

Chemical & Enhanced Preservation Methodologies Endeavors to Maintain the Integrity of Joint Operation (JO) Surface Facilities

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ABSTRACT

The abrupt shutdown of the Joint Operations (JO) production facilities led to a deviation from normal shutdown standard operating procedures such as draining and purging of the corrosive production fluids. Consequently, the ensuing deterioration, as a result of corrosion and other associated damage mechanisms, is bound to increase the integrity threats to JO equipment and therefore, negatively impact the restart of operation. The main anticipated damage mechanisms such as microbiologically influenced corrosion (MIC) and under deposit corrosion (UDC) are likely to manifest in the form of pinhole leaks, leading to increased incidence of loss of containment and subsequent negative Environmental, Health and Safety (EHS) consequences. This paper explores different mitigations that were utilized in maintaining the integrity of the JO equipment, including chemical preservation, the use of risk based assessment for the optimization of the chemical preservation methodology and subsequently, the use of enhanced preservation as a long-term preservation approach.

The chemical methodology relied on the use of corrosion inhibitor and biocide coupled with extensive chemical and corrosion monitoring key performance indicators, which were utilized to determine the treatment efficacy. An improved risk-based approach of the chemical methodology, using an integrated inspection, chemical and monitoring data was subsequently devised, leading to the identification and subsequent risk-ranking of susceptible equipment. These equipment were subjected to an increased and targeted chemical preservation retreatment frequency. A realization that the chemical preservation efficacy will diminish with time, alongside the desire to effectively assure the long-term integrity of the equipment, spurred the development of an enhanced preservation methodology. This typically involved equipment desludging, inspection and/or repair, if necessary. The enhanced preservation methodology utilized a qualitative assessment, where criticality and prioritization of equipment were based on number

of factors such as; production handling, equipment integrity, impact on startup, redundancy, and environment risk etc. These alongside samples of the post-inspection findings of the equipment will be highlighted and discussed

Key words: chemical treatment, CoF, damage mechanism, inspection, KPI, MIC, monitoring, preservation program, risk based assessment, sampling, shutdown, treatment frequency, UDC.

INTRODUCTION

The Wafra Joint Operation (WJO) Oilfield is located in the central-west part of the Kuwait-Saudi Arabia Neutral Zone. The Wafra oilfield reserves were first discovered and wells drilled in 1954. This field produces two types of crude oil, Ratawi (light oil) and Eocene (heavy oil), with average water cut of 80-85%. During operation, the production wells produce the oil emulsion through mostly coated flowlines to sub-centres (SC) where the sour oil, water and gas are separated. The facility has two gathering fields; Eocene and Ratawi. Eocene has 2 phase separation, whilst Ratawi has 3 phase separation. The sour gas is either flared or flows to the Main Power Generation Plant, whilst the oil is processed to the Main Gathering Center (MGC). The produced waters (PW) are routed to the Pressure Maintenance Plant (PMP).

The treated produced water at PMP is used for re-injection to mitigate the production decline in the production field. Consequently, the produced fluids from the reservoirs are highly corrosive due to the high water cut and other corrosive species (Table 1). The produced fluids also contain high populations of deleterious bacteria, which has led to increased frequency of microbiologically influenced corrosion driven failures across the field.

Table 1: Reservoir Water and Microbiological Analyses

Water Analysis	Average Ratawi-1	Average Ratawi- 2	Average Eocene-2	Average Eocene-1
	(mg/l)	(mg/l)	(mg/l)	mg/l
Sodium (Na)	187790	82998	44127	15688
Calcium (Ca)	13710	4612	2252	1877
Magnesium (Mg)	4271	1289	763	635
Potassium (K)	2901	1097	455	379
Strontium (Sr)	609	151	140	145
Barium (Ba)	2.5	0.75	0.25	0.22
Total Iron ($\text{Fe}^{2+}/\text{Fe}^{3+}$)	0.3	7.6	0.1	0.1
Soluble Iron (Fe^{2+})	0.1	0.1	0.1	0.1
Silicon (Si)	19.4	10	12	8
Chloride (Cl)	121500	53700	28550	10150
Sulphate (SO_4^{2-})	380	232	1006	805
Carbonate (CO_3^{2-})	0	0	0	0
Bi-Carbonate (HCO_3^-)	268	268	1530	1224
Sulfide (S^{2-})	74.1	0.1	636	510

Water Analysis	Average Ratawi-1	Average Ratawi- 2	Average Eocene-2	Average Eocene-1
	(mg/l)	(mg/l)	(mg/l)	mg/l
Sulfur (S)	202	7.4	1046	945
Carbon Dioxide (CO ₂)	272	242	453	380
Oxygen (O ₂)	0	0	0	0
Specific Gravity (20°C)	1.1592	1.1052	1.089	1.061
Conductivity (25°C)	367	151	36	32
Total Dissolved Solids	246200	84635	28442	22612
Lab pH (25°C)	6.13	6.17	6.18	6.22
SRB Bacteria	1000 (cfu/ml)	100 (cfu/ml)	1000 (cfu/ml)	1000 (cfu/ml)
GAB Bacteria	100 (cfu/ml)	100 (cfu/ml)	1000 (cfu/ml)	100 (cfu/ml)
GAnB Bacteria	1000 (cfu/ml)	1000 (cfu/ml)	100 (cfu/ml)	100 (cfu/ml)

In May 2015, the field initiated an unscheduled shutdown of the entire oilfield for an undetermined period. Due to the short notification of the shutdown, a stage-wise plan that ensured safe shutdown and protection of the facilities was performed by the field operation team:

- Draining and depressurization of some surface facilities
- Flushing of all gas lines with nitrogen
- Reduction tank levels to the extent possible.
- Nitrogen blanketing for critical MGC and PMP facilities

Despite the above endeavors, many critical facilities were either partially or incompletely drained, or purged, leading to increased internal corrosion threats, which might subsequently impact the integrity of FIELD production and safety critical facilities. Under the shutdown conditions, the corrosive stagnant fluid alongside the increased solid deposition are anticipated to lead to the dominance of both microbiologically influenced corrosion (MIC) and under-deposit corrosion (UDC) damage mechanism.

The FIELD preservation steering technical team was tasked with spearheading endeavors to safeguard the integrity of critical facilities for eventual field restart-up. After much deliberation, a short-term chemical preservation strategy was pursued, partly due to the uncertainty of when production will start, precluding more long-term mothballing methods.^{1,2,3}

CHEMICAL TREATMENT METHODOLOGY

The challenges posed by the shutdown were tackled by devising an integrated methodology combining effective chemical treatment alongside robust sampling and corrosion monitoring.⁴ The chemical treatment program involved the use of water-soluble corrosion inhibitor (CI), an oxygen scavenger, and THPS (tetrakis hydroxy methyl phosphonium sulphate) as biocide. The ready availability of the chemicals was a major factor in the chemical selection, and luckily the incumbent water injection corrosion inhibitor fulfilled all the requirements of a suitable preservation chemical. The preservation treated water was prepared in bulk by the injection of the inhibitor product (3500 ppm) into a 40000 BBLs Fire Water Tank containing brackish water with an average salinity of 5000 mg/l (Figure 1). As the CI contained bisulphite based oxygen scavenger, the THPS biocide (1500 ppm) was injected into the recirculating brackish water mixture after 30 minutes to avoid the deactivation of the biocide due to the formation of bisulfite-adheyde

adduct.⁵ The combined chemical mixture was then recirculated for an additional 24 hours and a sample collected to ensure the target corrosion inhibitor concentration was attained. Despite the high salinity, a high bio-loading and solid content, the use of brackish water was considered mandatory due to the large number of equipment and subsequent large volume of chemically treated water required. To avoid the ingress of oxygen, the firewater tank was blanketed with Nitrogen to obtain an inert atmosphere.

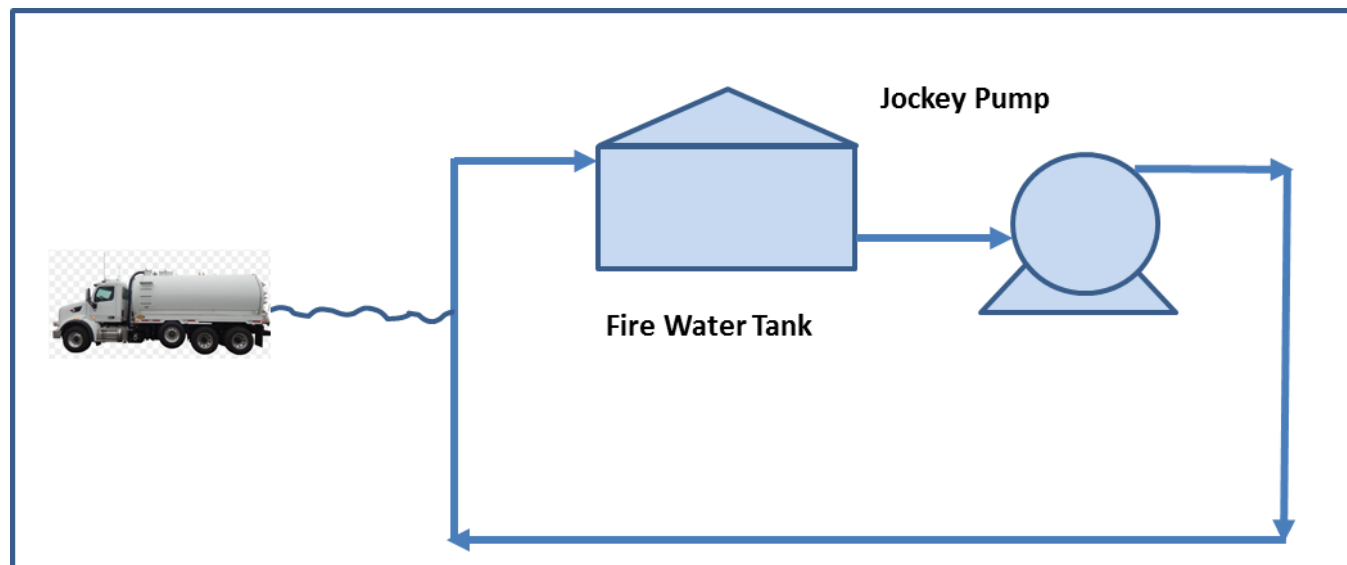


Figure 1: Chemical Batching of Brackish Water with Corrosion Inhibitor and Biocide

Surface Facilities Treatment Philosophy

The initial preservation of the facilities involved a process consisting of draining the equipment to remove the corrosive production fluids, followed by thorough flushing with the treated water. The equipment was then filled with treated water upon compliance with stringent treated water parameters. Sampling and routine monitoring of the treated facilities occupied central role in monitoring the continued efficacy of the preservation chemicals. As a result, an integrated monitoring program including chemical residuals, bacterial proliferation, water chemistry and coupons corrosion rates were implemented across the field. Error! Bookmark not defined.

The coupons were installed at suitable locations such as inlets and outlets of vessels and commingling points using available provisions (mixture of 6 O'clock and 12 O'clock positions) and fully submerged in the treated water. The coupons provide general corrosion rate and therefore give an indication of the inhibitor efficacy. Corrosion rates obtained from coupons are categorized as 'Low, Moderate, High and Severe' as per guidelines in NACE document RP 0775,⁶ and the coupon processing done as per ASTM⁽¹⁾ procedure G-1.⁷ A conservative approach of using the higher of either localized pitting rate or general corrosion rate was used. The coupons were retrieved/installed on quarterly basis, although coupon locations with severe corrosion rates were on occasions retrieved monthly. Whenever feasible, the coupons were also utilized to sample for sessile bacteria which provide a true reflection of the risk of MIC. The integrated four major monitoring parameters were subsequently used as key performance indicators (KPI) in driving the retreatment schedule of the preserved facilities (Table 2). Given the multiple combinations of the KPI parameters, a logical program, to provide a single Performance Index (PI) was devised. The highest weighting factors in determining the equipments leading PI's were assigned to SRB/bacterial enumeration and corrosion rates. The severe (red) and moderate (amber) PI indicators

⁽¹⁾ ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA, 19428-2959, USA

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