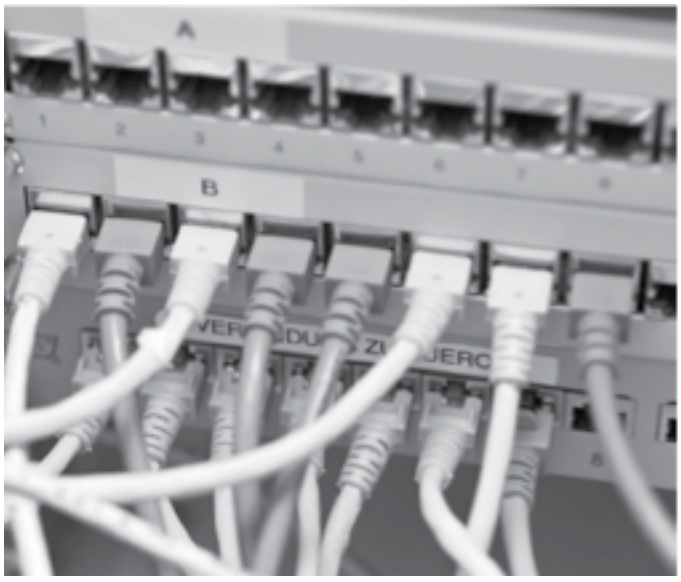
TECHNICAL REPORT

Maximizing Conductive Efficiency of Fuel Cell Connections

By Lisa Rinaldo
President of Prohm-tect USA Sioux Falls, South Dakota
Email: info@prohmtect.com

Fuel cell engineers and technicians responsible for installing fuel cells understand the interface resistance issues resulting from dissimilar metals coming into contact with each other in a connection. Electrically conductive silver paste – a proven resource in other applications – is now proving a reliable corrosion preventative and cooling substance for fuel cell connections. While silver paste is thought of primarily for computer heat sink applications or grounding, it has not generally been a "go-to" substance for fuel cell connectivity. Currently, the major concerns of the fuel cell industry center on electrochemical issues, hydrogen production/delivery/storage, systems analysis, or ways to ensure that fuel cells are reliable, low-cost, and high-performance.

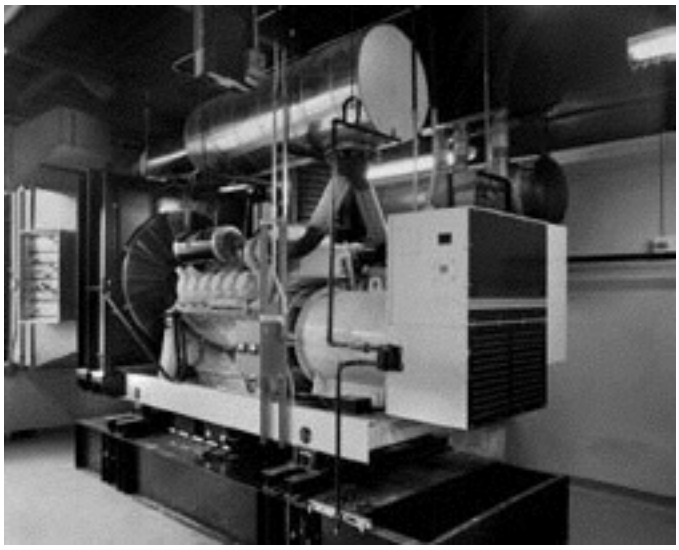


In the drive toward greater reliability inside the fuel cell, reliability of the physical electrical connection to the exterior is often overlooked. Yet, statistics reveal that a high percentage of electrical failures in equipment

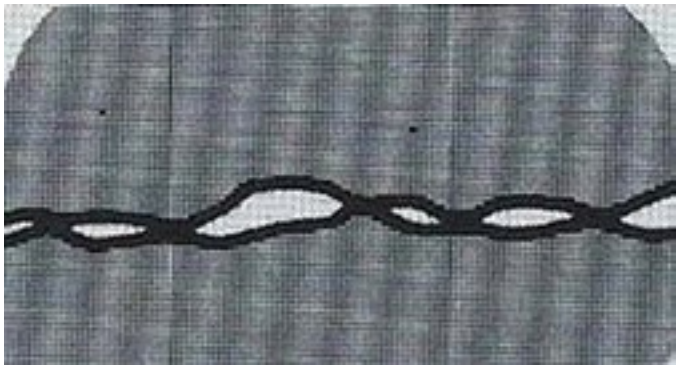
occur in the connection itself, and real-life field experience confirms these numbers. In the case of fuel cells, this deserves a closer analysis.

Silver Paste Multitasks Well

According to Navigant Research's 2013 study for the Department of Energy's Fuel Cell Technologies Market Report, the stationary fuel cell sector is leading the overall global fuel cell industry in production.



Stationary megawatt fuel cells installed in outdoor groupings ("parks"), or cells in CHP (combined heat and power) installations are exposed to environmental humidity, which can produce corrosion on the exterior electrical connection, resulting in reduced conductivity and increasing resistance on the connector interface.

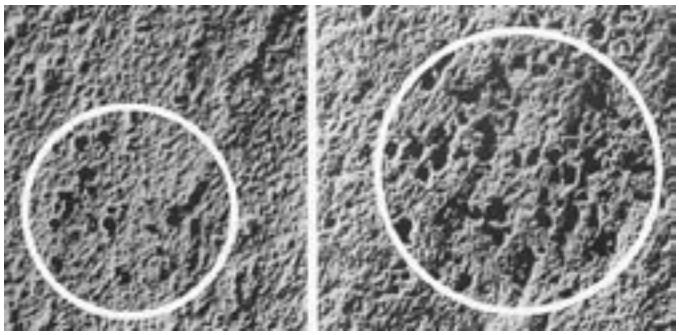


When applied in small amounts to both sides of the connection, silver paste prevents this problem. In addition, if a fuel cell connection has been coated

with silver paste at installation, it will be easier to disconnect for repair or replacement due to the lubricity of the silver. A fresh application of silver on re-installment will ensure years of corrosion-free, efficient conductivity, and protection from moisture and other environmental contaminants.

The cooling properties of silver in conductive paste reduce the extreme heat generated in the connection itself – which can range up to 350-550°C, depending on the type of fuel cell. (If the temperature of the connection interface exceeds 290°C, then the carrier of the silver disappears, leaving no residue – just silver.) When the connection contains rods or bolts that are threaded, these expand-or stretch – with the heat and change the conductivity. Again, silver paste prevents damage to rods and bolts by lowering the resistance at the interface, with the additional benefit of having them become conductors of current.

Another consideration when seeking maximum conductivity from a fuel cell is this: A microscopic view of any metal-to-metal contact involved in the connection reveals tiny pits, which reduce the conductive efficiency at the contact interface and may cause voltage fluctuations.



Despite the most precise polishing, or even coating a plate with silver or other metal, some irregularities in the surface of the plate will remain. However, silver paste, when heated, becomes like a flexible plating, actually flowing into the microscopic pits, providing millions of points of connection for the current to follow and maintaining a superior connection. This is a simple solution that eliminates physical remediation on the connectors, installation delays, or costly downtime resulting from connective problems.

Ingredients Matter

John Ebbinghaus, a senior engineer with Prohm-tect USA, a conductive electrical paste manufacturer in Sioux Falls, South Dakota, has 40-plus years of experience formulating silver conductive pastes and performing materials failure analysis for companies. He warns, “Not all silver paste is created equal. Most of it is formulated with a silicone oil or grease, to keep costs down. However, silicone often cakes and dries out in time, especially in high-heat applications. It also migrates along wiring insulation, causing problems in other parts of equipment. It’s essential to use a paste with a non-silicone oil base for fuel cell connectors.” Furthermore, silicone greases can introduce a form of connector failure, especially when exposed to salt, which combines with the silicone to form a thin, hard film or even grains of hard-to-remove sodium silicate.

Ebbinghaus began his foray into pastes by inventing a unique stainless-steel alloy paste for the Navy’s use on aircraft guidance systems, then went on to create a specialty silver paste in 2008 for a large U.S. fuel cell manufacturer. Although the formula took several years of testing to perfect, “In the end, they were very pleased that the conductive efficiency of their cells rose to 94% at the connection without damaging the connectors. The average fuel cell conductive efficiency at a connection is in the 80-85% range. Now that we’ve witnessed and tested the performance of silver paste on fuel cell connections for six years, we know that this new application for silver paste will be of interest to other fuel cell manufacturers as well, from stationary to transportation-related.”

Wide Range of Applications

As one example, the March/April issue of *Advanced Fuel Cell Technology* Journal highlights a new fuel cell demonstration project led by Sandia National Laboratories: “a portable, self-contained hydrogen fuel cell unit that can float on a barge, sit on a dock or be transported to wherever it’s needed to provide electrical power.” Plans call for the unit to be deployed in the Port of Honolulu, where salt spray and moisture will threaten electrical connections, as in any port where future units will be located. Corrosion, together with wind and vibration combine to produce an inhospitable environment for electrical connections, including those of fuel cells.

In urban locations, during major natural disasters, fuel cell reliability is crucial for continuous electrical service to businesses, hospitals, schools, and emergency shelters. Silver paste on connections in those settings could mean the difference between continued power to critical facilities or a power outage crisis.

Other sectors of fuel cell use, such as in materials handling equipment and transportation, also offer opportunities to put the protective and conductive properties of silver paste to good use. Besides exposure to moisture, heat, dust, and dirt from the environment, one of the issues encountered in vehicle and bus fuel cell connections is vibration loosening the connections and/or causing fretting. Silver paste ensures an effective connection due to the particles of silver maintaining contact with both sides of the connection at all times. For rapid-recharging stations for electric buses, the cooling action of silver paste would help extend the lifespan of the charging contacts, extending the lifespan of the cell itself. Navsea (Navy) publication SD-18 on

connector failure mechanisms recently stated, “Repeated mating and un-mating results in physical wear of the contact material, affecting the integrity of the connecting interfaces, the connector shell engagement interfaces, and the mounting/cable attachment hardware. The result can be a significantly increased interface resistance, and in power connection applications, an increase in temperature at the interface that can accelerate further contact interface deterioration.”

An Ounce of Prevention

Is silver paste worth the cost and time to add it to fuel cell connections? First, it is important to note that conductive silver paste and inexpensive dielectric grease are not the same thing. Dielectric grease contains no conductive metal and is applied liberally to block out moisture. However, silver paste is applied by service technicians to connectors in a very thin film at the time of installation and again if the fuel cell is disconnected for repair. The product can be purchased in a kit format, containing a syringe of silver paste, alcohol wipes, a lint- free cloth, and finger cots, for application in the field.

At approximately $10 for a CC (cubic centimeter), which provides one application covering about 10 square inches, you can argue that a little paste delivers a high return on investment to prevent problems and protect crucial connections.

Lisa Rinaldo is president of Prohm-tect USA (www. prohmtect.com), a company that develops and markets electrically conductive pastes. She can be reached at info@ prohmtect.com.