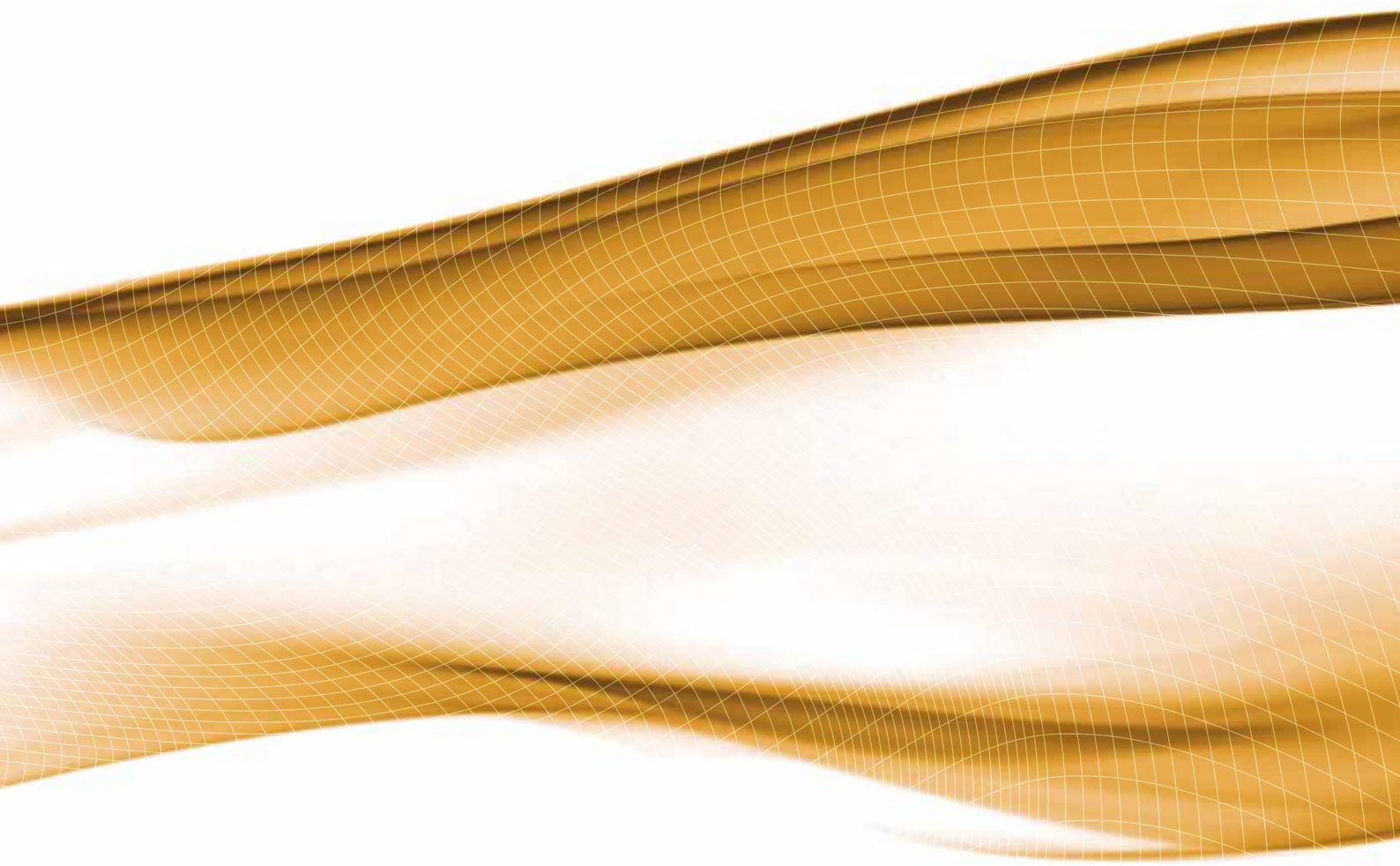
Thermal Management Solutions

Created to perform when the heat is on



ELECTROLUBE
THE SOLUTIONS PEOPLE

Thermal Management Solutions

- Non-Silicone Pastes
- Silicone Pastes
- RTVs and Bonding Products
- Encapsulation Resins
- 0.9 to 3.4W/m.K

During use, some electronic components can generate significant amounts of heat. Failure to effectively dissipate this heat away from the component and the device can lead to reliability concerns and reduced operational lifetimes.

Newton's law of cooling states that the rate of loss of heat is proportional to the temperature difference between the body and its surroundings. Therefore, as the temperature of the component increases and reaches its equilibrium temperature, the rate of heat loss per second will equate to the heat produced per second within the component. This temperature may be high enough to significantly shorten the life of the component or even cause the device to fail. It is in such cases that thermal management measures need to be taken. The same considerations can be applied to a complete circuit or device which incorporates heat producing individual components.

Heat is lost from a component to its surroundings at the surface of the component. The rate of loss of heat will increase with the surface area of the component; a small device producing 10 watts will reach a higher temperature than a similar powered device with a larger surface area.

This is where heat sinks are used – varying in size and shape, heat sinks can be designed to offer a significantly increased surface area to maximise heat dissipation. They are typically connected to components which generate a large amount of thermal energy when used and therefore dissipate such energy away from the device to avoid failure due to over-heating.

Heat sinks have proven to be very effective over the years however in order to ensure full contact and therefore maximum efficiency, thermal management products are used alongside.

Metal surfaces, even when polished to a fine degree, have a certain amount of roughness. It can therefore be deduced that when two metal surfaces are placed together contact is not 100% and there will always be an air gap between the two surfaces. The use of a thermal interface material between such gaps ensures complete contact between the two surfaces and in turn more efficient heat conductance.

The ongoing trend for product miniaturisation – coupled with more modern, higher powered devices – has ensured that efficient thermal management is an essential part of both modern and future electronics design, the LED lighting market being just one example. Thermal management products are also offering solutions for greater efficiency in green energy development; photovoltaic inverters – which are known to be particularly sensitive to temperature; connections between the heat-pipe and water storage tank for solar-heating applications; hydrogen fuel cells; wind power generators, are just a few examples.

Thermal Pastes

Thermally conductive pastes consist of thermally conductive fillers in a carrier fluid. Thermal pastes do not cure; therefore, they offer the best solution when rework is important and provide versatility by avoiding geometrical restrictions affecting cure.

Silicone and Silicone-Free

Electrolube offers silicone and non-silicone thermal pastes. The silicone products offer a higher upper temperature limit of 200˚C and a lower viscosity system, due to the silicone base oil used.

The use of products based on, or containing, silicone may not be authorised in certain applications. This could be due to a number of factors, for instance certain electronic applications or where problems exhibited in cleaning or adhesive processes are observed.

Such issues are due to the migration of low molecular weight siloxanes; these volatile species can lower the surface tension of a substrate, making them extremely difficult to clean or adhere to. In addition, the migration of low molecular weight siloxanes can lead to failures in electronic applications, through the formation of insulative byproducts.

Electrolube products are formulated from raw materials specifically designed for the electronics industry. Thus, silicone containing products are only utilised where the low molecular weight fractions are monitored and kept to an absolute minimum. As an alternative, a range of non-silicone products are also provided for critical applications.

The ‘Plus’ Range

Electrolube’s ‘Plus’ range contains a specialist blend of fillers carefully designed to achieve an optimised particle size combination and therefore can achieve higher thermal conductivity values than the Electrolube standard range.

The ‘Xtra’ Range

Electrolube’s ‘Xtra’ range of thermal products are enhanced versions of the non-silicone products HTC and HTCP. These ‘X’ versions are manufactured using one of the company’s proprietary technologies and possess the following benefits with almost no compromise in usability and viscosity: an increase in the comparative thermal conductivity, lower oil bleed and lower evaporation weight loss. HTCPX is mainly used as a gap filler and has been approved by one of the top manufacturers in the automotive industry.

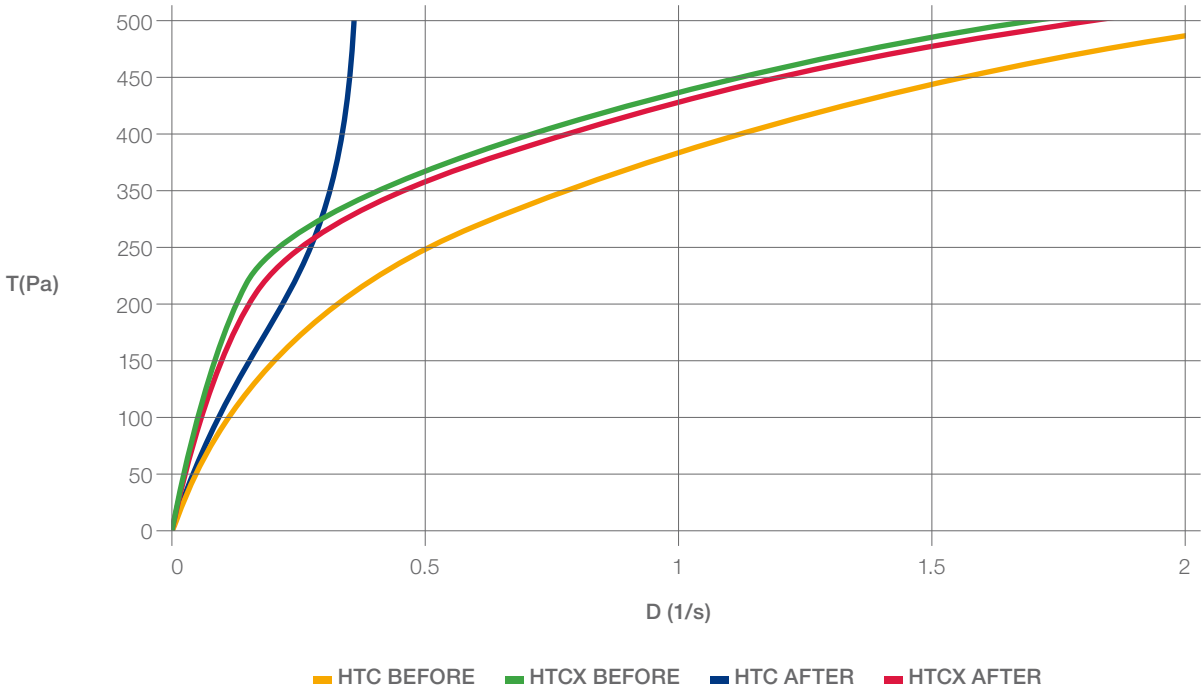
The ‘Xtra’ range of products are also more resistant to humidity and thermal cycling (rapid changes in heating and cooling) than the standard range.

The following graph shows the effects of humidity (168 hours, 25°C, 90% RH) and thermal cycling (25 cycles between -25°C and 65°C) on HTC and HTCX.

The results show that the rheology of HTC changes after exposure to such conditions and as a result the viscosity also increases with increasing shear rate, exhibiting dilatant behaviour.

HTCX however shows greater stability under such conditions with the rheology and viscosity remaining unchanged after the exposure. HTCX exhibits pseudoplastic behaviour; decreasing viscosity with increasing shear rate.

RHEOLOGY OF HTC AND HTCX BEFORE AND AFTER HUMIDITY AND THERMAL CYCLING TESTING



Adhesives & Encapsulants

Adhesives and RTVs

Electrolube offer a thermal bonding adhesive called TBS, as well as two RTV (room temperature vulcanising) products: TCOR and TCER.

TBS (Thermal Bonding System) is a two-part, high strength epoxy adhesive designed to bond a heat sink to the component. In addition to the mineral fillers, the adhesive contains small glass beads of controlled diameter: these allow for a set thickness of 200 microns to be achieved, providing optimal performance.

TCOR and TCER are Electrolube's silicone RTV products. TCOR is an oxime-cure RTV, and TCER is an ethanol-cure version. TCER has the advantage that it is very low in viscosity and higher in thermal conductivity compared to TCOR; however, TCOR exhibits improved bond-strength properties.

Encapsulation Resins

For certain types of heat generating circuitry, it may be beneficial to encapsulate the device in a heat-sink enclosure using a thermally conductive potting compound. This method offers both heat dissipation and protection from the surrounding environment, such as high humidity or corrosive conditions.

Electrolube produces a variety of two-part encapsulation solutions utilising epoxy, polyurethane and silicone technologies:

ER2220 provides the highest level of thermal conductivity combined with environmental protection afforded from the encapsulation process. This highly-filled epoxy resin possesses very high thermal conductivity (1.54 W/m.K), resulting in a high viscosity (15,000 mPa s).

ER2183 is a lower viscosity version of ER2220 (5000 mPa s). The reduced filler content required to achieve this viscosity has little effect on the thermal conductivity performance: ER2183 is 67% lower in viscosity, but only exhibits a 28% decrease in thermal conductivity as a result (1.10 W/m.K).

UR5633 is a polyurethane encapsulation resin that offers very good thermal conductivity of 1.24 W/m.K. This is ideal for applications where thermal conductivity and a degree of flexibility are required.

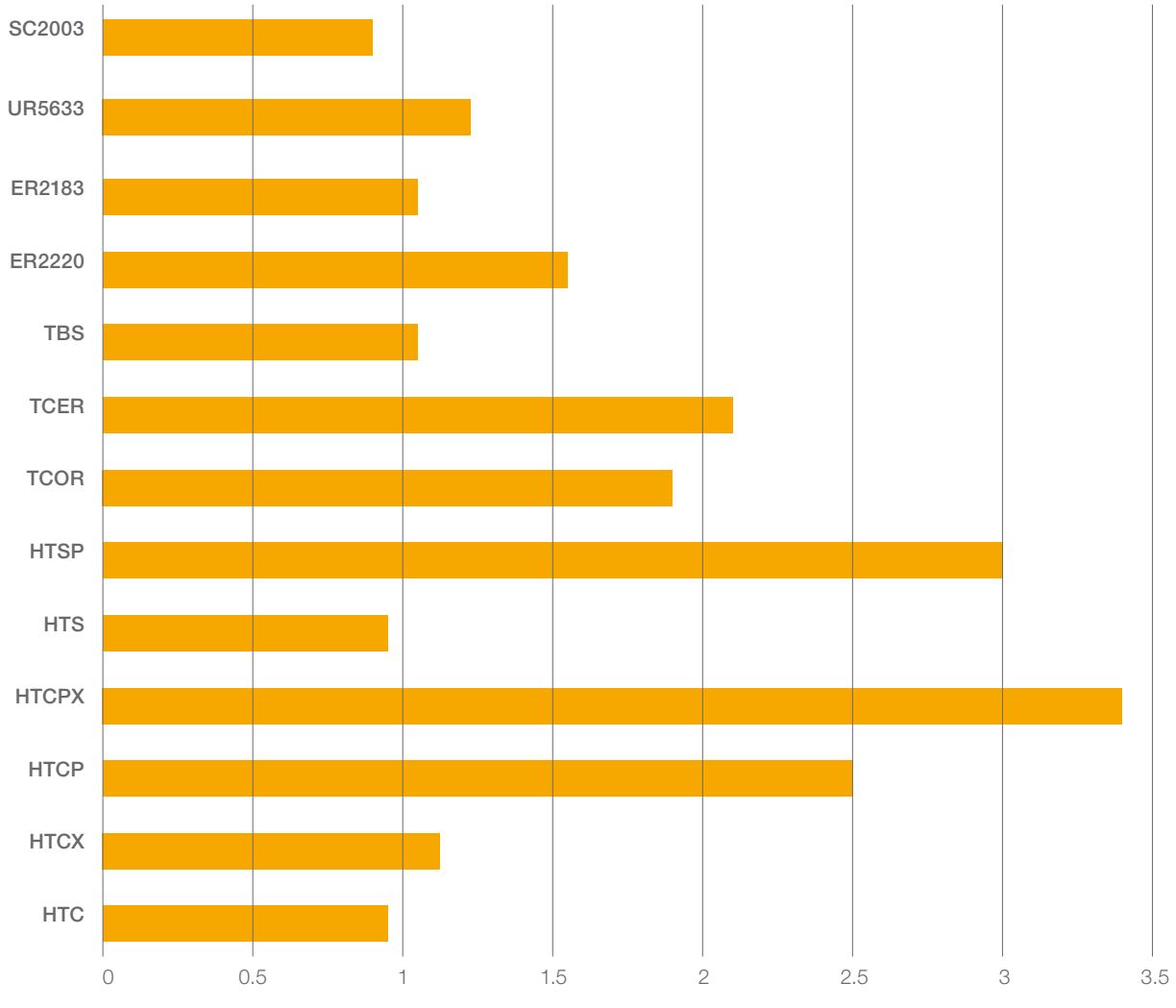
SC2003 is a silicone encapsulation resin, offering a good level of thermal conductivity (0.80 W/m.K) over an exceptionally wide temperature range (-60 to +200°C). The product is thixotropic, making it ideal for applications where the resin should not flow through small gaps.

Typical Properties

Thermal Conductivity

Thermal conductivity, measured in W/m.K, represents a materials' ability to conduct heat. Bulk thermal conductivity values give a good indication of the level of heat transfer expected, allowing for comparison between different materials. Some techniques only measure the sum of the materials' thermal resistance and the material/instrument contact resistance.

Electrolube use a version of the heat-flow method that measures both of these values separately, giving a much more accurate bulk thermal conductivity measurement. The following graph shows the comparative thermal conductivities of Electrolube's thermal products:



NOTE: Thermal Conductivity of air = 0.024 W/m.K

Thermal Conductivity

Relying on bulk thermal conductivity values alone will not necessarily result in the most efficient heat transfer, however.

Thermal resistance, measured in K cm^2/W, is the reciprocal of thermal conductivity. It takes into account the interfacial thickness and although it is dependent on the contact surfaces and pressures applied, some general rules can be followed to ensure thermal resistance values are kept to a minimum and thus maximising the efficiency of heat transfer.

As discussed, a thermal interface material (TIM) would be used between a heat generating device and its associated heat sink. As the heat sink will have a significantly higher thermal conductivity than the interface material, it is important that only a thin layer of the interface material is used; increasing thickness will only increase the thermal resistance in this case. Therefore, lower interfacial thicknesses and higher thermal conductivities give the greatest improvement in heat transfer. In some cases, however, utilising a material with a higher bulk thermal conductivity could be to the detriment of contact resistance and thus, no improvement will be accomplished.

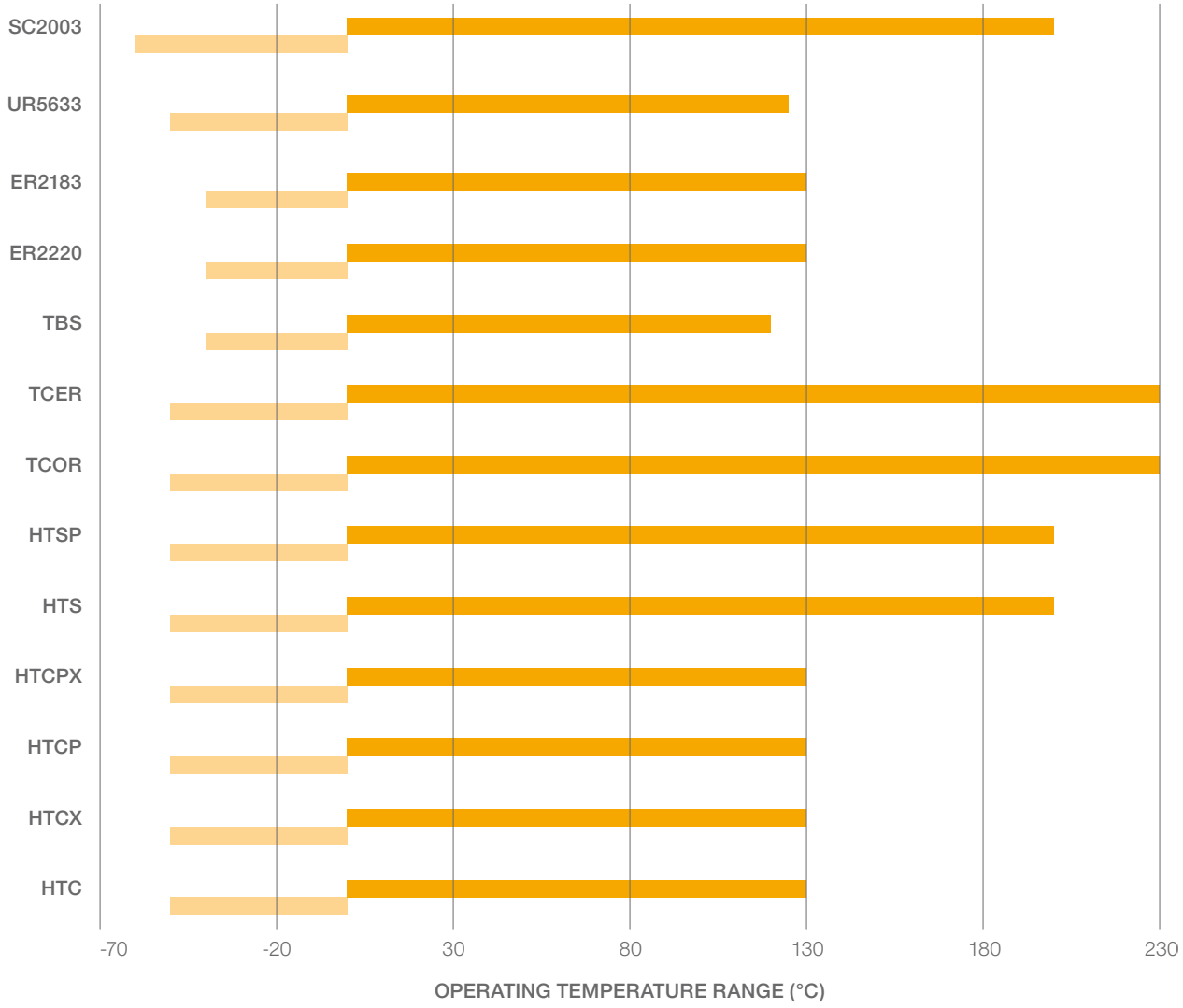
An example of this difference can be drawn from the comparison of thermal pastes and thermal pads. Thermal pads are solid, polymerised materials of a fixed thickness which are available in a variety of thermal conductivities. Thermal pastes, as discussed above, are non-curing compounds and as a result, their viscosity can alter slightly as the temperature increases. This allows for a further reduction in interfacial resistance. In the case of thermal pads, high pressures are needed to achieve an adequate interface, thus, a paste and pad of similar bulk thermal conductivity may have very different thermal resistance measurements in use, and as such a difference in the efficiency of heat transfer will be observed.

Users must address bulk thermal conductivity values, contact resistance and application thicknesses and processes in order to successfully achieve the optimum in heat transfer efficiency.

Temperature Range

Electrolube's thermal management products cover an extensive operating temperature range. It is important that the temperature extremes experienced during application fall within the operating temperature range of the product selected.

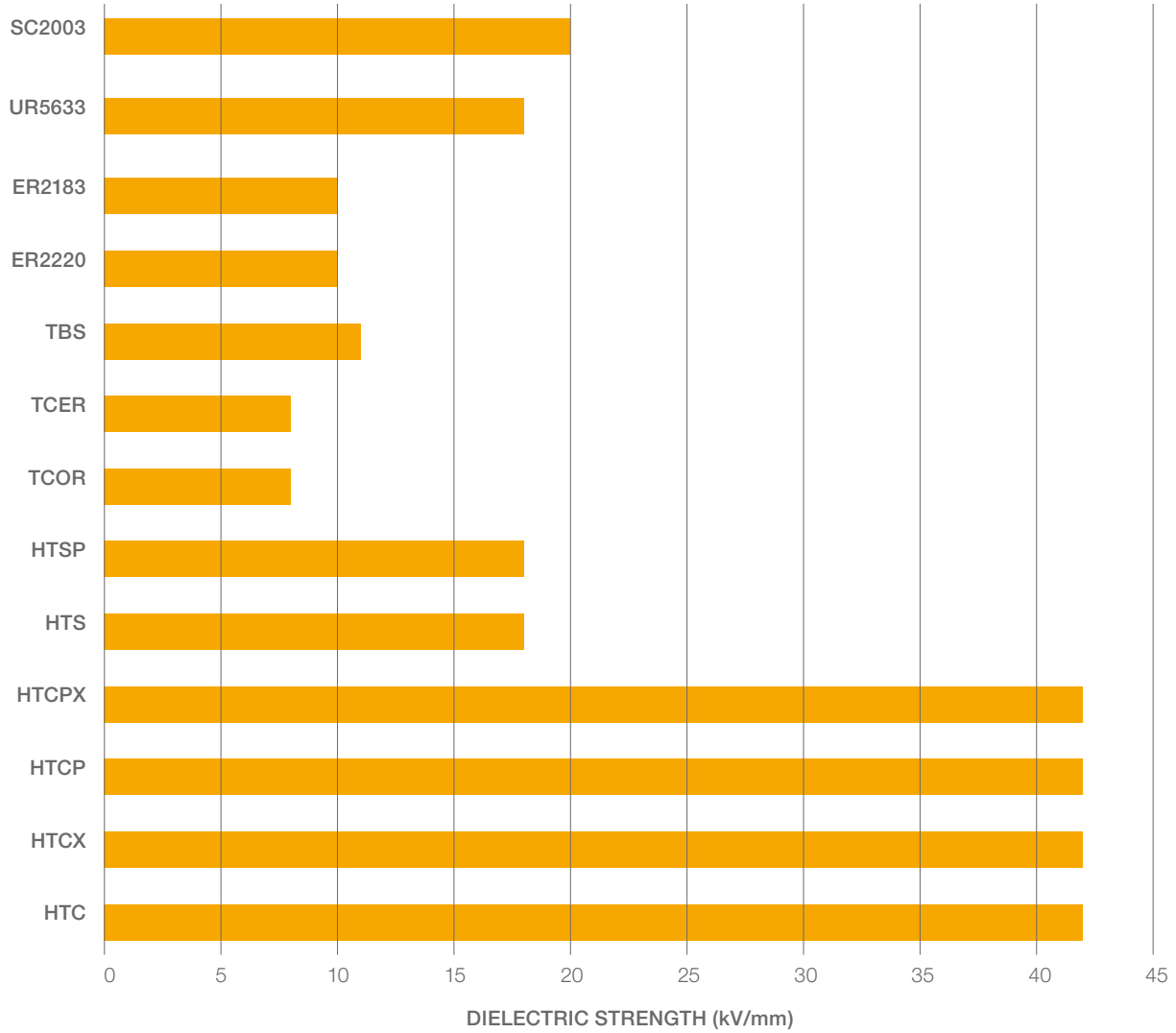
Depending on the type of product and chemistry chosen, the temperature range will differ. Some products may be suitable for short-term excursions outside of the recommended operating temperature ranges. Testing in representative end-use conditions is always advised.



Dielectric Strength

Thermal management products are used within electrical applications and therefore must not have any detrimental effect on the performance of the device. Measurements of the electrical properties of such products can assist in proving suitability for use. For example, the dielectric strength is the maximum electric field strength that a product can withstand intrinsically without breaking down, i.e. without experiencing a failure of its electrical properties.

This is sometimes also referred to as the dielectric withstanding voltage. Conversely, the breakdown voltage is the minimum voltage that causes a portion of an insulator to become electrically conductive.

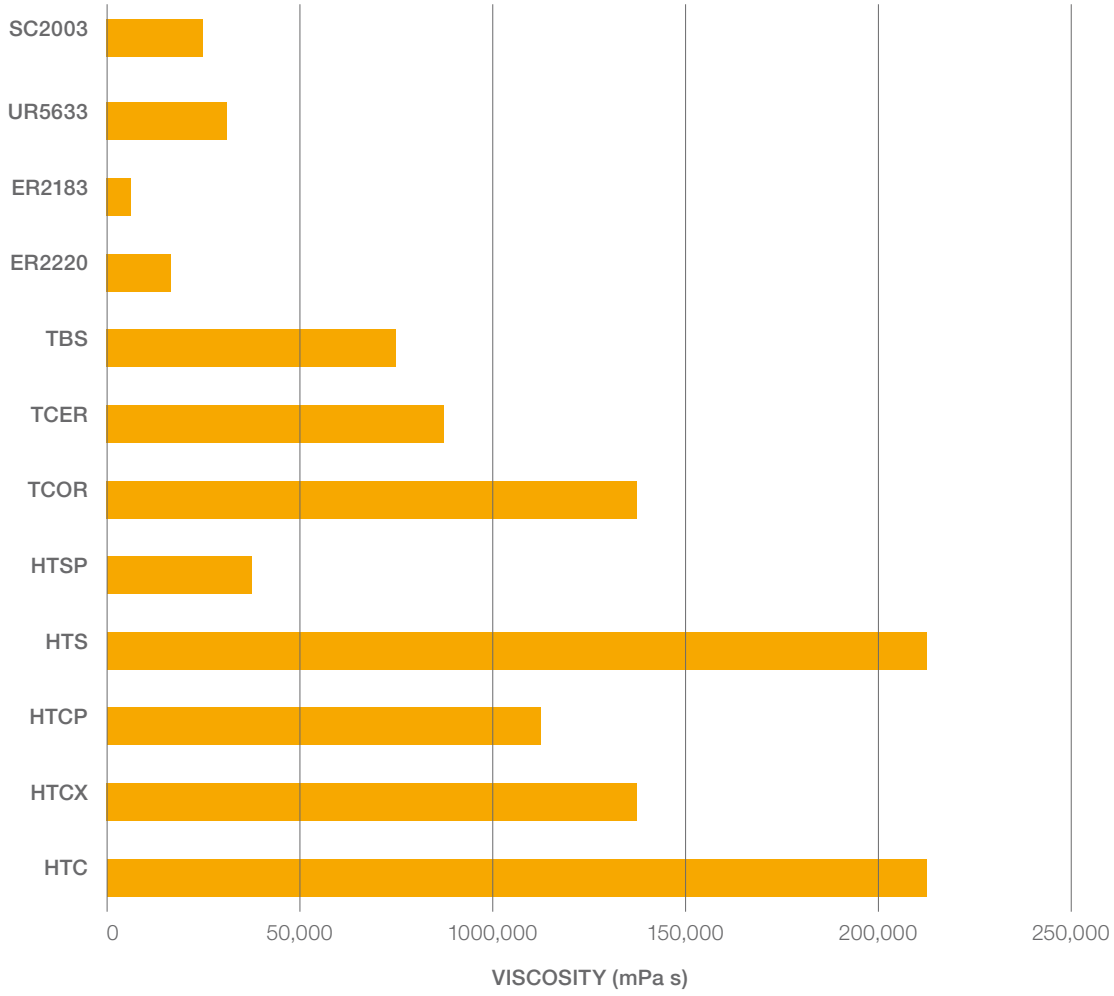


Viscosity

The viscosity of thermal pastes will affect the processing parameters of application as well as the performance of the product in use. For example, the standard range of products are designed as thermal interface materials (TIM) and so should be applied in a thin layer. The stability of these products avoids problems associated with 'pump out' (changing viscosity with temperature, causing the paste to gradually move out from between the interface) but only when used in thin films.

Gap filling materials, such as HTCPX, are designed to offer the ultimate in stability, even in high thicknesses and under vibration. Consequently, this increase in stability also means that the viscosity of the material is very high.

The viscosity of thermal management materials that cure, such as RTV's or encapsulation products, is only relevant for application purposes and must be considered when choosing suitable dispensing equipment or application methods; once the material is applied to the unit/substrate, it will cure to a solid material. A comparison of the various product viscosities is given in the graph below:



Application Options

Thermal Pastes

As highlighted previously and with the exception of gap filling products, it is important that thermal interface materials (TIM) are applied in the thinnest layer possible to reduce the effects of thermal resistance. Therefore, the application of thermal pastes can be as important as the product selection stage.

Thermal pastes can be applied via a range of methods, either manual or automated.

i. Manual applications can be carried out using a roller, squeegee or spatula; often a roller is the best method to ensure a thin even film is deposited across the entire surface.

ii. Automated applications involve the use of specialist equipment. This usually consists of an applicator head where the material is fed to the applicator via dispensing equipment. Due to the viscosities of these materials, the dispensing equipment is usually a follower-plate system which connects to the thermal paste container as supplied. Please contact Electrolube where container dimensions are required.

RTVs

Electrolube RTVs are supplied in ready-to-use cartridges and should be used with the TCR Gun applicator. Please contact Electrolube regarding bulk quantities.

These materials are often used for combined thermal transfer and fixing, therefore a thin layer should be applied and tests conducted to ensure the level of bonding achieved is sufficient for the application.

As these are moisture cure products, ambient humidity must be considered during application. Extreme conditions (very dry or very wet) will inhibit the cure and elevated temperatures will not speed up the process, unless humidity is also increased.

Encapsulation Resins

Encapsulation resins are two part systems which can be applied manually or through automated equipment. In all cases, the mixing procedure used should avoid the introduction of air; the introduction of air or moisture can affect the cure process of these materials as well as leave air voids in the cured product, which will significantly reduce the thermal conductivity.

i. Electrolube supply encapsulation resins in resin pack form; a pouch divided by a clip and rail which separates the Part A and B until the time of mixing. These packs are ideal for air-free mixing and are advised for all manual application of encapsulation resins. When supplied in an aluminium outer, this outer material should not be removed until immediately before use.

ii. Automated mixing and dispensing machines are also available either in benchtop or large scale models. Electrolube work with a number of local and international equipment manufacturers, please contact us for further information.

The Product Range

Thermal Pastes

HTC – Non-Silicone Heat Transfer Compound

- Excellent non-creep characteristics
- High thermal conductivity: 0.90 W/m.K
- Wide operating temperature range: -50°C to +130°C
- Low evaporation weight loss
- Available in aerosol form, HTCA
- Low in toxicity

HTS – Silicone Heat Transfer Compound

- Excellent non-creep characteristics
- Very wide operating temperature range -50°C to +200°C
- Very low evaporation weight loss
- High thermal conductivity even at high temperatures: 0.90 W/m.K
- Low in toxicity and economic in use
- White colour enables treated parts to be easily identified

HTCP – Non-Silicone Heat Transfer Compound Plus

- Excellent non-creep characteristics
- Very high thermal conductivity: 2.50 W/m.K
- Wide operating temperature range: -50°C to +130°C
- Low evaporation weight loss
- White colour enables treated parts to be easily identified
- Low in toxicity

HTSP – Silicone Heat Transfer Compound Plus

- Superior thermal conductivity even at high temperatures: 3.0 W/m.K
- Excellent non-creep characteristics
- Very wide operating temperature range: -50°C to +200°C
- Very low evaporation weight loss
- Low viscosity for ease of processing
- Low in toxicity

HTCPX – Non-Silicone Heat Transfer Compound Plus Xtra

- Excellent non-creep characteristics
- Vibration stable, designed for gap filling applications
- Wide operating temperature range: -50°C to +130°C
- Exceptional thermal conductivity: 3.40 W/m.K
- Low in toxicity
- Low evaporation weight loss

HTCX – Non-Silicone Heat Transfer Compound Xtra

- Very low oil bleed and evaporation weight loss
- Reduced viscosity for ease of application
- Excellent non-creep characteristics
- Wide operating temperature range: -50°C to +130°C
- Excellent thermal conductivity: 1.35 W/m.K
- Low in toxicity

Adhesives and Encapsulants

TCOR - Thermally Conductive Oxime RTV

- Single part, low odour RTV
- Very high thermal conductivity: 1.80 W/m.K
- Exceptionally wide operating temperature range: -50ºC to +230ºC
- Moisture cure – releasing oxime upon cure
- Easy to apply – use with TCR Gun Applicator
- Good bond strength and remains flexible at high temperatures

TCER - Thermally Conductive Ethoxy RTV

- Single part, low odour RTV
- Very high thermal conductivity: 2.20 W/m.K
- Moisture cure – releasing ethanol upon cure
- Low viscosity for ease of application – use with TCR Gun Applicator
- Remains flexible and elastic at high temperatures: -50ºC to +230ºC
- Low bond strength for ease of rework

TBS – Thermal Bonding System

- Two part epoxy bonding system
- Very high bond strength
- High thermal conductivity: 1.10 W/m.K
- Eliminates need for mechanical fixing by providing a permanent bond
- Wide operating temperature range: -40ºC to +120ºC
- Include glass beads for a set thickness to be applied

ER2220 – Thermally Conductive Epoxy Resin

- Very high thermal conductivity: 1.54 W/m.K
- Flame retardant
- Utilises non-abrasive fillers
- Used for encapsulating PCBs or devices requiring effective thermal dissipation
- Provides environmental protection
- Wide operating temperature range: -40ºC to +130ºC

ER2183 – Low Viscosity, Thermally Conductive Epoxy Resin

- Low viscosity alternative to ER2220: 5000mPa s
- High thermal conductivity: 1.10 W/m.K
- Easy to mix, uses non-abrasive fillers
- Used for encapsulating PCBs or devices requiring effective thermal dissipation
- Provides environmental protection
- Wide operating temperature range: -40ºC to +130ºC

UR5633 – Thermally Conductive Polyurethane Resin

- Flame retardant
- Excellent thermal conductivity: 1.24 W/m.K
- Excellent electrical properties
- Wide operating temperature range: -50ºC to +125ºC
- Very high water resistance
- Excellent performance in harsh conditions such as marine, automotive and tropical environments

SC2003 – Thermally Conductive Silicone Resin

- Flame retardant
- Good thermal conductivity: 0.80 W/m.K
- Excellent electrical properties
- Exceptionally wide operating temperature range: -60ºC to +200ºC
- Simple mix ratio: 1:1
- Especially suited to potting of electrical and electronic devices operating in high temperatures

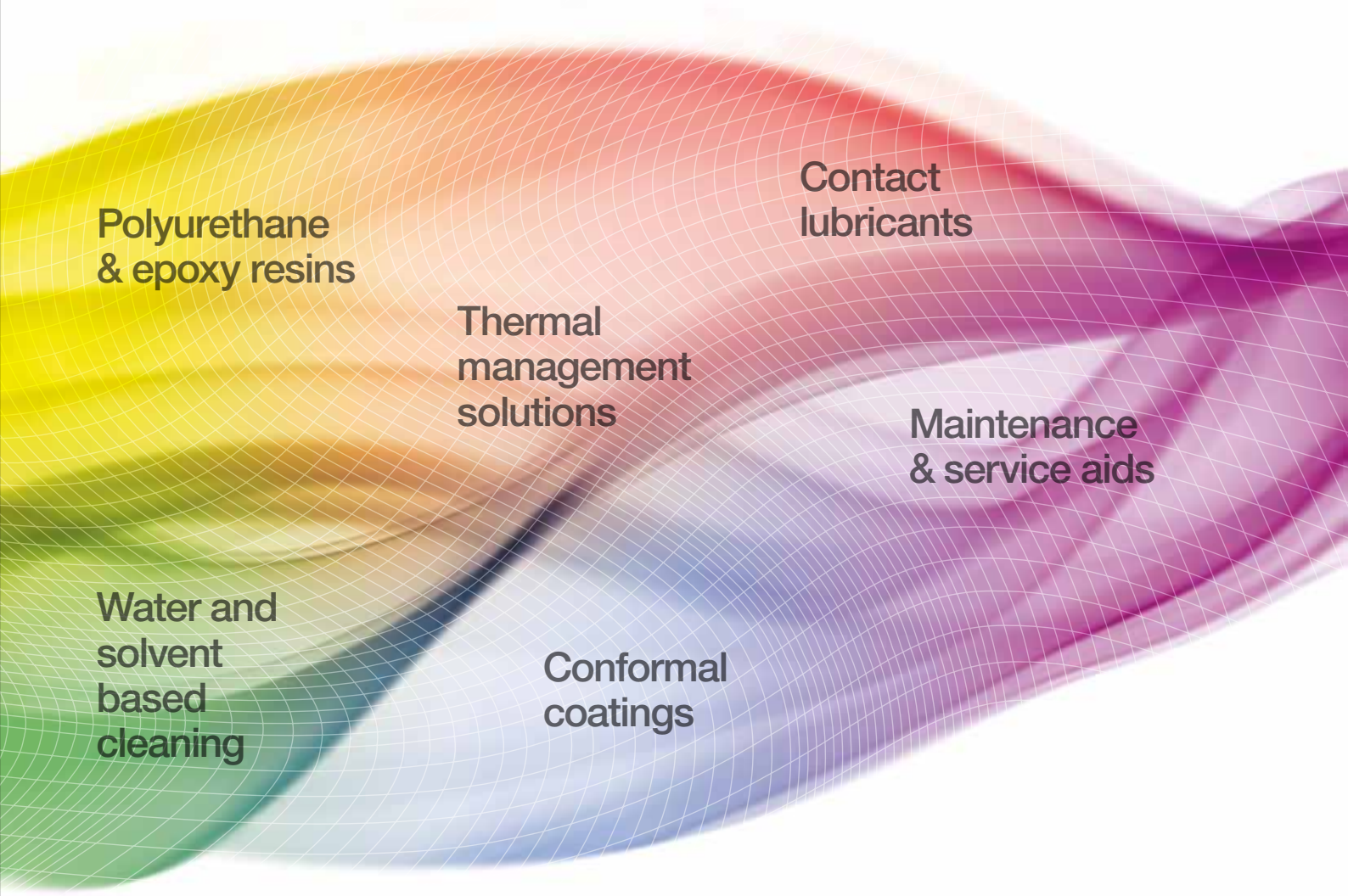
**Various sizes are available for most products, including bulk.*

Thermal Management

	HTCX	HTCP	HTCPX	HTS	HTSP	TCOR	ER2220	ER2183	UR5633	SC2003
	Non-Silicone Heat Transfer Paste Xtra	Non-Silicone Heat Transfer Paste Plus	Non-Silicone Heat Transfer Compound Plus Xtra	Silicone Heat Transfer Compound	Silicone Heat Transfer Compound Plus	Thermally Conductive RTV	2 Part Epoxy Resin	2 Part Epoxy Resin	2 Part Polyurethane Resin	2 Part Silicone Resin
Thermal Conductivity (W/m.K)	1.35	2.50	3.40	0.90	3.00	1.80	1.54	1.10	1.24	0.8
Density (g/ml)	2.61	3.00	3.10	2.10	3.00	2.30	2.22	1.95	1.65	1.60
Viscosity/mPa s**	130,000	105,000	640,000	210,000	45,000	145,000	15,000	5,000	30,000	30,000
Cure Time (Hours @ 20°C / 60°C)	N/A	N/A	N/A	N/A	N/A	24*	24/4	24/4	24/4	24/1
Temperature Range (°C)	-50 to +130	-50 to +130	-50 to +130	-50 to +200	-50 to +200	-50 to +230	-40 to +130	-40 to +130	-50 to +125	-60 to +200
Evaporation Weight Loss (96hrs @ 100°C IP-183)	≤0.40%	≤1.00%	≤1.00%	≤0.80%	≤0.80%	N/A	N/A	N/A	N/A	N/A
Dielectric Strength (kV/mm)	42	42	42	18	18	>8	10	10	18	20
Volume Resistivity (Ω-cm)	1×10^{14}	1×10^{14}	1×10^{14}	1×10^{15}	1×10^{15}	1×10^{14}	1×10^{15}	1×10^{15}	1×10^{14}	1×10^{15}

** Requires moisture to cure, elevated temperatures not recommended unless moisture is present. **This information should be used as a guideline only.*

Every solution is within our spectrum



In the formulation, manufacture and supply of conformal coatings, thermal pastes, encapsulants, cleaners and lubricants, we have the solution. Through collaboration and research, we're developing new, environmentally friendly products for many of the world's best known industrial and domestic manufacturers – always to ISO standards.

Combine this unique ability to offer the complete solution with our global presence and you have a more reliable supply chain and a security of scale that ensures you receive an exemplary service.

Want to know more about this successful formula? Simply call, or visit our website.

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