EMI Shielding Caulk Delivers Superior Performance in Military Radar Systems

Parker

ENGINEERING YOUR SUCCESS.

Next Generation EMI Shielding Caulk

Delivers Superior Performance Over Legacy Caulks in Military Electronic Systems

Nick Pascucci,
Product Development Engineer

Nick has been working for Parker Chomerics for 8 years developing new Specialty Materials for advanced EMI Shielding applications. Nick attended the University of Rhode Island majoring in Chemical Engineering and is pursuing his Masters in Chemical Engineering at UMass Lowell.

Shielding for electromagnetic interference (EMI) is critical to military electronics systems operating in demanding environments requiring low emitted electronic signatures and protection from electromagnetic radiation. In mobile military applications, EMI shielding must be maintained during storage, transport and operation in a wide variety of demanding and corrosive environments.

An integral part of the EMI shielding system is an EMI shielding caulk that seals the seams on external structures from panel to panel to ensure conductivity around the entire system. The caulking maintains a faraday cage that protects the internal electronic components against external electromagnetic interference and/or electromagnetic pulses (EMP). This prevents a possible failure mode of the EMI shielding enclosure when two metal panels are joined together without protecting the seam with a reliable caulking. If there is no caulking or if an inferior caulking fails, there is a significant opportunity for EMI emissions/susceptibility.

Parker Chomerics has developed the next generation EMI shielding caulk for use on military radar shelters.

The new CHO-BOND® 1019 provides a substantial increase in performance over existing legacy materials by improving EMI shielding performance, corrosion resistance and by reducing application time. In addition, the new CHO-BOND® 1019 is paintable, eliminating the need for expensive intermediate layers. Along with better shielding performance, these features translate to significant savings by reducing manufacturing and material cost, increasing throughput, increasing the working life of the shelter and reducing maintenance costs.

Military electronics systems operating in demanding, corrosive environments.

Military Systems Require Rugged Performance

EMI shielding plays a major role in military applications. The U.S. military has utilized EMI shielding caulks for decades on electronics' housings such as radar shelters, radar test facilities, etc. A popular example, the AN/MSQ-104 Engagement Control Station (ECS), the command and control unit of the Patriot Missile firing battery, is housed in an EMI shielded radar shelter mounted onto the bed of a cargo truck or similar vehicle. Whether the ECS is being transported or operated under battle conditions, it experiences jolts and vibrations that can fatigue the rivets holding the aluminum shelter panels together. Any loosening of the rivets will compromise the integrity of the EMI Shielding system around the command and control electronics inside the unit.

This would result in the system being vulnerable to EMI, thereby risking the proper operation or exposure to enemy anti-missile systems. This risk must be minimized since the U.S. Army and allied nations rely on the Patriot as their primary anti-ballistic missile system in the mission to protect strategic areas. Systems such as the AN/MSQ-104 have advanced technologically and increased in usage over the years. Furthermore, newer electronic components require even more EMI shielding levels that legacy caulks cannot attain.

CHO-BOND 1019 is a fast-curing, paintable caulk that provides improved shielding and corrosion properties over the traditional caulks.

The command and control unit of the Patriot Missile firing battery.

Features and benefits of CHO-BOND 1019

- **Paintability - no intermediate polysulfide layer means reduced labor and materials.**
- **Faster cure for increased throughput and reduced inventory costs.**
- **Increased application temperature range equals decreased heating / cooling costs.**
- **Improved EMI shielding performance for better EMP protection and ability to use more equipment.**
- **Superior corrosion resistance extends working shelter life.**
- **Increased flexibility for reduced vulnerability to transportation and vibration.**

Legacy EMI Shielding Caulks Failure Modes

Legacy EMI shielding caulks are single-component, non-hardening compounds made of traditional materials such as silicone filled with silver-plated copper. A key vulnerability of these materials traditionally has been corrosion issues. These legacy formulations have shielded against EMI but now fall short in applications where modernized high speed and high energy electronics are concerned. These advanced electronics are more sensitive to EMI and operate in a wider range of frequencies and, therefore, require improved shielding across the frequency range to receive proper protection.

In order to provide improved shielding and corrosion resistance, it is necessary to use conductive fillers that deliver high levels of shielding typically provided by silver-plated particles while improving upon the mediocre corrosion resistance typically experienced with copper-based particles. Three different conductive particles were considered for this:

- Silver-plated aluminum
- Nickel-plated aluminum
- Nickel-coated graphite

Since the theoretical shielding effectiveness of a material is determined by its electrical conductivity and magnetic permeability, silver-plated and nickel-plated particles are considered excellent choices. Also, since the galvanic corrosion resistance of a material is determined by its similarity to the material it has come in contact with (aluminum panels) and the kinetics of the resulting reaction, aluminum-based particles are preferred, but graphite-based particles could also be considered a viable option.

EMI shielded radar shelter mounted on a cargo truck. For improved shielding and corrosion resistance, careful consideration of filler-polymer combination is necessary.

Combining a high-performance polymer with a high-performance, conductive filler does not necessarily translate into a high-performance product. There are other elements that must be considered to achieve real results from the final product. First, the “resin demand” of the filler will dictate the minimum resin-to-filler ratio capable of providing a workable caulk. If this minimum ratio is too high, proper shielding will never be achieved. Careful selection of a filler-polymer combination is necessary since the resin demand is a function of the size and morphology of a particle and the liquid properties of the uncured polymer. Second, the binding properties of the polymer resin will dictate the degree to which the conductive filler particles are held together in the matrix. If this is not adequate, shielding performance will suffer and corrosion resistance may decrease. An important binding property is “shrinkage”. When a liquid polymer cures, there is a certain amount of decrease in overall volume that occurs as a result of the tightening of the filler-containing matrix, which maximizes the impact of the filler’s inherent conductive properties. When polymers lose their tightly bound matrix, whether due to environmental exposure or changing physical loads, the final product fails to retain the performance properties which the filler is otherwise capable of delivering.

Scientific Testing and Trial Formulations

Several trial formulations were subjected to initial shielding effectiveness testing in order to separate the products with the potential for success from products unlikely to be improved during development. During this process, it was determined PTE experienced resin-demand issues when mixed with nickel-plated aluminum. Consequently, the associated formulation was left out of further testing. The final four trial formulations (along with the control compounds) subjected to the full battery of shielding and environmental testing included:

1 Silver-plated aluminum (Ag/Al) filled PTE (Cho-Bond® 1019)
2 Silver-plated aluminum (Ag/Al) filled PU
3 Nickel-plated aluminum (Ni/Al) filled PU
4 Nickel-coated graphite (Ni/C) filled PTE

The two control materials were currently available alternatives offered by other EMI shielding manufacturers:

1 Silver-plated copper (Ag/Cu) filled silicone
2 Nickel (Ni) filled PTE

The full battery of tests included:

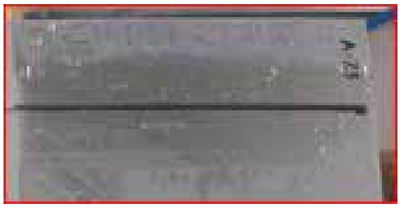
- Environmental Testing (ET)
- Shielding Effectiveness (SE)
- Physical Testing

The environmental tests measured the effect of thermal cycling on adhesion (ASTM D3359) and flexibility of the epoxy-painted compound and the effect of salt fog (ASTM B117, 1000 hours total) on the compounds and aluminum panels with and without the protective paint. The SE tests (IAW modified IEEE-STD-299) measured the effect of thermal cycling and salt fog (ASTM B117, 1000 hours total) on the compounds' ability to shield against EMI. Lastly, the physical tests measured the cured compounds' ability to adhere to the aluminum panels and also verified adequate workability of the uncured compounds for application purposes.

Ag/Cu Control

Ag/Al PTE

Ni/C PTE



Each ET panel was comprised of two 12" x 4" x 1/32" panels riveted together with a 1" overlap to create a 12" x 7" x 1/16" test panel. These panels had the compounds applied to them on both surfaces in a manner resembling their actual intended application and were then painted with the MIL-PRF-22750 epoxy coating on only one side of each surface. Test specimens for each compound were then exposed to three rounds of salt fog (166, 500, and 1000 total hours) with the results showing all four of the trial materials performed far better than the Ag/Cu control, especially in the unpainted sections of the panels. Other than traces of surface oxidation, there were no signs of corrosion on the trial materials while the control had clear signs of galvanic corrosion even through the polysulfide environmental seal.

Other specimens with the same compounds were exposed to thermal cycling (157°F to -57°F) and then had wet and dry tape adhesion and flexibility testing performed. All of the compounds showed adequate adhesion and flexibility except for the Ni PTE control, which showed poor adhesion of the MIL-PRF-22750 coating. This would be unacceptable for all applications which require the adhesion of an epoxy coating. Consequently, the Ni PTE control was removed from further testing.

Scientific Testing and Trial Formulations

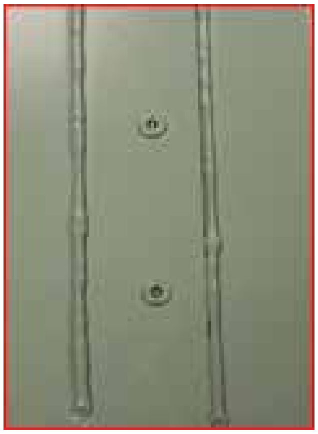
Each SE test panel was 26” x 26” x 1/4” with a 3/8” through-slot down the middle. The SE panels were mounted to the wall of the Chomerics SE test chamber and attenuation measurements were taken before and after the slots were filled with the conductive compounds and painted. The panels were then exposed to thermal cycling (157°F to -57°F). SE tests were performed and followed by three rounds of salt fog (166, 500, and 1000 total hours). The results showed the Ag/Al PU to have poor shielding even before thermal cycling and the Ni/Al PU lost its shielding ability after 500 hours of salt fog. The Ni/C PTE compound retained adequate shielding throughout and the Ag/Al PTE was exceptional throughout compared to the remaining Ag/Cu silicone control compound.

Physical tests included lap shear according to ASTM C961, hardness according to ASTM C661 and also the uncured compounds’ change in flow rate over time according to ASTM C603. Results showed the cured PTE trial materials to be stronger and harder than the control while also retaining good workability for application purposes. While every compound needs to be tried out in each given application, it’s easy enough to adjust a formulation to make a strong compound more workable when necessary.

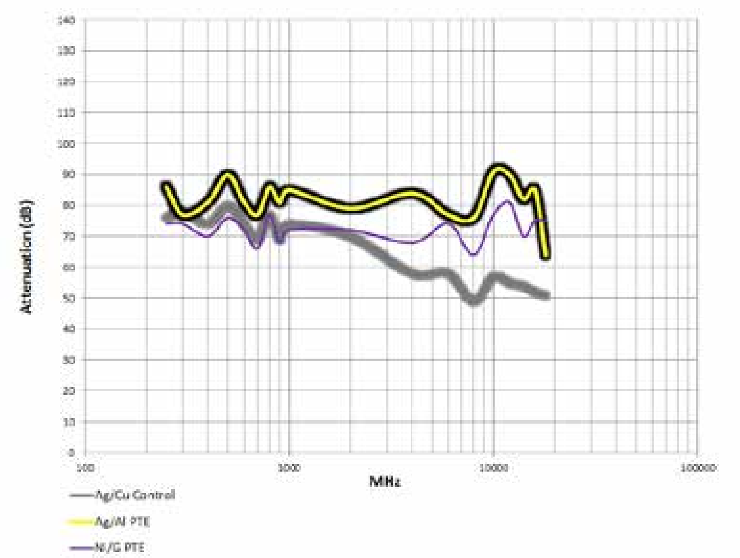
These results, along with those from environmental and SE testing, indicate that both PTE-based compounds are superior to the incumbents. The Ag/Al PTE was the “standout” with its 80 dB shielding and would be the preferred replacement for any existing EMI shielding caulk. The Ni/C PTE exhibited moderate shielding compared to the Ag/Al version. Both showed no signs of galvanic corrosion between the compound and the aluminum panel after 1000 hours of salt fog exposure. It should be further emphasized that both PTE materials have a wider application temperature range than their predecessors, are paintable 24 hours after application, and do not require a polysulfide paintable sealant. They will save application costs and field repair costs while delivering equal or better operating performance than current industry favorites.

Ni PTE Control

Ag/Al PTE



Shielding Effectiveness (1000 hours)



Application Challenges

Application issues to be addressed in addition to the subjected trial formulations

The following application issues should be addressed in addition to the subjected trial formulations:

- Compound cure time
- Application temperature ranges
- Ease of paintability with camouflage patterns

Often, epoxy-based paints applied to radar shelters will not adhere to silicone compounds. In this case, it is necessary to apply a polysulfide environmental sealant over the caulk to provide a paintable surface. The caulk and the polysulfide each require seven days (fourteen days total) to cure and must be applied in a temperature-regulated environment to ensure proper final-cured properties. In manufacturing, the fourteen days of waiting are logistically time-consuming and costly. Maintaining acceptable warehouse temperatures for application is also challenging.

CHO-BOND® 1019 cures quickly and requires less time in narrow temperature ranges after application. Legacy caulks regularly experience cracking and corrosion over time, which leads to costly field repairs. CHO-BOND® 1019 resists cracking and corrosion significantly over those legacy products.

Radar Installation

Optimizing the Process

With CHO-BOND 1019 Caulk

The next-generation CHO-BOND 1019 is a fast-curing, paintable caulk that provides improved shielding and corrosion properties over the traditional caulks. It also has an improved application temperature range. In this product, we combine our metallic filler technology with cutting-edge base polymers to provide a unique formulation. This new technology transcends the legacy EMI shielding caulks as well as those compounds recently developed for similar modern military applications.

Our R&D engineers are experts at filler-resin combinations that will deliver the performance improvements necessary for the latest technologies. In this effort, our team benefits from its proximity to the University of Massachusetts - Lowell and its internationally recognized Plastics Engineering Department as well as Harvard Medical School's Core Facilities. Between Harvard and UML, they have the polymer research experience and test facilities to complement our product development capabilities and EMI shielding test service facility; thus providing an edge on developing these types of polymer and conductive particle combinations.

"Our CHO-BOND 1019 is the newest lowest cost material that delivers exceptional long term EMI and corrosion resistance performance on the market today"

— Robert Foster, Global Business Unit Manager, Parker Hannifin Chomerics Division

Parker Chomerics

Our innovative products are custom engineered, providing advanced solutions for the most demanding military applications

About us

Parker Chomerics Division is a total solutions provider of EMI Shielding, Thermal Management, Integrated Display Products, Engineered Plastics and Metal Based Assemblies. These products built on core competencies in material science and process technology, serving as the basis for:

Product development
Custom engineered solutions
Integrated electronics housings and displays
Supply chain management

Chomerics Division has been working closely with customers to provide superior customize solutions for all of our customers most demanding needs.

Our strong technology portfolio has delivered cutting edge solutions to our global customers serving the following markets:

Military
Telcom/IT
Automotive & Transportation
Aerospace
Consumer
Semiconductor
Industrial
Medical & Life Sciences

Parker Hannifin Corporation
Chomerics Division
77 Dragon Court
Woburn, MA 01888
phone 781 935 4850
fax 781 933 4318
CHOinfo@parker.com
www.parker.com/chomerics