

Corrosion Inhibitors Use: Case Study for Guinea Gulf Assets Application

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ABSTRACT

Traditional solution for oil and gas production equipment is the use of carbon steel (CS) due to its reduced cost, compared to more noble and corrosion resistant materials. To ensure the integrity of these equipment, the use of carbon steel needs to be accompanied by corrosion mitigation measures, like the use of Corrosion Inhibitors (CI). In the present context with more and more constraining environmental requirements and with the increase of water cut, the use of corrosion inhibitors become challenging. An optimized use of these chemicals is necessary to limit as much as possible, their impact on the environment, but also to limit the costs associated to their use, while the anticorrosion efficiency is kept sufficient to protect the carbon steel (CS) equipment.

The Company strategy is to use CI that are selected via laboratory testing programs. The corrosion inhibitors are evaluated through a series of tests aiming to be representative of the future use conditions. Parameters like carbon dioxide (CO₂) content in the associated gas, temperature and produced water salinity, flow velocity and flow regime, presence of sand are considered when the anti-corrosion efficiency is evaluated. Nevertheless, the field conditions cannot be fully reproduced in the laboratory and some aspects like foaming and emulsion tendencies, are not fully assessed during testing. This can be assessed only during a field test, where the CI is exposed to the real conditions.

The paper presents the experience of the use of 5 corrosion inhibitors in our assets in Guinea Gulf. Monitoring results in term of performance of injection and anti-corrosion efficiency are presented. Issues

experienced, such as production instabilities, oil/water separation, unreliability of monitoring techniques are also presented. These feedbacks are intended to be used further on to adapt the testing methodology used during the selection of the CI in the laboratory.

Key words: monitoring, optimization, environmental impact

INTRODUCTION

Carbon steel (CS) material is widely used for the equipment in oil and gas production industry due to its mechanical properties associated with a relatively low cost, compared to other materials. Depending on the corrosiveness of the fluid that is vehiculated, the use of carbon steel is generally associated with the injection of a corrosion inhibitor (CI) in order to mitigate internal corrosion. Corrosion inhibitors are generally used in continuous injection at an injection rate that is depending on the corrosiveness of the fluid. Based on the operational feedback, the internal standards are recommending for multiphase pipelines CI injection rates in the range of 50 - 70 ppm for temperature below 80°C and of 150 to 200ppm for temperatures above 100°C. These injection dosages are typical values that are considered in the laboratory tests for the qualification of the CI and they are adjusted on-site based on the monitoring results.

This paper presents the operational feed-back from the field use of 5 corrosion inhibitors on our assets located in Guinea Gulf. First a background on how these CIs were selected in the laboratory throughout a selection program will be presented. Then field results in term of monitoring of injection performance and anti-corrosion efficiency are given. Finally, the agreement or discrepancies between the laboratory data and the field data are discussed.

LABORATORY SELECTION PROGRAM

Integrity Operating Window (IOW)

The in-house strategy is to use a 'tailor made' corrosion inhibitor for a given application. The approach is similar to NACE TG-550 standard¹ and used by other Majors²: the field characteristics and the most relevant operating conditions are collected to define the CI application window and furthermore the CI Integrity Operating Window (CI -IOW). These ranges of parameters and operating conditions will be used to define the testing program, meaning the test methods and conditions for which the CI will be qualified. The CI-IOW is shared with the product suppliers in order to formulate and propose the most appropriate product. Then the proposed products undergo the selection testing program in the laboratory, aiming to select the most performant product, among the ones that were proposed.

As it can be observed in Table 1, the fields' characteristics of our assets located in Guinea Gulf are covering a wide range of conditions. The corrosiveness associated to these conditions, as they were evaluated with 'PreCorr' (an in-house developed software), can vary from Low (L) to High (H) or very high (V.H). The corrosion rates associated to each of these corrosiveness categories are presented in Table 1. The oil characteristics are also very different from one field to another: for example, the API density as presented in Table1 is ranging from 17 to 38, indicating that produced crude oils vary from light (field A, C, D and E) to more heavy oil (for field B and E). It is worth mentioning that each of the fields is a mixture of different oils, not necessarily coming from the same reservoir.

In addition, for some of the fields, due to the nature of the reservoir and the type of completion, sand events or sand production were identified. The detrimental effect of sand is well known in addition to CI adsorption and thus lower availability of the CI into the water phase³, sand can promote under deposit corrosion⁴ at lower flow velocity of the fluid, as it can be the case in some of subsea pipelines. At high flow velocity, such is the case of risers, the presence of sand can promote erosion-corrosion and even pure erosion, depending on the sand amount present in the produced fluids.

Table 1. Fields' main characteristics and associated corrosiveness

Field identification	A	B	C	D	E	F
Produced Water salinity (g/l)	117	110	145	132	129	50
CO ₂ content (%)	0.5	3.5	1.5	0.5	2	1,5
Temperature (°C)	50 -70	50-55	64 -68	60	60	100
Pressure (bar)						
Well head	85-110	65-113	100-141	85-110	34-115	84-220
Topside	25	25	25	25	18-32	24
Oil characteristics (°API)	32.5	22	30	30	17-22	35 -38
Sand presence	Spot events	Confirmed	NO	NO	NO	NO
Expected corrosiveness	Low to Medium	High	Medium	Low to Medium	Medium	High to very High
Corrosion rate with no inhibition (mm/y)	0.1 to 1	1 to 3	0.3 to 1	0.1 to 1	0.3 to 1	1 to 3 and above

Laboratory Test Methods and Selection Program

Typical CI selection program consists of several steps, starting with a screening phase where numerous products can be quickly tested throughout simple tests. Then as the testing program progresses the products are submitted to more complex, longer, and more expensive tests. After each step, the less performant products are eliminated, the final aim being to select 2 or 3 best candidates that are efficient in the operating conditions as defined by CI-IOW.

Table 2 presents the typical testing methods that were used during laboratory selection in our selection programs. These testing methods are widely used by both product suppliers, during the formulation and assessment of the new products, and by the Majors⁵ during the selection program.

Over time, the protocols and the methods used to select corrosion inhibitors have evolved in order to include the parameters that are considered to be the most representative for the studied field. For the 5 corrosion inhibitors that are discussed in the present paper, 5 selection programs were conducted (see Table 3): while at the beginning, the testing program was considering only bubble test, partitioning and flow-loop test, latter on, wheel test and rotating cage were included to assess the pitting tendency and the effects of sand, respectively. In addition, although the foaming and emulsion tendencies testing protocol remained the same, the weight given to these tests was increased for the fields where the process instabilities were challenging. For the latest selection programs, the efficiency of the CI was tested in the presence of other chemicals that are present in the production fluid and could interfere, like demulsifiers and scale inhibitors.

Table 2. Test methods used during selection programs

Test method	Description	Main purpose	Advantages	Limitations
Bubble test	Glass cell at ambient pressure, under CO ₂ . CR* measured by LPR**	•Efficiency of inhibition at a given CI concentration	•Easy to implement •Screening of numerous products	•Limited in temperature and pressure. •Static test
Partitioning	Glass cell, mixture oil/water; under CO ₂ ; CR by LPR and CI residual measured in the water phase after contact with oil and CI and separation	•Efficiency of inhibition in the presence of oil •Possibility to monitor CI residual	•Screening •Easy to implement	•Representativity of the oil sample
Wheel test	Autoclave at HT/HP CR measured by LPR and weight loss coupons Periodic stirring	•Efficiency in more representative conditions of temperature and pressure	•Several products can be tested in parallel •Long time of test (one week) that allows CR measurement by weight loss and to evaluate pitting tendency	•Limited volume, thus saturation of the test solution may occur
Loop Test / jet impingement	Loop test to measure CR by LPR after several hours of pre-corrosion	•Efficiency in dynamic conditions	•Representative condition for temperature, pressure and flow •Several hours of test	•Only water phase •Expensive
Rotating cage	Autoclave test	•Efficiency in dynamic conditions and in the presence of sand	•Representative condition for temperature, pressure •Presence of solid particles	
Emulsion tendency	Glass vial, with high excess of CI (300 ppm). Measure the time to solve the emulsion after stirring	•Comparative test to assess the tendency of CI to stabilize emulsion	•Fast •Comparative between the tested products	•Not representative of process conditions (ambient pressure, no gas, stabilized crude oil)
Foaming tendency	Glass column, with high excess of CI (300 ppm); measure the height of foam column and the time for the foam to collapse	•Comparative test	•Fast •Comparative between the tested products	•Not representative of process conditions

*CR: Corrosion Rate (mm/y)

**LPR: Linear Polarisation Resistance