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**CORROSION PROTECTION OF FLANGES, VALVES AND WELDED JOINTS:
APPLICATION EXPERIENCE**

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ABSTRACT

Corrosion of flanges, valves and welded joints are major problems in the Oil & Gas, Chemical Process, and other industries. This paper presents a summary of new cover designs, laboratory test results, and application experiences in highly corrosive environments. This paper also describes the efficiency and experiences of these new covers and systems using VCI protection in combination with desiccants. In addition to offering corrosion protection, these covers have the added advantage of fast installation and easy removal and cleanup. The results show that these covers provide increased efficiency and service life for corrosion protection of various types of flanges, valves, welded joints in outdoor and indoor environments.

Keywords: flanges, valves, welded joints, corrosion, protection, inhibitor, desiccant, efficiency

INTRODUCTION

Corrosion of flanges, valves and welded joints is a major world-wide problem in many industries, including Oil and Gas Exploration and Production, Petroleum Refining, Mining, Chemical Process, Petrochemical, etc. Various forms of corrosion, including general, pitting and crevice come into play, which can lead to leaks and increased maintenance, repair and replacement costs. Attacks occur on surfaces between the flange faces, on welded joints, as well as on flange bolts and nuts, the severity of which depends on the external environment and operating conditions (see Figure 1).



FIGURE 1 – Examples of Flange corrosion

There exist numerous solutions, including various forms of coatings, covers, tapes, wraps, housing guards, etc. These vary in complexity of installation and cost, and work primarily by forming a barrier between the flange to be protected and the corrosive environmental elements. Unfortunately, these simple barrier products often are not effective in combating the atmospheric conditions encountered at many industrial sites.

Volatile corrosion inhibitors (VCI) have been used in packaging to protect metal parts during storage, handling and transportation for many years, dating back to the original Shell patents and the Northern Technologies International Corporation (NTIC) patent for VCI film. This VCI technology has been combined with barrier films to develop a flange and valve protection system (FPS)⁽¹⁾, which provides an effective protection solution against aggressive industrial environments. The FPS was designed to be an economical solution with operational and handling requirements aimed at:

- ease of installation and replacement
- ability to customize, in the field, for installation on typical as well as unconventional and complex flange and valve configurations

⁽¹⁾ NTIC trade name Zerust® Flange Saver™

On a functional level, basic operational requirements for the FPS included:

- low water vapor transmission rate
- minimum one-year stability in full-sun exposure, outdoor environments
- protection against a wide range of aggressive corrosive conditions

Principally, two styles of FPS were developed (see Figure 2):

- One-layer system, with VCI incorporated into the barrier film
- Two-layer system, consisting of a barrier film (low permeability polymeric, without VCI) as the outer layer and a separate inner VCI film layer; then desiccant is placed between the layers

This paper summarizes laboratory and field tests in highly corrosive environments.

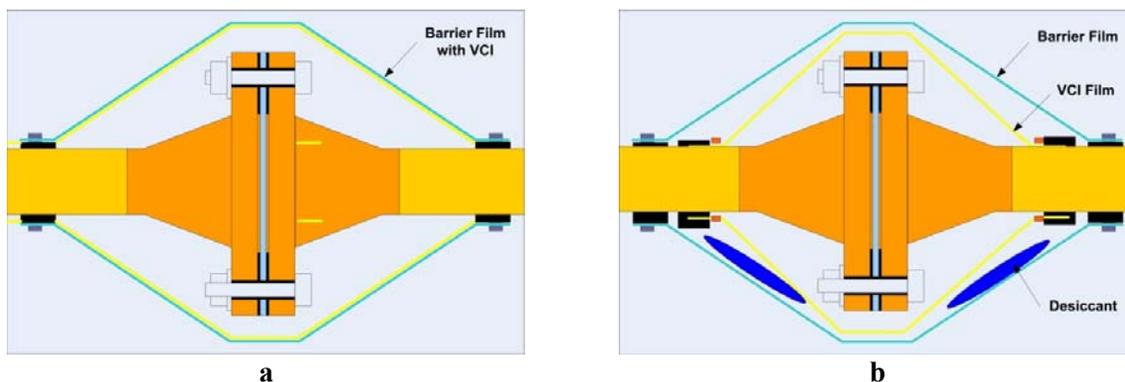


FIGURE 2 – Styles of FPS: a) One-layer system, b) Two-layer system

EXPERIMENTAL PROCEDURES

Laboratory Chamber Cycle Tests - Salt Spray/SO₂ Gas

Samples were exposed to repetitive cycles of the following sequence of salt fog and SO₂ gas conditions (Note: Temperature and humidity were maintained at approximately 35°C and 100%, respectively), per ASTM G85-98³ (see Table 1):

**TABLE 1
CHAMBER TESTING CONDITIONS**

Step	Time (h)	Chamber Conditions
1	0.5	Salt Spray
2	0.5	SO ₂ input at 35 cm ³ /min per m ³ chamber volume
3	2	Soak period

Sample Evaluation

Quantitative Evaluation: Steel specimens or were installed inside (test) and outside (control) an FPS cover at the start of testing. At the end of the trial period, the FPS cover was removed and the specimens were inspected. Corrosion rates exhibited inside and outside the FPS cover were determined per ASTM G1-90¹.

Qualitative Evaluation: An FPS cover was installed onto the test sample, while the control sample was left unprotected. Results were evaluated qualitatively at the end of the trial period by comparing the amount of corrosion on the FPS test sample vs. the amount of corrosion on the unprotected control sample.

RESULTS AND DISCUSSION

Laboratory Testing

Two identical flange assemblies were exposed to Salt Spray/SO₂ Gas Cycle testing. One assembly (test) was protected by a two-layer FPS, the second (control) was unprotected. Following exposure of 232 cycles, samples were examined qualitatively. Figure 3 presents flanges and flange components before and after testing. Similar results were obtained using the one-layer FPS covers.

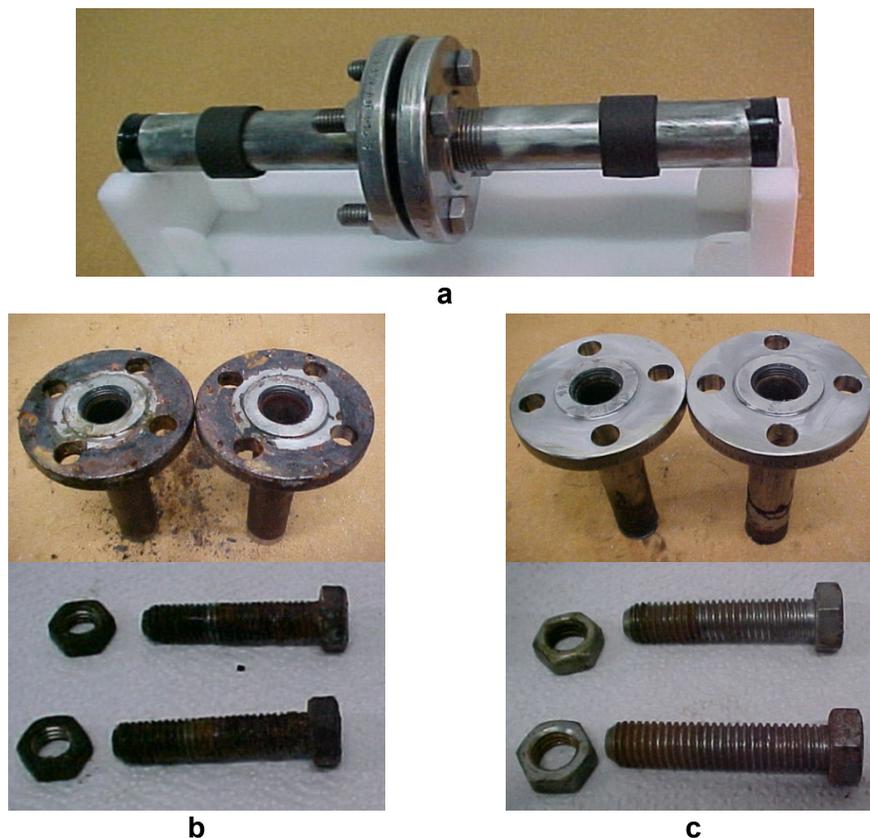


FIGURE 3 – SaltSpray/SO₂ Gas Testing Results: a) Flange assembly before exposure, b) Flange Assembly Parts – Control – No FPS Protection, c): Flange Assembly Parts – Test – Two-Layer FPS Protection

Field Testing

Field trials were performed at several locations worldwide, focusing on warm, humid climates that were more prone to accelerated corrosion problems. Table 2 lists each of the test site locations with a brief description of the local environmental conditions.

**TABLE 2
FIELD TESTING SITE ENVIRONMENTS**

Test Location	Location Type	Exposure Time (months)	Facility Type	Corrosion Environment Severity	Conditions	
Brazil	1	Offshore	11	Platform	Aggressive	Warm, Humid, Salt spray from ocean
	2	Seaside	11	Refinery	Moderate	Warm, Humid
	3	Inland	5			
	4	Inland	11			
	5	Inland	11			
Singapore	Seaside	4	Gas Terminal	Moderate	Warm, Humid	
Vietnam	1	Inland	3	Gas Distribution Center	Moderate	Warm, Humid
	2	Seaside	3		Aggressive	Warm, Humid, Salt spray from cooling tower at adjacent power plant

Quantitative results were obtained using metal specimens at the Brazil and Singapore test locations. Results for the five Brazil locations are presented in Figure 4. Results for the Singapore location are presented in Figure 5. In all cases, significant reductions in corrosion rates are observed, ranging from 10- to 26-fold.

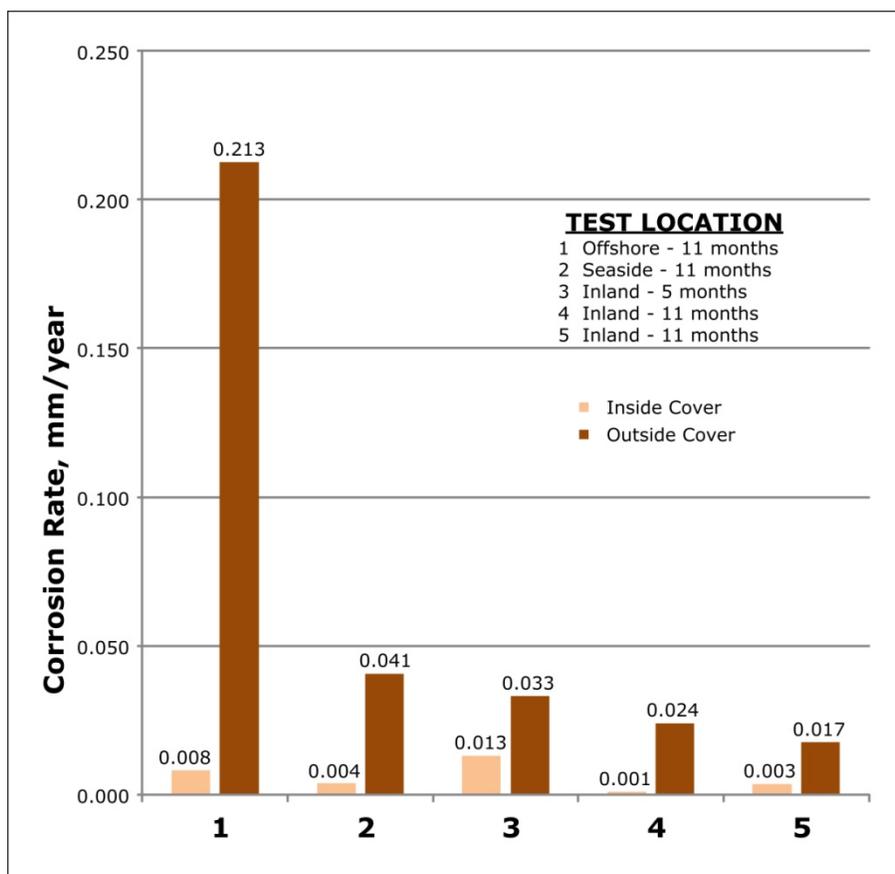


FIGURE 4 – Corrosion Rates of Metal Specimens – Brazil Locations

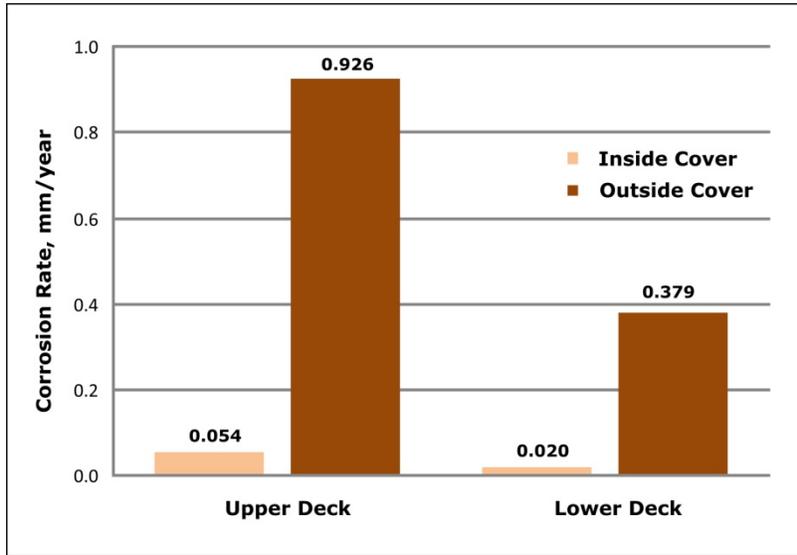


FIGURE 5 – Corrosion Rates of Metal Specimens – Singapore Location

Qualitative evaluation of field testing results also produced visually discernable differences in corrosion levels. FPS covers were installed on flanges and valves of various configurations (see Figure 6). Typical results, comparing specimens, demonstrated clear differences in amount of corrosion inside vs. outside the FPS covers (see Figures 7 and 8).



FIGURE 6 – Various Configurations of FPS Cover Installations



**FIGURE 7 – Brazil Field Trial Specimens: a) Offshore - 11 months;
b) Seaside - Start of trial (left), 11 months (right)**

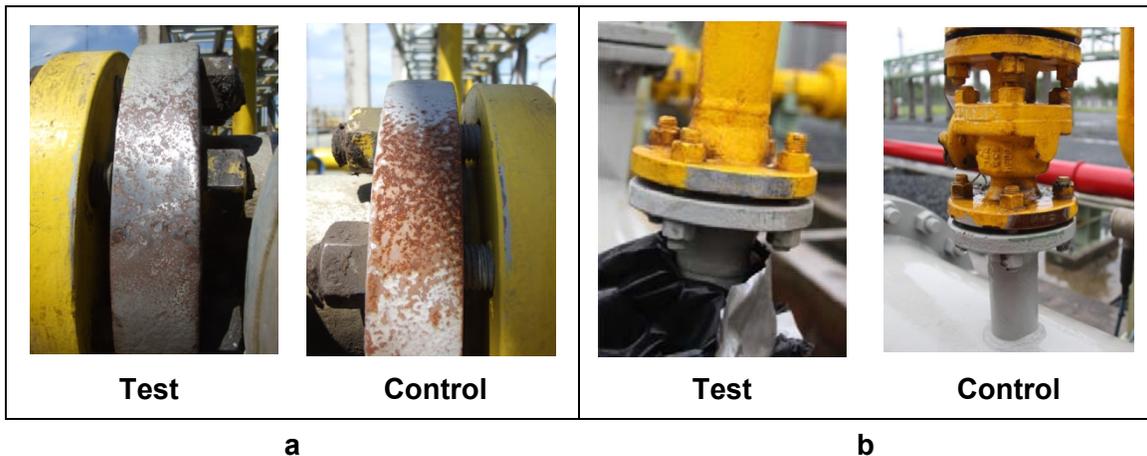


FIGURE 8 – Vietnam Field Trial Specimens after 3 months: a) Inland, b) Seaside

CONCLUSIONS

1. Both the one-layer and two-layer FPS provided significant corrosion protection of flanges, valves and welded joints in a wide variety of laboratory and industrial environments. The industrial test sites included offshore, refinery, seaside and inland locales.
2. In laboratory testing, the two-layer FPS met the design goals of effectiveness and stability in corrosive environments containing Cl^- and SO_2 , with temperatures at $+35^\circ\text{C}$ and relative humidities up to 100%.
3. The one-layer FPS also demonstrated high effectiveness and stability in industrial environments containing Cl^- , H_2S , SO_2 and CO_2 , with relative humidities up to 100%, temperatures up to $+35^\circ\text{C}$, and exposure to intense ultraviolet radiation for periods up to one year.
4. The FPS is easy to install and can be customized, in the field, for application with typical as well as unconventional and complex flange and valve configurations.

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