Corrosion protection of flanges and valves

E. Lyublinski,[1]* Ye. Vaks,[1] G. Begunova,[2] E. Kopilova,[3] M. Schultz[4] and R. Singh[5]

[1]Northern Technologies International Corporation, 23205 Mercantile Rd., Beachwood, OH 44122, USA
**E-mail: elyublinski@ntic.com*
[2]Astrakhan Gas Processing Plant, Astrakhan, Lenin St. 30, 414000 Russian Federation
[3]VPK Engineering, Saint Petersburg, Tuchkov Per. 3, 199053 Russian Federation
[4]Petrobras, República do Chile Av., Nr. 65, Rio de Janeiro – RJ, CEP: 20031-912, Brazil
[5]ZERUST, Brazil, 1424 João Wagner Wey St. House 17, Sorocaba – SP, Brazil 18046-695

Abstract

Corrosion of pipeline flanges and valves is a major worldwide problem. These pipeline connections are highly susceptible to pitting and crevice corrosion, which is the primary cause of pipeline failure. Often, to reduce or eliminate the risk of leaks and the resultant problems (fire, explosions, environmental contamination, *etc.*), pipelines are taken out of operation. Many effective corrosion protection solutions exist, but none are universally applicable due to application limitations and/or cost. Over the last 10 years, we have developed different types of covers/systems that, when applied, provide efficient corrosion protection. This paper presents field trial test results over a one year period in a very harsh environment − at temperatures from −30 to +40°C and relative humidity higher than 50%. The new data demonstrates a high level of corrosion protection efficiency that allows to expand areas of flange savers application. This is an alternative, low-cost method which uses volatile corrosion inhibitors (VCI) to protect flanges, valves and welded joints from corrosion.

Keywords: *corrosion, protection, inhibitor, efficiency, risk, flanges, valves.*

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Introduction

Corrosion of pipeline connections (flanges, valves, welded joints) is a well-known major worldwide problem in all industries including oil and gas, mining, chemical process, water and gas distribution systems in all cities, and *etc.* Pitting, crevice and galvanic corrosion in many cases can result in leaks, contamination of environment, systems taken out of operation, increased maintenance and replacement costs. Attacks occur on surfaces between the flange faces, flange bolts and nuts and on welded joints. In some cases these types of corrosion can be the source of an explosion. Many examples of this catastrophic situation can be found in oil and gas production countries. Corrosion of pipelines by itself is a big problem, but the most critical parts are the flanges, valves and welded joints. The severity depends on the external environment and operating conditions (Figure 1). Existing solutions (coatings, covers, tapes, wraps, housing guards, *etc.*) are often are not effective in combating the atmospheric conditions encountered at many industrial sites.

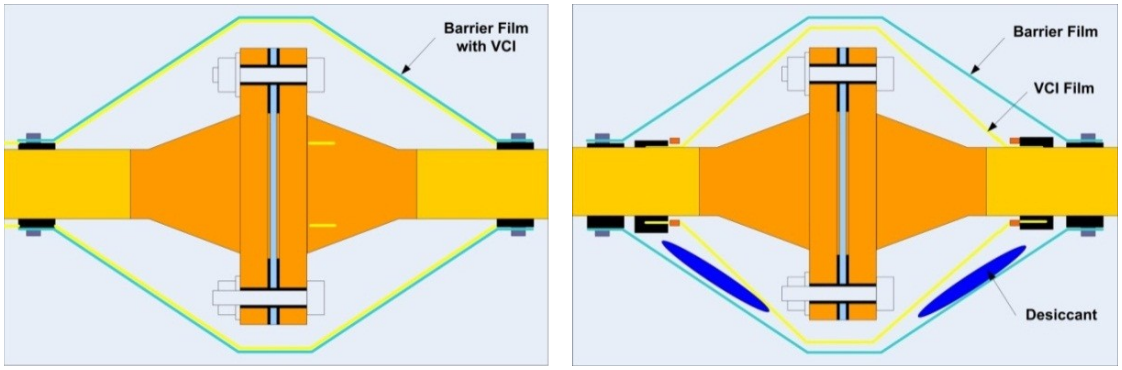
Figure 1. Examples of flanges, valves and welded joint corrosion.

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 patents for VCI film [1–9]. This VCI technology was selected and has been combined with barrier films to develop a flange, valve and welded joints protection system (FPS), which provides an effective corrosion protection solution against aggressive industrial environments [6]. Two types of the FPS were designed (Figure 2) 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.

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



a *b*

Figure 2. Styles of FPS: *a*, one-layer system; *b*, two-layer system.

A wide range of the lab tests in highly corrosive environments (In salt fog and SO_2 gas conditions, per IEC 68-2-30 and ASTM G85-983 at temperature and humidity are maintained at approximately 35°C and 100%, respectively during 232 cycles) and field tests in different countries during many years allowed to recommend the developed FPS for industrial application [6].

Field trials were performed at several (worldwide) locations (Figure 3) focusing on warm, humid climates that are more prone to accelerated corrosion problems.

Figure 3. Trial tests locations.

FPS covers were installed on flanges and valves of various configurations. Some of them are shown on Fig. 4. The field trials cover main locations – offshore platforms, refineries, gas terminals, gas distribution centers, *etc.* In all cases, significant reductions in corrosion rates (from 0.93 to 0.05 mm/yr. in the most corrosive environment) ranging from 10 to 26 fold.

Figure 4. Various configurations of FPS cover installation.

Qualitative evaluation of field testing results also produced visually discernible differences in corrosion levels. Typical results demonstrate clear differences in amount of corrosion on the specimens inside *vs.* outside the FPS covers (Figure 5).

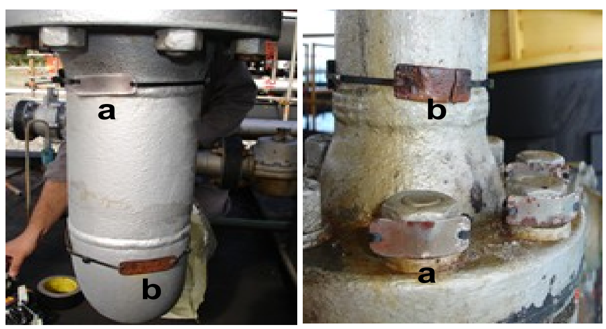


Figure 5. Specimens inside (*a*) and outside (*b*) FPS after 11 months offshore field trials.

The above results are very important for countries where the temperature is above 0°C. To expand the areas of FPS application in other countries (European and in North American countries) during last year were conducted trial tests in Russia near the Caspian Sea where the temperature can vary from –30 to +40°C and RH from 50 to 100%. The field trials were performed focusing on warm and cold weather, humid climates due to raining and snowing periods. The environment in this area is typical for most of Oil&Gas, Chemical, Metallurgy industries, all onshore locations and create many corrosion problems due to the unpredictable large range of the temperature and relative humidity, contamination of environment – presence of acidic gases CO_2, H_2S, Cl_2 in the atmosphere, *etc.* Due to the strong general pitting and crevice corrosion of the pipeline connections (flanges, valves, welded joints) in the facility where the trials were conducted, the pipeline systems often were taken out of operation for maintenance or replacement. Due to this situation it was very important to find out the efficiency of the FPS and make decision of their application in this and other similar environment and application conditions [6]. The field trials were conducted by applying FPS on 17 carbon steel flanges situated in the existing systems for transportation of different products (heating and acidic gases, water, *etc.*). All flanges/valves were covered with corrosion products on the surface area from 25 to 100% (Fig. 6). It shows that the corrosion environment is very aggressive and creates many problems during operation of the pipelines systems.

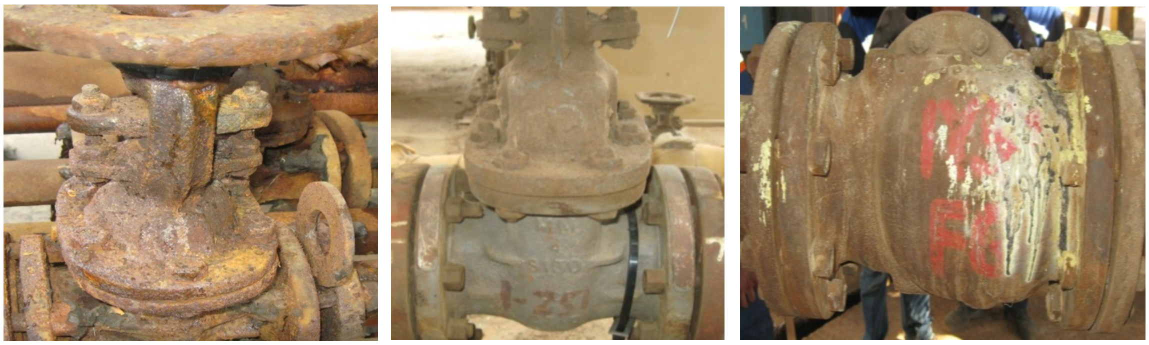


Figure 6. Typical corrosion condition of the flanges/valves.

To control the efficiency of the FPS, carbon steel coupons' installed inside and outside of each FPS were used. Some of the test results are shown in Figures 7 and 8.

Figure 7. Corrosion conditions of the front (*a*) and the back (*b*) sides of the test and control coupons after one year field trial.

In all cases it was found that the **test** steel coupons installed in the FPS after one year trials are in very good condition (Figure 7) in comparison with the **control** coupons installed outside of the FPS. The one year trial test results showed that the flanges condition does not depend on the initial corrosion condition of the flanges protected with FPS (Figure 8). It means that FPS can be applied to protect flanges from corrosion without the necessity to remove the corrosion products before applying FPS. This is very important remark/conclusion because in most cases it is impossible to remove corrosion products from the existing flanges and valves during the operation. FPS allows extending service life of new and existing flanges, valves, and welded joints.

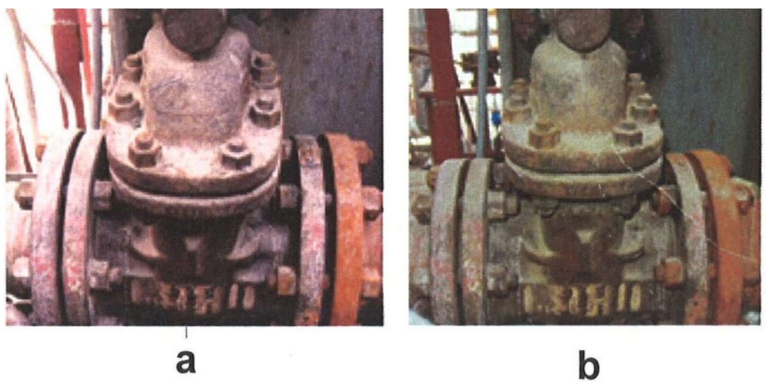


Figure 8. Typical examples of the flanges corrosion conditions before (*a*) and after (*b*) one year field trial.

Conclusions

1. The FPS provides significant corrosion protection of flanges, valves and welded joints found in a wide variety of industrial environmental conditions, including offshore, refinery, coastal and inland locales.
2. The FPS has met the design goals of effectiveness and stability in corrosive industrial environments containing Cl^-, H_2S, SO_2 and CO_2, with relative humidity up to 100% and temperatures up to +55°C. These covers also have demonstrated mechanical stability with exposure to intense ultraviolet radiation for periods of two years.
3. These new field trial test results allow expanding application of FPS to protect from corrosion for pipeline connections also in countries with periodically cold environment, where the temperature can be down to –40°C.
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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