

A COMPARISON OF SEVERAL CORROSION INHIBITING PAPERS IN VARIOUS ENVIRONMENTS

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Published: NACE,
National Association of Corrosion Engineers
Paper # 237
March 1998
San Diego, CA

ABSTRACT

Volatile corrosion inhibiting (VCI) papers are a popular choice for protecting metallic parts from corrosion. Accelerated corrosion tests were conducted to compare the effectiveness of papers formulated for multimetal protection to those formulated for the protection of ferrous metals only. The tests were conducted using SAE C1010 steel panels. Chlorides and sulfur dioxide were used to accelerate the corrosion rate. The results indicate that in highly corrosive conditions, the multimetal papers provide better protection to carbon steel than the papers formulated for ferrous metals only.

KEYWORDS: VCI, Volatile Corrosion Inhibitors, VCI Papers, Multimetal VCIs, Sulfur Dioxide

INTRODUCTION

The use of volatile corrosion inhibiting (VCI) papers for the protection of metals during storage and shipment is a popular choice. VCI papers are suitable for wrapping single items, interleaving (paper layered between stacked products), or to line boxes and crates. Many VCI papers can be recycled or repulped, making them environmentally friendly.

A user of VCI papers is confronted with a wide variety of choices in products. Papers are available to protect a specific metal, ferrous, copper, aluminum, silver, or zinc. Multi purpose papers that will protect all of these metals are also available. It was desired to determine if using a multipurpose paper resulted in a sacrifice in protection, comparable protection or an improvement in protection.

In developing a test protocol it was desired to use tests that would represent conditions that the papers might be exposed to in actual usage. Two factors were considered as important in the corrosion of packaged metal parts. These are temperature fluctuations and contaminating species.

Temperature fluctuations are common during storage and shipment. Most warehouses are not climate controlled and reach much higher temperatures during the day than at night. This also holds true for shipment, with a potentially greater fluctuation as the package travels to different climates. These temperature swings can result in a large amount of condensation inside a package. During the warmer period water vapor penetrates that packaging materials. This gives way to the cooler period. When the temperature reaches the dew point inside the package condensation forms and the corrosion rate for the metal part increases tremendously. The number of cycles that are required for corrosion to occur depend upon the actual atmospheric conditions and the condition of the metal. Typically, between storage and shipment there are sufficient cycles for corrosion to occur on unprotected surfaces.

There are many species that can act as a contaminant. Salts containing halogens or sulfur compounds are readily available in the atmosphere and are well known as accelerators of corrosion. There are many common air pollutant that cause accelerated corrosion. Species such as sulfur dioxide, hydrogen sulfide NO_x , and ozone all also cause corrosion rates to increase.

The accelerated corrosion tests that were performed incorporated the above considerations. The first test used cycling temperatures and water solution that contain ammonium chlorides and sodium sulfate. The second test was made more corrosive by the introduction of sulfur dioxide. Sulfur dioxide was chosen because it is commonly found in the atmosphere, it is relatively easy to produce in the laboratory and does not have the health concerns of some of the other species mentioned above.

EXPERIMENTAL PROCEDURE

Four papers were tested using two different corrosion tests. It was designed such that one test would be more corrosive than the other. This was desired in an effort to highlight the differences in performance amongst the papers.

Test materials

Four different VCI papers were tested to determine their ability to protect carbon steel. The first set of papers tested were designed to protect ferrous metals only. One used sodium nitrite and triethanol amine as inhibitors, the other was based up on amine salts of benzoic acid. The second set of papers were formulated for the protection of several metals. Inhibitors for several metals were added to each of the above types of papers. Therefore the final set was a multimetal sodium nitrite paper and a multimetal amine salt of benzoic acid based paper.

The metal specimens tested were carbon steel panels. These are manufactured for corrosion testing and are specified as SAE CS 1010. The only surface preparation that was done on the panels was the polishing done by the manufacturer of the panels.

There were four reagents used for this test. Two of these, sodium sulfate and ammonium chloride are each used at one percent in deionized water to make the test solution. Sodium thiosulfate and 1N sulfuric acid are reacted to produce sulfur dioxide.

Accelerated corrosion test without sulfur dioxide

The concept of the first test is that it simulates the conditions that may occur when a metal part is stored or shipped. Water is placed inside a jar with a panel wrapped in the material to be tested. The jar is then put in an oven that cycles between room temperature and fifty degrees Celsius. When the oven is on the water evaporates from the beaker and penetrates the paper. When it returns to room temperature water condenses on the metal panel and causes corrosion.

SAE C1010 panels were washed in methanol and allowed to dry. They were then wrapped in the paper to be tested. For the control specimen, a panel was wrapped in untreated paper. The edges were held in place with the use of tape. All handling of the panels was done with gloved hands or tweezers.

The wrapped panels were placed in one liter jars. A fifty milliliter beaker containing 30 milliliters of a solution comprised of 1% sodium sulfate and 1% ammonium chloride in deionized water was added to the jar. The jar was then sealed and placed in the oven.

The oven used was programmed such that it would be at on for sixteen hours and off for eight hours. It was set for fifty degrees Celsius. Thus one cycle was approximately sixteen hours at fifty degrees Celsius and eight hours at room temperature.

After four cycles the test was completed. The jars were removed from the oven and opened. The panels were removed from the jar, unwrapped and inspected for signs of corrosion. Panels were considered to be a pass if they had less than ten percent of the corrosion that the control sample had.

Sulfur dioxide corrosion test

The second test was similar to the first, but more severe. The test was run inside of a four liter jar. In addition to the above components, reagents that would react to form sulfur dioxide were also added. Again the temperature was cycled. Thus, when the water condensed on the metal panel it formed sulfurous acid.

SAE C1010 panels were washed in methanol and allowed to dry. They were then wrapped in the paper to be tested. For the control specimen, a panel was wrapped in untreated paper. The edges were held in place with the use of tape. All handling of the panels was done with gloved hands or tweezers.

The wrapped panels were placed inside a four liter jar. A fifty milliliter beaker containing 30 milliliters of a solution comprised of 1% sodium sulfate and 1% ammonium chloride in deionized water was added to the jar. In addition, a small dish containing 0.04 grams of sodium thiosulfate was also added to the jar. Next, 0.5 milliliters of 1 N sulfuric acid was added to the dish containing the sodium thiosulfate. The jar was immediately sealed. The jar was then placed in the oven.

The oven used was programmed such that it would be at on for sixteen hours and off for eight hours. It was set for fifty degrees Celsius. Thus one cycle was approximately sixteen hours at fifty degrees Celsius and eight hours at room temperature.

After one cycle test was completed. The jars were removed from the oven and opened. The panels were removed from the jar, unwrapped and inspected for signs of corrosion. Panels were considered to be a pass if they had less than ten percent of the corrosion that the control sample had.

RESULTS

The results of testing the four papers in the first test are given in Table 1. All four papers showed adequate protection of carbon steel. All four papers were found to be corrosion free. The control sample had general corrosion covering at least thirty percent of the test panel. Under the mildly corrosive conditions of cycling temperatures and condensing water vapor all four papers were found to protect carbon steel.

The results for the four papers tested in the second test are given in Table 2. In the more severe conditions of the second test a difference in protection is observed. The multimetal papers were found to be corrosion free. The papers designed for single metal protection failed this test, they had more than five percent of their surface covered with corrosion. The control sample had more than fifty percent of its surface covered with a pattern of general corrosion.

CONCLUSIONS

The results show that all of the papers provide protection to carbon steel. The first test showed a great difference between the VCI papers and the control. While the control specimen was heavily corroded, the panels wrapped in the VCI papers were corrosion free.

When the conditions were made to be more severe in the second test, the papers designed for multimetal protection performed better than the papers formulated for the protection of ferrous metals only. The results also indicate that this is true for different types of inhibitors. Papers treated with sodium nitrite and amine salts of benzoic acid both gave the same result of improved protection for the multimetal papers in an acidic environment.

There are several possible explanations for the improved protection. It is possible that the use of several different inhibitors results in a synergism that increases the volatility of the inhibitor so it provides better protection. Alternatively, the inhibitors could be acting synergistically on the surface of the metals. Additionally, another plausible explanation is that the inhibitors that are designed to protect the non ferrous metal are also inhibitors for ferrous metals.

RECOMMENDATIONS FOR FUTURE WORK

One possibility for future work would be a similar study for various non ferrous metals. Papers designed to protect copper, zinc or aluminum could be tested against a multimetal paper. This would determine if the above results are dependent upon the metal to be protected. This would give insight to cause for the results of this study.

Another possibility would be to determine the underlying reason for the above results. One possibility would be to compare the vapor pressure of a multimetal paper to that of the papers designed for ferrous metal protection. Another means of doing this would be to study the adsorption of VCI to the surface of the metal.

Finally, it might be of interest to determine if the environment in which the papers are tested influences the above results. Hydrogen sulfide could be substituted for sulfur dioxide in the second test. An alternative modification would be to use acetic acid as a substitute for the water. Acetic acid is a good choice as it is inorganic acid which will test the above results. Also, it is volatile, making it well suited for this type of use.

ACKNOWLEDGMENTS

I would like to thank the Cortec Corporation for its continuing support.

Table 1 Condensation based Accelerated Corrosion Test

<u>Sample</u>	<u>Results</u>
Paper for ferrous metal, nitrite based	Pass
Paper for ferrous metal, amine benzoate based	Pass
Paper for multimetal, nitrite based	Pass
Paper for multimetal, amine benzoate based	Pass
Control	Fail

Table 2 Sulfur Dioxide based Accelerated Corrosion Test

<u>Sample</u>	<u>Results</u>
Paper for ferrous metal, nitrite based	Fail
Paper for ferrous metal, amine benzoate based	Fail
Paper for multimetal, nitrite based	Pass
Paper for multimetal, amine benzoate based	Pass
Control	Fail