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# Thermal Management
## Products & Custom Solutions Catalog

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Responsibility</td>
<td>2</td>
</tr>
<tr>
<td>Offer Of Sale</td>
<td>2</td>
</tr>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>Heat Transfer Fundamentals</td>
<td>6</td>
</tr>
<tr>
<td>Gap Filler Pads</td>
<td></td>
</tr>
<tr>
<td>THERM-A-GAP™ HCS10, 569, 570, 579, 580, Thermal Pads</td>
<td>11</td>
</tr>
<tr>
<td>THERM-A-GAP™ 974, 974, 976, High Performance Thermal Pads</td>
<td>13</td>
</tr>
<tr>
<td>THERM-A-GAP™ 575NS, Silicone-Free Thermal Pads</td>
<td>15</td>
</tr>
<tr>
<td>Thermal Gels</td>
<td></td>
</tr>
<tr>
<td>THERM-A-GAP™ T63X Series, Dispensed Gels</td>
<td>16</td>
</tr>
<tr>
<td>GEL 8010 Thermally Conductive Dispensable Gel</td>
<td>18</td>
</tr>
<tr>
<td>Phase Change Material</td>
<td></td>
</tr>
<tr>
<td>THERMFLOW® Phase Change Pads</td>
<td>20</td>
</tr>
<tr>
<td>Attachment Tapes</td>
<td></td>
</tr>
<tr>
<td>THERMATTACH® Thermal Tapes</td>
<td>23</td>
</tr>
<tr>
<td>Liquids (Compounds)</td>
<td></td>
</tr>
<tr>
<td>THERM-A-FORM™ Cure-in-Place Potting and Underfill Materials</td>
<td>27</td>
</tr>
<tr>
<td>Thermal Grease</td>
<td></td>
</tr>
<tr>
<td>Thermal Greases</td>
<td>29</td>
</tr>
<tr>
<td>Insulator Pads</td>
<td></td>
</tr>
<tr>
<td>CHO-THERM® Commercial Grade</td>
<td>31</td>
</tr>
<tr>
<td>CHO-THERM® High Power</td>
<td>33</td>
</tr>
<tr>
<td>Heat Spreaders</td>
<td></td>
</tr>
<tr>
<td>T-WING® and C-WING™ Thin Heat Spreaders</td>
<td>38</td>
</tr>
<tr>
<td>Glossary</td>
<td>40</td>
</tr>
<tr>
<td>Safety Guide</td>
<td>43</td>
</tr>
<tr>
<td>Terms of Sale</td>
<td>51</td>
</tr>
</tbody>
</table>
INTRODUCTION

Chomerics, a division of Parker Hannifin Corporation (NYSE:PH), is a global provider of EMI shielding and thermal management materials and services to OEM and CEM electronics companies in the telecommunications, information technology, consumer, power conversion, defense and transportation markets.

Since 1961, Chomerics has been a leader in the development of electrically conductive elastomers for use as extruded, molded and form-in-place EMI gaskets for telecommunications and electronics applications. Chomerics offers an extensive family of thermal interface materials, which transfer heat from electronic components to heat sinks. Careful management of thermal interfaces is crucial to maintaining the reliability and extending the life of electronic devices and equipment. As each new electronic product generation requires higher power in smaller packages, the challenges associated with thermal management become more intense. Thermal material drivers include:

- Lower thermal impedance
- Higher thermal conductivity
- Greater compliance and conformability
- High reliability
- Greater adhesion
- Ease of handling, application and use
- Long service life

Chomerics has a successful history of providing thermal materials expertise and commitment to developing new, high performance products to meet the thermal challenges of systems designers. Chomerics products have been designed into thousands of applications and help assure the performance, integrity, survivability and maintainability of communications equipment, radar, aircraft, computers, control systems, telecommunications, consumer devices, automotive and industrial electronics. Our customers are supported with comprehensive applications engineering, supply chain and fabrication services worldwide.
Chomerics Capabilities Include:

**THERMAL MANAGEMENT & CONTROL**
- Thermally conductive gap filler pads
- Dispensed thermal gap fillers
- Silicone-free thermal pads
- Phase-change materials (PCM)
- Polymer solder hybrids (PSH)
- Dispensable thermal compounds
- Thermal grease and gels
- Insulator pads
- Thin flexible heat spreaders
- Custom integrated thermal/EMI assemblies

**EMI SHIELDING & COMPLIANCE**
- Conductive elastomers – molded, extruded, and form-in-place (FIP)
- Conductive foam based gaskets – fabric-over-foam and z-axis foam
- Conductive compounds – adhesives, sealants and caulks
- RF and thermal/RF absorbing materials
- EMI shielding plastics and injection molding services
- Coatings – direct metallization and conductive paints
- Metal gaskets – Springfingers, metal mesh and combination gaskets
- Foil laminates and conductive tapes
- EMI shielding vents – commercial and military honeycomb vents
- Shielded optical windows
- Cable shielding – ferrites and heat-shrink tubing/wire mesh tape/zippered cable shielding
- Compliance and safety test services

**OPTICAL DISPLAY PRODUCTS**
- EMI shielding filters
  (conductive coating & wire mesh)
- Ant-reflective/contrast enhancement filters
- Plastic or glass laminations
- Hard coated lens protectors
- Touch screen lenses

**About Parker Hannifin Corporation**
With annual sales exceeding $12 billion, Parker Hannifin is the world’s leading diversified manufacturer of motion and control technologies and systems, providing precision-engineered solutions for a wide variety of commercial, mobile, industrial and aerospace markets. The company employs more than 61,000 people in 48 countries around the world. Parker has increased its annual dividends paid to shareholders for 52 consecutive years, among the top five longest-running dividend-increase records in the S&P 500 index. For more information, visit the company’s web site at http://www.parker.com, or its investor information site at http://www.phstock.com.
**Heat Transfer Fundamentals**

**Introduction**

The objective of thermal management programs in electronic packaging is the efficient removal of heat from the semiconductor junction to the ambient environment. This process can be separated into three major phases:

1. heat transfer within the semiconductor component package;
2. heat transfer from the package to a heat dissipater (the initial heat sink);
3. heat transfer from the heat dissipater to the ambient environment (the ultimate heat sink)

The first phase is generally beyond the control of the system level thermal engineer because the package type defines the internal heat transfer processes. In the second and third phases, the packaging engineer’s goal is to design an efficient thermal connection from the package surface to the initial heat spreader and on to the ambient environment. Achieving this goal requires a thorough understanding of heat transfer fundamentals as well as knowledge of available interface materials and how their key physical properties affect the heat transfer process.

**Basic Theory**

The rate at which heat is conducted through a material is proportional to the area normal to the heat flow and to the temperature gradient along the heat flow path. For a one dimensional, steady state heat flow the rate is expressed by Fourier’s equation:

\[
Q = kA \frac{dT}{d}
\]

Where:

- \(k\) = thermal conductivity, W/m-K

This property is a measure of how a material of a specific thickness resists the flow of heat. The relationship between \(k\) and \(R\) is shown by substituting Equation (2) into (1) and rearranging to form (3)

\[
k = \frac{d}{R}
\]

Equation 3 shows that for homogeneous materials, thermal resistance is directly proportional to thickness. For non-homogeneous materials, the resistance generally increases with thickness but the relationship may not be linear.

Thermal conductivity and thermal resistance describe heat transfer within a material once heat has entered the material. Because real surfaces are never truly flat or smooth, the contact plane between a surface and a material can also produce a resistance to the flow of heat. Figure 1 depicts surface irregularities on a micro scale and surface warp on a macro scale. Actual contact occurs at the high points, leaving air-filled voids where the valleys align. Air voids resist the flow of heat and force more of the heat to flow through the contact points. This constriction resistance is referred to as surface contact resistance and can be a factor at all contacting surfaces.

The impedance \(\Theta\) of a material is defined as the sum of its thermal resistance and any contact resistance between it and the contacting surfaces as defined in Equation 4.

\[
\Theta = R_{material} + R_{contact}
\]

Surface flatness, surface roughness, clamping pressure, material thickness and compressive modulus have a major impact on contact resistance.
Because these surface conditions can vary from application to application, thermal impedance of a material will also be application dependent.

**Thermal Interface Materials (TIM)**

Heat generated by a semiconductor must be removed to the ambient environment to maintain the junction temperature of the component within safe operating limits. Often this heat removal process involves conduction from a package surface to a heat spreader that can more efficiently transfer the heat to the ambient environment. The spreader has to be carefully joined to the package to minimize the thermal resistance of this newly formed thermal joint.

Attaching a heat spreader to a semiconductor package surface requires that two commercial grade surfaces be brought into intimate contact. These surfaces are usually characterized by a microscopic surface roughness superimposed on a macroscopic non-planarity that can give the surfaces a concave, convex or twisted shape. When two such surfaces are joined, contact occurs only at the high points. The low points form air-filled voids. Typical contact area can consist of more than 90 percent air voids, which represents a significant resistance to heat flow.

Thermally conductive materials are used to eliminate these interstitial air gaps from the interface by conforming to the rough and uneven mating surfaces. Because the material has a greater thermal conductivity than the air it replaces, the resistance across the joint decreases, and the component junction temperature will be reduced. A variety of material types have been developed in response to the changing needs of the electronic packaging market. These materials can be categorized as follows:

**Phase-Change Materials**

THERMFLOW® materials are formulated with silicone or other polymer resins that are loaded with thermally conductive fillers. They combine the high thermal performance of grease with the ease of handling and “peel-and-stick” application of pads. They are used between high performance microprocessors, graphics processors, chipsets and heat sinks.

- Can achieve less than 0.3°C-cm²/W thermal impedance
- Conform at operating temperature to minimize thermal path thickness
- Excellent surface “wetting” eliminates contact resistance

Phase change materials behave like thermal greases after they reach their melt temperature, typically 45–55°C. Their viscosity rapidly diminishes and they flow throughout the thermal joint to fill the gaps that were initially present. This process requires some compressive force, usually a few psi, to bring the two surfaces together and cause the material to flow. This process continues until the two surfaces come into contact at a minimum of three points, or the joint becomes so thin that the viscosity of the material prevents further flow. These materials inherently do not provide electrical isolation because they may allow the two surfaces to make contact; however, variations with dielectric films are available. These materials have demonstrated excellent long-term reliability and performance.

**Polymer Solder Hybrids**

These THERMFLOW® materials incorporate low-melt metal alloy fillers which flow at temperatures around 65°C and provide ultra low thermal impedance, less than 0.1 °C-cm²/W at minimum bond line thickness.

**Thermal Tapes**

THERMATTACH® tapes are formulated with acrylic or silicone based pressure sensitive adhesive (PSA) loaded with thermally conductive fillers. They are designed to securely bond heat sinks to power dissipating components without an additional clamping mechanism.

- Acrylic based adhesives for metal or ceramic packages
- Silicone based adhesive for bonding plastic packages to heat sinks
- Ionically pure formulations for use inside component packages and on printed circuit boards
- Limited gap filling properties require reasonable surface flatness
- High shear strength at elevated temperatures

Thermal tapes are used primarily for their mechanical adhesive properties, and to a lesser extent for their thermal properties. The thermal conductivity of these tapes is moderate and their thermal performance in an application is dependent on the contact area that can be achieved between the bonding surfaces.

**Gap Fillers**

THERM-A-GAP™ gap fillers are a family of low modulus (soft), thermally conductive silicone elastomers for applications where
heat must be conducted over a large and variant gap between a semiconductor component and a heat dissipating surface.

• Soft silicone gel binder provides low modulus for conformability at low pressures

• Low modulus allows materials to make up for large tolerance stack ups

• Low pressure applications

Gap fillers are used to bridge large gaps between hot components and a cold surface. The gaps are not only large, but their tolerances can be ±20 % or greater. This means that the gap filler must have sufficient compliance to fill such spaces without stressing components beyond their safe limits. Non-silicone gap fillers are available for silicone sensitive applications. Hybrid gap fillers that combine thermal and RF absorption properties are also available.

Gap fillers are supplied in pad-form over a wide range of thickness, 0.5 to 5mm, and can be molded into complex shapes. They are also supplied as pre-cured, single component compounds that can be dispensed over the heat generating component.

These unique materials result in much lower mechanical stress on delicate components than even the softest gap-filling sheets. They are ideal for filling variable gaps between multiple components and a common heat sink.

Form In Place Compounds

THERM-A-FORM™ compounds are reactive, two-component silicone RTVs (room temperature vulcanizing materials) that can be used to form thermal pathways in applications where the distance between a component and a cold surface is highly variable. They are dispensed onto the component and readily conform over complex geometries and then cured in place.

• Low-modulus, ceramic filled compounds

Insulating Pads

CHO-THERM® insulating pads were developed as a user-friendly alternative to greased mica insulators to be used between discrete power devices and heat sinks.

• Silicone binder provides high temperature stability and good electrical insulation properties

• Glass mesh reinforcement provides cut-through resistance

• High mounting pressure required to minimize contact resistance

• U.L. recognized flammability ratings

This class of product is characterized by high thermal conductivity, very high dielectric strength and volume resistivity. Pads must conduct very large heat loads from discrete power semiconductors to heat sinks, while providing long-term electrical insulation between the live component case and the grounded heat sink.

Thermal Greases

Thermal greases are formulated with silicone or hydrocarbon oils that are loaded with conductive fillers. They are viscous liquids that are typically stenciled or screen printed onto the heat spreader or heat sink. Greases have good surface wetting characteristics and flow easily to fill up voids at the interfaces resulting in low thermal impedance even at low application pressure.

Thermal Gels

Thermal gels are silicone-based formulations that are loaded with conductive fillers and are cross-linked to form a low-modulus paste. They are highly conformable and
provide low thermal impedance like greases but are designed to overcome the pump-out and dry-out issues of grease.

**Key Properties of Thermal Interface Materials**

**Thermal Properties**

The key properties of interface materials are thermal impedance and thermal conductivity.

**Thermal Impedance**

This is the measure of the total resistance to the flow of heat from a hot surface through an interface material into a cold surface. Thermal impedance is measured according to the ASTM D5470 test method. Although the current version of this method is specific to high durometer insulating pad materials tested at high clamping forces, the method has been successfully adapted for use with low durometer materials as well as fluid compounds. Thermal impedance can be measured using D5470 at several clamping forces to generate a pressure versus thermal impedance plot as shown in Figure 2. This type of data can be used to generate information about the ability of a material to conform to surfaces to minimize contact resistance. Care must be taken with this type of data because contact resistance is also highly influenced by surface characteristics. To minimize the impact of test equipment variations, this type of work is best performed with the same test surfaces for all materials being tested.

**Thermal Conductivity**

Thermal impedance data measured according to ASTM D5470 can be used to calculate the thermal conductivity of an interface material. Rearranging Equation (3) to give Equation (5) yields Equation (6).

\[
(6) \ \Theta = \frac{d}{k} + R_{\text{contact}}
\]

Equation (6) shows that for a homogeneous material, a plot of thermal impedance \(\Theta\) versus thickness \(d\) is a straight line whose slope is equal to the inverse of the thermal conductivity and the intercept at zero thickness is the contact resistance shown in Figure 2. Thickness can be varied by either stacking up different layers of the material or by preparing the material at different thicknesses.

![Figure 2. Thermal Impedance vs. Thickness](image)

**Electrical Properties**

**Voltage Breakdown**

This is a measure of how much voltage differential a material can withstand under a specific set of test conditions. This property is usually measured using ASTM D149 where a test specimen is subjected to ramped alternating current voltage such that dielectric failure is reached within twenty seconds after the start of the test. Five specimens are tested and the average voltage breakdown is calculated and reported. The value is an average, not a minimum. Voltage Breakdown can be converted to Dielectric Strength by dividing the voltage breakdown value by the specimen thickness where the dielectric failure occurred. This test is an indication of the ability of a material to withstand high voltages, but does not guarantee how a material will behave over time in a real application. The value is influenced by several factors. Humidity and elevated temperature will reduce the voltage breakdown because absorbed water will degrade the electrical properties of the material. The size of the test electrode will affect the observed breakdown voltage. A larger test electrode will typically yield a lower breakdown voltage. The presence of partial discharge, as well as mechanical stresses imposed on the interface material, also reduce voltage breakdown.

**Volume Resistivity**

Volume resistivity is a measure of the bulk electrical resistance of a unit cube of a material. When determined per ASTM D257, volume resistivity can give an indication of how well an interface material can limit leakage current between an active component and its grounded metal heat sink. As with voltage breakdown, volume resistivity can be significantly lowered by humidity and elevated temperature.

**Elastomeric Properties**

Interface materials exhibit properties typical of highly filled elastomers, namely compression deflection, compression set and stress relaxation.

**Compression Deflection**

Compression deflection refers to resultant forces a material exerts while being deflected. As a compressive load is applied, the elastomer material is deformed but the volume of the material remains constant. The compression deflection characteristics can vary, depending on part geometry (i.e., thickness and surface area), rate of deflection, size of probe, etc.

**Stress Relaxation**

When a compressive load is applied to an interface material, there is an initial deflection followed by a slow relaxation process whereby some of the load is relieved. This process continues until the compressive load is balanced by the cohesive strength of the material.
**Compression Set**
Compression set is the result of stress relaxation. After a material has been subjected to a compressive load for an extended time, part of the deflection becomes permanent and will not be recoverable after the load is reduced.

<table>
<thead>
<tr>
<th>Multiplier</th>
<th>Cal/sec-cm°C</th>
<th>BTU-in/hr-ft°F</th>
<th>W/m-K</th>
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<tr>
<td>4.2 x 10³</td>
<td>2.9 x 10³</td>
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<table>
<thead>
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<th>To</th>
<th>W/m-K</th>
<th>BTU-in/hr-ft°F</th>
<th>W/m-K</th>
<th>Cal/sec-cm°C</th>
<th>BTU-in/hr-ft°F</th>
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| Thermal Conductivity Conversion Guide

**From**

- Cal/sec-cm°C
- BTU-in/hr-ft°F
- W/m-K

**To**

- W/m-K
- BTU-in/hr-ft°F
- W/m-K
- Cal/sec-cm°C
- BTU-in/hr-ft°F
- Cal/sec-cm°C
**DESCRIPTION**

THERM-A-GAP™ gap-filler sheets and pads offer excellent thermal properties and highest conformability at low clamping forces.

**FEATURES / BENEFITS**

- Ultra low deflection force
- High thermal conductivity
- High tack surface reduces contact resistance
- "A" version offers high strength acrylic PSA for permanent attachment
- UL recognized V-0 flammability
- RoHS compliant

All products are available on aluminum foil (A) or on "clean break" glass (G) fiber carrier. As with all previous Chomerics gap-fillers, the "A" versions have a high strength acrylic pressure sensitive adhesive (PSA) for permanent attachment to the cold surfaces.

---

**THERM-A-GAP™ HCS10, 569, 570, 579, 580 Thermally Conductive Pads**

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>HCS10</th>
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<th>579</th>
<th>580</th>
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<td>A or G</td>
<td>A or G</td>
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<td>0.25 – 5.0</td>
<td>0.5 – 5.0</td>
<td>0.25 – 5.0</td>
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<td>10</td>
<td>6</td>
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<td>Percent Deflection @ Various Pressures (0.125 in thick sample)</td>
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<td>% Deflected</td>
<td>% Deflected</td>
<td>% Deflected</td>
<td>% Deflected</td>
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<td>@ 34 kPa (5 psi)</td>
<td>26</td>
<td>20</td>
<td>10</td>
<td>22</td>
<td>7</td>
<td>(0.125 in &quot;G&quot; Type, 0.50 in dia. probe, 0.025 in/min rate)</td>
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<td>36</td>
<td>30</td>
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<td>@ 172 kPa (25 psi)</td>
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<td>55</td>
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<td>@ 345 kPa (50 psi)</td>
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<td>68</td>
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<td>-55 to 200</td>
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<td>-55 to 200</td>
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<td>Thermal Impedance, °C-cm²/W [°C-in²/W]</td>
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<td>@ 10 psi, @ 1 mm thick, G version</td>
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<td>0.44 (0.13)</td>
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<td>24 (18)</td>
<td>24 (18)</td>
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</table>

*Thickness tolerance, mm[in.]: ±10% nominal thickness @ 2.5mm (100 mil) or less;
± 0.25mm (10mil) @ nominal thickness greater than 2.5mm (100 mil). Custom thicknesses may be available upon request.

Yellow highlights new product since previous catalog edition.
THERM-A-GAP™ HCS10, 569, 570, 579, 580 Thermally Conductive Pads

TYPICAL APPLICATIONS
- Telecommunications equipment
- Consumer electronics
- Automotive electronics (ECUs)
- LEDs, Lighting
- Power conversion
- Desktop computers, laptops, servers
- Handheld devices
- Memory modules
- Vibration dampening

HANDLING INFORMATION
These products are defined by Chomerics as “articles” according to the following generally recognized regulatory definition for articles:

An article is a manufactured item “formed to a specific shape or design during manufacturing,” which has “end use functions” dependent upon its size and shape during end use and which has generally “no change of chemical composition during its end use.”

In addition:
- There is no known or anticipated exposure to hazardous materials/substances during routine and anticipated use of the product.
- The product’s shape, surface, and design is more relevant than its chemical composition.

These materials are not deemed by Chomerics to require an MSDS. For further questions, please contact Chomerics at 781-935-4850.

PRODUCT ATTRIBUTES
HCS10
- Economical solution
- Highest conformability

569
- Economical combination of thermal performance and conformability

570
- Best for molding complex parts and vibration dampening

579
- Best combination of thermal performance and conformability
- Lowest outgassing

580
- Best for molding complex parts and vibration dampening
- Lowest outgassing

Ordering Information

Thermally conductive pads are available in the following formats. Contact Chomerics for custom widths, part sizes, etc.

Distributor Part Numbers - 18" X 18" Sheets

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.010 in</td>
<td>69-XX-27082-ZZZZ</td>
</tr>
<tr>
<td>0.015 in</td>
<td>69-XX-27083-ZZZZ</td>
</tr>
<tr>
<td>0.020 in</td>
<td>69-XX-26996-ZZZZ</td>
</tr>
<tr>
<td>0.030 in</td>
<td>69-XX-27070-ZZZZ</td>
</tr>
<tr>
<td>0.040 in</td>
<td>69-XX-26884-ZZZZ</td>
</tr>
<tr>
<td>0.050 in</td>
<td>69-XX-27072-ZZZZ</td>
</tr>
<tr>
<td>0.060 in</td>
<td>69-XX-20991-ZZZZ</td>
</tr>
</tbody>
</table>

XX = 11 for “G” Version
XX = 12 for “A” Version
ZZZZ = THERM-A-GAP™ Material Code

Custom die-cut parts on sheets, or as individual parts “A” version offered die-cut (up to 70 mil) on continuous rolls (higher volumes)
Custom thicknesses available upon request (up to 1” thick)
Custom molded designs and ribbed sheets

OEM Part Number Examples - 9” X 9” Sheets

Standard OEM Sheet, 0.070 Thick, “G” carrier, no PSA, 570 material: 61 - 07 - 0909 - G570
Standard OEM Sheet, 0.200 Thick, “A” carrier, with PSA, 579 material: 62 - 20 - 0909 - A579

Custom Part Number Examples

Custom configuration, (69 Prefix) “A” carrier, with PSA, 569 material: 69 - 12 - XXXXX - A569
(Where “XXXXX” is assigned by Chomerics at time of quotation)

XX = 11 for “G” Version
XX = 12 for “A” Version

ZZZZ = THERM-A-GAP™ Material Code
**DESCRIPTION**
THERM-A-GAP™ 97X gap fillers offer the highest thermal conductivity for low to moderate clamping force applications.

**FEATURES/BENEFITS**
- High thermal conductivity
- 974 and G974 supplied with PSA for ease of use
- 976 is softer compared to similar high conductivity materials

### Table: THERM-A-GAP™ 974, G974 and 976 Thermally Conductive Gap Filler Pads

<table>
<thead>
<tr>
<th>Physical</th>
<th>974</th>
<th>G974</th>
<th>976</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Blue</td>
<td>Blue</td>
<td>Gold</td>
<td>Visual</td>
</tr>
<tr>
<td>Carrier</td>
<td>PSA</td>
<td>Fiberglass with PSA</td>
<td>None</td>
<td>--</td>
</tr>
<tr>
<td>Standard Thicknesses*, mm (in)</td>
<td>0.5 - 1.50 (0.020 - 0.060)</td>
<td>0.25 - 1.50 (0.010 - 0.060)</td>
<td>1.00 - 5.00 (0.040 - 0.200)</td>
<td>ASTM D374</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.40</td>
<td>1.40</td>
<td>1.30</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Hardness, Shore A</td>
<td>40</td>
<td>40</td>
<td>10</td>
<td>ASTM D2240</td>
</tr>
<tr>
<td>Penetrometer, mm</td>
<td>25</td>
<td>25</td>
<td>60</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Percent Deflection @ Various Pressures (0.070 in thick sample)</td>
<td>% Deflected</td>
<td>% Deflected</td>
<td>% Deflected</td>
<td>ASTM C165 MOD</td>
</tr>
<tr>
<td>@ 34 kPa (5 psi)</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>0.50 in diameter, 0.025 in/min rate</td>
</tr>
<tr>
<td>@ 69 kPa (10 psi)</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>@ 172 kPa (25 psi)</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>@ 345 kPa (50 psi)</td>
<td>13</td>
<td>13</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Thermal Impedance, °C-cm²/W (°C-in²/W) @ 345 kPa (50 psi), 1 mm</td>
<td>2.9 (0.45)</td>
<td>3.3 (0.51)</td>
<td>1.9 (0.30)</td>
<td>ASTM D5470</td>
</tr>
<tr>
<td>Thermal Conductivity, W/m-K</td>
<td>6.0</td>
<td>5.0</td>
<td>6.5</td>
<td>ASTM D5470</td>
</tr>
<tr>
<td>Heat Capacity, J/g-K</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>ASTM E1269</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, ppm/°C</td>
<td></td>
<td></td>
<td></td>
<td>ASTM E831</td>
</tr>
<tr>
<td>Operating Temperature Range, °C (°F)</td>
<td>-55 to 200°C (-67 to 392)</td>
<td>-55 to 200°C (-67 to 392)</td>
<td>-55 to 200°C (-67 to 392)</td>
<td>--</td>
</tr>
<tr>
<td>Dielectric Strength, kV/mm (Vac/mil)</td>
<td>5.1 (200)</td>
<td>5.1 (200)</td>
<td>5.1 (200)</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Volume Resistivity, ohm-cm</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
<td>ASTM D257</td>
</tr>
<tr>
<td>Dielectric Constant @1,000 kHz</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>ASTM D150</td>
</tr>
<tr>
<td>Dissipation Factor @ 1,000 kHz</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>Chomerics Test</td>
</tr>
<tr>
<td>Flammability Rating (See UL File E140244 for Details)</td>
<td>Not Tested</td>
<td>V-0</td>
<td>V-0</td>
<td>UL 94</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Chomerics Certification</td>
</tr>
<tr>
<td>Outgassing, % TML (%CVCM)</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>E595</td>
</tr>
<tr>
<td>Shelf Life, months from date of shipment</td>
<td>12</td>
<td>12</td>
<td>24</td>
<td>Chomerics</td>
</tr>
</tbody>
</table>

* Thickness tolerance, mm (in.) ±10% nominal thickness @ 2.5mm (100 mil) or less; ± 0.25mm (10mil) @ nominal thickness greater than 2.5mm (100 mil). Custom thicknesses may be available upon request.
THERM-A-GAP™ 974, G974 and 976 Thermally Conductive Gap Filler Pads

TYPICAL APPLICATIONS
- Telecommunications equipment
- Consumer electronics
- Automotive electronics (ECUs)
- LEDs, Lighting
- Power conversion
- Power semiconductors

PRODUCT ATTRIBUTES
974
- Excellent thermal performance
- PSA for improved application

G974
- Excellent thermal performance
- PSA for improved application
- Fiberglass reinforced for improved tear strength and improved rework capabilities

976
- Superior thermal performance
- Low compression force under pressure
- Minimal stress on components

TYPICAL APPLICATIONS
- Telecommunications equipment
- Consumer electronics
- Automotive electronics (ECUs)
- LEDs, Lighting
- Power conversion
- Power semiconductors

MATERIAL HANDLING
These products are defined by Chomerics as “articles” according to the following generally recognized regulatory definition for articles: An article is a manufactured item “formed to a specific shape or design during manufacturing,” which has “end use functions” dependent upon its size and shape during end use and which has generally “no change of chemical composition during its end use.”

In addition:
- There is no known or anticipated exposure to hazardous materials/substances during routine and anticipated use of the product.
- The product’s shape, surface, and design is more relevant than its chemical composition.

These materials are not deemed by Chomerics to require an MSDS. For further questions, please contact Chomerics at 781-935-4850.

Ordering Information

THERM-A-GAP products are available in the following formats.
Contact Chomerics for custom widths, part sizes, etc.

- Full Sheets, 9x12” to 20x25”
- Die-cut parts on sheets
- Custom die-cut parts on sheets, or as individual parts

Part Number:

6

1 = Sheet - No PSA (976 only)
2 = Sheet with PSA 1 side
[974/G974 only]
9 = Custom configuration

Material thickness* in mils
le.g. 10 = 0.010” or 0.254 mm

YYYY = 0808
(8” X 8” Sheet / 20.3 cm X 20.3 cm).
Custom YYYY sizes available.

ZZZZ = 974, G974, or 976

11 = Custom, no PSA (976 only)
12 = Custom, with PSA 1side
[974/G974 only]

YYYYY = Custom configuration
(Please contact Chomerics for a pre-assigned part number if necessary)

* See typical properties table for thicknesses.
THERM-A-GAP™ 575-NS
Silicone-Free Soft Acrylic Thermally Conductive Gap Filler Pads

DESCRIPTION
THERM-A-GAP™ acrylic gap filler pads are used in silicone sensitive applications.

FEATURES / BENEFITS
- Economical with good thermal conductivity
- No silicone outgassing or extractables
- RoHs compliant
- Inherently tacky on both sides for ease of application (No pressure sensitive adhesive option available/necessary)

TYPICAL APPLICATIONS
- Hard disk drives/storage
- Optical electronics
- Aerospace/Defense
- Desktop computers, laptops, servers
- Telecommunications equipment
- Consumer electronics

<table>
<thead>
<tr>
<th>THERM-A-GAP™ Silicone-Free Soft Acrylic Thermally Conductive Pads</th>
<th>575-NS</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Yellow</td>
<td>Visual</td>
</tr>
<tr>
<td>Composition</td>
<td>Ceramic Filled Acrylic</td>
<td>---</td>
</tr>
<tr>
<td>Thickness, mm (in)</td>
<td>0.5 – 2.5 (0.020 -0.100)</td>
<td>ASTM D374</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.8</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Thermal Conductivity, W/m-K</td>
<td>1.2</td>
<td>ASTM D5470</td>
</tr>
<tr>
<td>Hardness (Shore 00)</td>
<td>70</td>
<td>ASTM D2240</td>
</tr>
<tr>
<td>Operating Temperature Range, °C (°F)</td>
<td>-20 to 100 (-4 to 212)</td>
<td>---</td>
</tr>
</tbody>
</table>

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Thickness / mm (in)</th>
<th>Sheet Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>69-11-27154-575NS</td>
<td>0.5 (0.020)</td>
<td>300 X 400 mm (11.8 X 15.7)</td>
</tr>
<tr>
<td>69-11-27155-575NS</td>
<td>1 (0.040)</td>
<td></td>
</tr>
<tr>
<td>69-11-27156-575NS</td>
<td>1.2 (0.047)</td>
<td></td>
</tr>
<tr>
<td>69-11-27157-575NS</td>
<td>1.5 (0.060)</td>
<td></td>
</tr>
<tr>
<td>69-11-27158-575NS</td>
<td>2 (0.080)</td>
<td>200 X 300 mm (7.9 X 11.8)</td>
</tr>
<tr>
<td>69-11-27159-575NS</td>
<td>2.5 (0.100)</td>
<td></td>
</tr>
</tbody>
</table>
Chomerics

THERM-A-GAP™ Gels
Dispensable, Very Low Compression Force, Thermal Gap Fillers

DESCRIPTION
THERM-A-GAP™ Gels are highly conformable, pre-cured, single-component compounds. The cross-linked gel structure provides superior long term thermal stability and reliable performance. These unique materials result in much lower mechanical stress on delicate components than even the softest gap-filling sheets. They are ideal for filling variable gaps between multiple components and a common heat sink.

FEATURES / BENEFITS
- Dispensable
- Fully cured
- Highly conformable at low pressures
- No refrigeration, mixing or filler settling issues in storage
- Single dispensable TIM can eliminate multiple pad part sizes/numbers
- Reworkable

TYPICAL APPLICATIONS
- Automotive electronic control units (ECUs)
  - Engine control
  - Transmission control
  - Braking/traction control
- Power conversion equipment
- Power supplies and uninterruptible power supplies
- Power semiconductors
- MOSFET arrays with common heat sinks
- Televisions and consumer electronics

<table>
<thead>
<tr>
<th>THERM-A-GAP™ Dispensed Thermal Gels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Properties</strong></td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
</tr>
<tr>
<td>Flow Rate, cc/min - 30cc taper tip, 0.130&quot; orifice, 90psi (621 kPa)</td>
</tr>
<tr>
<td>Specific Gravity</td>
</tr>
<tr>
<td>Percent Deflection @ Various Force Levels</td>
</tr>
<tr>
<td>@ 0.20 kg (0.5 lb)</td>
</tr>
<tr>
<td>@ 0.45 kg (1 lb)</td>
</tr>
<tr>
<td>@ 1.0 kg (2 lbs)</td>
</tr>
<tr>
<td>@ 1.4 kg (3 lbs)</td>
</tr>
<tr>
<td>@ 1.8 kg (4 lbs)</td>
</tr>
<tr>
<td>@ 2.3 kg (5 lbs)</td>
</tr>
<tr>
<td>Typical minimum bondline thickness, mm (in)</td>
</tr>
<tr>
<td><strong>Thermal</strong></td>
</tr>
<tr>
<td>Thermal Conductivity, W/m-K</td>
</tr>
<tr>
<td>Heat Capacity, J/g-K</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, ppm/K</td>
</tr>
<tr>
<td>Operating Temperature Range, °C(°F)</td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
</tr>
<tr>
<td>Dielectric Strength, kV/cm (Vac / mil)</td>
</tr>
<tr>
<td>Volume Resistivity, ohm-cm</td>
</tr>
<tr>
<td>Dielectric Constant @1,000 kHz</td>
</tr>
<tr>
<td>Dissipation Factor @ 1,000 kHz</td>
</tr>
<tr>
<td>Flammability Rating [See UL File E140244 for Details]</td>
</tr>
<tr>
<td>RoHS Compliant</td>
</tr>
<tr>
<td>Outgassing, % TML</td>
</tr>
<tr>
<td>Shelf Life, months from date of manufacture</td>
</tr>
</tbody>
</table>
THERM-A-GAP™ Dispensed Thermal Gels

PRODUCT ATTRIBUTES

T630 / T630G
- Years of proven reliability in high-volume automotive applications
- General use material
- Good thermal performance
- Lowest deflection force required
- Minimal stress on components
- “G” version has 0.010” glass beads as compression stops for electrical isolation

T635
- Excellent thermal performance
- Low deflection force required
- Minimal stress on components

T636
- Superior thermal performance
- Solves the toughest heat transfer problems
- Low deflection force required
- Minimal stress on components

Ordering Information

These materials are available in the following formats. Contact Chomerics for custom widths, part sizes, etc.

PART NUMBERS
65-00-T6XX - 0010 10 CC SAMPLE
65-00-T6XX - 0030 30 CC CARTRIDGE
65-00-T6XX - 0180 180 CC CARTRIDGE
65-00-T6XX - 0300 300 CC CARTRIDGE
69-11-24419-T630 25 KG KIT
69-11-25177-T630 1 GAL PAIL (5 KG )

Dispensing Equipment Options

<table>
<thead>
<tr>
<th>Dispensing Equipment Options</th>
<th>Optional Supplier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-Gun Pneumatic Dispensing 300cc cartridges</td>
<td>Bergdahl Associates</td>
<td>Semco Model 550</td>
</tr>
<tr>
<td>Hand-Gun Pneumatic Dispensing 180cc (6oz) cartridges</td>
<td>Bergdahl Associates</td>
<td>Model 250A-6oz Sealant Gun</td>
</tr>
<tr>
<td>Pneumatic Shot Size Controllers 30cc, 180cc and 300cc Shot Size Dispensing Equipment</td>
<td>EFD</td>
<td>Ultra 2400 Series</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ultra 1400 Series</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ultra 870 Series</td>
</tr>
<tr>
<td>30cc/55cc Adapter Assembly</td>
<td>EFD</td>
<td>10000DS152</td>
</tr>
<tr>
<td>Dispensing Sleeve to support 6oz (180cc) Semco Tubes</td>
<td>EFD</td>
<td>5192-6</td>
</tr>
</tbody>
</table>

http://www.bergdahl.com
http://wwwefd-inc.com

SEMCO is a trademark of Semco, Inc.
DESCRIPTION

GEL 8010 is specifically formulated for use in high performance devices requiring minimum thermal resistance for maximum thermal performance and component reliability. GEL 8010 is a compliant material that requires low compression force to conform over irregular interfaces and can be applied to single devices with minimum bond-line thickness as well as to multiple devices with variable z-axis tolerances.

GEL 8010 can easily be applied by stencil printing or dispensing, either manually or with automated equipment. It requires no cure cycle and can be readily re-worked. GEL 8010 is supplied as a one-component gel and requires no refrigeration, no mixing and has no filler settling issues.

GEL 8010 has demonstrated reliable thermal performance during temperature cycling, humidity, long term thermal aging and power cycling tests. It was developed for next generation microprocessors.

TYPICAL APPLICATIONS

- Microprocessors
- Graphics Processors
- Chipsets
- Memory Modules
- Power Modules
- Power Semiconductors

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>GEL 8010</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>White</td>
<td>Visual</td>
</tr>
<tr>
<td>Flow Rate, cc/min - 30cc taper tip, 0.130&quot; orifice, 90psi (621 kPa)</td>
<td>70</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.70</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Percent Deflection @ Various Force Levels</td>
<td>% Deflection</td>
<td>Modified ASTM C165</td>
</tr>
<tr>
<td>@ .20 kg (0.5 lb)</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>@ .45 kg (1 lb)</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>@ 1.0 kg (2 lbs)</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>@ 1.4 kg (3 lbs)</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>@ 1.8 kg (4 lbs)</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>@ 2.3 kg (5 lbs)</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Typical minimum bondline thickness, mm (in)</td>
<td>0.10 (0.004)/ 0.25 (0.010)</td>
<td>--</td>
</tr>
<tr>
<td>Thermal Conductivity, W/m-K</td>
<td>4.0</td>
<td>ASTM D5470</td>
</tr>
<tr>
<td>Heat Capacity, J/g-K</td>
<td>.047</td>
<td>ASTM E1269</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, ppm/K</td>
<td>943</td>
<td>ASTM E831</td>
</tr>
<tr>
<td>Operating Temperature Range, °C(°F)</td>
<td>-55 to 200 (-67 to 392)</td>
<td>--</td>
</tr>
<tr>
<td>Dielectric Strength, kVac/mm (Vac/mil)</td>
<td>5.0 (200)</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Volume Resistivity, ohm-cm</td>
<td>10^14</td>
<td>ASTM D257</td>
</tr>
<tr>
<td>Dielectric Constant @100 kHz</td>
<td>6.3</td>
<td>ASTM D150</td>
</tr>
<tr>
<td>Dissipation Factor @ 100 kHz</td>
<td>0.002</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Flammability Rating</td>
<td>V-0 Pending</td>
<td>UL 94</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
<td>Chomerics Certification</td>
</tr>
<tr>
<td>Outgassing, % TML</td>
<td>--</td>
<td>ASTM E595</td>
</tr>
<tr>
<td>Shelf Life, months from date of manufacture</td>
<td>18</td>
<td>Chomerics</td>
</tr>
</tbody>
</table>

Yellow highlights new product since previous catalog edition.
GEL 8010 Thermally Conductive Dispensable Gel

FEATURES/BENEFITS

- Low thermal impedance
- High bulk thermal conductivity
- Excellent long term EOLife (End of Life) performance
- Proven performance at elevated temperatures
- Easy to handle and apply--stencil printable
- Highly conformable at low compression force
- End user license agreement may apply

- Applicable to single devices or multiple devices
- Requires no cure cycle, mixing or refrigeration
- No pump-out associated with thermal grease
- Lower joint stress compared to metallic solder
- Reworkable gel
- RoHS compliant
- UL 94 V-0 Flammability Ratings

INSTALLATION GUIDELINES

Thermal GEL 8010 is supplied in plastic syringes and aluminum cartridges. Apply pressure to the rear of the cartridge, simply dispense the desired amount onto components or cooling plates. Since GEL 8010 gel is conformable, the gel can be stencil printed onto the plates. The thickness of the printed gel can be adjusted depending on the component type and size, but about 6mil thickness is recommended. The gel is reworkable and excess material can be easily wiped off with a rag. Refer to Application Note for more detailed information about using this material.

Ordering Information

These materials are available in the following formats. Contact Chomerics for custom widths, part sizes, etc.

PART NUMBERS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>65-00-GEL8010-0010</td>
<td>10 CC sample</td>
</tr>
<tr>
<td>65-00-GEL8010-0030</td>
<td>30 CC Cartridge</td>
</tr>
<tr>
<td>65-00-GEL8010-0180</td>
<td>80 CC Cartridge</td>
</tr>
<tr>
<td>65-00-GEL8010-0300</td>
<td>300 CC Cartridge</td>
</tr>
<tr>
<td>69-11-25177-GEL8010</td>
<td>1 GAL PAIL (5 KG)</td>
</tr>
<tr>
<td>69-11-28020-GEL8010</td>
<td>1 GAL PAIL (9 KG)</td>
</tr>
</tbody>
</table>

BAKE TEST at 95 °C

TEMPERATURE CYCLING TEST
**DESCRIPTION**

THERMFLOW® phase-change Thermal Interface Materials (TIM) are designed to minimize the thermal resistance between power dissipating electronic components and heat sinks. This low thermal resistance path maximizes heat sink performance and improves component reliability. At room temperature, THERMFLOW materials are solid and easy to handle. This allows them to be consistently and cleanly applied as dry pads to a heat sink or component surface. THERMFLOW material softens as it reaches component operating temperatures. With light clamping pressure it will readily conform to both mating surfaces. This ability to completely fill interfacial air gaps and voids typical of component packages and heat sinks allows THERMFLOW pads to achieve performance superior to any other thermal interface materials. THERMFLOW products are electrically non-conductive. However, since metal-to-metal contact is possible after the material undergoes phase-change in a typical heat sink assembly. In general, THERMFLOW pads should not be used as electrical insulators - PC07DM-7 is offered as a dielectric version.

Chomerics offers two types of phase change materials—traditional thermal interface pads and polymer solder hybrids.

**POLYMER SOLDER HYBRID MATERIALS**

These Thermal Interface Materials provide superior long term reliability performance. These products exhibit the lowest thermal impedance of the phase-change family. For optimum performance, the pads must be exposed to temperatures above 64°C during operation or by a burn-in cycle to achieve lowest thermal impedance and highest thermal performance. Upon reaching the required burn-in temperature, the pad will fully change phase and attain MBLT (minimum bond-line thickness less than 0.001 inch or 0.0254mm) and maximum surface wetting.

**FEATURES/BENEFITS**

- Low thermal impedance
- Proven solution – years of production use in personal computer OEM applications
- Demonstrated reliability through thermal cycling and accelerated age testing
- Can be pre-applied to heat sinks
- Protective release liner prevents contamination of material prior to final component assembly
- Tabs available for easy removal of release liner (T710, T725, T557, T777)
- Available in custom die-cut shapes, kiss-cut on rolls
- Electrically non-conductive, non-silicone polymers
- RoHS Compliant

**TYPICAL APPLICATIONS**

- Microprocessors
- Graphics Processors
- Chipsets
- Memory Modules
- Power Modules
- Power Semiconductors

**HANDLING INFORMATION**

These products are defined by Chomerics as “articles” according to the following generally recognized regulatory definition for articles:

An article is a manufactured item “formed to a specific shape or design during manufacturing,” which has “end use functions” dependent upon its size and shape during end use and which has generally “no change of chemical composition during its end use.”

In addition:

- There is no known or anticipated exposure to hazardous materials/substances during routine and anticipated use of the product.
- The product’s shape, surface, and design is more relevant than its chemical composition.

These materials are not deemed by Chomerics to require an MSDS. For further questions, please contact Chomerics at 781-935-4850.

**APPLICATION**

Material may flow when oriented vertically, especially at higher temperatures. This does not affect thermal performance, but should be considered if appearance is important.
## THERMFLOW® Phase-Change Thermal Interface Pads

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>PC07DM-7</th>
<th>T710 with PSA</th>
<th>T725</th>
<th>T766</th>
<th>T557</th>
<th>T558</th>
<th>T777</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Pink</td>
<td>Pink</td>
<td>Purple / Gray foil</td>
<td>Gray</td>
<td>Gray / Gray foil</td>
<td>Gray</td>
<td>Gray</td>
<td>Visual</td>
</tr>
<tr>
<td>Carrier</td>
<td>1 mil polyester</td>
<td>2 mil Fiberglass</td>
<td>None - Free Film</td>
<td>1 mil Metal Foil</td>
<td>None - Free film</td>
<td>1 mil Metal Foil</td>
<td>None - Free film</td>
<td>--</td>
</tr>
<tr>
<td>Standard Thicknesses, mm (in)</td>
<td>0.178 (0.007)</td>
<td>0.138 (0.0055)</td>
<td>0.125 (0.005)</td>
<td>0.088 (0.0035)</td>
<td>0.125 (0.005)</td>
<td>0.115 (0.0045)</td>
<td>0.115 (0.0045)</td>
<td>ASTM D374</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.1</td>
<td>1.15</td>
<td>1.1</td>
<td>2.6</td>
<td>2.4</td>
<td>3.65</td>
<td>1.95</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Phase Transition Temperature, °C</td>
<td>55</td>
<td>45</td>
<td>55</td>
<td>55</td>
<td>45 / 62</td>
<td>45 / 62</td>
<td>45 / 62</td>
<td>ASTM D3418</td>
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<td>&lt;0.5%</td>
<td>&lt;0.5%</td>
<td>&lt;0.5%</td>
<td>&lt;0.5%</td>
<td>&lt;0.5%</td>
<td>&lt;0.5%</td>
<td>--</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Impedance @ 70°C, °C-cm/W (°C-in²/W)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ 69 kPa (10 psi)</td>
<td>2.26 (0.35)</td>
<td>1.48 (0.23)</td>
<td>0.71 (0.11)</td>
<td>0.97 (0.15)</td>
<td>0.13 (0.02)</td>
<td>0.19 (0.03)</td>
<td>0.13 (0.02)</td>
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<tr>
<td>@ 172 kPa (25 psi)</td>
<td>1.93 (0.30)</td>
<td>1.03 (0.16)</td>
<td>0.39 (0.06)</td>
<td>0.58 (0.09)</td>
<td>0.097 (0.015)</td>
<td>0.13 (0.02)</td>
<td>0.097 (0.015)</td>
<td>ASTM D257</td>
</tr>
<tr>
<td>@ 345 kPa (50 psi)</td>
<td>1.81 (0.28)</td>
<td>0.77 (0.12)</td>
<td>0.26 (0.04)</td>
<td>0.39 (0.06)</td>
<td>0.052 (0.008)</td>
<td>0.097 (0.015)</td>
<td>0.035 (0.0055)</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Volume Resistivity, ohm-cm</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
<td>10¹⁴ Metal Foil*</td>
<td>Nonconductive **</td>
<td>Nonconductive** / Metal Foil*</td>
<td>Nonconductive**</td>
<td>ASTM D257</td>
</tr>
<tr>
<td>Voltage Breakdown (Vac)</td>
<td>5.000</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>ASTM D149</td>
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<td>V-0</td>
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<tr>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Shelf Life, months from date of shipment</td>
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<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>Chomerics</td>
</tr>
</tbody>
</table>

*Phase-change material exhibits 10¹⁴ ohm-cm volume resistivity. Metal foil is electrically conductive.

**The phase-change material is electrically non-conductive. However, as it contains dispersed solder for enhanced thermal properties, it can exhibit through-conductivity at thinner bond line thickness [approximately <2 mils]. It should not be used as an electrical insulator.*
THERMFLOW® Phase-Change Thermal Interface Pads

TRADITIONAL PHASE CHANGE MATERIALS (PCM)

**PC07DM-7**
- Utilizes proven T725 phase-change material
- Polyester dielectric layer offers excellent mechanical and electrical properties
- Inherently tacky – no adhesive required
- Good thermal properties

**T725**
- Excellent thermal performance
- Inherently tacky – no adhesive required
- Ideal for vertical applications
- Sticky nature limits flowing in vertical applications

**T766**
- Excellent thermal performance
- Protective foil eliminates top liner
- Inherently tacky – no adhesive required
- Sticky nature limits flowing in vertical applications

**T710**
- General use material
- Good thermal performance
- Low deflection force required
- Fiberglass provides dielectric standoff
- Available with and without adhesive

**T557**
- Superior thermal performance
- Dispersed solder filler offers added thermal performance
- Resin system designed for higher temperature reliability
- Inherently tacky – no adhesive required

**T558**
- Superior thermal performance
- Conformal foil allows clean break/rework and eliminates top liner
- Dispersed solder filler offers added thermal performance

**T766**
- Superior thermal performance
- Protective foil eliminates top liner
- Inherently tacky – no adhesive required
- Sticky nature limits flowing in vertical applications

**T777**
- Superior thermal performance
- Ideal solution for mobile microprocessors
- Dispersed solder filler offers added thermal performance
- Resin system designed for higher temperature reliability
- Inherently tacky – no adhesive required
- End user license agreement may apply

**THERMFLOW® POLYMER SOLDER HYBRID MATERIALS (PSH)**

**T725**
- Excellent thermal performance
- Inherently tacky – no adhesive required
- Ideal for vertical applications
- Sticky nature limits flowing in vertical applications

**T766**
- Excellent thermal performance
- Protective foil eliminates top liner
- Inherently tacky – no adhesive required
- Sticky nature limits flowing in vertical applications

**T710**
- General use material
- Good thermal performance
- Low deflection force required
- Fiberglass provides dielectric standoff
- Available with and without adhesive

**T557**
- Superior thermal performance
- Dispersed solder filler offers added thermal performance
- Resin system designed for higher temperature reliability
- Inherently tacky – no adhesive required

**T558**
- Superior thermal performance
- Conformal foil allows clean break/rework and eliminates top liner
- Dispersed solder filler offers added thermal performance

**T777**
- Superior thermal performance
- Ideal solution for mobile microprocessors
- Dispersed solder filler offers added thermal performance
- Resin system designed for higher temperature reliability
- Inherently tacky – no adhesive required
- End user license agreement may apply

Ordering Information

THERMFLOW materials are supplied in several standard formats (see part number guide below).

Custom die-cut shapes can also be provided on kiss-cut rolls by Chomerics’ extensive network of distributor/fabricators. To ease release liner removal, an optional tab can be added.

Standard tolerances for slitting widths and individually cut pieces are ±0.020 inch (±0.51 mm).

<table>
<thead>
<tr>
<th>Part Number:</th>
<th>6W</th>
<th>XX</th>
<th>YYYY</th>
<th>ZZZZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>6W</td>
<td>6</td>
<td>XX</td>
<td>YYYY</td>
<td>ZZZZ</td>
</tr>
<tr>
<td>4 = Roll stock</td>
<td>10 = 100 ft.</td>
<td>YYYY = Roll stock width:</td>
<td>ZZZZ = Material class (T710, T725, T766, T557, T558, T777)</td>
<td></td>
</tr>
<tr>
<td>6 = Roll stock with PSA</td>
<td>40 = 400 ft.</td>
<td>0100 = 1”</td>
<td>ZZZZ = T710 only product available with PSA (no need for PSA) All others are inherently tacky</td>
<td></td>
</tr>
<tr>
<td>8 = Roll stock with PSA and release tabs</td>
<td>XX = Custom length</td>
<td>0750 = 7.5”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 = Custom die-cut part</td>
<td>11 = without PSA</td>
<td>2400 = 24”</td>
<td>12 = with PSA one side (T710 Only)</td>
<td></td>
</tr>
<tr>
<td>11 = without PSA</td>
<td>Custom Part Number. Contact Chomerics</td>
<td>ZZZZ = Material class (T710, T725, T766, T557, T558, T777)</td>
<td></td>
<td></td>
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</tbody>
</table>
THERMATTACH® Tape
Thermally Conductive Attachment Tapes

DESCRIPTION
THERMATTACH® double-sided thermal interface tapes provide exceptional bonding properties between electronic components and heat sinks, eliminating the need for mechanical fasteners. THERMATTACH® tapes are proven to offer excellent reliability when exposed to thermal, mechanical, and environmental conditioning. They are offered in a variety of configurations, as detailed in the typical properties table.

FEATURES / BENEFITS
- Offered in various forms to provide thermal, dielectric, and flame retardant properties
- Offered in custom die-cut configurations to suit a variety of applications

DESCRIPTION
THERMATTACH® double-sided thermal interface tapes provide exceptional bonding properties between electronic components and heat sinks, eliminating the need for mechanical fasteners. THERMATTACH® tapes are proven to offer excellent reliability when exposed to thermal, mechanical, and environmental conditioning. They are offered in a variety of configurations, as detailed in the typical properties table.

TYPICAL APPLICATIONS
- Mount heat sinks to components dissipating < ~25 W
- Attach heat sinks to PC (esp. graphics) processors
- Heat sink attachment to motor control processors
- Telecommunication infrastructure components

PRODUCT ATTRIBUTES
T418
- Superior adhesive strength
- Best conformability to components
- UL94 V-0 rated
- Good thermal performance

T412
- Good adhesion
- Superior thermal performance
- General use tape with added thermal conductivity of Al foil layer

T411
- Designed for adhesion to plastic packages
- Attaches to low surface energy packages

T404
- Excellent dielectric strength due to polyimide carrier
- Good thermal performance
- UL94 V-0 rated

T405
- General use tape with added thermal conductivity of Al foil layer
- Excellent thermal performance
- UL94 V-0 rated

T405-R
- T405 without halogenated flame retardant

T413
- Excellent thermal performance
- Fiberglass layer provides added strength

T414
- T404 without halogenated flame retardant
## THERMATTACH® Thermally Conductive Attachment Tapes

### Typical Properties

<table>
<thead>
<tr>
<th>Method</th>
<th>T411</th>
<th>T412</th>
<th>T413</th>
<th>T404</th>
<th>T405</th>
<th>T405-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Glass Transition Temperature Range</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
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<tr>
<td>Operating Temperature Range</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
<td>-30 to +125 (-22 to +257)</td>
</tr>
<tr>
<td>Glass Transition Temperature</td>
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<td>-20 to +125 (-4 to +257)</td>
<td>-20 to +125 (-4 to +257)</td>
<td>-20 to +125 (-4 to +257)</td>
<td>-20 to +125 (-4 to +257)</td>
<td>-20 to +125 (-4 to +257)</td>
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<tr>
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<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Thermal Impedance, °C-cm²/W (°C-in²/W)</td>
<td>7.7 (1.2)</td>
<td>2.0 (0.30)</td>
<td>3.7 (0.6)</td>
<td>3.4 (0.5)</td>
<td>6.5 (1.0)</td>
<td>4.0 (0.65)</td>
</tr>
<tr>
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<td>1.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
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<tr>
<td>Voltage Breakdown, (Vac)</td>
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<td>5,000</td>
<td>N/A</td>
<td>3,700</td>
<td>N/A</td>
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<td>Volume Resistivity, (ohm-cm)</td>
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<td>3.0 X 10¹⁰</td>
<td>6.9 X 10⁹</td>
<td>6.9 X 10⁹</td>
<td>3.5 X 10¹⁰</td>
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<td>RoHS Compliant</td>
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<td>Yes</td>
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<td>Yes</td>
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</tr>
<tr>
<td>Shelf-Life, months from shipment</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
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</tr>
</tbody>
</table>
THERMATTACH® Thermally Conductive Attachment Tapes

Ordering Information

These attachment tapes are available in the following formats. Contact Chomerics for custom widths, part sizes, etc.

Sheets form, roll form, or die-cut parts. Offered on continuous rolls. A general ordering information table is included below for reference.

| Part Number: | 6 | - | - | - | - |

| 0 = Standard Part | XX = 13 for PSA two sides | YYYY = 4 digit alpha/numeric part number. Contact Chomerics. |
| 7 = Roll of material @ various lengths | XX = 10 (100 foot roll) | XX = 40 (400 foot roll) | YYYY = 0600 for 6” wide | YYYY = 1000 for 10” wide | YYYY = 1150 for 11 ½” wide | YYYY = 2400 for 24” wide |
| 9 = Custom part | XX = 13 for PSA two sides | YYYY = Custom Part Number. Contact Chomerics |
| ZZZZ = Material class (T418, T411, etc) |

Handling Information

These products are defined by Chomerics as “articles” according to the following generally recognized regulatory definition for articles:

An article is a manufactured item “formed to a specific shape or design during manufacturing,” which has “end use functions” dependent upon its size and shape during end use and which has generally “no change of chemical composition during its end use.”

In addition:

- There is no known or anticipated exposure to hazardous materials/substances during routine and anticipated use of the product.
- The product’s shape, surface, and design is more relevant than its chemical composition.

These materials are not deemed by Chomerics to require an MSDS. For further questions, please contact Chomerics at 781-935-4850.
THERMATTACH® Tape

Tape Application Instructions: T404, T405, T405-R, T411, T412, T413, T414, T418

MATERIALS NEEDED
- Clean lint-free cloth rag
- Industrial solvent
- Rubber gloves

For optimal performance, Chomerics recommends interface flatness of 0.001 in/in (0.025 mm/mm) to 0.002 in/in (0.050 mm/mm) maximum.

**Step 1:** Ensure that bonding surfaces are free from oil, dust, or any contamination that may affect bonding. Using rubber gloves, wipe surfaces with a cloth dampened with industrial solvents such as MEK, toluene, acetone or isopropyl alcohol.

**Step 2:** Cut tape to size* and remove a liner or remove pre-cut tape from roll.

*Note: Due to variations in heat sink surfaces, Chomerics' data indicates that it sometimes is beneficial to be cut slightly smaller than the area of the heat sink. See illustration.

**Step 3:** Apply to center of heat sink bonding area and smooth over entire surface using moderate hand pressure / rubbing motion. A roller may be useful to help smooth the part to the surface by rolling from the center out to beyond the edges of the part. This ensures optimal contact between tape and heat sink.

**Step 4:** Center heat sink onto component and apply using any one of the recommended temperature/pressure options:

- More pressure equals better wetting out of the adhesive to the contact surfaces. A twisting motion during assembly of the substrates will typically improve wetting.

- Note that typically 70% of the ultimate adhesive bond strength is achieved with initial application, and 80-90% is reached within 15 minutes. Ultimate adhesive strength is achieved within 36 hours; however the next manufacturing step can typically occur immediately following the initial application.

REMOVAL INSTRUCTIONS
Materials needed: Single-edged razor blade or a small, thin-bladed pocketknife; soft, thin metal spatula. Use safety precautions when handling sharp instruments and organic solvents.

**Step 1:** Carefully insert the blade edge into the bond line at a corner between the heat sink and the component. The penetration need not be very deep.

**Step 2:** Remove the blade and insert the spatula into the wedge. Slowly twist the spatula blade so that it exerts a slight upward pressure.

**Step 3:** As the two surfaces start to separate, move the spatula blade deeper into the bond line and continue the twisting motion and upward force.

**Step 4:** After the two components are separated, the tape can be removed and discarded. If adhesive remains on the component surfaces, it must be removed. Adhesive is best removed by wiping with a clean rag (lint-free) dabbed with isopropyl alcohol, MEK or toluene. Use sufficient solvent to remove all adhesive.

**Step 5:** Solvent cleaned components must be verified 100% free of cleaning solvent and prior to reattachment of adhesive.

---

<table>
<thead>
<tr>
<th>Thermally Conductive Attachment Tapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Properties</td>
</tr>
<tr>
<td>Ceramic Attachment</td>
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<tr>
<td>Metal Attachment</td>
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<tr>
<td>Plastic Attachment</td>
</tr>
<tr>
<td>Dielectric Performance</td>
</tr>
<tr>
<td>Thermal Performance</td>
</tr>
</tbody>
</table>

*Performance rated on a scale of 1-5, 5 being the best. N/R = Not Recommended.*
### THERM-A-FORM™ 164x and T64x Series

**Cure-in-Place Potting and Underfill Materials**

**DESCRIPTION**
THERM-A-FORM™ thermally conductive silicone elastomer products are dispensable form-in-place compounds designed for heat transfer without excessive compressive force in electronics cooling applications. These versatile liquid reactive materials can be dispensed and cured into complex geometries for cooling of multi-height components on a PCB without the expense of a molded sheet. Each compound is available in ready-to-use cartridge systems, eliminating weighing, mixing, and degassing procedures.

<table>
<thead>
<tr>
<th>THERM-A-FORM™ Cure-in-Place Potting and Underfill Materials</th>
<th>T647</th>
<th>T646</th>
<th>T644</th>
<th>T642</th>
<th>1642</th>
<th>1641</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Gray</td>
<td>Yellow</td>
<td>Pink</td>
<td>Blue</td>
<td>Purple</td>
<td>White</td>
<td>Visual</td>
</tr>
<tr>
<td>Binder</td>
<td>Silicone</td>
<td>Silicone</td>
<td>Silicone</td>
<td>Silicone</td>
<td>Silicone</td>
<td>Silicone</td>
<td>--</td>
</tr>
<tr>
<td>Filler</td>
<td>Aluminum Oxide</td>
<td>Aluminum Oxide</td>
<td>Boron Nitride</td>
<td>Boron Nitride</td>
<td>Aluminum Oxide</td>
<td>Aluminum Oxide</td>
<td>--</td>
</tr>
<tr>
<td>Number of Components</td>
<td>2-part</td>
<td>2-part</td>
<td>2-part</td>
<td>2-part</td>
<td>2-part</td>
<td>1-part</td>
<td>--</td>
</tr>
<tr>
<td>Mix Ratio</td>
<td>1 : 1</td>
<td>1 : 1</td>
<td>1 : 1</td>
<td>10 : 1</td>
<td>100 : 3</td>
<td>N/A</td>
<td>--</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.80</td>
<td>2.45</td>
<td>1.45</td>
<td>1.50</td>
<td>2.30</td>
<td>2.10</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Hardness, Shore A</td>
<td>25</td>
<td>50</td>
<td>15</td>
<td>70</td>
<td>85</td>
<td>78</td>
<td>ASTM D2240</td>
</tr>
<tr>
<td>Viscosity, poise</td>
<td>&gt; 5000</td>
<td>&gt; 5000</td>
<td>3000</td>
<td>2500</td>
<td>2500</td>
<td>3000</td>
<td>ASTM D2196</td>
</tr>
<tr>
<td>Pot Life, minutes</td>
<td>300</td>
<td>300</td>
<td>360</td>
<td>60</td>
<td>60</td>
<td>30</td>
<td>Time to 2X Starting Viscosity at 23 °C</td>
</tr>
<tr>
<td><strong>Cure Cycles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chomerics</td>
</tr>
<tr>
<td>Cure at 150 °C</td>
<td>3 min.</td>
<td>3 min.</td>
<td>3 min.</td>
<td>3 min.</td>
<td>60 min.</td>
<td>60 min.</td>
<td>48 hrs. @ 23 °C</td>
</tr>
<tr>
<td>at 60 °C</td>
<td>@ 60 °C</td>
<td>@ 60 °C</td>
<td>@ 60 °C</td>
<td>@ 70 °C</td>
<td>@ 70 °C</td>
<td>@ 70 °C</td>
<td>@ 23 °C</td>
</tr>
<tr>
<td>at 48 hrs. @ 23 °C</td>
<td>48 hrs. @ 70 °C</td>
<td>48 hrs. @ 23 °C</td>
<td>48 hrs. @ 23 °C</td>
<td>48 hrs. @ 23 °C</td>
<td>48 hrs. @ 23 °C</td>
<td>48 hrs. @ 23 °C</td>
<td>48 hrs. @ 23 °C</td>
</tr>
<tr>
<td>Brittle Point, °C (°F)</td>
<td>44 (-67)</td>
<td>44 (-67)</td>
<td>44 (-67)</td>
<td>44 (-67)</td>
<td>44 (-67)</td>
<td>44 (-67)</td>
<td>ASTM D2137</td>
</tr>
<tr>
<td>Extractable Silicone, %</td>
<td>4</td>
<td>8.5</td>
<td>15</td>
<td>1 - 2</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Apparent Thermal Conductivity, W/m-K</td>
<td>3.00</td>
<td>0.90</td>
<td>1.20</td>
<td>1.20</td>
<td>0.95</td>
<td>0.90</td>
<td>ASTM D5470</td>
</tr>
<tr>
<td>Heat Capacity, J/g-K</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>ASTM E1269</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, ppm/K</td>
<td>150</td>
<td>250</td>
<td>300</td>
<td>300</td>
<td>200</td>
<td>150</td>
<td>ASTM E831</td>
</tr>
<tr>
<td>Operating Temperature Range, °C (°F)</td>
<td>50 to 150 (-58 to 302)</td>
<td>50 to 150 (-58 to 302)</td>
<td>50 to 150 (-58 to 302)</td>
<td>50 to 150 (-58 to 302)</td>
<td>70 to 200 (-94 to 392)</td>
<td>70 to 200 (-94 to 392)</td>
<td>--</td>
</tr>
<tr>
<td>Dielectric Strength, kV/μm (Vac / mil)</td>
<td>10 (250)</td>
<td>10 (250)</td>
<td>20 (500)</td>
<td>20 (500)</td>
<td>20 (500)</td>
<td>20 (500)</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Volume Resistivity, ohm-cm</td>
<td>1.0 x 10^14</td>
<td>1.0 x 10^14</td>
<td>1.0 x 10^13</td>
<td>1.0 x 10^13</td>
<td>1.0 x 10^13</td>
<td>1.0 x 10^13</td>
<td>ASTM D257</td>
</tr>
<tr>
<td>Dielectric Constant @1,000 kHz</td>
<td>8</td>
<td>6.5</td>
<td>4.0</td>
<td>4.0</td>
<td>3.9</td>
<td>3.9</td>
<td>ASTM D150</td>
</tr>
<tr>
<td>Dissipation Factor @ 1,000 kHz</td>
<td>0.010</td>
<td>0.013</td>
<td>0.001</td>
<td>0.001</td>
<td>0.010</td>
<td>0.010</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Flammability Rating (See UL File E140244)</td>
<td>Not Tested</td>
<td>HB</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>UL 94</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Chomerics Certification</td>
</tr>
<tr>
<td>Outgassing, % TML (%CVCM)</td>
<td>Not Tested</td>
<td>0.17 (0.10)</td>
<td>0.39 (0.29)</td>
<td>0.32 (0.21)</td>
<td>0.40 (0.18)</td>
<td>Not Tested</td>
<td>ASTM E595</td>
</tr>
<tr>
<td>Shelf Life, months from date of manufacture</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>12</td>
<td>6</td>
<td>Chomerics</td>
</tr>
</tbody>
</table>
Mixpac® Dispensing Systems are available from multiple sources. When contacting Mixpac® equipment suppliers, reference cartridge volume (cc) and dual element cartridge A:B mix ratio. Refer to table for volume and mix ratio information.

**FEATURES / BENEFITS**
- Dispensable form-in-place gap filling, potting, sealing, and encapsulating
- Excellent blend of high thermal conductivity, flexibility, and ease of use
- Conformable to irregular shapes without excessive force on components
- Ready-to-use cartridge system eliminates weighing, mixing, and degassing steps
- Variety of kit sizes and configurations available to suit any application (handheld twin-barrel cartridges, Semco® tubes, and pneumatic applicators)
- Vibration dampening

**PRODUCT ATTRIBUTES**

**1641**
- One-component moisture-cure RTV
- Non-acetic acid generating

**1642**
- General duty, economical thermal solution
- Two-component thermally conductive encapsulant/sealant/caulk/potting compound

**T642**
- High thermal performance with flexibility
- Ideal for underfilling
- Low outgassing

**T644**
- Very low modulus material for transferring heat from fragile electronic components

**T646**
- Provides combination of high thermal performance and low cost

**T647**
- Superior thermal performance while maintaining low modulus
- Flows into complex geometries to maintain intimate contact with components

**APPLICATION INSTRUCTIONS**
35cc and 45cc Kits [See Figure 1] Push safety latch [A] upward. Insert the pushrod [B] into the applicator with the pushrod gear teeth facing downward. Insert the cartridge [C] into the slots on top of the applicator. Push the retainer clamp [D] down firmly to lock the cartridge in place. Remove the cartridge cap [E] with a 1/4 turn counter-clockwise. Attach the static mixer [F] to the cartridge. [For the 10:1 cartridge, make certain that the small notch on the mixer tube face is toward the large barrel containing Part A.] Turn the mixer tube 1/4 turn clockwise to lock it in place. Cut the tip of the mixing nozzle to obtain the desired bead size, or attach a needle with the Luer adapter. After use, discard the static mixer and replace the cap on any remaining material.

![Figure 1: Typical Applicator](image)

**Ordering Information**

<table>
<thead>
<tr>
<th>Product</th>
<th>Part Number</th>
<th>Volume (mass)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1641</td>
<td>65-00-1641-0000</td>
<td>2.5 fluid ounces (70 grams)</td>
<td>1-Component squeeze tube</td>
</tr>
<tr>
<td></td>
<td>65-01-1641-0000</td>
<td>12 fluid ounces (340 grams)</td>
<td>1-Component SEMCO® cartridge</td>
</tr>
<tr>
<td>1642</td>
<td>65-00-1642-0000</td>
<td>277 grams (approx 120 cc)</td>
<td>1-Pint Plastic jar / vial B</td>
</tr>
<tr>
<td></td>
<td>65-00-T642-0035</td>
<td>35 cc (53 grams)</td>
<td>10:1 Dual element Cartridge</td>
</tr>
<tr>
<td></td>
<td>65-00-T642-0250</td>
<td>250 cc (372 grams)</td>
<td></td>
</tr>
<tr>
<td>T644</td>
<td>65-00-T644-0045</td>
<td>45 cc (68 grams)</td>
<td>1:1 Dual element Cartridge</td>
</tr>
<tr>
<td></td>
<td>65-00-T644-0200</td>
<td>200 cc (300 grams)</td>
<td></td>
</tr>
<tr>
<td>T646</td>
<td>65-00-T646-0065</td>
<td>45 cc (115 grams)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65-00-T646-0200</td>
<td>200 cc (507 grams)</td>
<td></td>
</tr>
<tr>
<td>T647</td>
<td>65-00-T647-0045</td>
<td>45 cc (125 grams)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65-00-T647-0200</td>
<td>200 cc (560 grams)</td>
<td></td>
</tr>
</tbody>
</table>

MIXPAC is a trademark of ConProTec, Inc.
SEMCO is a trademark of Semco, Inc.
**DESCRIPTION**
Chomerics thermal greases offer a range of performance covering the simplest to the most demanding thermal requirements. These materials are screened, stenciled or dispensed and require virtually no compressive force to conform under typical assembly pressures. The excellent surface wetting results in low interfacial resistance.

- **T670** is offered with a very high bulk thermal conductivity of 3 W/m-K. Product offers low impedance as it will achieve a thin bondline of about 0.001 in.
- **T660** contains solder fillers for extremely low thermal impedance at thinner bondline thicknesses (down to about 0.001 in.).
- **T650** is a general duty grease for typical applications.

**FEATURES/BENEFITS**
- Silicone based materials conduct heat between a hot component and a heat sink or enclosure
- Fills interface variable tolerances in electronics assemblies and heat sink applications
- Dispensable, highly conformable materials require no cure cycle, mixing or refrigeration
- Thermally stable and require virtually no compressive force to deform under typical assembly pressures
- Supports high power applications requiring material with minimum bond line thickness and high conductivity
- Ideal for rework and field repair situations

**Thermal Greases**

<table>
<thead>
<tr>
<th>Physical</th>
<th>T650</th>
<th>T660</th>
<th>T670</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Blue</td>
<td>Light Gray</td>
<td>White</td>
<td>Visual</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.3</td>
<td>2.4</td>
<td>2.6</td>
<td>ASTM D792</td>
</tr>
<tr>
<td>Viscosity, cps</td>
<td>190,000</td>
<td>170,000</td>
<td>350,000</td>
<td>NA</td>
</tr>
<tr>
<td>Operating Temperature Range, °C [°F]</td>
<td>-50 to +200 (-58 to 392°F)</td>
<td>-50 to +200 (-58 to 392°F)</td>
<td>-50 to +200 (-58 to 392°F)</td>
<td>NA</td>
</tr>
<tr>
<td>Melting Point, °C [°F]</td>
<td>N/A</td>
<td>62 (144)</td>
<td>N/A</td>
<td>ASTM D3418</td>
</tr>
<tr>
<td>Weight Loss % @ 150°C, 48 Hours</td>
<td>0.21</td>
<td>0.17</td>
<td>&lt; 0.2</td>
<td>TGA</td>
</tr>
<tr>
<td>Thermal Impedance, °C-cm²/W (°C-in²/W) @ 100 psi</td>
<td>0.13 (0.02) @ 50°C 0.13 (0.02) @ 65°C</td>
<td>0.13 (0.02) @ 50°C 0.06 (0.009) @ 65°C</td>
<td>0.07 (0.01) @ 50°C 0.07 (0.01) @ 65°C</td>
<td>ASTM D5470</td>
</tr>
<tr>
<td>Apparent Thermal Conductivity, W/m-K</td>
<td>0.8</td>
<td>0.9</td>
<td>3.0</td>
<td>ASTM D5470</td>
</tr>
<tr>
<td>Heat Capacity, J/g-K</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>ASTM E1269</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, ppm/K</td>
<td>300</td>
<td>300</td>
<td>150</td>
<td>ASTM E831</td>
</tr>
<tr>
<td>Volume Resistivity, ohm-cm</td>
<td>$10^{14}$</td>
<td>N/A</td>
<td>$10^{14}$</td>
<td>ASTM D257</td>
</tr>
<tr>
<td>Voltage Breakdown Vac/mil</td>
<td>150*</td>
<td>N/A*</td>
<td>150*</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Flammability Rating</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>UL 94</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Chomerics Certification</td>
</tr>
<tr>
<td>Outgassing, % TML</td>
<td>0.21</td>
<td>0.17</td>
<td>&lt;0.2</td>
<td>E595</td>
</tr>
<tr>
<td>Shelf Life, months from date of manufacture</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>Chomerics</td>
</tr>
</tbody>
</table>

*Not recommended for dielectric applications.
 Thermal Greases

**TYPICAL APPLICATIONS**
- Mobile, desktop, server CPUs
- Engine and transmission control modules
- Memory modules
- Power conversion equipment
- Power supplies and UPS
- Power semiconductors

**PRODUCT ATTRIBUTES**

**T670 Highest Thermal Performance**
- High bulk thermal conductivity
- Extremely low thermal impedance at thin and thick bondline thicknesses
- Stencil screen printed part application

**T660 High Performance**
- Dispersed solder spheres for high performance applications above 62°C
- Excellent thin bondline performance (less than 0.02 - 0.03 in)

**T650 General Duty**
- Used on general purpose applications

**MATERIAL APPLICATION**

**T650:**
Material is supplied in 3, 15 or 30cc syringes for easy dispensing onto components or heat sinks. Bulk packaging is also available. Excess material can be wiped with a clean cloth and suitable solvent.

**T660:**
Packaging the same as T650. For optimum performance, the processor should be allowed to reach temperatures greater than 65°C (149°F). This causes the solder fillers to melt and conform to the mating surfaces, obtaining a minimum bondline thickness at the interface. This process only needs to occur one time to achieve optimum thermal performance of the grease.

**T670:**
T670 high performance thermal grease is supplied in easy access metal cans or pails. Mix with a spatula and remove the desired amount onto the component or stencil screen. Stencil desired pad part size onto heat sink for immediate assembly or shipping.

---

**Ordering Information**

Part Number Examples
65-00-T650-0003 = T650 Material in a 3 CC Syringe
65-00-T670-3790 = T670 Material in a 3790 CC [Gallon Pail]

**Part Number:**

```
<table>
<thead>
<tr>
<th>65</th>
<th>00</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>YYYY</th>
<th>ZZZZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>YYYY = Material (T670, T660, or T650)</td>
<td>ZZZZ = Volume in CC</td>
</tr>
<tr>
<td>0003 = 3 cc syringe</td>
<td>0003 = 3 cc syringe</td>
</tr>
<tr>
<td>0015 = 15 cc syringe</td>
<td>0015 = 15 cc syringe</td>
</tr>
<tr>
<td>0030 = 30 cc syringe</td>
<td>0030 = 30 cc syringe</td>
</tr>
<tr>
<td>0300 = 300 cc cartridge</td>
<td>0300 = 300 cc cartridge</td>
</tr>
<tr>
<td>3790 = 1 gallon pail</td>
<td>3790 = 1 gallon pail</td>
</tr>
</tbody>
</table>
```
**CHO-THERM® Commercial Grade Thermal Insulator Pads**

**DESCRIPTION**

CHO-THERM® Commercial Grade Thermal Insulator Pads are designed for use where solid thermal and electrical properties are required at an economical price. These products are offered as dry pads, or with an optional adhesive (PSA) layer for attachment. Materials with PSA are available die-cut on continuous rolls. Versions are offered with either polyimide or fiberglass reinforcement to protect pads against tear, cut-through and punctures.

**FEATURES / BENEFITS**

- Good thermal properties
- Good to excellent dielectric strength
- Excellent mechanical strength and puncture resistance
- Available with and without acrylic PSA
- UL recognized V-0 flammability rating
- Meet RoHS specifications
- Available on continuous rolls for easy peel and stick application

<table>
<thead>
<tr>
<th>Properties</th>
<th>T609</th>
<th>T444</th>
<th>1674</th>
<th>T441</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Lt. Green</td>
<td>Beige</td>
<td>Blue</td>
<td>Pink</td>
<td>Visual</td>
</tr>
<tr>
<td>Reinforcement Carrier</td>
<td>Fiberglass</td>
<td>Kapton® MT</td>
<td>Fiberglass</td>
<td>Fiberglass</td>
<td>Visual</td>
</tr>
<tr>
<td>Thickness, mm (inch)</td>
<td>0.25 (0.010)</td>
<td>0.08 (0.003)</td>
<td>0.25 (0.010)</td>
<td>0.20 (0.008)</td>
<td>--</td>
</tr>
<tr>
<td>Thickness Tolerance, mm (inch)</td>
<td>± 0.025 (0.001)</td>
<td>± 0.013 (0.0005)</td>
<td>± 0.025 (0.001)</td>
<td>± 0.025 (0.001)</td>
<td>± 0.025 (0.001)</td>
</tr>
<tr>
<td>Operating Temperature Range, ºC (ºF)</td>
<td>-40 to +200 (-40 to +392)</td>
<td>-40 to +200 (-40 to +392)</td>
<td>-40 to +200 (-40 to +392)</td>
<td>-40 to +200 (-40 to +392)</td>
<td>--</td>
</tr>
<tr>
<td>Thermal Impedance, °C-cm²/W (°C-in²/W)</td>
<td>2.1 (0.33)</td>
<td>2.4 (0.37)</td>
<td>2.6 (0.41)</td>
<td>2.6 (0.41)</td>
<td>3.6 (0.56)</td>
</tr>
<tr>
<td>Apparent Thermal Conductivity, W/m-K</td>
<td>1.5</td>
<td>0.4</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Heat Capacity, J/g-°C</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion, ppm/°C</td>
<td>150</td>
<td>400</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Voltage Breakdown Dry, Vac</td>
<td>4,000</td>
<td>5,000</td>
<td>2,500</td>
<td>8,700</td>
<td>11,400</td>
</tr>
<tr>
<td>Voltage Breakdown Wet, Vac</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>8,100</td>
<td>10,500</td>
</tr>
<tr>
<td>Volume Resistivity Dry, ohm-cm</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
<td>10¹⁴</td>
</tr>
<tr>
<td>Volume Resistivity Wet, ohm-cm</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>10¹⁴</td>
</tr>
<tr>
<td>Tensile Strength, Mpa (psi)</td>
<td>26.2 (3,900)</td>
<td>20.7 (3,000)</td>
<td>10.3 (1,500)</td>
<td>19.3 (2,800)</td>
<td>17.3 (2,500)</td>
</tr>
<tr>
<td>Tear Strength, kN/m (lb/in)</td>
<td>52.5 (300)</td>
<td>26.3 (150)</td>
<td>17.5 (100)</td>
<td>23.6 (135)</td>
<td>19.3 (110)</td>
</tr>
<tr>
<td>Elongation, %</td>
<td>30</td>
<td>NA</td>
<td>2</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Hardness, Shore A</td>
<td>70</td>
<td>90</td>
<td>85</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.10</td>
<td>1.70</td>
<td>2.45</td>
<td>2.45</td>
<td>2.45</td>
</tr>
<tr>
<td>Flammability Rating [See UL File E140244]</td>
<td>V-0</td>
<td>V-0</td>
<td>V-0</td>
<td>V-0</td>
<td>V-0</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Outgassing, % TML (%CVCM)</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
<td>Not Tested</td>
</tr>
<tr>
<td>Shelf-Life, months from shipment, Dry Pad with PSA</td>
<td>24 (6)</td>
<td>12 (12)</td>
<td>24 (12)</td>
<td>24 (12)</td>
<td>24 (12)</td>
</tr>
</tbody>
</table>

*KAPTON is a trademark of E.I. Du Pont de Nemours and Company.*
CHO-THERM® Commercial Grade Thermal Insulator Pads

**TYPICAL APPLICATIONS**
- Power conversion equipment
- Power supplies and UPS
- Power semiconductors
- Automotive electronics
- Motor and engine controllers
- Televisions and consumer electronics

**PRODUCT ATTRIBUTES**

**T609**
- Good thermal and dielectric properties
- Economically priced
- Best value for moderate to high performance pad
- PSA version available in economical kiss-cut format on continuous rolls

**T444**
- Non-silicone with excellent dielectric and mechanical strength (polyimide interlayer)
- Strong acrylic adhesive (one side)
- Available in economical kiss-cut format on continuous rolls

**T441**
- Superior dielectric strength (wet and dry)
- Economically priced
- Excellent for outdoor, high-humidity power supplies
- PSA version available in economical kiss-cut format on continuous rolls

**1674**
- Original commercial grade pad with good thermal and electrical performance
- Available in economical kiss-cut format on continuous rolls (with and without PSA)
- Passes NASA outgassing

An article is a manufactured item "formed to a specific shape or design during manufacturing," which has "end use functions" dependent upon its size and shape during end use and which has generally "no change of chemical composition during its end use."

In addition:
- There is no known or anticipated exposure to hazardous materials/substances during routine and anticipated use of the product.
- The product’s shape, surface, and design is more relevant than its chemical composition.

These materials are not deemed by Chomerics to require an MSDS. For further questions, please contact Chomerics at 781-935-4850.

**HANDLING INFORMATION**
These products are defined by Chomerics as “articles” according to the following generally recognized regulatory definition for articles:

**Ordering Information**

Thermal insulator pads are available in the following formats.
Contact Chomerics for custom widths, part sizes, etc.

Die-cut parts on continuous rolls
Slit rolls from ½" wide to 24" wide
Custom die-cut parts on sheets, or as individual parts

| Part Number: 6 | --- | --- | --- |
|----------------|------------------|------------------|

<table>
<thead>
<tr>
<th>6W</th>
<th>XX</th>
<th>YYYY</th>
<th>ZZZZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = Standard die-cut Part</td>
<td>11 = without PSA</td>
<td>YYYY = Custom 4-digit part number. Contact Chomerics.</td>
<td></td>
</tr>
<tr>
<td>12 = with PSA one side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 = Roll Stock</td>
<td>10 = 100 ft Roll Stock</td>
<td>0075= 0.75 in</td>
<td></td>
</tr>
<tr>
<td>6 = Roll Stock with PSA</td>
<td>40 = 400 ft Roll Stock</td>
<td>0100= 1.00 in</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0150= 1.50 in</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0200= 2.00 in</td>
<td></td>
</tr>
<tr>
<td>1150 = 11.5 in.</td>
<td>2400 = 24 in.</td>
<td>ZZZZ = Material class</td>
<td></td>
</tr>
<tr>
<td>0800 = 8 in.</td>
<td>1600 = 16 in.</td>
<td>(1674, T441, T444, T609)</td>
<td></td>
</tr>
<tr>
<td>1100 = 11 in.</td>
<td>2200 = 22 in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2200 = 22 in.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Parker Chomerics
**CHO-THERM® HIGH-POWER THERMAL INSULATOR PADS** are thermally conductive materials designed for use where the highest possible thermal, dielectric, and mechanical properties are required.

Fiberglass cloth reinforcement strengthens CHO-THERM® pads against tear, cut-through and punctures.

These materials are available in sheet form and die-cut configurations. An optional adhesive layer (with PSA) is available on one or two sides. With a proven track record spanning several decades in multiple applications, these products are the first choice for high-end power supplies, industrial, aerospace, and military/avionics applications.

Available in several different forms to suit various applications.

**FEATURES / BENEFITS**
- Excellent thermal properties
- High dielectric strength
- Excellent mechanical strength and puncture resistance

<table>
<thead>
<tr>
<th>CHO-THERM® High Power Insulator Pads</th>
<th>T500</th>
<th>1678</th>
<th>1671</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Color</td>
<td>Green</td>
<td>Pink</td>
<td>White</td>
<td>Visual</td>
</tr>
<tr>
<td>Reinforcement Carrier</td>
<td>Fiberglass</td>
<td>Fiberglass</td>
<td>Fiberglass</td>
<td>--</td>
</tr>
<tr>
<td>Thickness, mm (inch)</td>
<td>0.25 (0.010)</td>
<td>0.25 (0.010)</td>
<td>0.38 (0.015)*</td>
<td>ASTM D374</td>
</tr>
<tr>
<td>Thickness Tolerance, mm (inch)</td>
<td>±0.002</td>
<td>±0.002</td>
<td>±0.002</td>
<td>--</td>
</tr>
<tr>
<td>Operating Temperature Range, °C (°F)</td>
<td>-40 to +200 (-40 to +392)</td>
<td>-40 to +200 (-40 to +392)</td>
<td>-40 to +200 (-40 to +392)</td>
<td>--</td>
</tr>
<tr>
<td>Thermal Impedance, °C-cm²/W (°C-in² / W)</td>
<td>1.2 (0.19)</td>
<td>1.26 (0.20)</td>
<td>1.48 (0.23)</td>
<td>ASTM D5470</td>
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<tr>
<td>Apparent Thermal Conductivity, W/m-K</td>
<td>2.1</td>
<td>2.0</td>
<td>2.6</td>
<td>ASTM D5470</td>
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<tr>
<td>Heat Capacity, J/g-°C</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>ASTM E1269</td>
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<tr>
<td>Coefficient of Thermal Expansion [ppm/K]</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>ASTM E831</td>
</tr>
<tr>
<td>Voltage Breakdown Dry, (Vac)</td>
<td>4,000</td>
<td>2,500</td>
<td>4,000</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Volume Resistivity Dry, (ohm-cm)</td>
<td>10¹⁰</td>
<td>10¹⁰</td>
<td>10¹⁰</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Dielectric Constant at 1,000 kHz</td>
<td>3.5</td>
<td>3.6</td>
<td>3.6</td>
<td>ASTM D150</td>
</tr>
<tr>
<td>Dissipation Factor at 1,000 kHz</td>
<td>0.003</td>
<td>0.007</td>
<td>0.007</td>
<td>Chomerics Test</td>
</tr>
<tr>
<td>Tensile Strength, Mpa [psi]</td>
<td>20.7 (3,000)</td>
<td>20.7 (3,000)</td>
<td>20.7 (3,000)</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Tear Strength, kN/m (lb/in)</td>
<td>70 (400)</td>
<td>35 (200)</td>
<td>70 (400)</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Elongation, %</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>Chomerics</td>
</tr>
<tr>
<td>Hardness, Shore A</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>ASTM D2240</td>
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<tr>
<td>Specific Gravity</td>
<td>1.60</td>
<td>1.55</td>
<td>1.55</td>
<td>ASTM D792</td>
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<tr>
<td>Flammability Rating (See UL File E140244)</td>
<td>V-0</td>
<td>V-0</td>
<td>HB</td>
<td>UL 94</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Chomerics Certification</td>
</tr>
<tr>
<td>Outgassing, % TML (%CVCM)</td>
<td>0.40 (0.10)</td>
<td>0.55 (0.12)</td>
<td>0.76 (0.07)</td>
<td>ASTM E595</td>
</tr>
<tr>
<td>Shelf-Life, months from shipment, Dry Pad (with PSA)</td>
<td>24 (18)</td>
<td>24 (18)</td>
<td>24 (18)</td>
<td>Chomerics</td>
</tr>
</tbody>
</table>

* 1671 material is available in custom thicknesses.
CHO-THERM® High Power Thermal Insulator Pads

Features/Benefits...cont.
- 100% inspected for dielectric properties on every sheet
- PSA attachment option available
- UL recognized flammability ratings
- Meets RoHS specifications
- Extremely low NASA outgassing
- Proven through decades of use in demanding military and aerospace applications

TYPICAL APPLICATIONS
- Power conversion equipment
- Power supplies and UPS
- Power semiconductors
- Automotive electronics
- Motor and engine controllers
- Televisions and consumer electronics

PRODUCT ATTRIBUTES

T500
- Best thermal performance
- Excellent dielectric properties

1671
- Highest reliability in rigorous applications
- Proven in aerospace/defense applications

1678
- Economically-priced
- Low thermal impedance

HANDLING INFORMATION
These products are defined by Chomerics as “articles” according to the following generally recognized regulatory definition for articles:
An article is a manufactured item “formed to a specific shape or design during manufacturing,” which has “end use functions” dependent upon its size and shape during end use and which has generally “no change of chemical composition during its end use.”

In addition:
- There is no known or anticipated exposure to hazardous materials/substances during routine and anticipated use of the product.
- The product’s shape, surface, and design is more relevant than its chemical composition.

These materials are not deemed by Chomerics to require an MSDS. For further questions, please contact Chomerics at 781-935-4850.

Ordering Information

Thermal insulator pads are available in the following formats.
Contact Chomerics for custom widths, part sizes, etc.

Sheets 8” X 10” or 17” X 21”
Custom die-cut parts on sheets, or as individual parts

Part Number: 6

<table>
<thead>
<tr>
<th>W</th>
<th>XX</th>
<th>YYYY</th>
<th>ZZZZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>11</td>
<td>without PSA</td>
<td>YYYY = Custom 4-part alpha/numeric part number. Contact Chomerics.</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>PSA 2 Sides</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>XX</td>
<td>material thickness in mils [1671 material available up to 60 mils]</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0808</td>
<td>8” X 8” Sheet</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0810</td>
<td>8” X 10” Sheet</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>without PSA</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>PSA 1 Side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>YYYY = Custom Part Number. Contact Chomerics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PSA 1 Side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>PSA 2 Sides</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chomerics
How to Order Die-Cut CHO-THERM® Insulators

Standard die-cut parts are ordered using the following part number system. For custom parts, contact Chomerics.

**Part Number:**

- **60** = standard die cut part
- **11** = No PSA
- **12** = PSA one side

**Standard Configuration Drawing Number**

**CHO-THERM® Material Example:** 1671, T500, etc.

<table>
<thead>
<tr>
<th>Recommended Screw Torque</th>
<th>Configuration</th>
<th>Dimensions (inches)</th>
<th>Ordering Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D065-ZZZZ</td>
</tr>
<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-4305-ZZZZ</td>
</tr>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-4511-ZZZZ</td>
</tr>
<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D370-ZZZZ</td>
</tr>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D371-ZZZZ</td>
</tr>
<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-6875-ZZZZ</td>
</tr>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D372-ZZZZ</td>
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<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D373-ZZZZ</td>
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<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D374-ZZZZ</td>
</tr>
<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D375-ZZZZ</td>
</tr>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D376-ZZZZ</td>
</tr>
<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D377-ZZZZ</td>
</tr>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D378-ZZZZ</td>
</tr>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D379-ZZZZ</td>
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<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D380-ZZZZ</td>
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<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D381-ZZZZ</td>
</tr>
<tr>
<td><strong>#6-32 6 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D382-ZZZZ</td>
</tr>
<tr>
<td><strong>#4-40 5 in-lb</strong></td>
<td></td>
<td></td>
<td>WW-XX-D383-ZZZZ</td>
</tr>
</tbody>
</table>

**Note:**

- **WW-XX** indicates the specific model or configuration number.
- **ZZZZ** can be any combination of digits, excluding special characters or symbols.
<table>
<thead>
<tr>
<th>Recommended Screw Torque</th>
<th>Configuration</th>
<th>Dimensions (inches)</th>
<th>Ordering Number</th>
</tr>
</thead>
</table>
| **#4-40 3 in-lb**  
**#6-32 4 in-lb** | TO-65 | 
1.250 0.700 0.140 0.062 | WW-XX-4353-ZZZZ  
1.312 0.762 0.140 0.062 | WW-XX-5527-ZZZZ  
1.375 0.825 0.140 0.062 | WW-XX-4997-ZZZZ  
1.440 1.000 0.140 0.075 | WW-XX-D384-ZZZZ |
| **#4-40 3 in-lb**  
**#6-32 4 in-lb** | 3 LEAD TO-66 | 
1.275 0.750 0.156 0.100 0.960 | WW-XX-D385-ZZZZ |
| **#4-40 3 in-lb**  
**#6-32 4 in-lb** | 4 LEAD TO-66 | 
1.312 0.762 0.140 0.062 0.960 0.200 0.100 | WW-XX-D386-ZZZZ |
| **#4-40 3 in-lb**  
**#6-32 4 in-lb** | 9 LEAD TO-66 | 
1.440 1.000 0.140 0.055 0.960 0.480 0.325 | WW-XX-D387-ZZZZ |
| **#4-40 3 in-lb**  
**#6-32 4 in-lb** | MULTI LEAD TO-66 | 
1.35 0.800 0.140 0.400 | WW-XX-D388-ZZZZ |
| **#4-40 2 in-lb** | TO-220 | 
0.437 0.312 0.140 0.093 | WW-XX-D389-ZZZZ  
0.437 0.312 0.140 0.122 | WW-XX-D390-ZZZZ  
0.500 0.385 0.170 0.120 | WW-XX-D391-ZZZZ  
0.610 0.560 0.245 0.125 | WW-XX-D392-ZZZZ  
0.687 0.562 0.218 0.125 | WW-XX-5791-ZZZZ  
0.710 0.500 0.160 0.141 | WW-XX-8302-ZZZZ  
0.750 0.410 0.225 0.156 | WW-XX-D393-ZZZZ  
0.750 0.500 --- --- | WW-XX-8531-ZZZZ  
0.750 0.500 0.187 0.147 | WW-XX-6956-ZZZZ  
0.750 0.500 0.187 0.125 | WW-XX-D394-ZZZZ  
0.750 0.600 0.240 0.150 | WW-XX-D395-ZZZZ  
0.750 0.600 0.240 0.115 | WW-XX-D396-ZZZZ  
0.855 0.562 0.218 0.125 | WW-XX-D397-ZZZZ  
0.855 0.630 0.230 0.093 | WW-XX-D398-ZZZZ  
0.860 0.740 0.200 0.160 | WW-XX-D399-ZZZZ  
1.125 0.625 0.200 0.145 | WW-XX-D400-ZZZZ  
1.410 0.810 0.355 0.147 | WW-XX-D401-ZZZZ |
| **#4-40 2 in-lb** | | 
0.910 0.500 0.200 0.125 | WW-XX-402-ZZZZ  
0.983 0.750 0.432 0.156 | WW-XX-D403-ZZZZ |
<p>| | | | |
|  |  |  |  |</p>
<table>
<thead>
<tr>
<th>Recommended Screw Torque</th>
<th>Configuration</th>
<th>Dimensions (inches)</th>
<th>Ordering Number</th>
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<tbody>
<tr>
<td>#4-40 2 in-lb</td>
<td>TYPE II TO-220</td>
<td>DIA. 2 0.5 0.2</td>
<td>WW-XX-4969-ZZZZ</td>
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<tr>
<td>#10-32 2 in-lb</td>
<td>DIODE WASHERS</td>
<td>DO-4 0.360 0.260</td>
<td>WW-XX-D404-ZZZZ</td>
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<tr>
<td>#25-28 7 in-lb</td>
<td></td>
<td>DO-5 0.750 0.125</td>
<td>WW-XX-D408-ZZZZ</td>
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<td>WW-XX-D409-ZZZZ</td>
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<td>WW-XX-D410-ZZZZ</td>
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<td>WW-XX-D411-ZZZZ</td>
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<td>WW-XX-D428-ZZZZ</td>
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<td>WW-XX-D430-ZZZZ</td>
</tr>
</tbody>
</table>

(1 in-lb = 1.152 kg-cm)
Chomerics’ family of thin heat spreaders provides a low-cost, effective means of cooling IC devices in restricted spaces where conventional heat sinks are inappropriate.

T-Wing spreaders consist of 5oz. (0.007inch/0.18mm thick) flexible copper foil between electrically insulating films. High strength silicone PSA (pressure-sensitive adhesive) provides a strong bond to the component. The compliant nature of these “thermal wing” heat spreaders permits nearly 100% adhesive contact with non-flat package surfaces, optimizing thermal and mechanical performance.

C-Wing spreaders are a ceramic version available for EMI-sensitive applications. They consist of aluminum oxide substrates with the same silicone PSA used on T-Wing heat spreaders.

FEATURES/BENEFITS
- Component junction temperature reduction of 10-20°C is common
- Easily added to existing designs to lower component temperatures and improve reliability
- Custom shapes available for complex designs

TYPICAL APPLICATIONS
- Microprocessors
- Memory modules
- Laptop PCs and other high density, handheld portable electronics
- High speed disk drives

C-Wing
- Used where localized sensitivity to EMI (electromagnetic interference) exists
- Low profile
- Peel and stick application

T-Wings
- Low profile (0.33mm/0.013in) allows use in limited space environments
- Easy peel and stick adhesion to all surfaces, including packages with residual silicone mold release
- Offers low cost cooling for many package types

### T-WING® and C-WING™ Heat Spreaders

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>T-Wings</th>
<th>C-Wings</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>Black</td>
<td>Tan</td>
<td>Visual</td>
</tr>
<tr>
<td>Total Thicknesses, mm [inches]</td>
<td>0.33 (0.013)</td>
<td>1.53 (0.060)</td>
<td>ASTM D374</td>
</tr>
<tr>
<td>PSA Type</td>
<td>Silicone based</td>
<td>Silicone based</td>
<td>--</td>
</tr>
<tr>
<td>PSA thickness, mm [inches]</td>
<td>0.05 (0.002)</td>
<td>0.076 (0.003)</td>
<td>Visual</td>
</tr>
<tr>
<td>Insulator Type</td>
<td>Black polyester</td>
<td>N/A</td>
<td>--</td>
</tr>
<tr>
<td>Insulator Layer Thickness, mm [inches]</td>
<td>0.025 (0.001)</td>
<td>N/A</td>
<td>--</td>
</tr>
<tr>
<td>Weight, oz/inch²</td>
<td>0.039</td>
<td>0.076</td>
<td>--</td>
</tr>
<tr>
<td>Thermal Conductor</td>
<td>Copper</td>
<td>Aluminum Oxide</td>
<td>--</td>
</tr>
<tr>
<td>Thermal Conductor Thickness, mm [inches]</td>
<td>0.178 (0.007)</td>
<td>1.6 (0.063)</td>
<td>--</td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dielectric Strength, KVac/mm [Vac /mil]</td>
<td>200 (5,000)</td>
<td>12 (300)</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Volume Resistivity, [ohm-cm]</td>
<td>N/A</td>
<td>&gt;10¹⁴</td>
<td>ASTM D149</td>
</tr>
<tr>
<td>Dielectric Constant @1,000 MHz</td>
<td>N/A</td>
<td>9.1</td>
<td>ASTM D150</td>
</tr>
<tr>
<td>Dissipation Factor @ 1,000 kHz</td>
<td>N/A</td>
<td>0.001</td>
<td>Chomerics Test</td>
</tr>
<tr>
<td>Flammability Rating [See UL File E140244]</td>
<td>V-0</td>
<td>Not Tested</td>
<td>UL 94</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
<td>Yes</td>
<td>Chomerics Certification</td>
</tr>
<tr>
<td>Shelf Life, months from date of manufacture</td>
<td>12</td>
<td>12</td>
<td>Chomerics</td>
</tr>
</tbody>
</table>
T-Wing® and C-Wing™ Heat Spreaders

T-Wings Continued...
- Low application force (<5psi/0.03MPa) minimizes risk of damage to component
- Wide range of standard sizes
- Pliable nature allows conformance to concave or otherwise non-flat surfaces for optimal thermal and mechanical performance
- Light weight (0.039 oz/inch²)
- Standard parts are scored for easy forming and alignment
- Easy removal for device replacement
- Available die-cut on continuous rolls

Ordering Information

Available in standard sizes 1,000 parts per plastic tray. Also available die-cut on continuous rolls.

<table>
<thead>
<tr>
<th>Material</th>
<th>Part Numbers</th>
<th>Length mm (inches)</th>
<th>Width mm (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Wing</td>
<td>60-12-20264-TW10</td>
<td>12.7 (0.50)</td>
<td>50.8 (2.0)</td>
</tr>
<tr>
<td></td>
<td>60-12-20265-TW10</td>
<td>12.7 (0.50)</td>
<td>76.2 (3.0)</td>
</tr>
<tr>
<td></td>
<td>60-12-20266-TW10</td>
<td>19.1 (0.75)</td>
<td>76.2 (3.0)</td>
</tr>
<tr>
<td></td>
<td>60-12-20267-TW10</td>
<td>25.4 (1.00)</td>
<td>76.2 (3.0)</td>
</tr>
<tr>
<td></td>
<td>60-12-20268-TW10</td>
<td>25.4 (1.00)</td>
<td>101.6 (4.0)</td>
</tr>
<tr>
<td></td>
<td>60-12-20269-TW10</td>
<td>38.1 (1.50)</td>
<td>101.6 (4.0)</td>
</tr>
<tr>
<td>C-Wing</td>
<td>69-12-22745-CW10</td>
<td>20.0 (0.79)</td>
<td>14.0 (0.55)</td>
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<tr>
<td></td>
<td>69-12-23802-CW10</td>
<td>19.1 (0.75)</td>
<td>19.1 (0.75)</td>
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<tr>
<td></td>
<td>69-12-22849-CW10</td>
<td>31.8 (1.25)</td>
<td>31.8 (1.25)</td>
</tr>
</tbody>
</table>

HANDLING INFORMATION

These products are defined by Chomerics as “articles” according to the following generally recognized regulatory definition for articles:

An article is a manufactured item “formed to a specific shape or design during manufacturing,” which has “end use functions” dependent upon its size and shape during end use and which has generally “no change of chemical composition during its end use.”

In addition:
- There is no known or anticipated exposure to hazardous materials/substances during routine and anticipated use of the product.
- The product’s shape, surface, and design is more relevant than its chemical composition.

These materials are not deemed by Chomerics to require an MSDS. For further questions, please contact Chomerics at 781-935-4850.

Typical Thermal Properties

<table>
<thead>
<tr>
<th>Environment*</th>
<th>Sizes (inches)</th>
<th>Without T-Wing</th>
<th>0.5x2 (12.7x50.8)</th>
<th>0.5x3 (12.7x76.2)</th>
<th>0.75x3 (19.1x76.2)</th>
<th>1x3 (25.4x76.2)</th>
<th>1x4 (25.4x101.6)</th>
<th>1.5x4 (38.1x101.6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Wing</td>
<td>Restricted Convection**</td>
<td>Thermal Resistance Rj-a (°C/W)</td>
<td>26</td>
<td>25</td>
<td>23</td>
<td>23</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Case Temperature (°C)</td>
<td>92</td>
<td>82</td>
<td>78</td>
<td>76</td>
<td>72</td>
<td>70</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>100 LFM***</td>
<td>Thermal Resistance Rj-a (°C/W)</td>
<td>18</td>
<td>16</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Case Temperature (°C)</td>
<td>68</td>
<td>57</td>
<td>52</td>
<td>49</td>
<td>46</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>C-Wing</td>
<td>Restricted Convection**</td>
<td>Case Temperature (°C)</td>
<td>102</td>
<td>96</td>
<td>90</td>
<td>90</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>100 LFM</td>
<td>85</td>
<td>80</td>
<td>75</td>
<td>76</td>
<td>73</td>
<td>74</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Measured values do not account for heat losses through bottom of case and leads. Ambient temperature range from 21°C to 24°C
** Restricted convection in a simulated notebook computer environment—a 1x5x6 inch (2.54x12.7x15.2cm) plexiglass box
*** T-Wing long axis perpendicular to air flow direction in wind tunnel

Notes
- Rj-a = thermal resistance from junction to ambient
- LFM = airflow rate [linear feet per minute]
**Alumina (Al₂O₃):** A relatively inexpensive ceramic in powder or sintered sheet form. Its thermal conductivity of 30 W/m-K and excellent dielectric properties make it useful in low to moderate power commercial applications.

**Ambient Temperature:** The temperature of the air surrounding a heat source.

**Apparent Thermal Conductivity:** This value differs from thermal conductivity as apparent thermal conductivity also includes contact resistance when measured, as described in the Heat Transfer Fundamentals section of this guide. Also see Thermal Conductivity.

**Arcing:** An electrical discharge between the edges of metal semiconductor package and the metal heat sink on which it is mounted.

**Binder:** A polymer (i.e. silicone, urethanes, acrylic, epoxy etc.) used in thermal interface materials to provide desired mechanical, thermal and electrical properties and hold in a stable form the fillers whose primary purpose is the transfer of heat. Binders are also good electrical insulators.

**Bondline Thickness:** Average thickness between heat spreading device and components.

**Boron Nitride (BN):** A non-abrasive ceramic material that has higher thermal conductivity than alumina. Because it is an expensive raw material, it is usually used in high performance interface materials.

**Breakdown Voltage:** The amount of voltage required to cause a dielectric failure through an insulator when tested under a set of specific conditions. This value does not imply that the insulator can be operated at those voltages.

**Burr:** A thin ragged fin left on the edge of a piece of metal (semiconductor package or heat sink) by a cutting or punching tool.

**Calorie:** A unit of energy equal to the quantity of heat required to raise the temperature of 1 gram of water by one degree celsius.

**Ceramic:** A name given to oxides of metals. Ceramics are usually hard, heat and corrosion resistant and high dielectric strength powders that can be formed into shapes by fusion or sintering.

**Chamfer:** A bevel cut into the edge of heat sink mounting holes.

**Compression Set:** The permanent deformation of an elastomeric material caused by a compressive force.

**Conduction:** The transfer of heat energy through matter.

**Convection:** The transfer of heat that results from motion of a fluid (gas or liquid).

**Corona:** An electrical discharge within or on an insulator accompanied by ionization of the air within or contacting the surface of the insulator. Also called partial discharge. It is the main mode of insulation failure exposed to long term AC voltages.

**Creep Distance:** The distance that an insulator has to extend beyond the edge of a semiconductor package to prevent arcing.

**Cut-Through:** A phenomenon that occurs when sharp edges or burrs on the metal semiconductor package or heat sink cut through the thermal pads and reduce or eliminate their insulating strength.

**Deflection:** The change in thickness of an elastomeric interface material in response to a compressive load. Because these materials are incompressible, deflection is accompanied by a proportional increase in area.

**Degreaser or Degreasing Solvent:** The solvent used to clean flux and other organic residues off printed circuit boards after they are manufactured. Interface materials must be able to tolerate exposure to degreasing solvents without degrading performance.

**Dielectric:** A material that acts as an insulator.

**Dielectric Constant:** See Permittivity.

**Dielectric Strength:** The voltage gradient, expressed as kV/mm, that will cause a dielectric failure in an insulating material under very specific test conditions. Dielectric strength does not imply that the insulator can withstand those potential gradients for an extended period of time.

**Durometer:** An instrument for measuring the hardness of rubber. Measures the resistance to the penetration of an indenter point into the surface of the rubber.

**Electrical Insulator:** A material having high electrical resistivity and high dielectric strength and therefore suitable for separating components at different potentials to prevent electrical contact between them.

**Filler:** A fine, dispersible ceramic or metallic powder (i.e. boron nitride, alumina, graphite, silver flake, etc.) whose thermal conductivity is at least twenty times greater than that of the binder.

**Flow Rate:** The volume, mass, or weight of a fluid passing through any conductor per unit of time, expressed in gallons or liters-per-hour.
**Flux:** An organic compound used to enhance the wetting and adhesion of metal solder to the copper surfaces on printed circuit boards.

**Footprint:** The area of the base of an electronic device which comes in contact with a thermal interface material.

**Hard Tooling:** A die cutting tool manufactured from a machined metal block. The cost is high, therefore it is normally used when long runs are anticipated.

**Hardness:** A measure of the ability of a material to withstand penetration by a hard pointed object. Regarding thermal interface materials, this property is usually inversely proportional to the ability of a material to conform to uneven surfaces.

**Hardness Shore A (Shore D, Shore 00):** An instrument reading on a scale of 0 to 100 measuring the hardness of a material. There are three scales: Shore 00, A and D. Shore 00 is used for soft rubbers like gels, Shore A is used for hard rubbers and Shore D for inelastic plastics.

**Heat (Q):** A form of energy generated by the motion of atoms or molecules. Heat energy is expressed in units of joules.

**Heat Flow:** The rate at which heat is flowing per unit time expressed as Watts.

**Heat Flux (Q/A):** The rate of heat flow per unit surface area expressed as Watts / cm².

**Heat Transfer:** The movement of heat from one body to another (solid, liquid, gas, or a combination) by means of conduction, convection, or radiation.

**Interface:** A boundary that exists between any two contacting surfaces. There are five types of interfaces that can exist between the different forms of matter: gas-liquid, liquid-liquid, gas-solid, liquid-solid, and solid-solid.

**Junction:** The junction is the active part of a semiconductor, usually silicon, where the current flow causes heat to be generated.

**MBLT:** Minimum bond line thickness. When two opposing substrates obtain closest possible distance under pressure.

**Micro-inch:** This unit of measure, a millionth of an inch, is used to describe the roughness of a surface and is the average distance between the peaks and valleys on the surface.

**Mil:** A unit of length equal to one-thousandth of an inch.

**PCM:** Abreviation of phase change material.

**Permeability:** A measure of a material’s ability to align its magnetic domains in response to an applied magnetic field.

**Permittivity:** A measure of a dielectric material’s ability to polarize in response to an applied electric field, and transmit the electric field through the material.

**Polyimide:** An organic polymer with exceptional electrical insulation and high temperature capabilities. In film form, it is used on everything from printed circuit boards to space suits.

**Power Supply:** A self contained unit which converts AC current to DC for use in electronic devices.

**Pressure Sensitive Adhesive (PSA):** An adhesive that is tacky at normal temperatures and requires only slight pressure to form a permanent bond. A PSA requires no further cure to maintain the bond.

**PSH:** Class of polymer solder hybrid. A synergistic blend of eutectic solder and specialty polymers. They provide a highly reliable thermal interface material with a resin carrier and filler content that both melt to obtain minimum bond line thickness.

**Radiation:** A heat transfer process whereby heat is given off through electromagnetic radiation, usually infrared rays.

**Reinforcement:** A woven glass mesh or polymer film that is used as a support in thermal interface materials.

**Permanent Set:** Permanent Set is defined as the amount of residual displacement in a rubber part after the distorting load has been removed.

**Relaxation:** Stress Relaxation is a gradual increase in deformation of an elastomer under constant load over time, accompanied by a corresponding reduction in stress level.

**Rheology:** The science of the deformation and flow of materials.

**Semiconductor:** An electronic material that can be an insulator under one condition and switch to a conductor under a different condition.

**Silicon:** A non-metallic element occurring extensively in the earth’s crust in silica and silicates. Silicon is the basis for the junction found in most semiconductor devices.

**Solder:** A mixture of metals that is used to connect electronic devices to the copper patterns on a printed circuit board.

**Solvent Resistance:** The ability of thermal management products to resist swelling when exposed to organic solvents such as degreasing solvents, hydraulic fluids, coolants and jet fuel.

**Specific Gravity:** The ratio of the density of a substance to the density of water. The specific gravity of water is 1 at standard condition temperature and pressure.

**Steel Mill Die:** A die cutting tool of moderate cost, cast from steel. It is used for high speed cutting.
Steel Rule Die: A low cost die cutting tool manufactured by shaping sharpened steel foil to the desired shape and fixing in a plywood and steel rule metal. It is used for short runs.

Surface Finish: A measure of the roughness of a surfaces, usually expressed in units of micro-inches.

Swelling: A phenomenon that results when an elastomer is exposed to a degreasing solvent and the elastomer absorbs the solvent. The volume of the elastomer increases and its physical strength is greatly reduced. In this swollen state, the elastomer can be easily damaged and should not be subjected to any mechanical stress until the elastomer has been dried.

Tear Strength: A measure of the ability of a material to withstand tearing/ripping stresses. It is usually measured in pounds force per inch of thickness.

Temperature: A measure of the average kinetic energy of a material. The standard unit of temperature is a Kelvin, (K). Temperature determines the direction of heat flow between any two systems in thermal contact. Heat will always flow from the area of higher temperature (T source) to one of lower temperature (T sink).

Temperature Gradient (ΔT): The difference in temperatures in the direction of the heat flow between two points in a system.

Tensile Strength: A measure of the ability of a material to withstand a tension (pulling apart) force. It is usually measured in MPa or psi of material cross section.

Thermal Conductivity [K]: A quantitative measure of the ability of a material to conduct heat expressed in units of W/m-K.

Thermal Contact Resistance (R): The resistance to the flow of heat caused by interstitial air trapped in the irregularities of between contacting solid surfaces. Units are K·cm²/W.

Thermogravimetric Analysis: Chemical analysis by the measurement of weight changes of a system or compound as a function of increasing temperature.

Thermal Impedance (θ): Thermal impedance is the sum of the thermal resistance of an interface material and the thermal resistances at the interfaces in contact with the material. K·in²/Watt.

TIM: Thermal interface material.

Thermal Interface Materials (TIMs): Materials that are inserted between two contacting solid surfaces and aid heat flow by eliminating gaps between the irregular surfaces. Interstitial air is replaced by material that is significantly more conductive than air.

Thermal Resistivity: The quantitative measure of a material’s resistance to the conduction of heat. (It is the inverse of thermal conductivity.)

Thermocouple: A thermoelectric device consisting of two dissimilar metallic wires fused into a bead which generates a voltage proportional to the temperature of the bead.

Thixotropic: A characteristic of a liquid whereby the application of a shear causes a reduction in the viscosity of that liquid. The liquid is said to be shear thinning. Polymer solutions filled with dispersed particles exhibit thixotropic behavior. Example: toothpaste is thixotropic. It is solid when left alone, but when squeezed (sideways force) it flows much like a liquid.

Tolerance: The permissible variations in the dimensions of formed parts.

Torque: A turning or twisting that is equal to the value of the force (f) multiplied by the rotational distance over which it is applied (usually measured in ft-lbs.).

Viscoelastic material: A material whose response to a deforming load combines both viscous (does not recover its original shape/size when load removed) and elastic (will recover size/shape when load removed) qualities. The common name for such a material is “plastic.”

Volume Resistivity: A measure of a material’s inherent electrical resistance expressed as ohm-cm.

Watt: An SI unit of power equal to one joule per second.
1.0 GENERAL INSTRUCTIONS

1.0.1 Scope
This safety guide provides instructions for selecting and using (including designing, assembling, installing and maintaining) seals (including all elastomeric, polymeric, thermoplastic, metallic and/or plastic products commonly called ‘seals’); isolation devices (including elastomeric, polymeric, thermoplastic and/or thermoplastic in the form of boots, bearings, bellows, bushings, grommets, and/or vibration isolation mounts); EMI (electromagnetic interference) shielding (including all conductive elastomers, metal-based materials, conductive fabric-based materials, conductive paints, conductive adheres and caulks, metal/plastic laminates, and/or conductively coated or plated substrates commonly referred to as ‘EMI shielding’); and thermal management materials (including thermally conductive elastomer or acrylic-based interface materials, thermally conductive adhesive tapes, metal or ceramic-based heat spreaders, thermally conductive adheres and caulks, and/or solder/film-based thermally conductive assemblies) manufactured or sold by the world wide Parker Hannifin organization (including its Chomerics operations). It also includes related accessories (including mounting hardware, surface preparation solvents, protective liners, application systems, containers and packaging materials). All such devices are collectively referred to as “Products” in this safety guide. This safety guide is a supplement to and is to be used with the specific Parker publications for the specific seals, isolation devices, EMI shielding, thermal management materials, and related accessories that are being considered for use.

1.0.2 Fail-Safe
Products can and do fail without warning for many reasons. Design all systems and equipment in a fail-safe mode, so that failure of the Products will not endanger persons or property.

1.0.3 Distribution
Provide a copy of this safety guide to each person who is responsible for designing, specifying, selecting, purchasing of these Products. Do not select these Products without thoroughly reading and understanding this safety guide as well as the specific Parker publications for the products considered or selected.

1.0.4 User Responsibility
Due to the wide variety of operating conditions and uses for these Products, Parker and its distributors do not represent or warrant that any particular Product is suitable for any specific end use system. This safety guide does not analyze all technical parameters that must be considered in selecting a product. The users, through their own analyses and testing, are solely responsible for:

- Making the final selection of the seal, isolation device, EMI shielding product or thermal management material.
- Assuring that the users’ requirements are understood and met and that the use presents no health or safety hazards.
- Providing all appropriate health and safety warnings on and with the equipment on which the seals, isolation devices, EMI shielding or thermal manage-
ment materials are used.

1.0.5 Additional Questions
Contact the appropriate Parker applications engineering department or your Parker representative if you have any questions or require any additional information. See the Parker publication or web pages for the product being considered or used, for telephone numbers and/or e-mail addresses of the appropriate applications engineering department.

2.0 SEALING PERFORMANCE

2.0.1 Sealing Performance: Seals
In general, seals are used to maintain an unbroken sealing line separating adjoining volumes of media or fluid, under all normal operating conditions. Some seals may be designed to provide other functions (e.g., mechanical check valves). Maintaining the sealing line may be necessary when that line is formed on a surface that remains stationary relative to the seal (i.e., static sealing). Or, the sealing line may be formed against a surface that moves (i.e., dynamic sealing). Numerous criteria are involved in typical sealing designs, including choice of sealing material, gland design, and/or other seal retention and mating features, etc. Specific sealing requirements and the performance of any related sealing system must be clearly defined for every given application in order to select the best sealing solution. The user should provide these definitions, ideally in partnership with applications support from Parker at the earliest possible stages of the design process.

2.0.2 Sealing Performance: Isolation Devices
Many isolation devices are used to prevent ingress of environmental contaminants, including moisture, grease and dirt under normal operating conditions, while isolating noise, vibration and harshness. Other isolation products are used for absorbing shock, reducing equipment noise and insulating against vibration. Performance safety concerns should include the ability of the Parker isolation device to prevent contaminant ingress, and/or isolate noise, vibration, and shock depending on the application requirements. The user should provide Parker application engineers with the isolation performance criteria early in the design stages to optimize material choices and overall design/use of the isolation device. Certain isolation device solutions may be designed to incorporate separate and distinct sealing systems. For these applications, the specific sealing performance should also adhere to the goals described in Section 2.0.1.

2.0.3 Sealing Performance: EMI Shielding
EMI shielding materials are used to reduce the transmission of electromagnetic energy. While many EMI shielding materials may also provide some level of sealing, any specific sealing performance requirements should adhere to the goals described in Section 2.0.1 above. Certain EMI shielding solutions may be designed to incorporate separate and distinct sealing systems. For these applications, the specific sealing performance should also adhere to the goals described in Section 2.0.1. Other types of EMI shielding materials provide no sealing performance, inconsequential sealing performance, or widely varied sealing properties. Finally, EMI shielding materials, like other materials used in a given design, may affect the performance of proximate sealing systems. The above factors should be considered in the design stages and specification of EMI shielding (and seals), ideally in partnership with applications support from Parker at the earliest possible stages of the design process.

2.0.4 Sealing Performance: Thermal Management Materials
Thermal management materials are used to assist in the transmission of heat energy. Some thermal management products may also provide some level of sealing, but any specific sealing performance should adhere to the goals described in Section 2.0.1 above. Certain thermal management solutions may be designed to incorporate separate and distinct sealing systems. For these applications, specific sealing performance should also adhere to the goals described in Section 2.0.1. Other types of thermal management materials provide no sealing performance, inconsequential sealing performance, or widely varied sealing properties. Finally, thermal management materials, like other materials used in a given design, may affect the performance of proximate sealing systems. The above factors should be considered in the design stages and specification of thermal management materials (and seals), ideally in partnership with applications support from Parker at the earliest possible stages of the design process.

2.1 ELECTRICAL CONDUCTIVITY

2.1.1: Electrical Conductivity: Seals
Extreme care must be exercised when selecting seals for applications in which electrical conductivity or non-conductivity is a factor. Parker seals designed for sealing against liquids and gases may be developed with electrically conductive properties to meet specific application requirements. Conversely, non-conductive seals can be provided for applications prohibiting electrical conductivity.

The electrical conductivity or non-conductivity of Parker seals is dependent upon many factors and may be susceptible to change. These factors include, but are not limited to, the materials used to make the seal and/or related parts (including seal-bearing assemblies provided by Parker), and where the seals and/or related parts are installed, moisture content of the seal at any particular time, and other factors. Users should be aware of any safety-related issues with using electrically conductive, or insulating, seals in a given application. These concerns should be documented and discussed with Parker before or during the seal selection process.

2.1.2: Electrical Conductivity: Isolation Devices
Most isolation device materials are made from elastomeric, polymeric, thermoplastic or plastic materials that are typically non-conductive. However, some isolation devices are fabricated with conductive features, e.g., metal frames, threaded fasteners, metallic sealing materials, etc. Users should be aware of any safety-related issues with using electrically conductive, or insulating, isolation devices in a given application. These concerns should be documented and discussed with Parker before or during the isolation device selection process.
2.1.3: Electrical Conductivity: EMI Shielding

Parker EMI shielding materials are inherently electrically conductive, which is essential to providing shielding performance. Levels of conductivity vary by product type and factors of application. Thus, care should be used when selecting these materials. EMI shielding products can be designed with non-conductive elements, e.g., mounting features depending on the application requirements.

The electrical performance of Parker EMI shielding is dependent upon many factors and may be susceptible to change. These factors include but are not limited to the various materials used to make the EMI shielding and/or related parts (including shielding assemblies provided by Parker), how and where the EMI shielding and/or related parts are installed, moisture content of the shielding at any particular time, corrosion over time, and gap mechanics (stiffness, fastener spacing, etc.).

2.1.4: Electrical Conductivity: Thermal Management Materials

Extreme care must be used when selecting thermal management products in which electrical conductivity or non-conductivity is a factor. Certain Parker thermal management materials are designed to be electrically non-conductive, i.e., electrical insulators, while others are specifically designed to be electrically conductive. And other thermal management materials are inherently electrically non-conductive only below certain current levels.

The electrical conductivity of Parker thermal management products is dependent upon many factors and may be susceptible to change. These factors include the various materials used to make the thermal management materials and/or related parts (including thermal management assemblies provided by Parker), how and where the thermal management parts and/or related parts are installed, moisture content of the thermal products at any particular time, and other factors.

2.2 TEMPERATURE RANGE AND FLAMMABILITY

2.2.1 Temperature Range and Flammability: Seals

Temperatures can affect seal performance, including occurrences such as heat hardening and oxidation. The temperature range of a given seal application, and the expected performance of any sealing system within this range, must be clearly defined in order to select the best sealing solution. Temperature at the seal itself may vary widely from the ambient condition, sometimes by hundreds of degrees. The user should provide the temperature range, ideally in partnership with applications support from Parker at the earliest possible stages of the design process. Temperature range is generally defined as the maximum and minimum temperature limits within which a seal compound is expected to function properly in a given application.

Virtually all Parker sealing materials feature a recommended use temperature range, which should be regarded in the seal selection process. This information can normally be found on related Parker web pages, product literature or from Parker Seal Group applications engineering. In addition, temperature range should be considered for all integral seal elements (e.g., fasteners, adhesives, plastics, metals, etc.) and for application features such as gland dimensions, fluid temperatures, dynamic or static operation, etc. For example, temperature, or the range of temperature, for a given operation may require some modification of the gland dimensions.

Changing the fluids a seal is exposed to will change the temperature limits of the seal. This is because some chemical reactions take place at elevated temperatures, but not necessarily at lower temperatures. Seals can fail at low temperatures as well. These failures are typically caused by some mechanical instability in the system, which would cause the seal to lose its seal interface. The temperature limit in a particular sealing application cannot be properly determined without knowing what specific fluids or other media the seal will be exposed to. Flammability information is available for most Parker seal materials. Certain materials are available with various UL (Underwriters Laboratories) ratings for flammability/flame resistance. When Parker seal materials are integrated with other materials (e.g., plastic frames), the user, or Parker, may need to determine the flammability data for these other materials.

2.2.2 Temperature Range and Flammability: Isolation Devices

Most Parker isolation devices are produced from materials that perform over a broad temperature range, e.g., -65 to +600 degrees F. Some materials are better suited for wider temperature ranges, or for higher or lower temperature extremes. Temperature range data is available for most of these materials and should be considered in the overall selection process.

Users should also determine whether flammability issues are of concern to their application. When Parker isolation devices are integrated with other materials (e.g., plastic frames), the user, or Parker, may also need to determine the flammability data for these other materials.

Consult with Parker engineers on available flammability data, e.g., UL ratings, required for a choice of an isolation device.

2.2.3 Temperature Range and Flammability: EMI Shielding

Temperatures can affect EMI shielding performance to the extent they may affect electrical continuity within a shielding design. This could result from physical changes to electrically conductive shielding components (conductive panels, coatings, platings, flanges, compounds, gaskets, fasteners, adhesives, etc.) due to temperature extremes, changes, etc. In addition, while some shielding materials such as conductive compounds (paints, adhesives, caulks, inks) should be applied at specific temperature ranges (e.g., ambient), they will provide shielding performance over a broader temperature range. Other shielding materials such as compounds may require curing at elevated temperatures, which may in turn affect substrates or other exposed components. Temperature ranges for effective shielding performance are available for most Parker EMI shielding materials, including integral attachment systems (e.g., pressure sensitive adhesives). Consult Parker’s literature or web pages, and consult with Parker applications engineers to review shielding material selection relevant to temperature range.
Flammability information is available for many Parker shielding materials. Certain materials are available with various UL (Underwriters Laboratories) ratings for flammability/flame resistance. When Parker shielding products are integrated with other materials (e.g., plastic frames), the user, or Parker, may need to determine the flammability data for these other materials.

For more safety information on temperature and flammability, consult with Parker technical service department. Curing of products at elevated temperatures may generate off gas components. Any need to use local exhaust ventilation should be based off customer assessment.

2.2.4 Temperature Range and Flammability: Thermal Management Materials

Temperature range is defined as the maximum and minimum temperature limits within which a thermal management material or product will function properly in a given application. Normally, the key feature of these products is their ability to conduct thermal energy (heat), particularly within a target temperature range and in specific design configurations. However, temperature extremes can affect the performance of these thermal management materials or systems.

Many Parker thermal management materials feature a recommended application temperature range, which should be regarded in the seal selection process. This information can normally be found on related Parker web pages, product literature or from Parker technical services departments.

In addition, temperature range should be considered for all integral elements of a thermal management system (e.g., fasteners, adhesives, plastics, metals, etc.) and for various other application features, such as mounting surfaces, etc. The temperature range of a given thermal management system, and the expected performance of any thermal management system within this range, must be clearly defined in order to select the best solution. The user should provide the temperature range, ideally in partnership with applications support from Parker at the earliest possible stages of the design process. Flammability information is available for most Parker thermal management materials. Certain materials are available with various UL (Underwriters Laboratories) ratings for flammability/flame resistance. When Parker thermal management materials are integrated with other materials (e.g., plastic frames), the user, or Parker, may need to determine the flammability data for these other materials. For more information, consult with Parker technical service department.

2.3 COMPRESSION AND PRESSURE

Most Products require some level of compression to function properly. Different materials and configurations will have varying compression characteristics, including resilience, and diverse compressive force requirements. Product materials may undergo compression set or other compression-related changes depending on the specific application. Fluids and other media may physically affect a Product and cause changes to the Product’s compression characteristics in an application. Compression (and decompression) qualities of materials, compression force requirements, and related compression requirements should be considered for a given application in order to select the best Product solution. This also includes the number of pressure cycles to which the Product will be exposed, and the number of times a Product will be disassembled. Compression data is available on most Parker Product materials, and users should consult with Parker applications engineering early in their design and Product selection processes.

Pressure has a bearing on Product design and selection, as it may affect the choice of compound composition, geometry, hardness and other properties. Proper selection may require the choice of higher or lower durometer materials to accommodate more severe pressure situations. Compatibility with the medium should be a concern e.g., excessive swell in an application can generate extremely high pressures. If not considered in the design and selection stages, high pressures in an application can affect mating assemblies and lead to Product failure, e.g., by extrusion of the Product material. Pressure data should be provided as part of the selection process, as well as the choice of interface design and materials. This includes maximum and minimum pressures and cycling conditions.

2.4 FLUID AND OTHER MEDIA COMPATIBILITY

2.4.1 Compatibility: Seals

This is a critical aspect of proper seal selection, based on the number of fluids or other media with which seals are expected to interact. All media that may come in contact with the seal and retainer should be considered. For example, if the system is to be cleaned or purged periodically, be sure to anticipate what cleaning fluids will be used. Also, consider any lubricants, e.g., friction reducers, which may be affected by the sealed media. These secondary fluids are as important to selecting the most compatible seal material as the principal operating media selects.

Any increase in seal mass (volume) due to exposure to the sealed fluid, must be a design consideration. Excessive swell in an application can generate extremely high pressures and affect the seal function. Conversely, any decrease in seal volume, caused by a reaction to the sealed fluid can also degrade performance by reducing compression force or causing other severe dimensional changes resulting in possible loss of the sealing interface.

Seals exposed to atmosphere, including ozone and air pollutants, or to vacuum may experience some types of degradation. Corrosion issues should also be considered, particularly of metallic mating or seal mounting hardware (see 2.6.1). In all cases, fluid and gas compatibility should be a major consideration for every sealing application, and fully discussed with Parker Seal Group applications engineering.

2.4.2 Compatibility: Isolation Devices

Many isolation devices are designed to retain or seal a number of fluids across a variety of applications, while also protecting against contaminants (see 2.6.2). Others are designed exclusively to control noise, vibration, shock or motion. Users should assess the nature, volume, etc., of all fluids and gases that will be contact with the isolation devices in their applications. These assessments should be discussed with Parker applications en-
2.4.3 Compatibility: EMI Shielding
Fluid and gas compatibility concerns in EMI shielding applications include the potential effects on electrical conductivity, corrosion, and issues related to shielding materials that also provide environmental sealing. Consider ALL media that may come in contact with the shielding components. For example, if the system is to be cleaned or purged periodically, be sure to anticipate what cleaning fluids will be used. Exposure to fluids and gases may affect shielding performance (immediately and long term) and the application conditions should be discussed with Parker engineers. Occurrence of galvanic corrosion should be a major concern where metal or metal-filled shielding materials are used in the presence of fluids or humidity. This includes metallic parts used for attaching shielding gaskets or other shielding components. Consult with Parker applications engineers to optimize the shielding design and/or choice of shielding materials to address corrosion issues. Many EMI gasket forms will provide little or no barrier to fluids or gases, unless they include an integrated sealing system. The environmental seal, such as a non-conductive rubber, will feature its own fluid and gas compatibility issues. (Refer to 2.4.1 when considering non-conductive and/or conductive elastomers for use in an EMI shielding system.) In all cases, fluid and gas compatibility should be addressed in each EMI shielding application, and fully discussed with Parker technical service department.

2.4.4 Compatibility: Thermal Management Materials
Fluid and gas concerns in thermal management applications include the potential effects on thermal performance, and safety-related effects such as corrosion occurring to the Parker thermal product or associated hardware. Consider ALL media that may come in contact with the thermal components. For example, if the system is to be cleaned or purged periodically, be sure to anticipate what cleaning fluids will be used. Exposure to fluids and gases may affect thermal performance (immediately and long term) and the application conditions should be discussed with Parker engineers. Fluid or gas exposure may also affect integral portions of the supplied thermal management product, such as pressure sensitive adhesives. Occurrence of corrosion should be a concern where metal or metal-filled thermal materials are used in the presence of fluids or humidity. This also includes metallic parts used for attaching thermal management components. Consult with Parker applications engineers to optimize the thermal design and/or choice of materials to address corrosion issues. In all cases, fluid and gas compatibility should be addressed in each application, and fully discussed with Parker technical service department.

2.5 CORROSION AND ENVIRONMENT

2.5.1 Corrosion and Environment: Seals
Seal corrosion is not typically seen with elastomer-based sealing materials, but corrosion of integrated metal seal components, mounting devices and mating hardware can be a safety-related factor when choosing sealing solutions. Corrosion of these materials can compromise the integrity, proper function and normal results of the seal design. As such, potential corrosion opportunities should be determined and accounted for in the seal design process (e.g., using coated or plated metals). Similarly, environmental issues should be considered when developing sealing designs and specifying seal materials. Environmental conditions, e.g., weather, temperature, salt spray, dust, etc. can affect the sealing material, sealing hardware and/or the media being sealed, which in turn can affect the sealing properties. Consult with Parker Seal specialists on seal design in respect to corrosion and environmental issues.

2.5.2 Corrosion and Environment: Isolation Devices
Corrosion issues should factor into selecting elastomeric and thermoplastic-based isolation devices. Isolation devices with integral metal plates, flanges, screws, fasteners and other metallic features may experience corrosion under certain conditions. Further, corrosion can affect the integrity of other component parts in an isolation system. Corrosion control should be part of the design and selection process when choosing isolation devices. Some types of isolation devices, such as boots and bellows, are typically designed for preventing ingress of environmental dust and dirt, water, fuel and other fluids, grease and other potential contaminants. Users should carefully review potential environmental conditions and contaminants to which an isolation device or system may be exposed. Some isolation materials may also be affected by exposure to ultraviolet (UV) light, e.g., reflected solar energy. Selection of the materials, attachment systems and overall design should have the primary goal of keeping out contamination from the environment. Review corrosion and environmental issues with Parker applications engineers as part of the selection process.

2.5.3 Corrosion and Environment: EMI Shielding
Corrosion issues must be considered in the design and selection of EMI shielding. The metals used in providing a conductive pathway, enclosure, etc. and ultimately an effective EMI shield can be subject to corrosion that can affect shielding performance. The level of this corrosion is determined by the metals used and by their exposure to corrosion-supporting environments. For example, galvanic corrosion can occur when conductive shielding materials experience battery-like physical conditions. As such, potential corrosion opportunities should be determined and accounted for in the EMI shielding design process (e.g., choice of EMI gasket type, use of corrosion inhibiting coatings, weather seals, etc.). Similarly, environmental factors should be considered when developing EMI shielding designs and selecting shielding materials. Environmental situations, e.g., weather, temperature, radiation, salt spray, dust, etc. can affect the shielding material, integrated hardware and other components of a system's overall shielding design. Consult with Parker technical service department on shielding design in respect to corrosion and environmental issues.

2.5.4 Corrosion and Environment: Thermal Management Materials
Corrosion should be addressed when designing and choosing thermal management products. Those products containing metals as thermal conductors or as part of an integral thermal
management assembly can be subject to corrosion that may affect thermal performance. The level of this corrosion is determined by the metals used and by their exposure to corrosion-supporting environments. Potential corrosion opportunities should be determined and accounted for in the thermal management design process (e.g., choice of thermally conductive materials, integrated fasteners or other components, use of corrosion inhibiting coatings, weather seals, etc.). Similarly, environmental issues should be considered when designing and selecting thermal management systems. Environmental situations, e.g., weather, temperature, radiation, salt spray, dust, etc. can affect the thermal transfer material, integrated hardware (fasteners, clips, heat sinks, etc.), and other components of a system’s overall thermal management design. Consult with Parker specialists on thermal management design in respect to corrosion and environmental issues.

2.6 LEAKAGE

2.6.1 Leakage: Seals
Leakage control and acceptable leakage rates are fundamental to the design of any efficient sealing system. When properly used in sealing liquids there should be no detectable leakage of a liquid over a given period of time in the case of static sealing. Dynamic sealing provides a controlled leakage that is typically very low concentrations over extended periods of time.

Gases, on the other hand, will typically diffuse through the rubber at some very low rate that can be detected by a leak detector, a mass spectrometer or other very sensitive measuring device. The leakage rate depends primarily on the temperature, the pressure differential, the type of gas and the type of elastomer used. Out-gassing is a vacuum phenomenon wherein a substance spontaneously releases volatile constituents in the form of vapors or gases. In rubber compounds, these constituents may include water vapor, plasticizers, air, inhibitors, etc. To identify and address safety concerns, consult with Parker Seal applications engineers on leakage issues relevant to all seal designs and selections.

2.6.2 Leakage: Isolation Devices
When properly designed and installed, isolation devices for preventing ingress of contaminants should demonstrate either no leakage or an ingress level well within the user-provided specifications. This need for properly selecting isolation devices may also pertain to preventing or minimizing ‘leakage’, or egress, of noise, vibration, shock or other phenomena. Leakage problems can lead to system malfunctions, breakdowns, and safety hazards to equipment, operators and other personnel. User-specifications must address any and all safety concerns over leakage. These should be reviewed with Parker applications engineers early in the selection process.

2.6.3 Leakage (Including Electromagnetic Energy Leakage): EMI Shielding
Leakage in an EMI shielding design can refer to the flow of fluids and gases, as well as the passage of electromagnetic energy through the shield.

With respect to the flow of fluids and gases, some Parker EMI shielding products will provide a certain barrier level to fluid and gas leakage, e.g., sealed windows, conductive elastomer gaskets. However, only a limited number of these products are specifically designed for this feature, e.g., conductive sealants. Other Parker shielding products e.g., shielded vents, are actually designed to facilitate airflow. Conductive elastomers and other kinds of conductive shielding materials may also experience out-gassing. This is a vacuum phenomenon wherein a substance spontaneously releases volatile constituents in the form of vapors or gases. In rubber compounds, these constituents may include water vapor, plasticizers, air, inhibitors, etc. In addition, improperly installed shielding products, as well as gaps throughout a device’s shielding system, may lead to leakage. This includes any leakage of improperly cured shielding compounds, e.g., coatings, inks, epoxies, etc. To help you identify and address fluid and gas leakage concerns, consult with Parker Seal applications specialists on leakage issues relevant to all EMI shielding designs and selections.

With respect to the passage of electromagnetic energy through the EMI shielding material, EMI shielding materials reduce but do not eliminate this passage. Specifications and testing of EMI shielding materials are directed toward the amount of the reduction. The electromagnetic energy that is emitted from any electronic device is dependent upon many factors including the source of the electromagnetic energy, the amount of electromagnetic energy developed or transmitted by the source, the distance from the source, and any desired transmission of signals from the device such as through an antennae. The EMI shielding material is just one component of the entire device, and the designers of the device are solely responsible to determine the amount of electromagnetic energy transmitted by the device under all conditions and to assure that all performance, endurance, maintenance, safety and warning requirements for the device are met.

2.6.4 Leakage: Thermal Management Materials
Leakage potential of fluids or gases through thermal management materials should be addressed by consulting with Parker Seal design engineers before or during the material selection process. Some Parker thermal management products will provide a certain barrier level to fluid and gas leakage, but only a limited number of these products are specifically designed for this feature, e.g., thermal potting compounds. Elastomers and other types of thermally conductive materials may also experience out-gassing. This is a vacuum phenomenon wherein a substance spontaneously releases volatile constituents in the form of vapors or gases. In rubber compounds, these constituents may include water vapor, plasticizers, air, inhibitors, etc. In addition, improperly installed thermal management products, as well as gaps throughout a thermal management system, may lead to leakage and resulting safety problems. This includes any leakage of improperly cured thermally conductive compounds, e.g., adhesives, caulks, etc. To identify and address safety concerns, consult with Parker Seal applications specialists on leakage issues relevant to all thermal management designs and selections.

2.7 AGING
Product selection should consider both the shelf life and the installed life. Parker maintains cure date records for many Products. For some Products, Parker also follows established industrial, customer, United States or other global age control standards. Certain materials, e.g. conductive coatings,
inks, adhesives, etc. have a relatively limited shelf life and use life. Integral materials, e.g., pressure sensitive adhesives; on Products may have aging properties different from the main Product material. Users should consult available Parker data, and consult with Parker applications engineers to determine shelf life standards and installed seal life guidelines, and relevant procedures, when selecting seals for their applications.

2.8 SYSTEM WEIGHT
Product selection should include considerations related to Product weight, hardware/peripherals weight, and total system weight. Material weights are available from Parker web sites, literature, or from Parker applications engineers. When weight is critical to achieving a proper application, this should be addressed as early as possible with Parker applications engineers.

Parker can often provide technical prediction of Product performance via finite element analysis and other analytical tools. Successful results are best accomplished by working closely with Parker applications engineers beginning early in the design stages.

3.0 HANDLING
Safe handling of Products refers to the safety of the handlers and to the security of the seal parts. Any safety concern relative to the safety of Product assemblers; inspectors, maintenance personnel, etc. should be addressed with Parker before the Products enter the handling stages. Though not usually required, Parker can provide available Material Safety Data Sheets and other safe handling and storage documents for certain Products. Consult with Parker applications engineers on the need and availability of this form of documentation. The Products should always be handled in ways that will not cause physical (visible or not) changes to the materials that could affect performance in their intended application. It is recommended that Parker applications engineers consult on best practices for safe storage and handling of these Products.

Safe operation of automated handling, assembly, insertion, storage, etc. equipment used with the Products, should be optimized for safe use by operators, maintenance personnel, etc. Automated or manual equipment, used for handling seal products, should not affect the Products in any way that can alter their attributes and result in unsafe conditions. It is recommended that Parker applications engineers be consulted on best practices for safe handling of the Products.

3.1 PRE-INSTALLATION INSPECTION
Prior to installation, a careful examination of the Product must be performed. This includes checking for correct size, style, quantity, and part number. The Product should be examined for cleanliness, abrasion and any other visible defects. Faulty Products should be properly discarded or carefully stored away from other inventories. Quality assurance testing programs for the Products should be established in consultation with Parker quality engineers or other authorized personnel.

3.2 PREPARING THE INSTALLATION AREA
Cleanliness of the Product and its installation area are key to successful installation and performance. Every precaution must be taken to insure that all parts are clean at assembly. Cleanliness is important for proper Product functions. Foreign particles in the installation area, including dirt, metal debris etc. can damage the Product or impede function. Remove all sharp edges near mounting surfaces. When required, use lubricants on the isolation parts and/or contacting surfaces only after discussion with Parker applications engineers. Cleaning solvents can cause swelling or other damage of some Products. Thus, cleaning solvents should be cleaned off thoroughly. Some Products may require priming of installation surfaces. These processes should be done according to instructions from Parker. EMI gaskets may have specific installation requirements depending on their construction and composition. Consult with Parker applications engineers for specific gasket application needs and to review installation requirements for all Parker EMI shielding. Customer assumes responsibility/risk assessment when handling hazardous substances for cleaning or surface preparation.

3.3 ASSEMBLY

3.3.1 Assembly: SEALS AND ISOLATION DEVICES
Seal and isolation devices typically do not have assembly requirements beyond normal installation into a system or a system sub-assembly.

3.3.2 Assembly: EMI Shielding and Thermal Management Materials
While most Parker EMI shielding and thermal management materials are provided ready to install, some types require minor assembly, sizing, mixing or other preparatory operations prior to installation. Assembly may include customer-performed integration of attachment systems, i.e. adding hardware or adhesive. Sizing operations include customer-performed trimming or other fabrication. Mixing operations are often required of customers using Parker conductive coatings and adhesive products. In all cases, customers should use good safety procedures and equipment used in performing these functions. Consult with Parker Seals applications engineers with any questions or concerns regarding the safe assembly, sizing or mixing of EMI shielding and thermal management materials.

3.4 INSTALLATION
The Products have various installation methods, including manual insertion, use of hand tools and automated systems. Sharp-edged installation tools should be used with care, or avoided, to prevent Product damage. If clamping or crimping is used, avoid over clamping or over crimping. Consult with Parker applications engineers to determine the issues to be addressed using whatever installation method is selected.

3.5 CURE/SET TIME

3.5.1 Cure/Set Time: Seals and Isolation Devices
Parker seals and isolation devices are typically supplied in cured form. When using uncured seal material (or other curable products) follow the cure time instructions provided by Parker.

3.5.2 Cure/Set Time: EMI Shielding and Thermal Management Materials
Some Parker EMI shielding and thermal management materials require customer-managed cure periods. These include conductive coatings, inks, adhesives, and form-in-place
gasket compounds, caulks and primers. Some adhesives (conductive or non-conductive) used for bonding may have a recommended set time. Temperature, humidity and other conditions can affect curing. Improperly cured materials may provide abnormal performance, working life, abrasion resistance, attachment, and other properties. Some curable materials are volatile and/or pose health issues in uncured form. Refer to all relevant Material Safety Data Sheets (MSDS) and consult with Parker applications engineers on the appropriate curing methods, timing and evaluation for Products requiring curing or setting periods.

3.6 POST INSTALLATION INSPECTION AND TESTING

Installed Products should be inspected for proper fit and any damage incurred during installation. In some cases, pressure, conductivity (electrical or thermal), or impedance testing, or other procedures can help identify any performance problems. Identified problems should be documented and brought to the attention of all associates involved. Consult with Parker applications engineers in developing appropriate inspection and test standards and procedures.

3.7 REMOVAL

3.7.1 Removal: Seals

Seal removal may require use of manual or automated tools. Safety procedures and training may also be necessary to ensure the safe use of removal tools, compounds, etc. Care must be taken to preserve surface finishes and other application part features. Inspect and clean/repair application parts as needed prior to installing new seals. Inspect removed seals for wear, damage and other features that may indicate conditions requiring attention. Consult with Parker regarding appropriate removal tools and procedures.

3.7.2 Removal: Isolation Devices

Many isolation devices are intended to remain in place for the life of the system, e.g. vehicle. When necessary, these parts must be carefully removed to avoid damaging material or attachment hardware; changing the part dimensions, or contaminating protected areas. Inspect removed devices for wear, damage and other features that may indicate conditions requiring attention. Consult with Parker regarding appropriate tools and procedures.

3.7.3 Removal: EMI Shielding and Thermal Management Materials

Removing EMI shielding or thermal management materials may require use of manual or automated tools, as well as the use of solvents, abrasives or other compounds. Safety procedures and training may also be necessary to ensure the safe use of removal tools, compounds, etc. Care must be taken to preserve surface finishes and other part features, particularly those comprising the shielding or thermal management system. Inspect and clean/repair application parts as needed prior to installing new Products. If possible, inspect removed materials for wear, damage, performance and other features that may indicate conditions requiring attention. Consult with Parker regarding appropriate removal tools and procedures.

4.0 STORAGE

Storage conditions can affect Product integrity and performance, and pose safety issues. These include temperature extremes, contamination and time. Storage procedures should address these issues. Typically, the Products should be kept at room temperature, and away from temperature extremes or high humidity. Product lots and part numbers should be identified and tracked to ensure attention to shelf life and that the correct Products are always installed. Products installed on stored equipment should also be protected from potential temperature and environmental effects. Avoid sulfur containing packaging materials when storing conductive elastomers as it will promote corrosion. Their working life must also be tracked and distinguished from typical bulk/bag storage life. Discuss proper storage procedures with Parker engineers. Follow guidelines in Parker literature for special handling and storage instructions.

4.1 MAINTENANCE

Users of these Products should establish maintenance procedures, and these are typically determined through customer component testing. Maintenance should normally include Product inspection, correct part replacement, and for those specific Products approved by Parker, conditioning of the Product for reuse. Parker applications engineers can be consulted when creating maintenance procedures.

5.0 USER RESPONSIBILITY

This document and other information from the world wide Parker-Hannifin organization (including Chomerics) and its subsidiaries and authorized distributors provide product or system options for further investigation by users having technical expertise. To the extent that Parker or its subsidiaries or authorized distributors provide component or system options based upon data or specifications provided by the user, the user is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the components or systems. The user, through its own analysis and testing, is solely responsible for making the final selection of the system and components and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application, follow applicable industry standards, and follow the information concerning the product in the current product catalog and in any other materials provided from Parker or its subsidiaries or authorized distributors.
1. Terms and Conditions of Sale: All descriptions, quotations, proposals, offers, acknowledgments, acceptances and sales of Seller’s products are subject to and shall be governed exclusively by the terms and conditions stated herein. Seller’s prices for the products have been established on the understanding and condition that the terms set forth herein shall apply to this sale to the exclusion of any other terms. Seller expressly reserves the right to an equitable adjustment to the price in the event that any material provision hereof is deemed not to govern the rights and obligations of the parties hereto. Buyer’s acceptance of any offer to sell is limited to these terms and conditions. Any terms or conditions in addition to, or inconsistent with those stated herein, proposed by Buyer in any acceptance of an offer by Seller, are hereby objected to. No such additional, different or inconsistent terms and conditions shall become part of the contract between Buyer and Seller unless expressly accepted in writing by Seller. Seller’s acceptance of any offer to purchase by Buyer is expressly conditional upon Buyer’s assent to all the terms and conditions stated herein, including any terms in addition to, or inconsistent with those contained in Buyer’s offer. Acceptance of Seller’s products shall in all events constitute such assent.

2. Product Selection. If Seller has provided Buyer with any component and/or system recommendations, such recommendations are based on data and specifications supplied to Seller by Buyer. Final acceptance and approval of the individual components as well as the system must be made by the Buyer after testing their performance and endurance in the entire application under all conditions which might be encountered.

3. Payment: Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer’s receipt of the shipment.

4. Delivery: Unless otherwise provided on the face hereof, delivery shall be made F.O.B. Seller’s plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller’s delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

5. Warranty: Seller warrants that the items sold hereunder shall be free from defects in material or workmanship for a period of 365 days from the date of shipment to Buyer. THIS WARRANTY COMPRISSES THE SOLE AND ENTIRE WARRANTY PERTAINING TO ITEMS PROVIDED HEREUNDER. SELLER MAKES NO OTHER WARRANTY, GUARANTEE, OR REPRESENTATION OF ANY KIND WHATSOEVER. ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO, MERCHANTABILITY AND FITNESS FOR PURPOSE, WHETHER EXPRESS, IMPLIED, OR ARISING BY OPERATION OF LAW, TRADE USAGE, OR COURSE OF DEALING ARE HEREBY DISCLAIMED.

6. Limitation of Remedy: SELLER’S LIABILITY ARISING FROM OR IN ANY WAY CONNECTED WITH THE ITEMS SOLD OR THIS CONTRACT SHALL BE LIMITED EXCLUSIVELY TO REPAIR OR REPLACEMENT OF THE ITEMS SOLD OR REFUND OF THE PURCHASE PRICE PAID BY BUYER, AT SELLER’S SOLE OPTION. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES OF ANY KIND OR NATURE WHATSOEVER, INCLUDING BUT NOT LIMITED TO LOST PROFITS ARISING FROM OR IN ANY WAY CONNECTED WITH THIS AGREEMENT OR ITEMS SOLD HEREUNDER, WHETHER ALLEGED TO ARISE FROM BREACH OF CONTRACT, EXPRESS OR IMPLIED WARRANTY, OR IN TORT, INCLUDING WITHOUT LIMITATION, NEGLIGENCE, FAILURE TO WARN OR STRICT LIABILITY.

7. Inspection: Seller shall be given the opportunity to correct or replace defective products prior to cancellation. Final acceptance by Buyer shall take place not later than 90 days after shipment.

8. Changes, Reschedules and Cancellations: Buyer may request to modify the designs or specifications for the items sold hereunder as well as the quantities and delivery dates thereof, or may request to cancel all or part of this order; however, no such requested modification or cancellation shall become part of the contract between Buyer and Seller unless accepted by Seller in a written amendment to this Agreement. Acceptance of any such requested modification or cancellation shall be at Seller’s discretion, and shall be upon such terms and conditions as Seller may require.

9. Special Tooling: A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller’s property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller that is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

10. Buyer’s Property: Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer’s property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller’s possession or control.

11. Taxes: Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority.
authority upon the manufacture, sale or
delivery of the items sold hereunder. If
any such taxes must be paid by Seller
or if Seller is liable for the collection of
such tax, the amount thereof shall be
in addition to the amounts for the items
sold. Buyer agrees to pay all such taxes
or to reimburse Seller therefor upon
receipt of its invoice. If Buyer claims
exemption from any sales, use or other
tax imposed by any taxing authority,
Buyer shall save Seller harmless from
and against any such tax, together with
any interest or penalties thereon which
may be assessed if the items are held to
be taxable.

12. Indemnity For Infringement of Intel-
lectual Property Rights: Seller shall
have no liability for infringement of
any patents, trademarks, copyrights,
trade secrets or similar rights except
as provided in this Part 12. Seller will
defend and indemnify Buyer against
allegations of infringement of U.S. pat-
ents, U.S. trademarks, copyrights, and
trade secrets [hereinafter 'Intellectual
Property Rights']. Seller will defend at
its expense and will pay the cost of any
settlement or damages awarded in an
action brought against Buyer based on
an allegation that an item sold pursuant
to this contract infringes the Intellectual
Property Rights of a third party. Seller's
obligation to defend and indemnify
Buyer is contingent on Buyer notifying
Seller within ten (10) days after Buyer
becomes aware of such allegations of
infringement, and Seller having sole
test control over the defense of any allega-
tions or actions including all negotia-
tions for settlement or compromise.
If an item sold hereunder is subject to a
claim that it infringes the Intellectual
Property Rights of a third party, Seller
may, at its sole expense and option,
procure for Buyer the right to continue
using said item, replace or modify said
item so as to make it noninfringing,
or offer to accept return of said item
and return the purchase price less a
reasonable allowance for depreciation.
Notwithstanding the foregoing, Seller
shall have no liability for claims of
infringement based on information pro-
vided by Buyer, or directed to items de-
levered hereunder for which the designs
are specified in whole or part by Buyer,
or infringements resulting from the
modification, combination or use in a
system of any item sold hereunder. The
foregoing provisions of this Part 12 shall
constitute Seller’s sole and exclusive
liability and Buyer’s sole and exclusive
remedy for infringement of Intellectual
Property Rights. If a claim is based on
information provided by Buyer or if the
design for an item delivered hereunder
is specified in whole or in part by Buyer,
Buyer shall defend and indemnify Seller
for all costs, expenses or judgments
resulting from any claim that such item
infringes any patent, trademark, copy-
right, trade secret or any similar right.

13. Export Limitations. The items sold
hereunder are authorized by the U.S.
government for export only to the coun-
try of ultimate destination indicated on
the face hereof for use by the end-user.
The items may not be transferred,
transshipped on a non-continuous voy-
age, or otherwise be disposed of in any
other country, either in their original
form or after being incorporated into
other end-items, without the prior writ-
ten approval of the U.S. government.

14. Commercial Items. Unless oth-
wise indicated on the face hereof,
the items being sold hereunder if
sold for military or government pur-
poses constitute Commercial Items
in accordance with FAR 2.101, and as
such the assertions delineated in the
DFAR’s 252.227-7013, 252.227-7014,
252.227-7017 and FAR 52.227-15 (c)
shall not apply to this contract. Ad-
ditionally, in view of the Commercial
Item status, any deliverable technical
data and/or computer software to be
provided will contain Seller’s normal
commercial legend subject to the re-
strictions contained therein.

15. Force Majeure: Seller does not
assume the risk of and shall not be
liable for delay or failure to perform
any of Seller’s obligations by reason of
circumstances beyond the reasonable
control of Seller (hereinafter ‘Events
of Force Majeure’). Events of Force
Majeure shall include without limitation,
accidents, acts of God, strikes or labor
disputes, acts, laws, rules or regula-
tions of any government or government
agency, fires, floods, delays or failures
in delivery of carriers or suppliers,
shortages of materials and any other
cause beyond Seller’s control.

16. Premier™ Conductive Plastics:
Parker Chomerics™ Premier™ con-
ductive plastics are sold under license
solely for use in the following ap-
plications: (i) EMI/RFI shielding, i.e.,
electromagnetic and/or radio frequency
interference shielding or compatibil-
ity and surface grounding therefore;
(ii) earth grounding, corona shielding,
animal-static and/or electrostatic
discharge protection shielding; and (iii)
as thermally conductive members to
dissipate heat generated by electronic
devices.

The resale of Premier™ conductive
plastics in pellet or any other raw mate-
rial form is expressly prohibited, as is
their use in any application other than
as stated above, and any such resale
or use by you or your customers shall
render any and all warranties null and
void ab initio.

You shall defend, indemnify, and hold
Parker Hannifin Corporation and its
subsidiaries (Parker) harmless from
and against any and all costs and
expenses, including attorney’s fees,
settlements, and any awards, damages,
including attorney’s fees, and costs, re-
sulting from any claim, allegation, suit
or proceeding made or brought against
Parker arising from any prohibited use
of Premier™ conductive plastics by you
or your customers.

17. Entire Agreement/Governing Law:
The terms and conditions set forth
herein, together with any amendments,
modifications and any different terms
or conditions expressly accepted by
Seller in writing, shall constitute the
entire Agreement concerning the items
sold, and there are no oral or other
representations or agreements which
pertain thereto. This Agreement shall
be governed in all respects by the law of
the State of Ohio. No actions arising out
of the sale of the items sold hereunder
or this Agreement may be brought by
either party more than two (2) years
after the cause of action accrues.
1. DEFINITIONS
In these Conditions:
“the Company” means Parker Hannifin Plc including all divisions and businesses thereof and any subsidiary undertaking thereof (as defined in Sections 258 and 259 Companies Act 1985 as amended);
“Conditions” means the Standard Conditions of Sale set out in this document together with any special terms agreed in writing between the Company and the Buyer;
“Contract” means any contract between the Company and the Buyer for the sale and purchase of the Goods formed in accordance with Condition 2;
“the Buyer” means any company, firm or individual or agent thereof to whom the Company’s quotation or acknowledgement of order is addressed;
“the Goods” means the products (including any parts or accessories), materials and/or services to be supplied by the Company.

2. APPLICABILITY OF CONDITIONS
The Company concludes Contracts for the supply of Goods subject only to these Conditions. The Buyer accepts that these Conditions shall govern relations between himself and the Company to the exclusion of any other terms and conditions including, without limitation, conditions and warranties written or oral express or implied even if contained in any of the Buyer’s documents which purport to provide that the Buyer’s own terms and conditions shall prevail. No variation or qualification of these Conditions or of any quotation or Contract arising herefrom shall be valid unless agreed in writing by the Secretary or a Director of the Company or other person duly authorised by the Board of Directors of the Company.

3. QUOTATIONS
The Company’s quotations are given without commitment and no Contract between the Company and the Buyer shall arise unless and until the Company has accepted in writing the Buyer’s order placed on the Company’s quotation. Quotations shall be valid for a period of 30 days from the date of issue, or (if different) the period specified with the quotation itself.

4. REPRESENTATIONS
No employee of the Company other than the Secretary or a Director of the Company is authorised to make any statement or representations as to the Goods, save that this restriction shall not apply to any notice or statement containing a warning or restriction of use (“Warnings”) which may be provided in connection with the Goods. Subject to such Warnings, the Buyer, therefore, shall not be entitled to rely or to seek to rely upon any statement or representation made by an employee or agent of the Company other than the Secretary or a Director.

5. PRICES
(i). Subject to Condition 3, prices contained in a quotation price list catalogue and similar matter shall be based upon current costs ruling at the date thereof and are for guidance only. Subject to the later provisions of this Condition 5 the contract price shall be the price current at the date of delivery of the goods and/or when services are performed as the case may be.
(ii). In the event that the Company shall deliver the Goods to the Buyer or by a carrier for despatch to the Buyer (whether or not such carrier be the Company’s agent or servant)
(b) 14 days from the date of notice given by the Company that the Goods are ready for collection or despatch.
(iii). Where firm prices are agreed (including without limitation any quotation where the price is fixed pursuant to Condition 3) the prices will remain firm provided that full information permitting manufacture to proceed is received by the Company promptly after acknowledgement of the order by the Company, and further provided the Buyer takes delivery of the order when ready. If delivery of the order or any part thereof is delayed at the Buyer’s request or through the Buyer’s failure to provide the full information mentioned above, the Company reserves the right to amend the price of the undelivered portion to the Company’s price list prevailing at the date when delivery is made.
(iv). Unless otherwise stated prices do not include VAT which will be chargeable at the date of despatch and/or performance of services as the case may be.

6. DESPATCH AND DELIVERY
(i). Delivery shall be deemed to occur and the risk of loss or damage of any kind in the Goods shall pass to the Buyer on whichever of the following events occur earlier.
(a) collection by or on behalf of the Buyer or by a carrier for despatch to the Buyer (whether or not such carrier be the Company’s agent or servant)
(b) 14 days from the date of notice given by the Company that the Goods are ready for collection or despatch.
(ii). In the event that the Company shall at the specific request of the Buyer store the Goods or arrange for the Goods to be despatched or dealt with otherwise than by collection by the Buyer then the Buyer shall pay to the Company any reasonable charges made in the Company’s absolute discretion for the provision or procurement of such services. Any such services provided by the Company shall be performed subject to these Conditions. In the event that such services are to be provided by a carrier or other third party then the Company shall in arranging for the provision of the same act only as the agent of the Buyer and the Buyer shall indemnify the Company against any cost, charge liability or expense (including demurrage) thereby incurred by the Company.
iii. The Buyer shall carefully examine the Goods on receipt of the same and shall by written notice to be received by the Company within 21 days of receipt of the Goods notify the Company of any short delivery, over delivery or any defects reasonably discoverable on careful examination. In the absence of receipt of such notice, then subject only to Condition 11, the Company shall be discharged from all liability in respect of such defects or short or over delivery.

iv. If the Buyer neglects to serve notice under sub Condition (iii) above of any over delivery then the Company may at its option either repossess the excess Goods or invoice them and be paid forthwith by the Buyer for the excess Goods at the price ruling at the date of delivery.

7. TIME FOR AND FORM OF DELIVERY

(i). The Company will use reasonable commercial endeavours to deliver the Goods and to perform services in accordance with any time stated in the contract but time of delivery or performance shall not be of the essence to the contract. Any such times are stated by way of general information only and in the event of failure to despatch or deliver or perform within such times for any cause (whether within or outside the Company’s reasonable control, the same shall not be a breach or repudiation of the contract nor shall the Company have any liability to the Buyer for any direct, indirect or consequential loss (all three of which terms include without limitation pure economic loss, loss of profits, loss of business, depletion of goodwill and like loss) however caused (including as a result of negligence) by delay or failure in delivery except as set out in this Condition 7(i). Any delay or failure in delivery will not entitle the Buyer to cancel the order unless and until the Buyer has given 60 days’ written notice to the Company requiring delivery to be made and the Company has not fulfilled delivery within that time. If the Buyer then cancels the order:

(a) the Company will refund the Buyer any sums the Buyer has paid to the Company in respect of that cancelled order; and

(b) the Buyer will be under no liability to make any payments in respect of that cancelled order.

(ii). If the Contract does not otherwise provide the Company shall be entitled to deliver Goods by single delivery or by instalments at its option.

(b) If the Contract provides for delivery by instalments or the Company so elects each instalment shall be deemed to be the subject of a separate contract on these conditions and without prejudice to sub-paragraph (i) hereof non-delivery or delay in delivery shall not affect the balance of the contract nor entitle the Buyer to terminate the same.

(iii). In the event that the Goods shall not have been collected by or on behalf of the Buyer or by a carrier for despatch to the Buyer within 14 days of the Company’s written notice pursuant to Condition 6 (i) (b) hereof then the Company may at any time thereafter send to the Buyer a further notice notifying the Buyer of the Company’s intention to sell the same after the expiration of a period of not less than 7 days from the date of the notice and any such sale by the Company may be on a forced sale basis. The Buyer shall be liable for the Company’s charges and expenses for the sale and for the storage of the Goods (which shall be at the risk of the Buyer) pending their sale hereunder or delivery to the Buyer. The Company shall charge all costs incurred on a weekly basis for storage.

8. PERFORMANCE PREVENTED OR HINDERED

The Company shall not be liable for any delay of failure in carrying out its obligations which is caused wholly or partly by reason of act of God, delay in transportation, labour disputes, fire, flood, war, accident, Government action, inability to obtain adequate labour, materials, manufacturing facilities or energy, or any other cause beyond the Company’s control or that of its servants or agents, and if the delay or failure has continued for a period of 3 months then either party may give notice in writing to the other determining the contract and on such termination the Company shall refund to the Buyer the price of the Goods or any part thereof already paid to the Company after deduction of any amount due to the Company including any amount under Condition 17 hereof.

9. PAYMENT

(i). Unless expressly agreed in writing payment shall be made in sterling in cleared funds without any deduction set-off, restriction condition or deferment on account of any disputes or cross claims or present or future taxes, levies, duties or charges whatsoever (unless and to the extent the Buyer is required by law to make such deduction) on or before the last day of the month following the month of the invoice for the Goods. Where full payment is not received by the due date interest shall accrue on the sum outstanding at the rate of 3% per annum above the base rate of Lloyds Bank plc (as varied from time to time) calculated on a daily basis but without prejudice to the Company’s rights to receive payments on the due dates.

(ii). Time for payment shall be of the essence and in the event of delay or default in any payment for more than 7 days, the Company shall be entitled to suspend deliveries of Goods (being those Goods the subject of the default and any other Goods the subject of any agreed order) and/or treat the Contract and any other Contract between the Company and the Buyer as repudiated and/or re sell any of the Goods in its possession and be indemnified by the Buyer for any loss thereby incurred.

(iii). All sums payable to the Company under the Contract will become due immediately on termination of the Contract.

(iv). The Buyer shall pay for any samples, sale or return, loan or demonstration goods and/or materials, including drawings, plans, specifications etc. not returned within one month from the date of receipt by the Buyer unless a different period for the return of such goods and/or materials is agreed between the Company and the Buyer.

10. PROPERTY IN GOODS

(i). The Company shall retain absolute ownership of the property in the Goods which shall not pass to the Buyer and the Buyer shall keep and retain the Goods as bailee for and on behalf of the Company and shall deliver up the Goods to the Company at the Company’s request until the Company has received full payment of the price of the Goods and full payment of any other sums whatsoever which are outstanding from the Buyer to the Company whether or not due and owing, and until such time the Buyer:

(a) shall insure the Goods against the usual risks with an insurance office of repute;

(b) shall store separately the Goods or in some other way ensure that the Goods are readily identifiable as the property of the Company;
(c) irrevocably authorises the representatives of the Company at any time in circumstances where the provisions of Condition 19 may apply to enter the Buyer’s premises where the Goods are or are thought by the Company to be stored for the purpose of repossessing the Goods;

(d) shall keep and retain the Goods free from any charge lien or other encumbrance thereon.

(ii). Provided always that no circumstances have arisen where the provisions of Condition 17 may apply the Buyer shall be entitled to offer for sale and sell the Goods in the ordinary course of business as principal and not as agent at the best obtainable price, and shall be a sale of the Company’s property on the Buyer’s own behalf and the Buyer will deal as principal in respect of such sale. Notwithstanding the other provisions of the Contract, payment shall become due (unless payment has already become due or been paid) when the Buyer receives payment upon its own sale of the Goods (or other items incorporating the Goods).

(iii). If the Buyer incorporates any Goods within other equipment or products provided that the Goods remain readily identifiable and a removable part of such other equipment or products the provisions of Condition 10(ii) shall apply.

(iv). If the provisions of Condition 10(iii) apply the Buyer shall store separately the other equipment or products incorporating the Goods and shall notify the Company of the precise location and position thereof. The provisions of Condition 10(ii) hereof shall apply mutatis mutandis in respect of such replace-
ment, repair or remedial services.

The above warranty shall apply in respect of matters whereof the Buyer gives written notice within 12 months of delivery or 6 months from installation (whichever is the shorter period) or within 12 months of performance or of replacement repair or remedial ser-

The warranty obligation shall not apply to the Goods or parts thereof privately or by auction or otherwise and to keep the proceeds of sale in diminution of such sums and of all costs and expenses incurred by the Company in effecting the said sales.

11. WARRANTY AND LIMITATION OF LIABILITY

(i). The Company warrants that prod-

(ii). The Company warrants that prod-

ducts, parts or materials manufactured by it will be of good materials and work-
manship and that reasonable care will be employed in assembling or incorpo-
rating items not manufactured by it and in performing services so that upon the Buyer giving written notice to the Com-
pany that Goods have not been supplied or services performed as aforesaid if the same be established the Company will at its own expense at its option replace or repair such defective goods or remedy such defaults in service. The warranty obligation shall not apply where the Goods have been tampered with, improperly altered, repaired or maintained, installed or connected or subject to misuse (in each case other than as a result of the Company’s own acts or omissions). The Buyer shall at its own cost return the Goods to the Company for inspection.

The same term shall apply mutatis mutandis in respect of such replace-
ment, repair or remedial services.

(iii). The above warranty shall apply in respect of matters whereof the Buyer gives written notice within 12 months of delivery or 6 months from installation (whichever is the shorter period) or within 12 months of performance or of replacement repair or remedial ser-

(iv). The Company does not exclude its liability (if any) to the Buyer:

(a) for breach of the Company’s obligations arising under Section 12 Sale of Goods Act 1979 or Section 2 Supply of Goods and Services Act 1982;

(b) for personal injury or death resulting from the Company’s negligence;

(c) under section 2(3) Consumer Protection Act 1987;

(d) for any matter which it would be illegal for the Company to exclude or to attempt to exclude its liability; or

(e) for fraud.

(1) Except as provided in Conditions 7(i) and 11(i) to (iv), the Company will be under no liability to the Buyer whatsoever (whether in contract, tort (including negligence), breach of statutory duty, restitution or otherwise) for any injury, death, damage or direct, indirect or consequential loss (all three of which terms include, without limitation, pure economic loss, loss of profits, loss of

12. OPERATING INSTRUCTIONS

(i) The Company supplies with the Goods adequate information as to their design and conditions of the instructions for operation for compliance with its obligations under Section 6 (1) (c) of the Health and Safety at Work Act 1974.

(ii) The Buyer undertakes that all necessary steps will be taken to ensure that the Goods will be safe and without risk to health when properly used in ac-
13. DRAWINGS, SPECIFICATIONS ETC.
(i) All descriptions, drawings, illustrations, particulars of weights and measures rating standard statements or details or specifications or other descriptive matter, whether or not contained in the contract document, are approximate only. The Goods will be in accordance with the Company’s specifications at the time of manufacture and any earlier specifications drawings, descriptions, illustrations, particulars as to weights and measures rating standard statements or details shall not form part of the description of the parts or services supplied or to be supplied so that the Company shall not be under any liability in respect thereof.
(ii) Where Goods are supplied by the Company to the Buyer in accordance with the Buyer’s design or specifications or where the Company shall design items not within the standard range of products at the Buyer’s request no warranty is given or implied as to the suitability of such goods or items unless the Buyer has made the Company aware of the particular purpose for which the Buyer is proposing to use the goods or items in which case Condition 11 shall apply. The Company shall be entitled to charge a fee for any research or design undertaken in connection with the supply of Goods not within their standard range of products.

14. INSPECTION AND TESTING
The Company undertakes inspection of all Goods prior to delivery and where practicable submits to standard tests at the Company’s premises Special tests or standard tests in the presence of the Buyer or his representative may be undertaken by the Company at the request and expense of the Buyer but unless otherwise agreed such tests shall be conducted at the Company’s premises.

15. INDUSTRIAL PROPERTY RIGHTS
(i) All intellectual property rights subsisting in or relating to any calculations, data, specifications, designs, drawings, papers, documents, procedures, techniques, acceptance, maintenance and other tests special and recommended parts and other equipment and any other material and information whatsoever given to the Buyer by the Company in connection with the supply of the Goods by the Company to the Buyer or otherwise are vested in the Company. The Buyer will not whether by itself its officers servants agents or any of them or otherwise howsoever copy or reproduce any such items or material in whole or in part nor will it disclose any such information in whole or in part to any third party. Further the Company shall be entitled to the ownership of all intellectual property rights subsisting in or relating to any calculations, data, specifications, designs, drawings, papers, documents or other items material or information conceived originated developed or produced by the Company for the Buyer pursuant to the contract for the supply of Goods.
(ii) The Buyer shall not at any time for any reason whatsoever disclose or permit to be disclosed to any person or persons whatsoever or otherwise make use of or permit to be made use of any trade secrets or other confidential information relating to the equipment technology business affairs or finances of the Company or any associated Company or organisation of the Company or relating to the Company’s agents distributors licensees or other customers or in respect of any of their dealings or transactions.
(iii) The Buyer shall not seek to apply or apply to register in its own name any of the Company’s intellectual property rights and in particular those subsisting in or relating to the Goods or a part thereof nor shall it represent in any way that it has any right or title to the ownership of any such intellectual property rights nor shall it do any act or thing which might be contrary to the interest or rights of the Company in such rights and in particular challenge the ownership or validity of such rights.
(iv) The Buyer at its own expense shall do all such acts and things and shall sign and execute all such deeds and documents as the Company in its sole discretion may require in connection with any steps or proceedings taken by the Company to restrain the infringement of its intellectual property rights.
(v) The Buyer undertakes and agrees that the use of any of its calculations, data, specifications, designs, drawings, papers, documents, procedures, techniques, acceptance, maintenance and other tests special and recommended parts and other equipment and other material and information by the company when manufacturing and supplying the Goods will not infringe any intellectual property rights of a third party and shall indemnify the Company in respect of any such infringement.
(vi) The Buyer shall not alter or remove any trade mark of the Company which has been applied to the Goods nor apply any other trade mark to the Goods nor make any alteration to their packaging and get up.
(vii) The provisions of this Condition 15 shall survive the expiry or termination of any Contract for whatever reason.

16. SUB CONTRACTING
The Company shall be entitled to sub contract all or any of its obligations hereunder.

17. DETERMINATION
If the Buyer shall make default in or commit a breach of the contract or of any of his obligations to the Company or if any distress or execution shall be levied upon the Buyer’s property or assets, or if the Buyer shall make or offer to make any arrangement or composition with creditors or commit any act of bankruptcy, or if any petition or receiving order in bankruptcy shall be presented or made against him, or if the Buyer is a limited company and any resolution or petition to wind up such company’s business (other than for the purpose of a solvent amalgamation or reconstruction) shall be passed or presented, or if a receiver of such company’s undertaking property or assets or any part thereof shall be appointed the Company shall have the right forthwith to determine any Contract then subsisting and upon written notice of such determination being given to the Buyer any subsisting Contracts shall be deemed to have been determined and the Company shall be entitled to recover from the Buyer all losses thereby arising including but not limited to those under Condition 18 of these Conditions or otherwise.

18. PARTIAL COMPLETION
In the case of partial completion of an order by reason of any of the events referred to in Conditions 8 or 17 the Company shall be entitled to a quantum meruit in respect of all work done by it including labour costs and materials and any charges or expenses which the Company is committed to pay sub contractors or third parties without prejudice to its rights should non completion be occasioned by the Buyer.
19. NOTICES
Unless otherwise provided in writing any written communication or notice under the Contract shall be made or given by sending the same by ordinary prepaid first class letter post in the case of the Company to its current address and in the case of the Buyer to its last known address and if so sent shall be deemed to be made or given two days after the date when posted.

20. WAIVER
Any failure by the Company to enforce any or all these Conditions shall not be construed as a waiver of any of the Company’s rights.

21. CONTRACTS (RIGHTS OF THIRD PARTIES) ACT
The parties to the Contract do not intend that any of its terms will be enforceable by virtue of the Contracts (Rights of Third Parties) Act 1999 by any person not a party to it.

22. LAW AND INTERPRETATION
The Contract shall be governed by English law and the Buyer shall submit to the non exclusive jurisdiction of the English Courts. If any of these Conditions or any part thereof is rendered void or unenforceable by any legislation to which it is subject or by any rule of law it shall be void or unenforceable to that extent and no further.
Chomerics Capabilities Include:

**THERMAL MANAGEMENT & CONTROL**
- Thermally conductive gap filler pads
- Dispensed thermal gap fillers
- Silicone-free thermal pads
- Phase-change materials (PCM)
- Polymer solder hybrids (PSH)
- Dispensable thermal compounds
- Thermal grease and gels
- Insulator pads
- Thin flexible heat spreaders
- Custom integrated thermal/EMI assemblies

**EMI SHIELDING & COMPLIANCE**
- Conductive elastomers – molded, extruded, and form-in-place (FIP)
- Conductive foam based gaskets – fabric-over-foam and z-axis foam
- Conductive compounds – adhesives, sealants and caulks
- RF and thermal/RF absorbing materials
- EMI shielding plastics and injection molding services
- Coatings – direct metallization and conductive paints
- Metal gaskets – Springfingers, metal mesh and combination gaskets
- Foil laminates and conductive tapes
- EMI shielding vents – commercial and military honeycomb vents
- Shielded optical windows
- Cable shielding – ferrites and heat-shrink tubing/wire mesh tape/zippered cable shielding
- Compliance and safety test services

**OPTICAL DISPLAY PRODUCTS**
- EMI shielding filters
  - (conductive coating & wire mesh)
- Ant-reflective/contrast enhancement filters
- Plastic or glass laminations
- Hard coated lens protectors
- Touch screen lenses

**About Parker Hannifin Corporation**
With annual sales exceeding $12 billion, Parker Hannifin is the world’s leading diversified manufacturer of motion and control technologies and systems, providing precision-engineered solutions for a wide variety of commercial, mobile, industrial and aerospace markets. The company employs more than 61,000 people in 48 countries around the world. Parker has increased its annual dividends paid to shareholders for 52 consecutive years, among the top five longest-running dividend-increase records in the S&P 500 index. For more information, visit the company’s website at http://www.parker.com, or its investor information site at http://www.phstock.com.
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