STABILANT 22

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APPLICATION NOTE

Marine Electrical & Electronics Maintenance using Stabilants

- *Background*

Many pieces of electrical or electronic equipment function perfectly when first installed and often function perfectly when removed for bench-testing.

Unfortunately, they prove to be erratic in their operation when re-installed and used in a marine environment.

This type of failure is quite frustrating both to the owner and to the installer, or service technician who has to cope with the type of intermittancies that cannot often be duplicated on the bench.

- ***What are some of the environmental conditions that cause connector failure?***

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

- ***What are some of the 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 unservicable. 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:
The 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 costs to account for the choice of a connector. Often costs due to such items as: unanticipated corrosion due to galvanism between the connector and the cable, dis-similar metals in a connector and another part of the equipment housing, as well as environmental-effects due to increasing pollution levels are underestimated. This is similar to the way in which long term maintenance costs due to increased wages are underestimated.

The most common physical failure results from corrosion eating away the parts of the connector holding the male and female components together. The result is that the connector simply disconnects. The cause of the corrosion is usually a lack of resistance of the connector body material and/or finish to the combination of salt/water and/or chemicals in the environment; but the corrosion can be hastened by the use of dissimilar metals. These are materials which are incompatable galvanically.

Electrical Failures:

Quite frequently encountered is an electrical-based erosion caused by the use of the connector shell as both a physical coupling and a current carrying element. This same type of breakdown can occur where a connector no longer is able to carry its rated current without electrical erosion taking place. Eventually so much material is lost from the mating contacts that the actual area of the contact-surface is so reduced that the connector runs hot, or even gets 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 saltfcorrosion 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 "buttering" over the connector body with a high viscosity silicon grease and placing it in some sort of protective sleeve which will prevent the grease from being eroded away although 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.

In spite of the general use of silicone greases, they themselves can introduce a form of connector failure, especiallyv hen exposed to salt. Where a silicone is present it can combine with the salt to for atbin, hard film of sodium silicate that is not only non-conductive, but very difficult to remove-w.itheut damaging the connector. Even where silicon-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 into 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 shell that has already been weakened by corrosion.

Sometimes it is necessary to use a supplementary means of cable/wire strain relief in order to minimise the effects of wind-induced vibrations in the cable in causing a "grinding" action between the two halves of the connector.

A third type of failure is the exposure of the connector to unusual corrosive liquids or gasses not normally encountered in the environment but which might be generated, from time to time, by other failures in the operating plant. This can also extend to corrosion-inducing chemicals being liberated from connector components subject to over-heating due to thermal runaway of contact-wire junctions.

It must also be remembered that there are two elements involved in the electrical failure of a connector: the insulation, and the conductor/contacts/connections; in other words, the non-conductive parts and the conductive parts.

Dealing for the moment only with the part of the connector that is meant to disconnect and reconnect (and not with the parts that are attached electrically or otherwise, to the cable) any connector may be broken down into a male-female or hermaphroditic component which is designed to mate with an equivalent part, and thereby pass electricity, and the parts needed to hold the former in alignment. The latter are usually insulators. In many connectors carrying Radio Frequency signals it is necessary to have the latter parts dimensioned so that the *electrical impedence* of the connector is the same as that of the wire. Otherwise there will be a discontinuity and a reflection will occur in the transmission system. This can reduce the effective radiating power of a transmitter, or cut the signal-strength of a received signal. Insulation leakage can cause loss of signal strength and/or unacceptable modification of the signal caused by line reflections. A good example of the latter is ghosts or detail blurring in cable TV.

The result can be a radio, communication system, a GPS or Loran, or even a radar system that is unserviceable!

Where the RF impedence 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 could be destruction of the connector and a fire hazard to consequential damages due to failure of a process-control, alarm, or communications system.

The introduction of corrosion products into the gap between the connecting pair or connecting means can also result in problems ranging from rectification effects (most corro i,06 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 whatever RF (conventional RF of even fast rise time) signals may be present in the environment. Generally this is characterized as excessive sensitivity to "electronic smog".

As noted earlier, corrosion products can completely break the contact means or through its increased volume, lock-up the connector so that it cannot be disconnected.

- *How can I achieve electrical contact improvement?*

If a mated contact were potted in a clear material, sawn along 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 are really almost mountainous. As a consequence, the contact area is far from continuous. One of the benefits of gold plating in the days when gold was much less expensive was derived from 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, being thicker, was much less likely to be porous, and so corrosion was also prevented. In addition, the closely mated surface prevented the intrusion of oxygen and other contaminants.

At the present cost of gold, where gold is used, 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.

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 less noble metals than gold are used in a contact pair and combined with sufficiently high contact pressure, they perform with greater reliability than gold to gold, or gold to ? at lower pressure. The key here is to have enough pressure to exclude oxygen and other contaminants.

Stabilant 22 (or either of its diluted form, **Stabilant 22A** • isopropanol or **Stabilant 22E** - ethanol) when used on a contact need only be present in a film thick enough to fill the interstices (or gaps) between the contact surfaces. Because of its switching ability, it will become conductive across these minute gaps without becoming conductive between adjacent pains or causing leakage across insulating surfaces.

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

The action of **Stabilant** on an aging or older contact is somewhat different. Here the contact will not be as good; thus the conductivity of the **Stabilant** (once switched on) will appreciably lower any contact resistance.

On high current applications, the lowered resistance well may be enough to stop thermal runaway of the contact means, a situation where the heating of a joint causes expansion which by stretching the clamping means beyond their elastic limit results in a reduced contact pressure, increasing the resistance of the contact area, and further increasing the heating. In extreme cases this can literally cause a high current connector to explode.

Because of the "switching threshold effect", **Stabilant** will not "switch" to a conductive state between adjacent contacts and its "off" resistivity is high enough to prevent signal leakage.

Another potential problem in connectors is the area where the wire and or cable is connected to the contact means. Frequently the wire may be of solder or tin plated copper, while the rear of the contact body could be anything from gold-plate, through silver or tin plate, to an as-machined alloy. The introduction of solder itself on a bare copper wire can provide a potential problem of galvanic corrosion while some of the fluxes themselves can cause problems if they wick up into stranded wires. Then too there is the possibility that breakdown products from the cable jacket can cause corrosion of the copper.

Multiple point crimps, (made with properly designed tools) which insure that there is sufficient pressure on the conductors to absolutely exclude the entry of oxygen (and any contaminents as well) are often much more reliable than soldered joints besides having greater consistency. The **Stabilants** can be used to enhance the operation of such joints.

- ***What procedures can be followed on complete connectors?***

Once a connector is assembled, it may be necessary to protect it against the environment by somewhat (in the eyes of the connector manufacturer) less orthodox means. One of the simplest of these is the use of a heat-shrinkable polyolefin tubing with an internal low-molecular weight polyolefin (or equivalent) material that literally melts when the outer tube layer is being shrunk. This provides a much more intimate seal, especially when the length is long enough to stretch from the wire jacket over the connector and over the connecting wire jacket. A problem with this material is that it looses its elasticity and gets stiff at low temperatures.

Because the polyolefin material looses its resiliency at low temperatures, leaks may occur when its cold. We have seen this material used with rubber splicing compound (as used on high voltage connections) where a single layer of stretched splicing compound is 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 SO% overlap and stretched while being applied.
2) A Layer of Scotch™ 3M type 33+ Vinyl tape wound with a SO% overlap and stretched while being applied, followed by a similar layer wound in the opposite direction. (also at a stretched - 50% overlap).
3) A sealant layer of ScotchkoteᵀᴹLiquid Vinyl is applied overlap the layer of 33+ tape. Scotchkote™ has a MEK 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, of course, designed to exclude the 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 themselves by ultraviolet, ozone, or chemical contaminants.

- ***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 Radio consists of a transmitter/exciter, a RF power-amplifier, and a receiver (possibly mounted separately), as well as high and low-voltage power-supplies all of which may be connected with 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, discreet card-connectors, as well as connectors which allow cards to be stacked, wiring-harness-mounted connectors, coaxial RF connectors (either discreet or modular) 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 erosion. The application of **Stabilants** to all of these areas would improve the service life of the equipment and reduce "resistance erosion with the concomitant increase in operational reliability.

One caveat; Where connectors operate under high-voltage conditions (such as on some power-amplifer tubes) it is advisable to confine the **Stabilant** coated areas to the actual contact surfaces.

RF connections - Interior and Exterior:
Radio-Frequency Coaxial and Waveguide connections operate in both dry-air pressurized and unpressurized (ambient-air) conditions. **Stabilants** 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. an obvious application for **Stabilants.**

Transmitter/Receiver switchboards on Military Ships:
Transmitter and receiver switchboards consist of rotary wafer-type switches with typically 5 receiver or 20 transmitter positons 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. An obvious **Stabilant** application.

Instrument connections:
These include everything from navagational equipment to pilot lights and comprise every imaginable sort of connection from microprocessors to remote-compass readouts (not to forget engine instrumentation). **Stabilants** can reduce or eliminate problems here.

Miscellaneous Appications in the Marine Field:
These can cover everything from outboard-motor connections. flashlight batteries, to emergency equipment and cameras. One often overlooked use is the application of a minute amount of **Stabilant** to the micro-power battery of a wristwatch or camera.

Quite literally, every electromechanical connection can benefit from the use of the **Stabilant** family of materials.

- ***In what forms is Stabilant available?***

The **Stabilants** come in several common forms. The basic material or concentrate is called **Stabilant 22,** while the isopropanol-diluted form is designated **Stabilant 22A.** This is a 4:1dilution (by volume) and is much easier to apply. (A third type is used for some military applications where isopropyl alcohol cannot be used, This is **Stabilant 22E,** which has an ethanol diluant. It is available on special order.) When used at normal room temperatures or higher, the diluant will evaporate after the application, leaving a thin film of the concentrate in place. In some applications such as socketed IC's it is not even necessary to unplug the IC to treat the connection.

The dilute form should be used for treating existing crimp type joints between multiple stranded wire and the contact.

- ***What are the names of some of the materials that can be used to exclude water?***

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.

D.W. Electrochemicals Ltd. has NSCM Cage Code/ NATO Supplier Code 38948

15 ml of Stabilant 22a (isopropanol-diluted) has NATO Part# 5999-21-900-6937
15 ml of Stabilant 22E (ethanol-diluted) has NATO Part # 5999-21-909-9984
15 ml of Stabilant 22 (concentrate) has NATO Part# 5999-21-909-9981

The **Stabilants** are patented in Canada 1987; US Patent number 4696832. World-wide patents applied for. Because the patents cover contacts treated with the material, a Point-of-sale License is granted with each sale of the material.

I MATERIAL SAFETY DATA SHEETS ARE AVAILABLE ON REQUEST