FIELD APPPLICATIONS OF A UNIQUE, BATCH-APPLIED, PROLONGED TREATMENT INTERVAL CORROSION INHIBITOR

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ABSTRACT

Historically, batch applications of corrosion inhibitors have been utilized to protect the downhole tubulars in oil and gas producing wells. Previously, a paper was presented which detailed the laboratory development and initial field evaluations of a new, unique corrosion inhibitor which enabled the Operator to extend the frequencies of his conventional batch treatments. This paper addresses the practical application of this chemistry, and the monitoring of its performance over the last year in several producing fields in the Permian Basin.

BACKGROUND

The majority of conventional oil wells that are produced through artificial lift, especially those produced with rod strings and insert pumps, are treated with batch-applied corrosion inhibitors. This is done to protect the material investment of the downhole tubulars from the debilitating effects of corrosion. As corrosion inhibitor films are not permanent, the applications of these products are generally repeated on a frequent schedule. While the depth of a well (with regards to the amount of tubulars present) is taken into consideration, the most common factor used to determine treatment frequency is fluid production rates. Some companies rely on water production volumes for this process, while others utilize the combination of both water and oil. Table 1 presents a commonly used set of production criteria for determining corrosion inhibitor batch frequencies. Once the frequency of treatment has been determined and the desired parts per million (ppm) treating rate is known, the amount of corrosion inhibitor to be applied with each treatment can be determined using the formula:

$$\text{Corrosion Inhibitor (gallons / treatment)} = \frac{\text{(Barrels fluid per day) (Desired ppm) (30.4 days/month) (42 gallons / barrel)}}{\text{(\# of treatments per month) (1,000,000)}}$$

This formula and the frequencies presented in Table 1 are used throughout the oilfield with some minor modifications from one company to the next.

In 2002, a new corrosion inhibitor was developed as part of an effort to increase the interval between field applications of corrosion inhibitors, while at the same time maintaining the original treatment quantities. For clarification, if a conventional oil well was treated with two gallons of a corrosion inhibitor every 14 days, the goal was to develop a product that could be applied at the rate of two gallons every 28 days in the same well.

After the newly developed inhibitor passed laboratory corrosion inhibitor testing, several small-scale field trials were conducted in West Texas. As mentioned above, the performance of the inhibitor in both the laboratory and the small field trials has been reported previously. The next step was to evaluate the inhibitor "fieldwide" on several oil producing leases in West Texas.

DISCUSSION

Three unitized production leases containing a total of 600 producing oil wells were selected for the full-scale test of the experimental, prolonged treatment interval inhibitor. All leases were mature waterfloods that had been treated with conventionally applied batch corrosion inhibitors for many years. Two of the units contained a total of 500 producing wells with all production coming from the San Andres formation. The remaining unit contained 100 producers with production coming from the Clearfork formation. Both the Clearfork and San Andres waters contain moderate quantities of dissolved hydrogen sulfide (H_2S) and carbon dioxide (CO_2) resulting in a corrosive environment.

To properly evaluate the performance of the new inhibitor, all producing wells, with the exception of those receiving minimal treatments, had their inhibitor application frequency doubled. If a well had been treated at one of the frequencies shown in Table 1 with a conventional corrosion inhibitor, the prolonged interval inhibitor treatment frequency would be one level higher. Simply put, if a well had been treated weekly, it would now be treated every other week with the new inhibitor. As a rule of thumb, minimum corrosion inhibitor treatments in wells producing "sour" (H_2S-containing) fluids are usually maintained at 1 to 2 gallons applied once per month. Initially, this minimum was continued for those wells out of the 600 that met the low production volume requirement; however, this limiting them from any opportunity for treatment enhancement. Once a promising trend was seen in the wells that had been adjusted with longer treatment intervals, a decision was made to further test the capability of the experimental inhibitor by lengthening the minimum treatment to 1 to 2 gallons applied every other month. This step, along with the interval adjustment on higher production wells, resulted in the overall field corrosion inhibitor treating rate being reduced from 35-50 parts per million (ppm) to 17-25 ppm.

Monitoring of the large-scale trial of the prolonged interval corrosion inhibitor was accomplished primarily by analyzing produced water samples for dissolved iron (Fe) and dissolved manganese (Mn) using inductively coupled plasma (ICP) spectrophotometry. Dissolved iron has been used historically as a corrosion monitoring tool, though poorly representative numbers are often seen in "sour" production as the dissolved iron readily precipitates as iron sulfide (FeS). Manganese is present in oilfield tubulars and is also released into the produced water as a result of the corrosion process. As manganese does not readily precipitate at low concentrations in "sour" fluids, it is more desirable as an accurate monitoring tool where dissolved H_2S is present. Manganese is also very accurately determined into the parts per billion range with the aid of plasma spectroscopy. Additionally, corrosion weight loss coupons were also employed.

Figure 1 depicts average, dissolved iron and manganese concentrations for the Clearfork producers. Average values were determined from 110 samples taken during the conventional inhibitor treatments and compared to the average of 102 samples taken during the course of the experimental inhibitor evaluation. As seen, a very slight increase in dissolved iron was calculated while the average dissolved manganese value decreased significantly. The comparison using iron and manganese was repeated on each of the two San Andres producing units (San Andres 1 and San Andres 2). This data is graphically presented in Figures 2 and 3, respectively.

On the first San Andres unit (Figure 2), values were determined comparing the average of 101 samples taken prior to the experimental inhibitor trial to 103 samples taken during the trial. Dissolved iron decreased during the experimental inhibitor treatments, as did dissolved manganese though only slightly. The data compiled from the second San Andres unit demonstrated a significant decrease in both dissolved iron and manganese averages. A larger sample set was used for these average calculations, with 215 samples being taken during the conventional inhibitor treatments and 178 caught during the prolonged treatment interval trial.

In Figure 4, the average mil per year (mpy) value for the corrosion weight loss coupons installed during the conventional inhibitor program is compared to the average mpy rate determined from coupons installed during the experimental inhibitor trial. Again, a noticeable decrease was seen in the average mpy corrosion rate during the prolonged treatment intervals.

The extensive monitoring discussed above proved the prolonged treatment interval inhibitor to be a technical success. More importantly to the unit Operator were the proven economical and environmental risk benefits. Individual well treatments were almost cut in half and an over one/third reduction was seen in the amount of corrosion inhibitor applied per month. The combination of these two items produced a significant decrease in the total corrosion inhibition cost for the three units. An extra benefit of the prolonged treatment inhibitor relates to the majority of batch-applied corrosion inhibitors being hazardous and toxic. Considering this, a reduction in the quantity and the amount of time these materials were being transported within the units produced a real reduction in the amount of environmental risk posed by the chemical treatment program.

CONCLUSIONS

Overall, the following relevant achievements were accomplished:

- The prolonged treatment interval corrosion inhibitor performed very well on the large-scale field trial. Based on the presented data, the unit Operator elected to continue with this program as the primary corrosion inhibition mechanism for these wells.

- The average corrosion-related failure rate across all three units decreased from 0.022 corrosion failures / well / year to 0.018 failures / well / year after complete coverage of the units with the prolong treatment interval inhibitor.

- With the exception of a very minor increase in the average dissolved iron concentration on one unit, decreases were seen in the dissolved iron and manganese concentrations and in the average mpy corrosion rate from the prior conventional program through the prolonged interval inhibitor trial.

- The numbers of monthly truck stops, or individual well applications of corrosion inhibitor, were reduced by 42% from the conventional to the prolonged interval program. This also relates to the amount of time the inhibitor-carrying truck was on the units, thus reducing spill potential and environmental risk.

- Monthly corrosion inhibitor costs were reduced by 35% and all costs associated with the corrosion inhibition programs on all three units were reduced by 41% from the conventional to the prolonged interval program.

REFERENCES

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Table 1
Commonly Used Corrosion Batch Interval Guidelines

Barrels Fluid Per Day	Treatment Frequency	Treatments per Month
<50	Monthly	1
50 – 150	Every other week	2
150 – 300	Weekly	4
300 – 500	Twice per week	8
500 - 800	Three times per week	12

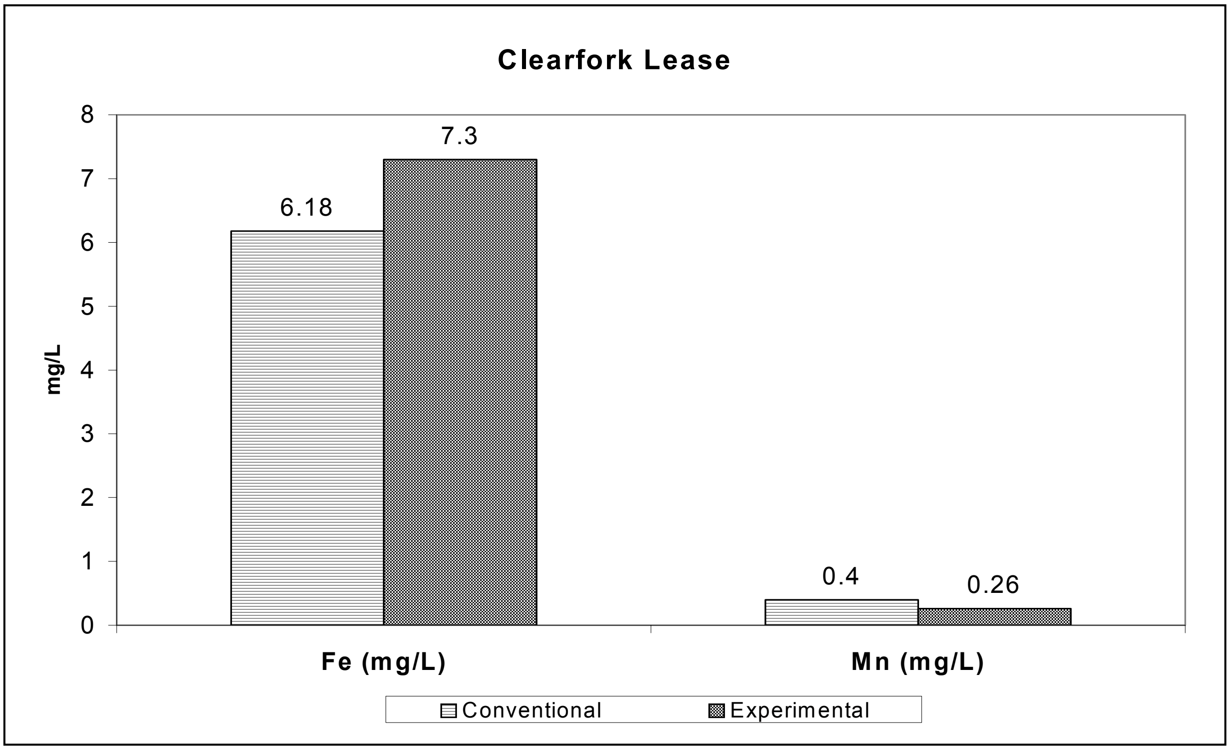

Figure 1

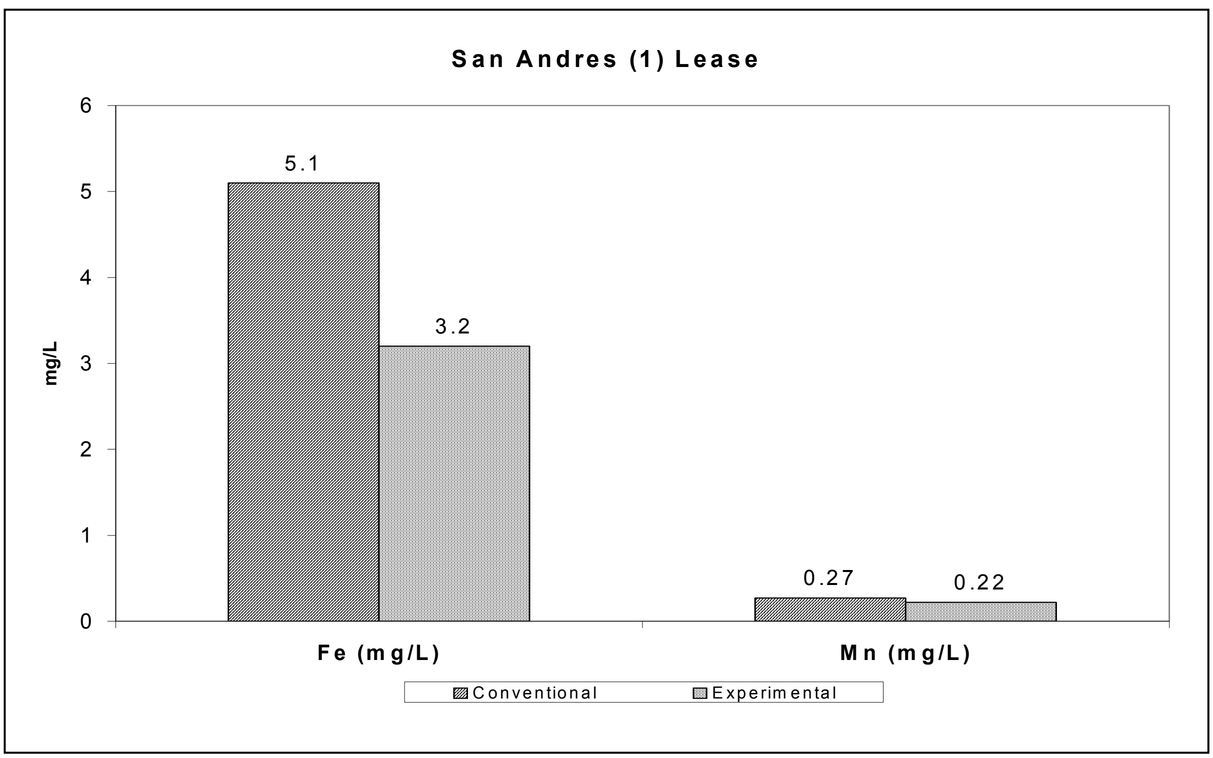

Figure 2

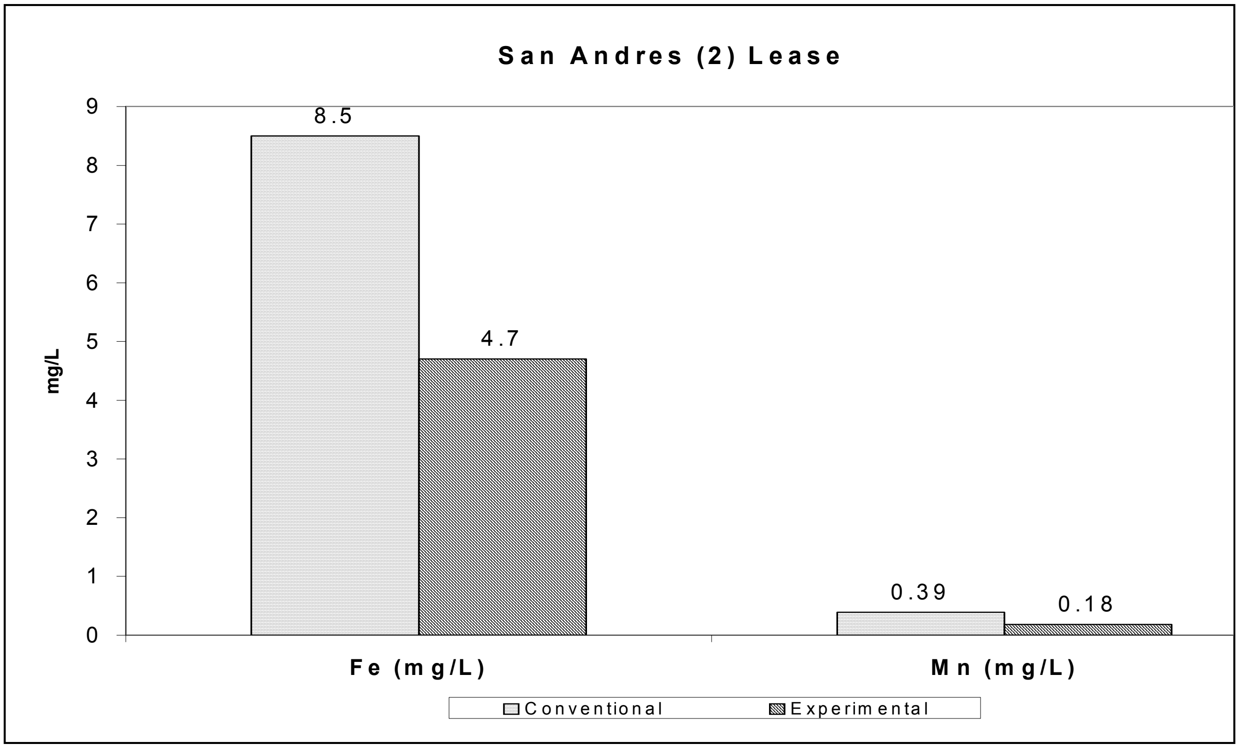

Figure 3

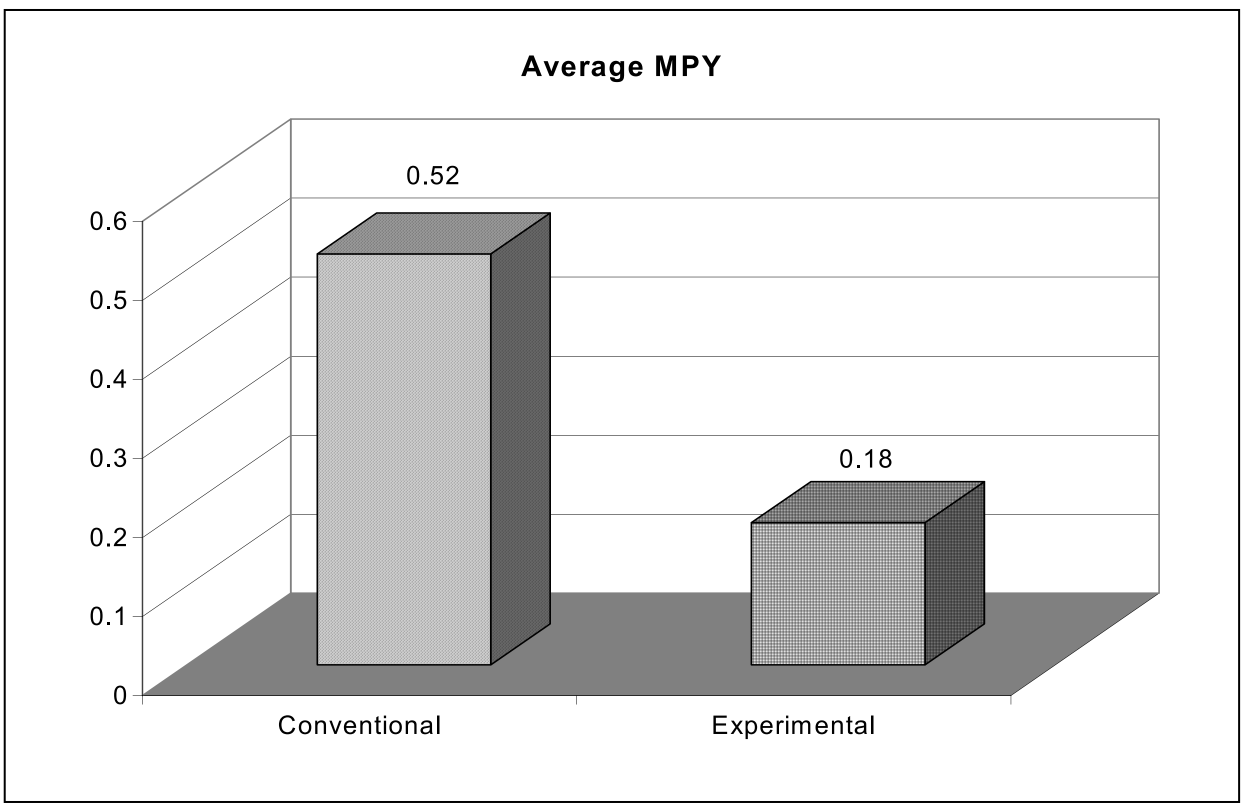

Figure 4