

Using Connector Lubricants for Warranty Reduction

By Kevin D. Akin

The Apollo Program had more electrical connector problems than all other problems combined. And though most earth-bound products do not have anywhere near as many contacts as a NASA rocket, connector headaches can be some of the most annoying — and costly.

For the consumer, faulty connectors usually mean intermittent operation, so perceived quality and the manufacturer's reputation take a nose-dive. For OEMs — and increasingly for their component suppliers — connector troubles mean more customer service calls, more field maintenance, and more part or product replacements.

The good news, however, is that manufacturers can reduce or eliminate most pesky connector issues simply by applying the right lubricant to the contacts. Extensive testing and a long track record in the automotive, aerospace, appliance, computer, and telecommunications industries confirm that lubricants protect electrical contacts from wear and corrosion, a common cause of intermittency; reduce insertion forces, even for connectors with hundreds of pins; and extend the operating life of any stationary separable connector, tin/lead or gold.

A PEAK EXPERIENCE

If lubricants are insulators in bulk, how can they enhance the performance of a connector, where contact resistance must be minimal? The answer is found on the lunar-landscape-like surface of a contact.

On a microscopic level, the contact surface is a series of peaks and valleys. Current only flows where the peaks or

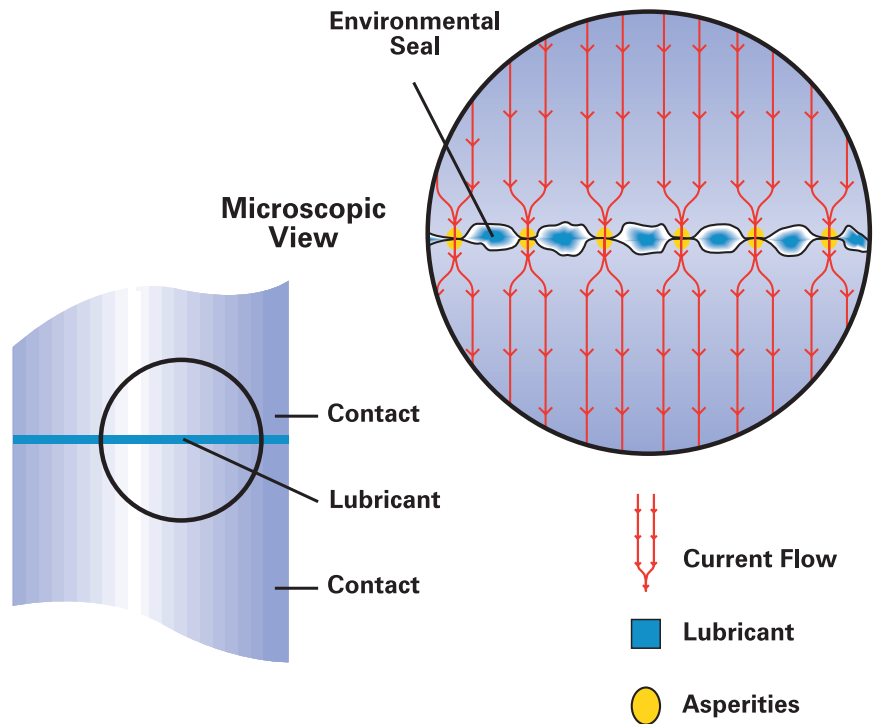


Figure 1: Contact and Lubricant The contact surface is a series of peaks and valleys. Current only flows where the peaks or asperities touch. When the normal force on the contact is distributed across the tips of the asperities, it easily squeezes the lubricant out of the contact zone, eliminating resistance. In the “valleys,” the lubricant coating continues to protect the contact from environmental and fretting corrosion.

asperities touch (*Figure 1*). The actual contact area, therefore, is rather small — in some cases, less than 1% of the entire contact. When the normal force on the contact is distributed across the tips of the asperities, pressure increases to hundreds of pounds per square inch, easily forcing the lubricant out of the contact zone. In fact, tests show virtually no difference in contact resistance between lubricated and unlubricated connectors, however, there is an unmistakable difference in connector performance and operating life.

A connector lubricant helps minimize environmental and galvanic corrosion. Even properly mated connectors can be

An edited version of this article was published in *Connector Specifier*, August 1999.

Table 1 Cost/Performance of Common Connector Base Oils

	Temperature Range (°C)	Relative Cost* (1-5)	Material Compatibility Plastic & Elastomers
Petroleum	-20 to 100	1	Fair
Synthetic Hydrocarbon	-60 to 125	2	Good
Fluoroether (PFPE)	-80 to 250	5	Excellent
Polyphenyl Ether (PPE)	+20 to 225	5	Good

**While synthetic lubricants may cost more than petroleum-based lubricants, they generally can be used in smaller quantities.*

exposed to oxygen, moisture, and aggressive gasses that can attack non-noble plating. A lubricant passivates the surfaces and keeps contaminants from the contact interface.

Tin and tin/lead contacts are prone to fretting corrosion, a phenomenon that occurs when thermal cycling or mechanical vibration cause contact surfaces to rub against each other. This micro-motion continually abrades thin tin-oxide layers and exposes fresh tin. Over time, the tin-oxide builds and interferes with current flow. Fretting-related intermittency is a common ‘ghost,’ sometimes temporarily remedied by separating and remating the connector. The proper lubricant helps to seal the contact surface and slows this oxidation process.

Gold-plated contacts have their own “corrosion” problem. Due to the softness of the metal, they are particularly susceptible to galling during mating and unmating. When thinner flashes of gold are used to reduce costs, the problem is exacerbated. If noble metal plating is worn or porous, oxygen can attack the substrate. Over time, oxides eventually exude through the pores and impair conductivity. A connector lubricant will reduce mating wear and help seal minute fractures in the plating to prevent substrate oxidation.

For multi-pin connectors, mating forces increase significantly. With smaller dimensions, tighter footprints, and hundreds of pins, misalignment, a common occurrence with multi-pin connectors, can wear or gall the contacts. A lubricant reduces the coefficient of friction between the mating surfaces by as much as 80%, easing insertion while protecting contact surfaces.

INTO THE MARKET

Countless real-life applications demonstrate how a lubricant is used to improve connector performance (Figure 2).

Moore Process Automation Solutions of Spring House, Pa., designs and manufactures industrial process controls and safety systems, sold under the trade name of APACS+ and QUADLOG. Typically, these products are used in steel mills, petrochemical plants, pulp

and paper plants, and other harsh, corrosive environments. Moore uses a high viscosity, water-resistant fluoroether gel to help control contact corrosion. By combining a 10% sodium hypochlorite (bleach) solution along with non-diluted “black liquor,” organic wastes reclaimed from the pulp-making process, they developed a testing protocol eight times more severe than a standard corrosion test. Unlubricated pins exhibited extensive corrosion. Lubricated contacts operated without failure.

UMI, a business unit in the industrial division of Molex in Orange, Calif., uses a six-ring polyphenylether-based lubricant in control circuits for vehicles used in natural gas mining fields. The circuit connectors, which have up to 50 pins, required a fairly high insertion force, and polyphenylethers (PPEs),

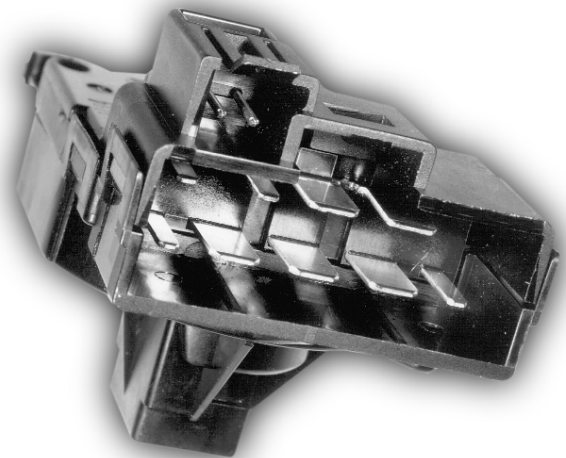


Figure 2: Protecting Automotive Connectors A connector grease would fill the housing of this tin/lead automotive connector to reduce fretting corrosion — and provide a “back-up” environmental seal once the male and female portions are mated.



Figure 3: Dispensing the Grease This semi-automatic connector grease dispensing system, custom designed by LCC/Dispensit of Indianapolis, Ind., allows the operator to dispense minute amounts of grease in multiple locations simultaneously, quickly, and precisely.

known for their excellent lubricity, make it easy to mate the connectors and tighten the threaded housings properly. Additionally, PPE's exceptional oxidative stability ensures long lubricant life, and its tight molecular bonds make it difficult for oxygen to penetrate to the contact surface — a good front-line defense against atmospheric corrosion.

GE Electric Vehicle Motors and Controls Department in Salem, Va., knows how aggravating intermittent connector problems can be. They also know that sometimes all it takes to avoid the problem is a lubricant — not a connector redesign. EMV&C specified a synthetic hydrocarbon grease to prevent fretting corrosion and oxidation in controllers it supplies to manufacturers of industrial trucks, golf carts, and other electric vehicles. It also recommended that electric vehicle owners relubricate connector sockets with the same synthetic grease every one to two years as preventative maintenance. In control studies at a major automotive factory that maintains a fleet of industrial trucks, fretting corrosion maintenance problems plummeted more than 90% after the grease regimen was initiated.

SPECIFYING AN ELECTRICAL CONNECTOR LUBE

The first question to ask is, grease or oil? With very light contact forces and a benign environment, an oil can be used. However, grease — which is a base oil immobilized by a thickener — is often preferred. Unlike oils, grease is less susceptible to migration, so it stays where it is needed.

Several base oil chemistries have been used successfully for connector lubricants (*Table 1*). When selecting a base oil, be sure that it can withstand the temperature range in which the connector must operate. At elevated temperatures, oils are subject to evaporation or thermal degradation. At low temperatures, they can become intractable (*see sidebar, “The Frozen Connector Question”*). Also note that even when selecting a grease, it is the temperature range of the oil — not the thickener — that defines the grease's temperature limits.

Be cautious about material compatibility. While lubricants do not affect most thermoplastics, esters (diesters and polyolesters) are noted for their incompatibility with polycarbonate, PVC, polystyrene, and ABS resins. Material densities (high vs. low) and additives, such as flame retardants, can also have an effect on compatibility. Elastomeric seals are vulnerable as well. Only the fluoroethers are inert enough to be safe with most every seal. While compatibility charts are available from many manufacturers, testing is the only way to guarantee a successful match between a lubricant and a design material.

For water resistance, specify a grease. Even though oils are generally not water-soluble, they are easily displaced by moisture. A grease's water resistance is determined by the thickener. Lithium soap greases have good fresh water resistance, but poor salt-water resistance. Silica can be hydrophobic or hydrophilic. Clay and PTFE generally perform well in wet environments.

GOING INTO PRODUCTION

Applying the right amount in the right location is the key to dispensing connector lubricants during the production cycle. Small connectors that need only a thin layer of lubricant call for a “solvent dispersion,” a grease or an oil (20% or less by weight) mixed into a solvent. When applied the solvent evaporates and leaves behind a thin, uniform lubricant coating. Dispersions and oils can be applied by dipping, brushing, or spraying.

To apply grease, hand-held syringes or brushes can be used for small runs. On production lines, where thousands of contacts or connectors are assembled per hour, special dispensing equipment is usually required. It can precisely dispense minute amounts, in multiple locations simultaneously (*Figure 3*). Most users apply the lubricant to the more accessible pins, but filling the sockets converts them into lubricant reservoirs, especially valuable in connectors where high temperatures can reduce lubricant supply over time.

To facilitate inspection, colored dyes can be added to the lubricant. Usually less than 1% by weight, they are dissolved into the oil and pose no contact issues. Ultraviolet dyes are used in conjunction with optical sensors for fast, automated inspection.

When to apply the lubricant is perhaps the final consideration. Some contact manufacturers or finish platers can provide pre-lubed contacts, but excessive handling of the contacts can remove lubricant. Further, solder baths could degrade the lubricant by exposing it to high temperatures. It can also be difficult to solder over a lubricated area. Whenever feasible, the ideal method is to apply the lubricant just before mating the connector.

The addition of a connector lubricant is an inexpensive way to enhance the quality of an electrical connector. Care must be taken to insure proper lubricant selection — and component testing is always recommended. But if a lubricant reduces warranty costs, the up-front effort will pay for itself many times over. ■

The Frozen Connector Question: How Low Should You Go?

By Kevin D. Akin

Is a connector lubricant helpful or harmful at freezing temperatures? The jury is still out, but here's the case summary.

Assume that you want to use a polyphenylether-based (PPE) lubricant, for several reasons. PPEs have a strong 10-year record as connector lubricants; offer better high-temperature stability (225°C) than polyalphaolefins (PAOs) (125°C); are more lubricious than perfluoropolyethers (PFPEs); and are exceptionally stable. The issue: below +20°C, they begin to solidify.

The “defense” says that's just fine. A frozen lubricant around the asperities on the contact surface (the points through which the current actually flows) keeps the surfaces “locked” together. With no sliding of one contact in relation to the other, you have a stable electrical connection.

The “prosecution” poses an interesting what-if? Suppose the lubricant is on an automotive connector, an industry where -40°C or lower is the standard. Under most conditions, there is no problem. The lubricant's becoming stiff around the contact points does not compromise the intimate metal-to-metal contact. The real issue is relative motion of the two contact surfaces. What if the automobile hits a pothole when the lubricant is frozen? If resulting mechanical shock does cause a contact to move, the asperity alignment will change. Because new surfaces need to connect, the lubricant must be displaced. But with viscosities of millions of centistokes, it will take much longer for the frozen lubricant to be forced out of the contact zone. This can cause an open circuit, and operating problems on control circuits.

While movements of five microns or less are sufficient to reorient the contact, the amount of force necessary to move the contact is generally high. How high, depends on connector designs — which have widely varying geometries, forces, and fastening methods. Since there is no hard and fast rule on low-temperature connector lubrication, one rule does apply: complete application testing is necessary to insure proper operation. And always consider the lubricant as part of the overall connector design.