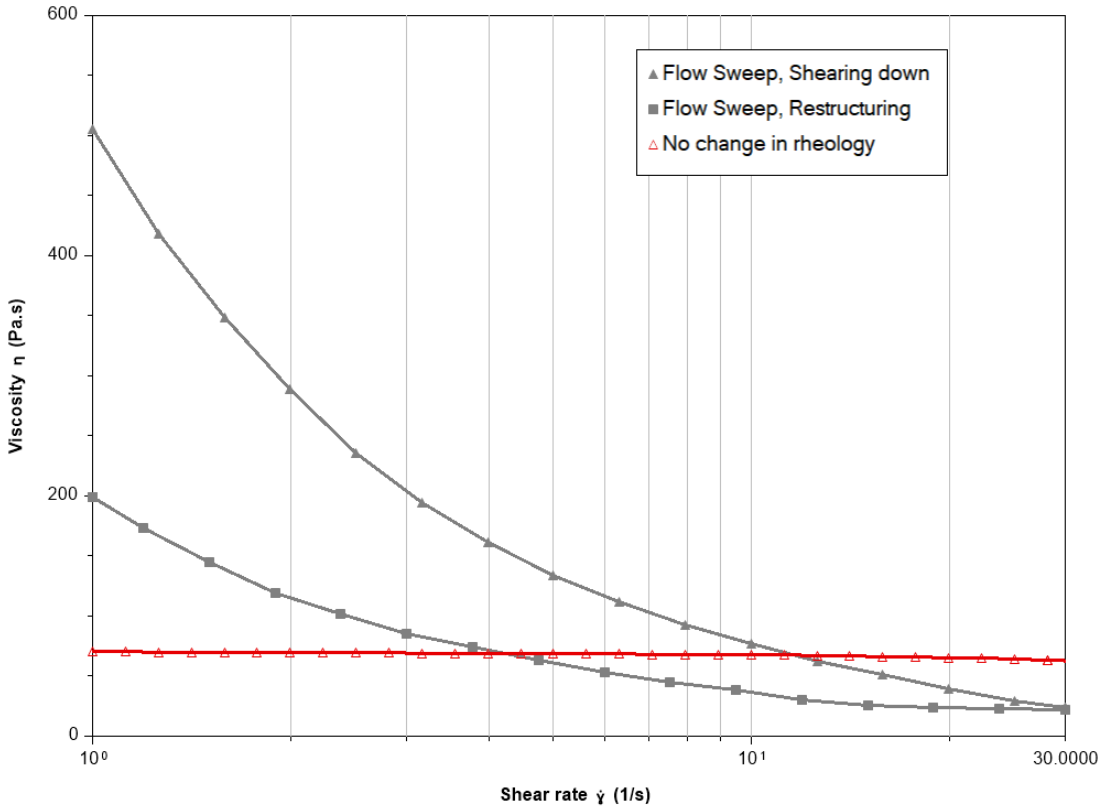
Because each application is unique, CHT's silicone experts will demonstrate their knowledge and flexibility in customizing formulations to meet your specific requirements. CHT's team will partner with you to solve challenges, improve your manufacturing processes, and enhance your electronics' performance.

A major advantage of silicones is its versatility and compatibility with other materials. Several of its physical properties can be tailored to meet particular design and manufacturing process requirements, including the following:

Rheology

Rheology studies the flow of matter. To protect all components, CHT has modified the flowability of silicones to improve encapsulation which minimizes air entrapment that could lead to failure. CHT has also created thixotropic materials for damming in electronics to help customers prevent runoff and eliminate material waste.

Rheology Comparison Graph



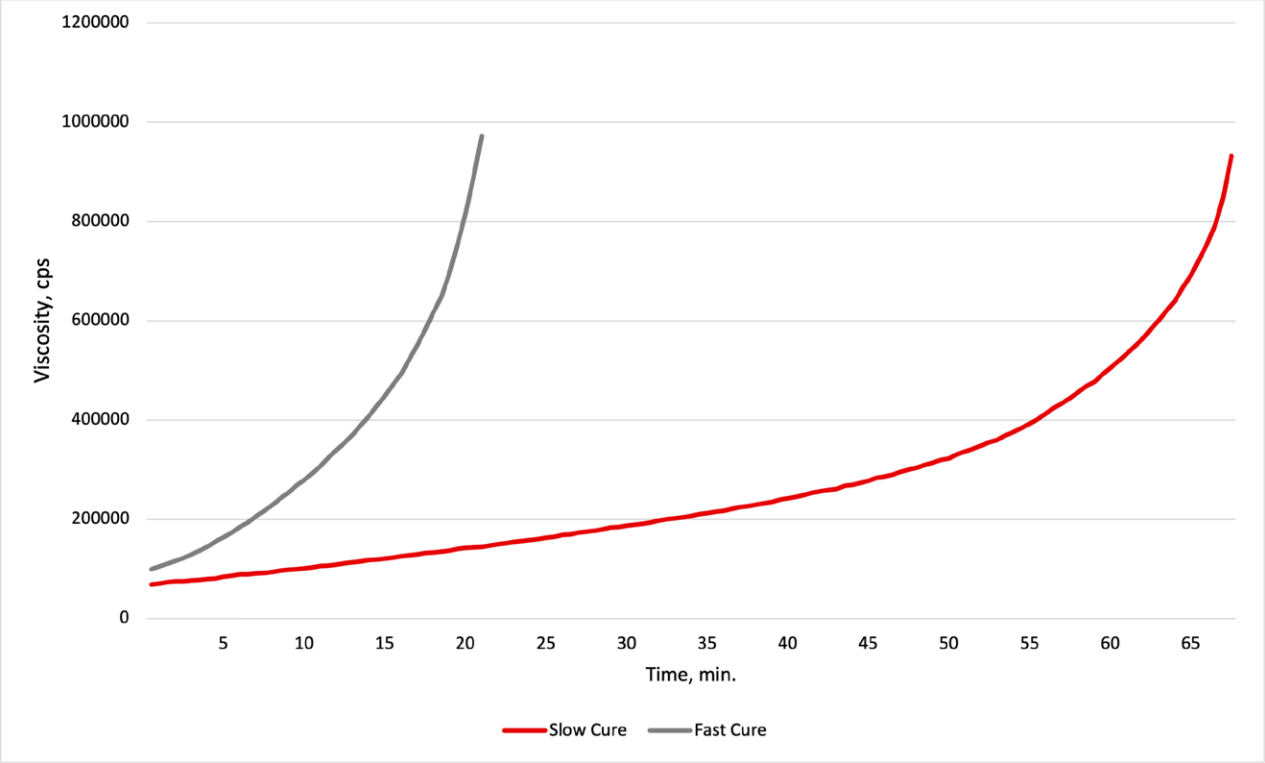
Durometer

Durometer measures the hardness of a material. As needed, CHT is able to adjust the durometer of silicone elastomers. CHT can increase the Shore A durometer to make it easier for the customer to remove dust and debris from the silicone's surface. Based on differing customer requests, CHT has modified silicone elastomers to feature lower durometers (1) in the Shore, 00 range for minimizing coefficient of thermal expansion (CTE) strain on components, (2) for improving vibration resistance and shock absorption, and (3) down to the Shore 000 range for self-healing properties in connector applications.

Gel time/Work life

Gel time/Work life is the length of time it takes for a material to thicken but not fully harden. For electronic potting applications, CHT has customized silicone elastomers with a faster gel time for customers looking to maximize production efficiency. As a result, faster processing times were achieved since components, once potted, could move on more rapidly to the next manufacturing step without silicone migrating or leaking.

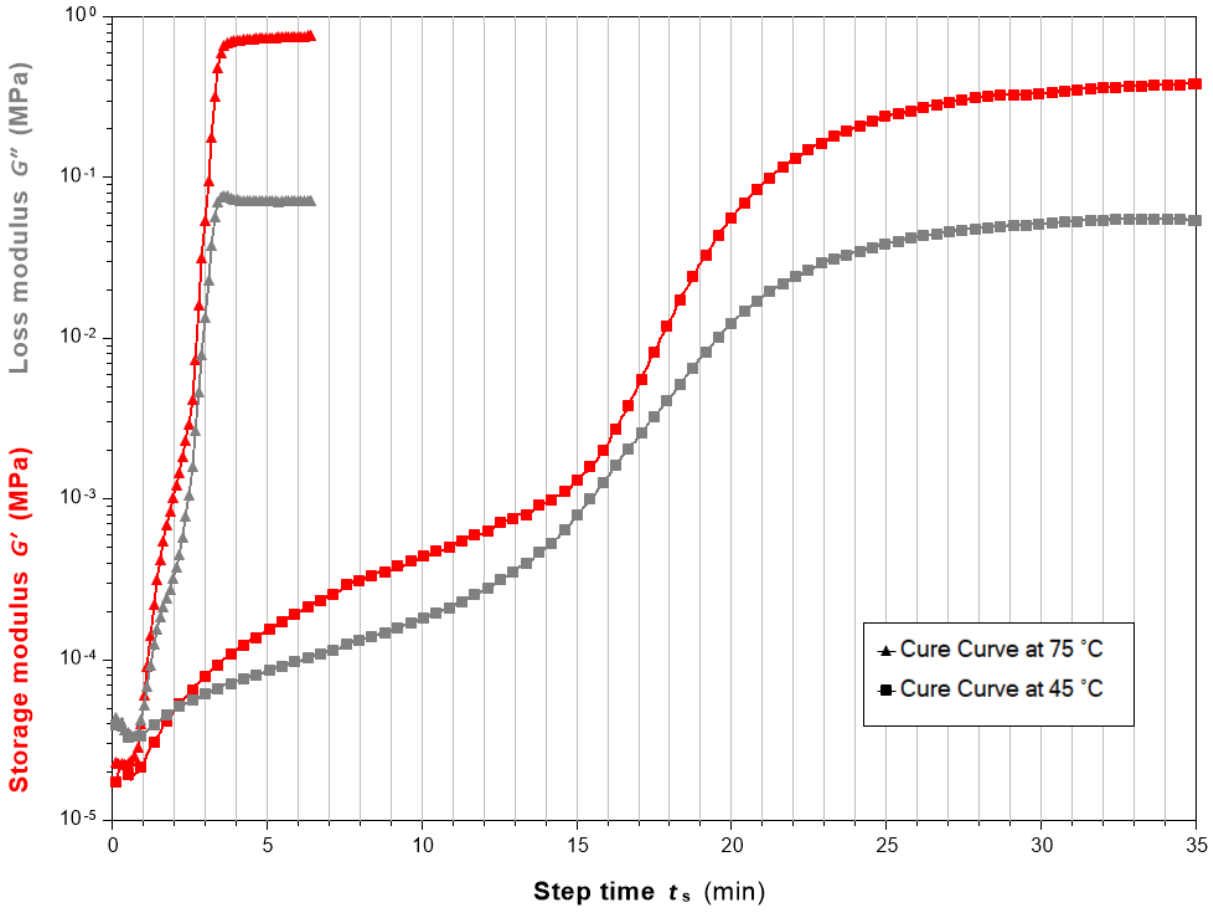
Work Life Graph



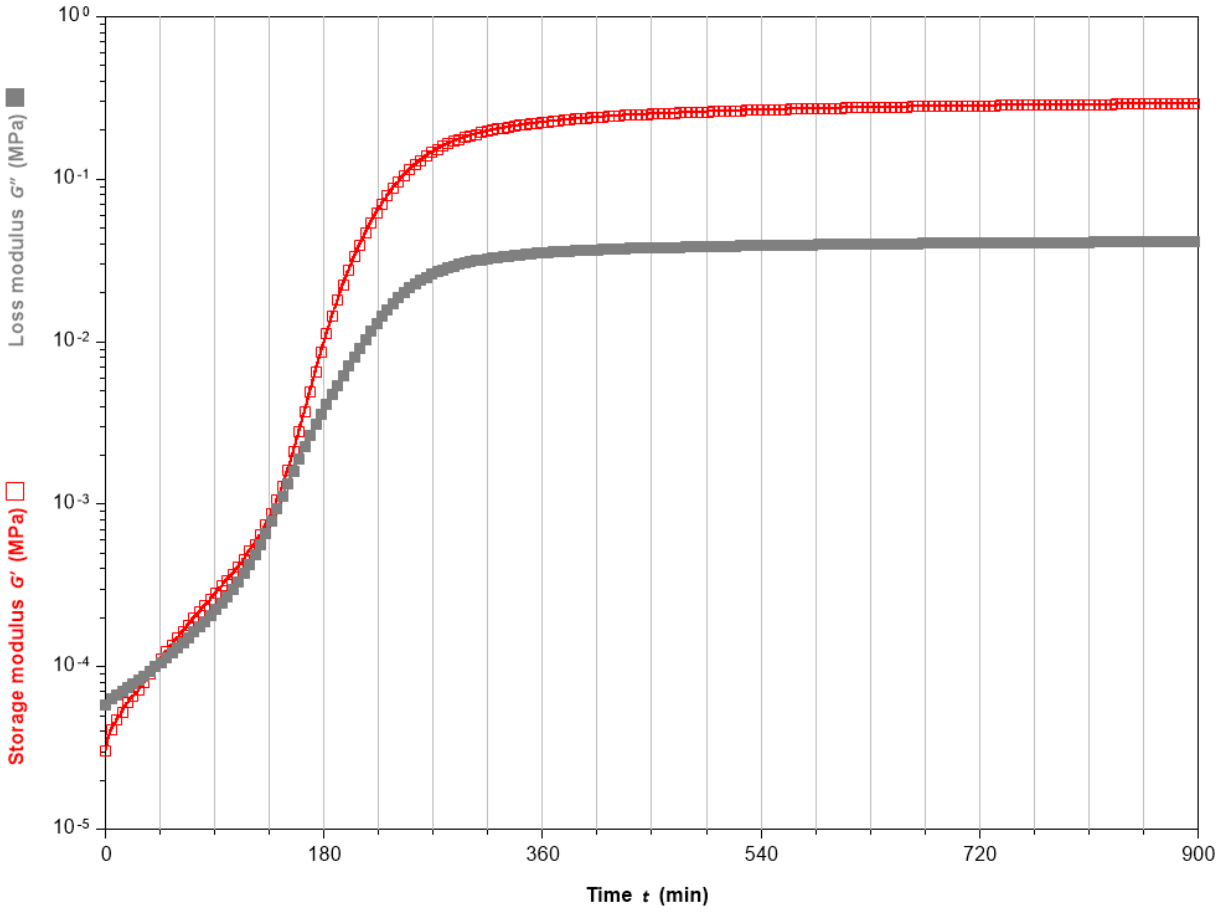
Cure time

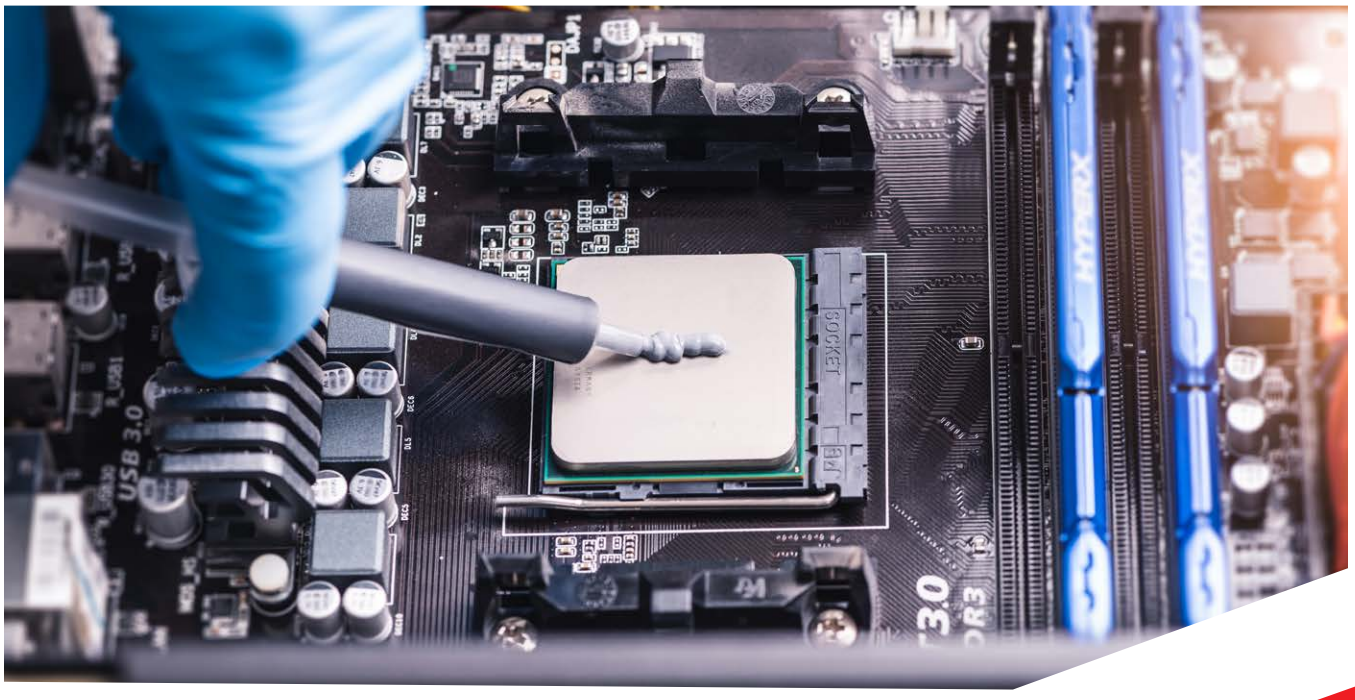
Cure time is the length of time it takes for a material to fully harden once the crosslinking process is complete. To improve processing speed, CHT has commonly received requests for customized cure times from customers who do not want to apply heat to speed the cure of platinum-catalyzed silicones or use additional chemistries such as accelerators. One application that can benefit from a faster cure time is cured in place gasket (CIPG). A bead of silicone elastomer is dispensed in the gasket channel and allowed to cure. This creates a gasket that will seal the two surfaces when they are assembled. With faster cure times, customers can assemble more parts in a shorter timeframe.

Cure Time Comparison Graph



Cure Time Graph #2
Sample Cured at 25 °C



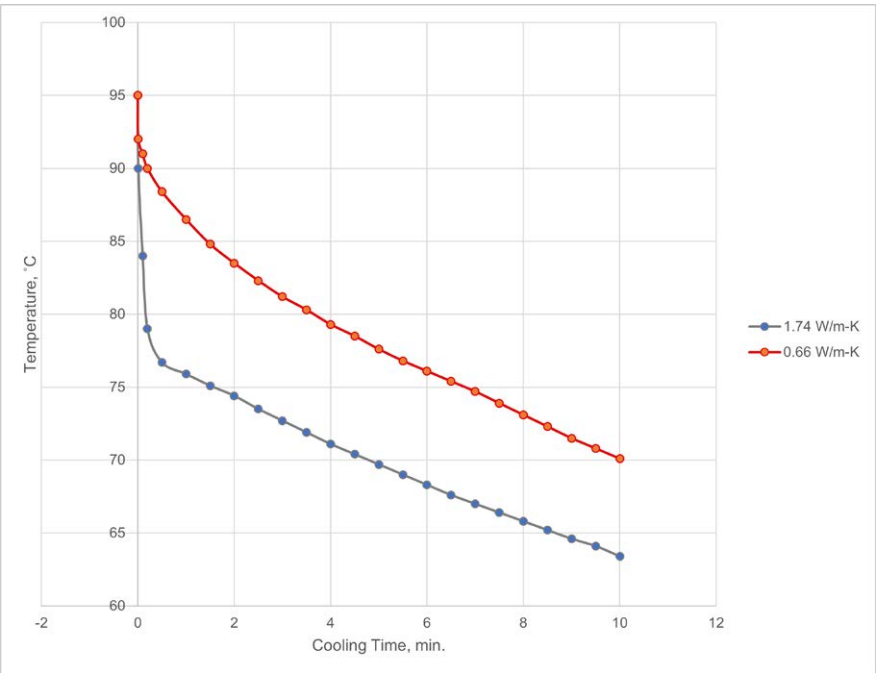


In addition, CHT customizes other properties key to electronic applications including:

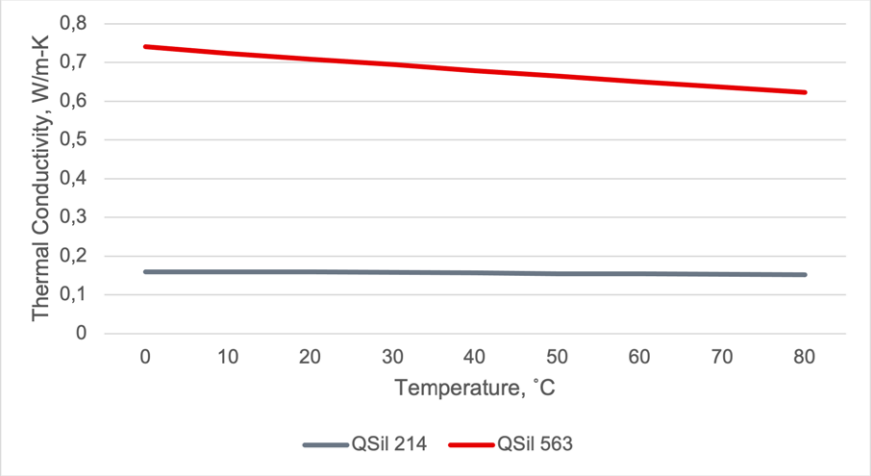
Thermal conductivity

Thermal conductivity is the ability of a material to conduct heat. Smaller electronic components generate more heat with less surface area, so the silicone needs to remove heat more efficiently. CHT's research and development team is continually increasing their focus in the area of thermal management and can customize silicone elastomers with different levels of thermal conductivity based on a customer-specific application.

Cooling Efficiency of Thermally Conductive Silicones



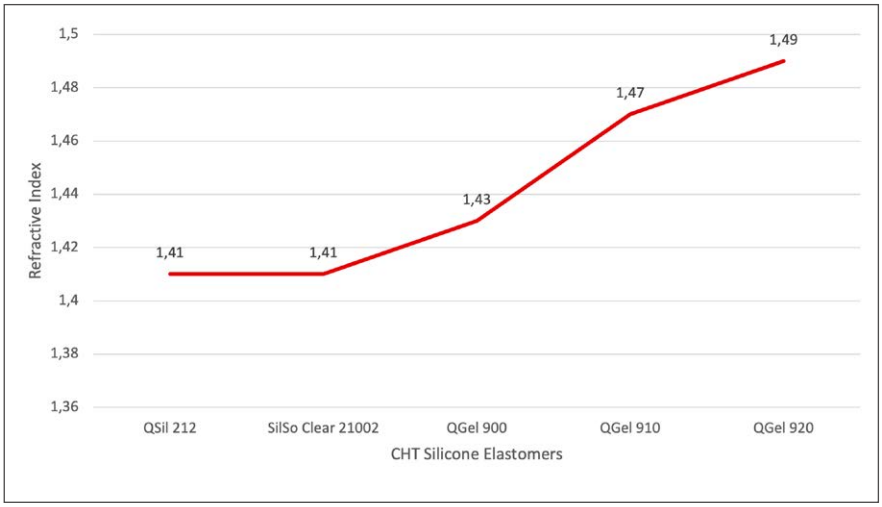
Thermal Conductivity Graph



Refractive index

Refractive index measures how light is bent when passing through a material. For LED and lighting applications, how light bends when it passes through the silicone coating can influence how bright and sharp the light appears. Utilizing a more closely matched refractive index can result in improved contrast and brightness. CHT can tailor certain refractive indices for customer applications to ultimately produce a sharper, clearer picture, by minimizing refractive index mismatch.

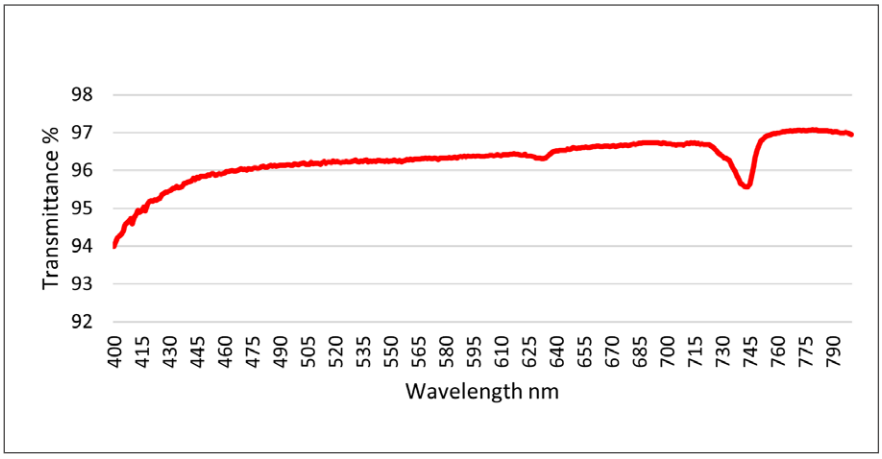
Refractive Index Graph



Optical transmission

Optical transmission measures the proportion of light transmitted through a medium. In LED displays and lighting applications, the use of optical silicone elastomers can result in improved performance. CHT has the capability to design optical materials with high, stable transmittance, stable yellowness index (Y.I.) and low diffusance.

CHT's QSil 214 Transmittance Graph



Color

Silicone elastomer formulations can be color customized. Customers have looked to CHT to tailor the color for various reasons including contrast enhancement, theft prevention, or improve visual inspection.

CASE STUDY
DAKTRONICS – SOUTH DAKOTA, USA

CHT was approached by Daktronics, an electronics manufacturer, about resolving a challenge with a new LED encapsulation designed for use in harsh environments. They needed a transparent silicone elastomer to be overmolded onto printed circuit boards (PCBs) with LEDs but were experiencing issues with achieving good adhesion to the populated PCB.

Based on these challenges, CHT custom designed a silicone encapsulant that met the company's specific manufacturing process. Low viscosity was required to easily flow throughout and fill the mold. The custom formulated silicone encapsulant met the required gel and cure times, and also featured excellent optical clarity. Good adhesion with both a custom primer and plasma treatment was developed in partnership with PVA TePla.

CASE STUDY
HIGH VOLTAGE POWER SUPPLY MANUFACTURER – USA

A major manufacturer of high-voltage power supplies was seeking an alternate source for a silicone elastomer for potting a high-voltage power supply used in medical imaging equipment. They were experiencing field failures due to delamination and shearing of components within the power supply due to high modulus.

CHT was able to develop a low modulus material that rectified this issue while continuing to maintain all of the desired attributes critical to performance. The critical to quality requirements were consistent modulus, low viscosity for better flow in and around components, and a custom cure profile to meet the requirements for pot life. The silicone potting compound also featured little-to-no shrinkage and was certified with UL approval for high voltage.

This new formulation developed by CHT helped the customer resolve issues they were facing with their power supply application.

COMMON ALTERNATIVE MATERIALS FOR ELECTRONIC PROTECTION

Electronic protection requires extremely durable materials that can withstand harsh operating conditions, such as extreme temperatures, moisture, chemical exposure, and radiation. Epoxies and polyurethanes exhibit many of these characteristics and are commonly available for electronic protection applications but have limitations.

- **Acrylic -** Acrylic coatings are typically transparent, solvent based, are easy to apply and are repairable. They can be dissolved with solvents to control layer thickness. Acrylic coatings have long pot life and short drying times. They have good bonding strength and cure to a hard durometer. These coatings tend to exhibit low moisture absorption and less vapor transmission than silicone. However, acrylic coatings do not remain stable when exposed to solvents and ultraviolet light. Under high temperatures, acrylic may further shrink or depolymerize. Components in acrylic coatings can also potentially pose a health risk by causing sensitization through constant exposure. Additionally, sustainability initiatives look to minimize or eliminate the use of solvent based materials.

- **Epoxies -** Epoxy coatings are very hard, usually opaque and are good at resisting the effects of moisture. They possess chemical and abrasion resistance but can cause stress on components during thermal extremes. Epoxies are vulnerable to humidity and moisture absorption and can crack from thermal shock. Many epoxy chemistries are susceptible to UV-degradation. Epoxy-based materials may continue to harden over time and may also become brittle and crack if exposed to high mechanical stress. When compared to silicones, epoxies generally are not as durable over time when exposed to environmental extremes or repairable if needed.

- **Polyurethanes –** Polyurethane coatings are often used for potting around electronic equipment to provide durable protection from the elements. Polyurethanes are tough, hard and exhibit resistance to solvents. Along with abrasion resistance and low moisture permeability, polyurethanes sometimes offer good low-temperature flexibility. However, the use of polyurethanes is often prevented because of its limited high-temperature capability and lack of repairability. Finally, polyurethanes feature a lower resistance to heat than silicones and are susceptible to damaging factors such as UV, shock, and aging.

- **Parylene** – Parylene coatings are uniform, yield good pin coverage, and offer good protection with the lightest coating weights. They cure at room temperature, are generally biocompatible and feature good dielectric strength. The downside to parylene is higher cost due to the special equipment needed for vapor deposition and batch processing is also required. In the case of component failure, field repairs would be prohibitive.

ADVANTAGES OF SILICONE TECHNOLOGY FOR ELECTRONICS

In comparison to the other chemistries previously mentioned, silicone elastomers are highly versatile. Silicone formulations can be customized and tailored to meet the requirements of a variety of applications. In general, the final properties remain consistent in a wide array of processing parameters. Silicone elastomers offer excellent stability and its physical properties are predictably consistent over broad temperature ranges. They exhibit excellent resistance to water and many chemicals. The versatility of silicones enable products to have targeted electrical or thermal properties ranging from insulative or conductive.

CHT's silicone experts develop high-quality solutions to ensure reliable operation, boost overall efficiency, and extend the service life of your equipment. Our optimized silicone elastomers can also help lower overall manufacturing costs by producing minimal scrap and facilitating efficient production processes.

The properties of silicone elastomers offer unique advantages, including:

- **Wide range of viscosities and flow:** CHT offers products that range from very low to highly viscous. The flowability of CHT's products also covers a broad spectrum including highly flowable to paste consistency while available rheology includes Newtonian, thixotropic and dilatant materials.
- **Multiple curing methods:** CHT's formulations are available to fit the needs for a variety of cure methods or chemistries including: moisture, platinum, UV, free radical, or a combination. Cure conditions can also be tailored to a customer's process.
- **Varying durometer/hardness:** CHT's silicone elastomers range from low to high durometers providing a selection for various application requirements.
- **Broad temperature range:** Silicone elastomers maintain their shape and physical properties in temperatures ranging from -55 ºC to 204 ºC, with some having useful temperature ranges up to 300 ºC or as low as -115 ºC. Silicone elastomers' ability to maintain elasticity and reliability in low temperatures make them particularly useful in aerospace applications.
- **Optical qualities:** Silicone elastomers can be designed with highly stable transmittance for a variety of applications including optical bonding, lenses, and LED encapsulation.
- **UV resistance:** Silicone elastomers have excellent UV resistance and exhibit long-term stability in a wide variety of environmental conditions.
- **High thermal conductivity:** CHT's silicone elastomers can be formulated with high levels of thermal conductivity while targeting specific properties which makes them ideal for thermal management in temperature-sensitive applications.
- **Superior adhesion:** Silicone elastomers can adhere to a wide variety of substrates, such as glass and aluminum with selected adhesion packages or primers.
- **Flame retardant:** Numerous grades of CHT's silicone elastomers are UL-listed for flame retardancy (See UL file numbers: QMFZ2.E205830, QMFZ2.E334038, QMJU2.E493561).
- **Shock and vibration absorption:** Silicone elastomers reduce shock and vibration which controls noise and mitigates damage from impacts in transportation and aerospace applications.
- **Easy repair:** CHT's silicone elastomers can be formulated to further enable repairability.

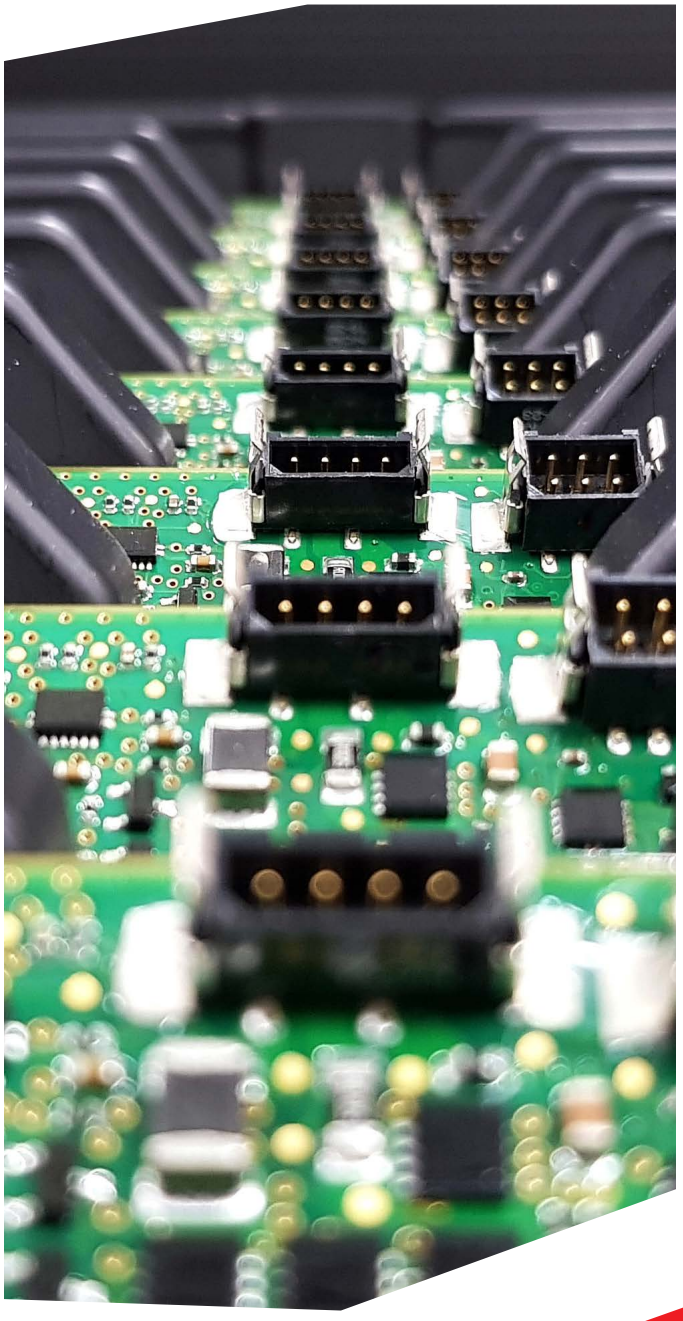
INDUSTRIES AND APPLICATIONS

The exceptional versatility of silicones enables them to be utilized in a wide array of electronic applications, from protective sleeves and sealing to LED encapsulation, thermal transfer, and optical bonding.

Industries that stand to benefit from silicones include:

- Automotive, including electric, hybrid, and autonomous vehicles
- Appliances
- Aerospace and aviation
- Industrial measurement and control
- LED and lighting
- Military and defense
- Power supplies and electronics
- Railway and transportation
- Telecommunication
- Wearable medical and recreational devices

As material technology continues to evolve, manufacturers continue to develop innovative new uses for silicone elastomers to meet technological challenges and improve equipment performance, electronic protection, and thermal management for increasingly miniaturized electronics.



GET THE LATEST SILICONE TECHNOLOGY FROM CHT

In today's increasingly technological world, electronics have become part of nearly every industry. Greater complexity and continuous miniaturization make thermal management and environmental protection for electronic components more important than ever. Advanced silicone elastomer technology possesses the physical attributes necessary to facilitate reliable electronic operation, thereby improving system lifetimes and enhancing industrial and commercial operations.

CHT's silicone experts take pride in providing custom solutions for customers globally in a wide range of industries. CHT's team establishes strong technical partnerships with customers in order to gain a thorough understanding of their operations and system requirements. With extensive experience in chemical and material development, CHT has the knowledge and expertise necessary to custom formulate silicone elastomers to meet your design specifications and improve overall process efficiency.

CHT offers the following for our customers worldwide:

- Technical partnership - project and application consultation
- Customized silicone formulations and solutions for small companies up to large manufacturers
- Reliable product performance quality
- ISO certified manufacturing sites
- Accessible inventory with no to low order minimums
- Superior and personalized customer service

To learn more about CHT's silicone solutions and services, contact CHT USA's silicone experts or schedule a call to discuss your project, explore new product formulations, or request product samples.

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