Evaluating Efficacy of Volatile Corrosion Inhibitors vs. Traditional Methods for Preservation of Industrial Equipment and Operational Spare Parts

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Corrosion protection of industrial equipment and spare parts during mothballing and deep storage is an ongoing issue worldwide. Many factors must be considered when determining best practice for asset preservation. Length of time, type of equipment, accessibility, preventative maintenance schedule, and environmental and storage conditions have the greatest influence, while other conditions may also need to be considered. Traditional preservation methods such as nitrogen blanketing, desiccation, or heavy, wax-based surface-applied coatings can be costly to implement and maintain, and can become even more costly if they fail. Incorporation of volatile corrosion inhibitor (VCI) systems is an effective method to replace traditional preservation programs. These systems are often more cost effective to implement, have little to no maintenance cost, and have less failures in long-term preservation programs. These systems are explored in both laboratory and real world settings, compared to traditional systems and costs of each are compared.

Extensive research has been done on the topic of mothballing and layup procedures using volatile corrosion inhibitors (VCIs). Effective preservation of industrial equipment and operational spare parts requires many considerations. These considerations follow.

Length of Protection
Short preservation times can mean high protection costs. Often, this leads to an approach where no VCI or other traditional methods of protection are used, because the upfront cost of preservation is perceived to be too high.

Conversely, long-term protection leads to low cost of protection. In this case, while clients will see the value in preservation, they struggle to determine the best method. Decisions are not always made based on the technical validity of the method, but rather convenience of application and/or inspection. Examples would include the use of humidity indicator cards or coupons to determine the presence or absence of corrosion protection within a package.

Accessibility
Storage in remote areas (jungle, undeveloped locations) creates challenges in corrosion monitoring and replenishing protection. Equipment design can create further challenges related to accessing some of the internal spaces and other critical areas that require protection.

Type of Equipment and Replacement Value
Value of equipment can be critical. However, the more important factor is replacement lead time and/or amount of time to rework equipment that is corroded. Unique or specially designed equipment often have long lead times if a replacement is required. This can lead to downtime at a plant, which can be orders of magnitude more costly than the equipment itself. Therefore, the cost of protection and preservation is irrelevant compared to the value of protecting the asset and the work time it provides.

Steam turbines, for example, are subject to regular, short-term down time for maintenance. In this time, corrosion can occur on ASTM A470 steel blades and discs. Specifically, these surfaces are subject to stress corrosion cracking (SCC), crevice corrosion, and hydrogen embrittlement. VCI liquids have been tested as effective corrosion preventives in this application.

Preventive Maintenance Schedule
Equipment and spare parts may have a regular preventive maintenance schedule, with weekly, monthly, or yearly inspections. Or, they have no scheduled inspection after the preservation process. This can have a significant impact on the preservation system used on a specific piece of equipment.
Environmental and Storage Conditions

Arguably, this is the most important factor to consider in any preservation job. Material selection will vary greatly depending on the conditions in which the equipment will be stored, ranging from tropical coastal conditions to climate-controlled warehouses.

Costs of VCI Protection Methods vs. Traditional Layup Methods

The total cost of preservation can be determined based on the specific method chosen. When using a method such as a nitrogen blanket, the cost of the nitrogen generator must also be considered. With a heavy-duty wax-based coating, removal time must be considered. Table 1 outlines the basic costs involved with traditional layup methods, compared to similar VCI systems.

The same costs would apply to protecting the internals of a piece of equipment, such as a pressure vessel (Table 2). However, a secondary VCI liquid can be used specifically for void space protection.

Material costs were calculated based on product cost combined with recommended application/dosage rate. Utilizing a VCI system of liquid and shrink film (250 μm), this piece of equipment can be preserved for $1,000, which includes the cost of material and all equipment needed.

When considering the cost of a system, setup and removal cost must also be considered. VCI products can be flushed or sprayed with water, in the case of VCI liquids, or simply removed, in the case of VCI shrink film. Traditional methods may require harmful solvents and/or time-consuming procedures for removal and disposal. Nitrogen blanketing often requires hours of monitored leak testing prior to final purge.

Experimental Procedure

The efficacy of VCI technology for corrosion protection of industrial equipment and spare parts during layup has been confirmed via multiple laboratory test methods, as well as real life applications (Figure 1).

Laboratory Testing—Vapor-Inhibiting Ability (VIA) Method

NACE TM0208-2008 was designed to determine the vapor-inhibiting ability of VCI products. In this test, carbon steel plugs are polished with sandpaper, cleaned with methanol, and then placed within a jar apparatus. Traditional methods may require harmful solvents and/or time-consuming procedures for removal and disposal. Nitrogen blanketing often requires hours of monitored leak testing prior to final purge.

Laboratory Testing—VCI Packaging vs. Barrier Film for 15-Year Storage

In preparation for a 15-year build ahead storage program, automotive transmission components were wrapped in one of the fol-
Volatile Corrosion Inhibitors

Results and Discussion

VIA Test

VCI films (both shrink and standard) are regularly run through VIA testing to ensure that they can provide effective corrosion protection while not in contact with the metal surface. Figure 2 shows the test setup. Figure 3 represents typical VIA results for an effective VCI film.

Laboratory Testing—VCI Packaging vs. Barrier Film for 15-Year Storage

After 20 weeks of modified ASTM D1748 testing, the most effective corrosion protection system was with a multi-layer VCI packaging system.15 This system was implemented for the 15-year warehouse storage program, and no corrosion claims were made during that time.

Conclusions

For more than 60 years, VCIs have been effectively implemented into preservation applications worldwide. VCI films are an integral part of these systems, and they will provide protection both in contact and vapor phase, as shown in NACE TM0208-2008. Multi-layer VCI packaging systems have been successfully implemented in preservation of operational parts for programs lasting over 10 years, with no corrosion claims.

In the case of larger pieces of equipment, more diverse VCI systems have been effectively implemented for preservation. These types of systems have been used for the United States Armed Forces and the United Kingdom Ministry of Defense,16 along with many manufacturers of heavy industrial equipment.

Real World Analysis

VCI preservation systems have been successfully used around the world in military and heavy industrial applications, on vehicles, various pieces of equipment, and critical operational spare parts. Storage conditions have ranged from indoors (temperature-controlled warehouses) to outdoor, tropical conditions. Applications have been successful in all of these areas. Figures 6 through 13 show examples of VCI preservation systems being used on a variety of equipment.

References

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Additionally, VCI systems provide a preservation method that is cost neutral at worst, and in many cases provide a cost benefit compared to traditional chemical methods. This does not take into account the labor savings, performance capability, or disposal costs, which can be difficult to quantify when speaking in generalities. When compared to nitrogen or dehumidification systems, VCI preservation programs provide a clear cost and performance benefit. Additionally, they can be implemented in virtually any environment, as they do not require access to power or other utilities needed to provide continuous protection and monitoring over an extended period of time. VCs provide an effective layup and mothballing system that traditional methods cannot meet from a cost or performance standpoint. Equipment costs are minimal for application, as are costs associated with maintenance, cleanup, and disposal of waste materials.

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