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NEW DEVELOPMENTS IN THE USE OF VAPOR PHASE CORROSION INHIBITORS IN THE ELECTRONIC INDUSTRY

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ABSTRACT

Vapor phase corrosion inhibitor (VpCI) technology is used to protect metallic parts used to build electronic equipment. The use of fiber optics is ever increasing in the electronic industry. Fiber optics found in cable connectors could, at times, be exposed to VpCI compounds. The emergence of VpCI technology for the protection of equipment used in the fiber optic industry required a further study of the impact that thin VpCI layers have on signal attenuation.

INTRODUCTION

Fiber optics are found in many industries, in particular computer networks and telecommunications. The current switch from the copper wire of last century to the fiber optic of today makes possible to transmit more information, faster and farther. Optical fibers have several advantages over copper wire. For example, they are less expensive and thinner than copper wire. They are also subject to less signal degradation. In addition, optical fibers are ideally suited for carrying digital information, which is especially useful in computer networks.

Basic transmission system

The basic point-to-point fiber optic transmission system consists of three elements: the optical transmitter, the fiber optic cable and the optical receiver. The optical transmitter converts an electrical signal into a corresponding optical signal. The fiber optic cable conducts the light signal over a distance. Finally, the receiver converts the optical signal back into a copy of the original electrical signal. Connectors provide the transmitter/fiber optic cable and the fiber optic cable/receiver interfaces (Figure 1).

Signal attenuation

During the process of transmission, loss of light signal can occur. Attenuation can be caused by internal and external reasons. Internal reasons can be absorption, scattering and excessive bending, while external ones can originate at the connectors and splices. Attenuation is usually expressed as decibels per kilometer (dB/km). Most general-purpose optical fiber exhibits losses of 4 to 6 dB per km (a 60% to 75% loss per km) at a wavelength of 850nm. When the wavelength is changed to 1300nm, the loss drops to about 3 to 4 dB (50% to 60%) per km.

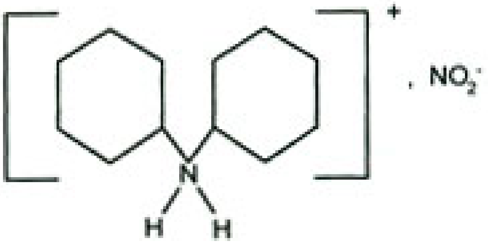
Optical connectors

Optical connectors are the means by which a fiber optic cable is usually connected to peripheral equipment and to other fibers. These connectors are similar to electrical ones in function and outward appearance but are actually high precision devices. The connectors must direct and collect light. They must also be easily attached and detached from the equipment.

Vapor phase corrosion inhibitors

Vapor phase corrosion inhibitors are chemical compounds that combine corrosion-inhibiting properties with their ability to vaporize. Protective vapors disseminate within an enclosed space until equilibrium is reached. This equilibrium is determined by the partial vapor pressure of the VpCI compound. The molecular layer formed by these chemicals provides anti-corrosion protection to metallic surfaces.

VpCIs are generally salts of moderately strong volatile bases and weak volatile acids. For example, one of the first VpCIs developed was the salt formed by the reaction of Dicyclohexylamine with Nitrous acid:



DICHAN (Dicyclohexylammonium nitrite) has a very limited use in electronics. It offers insufficient protection to copper and is not recommended in applications where solder or lead is present. Over the years, more performing and user-friendly VpCIs have been developed; some of them tailored for metals used in electronic equipment.

Besides its ease of use and cost effectiveness, VpCI technology offers several other advantages. One of them is cleanliness. Parts can readily be handled at any time during the protection stage or thereafter. Due to this benefit and a few others, vapor phase corrosion inhibitor technology is increasingly being used in the electronic industry[1-7].

VpCIs and fiber optics

Several independent work-studies were carried out to evaluate the impact that VpCIs have on non-metallic parts. Optical components and magnetic media were exposed to VpCIs for extensive periods of time and analyzed for optical and magnetic property variations. It was demonstrated that the corrosion inhibitors used for the studies had a very limited or no effect on these properties[8,9].

The emergence of VpCI technology for the protection of equipment used in the fiber optic industry required a further study of the impact that thin VpCI layers have on the transmission of a light signal. VpCI products are used to protect metals found in transmitters, receivers and other pieces of equipment. Fiber optics located in cable connectors could be and, at times, are exposed to VpCI compounds. This paper is to review the potential effects that these products have on signal attenuation.

EXPERIMENTAL

VpCI compounds

Three types of VpCI products used in the electronic industry were evaluated in this study.

The first one is a polyethylene film that is extruded with a blend of VpCI compounds and anti-static additives. The former component is for the protection of the metals used for the manufacturing of the electronic equipment, while the latter is used to prevent damage due to a discharge of static electricity. The equipment to be protected is wrapped in the plastic film for either transportation from one location to another or for extended storage in warehouses. The dimensions of the bag used in this study were 30mm x 36mm x 100 µm. An example of such a bag used for protecting electronic circuit boards is shown (Figure 2).

Another type of product that was evaluated in this study is a polyurethane foam that is coated with a VpCI compound. The open-cell foam dispenses corrosion inhibitors to the metal to be protected. The dimensions of the foam used in this study were 25mm x 25mm x 6.25mm. The foam was placed in an untreated clear polyethylene bag, which served as an enclosure. The dimensions of the bag were 30mm x 36mm x 100 µm. A typical use of the VpCI foam in shown (Figure 3).

Finally, the third product studied was a small pouch made of 1.4g of VpCI powder enclosed in a breathable non-woven membrane. Like the first two devices, the pouch emits a small amount of VpCI compounds that will deposit on the surface of the metals. The dimensions of the pouch were 64mm x 64mm x 3mm. As for the foam, the pouch was placed in a plain bag to form an enclosure for the VpCI compound. The dimensions of the untreated bag were identical to those of the bag used for the foam. An example of the VpCI pouch is shown (Figure 4).

Connectors

A single-mode fiber has a small core, only a few times the wavelength of the light transmitted. It only allows one mode of light to propagate. It is usually used with laser sources for high speed and long distance links. A multi-mode fiber has a core diameter much larger than the wavelength of light transmitted. It allows many modes of light to propagate. It is usually used with light-emitting diode sources for lower speed and short distance links.

There are many different types of connectors used in the fiber optic industry. The one used for this study is the SC type (Figure 5). It is used primarily with single-mode fiber optic cables. It offers low cost, simplicity and durability. It also provides for accurate alignment. It is a push on-pull off connector with a locking tab.

Three multi-mode cables and three single-mode cables were placed in an untreated polyethylene bag along with a VpCI source. The bags were then sealed and left at room temperature.

At specified time intervals (1 week, 1, 6 and 12 months), the cables were removed from the bags. They were then measured for signal attenuation. Once the measurement was done, the cables were replaced in the sealed bags along with the VpCI sources. They remained in the bags until the evaluation or the end of the study. As mentioned above, one of the VpCI sources was a film. It was used as both an enclosure and a VpCI source. No untreated bag was necessary for this product.

In addition, one of each type of cable was placed in an untreated polyethylene bag (without a corrosion inhibitor) to serve as a control.

Signal attenuation measurement

A standard signal source and a fiber optic power meter are necessary to make measurements of optical loss or attenuation in fibers, cables and connectors. The source was chosen for compatibility with the type of fiber in use and the wavelength desired for performing the test. Typical wavelengths of sources are 665 nm (plastic fiber), 820, 850 and 870 nm (short wavelength glass fiber) and 1300 and 1550 nm (long wavelength). The source wavelength can be a critical issue in making accurate loss measurements, since attenuation of the fiber is wavelength sensitive especially at short wavelengths.

The measurements of optical power were carried out according to the Electronic Industries Association (EIA) Fiber Optic Power Test FOTP-95 standard method. The instrumentation included a signal source and a power meter. The source generated a beam of light with a specific wavelength. This study was done using two wavelengths: 665nm and 850nm.

The setup for the test was similar to the basic fiber optic transmission system mentioned above. The source was the light transmitter, the fiber optic cable was one of the cables submitted to the VpCI products or the control cable, and the meter was the receiver. The test cables were connected to the source via a launch cable. This latter cable was used to set the proper conditions for testing the other cables. Sources greatly vary in how they launch light into cables, which can lead to undesirable variations in loss measurements. In addition, the coupled power can vary with each insertion, depending on the alignment of the connector ferrule in the source output connector (Figure 6).

For the measurements, the cables were removed from the bags containing the VpCI compounds and connected to the signal source via the launch cable on one end and to the power meter on the other end. The wavelength of the source was selected (665nm or 850nm). The transmitter was then turned on. The optical power was measured with the optical power meter. The reading was in dBm. Optical power is usually measured in watts and decibels (dB). dB is a ratio of two powers (for example the loss in a fiber optic cable). When power is measured in Watt (W), dB is calculated on a log scale using the following formula:

Power (dB) = 10 log (Power1/Power2)

If measuring absolute power levels, the measurement is generally referenced to 1 mW and is expressed as "dBm" according to the equation:

Power (dBm) = 10 log (Power/1 mW)

Equipment containing fiber optic connectors may need to be protected with VpCI products for a short time during transit from one point to another (a few weeks). It can be also be protected for extended time periods when placed in a storage area (several months). To evaluate the impact of exposure for various lengths of time, the measurements were carried out at one week (168hr), one month (730hr), six months (4380hr) and a year (8760hr).

DISCUSSION

Single-mode cables

At 665nm:

The results for single-mode cables at a wavelength of 665nm are shown in Figure 7. The data for the cables exposed to the VpCI film, the VpCI foam or the VpCI pouch along with the data for the cables not exposed to a VpCI source are indicated with the standard deviations attached to the measurements.

The transmitted power measured for the cables submitted to a VpCI atmosphere (film, foam or pouch) did not noticeably vary with time. It was very similar to that for the cables that were not submitted to the corrosion inhibitors. After a year, the power was identical to that measured at the beginning of the test (well within the limit of accuracy of the test equipment: ±5%).

From these results, it can be asserted that the VpCI compounds emitted by the tested film, foam or pouch have no effect on the transmission of a light signal via a single-mode cable at 665nm.

At 850nm:

The results for single-mode cables at a higher wavelength, 850nm, are shown in Figure 8. Similarly to the test carried out at 665nm, the power did not change after one year of exposure to VpCI products.

As for the results obtained at 665nm, it can be advanced that the transmission of an optical signal via a single-mode cable at 850nm was not affected by the exposure of the fiber optics to VpCIs.

The different values for the power at 665nm and 850nm are related to the different wavelengths. They cannot be compared as the each test is done for a specific wavelength.

Multi-mode cables

At 665nm:

Figure 9 displays the results for multi-mode cables at 665nm. As observed for the single-mode cables, the power does not greatly change with time. The values are well within the accuracy limits (±5%). The fiber optic cables exposed the VpCI products allowed the same light transmission as the one for the cables not placed in the presence of the corrosion inhibitors.

At 850nm:

Similar results were obtained at the wavelength of 850nm. Little change in the power was detected, indicating the VpCI compounds have essentially no impact on the signal transmission.

At indicated earlier, the different values in power are due to the different wavelengths used for this study and the mode of transmission. However, for each set of experiment the power for each cable did not change with time and was not dependent on the presence or absence of VpCI compounds.

SUMMARY

The ends of single-mode and multi-mode cables were exposed to a VpCI environment for a year. During that time, power measurements were carried out to determine if the VpCI compounds had an impact on the light transmission. It was found that the cables exposed to a VpCI atmosphere had properties identical to those of cables that were not placed in the presence of the corrosion inhibitors. This study indicates that vapor phase corrosion inhibitors can safely protect metals found in transmitters, receivers and other pieces of equipment used in the fiber optic industry. Fiber optics located in cable connectors can be exposed to VpCI compounds with no detrimental effect.

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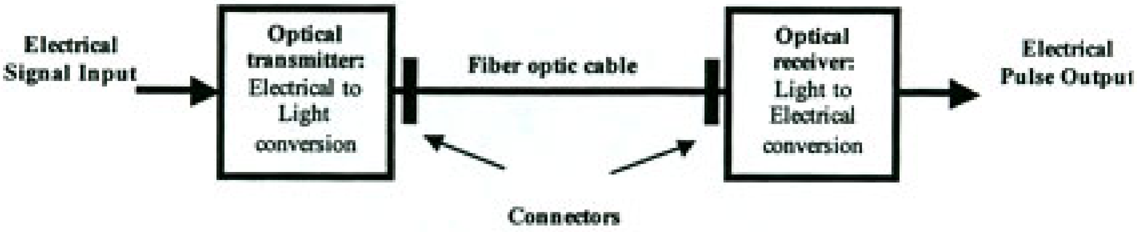

FIGURE 1 – Basic fiber optic transmission system

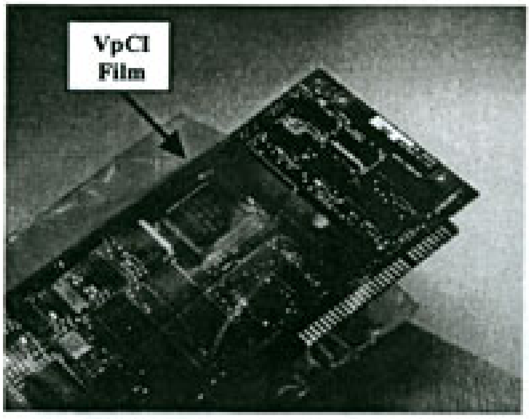

FIGURE 2 – VpCI bag used for protecting an electronic circuit board

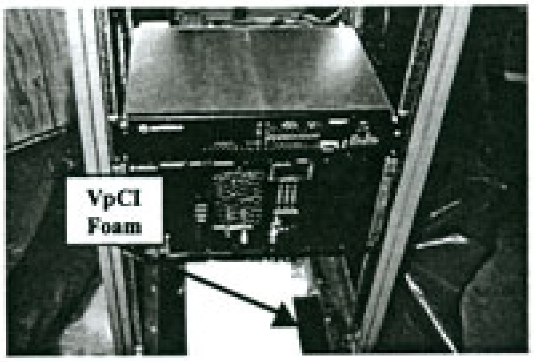

FIGURE 3 – VpCI Foam used for protecting electronic equipment

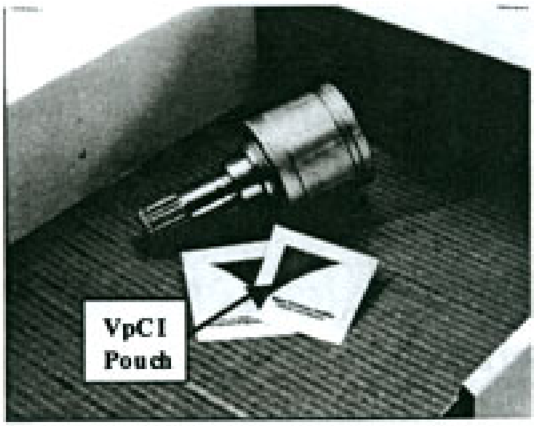

FIGURE 4 – VpCI Pouch used for protecting metal parts

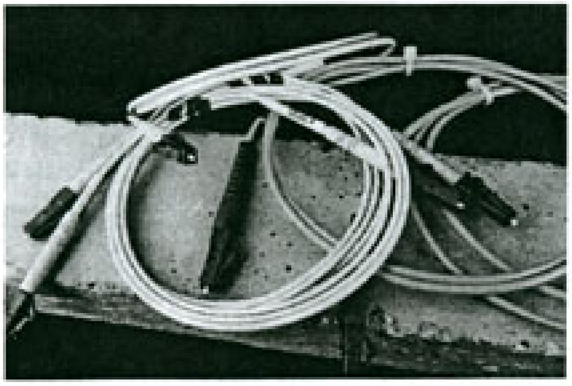

FIGURE 5 – SC connectors used for the study

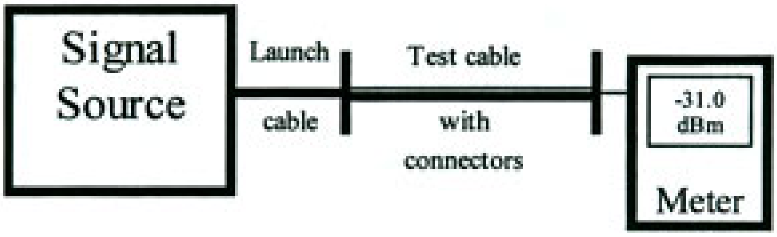

FIGURE 6 – Setup for the Fiber Optic Power Test FOTP-95 standard method

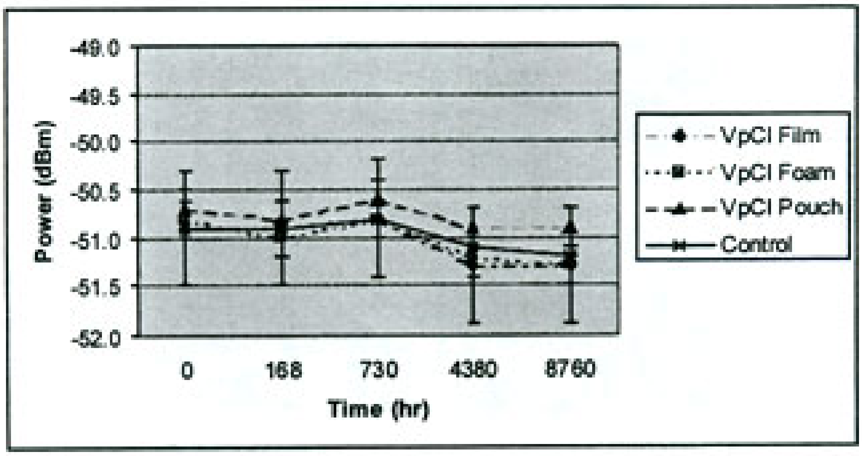

FIGURE 7 – Signal power for single-mode cables at 665nm

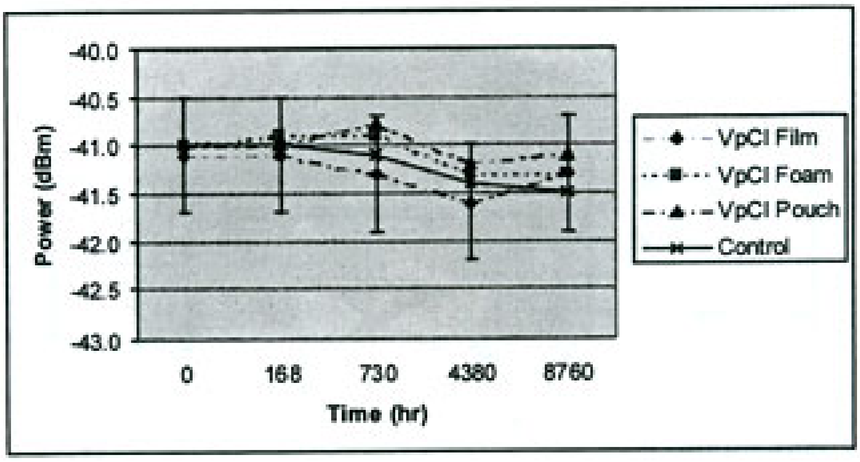

FIGURE 8 – Signal power for single-mode cables at 850nm

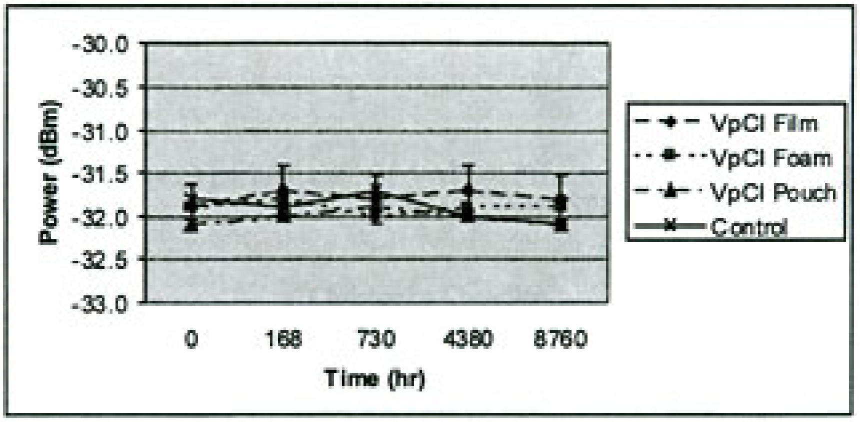

FIGURE 9 – Signal power for multi-mode cables at 665nm

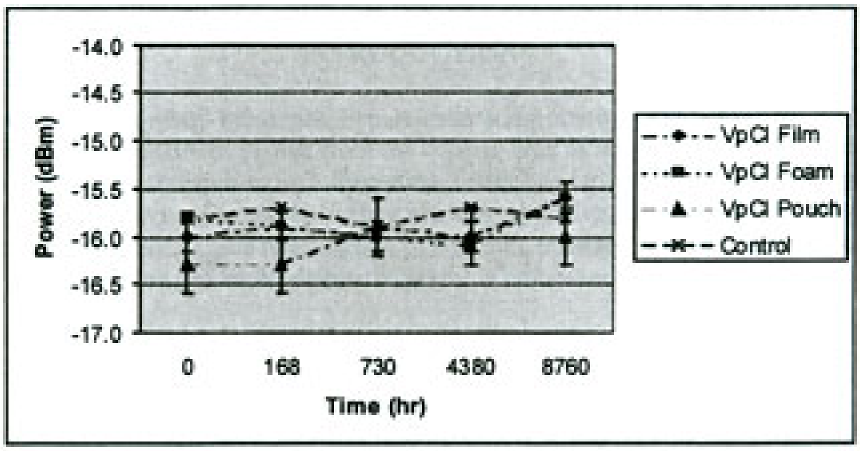

Figure 10 – Signal power for multi-mode cables at 850nm