ROTATING CYLINDER ELECTRODE: CORROSION INHIBITOR EVALUATION

Cormetrics Job #: 12-234

Prepared for: XYZ Company

1. Introduction

Two batch and two continuous corrosion inhibitors were submitted by XYZ Company for a performance evaluation. A water analysis was also supplied and used to prepare synthetic brine. Each of the chemicals was evaluated in the rotating cylinder electrode (RCE) test apparatus as outlined in this document.

2. Test Conditions

2.1. Chemicals

The following corrosion inhibitors were evaluated:

- A (Continuous)
- B (Continuous)
- C (Batch)
- D (Batch)

2.2. Brine

The synthetic water was prepared based on the supplied water analysis. The composition of the synthetic brine used is shown below.

Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Barium (mg/L)	Strontium (mg/L)	Chloride (mg/L)	Sulphate (mg/L)	Bicarbonate (mg/L)
1720	10.8	67.3	12.3	59.8	24.4	2403	1	290

Table 1 - Water Analysis

The synthetic brine was prepared fresh prior to testing. It was pre-purged with CO_2 for a minimum of 2 hours. The pH of the water was measured to be 4.82 prior to filling the test cells.

2.3. Rotating Cylinder Electrode (RCE) Test Apparatus

The appropriate test fluid was added to each RCE cell and a water/glycol solution was circulated around the cells to maintain an average temperature of 20°C for the entire test run. A CO_2 flow into the cell was established by means of a gas dispersion tube after the brine was transferred into the cell. Purging was then maintained at a high rate until the experiment had concluded.

The counter electrodes are constructed from graphite, while the reference electrodes are made from silver wire coated with silver chloride. The working electrodes are cylinders of 1018 carbon steel (8mm x 12mm diameter). The electrodes are degreased in solvent immediately prior to beginning the RCE test. The electrodes have a surface area of 3 cm^2 and this value has been used throughout for corrosion rate calculations. Each working electrode is mounted on a Teflon sleeve, attached to a Pine Instruments AFMSRX rotator.

For the continuous inhibitors the test was initiated with the electrode spinning at 2000 rpm. The speed was increased to 5000 rpm once the cells had been treated with the 3 doses of corrosion inhibitor and the corrosion rate had stabilized. The effect on the corrosion rate during this high speed portion of the test can be used to determine the tenacity of the corrosion inhibitor film. The elevated speed is maintained for 1 hour after which it is reduced back to the original level of 2000 rpm.

The batch corrosion inhibitor test was initiated with the electrode spinning at 2000 rpm for the first 2.5 hours. The speed was then increased to 5000 rpm for an additional 2 hours and then decreased back to 2000 rpm for the final 2 hours.

LPR measurements are obtained by connecting the electrodes in each cell to a Gamry PC4-300 potentiostat and controller, via a Gamry ECM8 multiplexer. Data acquisition was by means of Gamry's DC105 software package. At the completion of the test period the working electrodes were cleaned and examined under a low magnification optical microscope. Graphs of the LPR data and photographs of each electrode are included with this report.

2.4. Continuous Corrosion Inhibitor Application

The continuous inhibitors were evaluated at 3 different concentrations added in a step-wise fashion. The cells were initially run blank for 1.5 hours at a rotation speed of 2000 rpm. Once a stable corrosion rate was observed an initial dose of 25 ppm was injected via Hamilton syringe. Once the corrosion rate had again stabilised a second dose was injected, bringing the total dosage to 100 ppm. When the corrosion rate from the previous additions had stabilized the cells were dosed for a third time bringing the total to 250 ppm.

One cell was run with no chemical addition in order to determine the baseline corrosion rate over the course of the entire test.

2.5. Batch Corrosion Inhibitor Application

The batch inhibitors were diluted 1:1 in diesel. The electrodes were dipped in this solution at 100 rpm for a period of 10 seconds. The electrodes were then allowed to drip for 1 minute immediately followed by two consecutive 1 minute rinses in purged brine.

Once the entire batching sequence had been completed each working electrode was immersed into the appropriate test cell.

3. Results Summary

3.1. Linear Polarization Resistance Data

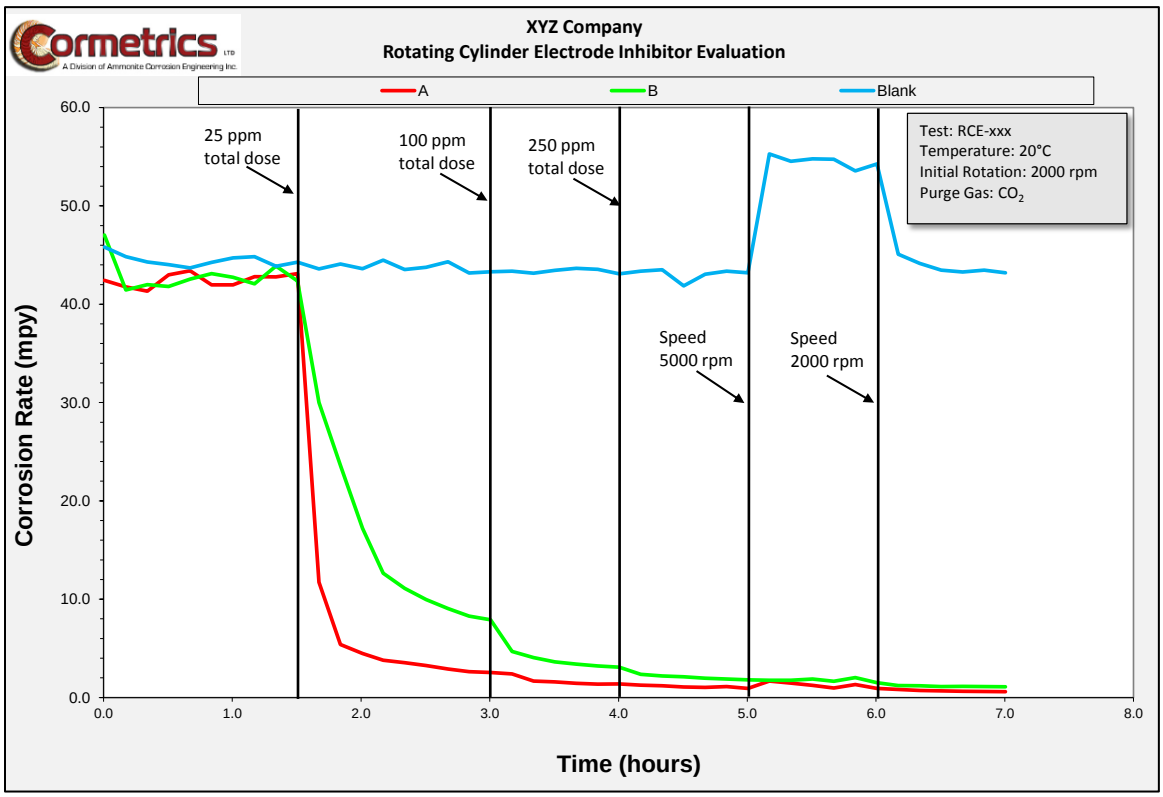


Table 2 - LPR Data (Continuous Inhibitors)

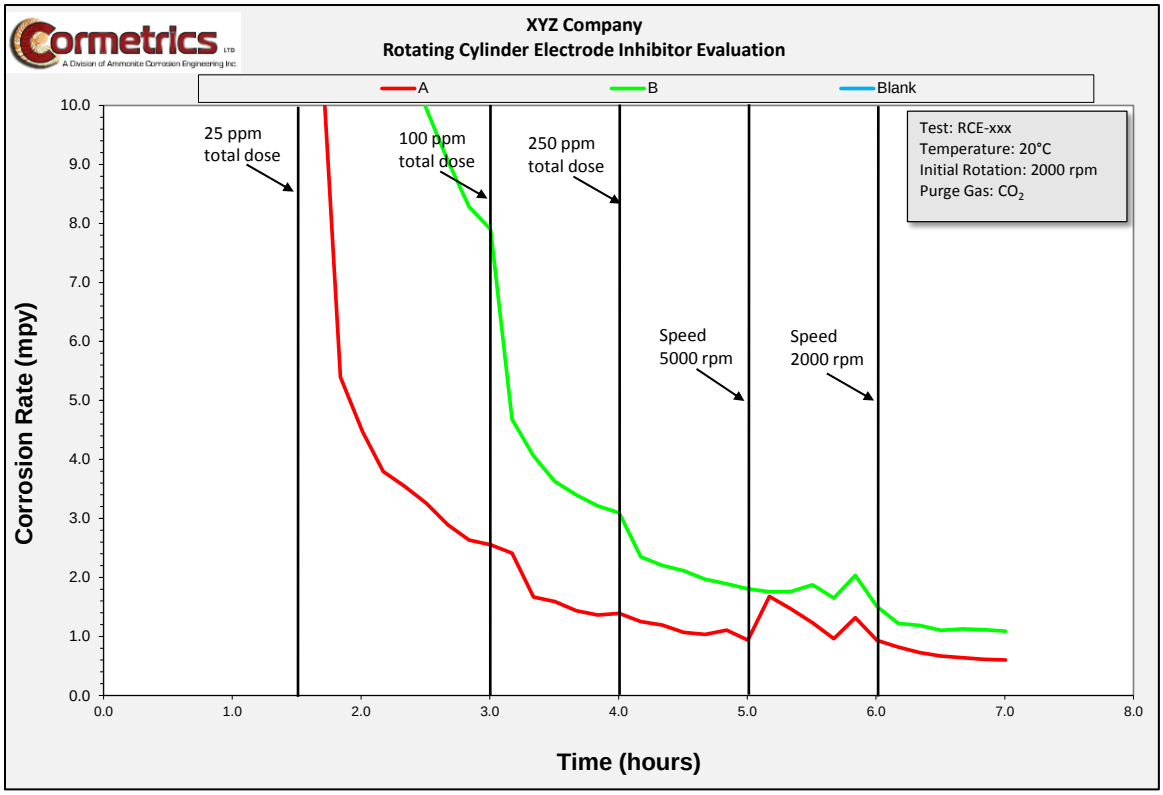


Table 3 - LPR Data: Expanded Scale (Continuous Inhibitors)

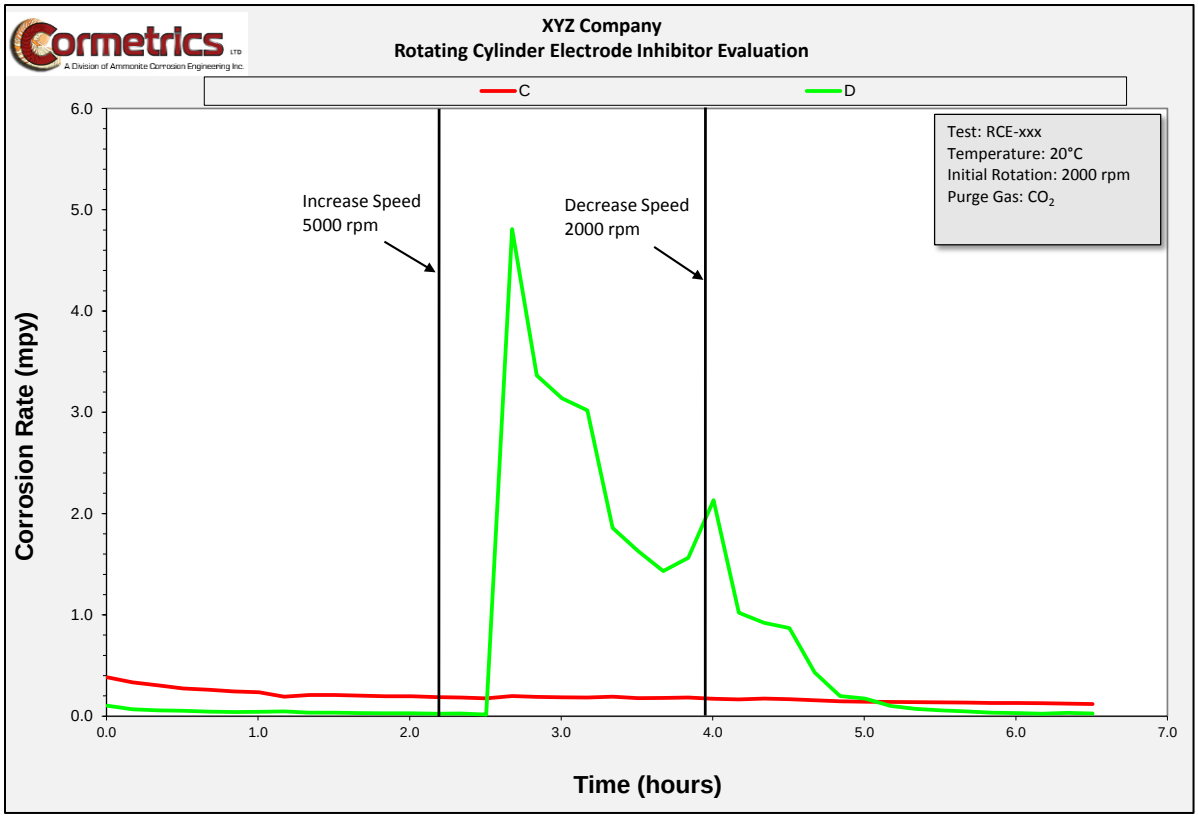


Table 4 - LPR Data (Batch Inhibitors)

3.2. Visual Observations of Test Electrodes

The visual results obtained from each cell are provided below.

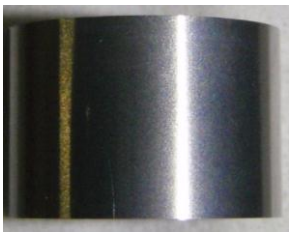
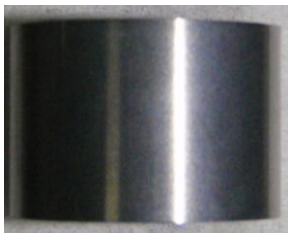
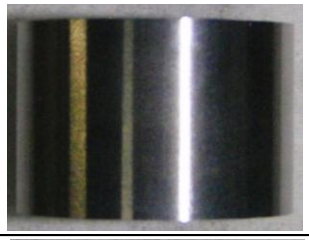
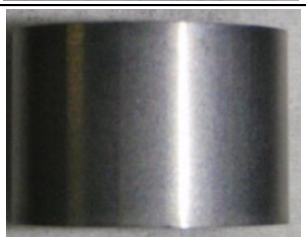
Inhibitor	Visual Description	Pit Depth (mils)	Pit Rate (mpy)	Electrode Photo
A	Light surface etch	N/A	N/A	
B	Light surface etch	N/A	N/A	
C	Shiny surface etched patches	N/A	N/A	
D	Overall surface etch	N/A	N/A	
Blank	Light patchy surface etch	N/A	N/A	

Table 5 – Visual Observations

4. Discussion

- The LPR corrosion rate for the synthetic water began at a rate of 45 mpy. The rate remained relatively steady for the first 5 hours of the test period. At this point in the testing the speed of the working electrode had been increased from 2000 to 5000 rpm. The rate jumped up sharply to about 55 mpy where it remained the entire time the speed was elevated. Upon lowering the speed back to its original level the corrosion rate stabilized out at a rate similar to before the speed adjustment.

  The working electrode visual observations under low magnification exhibited a light patchy surface etch on completion of testing.

- The A product began with an LPR corrosion rate similar to that of the blank. The 25 ppm dose lowered the rate sharply dropping from about 40 mpy to 2.5 mpy 1 hour after addition. The 100 ppm dose lowered the rate another 1 mpy in the next hour. The final dose stabilized out with a corrosion rate of 1 mpy. The product tolerated the increase in shear quite well with only a very slight increase in the rate to 1.8 mpy. Once the speed was declined back to its original level the rate continued to trend downwards slightly ending at a level of 0.60 mpy.

  The working electrode had only a light surface etch present post testing.

- The LPR corrosion rate of the B product also began at a level similar to the blank. The addition of 25 ppm lowered the rate to 8 mpy one hour after chemical addition. The 100 ppm dose further reduced the rate to 3 mpy in another hour. The final dose of 250 ppm was able to decrease the rate to 2 mpy by the time that the speed was increased. This product tolerated the increase in shear very well with only a slight increase in the corrosion rate. The trend continued downwards once the speed was decreased, ending with a final rate of 1.1 mpy

  A light surface etch was noted on the electrode surface post testing.

- The C batch inhibitor maintained a stable and low level for the entire test period beginning with a corrosion rate of 0.4 mpy and ending at 0.1 mpy.

The electrode exhibited a shiny surface with some etched patches post testing.

- The D batch inhibitor began with a very low corrosion rate of 0.01 mpy and remained at this level until the speed was increased. This product did not tolerate the increase well with the corrosion rate jumping up to 5 mpy; this typically indicates a weak inhibitor film that is easily broken down.

  The electrode demonstrated an overall surface etch post testing.

5. Conclusion

Of the two continuous inhibitors evaluated the A product was the best performer. It was able to decrease the corrosion rate quickly and to a low level.

The C product was the best performer of the two batch products. A low and stable corrosion rate was maintained for the entire experiment even during the high speed portion of the test.

Cormetrics Limited

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Lab Manager

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President

Please note, all inhibitor samples and electrodes are stored for 6 months prior to disposal.