

**LOCTITE®**

**BERGQUIST®**

**MATERIALS FOR WIRELESS INFRASTRUCTURE**  
**5G TELECOM SOLUTIONS**



**Henkel**

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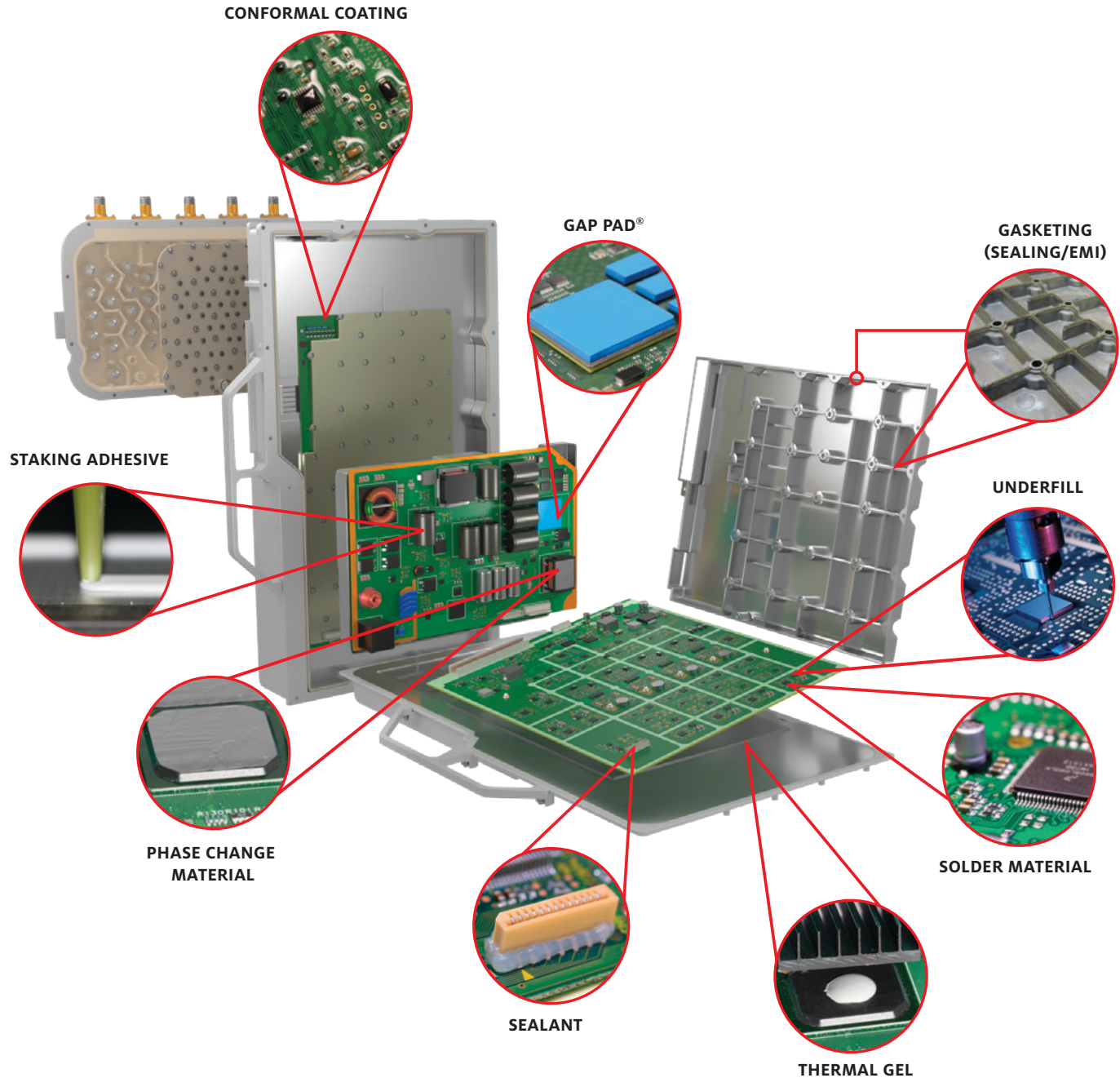
## 5G Telecom Solutions

As the commercial telecom market embraces new 5G mobile communication standards and early phase rollouts, wireless infrastructure system design specialists are preparing for the full market deployment set to begin in 2020. The broad heterogeneous network required to facilitate 5G enhanced media broadband speeds and low data latency continues to place demands on functional components, with reduced form factors and increased performance expectations pushing power densities to new limits.

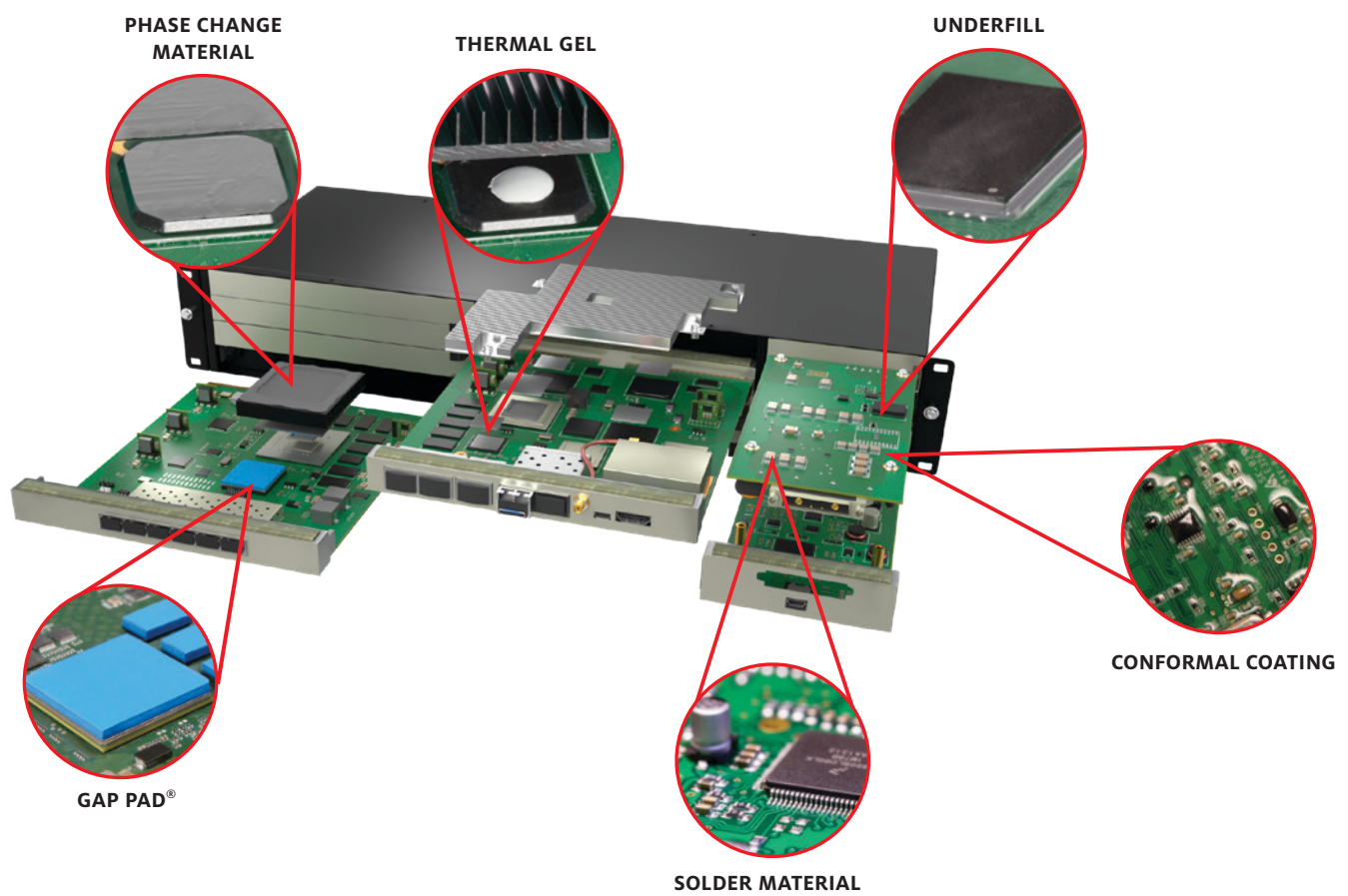
Because many of the telecom infrastructure components such as remote radio heads, base stations and fixed wireless network devices are positioned in outdoor environments, ensuring reliable long-term performance is critical. Unlike datacenters where active cooling can occur, commercial telecom infrastructure systems rely on strong electrical interconnects and robust thermal management solutions for dependable function. Henkel's award-winning bonding and protecting solutions, solder paste materials and *BERGQUIST* brand thermal control products have enabled the telecom sector for decades. Now, as the industry transitions to new 5G-capable designs, Henkel's applications expertise, formulation know-how and proven product performance will deliver once again for the telecom sector.

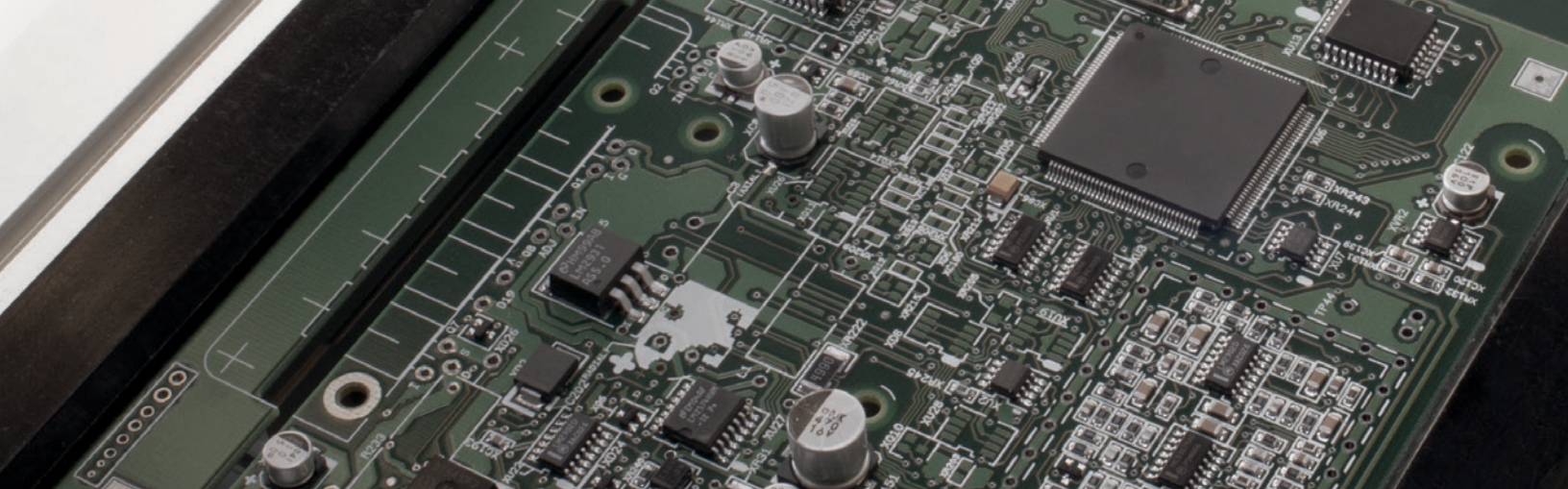


# Material Solutions For Remote Radio Unit (RRU)



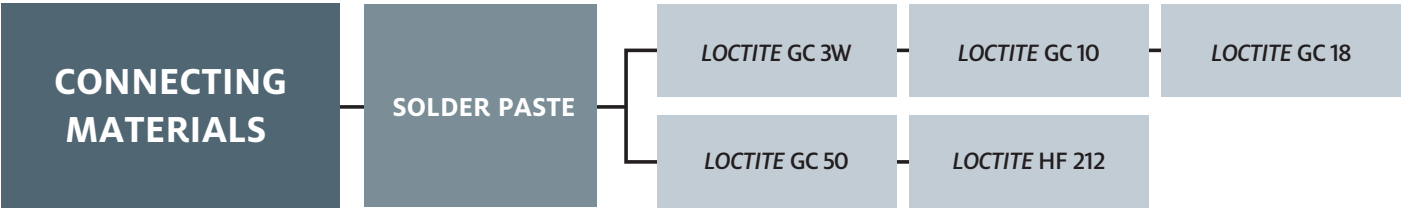
## Material Solutions For Base Band Unit (BBU)





## High-Performance Electrical Function

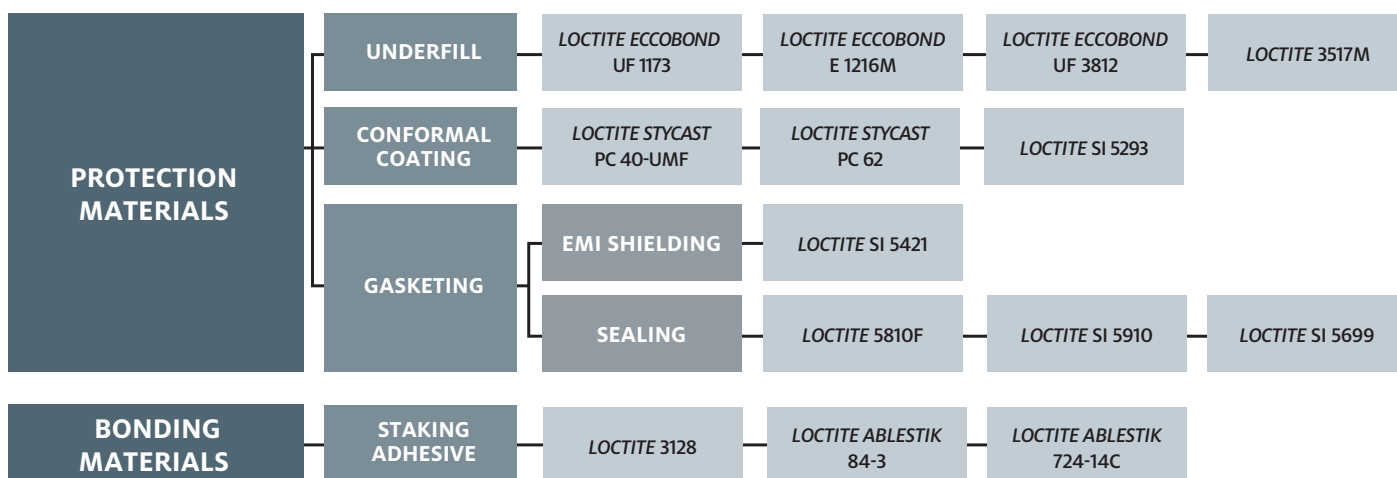
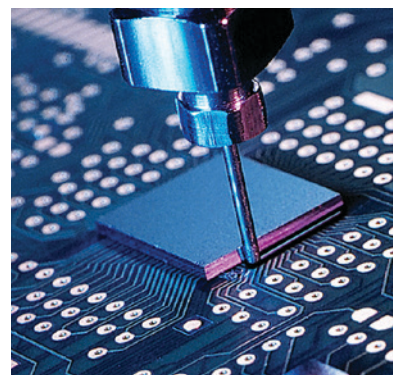
Highly-stable interconnect materials provide fundamental electrical function for reliable telecom infrastructure performance. As many as four printed circuit boards with countless components can make up a single 5G base station and each solder joint is critical to dependable in-field operation. Award-winning LOCTITE® brand solder pastes in lead-free and halogen-free formulations lead the market when it comes to processability, stability and reliability. With sustainability and cost-effectiveness as priorities, Henkel GC solder paste materials are temperature stable, allowing for reduced transport, storage and production costs while minimizing waste and delivering exceptional results.



| Product        | Description                                                                                                                                 | Alloy                                          | Particle Size Distribution                     | IPC J-STD-004B Classification | Optimal Shelf-life     | Reflow Atmosphere |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|------------------------------------------------|-------------------------------|------------------------|-------------------|
| LOCTITE GC 3W  | Pb-free, Water washable, halogen free, temperature stable solder paste                                                                      | • SAC305                                       | • Type 3<br>• Type 4                           | ORM0                          | 6 months up to 26.5°C  | Air and Nitrogen  |
| LOCTITE GC 10  | Pb-free, halogen-free, no-clean, RoHS-compliant, temperature stable solder paste with excellent resistance in high humidity                 | • SAC305                                       | • Type 3<br>• Type 4<br>• Type 5               | ROLO                          | 12 months up to 26.5°C | Air and Nitrogen  |
| LOCTITE GC 18  | 2nd Generation temperature stable solder paste designed for improved void control especially under QFN's                                    | • SAC305                                       | • Type 3<br>• Type 4                           | ROLO                          | 6 months up to 26.5°C  | Air and Nitrogen  |
| LOCTITE GC 50  | Pb-free, no clean, halogen-free jet dispensable solder paste                                                                                | • SAC305                                       | • Type 5                                       | ROLO                          | 6 months at 0 – 10 °C  | Air and Nitrogen  |
| LOCTITE HF 212 | Pb-free, halogen-free, high tack, low voiding solder paste with excellent fine pitch coalescence and extended stencil life and abandon time | • SAC0305<br>• SAC0307<br>• SAC0387<br>• 90iSC | • Type 3<br>• Type 4<br>• Type 4.5<br>• Type 5 | ROLO                          | 6 months at 0 – 10 °C  | Air and Nitrogen  |

## Bonding and Protection for Demanding Environments

For reliable 5G, electronics require protection against the environment, RF interference, in-operation stress, moisture and corrosion that can occur given the demanding conditions in which various network components are placed. Materials that secure enclosures, seal sensitive devices, provide interconnect protection for high-power components such as large ASICs used in antennas and base stations, and conformal coatings to protect critical remote radio PCBs from moisture and corrosion are all part of Henkel's expansive 5G materials portfolio.



### Protection Materials

| Product                  | Description                                                           | Viscosity (cP) | Coefficient of Thermal Expansion, CTE, ( ppm/°C) |                      | Glass Transition Temperature, T <sub>g</sub> | Pot Life (day) |
|--------------------------|-----------------------------------------------------------------------|----------------|--------------------------------------------------|----------------------|----------------------------------------------|----------------|
|                          |                                                                       |                | Below T <sub>g</sub>                             | Above T <sub>g</sub> |                                              |                |
| LOCTITE ECCOBOND UF 1173 | Low CTE, high T <sub>g</sub> underfill for extreme T-Cycle conditions | 7,500          | 26                                               | 103                  | 160                                          | 2              |
| LOCTITE ECCOBOND E 1216M | Fast flow, non-anhydride underfill                                    | 4,000          | 35                                               | 131                  | 125                                          | 3              |
| LOCTITE ECCOBOND UF 3812 | Room temperature flow, reworkable underfill                           | 350            | 48                                               | 175                  | 131                                          | 3              |
| LOCTITE 3517M            | Low temperature cure, reworkable underfill                            | 2,600          | 65                                               | 191                  | 78                                           | 7              |

| Product                   | Description                                                                                                                                                                    | Cure Schedules                    | Viscosity (cP) | Operating Temperature Range |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|----------------|-----------------------------|
| LOCTITE STYCAST PC 40-UMF | Rapidly gels and immobilizes when exposed to UV light and fully cures when exposed to atmospheric moisture                                                                     | 10 sec. UV + 3 days at RT         | 250            | -40°C to 135°C              |
| LOCTITE STYCAST PC 62     | Conformal coating that provides environmental and mechanical protection. Toluene-free alternative with superior toughness, abrasion resistance and fluorescence under UV light | 24 hr. at 25°C or 45 min. at 75°C | 52             | -40°C to 125°C              |
| LOCTITE SI 5293           | Repairable, solvent-free, medium viscosity, UV/moisture silicone                                                                                                               | 20 sec. UV + 3 days at RT         | 600            | -40°C to 200°C              |

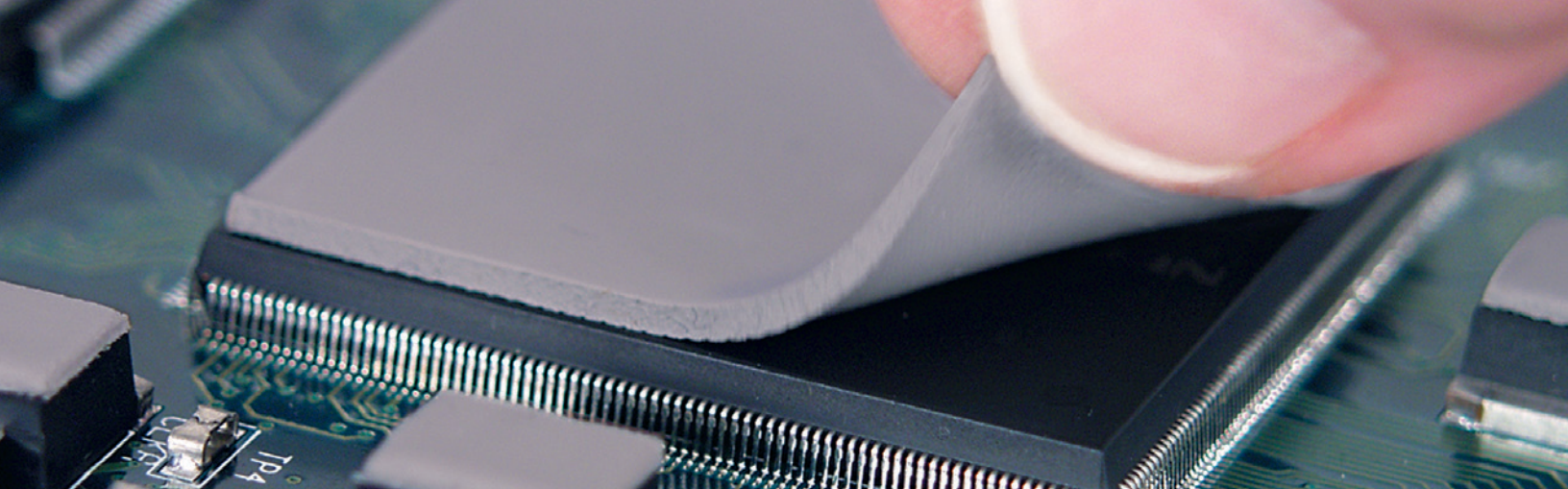
## Protection Materials – Continued

| Product          | Description                                                                                                                  | Chemistry       | Viscosity (cP) | Cure Condition (25°C / 50±5 % RH ) | Cure Type |
|------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------|----------------|------------------------------------|-----------|
| LOCTITE® SI 5421 | Electrically conductive room temperature vulcanizing (RTV) silicone for bonding and gasketing of EMI/RFI shielded enclosures | Alkoxy Silicone | Paste          | ≤ 60 min.                          | RTV       |
| LOCTITE 5810F    | Form in place gasketing primarily designed for sealing plastic and metal housings on electronic components                   | Polyacrylate    | Paste          | ≤ 120 min.                         | RTV       |
| LOCTITE SI 5910  | One-component, silicone sealant designed for sheet metal covers with good oil resistance                                     | Oxime Silicone  | Paste          | ≤ 40 min.                          | RTV       |
| LOCTITE SI 5699  | One-component, silicone sealant has excellent adhesion and can be used to seal electronic components                         | Oxime Silicone  | Paste          | ≤ 30 min.                          | RTV       |

## Bonding Materials

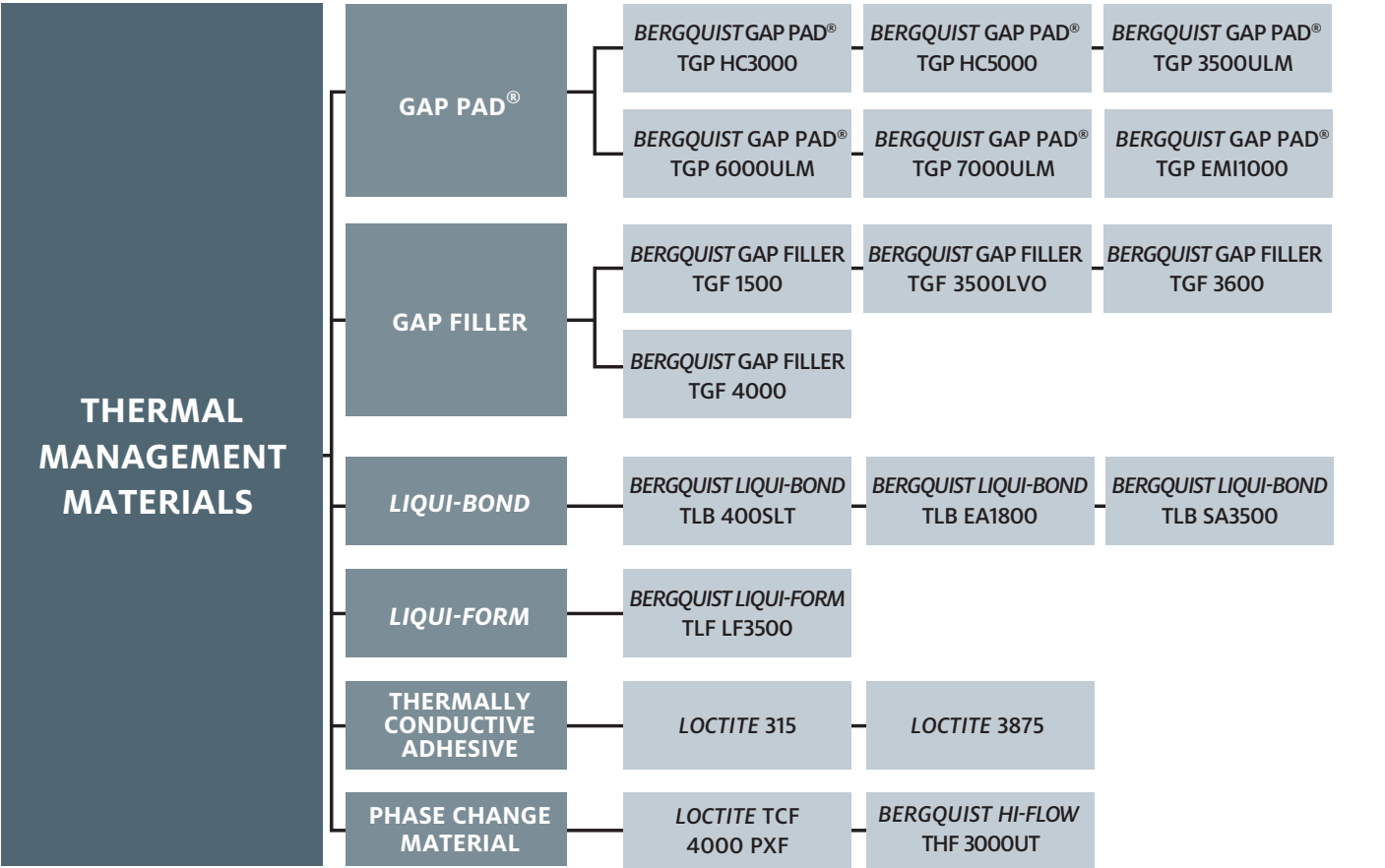
| Product                  | Description                                                                                                                                           | Viscosity (cP) | Volume Resistivity (Ω•cm) | Lap Shear Strength (psi) | Cure Condition  |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------|--------------------------|-----------------|
| LOCTITE 3128             | One part, heat curable epoxy designed to cure at low temperature and gives excellent adhesion on a wide range of materials in considerably short time | 44,000         | 2.9×10 <sup>16</sup>      | 3,000                    | 20 min. at 80°C |
| LOCTITE ABLESTIK 84-3    | Electrically insulating material for chip attach applications that eliminates concerns of reliability and outgassing                                  | 50,000         | 3.5 X 10 <sup>13</sup>    | 2,700                    | 1 hr. at 150°C  |
| LOCTITE ABLESTIK 724-14C | Polyurethane adhesive with excellent adhesion even in cryogenic conditions. Can be cured at room and elevated temperatures                            | 500,000        | 1 X 10 <sup>10</sup>      | 1,700                    | 72 hr. at 25°C  |





# Fail-Safe Thermal Management

5G telecom infrastructure components, most of which are positioned outdoors 24/7/365, are subjected to demanding conditions including extreme temperature swings, wind and moisture exposure and, vibration, to name a few. Not only must systems withstand these stresses, but they must do so while also packing exponentially more power and processing capability than their predecessors. With active cooling limited to environmental air flow, thermal management solutions for 5G infrastructure devices must be able to provide the consistent thermal relief necessary to ensure reliable performance and long lifespans. Thermal interface materials (TIMs) from Henkel are offered in multiple formats including pads, gels, liquids and adhesives to offer high-volume manufacturing compatibility, accommodate design complexities and maximize system reliability.



## Thermal Management Materials

### GAP PAD®

| Product                        | Description                                                                                 | Chemistry     | Thermal Conductivity (W/m•K) | Hardness       | Dielectric Breakdown Voltage (Vac) | Volume Resistivity ( $\Omega \cdot m$ ) | Reinforcement Carrier      |
|--------------------------------|---------------------------------------------------------------------------------------------|---------------|------------------------------|----------------|------------------------------------|-----------------------------------------|----------------------------|
| BERGQUIST GAP PAD® TGP HC3000  | High-compliance, thermally conductive, low modulus material                                 | Silicone Base | 3                            | 15 (Shore 00)  | > 5000                             | $10^{10}$                               | Fiberglass                 |
| BERGQUIST GAP PAD® TGP HC5000  | High-compliance, thermally conductive, low modulus material                                 | Silicone Base | 5                            | 35 (Shore 00)  | > 5000                             | $10^{10}$                               | Fiberglass                 |
| BERGQUIST GAP PAD® TGP 3500ULM | Highly conformable, thermally conductive, ultra-low modulus material                        | Silicone Base | 3.5                          | 70 (Shore 000) | > 5000                             | $10^{10}$                               | With or without fiberglass |
| BERGQUIST GAP PAD® TGP 6000ULM | A high performance, 6 W/m•K silicone thermal interface material, ultra-low modulus material | Silicone Base | 6                            | 60 (Shore 000) | > 5000                             | $10^{10}$                               | Fiberglass                 |
| BERGQUIST GAP PAD® TGP 7000ULM | A 7 W/m•K, extremely soft GAP PAD® with exceptional thermal performance at low pressures    | Silicone Base | 7                            | 75 (Shore 000) | > 5000                             | $1.2 \times 10^{11}$                    | None                       |

| Product                        | Technology | Application   | Key Attributes                                                                                                                                                                                                                     | Thickness (in./mm) | Shore Hardness (Shore 00) | Thermal Conductivity (W/m•K) |
|--------------------------------|------------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------------------|------------------------------|
| BERGQUIST GAP PAD® TGP EMI1000 | Silicone   | EMI Absorbing | <ul style="list-style-type: none"> <li>• EMI absorbing</li> <li>• Highly conformable</li> <li>• Low hardness</li> <li>• Fiberglass reinforced for puncture, tear and shear resistance</li> <li>• Electrically isolating</li> </ul> | 0.508 – 3.175      | 5                         | 1.0                          |

### GAP FILLER

| Product                          | Description                                                       | Chemistry         | Thermal Conductivity (W/m•K) | Hardness (Shore 00) | Dielectric Strength (V/mil) | Volume Resistivity ( $\Omega \cdot m$ ) | Cure Schedule (25°C / 100°C) |
|----------------------------------|-------------------------------------------------------------------|-------------------|------------------------------|---------------------|-----------------------------|-----------------------------------------|------------------------------|
| BERGQUIST GAP FILLER TGF 1500    | Thermally conductive, liquid gap filler material                  | 2K, Silicone Base | 1.8                          | 50                  | 400                         | $10^{10}$                               | 5 hr./10 min.                |
| BERGQUIST GAP FILLER TGF 3500LVO | Thermally conductive, low outgassing, liquid gap filling material | 2K, Silicone Base | 3.5                          | 40                  | 275                         | $10^{10}$                               | 24 hr./30 min.               |
| BERGQUIST GAP FILLER TGF 3600    | Thermally conductive, liquid gap filling material                 | 2K, Silicone Base | 3.6                          | 35                  | 275                         | $10^{10}$                               | 15 hr./30 min.               |
| BERGQUIST GAP FILLER TGF 4000    | Thermally conductive, liquid gap filler material                  | 2K, Silicone Base | 4                            | 75                  | 450                         | $10^{10}$                               | 24 hr./30 min.               |

## LIQUI-BOND

| Product                                   | Description                                                               | Tensile Strength (psi)               | Lap Shear (psi) | Dielectric Strength (V/mil) | Volume Resistivity ( $\Omega \cdot m$ ) | Breaking Strength (lb/in.) |
|-------------------------------------------|---------------------------------------------------------------------------|--------------------------------------|-----------------|-----------------------------|-----------------------------------------|----------------------------|
| <i>BERGQUIST LIQUI-BOND</i><br>TLB 400SLT | High performance silicone adhesive sealant with an adaptable cure profile | 300                                  | 300             | 250                         | $10^{10}$                               | 25                         |
| Product                                   | Description                                                               | Thermal Conductivity (W/m $\cdot$ K) | Hardness        | Dielectric Strength (V/mil) | Volume Resistivity ( $\Omega \cdot m$ ) | Shear Strength (psi)       |
| <i>BERGQUIST LIQUI-BOND</i><br>TLB EA1800 | Thermally conductive, two-part, liquid epoxy adhesive                     | 1.8                                  | 90 (Shore D)    | 250                         | $10^{10}$                               | 450                        |
| <i>BERGQUIST LIQUI-BOND</i><br>TLB SA3500 | Thermally conductive, two-part, liquid silicone adhesive                  | 3.5                                  | 90 (Shore A)    | 250                         | $10^{10}$                               | 450                        |

## LIQUI-FORM

| Product                                   | Description                                                  | Chemistry         | Thermal Conductivity (W/m $\cdot$ K) | Volumetric Expansion 25 – 275°C (ppm/°C) | Dielectric Strength (V/mil) | Volume Resistivity ( $\Omega \cdot m$ ) | Dispense Rate (g/min.) |
|-------------------------------------------|--------------------------------------------------------------|-------------------|--------------------------------------|------------------------------------------|-----------------------------|-----------------------------------------|------------------------|
| <i>BERGQUIST LIQUI-FORM</i><br>TLF LF3500 | Thermally conductive, one-part, liquid formable gel material | 1K, Silicone Base | 3.5                                  | 200                                      | 250                         | $10^{10}$                               | 40                     |

## THERMALLY CONDUCTIVE ADHESIVE

| Product      | Description             | Thermal Conductivity (W/m $\cdot$ K) | Cure Type         | Dielectric Strength (kV/mm) | Volume Resistivity ( $\Omega \cdot cm$ ) | Shear Strength (psi) |
|--------------|-------------------------|--------------------------------------|-------------------|-----------------------------|------------------------------------------|----------------------|
| LOCTITE® 315 | Acrylic                 | 0.8                                  | Activator or Heat | 678.18                      | $1.3 \times 10^{12}$                     | 1,000                |
| LOCTITE 3875 | Bead on Bead – Acrylate | 1.75                                 | Activator or Heat | 26.7                        | $4.3 \times 10^{14}$                     | 2,400                |

## PHASE CHANGE MATERIAL

| Product                        | Description                                                                                                                    | Key Attributes                                                                                                                           | Thermal Conductivity (W/m $\cdot$ K) | Thermal Impedance ( $^{\circ}C \cdot in^2/W$ )    | Thickness (mm)            | Phase Change Temperature |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------------|---------------------------|--------------------------|
| <i>LOCTITE</i><br>TCP 4000 PXF | Reworkable phase-change thermal interface material suitable for use between a heat sink and various heat generating components | <ul style="list-style-type: none"> <li>Low thermal resistance</li> <li>Non silicone</li> <li>No pump-out, dry-out or pull-out</li> </ul> | 3.4                                  | PXF-8: 0.015 at 20 psi<br>PXF-10: 0.023 at 20 psi | PXF-8: 0.2<br>PXF-10: 0.4 | 45°C                     |

| Product                                | Description                                                                                                        | Key Attributes                                                                                                                                       | Thermal Conductivity (W/m $\cdot$ K) | Thermal Impedance ( $^{\circ}C \cdot in^2/W$ ) | Phase Change Temperature | Thickness (mm) | Flammability Rating |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|------------------------------------------------|--------------------------|----------------|---------------------|
| <i>BERGQUIST HI-FLOW</i><br>THF 3000UT | Naturally tacky, thermally conductive phase change material, undergoes a phase change softening starting near 52°C | <ul style="list-style-type: none"> <li>Applied in high volumes to the target surface via low pressure from a roller or manual application</li> </ul> | 3.0                                  | 0.05 at 25 psi                                 | 52°C                     | 0.127 – 0.254  | UL 94 V-0           |

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**Across the Board,  
Around the Globe.**



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