



What We Do:

Established in 1977 based out of Calgary Canada, Cormetrics Ltd has a team of experts in corrosion and oil and gas processes that provides our clients with high quality cost-effective results in a timely and efficient manner.

Cormetrics Limited has been providing a variety of services to oil and gas companies in Canada, Middle East and South America.

These services include:

- Corrosion inhibitor and alloy performance testing
- Corrosion related failure analysis for oil and gas pipelines and well tubulars
- Crude corrosivity testing (ASTM G205)
- Corrosion coupon analysis
- Production chemical treatment consulting and evaluations of treatment programs
 - Corrosion inhibitor evaluations
 - Microbiological Testing
 - Foaming Tendency
 - Emulsion Forming Tendency
 - Solubility Testing
 - Dispersibility Tests
 - Gunking, Compatibility, and Partitioning Studies
 - Wax dispersant and solubility testing
- Designing corrosion monitoring programs

Corrosion Testing:

Cormetrics has highly specialized corrosion testing equipment with the ability to perform tests to meet a wide range of field conditions. These conditions include, but are not limited to: sweet and sour conditions, low to high pressures and temperatures as well as varying gas compositions. We meet ASTM and NACE standard methods as well as any customized test procedures that may be required. We are committed to working with our customers to develop the best protocol to meet their specific needs. Our open door policy allows our clients to be as involved in the testing as they wish.

Rotating Cylinder Electrode (RCE) Testing:



Figure 1: Photograph Showing RCE cells

The RCE allows testing of the corrosion inhibitor in a controlled shear environment. The rotating cylinder apparatus is designed to create a known and constant shear stress on the inhibitor film by spinning the working electrode at speeds up to 5,000 rpm. This way, surface shear stress up to 32 Pa may be readily obtained. The corrosion cell itself consists of a glass flask jacketed with a circulating glycol/water mixture keeping the cell at a constant temperature. A positive pressure, anaerobic environment is maintained during a test by means of a constant CO₂ purge. Electrochemical measurements are performed at intervals during the test, then the results are validated by weight loss and visual examination of the test element. This powerful technique allows rapid comparison of the performance of corrosion inhibitors in various applications. The tests for which RCE is particularly well suited are:

- Batch corrosion inhibitor film persistency and stability over time
- Performance of continuous chemicals under controlled shear
- Effect of water miscible chemicals such as methanol on inhibitor performance

Autoclave Testing:



Figure 2: Photograph Showing the Autoclaves

Corrosion inhibitors for severe environments require test conditions that simulates the system pressures and temperatures in order to realistically challenge the effectiveness of the products. Cormetrics uses 300 mL UNS N10276 (Hastelloy C) autoclaves, jacketed with electric heaters regulated by temperature controllers. The units can be pressurized to over 5500 kPa at temperatures up to 170°C. The units are stirred magnetically to impart sufficient agitation to perform valid electrochemical measurements.

The autoclaves hold a triangular array of electrodes; with a UNS N10276 reference and mild carbon steel working and counter electrodes. The electrochemical measurements are made using a Gamry potentiostat connected to several cells via a multiplexer.

The cells are purged and pressurized with a gas mixture blended according to the field acid gas content (H₂S, CO₂, methane or nitrogen). The cells are placed in the jacket heaters and brought

to system temperature using the temperature controller. Corrosion rate (LPR) readings are made every 30 minutes for the period of the test, usually 96 hours. The working and counter electrodes are cleaned, weighed for weight loss corrosion rate and photographed for the final report.

The test protocol can be modified to consider partitioning of inhibitors, use of mushroom cap coupons for under deposit corrosion or the crevice electrode.

Wheel Testing:



Figure 3 Photograph Showing Wheel Test Apparatus

Our corrosion testing laboratory also includes the Wheel Test apparatus for corrosion inhibitor performance testing. The Wheel Test is typically used as an initial test of all corrosion inhibitors in the brine. The brine is de-aerated with CO₂ for 2 hours and the purged brine is transferred to the wheel test bottle where inhibitor is injected at prescribed treatment levels. A CO₂ headspace is provided and the test proceeds onto the wheel test apparatus. Each inhibitor dose is tested in triplicate. An additional three bottles will be run with no inhibitor to determine a blank corrosion rate. The coupons used in the wheel test are made of UNS G10100 mild carbon steel shim stock (15 cm x 1.3 cm x 0.2 mm). The sealed bottles are placed inside a wheel test apparatus set to a maximum temperature of 75°C and rotated for 72 hours. Weight loss on the coupons is recorded over the exposure period to determine the corrosion rate and coupons are inspected to document if localized or general corrosion has occurred.

Electrochemical Techniques Used in Corrosion Testing:

Depending on the test requirements, the following electrochemical methods can be used in RCE or autoclave testing to monitor corrosion during the exposure period.

DC Electrochemical Techniques:

- Linear Polarization Resistance (LPR)
- Cyclic Potentiodynamic Polarization (CPP)
- Zero Resistance Ammeter (ZRA)



- Potentiostatic Polarization

Cormetrics provides clear, concise and "to the point" corrosion test reports. We are always able to customize any of our reports to the specific needs of our clients. Our standard corrosion test reports include the following:

- Test Protocol with details such as brine compositions and summarized test procedures
- LPR Graphs of time versus corrosion rate
- Electrode weight loss data and corresponding weight loss corrosion rates
- Visual inspection with photographs and description of electrode corrosion activity
- Summary and conclusions with specific chemical rankings if applicable

Failure Analysis:

Cormetrics performs corrosion related failure analyses for oil and gas pipelines and well tubulars. We take pride in presenting clear, understandable reports without compromising the scientific accuracy of the failure interpretation. We customize our analysis/reporting to suit your companies' requirements.

For each failure analysis our clients receive a comprehensive, in depth report that includes the following information:

System Description: This includes operating conditions, flow characteristics/modeling, production volumes, gas/liquid hydrocarbon analyses, system history and any other relevant information.

Water Chemistry: Discussion of water analysis, including scaling and corrosion tendencies-Validity of the water analysis is checked.

Sample Description: Description of sample as received including measurements and digital photographs as well as any other significant observations prior to any analysis being performed.

Sample Examination: Detailed description of all analysis performed in the laboratory including any spot tests and observations during and after cleaning of wall scale and corrosion products. Inhibited acid cleaning is used to preserve the fine details of the corrosion damaged surface. Mechanical properties of the sample as well as microstructure may be checked to ensure the material meets the expected specifications.

X-Ray Diffraction Analysis: Any significant/relevant scale and corrosion product will be sampled and analyzed by XRD. Identification of the nature of solids associated with a failure is often critical to understanding corrosion modes.

Degradation Mechanism: A detailed discussion of the root cause(s) of the failure and of any contributing factors will be presented. The role played by system parameters, operating methods and mitigation practices is usually discussed.

Conclusions & Recommendations: Clear and concise statements of conclusions are presented. Considering restrictions of the system, recommendations are made to avoid occurrence of further failures.



Crude Oil Corrosivity Testing:

ASTM G205-10 "Standard Guide for Determining Corrosivity of Crude Oils" has been developed to assess the bulk crude properties within a transmission pipeline for their propensity towards internal corrosion. The guide considers three main properties in its assessment of potential crude corrosivity:

1- The Emulsion Inversion Point (EIP): The EIP test evaluates the water cut required to change the oil/water mixture from a water-in-oil emulsion to an oil-in-water emulsion. This transition causes water to be present as the external phase of the emulsion, which is associated with higher rates of general corrosion.

2- Oil versus Water Wettability: For corrosion to proceed, the pipeline wall must first be wetted by water. The wettability test evaluates the crudes susceptibility to removal from the test electrode array allowing the electrode to become water-wet.

3- Effect of Crude Oil on the Corrosivity of Brine: This test evaluates the corrosivity of a reference brine that has been mixed with the crude oil. The effect of the crude on the brine corrosion rate provides an indication of the system corrosivity where brine has wet the pipewall.

Cormetrics Ltd has specialized experience and equipment for completion of this test methodology. Extensive experience with practical use of G205 has enabled Cormetrics to make improvements to the test procedures to improve repeatability and relevance of the test results. Our database of crude testing results allow us to rank the potential corrosivity of your crude compared to similar density crude streams.

Corrosion Coupon Analysis:

The corrosion rate in many production and drilling systems is monitored by means of electrically isolated carbon steel coupons and rings. Cormetrics offers a coupon inspection service for field coupons. Coupons and rings received from a facility are descaled, cleaned, weighed and inspected. A corrosion rate is calculated from the weight loss of each coupon.

A comprehensive report is submitted to the client, with the following features:

- Summary chart of coupon location, time in service, weight loss and corrosion rate
- Digital pictures of each coupon
- Photomicrographs of any significant features, such as blistering, pitting, crevice corrosion, etc.
- Graphical representation of historical data showing the trend of corrosion rate with time at each coupon location.



Chemical Programs:

Cormetrics has vast experience with application of production chemicals in oil and gas gathering systems. Cormetrics can assist the operator companies with selecting, implementing and managing cost effective, appropriate chemical programs for use in resolving production problems caused by corrosion, scale, bacteria, emulsion, or wax and asphaltenes. We have developed chemical standards specific to field conditions providing guidance to the operator on product selection, treatment levels and monitoring requirements.

Field Investigations:

Cormetrics has a wealth of technical and practical experience in finding solutions to field corrosion problems. Depending on the work activity, field investigations maybe required to:

- Complete system surveys to gain a better understanding of the field/plant layout, operating methods and review of field records.
- Assist with in-situ examination of failed equipment and pipelines. Important information can be obtained by being onsite when equipment is being repaired.
- Determine what analysis is required while ensuring proper sampling techniques and completion of any required field analysis is done for generation of the highest quality data.

Health & Safety:

Management and Employees at Cormetrics are committed to Health & Safety excellence. As members of Cormetrics' team, it is up to us to demonstrate to our clients, the communities in which we work and government regulatory agencies that Health & Safety is important to each and every one of us both corporately and at a personal level. As we apply these standards and exercise care and caution in our day-to-day operations, we have achieved a 100% lost time free workplace. In Canada we carry SECOR accreditation for our safety management program.



APPENDIX I - CORMETRICS SERVICES

Autoclave Testing

Standard test is four days, LPR measurements every 30 minutes, final electrode weight loss with documentation of corrosion attack on electrodes. Alternate is to use “Mushroom Cap” for under deposit corrosion rate or crevice test set up.

Rotating Cylinder Electrode

Standard test is 20 hour run time with up to two chemical injections and rotation rate adjustment prior to test completion. LPR measurements collected every 10 minutes, final electrode weight loss corrosion rate and documentation of corrosion attack on electrodes.

- **Test Options:**
 - Field Brine activated charcoal filtering.
 - Partitioning of continuous inhibitor pre-test

Inhibitor Characteristics

TEST
Emulsion Tendency
Foaming Tendency
Dispersability
High P/T Gunking Test
Atmospheric Pressure Gunking Test

Wheel Test

Final weight loss and visual observations of corrosion attack are reported. Standard test is three day run time in triplicate per chemical concentration and three blanks.

ELECTROCHEMICAL TEST METHODS

The following provides a reference to alternate electrochemical test methods to the standard linear polarization resistance (LPR).

Cyclic Potentiodynamic Polarization

Test design is to investigate the pitting and repassivation of materials. Also used to indicate inhibitor influence on pitting potentials. Test is run in the autoclaves over a two day period. Reporting includes discussion on the open circuit, pitting and repassivation potentials.

Potentiostatic Polarization

Test design is to apply a small potential to the electrode and determine the current response. This technique is used to evaluate materials and can be informative for corrosion inhibitor testing. The technique is combined with the CPP scan to determine the applied potential for the test and is typically run over a three day period.



Zero Resistance Ammeter (Galvanic Corrosion)

Test design is to record current flow and material potentials between dissimilar metals and report on corrosion rate identifying the extent to which one material is anodic to the other. Weight loss corrosion rate are also recorded. The experiment is completed over a four day period in the pressurized autoclaves or over a two day period at atmospheric pressure in the rotating cylinder electrode apparatus.

Failure Analysis

Standard failure analysis of a sample will document the as received condition, system description, review of produced water chemistry, modeling flow and water chemistry under operating conditions, XRD analysis of corrosion by-products, discussion on corrosion mechanisms, conclusions and recommendations for follow up activities or improvement to mitigation strategies.

Pipeline Corrosion Assessment

Corrosion assessment of a pipe segment will document the as received pipe condition and extent of corrosion activity. Activity entails splitting and cleaning of sample to allow documentation of corrosion activity. Pipe sample should be less than 2m in length.

Pipeline ILI Comparison

Corrosion assessment of a pipe segment in comparison to ILI inspection data will document the as received pipe condition and extent of corrosion activity in comparison to reported ILI inspection data. Activity entails splitting and cleaning of sample to allow documentation of corrosion activity. Pipe sample should be less than 2m in length.

Crude Corrosivity Testing (ASTM G205)

Three components of crude corrosivity are assessed in reference to ASTM G205 test methodology for transportation of crude oil streams. Wettability via the spreading method, Emulsion Inversion Point and Corrosivity of Brine partitioned from the oil phase with rotating cylinder electrode apparatus are evaluated. Report will categorize the crude characteristics per the ASTM guide for each of the three test parameters. It is a good reference to know the density, total sulfur, TAN and salt content of the crude we can facilitate testing of these parameters.

Wax Dispersant and Solubility Testing

Test design is to compare performance of wax dispersants and solvents with field samples. A ranking of performance characteristics and discussion on the test procedure is reported.

Corrosion Ring Analysis

Report provides, received description, determination of weight loss, general and pitting corrosion rate, comments on type of corrosion activity with photographs of before and after coupon surface. We require installation, removal dates and initial coupon weight.



Miscellaneous

- XRD Deposit Analysis
- Bacteria Testing (serial dilution, BART)