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Number 008

APPLICATION NOTE

Use of Stabilant 22 for Marine Electrical/Electronics Maintenance

Introducing Stabilant 22

Stabilant 22 is an initially non-conductive block polymer which when used in a thin film between metal contacts becomes conductive under the effect of an electrical field. This occurs at an electric field gradient such that the material will remain nonconductive between adjacent contacts in a multiple pin environment. In addition, Stabilant 22 exhibits surfactant action as well as lubrication ability, providing a single component resident solution to virtually all contact problems.

When applied to electromechanical contacts, Stabilant 22 provides the connection reliability of a soldered joint without bonding the contact surfaces together.

In this Application Note, we address answer a number of questions users may have about electrical/electronic problems in a marine environment. Please also refer to Application Note #001 for more information on the product and the answers to some questions commonly asked by users.

Environmental conditions that cause connector failure

Typically, these are those found in coastal or other regions where a combination of salt spray and moisture together with high winds and/or vibration combine with large temperature variations to produce an environment which is very hard on electrical connectors.

Reasons for connector failure under these conditions

There are two types of failure, either of which can render a piece of electrical or electronic equipment so erratic as to be unserviceable. While these can generally be classed as either physical or electrical failure of the connector and although there are some designs in which only one or the other failures will occur, normally a combination of the two will take place.

Physical Failures

Physical failures generally result from the use of connectors which are not designed for the environmental conditions encountered. Unfortunately, even with all the thousands of designs on the market today, it is often very difficult to find a connector which will survive some of the more severe environments. When one is found, the limited market for such a design usually results in a very high cost. The engineer specifying the connector has to face the decision of first cost vs. replacement/maintenance costs.

It is not unusual for an attractive first cost of the connector coupled with an apparently low replacement cost to account for the choice of a connector. Often costs due to such items as: unanticipated galvanic corrosion (between the connector and the cable, dissimilar metals in a connector and another part of the equipment housing) as well as environmental effects due to increasing pollution levels are underestimated. Similarly, long term maintenance costs due to increased wages are often underestimated.

The most common physical failure results from deterioration of the parts of the connector (whether metal or insulator) holding the male and female components together. The result is that the connector simply disconnects. This usually results from a lack of durability of the connector body material and/or finish to the salt, water or chemicals in the environment. Galvanic corrosion can occur with dissimilar metals even when not directly connected.

Electrical Failures

Quite frequently encountered is corrosion of a connector shell that serves as both a physical coupling and a current carrying element (usually a ground return). This leads to a breakdown when erosion of the contact area produces higher resistance and accelerates the corrosion process. Eventually so much material is lost from the mating contacts that the connector runs hot, in some cases so hot that it destroys itself.

Assuming that the connector cannot be replaced with a type more suitable for the climate, and that the connector is still functioning, the usual solution is to clean all traces of salt corrosion from the connector and re-assemble it. The final step may be enclosing it in such a way as to prevent the entry of the contaminants. This may consist of coating the connector body with a high viscosity silicone grease and placing it in some sort of protective sleeve which will prevent the grease from being eroded away. However, because of the potential for silicone-induced problems the preferable method would be to use a layer of self-fusing tape followed by layers of vinyl tape and vinyl coating as mentioned later.

Silicone greases can introduce another mode of connector failure, especially when exposed to salt – a silicone compound can combine with the salt to form a hard film of sodium silicate that is non-conductive and difficult to remove without damaging the connector. Even where silicone-based water-excluding gaskets are employed in the connector design, migration of the ethyl and methyl-silane based oils that are often added to the silicone rubber as softeners can cause problems. These are usually encountered where a connector is crimped to a cable.

Many physical failures take place because salt water has penetrated that part of the connector where the wires are crimped or soldered onto the pins. Quite apart from the electrical effects of the corrosion products, these products frequently occupy much more volume than the metal upon which they feed.

Occasionally enough pressure can be generated to rupture a connector shell. Before this stage, a connector may be jammed or “locked up”, unable to be normally disconnected.

Sometimes it is necessary to use a supplementary means of cable/wire strain relief to minimize the effects of wind-induced vibrations in the cable, which can cause a "grinding" action between the two halves of the connector.

Another type of failure results from exposure of the connector to unusual corrosive liquids or gases not normally encountered in the environment but which might be generated, from time to time, by other failures in the operating area.

This includes corrosion-inducing chemicals liberated from connector components subject to overheating, which can lead to thermal runaway involving current carrying contact-to-wire junctions. It must be remembered that the conductors and insulators used in connectors have their own vulnerabilities to failure, but once compromised, one can weaken the other.

In many connectors carrying radio frequency signals, it is necessary to have conductors and insulators dimensioned so that the electrical impedance of the connector is the same as that of the wire. A mismatch can cause RF reflections in a transmission system, which can reduce the effective radiating power of a transmitter or diminish received signal strength. Insulation leakage can cause unacceptable loss or modification of the signal caused by line reflections (e.g., ghosts or detail blurring in cable TV).

This simple concern can degrade the performance of a radio communication system, a GPS or Loran, or even a radar system to an unusable condition!

Where the RF impedance is not a consideration we still have to deal with losses in or on the electrical insulation. Excessive leakage across the insulation will result in heating in high-power applications, insulation breakdown in high-voltage applications. or signal leakage in multiple-pin control circuits. None of these are acceptable, and the consequences range from destruction of the connector to fire hazards and even consequential damages (legally speaking) due to failure of a process-control, alarm, or communications system.

The introduction of corrosion products into the gap between the connecting pair can also result in unwanted rectification effects (many corrosion products can act like crude semiconductors) which can produce strange modulation distortion of the signals or even introduce spurious signals derived from the rectification of RF (including fast rise time digital signals) present in the environment. Generally, this is characterized as excessive sensitivity to "electronic smog".

How can I achieve electrical contact improvement?

If a mated contact were potted in a clear material, sawn at right-angles to the connection plane, polished, and examined under a microscope, it would be seen that what we think of as smooth contact surfaces have the appearance of mountains and valleys at this scale. In reality, the contact area is far from continuous.

One of the benefits of gold plating (more notable when gold was less expensive) was the fact that gold is soft and malleable. Under the action of making the connection, the gold deformed, producing a much larger total contact area.

The plating, in earlier days was made thicker, thus less likely to be porous, and so pore corrosion was also prevented. In addition, the closely mated surface prevented the intrusion of oxygen and other contaminants.

As the price of gold has increased with time, in gold-plate applications it is applied in as thin a "flash" as possible consistent with low porosity. Even so, special processes must be used to try to minimize this porosity as will be evident upon reading almost any connector manufacturer's brochures. Reliability is ensured for a new component, but the rigors of field use can diminish the performance of this type.

Where gold is not used on both surfaces, the question becomes one of the compatibility of the connecting surfaces both with one another and with the intrusion environment. Often when metals other than gold are used in a contact pair and combined with sufficiently high contact pressure, they perform with greater reliability than gold to gold at lower pressure. The key here is to have enough pressure to exclude oxygen and other contaminants.

The conductivity of a new connector will not be substantially improved by the Stabilant, as there will probably be a sufficient effective contact area already. Thus any added conduction (aided by a material which has a higher volume resistance than the contacting metal) will be of little consequence. However, the Stabilant's presence will help to exclude oxygen and corrosive materials from the contacts, and its surfactant action will keep any existing contaminants in suspension.

The action of Stabilant on an aging, well-worn contact is somewhat different. Here the contact will not be as good, so the conductivity enhancement of the Stabilant film will appreciably lower the total contact resistance.

On high current applications, the lowered resistance provided by Stabilant treatment can prevent thermal runaway of the contact means. In thermal runaway, heating of a joint causes expansion, stretching the clamping means beyond their elastic limit, resulting reduced contact pressure, thus increasing the resistance of the contact area. This allows a further increase in heating - in extreme cases this can cause a high current connector to explode.

Another potential problem in connectors is the area where the wire and or cable is connected to the contact means, generally a crimped or soldered joint. Each has its own vulnerability to corrosion and mechanical wear. Stabilant 22 application on these connections will improve their long-term reliability.

Note: Soldered joints may allow galvanic corrosion in adjacent areas, while some fluxes can cause problems if they wick up into stranded wires. Breakdown products from heating of the cable jacket can also potentially cause corrosion of the conductors.

Multiple point crimps (made with properly designed tools) use sufficient pressure on the conductors to exclude the entry of oxygen and contaminants and can be more reliable than soldered joints besides having greater consistency.

What procedures can be followed on complete connectors?

Once a connector is assembled, it may be necessary to protect it against the environment by heat-shrinkable tubing or another means of sealing out water and contaminants.

Heat Shrinkable tubing is manufactured by such companies as Alpha. The surface irradiated type with the soft inner core is their type FIT-300 and FIT 321. Their standard shrinkable polyolefin tubing is type FIT-221 and the 6:1 High-ratio is FIT 621.

One problem with heat-shrink materials is that they lose elasticity and resiliency at very low temperatures. Because of this, leaks may occur in cold conditions. We have seen this material used with rubber splicing compound, wrapped around the wire-connector-wire area before the heat shrink tubing is used. The elasticity of the splicing compound under compression is certainly better than that of any of the heat shrinkable materials and the resultant "booted joint" is much less messy to open up.

A better method for environmental sealing to protect against the weather (as practiced by the U.S. Navy) is as follows:

1) A layer of Scotch™ 3M type 79 self-fusing tape wound with a 50% overlap and stretched while being applied.
2) A Layer of Scotch™ 3M type 33+ Vinyl tape wound with a 50% overlap and stretched while being applied, followed by a similar layer wound in the opposite direction (also stretched with 50% overlap).
3) A sealant layer of Scotchkote™ Liquid Vinyl is applied overlap the layer of 33+ tape. Scotchkote™ contains MEK (Methyl-Ethyl Ketone) as a solvent which melts into the surface of the 33+ tape to form a continuous layer of vinyl material.

This type of sealant procedure can be applied over any type of connector including heat-shrink boots to protect the polyolefin material against UV rays), although in this latter case only the 33+ and Scotchkote™ is needed to provide a protective and flexible layer.

This and other solutions are designed to exclude salt and moisture from the connector and a choice of which treatment to use will be based on the location of the connectors, the ease of application of the treatment, and the life of the materials used. Consideration must also be given to possible degradation of heat shrink materials by ultraviolet, ozone, or chemical contaminants in the operating environment.

What other uses are there for Stabilant materials in the marine/maritime field?

Mechanical switches in radios - digital, audio, RF or high-voltage usage

Typically, a two-way radio system consists of a transmitter, (possibly with an external RF power amplifier), and a receiver (possibly mounted separately), as well as high and low-voltage power supplies, all of which may be connected by multiple-pin plug and socket connectors. These unit are often modular for ease of service and the modules/cards may be, in turn, interconnected with a combination of card-edge, discrete card-connectors, as well as connectors which allow cards to be stacked, wiring-harness-mounted connectors, coaxial RF connectors and header connectors just to mention a few. The units may also have manual or motor-driven rotary selector switches that carry DC, AC or RF energy at many different levels. An area of significant failure within HF, VHF, and UHF transmitters is the final amplifier switching circuits. These often use relays and/or rotary switches. Failures are usually caused by heating and conductivity loss by contact erosion. The application of Stabilant 22 to all of these areas can improve the service life of the equipment with increased operational reliability.

One caveat: Where connectors operate under high-voltage conditions (such as on some power-amplifier tubes) it is advisable to confine the Stabilant coated areas to the actual contact surfaces (any excess or spill must be cleaned off).

RF connections - Interior and Exterior

Radio-Frequency Coaxial and Waveguide connections operate in both dry-air pressurized and unpressurized (ambient-air) conditions. Stabilant treatment would provide the appropriate protection for these connections.

RF wipers and Matrix RF power switches

These applications provide switching for HF transmitter-to-antenna coupling connections. In some of these applications the control signals are digitally multiplexed on the coaxial cable center-conductor and the matrix connection conductivity is critical. Such switches are an obvious application for Stabilants 22.

Transmitter/Receiver switchboards on Military Ships

One type of transmitter/receiver switchboard consist of rotary wafer-type switches with typically 5 receiver or 20 transmitter positions and 2 receiver to 12 transmitter poles of switches for each equipment position. Each patch panel consists of 10 of these switch elements. In a typical large ship installation, there may be over 4,000 individual switch wafers in the transmitter patch panel alone. These are a common source of intermittent operational problems that would benefit from Stabilant application.

Instrument connections

These include everything from navigational equipment to pilot lights and comprise every imaginable sort of connection from microprocessors to remote-compass readouts (including engine instrumentation). Stabilant 22 can reduce or eliminate problems here.

Miscellaneous Applications in the Marine Field

These can cover such devices as outboard motor connections, flashlight batteries, emergency equipment and cameras. Stabilant 22 can benefit every type of electromechanical connection, especially in challenging environments.

NATO CAGE/Supplier Code 38948

5mL Stabilant 22 (Concentrate), NATO Stock Number 5999-20-002-1112

15mL Stabilant 22 (Concentrate), NATO Stock Number 5999-21-909-9981

15mL Stabilant 22A (Isopropanol Diluted), NATO Stock Number 5999-21-900-6937

15mL Stabilant 22E (Ethanol Diluted), NATO Stock Number 5999-21-909-9984

Stabilant products are patented. Because the patents cover contacts treated with the material a Point-of-Sale license is granted with each sale of the material.

SAFETY DATA SHEETS ARE AVAILABLE ON REQUEST

NOTICE