STABILANT 22

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APPLICATION NOTE

Using Stabilant 22 in Severe Outdoor Environments

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

Typically, these are those found in coastal regions where a combination of salt-spray and high winds combine with fog, rain, and 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 areas of failure, physical failure of the connector, and electrical failure of the connector. While there are some designs in which only one or the other failures will occur, normally a combination of failures 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 severe environments, and when one is found, the limited market for such a design usually results in very high costs. The engineer specifying the connector has to face the decision of first cost vs replacement/maintenance costs and it is not unusual for the initial cost of the connector coupled with an apparently low replacement cost to account for the choice of connectors. But sometimes environmental effect costs due to increasing pollution levels are underestimated in the same way that long term maintenance costs due to rising labor costs 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. The corrosion can be hastened by the use of materials which are incompatable galvanically, or by the use of the connector shell as both a physical coupling and a current carrying element.

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, finishing by 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 enclosing it in some sort of protective sleeve which will prevent the grease from being eroded away.

A second vulnerable area is the connection between the wire or cable and the connector itself. 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 minimuse the effects of wind-indused 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.

This latter also suggests that we must also consider the possibility of other types of electric-current-induced physical failures. If the shell is being used as a conductor is there going to be sufficient heat rise caused by the combination of electrical resistance and current flow across the mechanical connection to cause physical failure of any of the other connector components, such as strain relief boots, seals, thermoplastic insulations, etc.? Could there be enough heat rise to cause failure of the electrical wire/cable connection to the connector?

It must 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/wire; 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 AC 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.

Where the AC electrical impedence is not a consideration we 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.

Where AC electrical impedence is a factor, 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.

Failure of what patent attorneys like to call the "connector means" can range from a simple erratic connection which could be called intermittent, to terminal failure of the contact pair.

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 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 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 before, the 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, and that 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, 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 porosity. Even then special processes are used to try to minimize 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 its isopropanol diluted form, **Stabilant 22a**) when used on a contact needs 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 there without becoming conductive between adjacent pains or causing leakage across insulating surfaces.

Now the conductivity of a new connector will not be substantially improved by the **Stabilant** for the reason that there will probably be sufficient contact already so that 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.

In an environment where it is impossible to guarantee the exclusion of contaminants, silicon grease can be used on the insulation to keep its surface resistance as high as possible. The problem them becomes one of preventing the contamination of the **Stabilant** by the Silicon, and vice versa.

On low frequency connector applications it is sometimes possible to take a thin sheet of soft silicon rubber (with a Durometer of about 30 to 40 Shore A) and make a washer which is perforated with holes for the male contacts and which will fit inside the connector shell. The material should be thick enough such that when the connector is screwed or clamped together, the silicon will deform and form a water and gas tight seal between the adjacent contacts.

This solution will work only where the connector design allows the silicon washer to be compressed.

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 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 such that there is sufficient pressure on the conductors 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) materials that literally melts when the outer tube layer is being shrunk. This provides a much more intimate seal when a length is used that is long enough to stretch from the wire jacket over the connector and on to the wire jacket. A problem with this material is that it looses its elasticity and gets stiff at low temperatures, and if leaks will occur, they will do so 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 used over 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.

Another treatment is to use a thick long-fiber-equivalent silicone dielectric grease such as vacuum grease applied in a layer over the connector and wire. This can be used inside heat shrink tubing. Enough should be applied so that the shrinking of the tubing extrudes the excess from the ends of the tubing. A possible problem here is that the grease may also be forced into the connector with degradation of the metal to metal contact. In an attempt to resolve this latter problem I have seen the same treatment used with an external wrapping of kitchen wrap being used to the point that the silicon is covered. Ordinary vinyl tape can be used over this providing the silicone has not got on the surface of the plastic.

Yet another technique is to use one of the low-temperature-melting tool-protection coating material such as the buterates. These are an oil bearing plastic material normally used in the tool-room to protect sharpened milling cutters against damage. The material melts easily and connectors can be dipped into the liquified buterate. It is not easy to apply in the field, but it can be readily cut and is easy to strip away from the connector.

All of these 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.

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

The **Stabilants** come in two forms. The basic material or concentrate is called **Stabilant 22**, while the isopropanol diluted form is designated **Stabilant 22a**. This is a 4:1 isopropanol dilution (by volume) and is much easier to apply. When used at normal room temperatures or higher, the isopropanol 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?***

Silicone greases are manufactured by several companies including Dow Corning and General Electric Silicones Division. Besides the usual silicone dielectric greases, which are available from many manufacturers there is a much stiffer silicone grease called High-Vacuum grease which is somewhat easier to handle as an external moisture barrier due to its higher viscosity.

If there is a restriction banning silicones from use we have been told that Apiezion™ Grease type T and the more rubbery Apiezion™ type N grease (both generally used in laboratory glassware applications) have had some success.

Heat Shrinkable tubing is manufactured by such companies as Alpha. The surface irradiated type with the soft inner core is their type FIT-300. Their standard shrinkable polyolefin tubing is type FIT-221.

NATO Supplier Code 38948 - 15 mL of S22A has NATO Part # 5999-21-900-6937

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.

MATERIAL SAFETY DATA SHEETS ARE AVAILABLE ON REQUEST

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