THERMAL INTERFACE MATERIAL DISPENSING GUIDE

for Thermally Conductive Gels, Cure-in-Place Potting Compounds and Thermal Greases

Parker Chomerics

Introduction

Parker Chomerics thermal interface material dispensable products are ideal solutions for today's electronic packages. Thermally conductive, dispensable materials have the ability to cover a variety of gaps and form complex geometries.

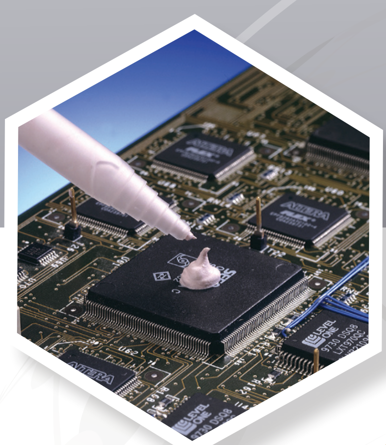
This ability to conform provides reduced thermal contact resistances and thus reduces the temperature and increases the efficiency of the electronic application, while providing low closure force. When using dispensable products, specifiers should consider factors such as pump equipment, mating surfaces, tolerance stack up, closure force and physical application of the material.

There are many options for dispensing equipment, ranging from manual syringes to high-volume automated dispensing systems. The choice of the proper equipment

will depend on several factors, including volume, labor/equipment cost, precision requirements and material type to be dispensed. When choosing the appropriate dispensing equipment, designers should keep in mind how the equipment may interact with the material, particularly as it relates to the degree of shear on the thermal material. The material and the delivery system need to be compatible to optimize equipment life and maintain material properties.

To achieve high thermal conductivity, our thermal materials are filled with ceramic particles. Due to this loading, the thermal compounds are highly viscous and may be abrasive. Therefore, they will dispense differently than common low-viscosity greases or adhesives. Once the proper equipment is chosen, certain factors should be considered to increase the quality and throughput of the material. These factors may include needle/nozzle height, dispensing pattern, dispensing speed, needle diameter, substrate surface finish, etc.

The intent of this guide is to help the user select Parker Chomerics thermally conductive dispensable materials and dispensing equipment and better understand the dispensing process.



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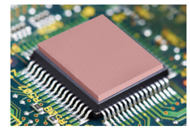
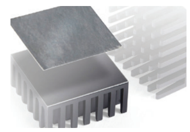
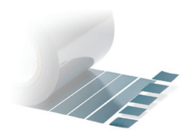
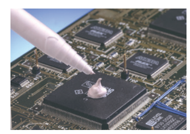
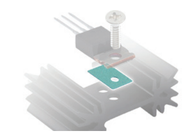
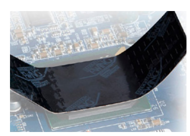












OVERVIEW OF DISPENSABLE MATERIALS

THERM-A-GAP® THERMALLY CONDUCTIVE GELS

1K Dispensable Thermal Gap Fillers

THERM-A-GAP™ Gels are high-performance, single-component, dispensable thermal materials that are either fully cured or require no curing. These unique gel materials result in much lower mechanical stress on delicate components than even the softest gap-filling pads.

These gels are highly conformable and provide low thermal impedance like greases but are designed to overcome the pump-out and dry-out issues associated with grease. THERM-A-GAP Gels are designed to be dispensed in applications requiring low compression forces and minimal thermal resistance for maximum thermal performance. They are ideal for filling variable thickness gaps in a single application.

FEATURES / BENEFITS

- Fully cured or require no curing
- Requires no refrigeration, mixing or additional curing
- Proven long-term reliability and superior performance
- No settling occurs in storage

HIGHLY CONFORMABLE AT LOW PRESSURES

- Ideal for multiple thickness gaps under one common heat sink
- Applies very low stress on components, which makes it ideal for delicate applications
- Allows for design flexibility compared to thermal pads

ONE-COMPONENT DISPENSABLE

- Eliminates hand assembly
- Decreases installation cost
- Eliminates multiple pad part sizes/numbers

EXCELLENT SURFACE WETTING

- Excellent for maintaining contact through thermal cycling

TYPICAL APPLICATIONS

- Automotive electronic control units (ECUs)
- Engine, transmission and braking/traction controls
- Power conversion equipment
- Power supplies and uninterruptable power supplies
- Power semiconductors
- MOSFET arrays with common heat sinks
- Televisions and consumer electronics

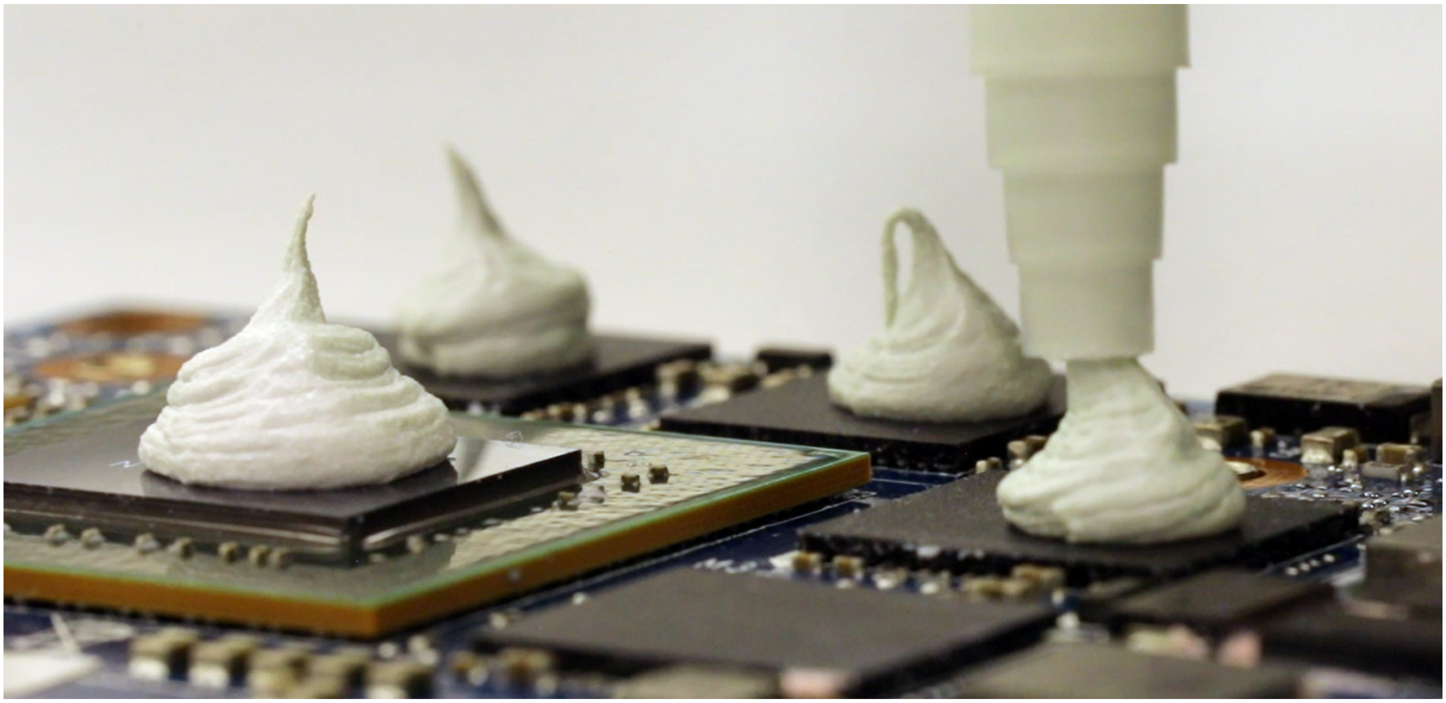
STORAGE CONDITIONS

- Materials should be stored at 50 to 90°F (10 to 32°C) at 50% relative humidity.

RoHS compliant

THERM-A-GAP® CURE-IN-PLACE GAP FILLERS

2K Dispensable Thermal Gap Fillers



THERM-A-GAP® CIP materials are highly conformable, two-component compounds.

FEATURES / BENEFITS

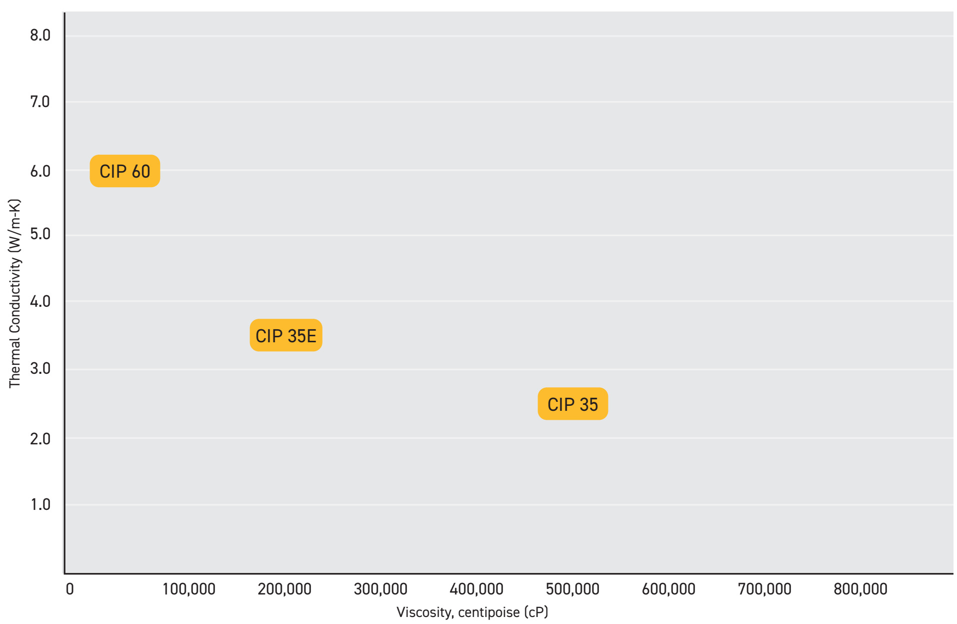
- Two-part (2k) dispensable material
- Excellent thermal performance
- Conformable to irregular shapes
- No pre-mixing or weighing of components required
- Vibration dampening

TYPICAL APPLICATIONS

- Automotive E-mobility (Converters, Inverters)
- Automotive Infotainment (Display, HUD, Audio)
- Automotive ADAS (DCU, Camera, Radar/Lidar)
- Energy Storage Application (Residential, Commercial, Grid-level)
- Power Electronics
- Telecommunications Infrastructure

RoHS compliant

PERFORMANCE GUIDE



THERM-A-FORM®

Cure-in-Place Potting and Underfill Materials

THERM-A-FORM™ Cure-In-Place (CIP) compounds are thermally conductive dispensed silicone elastomer products designed for heat transfer without excessive compressive force in electronics cooling applications. Unlike THERM-A-GAP Gels, which are either pre-cured or require no curing, THERM-A-FORM materials require curing, hence their name "cure-in-place."

THERM-A-FORM Cure-In-Place dispensable compounds are RTV (room temperature vulcanizing) liquid materials which can be dispensed and then cured into complex geometries for cooling of multi-height components on a PCB. Each compound is available in ready-to-use cartridge systems, eliminating weighing, mixing and degassing procedures.

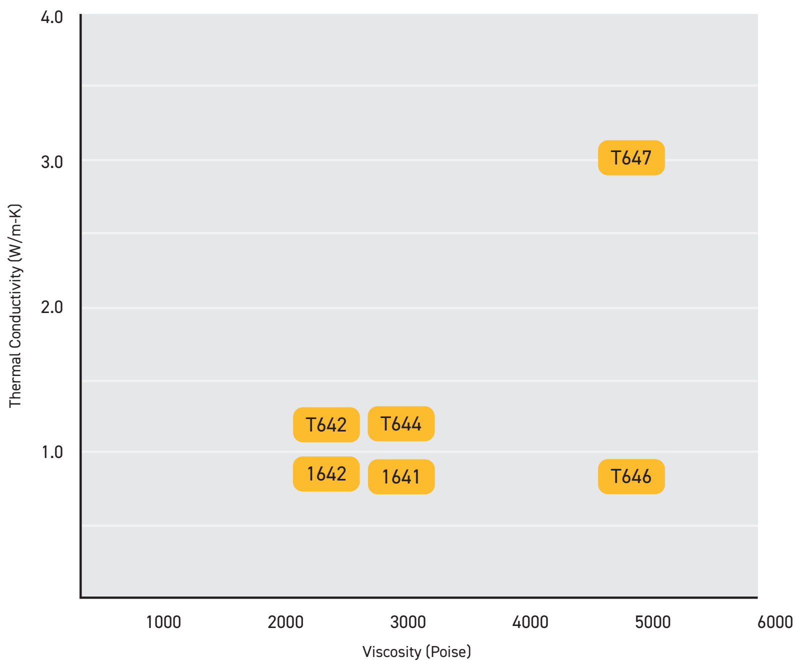
FEATURES / BENEFITS

CURE-IN-PLACE
DISPENSABLE COMPOUNDS

- Filling, potting, overfill, under fill, sealing and encapsulating
- Flows around complex parts
- Ideal for multiple thickness gaps under one common heat sink
- Can cure at elevated heat cycle or at room temperature
- Localized encapsulating of components
- Ceramic particles act as natural standoffs for electrical isolation
- Room temperature and elevated cure available

RoHS compliant

PERFORMANCE GUIDE



CONFORMABLE (LOW MODULUS)

- Mold to complex irregular shapes without excessive force on components
- Insulates against shock and vibration

TYPICAL APPLICATIONS

- Power conversion equipment
- Power supplies and uninterruptable power supplies
- LED modules & power drivers
- Telecom base stations

STORAGE CONDITIONS

- To maintain uniformity, tubes/ cartridges should be stored horizontally. Remixing prior to dispensing is not advised, unless the material can be vacuum degassed, to remove any air bubbles. They should be stored at 50 to 90°F (10 to 32°C) at 50% relative humidity.

THERM-A-GREASE®

Thermal Greases

TYPICAL APPLICATIONS

- LED modules
- Microprocessors (mobile servers & desktops)
- Memory modules
- DC/DC converters
- Power semiconductors
- Telecom base stations

STORAGE CONDITIONS

- Material may settle overtime in storage. Best practice is to remix the material prior to use. Materials should be stored at 50 to 90°F (10 to 32°C) at 50% relative humidity.

Parker 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. They are excellent for conforming to surface micro-voids created by machining/casting to reduce thermal impedance.

Thermal greases have excellent surface wetting characteristics and flow easily to fill voids at the interfaces resulting in low thermal impedance even at low pressure.

FEATURES / BENEFITS

HIGHLY CONFORMABLE

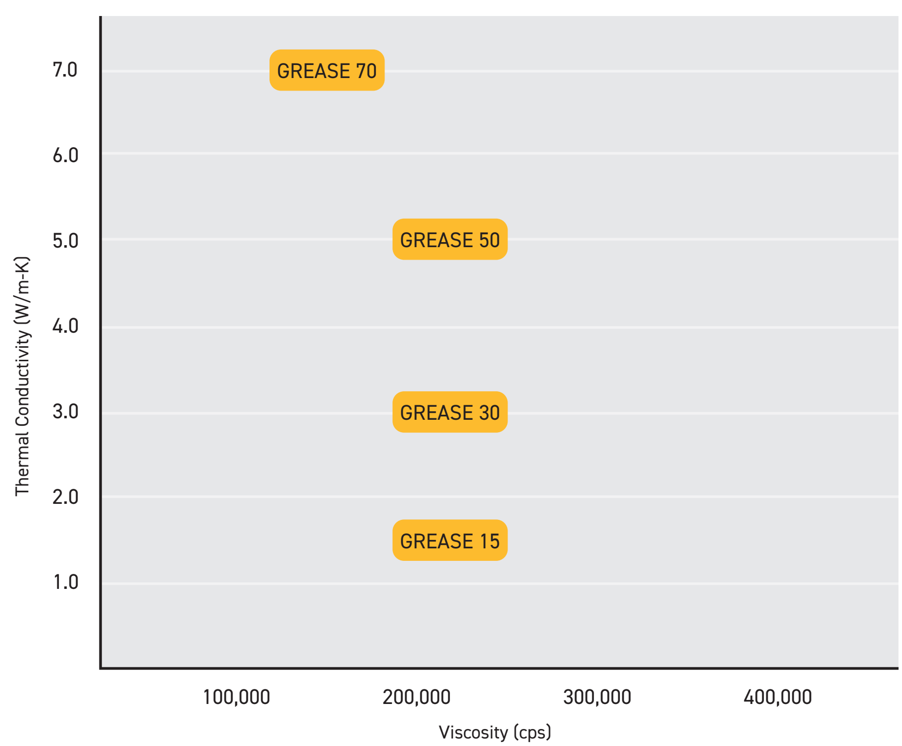
- Low thermal impedance
- Deflects under minimal compressive forces
- Great surface wetting
- Excellent ability to fill micro-voids

ONE COMPONENT

- Excellent for screening and stenciling
- Requires no cure cycle

RoHS compliant

PERFORMANCE GUIDE



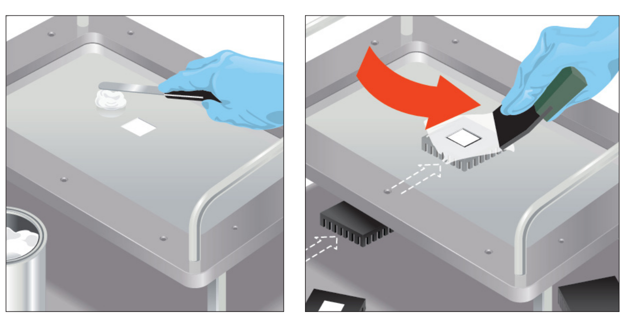
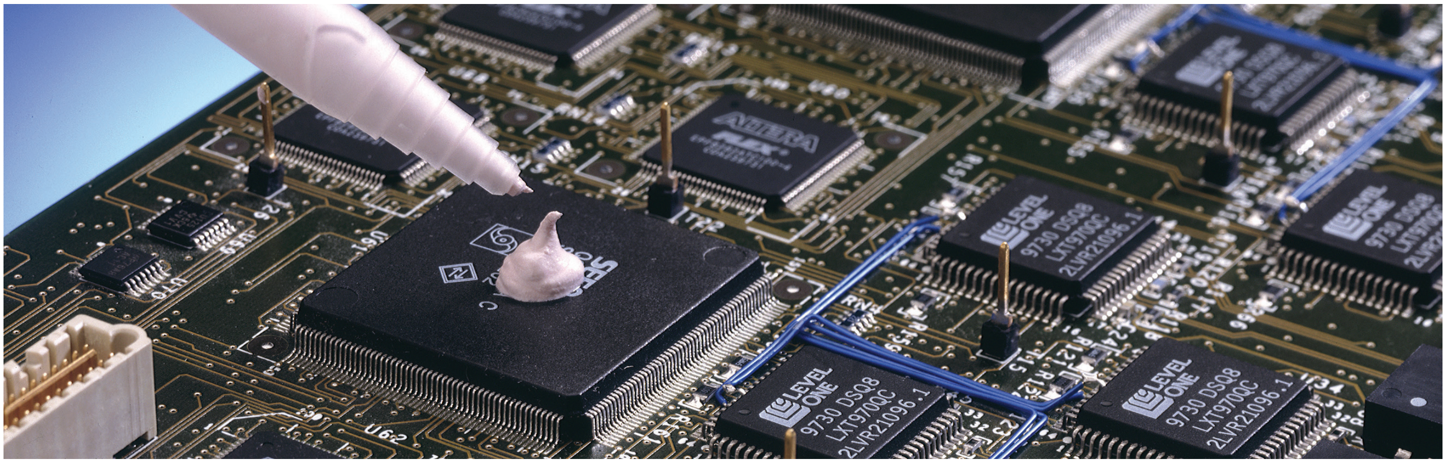


Figure 1: Stenciling Typical application method is to stencil the compound onto the chip or heat-sink. Application patterns can vary depending on the area of coverage. The image above depicts a typical square grease pattern being applied onto a heat-sink with a squeegee or spatula.

See Instructions for Stenciling THERM-A-GREASE here.

MATERIAL SELECTION

CHOOSING A THERMAL INTERFACE MATERIAL AND DISPENSING METHOD



When designing in a dispensable TIM, there are several considerations to keep in mind when determining the appropriate product. The main purpose of the material is to conduct heat, but with a dispensable TIM, there is more to the selection process than simply evaluating thermal conductivities.

Temperature and Environment

To choose the appropriate material for the application, there has to be an understanding of the heat generation that must be dissipated, as well as environmental conditions and limits. Occasionally there are substrates that limit the temperatures that be used for curing a THERM-A-FORM cure-in-place material. Other applications (automotive, under-the-hood) may present high vibration exposure or extreme temperature cycling that would restrict the type of material that can be used. For example, a THERM-A-GAP Gel material may be selected over a cure-in-place material in applications with extreme thermal shock and vibration because of its inherent tack and elasticity.

Mechanical

The nominal gap and expected variation in gap will dictate the amount, or thickness, of TIM required. Mechanical gaps as large as 4mm are typical for these thermal materials. For gaps larger than this it is highly recommended to reach out to Parker Chomerics Engineering to discuss your application. Forces generated by expansion/contraction or vibration, coupled material hardness, will result in stress on components. Selection of a soft, conformable material with appropriate thickness will minimize potential damage to critical components.

Dielectric Strength

Parker Chomerics thermal interface materials are comprised of resins and ceramic fillers that are inherently electrically isolating. The largest filler particles will dictate the minimum gap that can be achieved to prevent direct contact of electrical component to heat-spreader.

Package Size

Parker Chomerics offers various packaging formats and sizes. Selection of the appropriate format will be a function of throughput, shot size and expected change over time, as well as compatibility with dispensing equipment. Custom packaging may be available upon request.

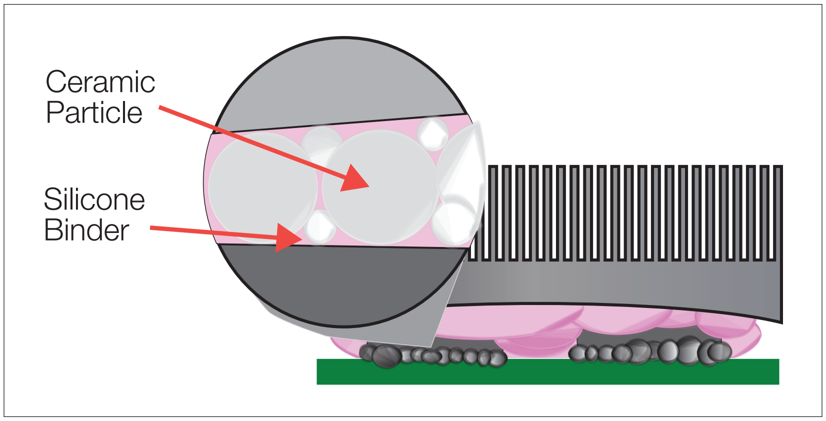


Figure 2: Electrical Isolation
Typical ceramic particles shown as natural mechanical stand-offs for electrical isolation.

EQUIPMENT TYPES

Table 1: Low-Volume Dispensing Methods

	Jar or Container	Manual Hand Dispensing		Cartridge Caulking Gun			Shot Size Controllers	
		Single Component Syringe	Mixpac™ with Static Mixer	Manual	Battery Powered	Air or Pneumatic	Pressure/Time	Positive Displacement
Features & Benefits	No capital, immediate installations, small & portable, versatile with tip attachment, no purging required					No capital, small & portable, ergonomically preferred	Repeatable shot size, no purging, versatile tip geometry	Precision shot size control, no purging, versatile tip geometry, improved bead termination
Operator Responsibility	Dispensed size, cycle-time, location & shape	Dispensed size, cycle-time, pressure, location & shape		Dispensed size, cycle-time, pressure, location & shape	Dispensed size, cycle-time, location & shape	Dispensed size, location & shape	Location & shape	Location & shape
Variability in Dispensed Part	Size, shape, rate & location			Size, shape, rate & location	Size, shape & location	Size, shape & location	Location & shape	Location & shape
Parker Chomerics Material Package Description	1.4 cc & 120 cc (1 pint with vial)	1-10 cc Syringe	10:1 35-250 cc 1:1 45-200 cc Cartridge with static mixer	300 cc Aluminum cartridge		30-360 cc Cartridge	30-360 cc Cartridge	30-360 cc Cartridge
Larger bulk containers are the most economical price per cc								
Common Equipment Vendors	None	None	Sulzer Mixpac™	Albion, SEMCO®	Albion	Albion & SEMCO®	Nordson EFD, SEMCO® & Fisnar	Fishman, PVA, Nordson EFD
Equipment Description	None		B System (35 cc & 45 cc Sulzer)	B26 (Albion)	846-1E (Albion)	846-1A (Albion)	Performus I, Performus X100 Dispensers (Nordson EFD)	TBD
							DSP501N & JB1113N (Fisnar)	TBD
			F System (200 cc & 250 cc Sulzer)	850 (SEMCO®)	TBD	250-A & 550 (SEMCO®)	250-B (SEMCO®)	TBD
							TBD	TBD
Comments	For Stenciling use a die-cut mylar that is thicker than the minimum bond-line thickness	Hand-held syringe	Manual dispense system with appropriate mix-ratio (material dependent).	Manual caulking gun may dispense faster depending on the operator.	Battery-powered caulking gun may dispense faster depending on the operator.	Air-powered caulking gun may dispense faster depending on the operator.	Table top unit, that can handle high viscosity compounds and regulates pressure and time. Flow rate is measured at 90 psi directly out of the cartridge.	Table-top unit, that can handle high viscosity compounds and regulates displacement.

NOTE: Parker Chomerics does not officially endorse any of the equipment above or supply it. For equipment technical support please contact the vendors listed. SEMCO is a registered trademark of PPG Aerospace. Mixpac is a trademark of Sulzer.

EQUIPMENT TYPES

Table 2: High-Volume Dispensing Methods

	Bench-Top Dispensing Systems	High-Volume Dispensing Module	
		Cartridge Pumping and Robotic Dispense System	**Pail Pump and Transport System**
Features & Benefits	Repeatable shot size and shape, programmable XYZ direction and speed, continuous dispensing, low capital investments	Fastest cycle type, lowest material cost, visual inspection systems, fully automated system, best control and yield, continuous dispensing, repeatability in shot size & shape	Fastest cycle type, lowest material cost, visual inspection systems, fully automated system, best control and yield, continuous dispensing, repeatability in shot size & shape, multi-process step
Operator Responsibility (Post Programing & General System)	Seating application under dispensing head	Purging dispense system between materials	Purging dispense system between materials
Variability in Dispensed Part	None		
Parker Chomerics Material Package Description	30-360 cc Cartridge	6 oz (180 cc), 8 oz (240 cc), 12 oz (360 cc), 20 oz (610 cc), & 32 oz (953 cc) Cartridge	1-5 Gallon pail
Material Cost	Larger bulk containers are the most economical price per cc		
Common Equipment Vendors	Camelot, Fisnar and Nordson EFD		
Equipment Description	F4200N (Fisnar) I+J4100LF & DSP501A-LF (Fisnar)	Please contact local territory sales manager or applications engineering for high-volume equipment recommendations	
Comments	Programmable table top unit that is compatible with available packaging.	Pump dispenses directly out of the cartridge to dispensing value. Gear pumps and soft metal component pumps are not recommended. Short hoses with minimum ID, and limited bends and elbows are ideal to minimize shear.	Pump dispenses directly out of the pail to dispensing value. Conductive filler is abrasive. Gear pumps and soft metal component pumps are not recommended. Short hoses with minimum ID, and limited bends and elbows are ideal to minimize shear.

NOTE: Parker Chomerics does not officially endorse any of the equipment above or supply it. For equipment technical support please contact the vendors listed.

TECHNICAL PARAMETERS

HIGH VOLUME EQUIPMENT CONSIDERATIONS

High volume applications will require an appropriate dispensing system designed for larger package formats (i.e.. SEMCO cartridges and pails).

- The proper equipment choice will be a function of geometry, throughput requirements, material type and package.
- Material selection should be defined *prior* to selecting equipment to optimize material performance and long-term equipment maintenance.

Most thermal interface materials contain high concentrations of ceramic filler to maximize their thermal performance, so they dispense differently than unfilled polymers or greases. THERM-A-GAP Gels are unique materials, in that they are thermally conductive polymers that are either fully cured or require no post cure and can be extruded.

The advantage in using THERM-A-GAP Gels is that they do not require any mixing or curing once they are dispensed.

- To maintain the material's integrity as it is dispensed in high volume, the user should minimize tubing lengths, maximize tubing inside diameters and reduce the number of elbows (i.e., bends or angular connections).
- Using a larger-orifice needle tip reduces the amount of shear on the material (please refer to "Technical Parameters: Dispense Patterns & Process Considerations").

To successfully dispense THERM-A-GAP Gels with minimal impact to their physical properties, simple ram/piston pump systems with adequate force capability have proven most reliable.

- It is not recommended to use reciprocating pumps, gear pumps or other complex pumping designs as they can impart excessive stress on the material.
- Pump systems that have high a degree of mechanical interaction with the material may increase maintenance needs due to the high concentrations of thermally conductive and sometimes abrasive fillers. The valve that dispenses, or controls, the amount of material dispensed needs to be constructed of wear-resistant components to endure a maximum number of cycles.
- It is highly recommended to increase the life-cycle of dispensing equipment that components that make contact with the thermal interface material be made from wear-resistant and abrasion-resistant materials such as Tungsten Carbide.

The most successful valves use a progressive cavity (i.e., displacement type option) and are geometrically simple. Other features that are available in valves, including a "snuff-back design" as well as built-in
shot-size calibration/control, can aid in the termination of the dispensed bead.

THERM-A-FORM CIP materials are two-component materials and require similar equipment design as THERM-A-GAP Gels, but must also take into consideration mixing, metering and curing.

- THERM-A-FORM materials require maximizing the tubing's inside diameter while minimizing tube lengths and number of elbows used (i.e., bends or angular connections).
- Mix carefully so as not to introduce any air voids – can also be done under vacuum.
- Use a static mixer to blend both components of the material.
- Metering, ensuring the proper amount of each side is blended, must be accurate to maintain the material's end properties.

PART CONSIDERATIONS

Once a thermal interface material (TIM) has been selected and the dispensing system has been defined, the next step is to analyze the part(s) to ensure that the correct volume of TIM is delivered to the required location in the correct shape.

As a starting point, use the following tasks to guide part analysis:

- Define number of target locations.
- Determine whether the TIM will be dispensed on the component side or heat sink side.
- Consider all operations that occur post-dispense and prior to final assembly that may affect form, placement, cleanliness, position, etc.
- Define dispense technique (this is a function of TIM type, geometry, etc.) Examples include screening, potting, injection and direct dispense to target.
- Consider any physical obstructions that the dispense head will have to navigate around.
- Calculate shot size per dispense location (function of the area of coverage, gap(s) and shape.
- Assess the surfaces that will be in contact with the TIM: composition, roughness and geometric features.
- Address cleanliness for proper wetting and thermal performance.

Assess the special conditions that the TIM will be subject to (please refer to "Technical Parameters: Special Material Considerations").

- Orientation, vibration, mechanical stresses and temperature extremes
- Cure conditions when high temperature cure is required for a THERM-A-FORM CIP, with low melt materials in proximity
- Transporting of part to multiple locations, i.e., packaging, climate, protection, etc.

Surface Roughness Values		
Grade number	**Micro-meter**	**Micro inches**
N8	3.2	125
N9	6.3	250

Table 3: A surface roughness of N8 or rougher is recommended

Figure 4: Multiple location casting

DISPENSE PATTERNS & PROCESS CONSIDERATIONS

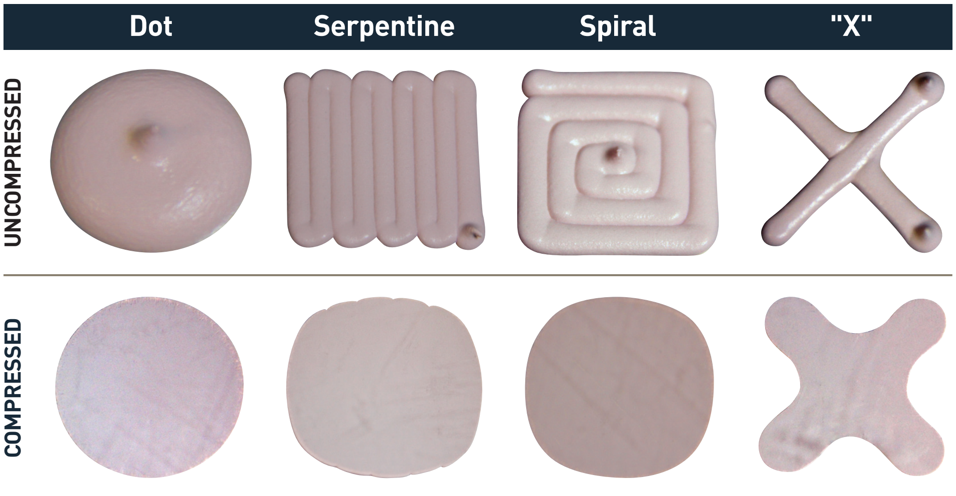


Figure 5: Dispensing Patterns A simple dot like the first pattern provides adequate coverage, shortest cycle time and least chance of introducing air into the TIM. The more complex the profile, the greater the probability for introducing air (e.g., serpentine and spiral).

To maximize thermal performance, the thermal material must contact the entire target area on both the component and heat sink surfaces without air entrapment. In order to achieve this, a proper dispense pattern is critical.

Taking part considerations into account (as discussed on the previous page), the next process design task is to specify the dispensed material pattern.

Consider the following parameters:

- Volume required – a function of the nominal gap, tolerances and geometries
- Shape of bead required to "wet out" the entire targeted area
- Shot location and registration
- Elimination of potential trapped air

Process verification:

- Visual inspection (if possible)
- Automatic/integrated optical verification
- Functional tests (measurement of critical junction temperatures as a function of power)

Achieve repeatable shot volume:

- If repeatability is inadequate, consider the effect of the dispense tip, the effect of shear and time, the effect of cure (if it is a CIP material) and the effect of adding a precision valve (if necessary).
- Always establish a minimum volume that is required to cover the entire range of gap volumes.
- Build in a shot-size calibration process to verify that dispense rates are not variable. Adjust dispense pressure or shot times as a function of shot-size measurements.

Optimize the shape of the dispensed material:

- Determine a dispense pattern (dot, line or serpentine) that will "wet" the entire target, and that offers a bead height enough to fully contact the opposing target surface without air voids
- Consider the path of egress to minimize any possible air entrapment.
- Optimization of pattern can reduce material consumption while ensuring the functional gap is filled.

To properly locate (or register) the dispensed material to the part:

- Start with a proper fixturing and adjustment scheme to ensure registration between dispense head and part.
- Build appropriate verification checks into the process.

To optimize cycle time:

- Adjust dispense pressure (increase), needle orifice diameter (increase) and hose lengths/angles/flow obstructions of the delivery system (decrease).
- Beware of trade-offs associated with improvement of flow and cycle time, such as effects of shear on the material, sag/slump behavior, effects on shape of pattern and filler separation in delivery system (damming).

SURFACE WETTING

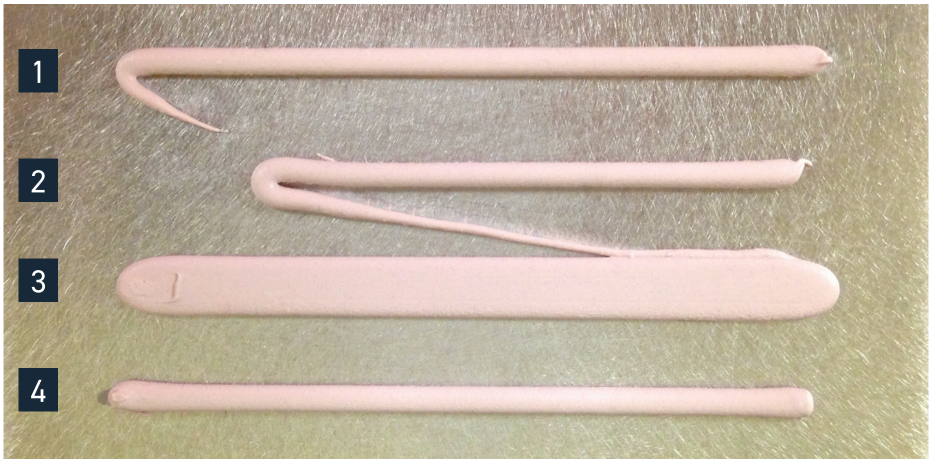


Figure 6: Common Line Dispensing Concerns Common dispensing issues: (1, top) system did not have a program for bead termination; (2, middle top) needle was too high and there was no bead termination programed; (3, middle bottom) needle too low; (4, bottom) correct height with bead termination.

Proper adherence starts with a clean surface. Confirm that your part's surface is free of lint, processing oils and FOD (foreign object debris). If there is a concern with cleanliness, the surface can cleaned with a mild solvent, such as isopropyl alcohol (IPA), or any suitable surface cleaner.

The objective is to have the dispense tip as low as possible to achieve sufficient wetting and bead initiation/termination (see figure 6). This may require some dispensing trials to determine the appropriate combination of dispense tip diameter, height
and corresponding speed and service pressure.

- Be sure to target each bead shape and volume to properly wet and fill the gap between the two surfaces.
- Consider a bead height of 2X to 3X the nominal gap to promote wetting.

As a general rule, increased surface roughness will increase the surface area available for wetting. In vertical applications, the increased surface roughness will provide an increased resistance to slide. For additional technical support regarding vertical gap dispensing, please contact Parker Chomerics Applications Engineering.

- Increasing the shot size, contact area and surface roughness will aid in slide resistance of the material.
- Staging time (prior to further processing) will enhance wetting of the material to the target surfaces (i.e., component, heat spreader).

For re-work:

- First remove the bulk of the material using a soft tool that will not damage the substrate (i.e., a rubber spatula, tongue depressor).
- Apply a mild surface cleaner such as IPA to remove remaining residue and clean the surface, then reapply the TIM.

As THERM-A-GAP Gel materials are either pre-cured or do not require a cure, THERM-A-FORM cure-in-place materials may be more difficult to peel once they cure.

The best way to remove the THERM-A-FORM material is to abrade the surface with a soft tool (wooden stick or cotton swab) and then clean
the surface with IPA (toluene may work better).

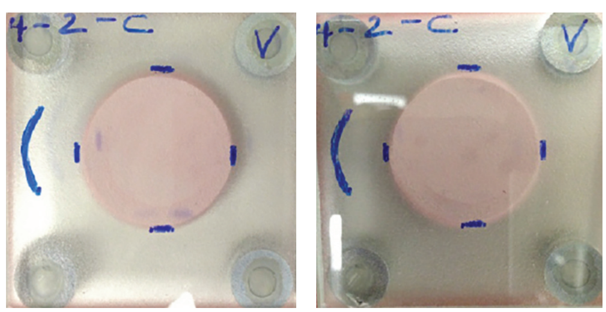


Figure 7: Reliability Reports The images above show one of the 18 trials that were performed on THERM-A-GAP Gel 30 in a vertical orientation tested under several different surface roughnesses, gaps and surface areas. The test fixtures were subject to temperature shock and random vibration. Contact Parker Chomerics Applications for report. (Image to the left is before and Image to the right is after the treatment.)

SPECIAL MATERIAL CONSIDERATIONS

THERM-A-GAP GELs are filled elastomers that are either fully cured or do not require post cure and are loosely cross-linked and can easily be extruded. Excessive shear force from complex dispense geometries and high pressure can affect the material structure and affect the rheology of the material.

- It is important to minimize the degree of shear imparted on THERM-A-GAP Gels during application by using a needle with a larger orifice, larger inner diameter tubing, fewer elbows and lower pressure.

Due to this sensitivity to shear, THERM-A-GAP Gels are designed to be dispensed out of the packaging *only once*. Repackaging would change the mechanical properties of the material.

For THERM-A-GAP Gel rework:

- Use a cloth, lint-free towel or spatula to remove the THERM-A-GAP Gels from the substrate.
- After the material is removed, fresh material should be reapplied.

THERM-A-FORM CIP (Cure-In-Place) compounds are designed to be dispensed and cured directly into the application.

- Surfaces should be free from any cure-inhibiting contaminants, especially those containing:
  - Nitrogen
  - Sulfur
  - Tin
  - Phosphorus
  - Latex

It is important to consider cure times and temperatures required to fully cure the material, and their effect on processing, cycle times and substrates.

- High temperature increase generally lends to quicker cure

THERM-A-FORM pot life considerations:

- Once catalyzed, there is a finite amount of time that the material will flow adequately.
- Proper measures must be addressed to ensure shot size control.
- Static mixing nozzles are provided with all standard two-component THERM-A-FORM products.
- Use the appropriate static mixing nozzle as they differ with mix ratio (i.e., 1:1 and 10:1).

For THERM-A-FORM compound rework:

Components encapsulated by a THERM-A-FORM compound can be removed by notching and peeling away the cured compound from the components.

Thermal Greases were designed to achieve minimum bond-line.

- Typical application is through stenciling or screen printing.
- Be sure that the screen or stencil is a minimum of 3X thicker than the maximum particle size in the compound.

If the holes of the screen are too small or the stencil is too thin, it may filter out some of the thermally conductive particles in the grease. Due to the non-crosslinked nature of thermal greases, they may tend to separate in the package. It is best practice to always mix the material prior to use.

For Thermal Grease rework:

- Thermal greases can be removed with a simple cleaning solvent prior to reapplying.

PACKAGING OPTIONS

Table 4 - Packaging Options

Code	Packaging Options Pictured Below	Standard Fill Level (cc)
A	30 cc Taper Tip Cartridge	27
B	30 cc Optimum Cartridge/Tip	27
C	35 cc Cartridge Kit (10:1) w/ Static Mixer	34/3.4
D	45 cc Cartridge Kit (1:1) w/ Static Mixer	22/22
E	200 cc Cartridge Kit (1:1)	95/95
F	250 cc Cartridge Kit (10:1) w/ Static Mixer	244/2.4
G	300 cc Aluminum Caulking Tube (13 oz)	300
H	6 oz SEMCO	150
I	6 oz EFD	150
J	20 EFD	320
K	20 oz SEMCO	570
L	1 Gallon Pail	3250
Code	**Packaging Options Not Pictured**	**Standard Fill Level (cc)**
M	10 cc Syringe w/ Cap	10
N	4 oz Primer Vial	118
O	1.4 cc Jar	1.4
P	2.5 cc Tube	2.5
Q	55 cc Optimum® Cartridge	52
R	8 oz SEMCO	225
S	8 oz Plastic Jar	80/160 for greases
T	12 oz SEMCO	320
U	20 oz SEMCO	570
V	32 oz SEMCO	900
W	32 oz EFD	900
X	5 Gallon Pail	7800

A B C D E F G H I J K

Figure 8: Typical packaging options

L

Figure 9: Typical high-volume packaging options

PARKER CHOMERICS LOCATIONS

To place an order please visit parker.com/chomerics or contact a Customer Service Representative at the following locations:

North America

Parker Chomerics
Global Division Headquarters
77 Dragon Court
Woburn, MA
Phone +1 781-935-4850
Fax +781-933-4318
chomailbox@parker.com

Product Disclosure
(ROHS/REACH, Material
Declarations, SDS)
choproductdisclosure@parker.com

parker.com/chomerics

CHOC1015 February 2026

Europe

Parker Hannifin Ltd
Chomerics Division Europe
Unit 6, Century Point
Halifax Road
High Wycombe
Bucks HP12 3SL
UK
Phone +44 1494 455400
Fax +44 14944 55466
chomerics_europe@parker.com

Asia Pacific

Parker Hannifin
Chomerics Shanghai
280 Yunqiao Road, Jin Qiao Export
Processing Zone, Shanghai 201206,
China
Phone +86 21 2899 5000
Fax +86 21 2899 5146
chomerics_ap@parker.com

Parker Hannifin
Chomerics Shenzhen
No.5 Bldg Jinrongda Technological Park
Gangtou Village, Bantian Longgang
District Shenzhen, 518122, China
Phone +86 755 8974 8558
Fax +86 755 8974 8560
chomerics_ap@parker.com

Asia Pacific

Parker Hannifin
Chomerics Kula Lumpur
Lot 15, Jalan Gudang 16/9
Section 16, Shah Alam
Industrial Estate, 40200 Shah Alam
Selangor, Malaysia
Phone +603 5510 9188
Fax +603 5512 6988
chomerics_ap@parker.com

Penang, Malaysia
No.3, Puncak Perusahaan 1, 13600 Prai,
Penang, Malaysia
Phone +604 398329
Fax +604 3983299
chomerics_ap@parker.com

Parker Hannifin India Private Limited
Chomerics Division
Plot No. 41/2, 8th AvenueDTA,
Anjur Village, Mahindra World City,
Chengalpattu, Tamilnadu - 603 004, India
Phone +91 44 67132333
Phone +91 44 67132045
chomerics_ap@parker.com

Manufacturing Facilities

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