UTILIZING ELECTRICAL RESISTANCE (ER) PROBES FOR CORROSION RATE MONITORING, INHIBITOR PERFORMANCE EVALUATION, AND CHEMICAL PRODUCT SELECTION

Shane Stroh
Coastal Chemical

ABSTRACT

Electrical Resistance (ER) probes offer a continuous, high-resolution method for measuring corrosion rates in oilfield systems. This study demonstrates how ER data can be used to establish baseline corrosion, evaluate corrosion inhibitor performance, and guide product selection under varying produced-water and multiphase conditions. Results show that ER data can quickly distinguish between inhibitor chemistries, quantify treatment effectiveness in a short period, and guide the selection of the most effective corrosion control products for specific fluid chemistries and operating conditions. Overall, ER probes proved to be a practical and sensitive tool for corrosion inhibitor performance verification and product selection, supporting more efficient chemical programs and stronger asset integrity management.

1 INTRODUCTION AND PROBLEM STATEMENT

Corrosion remains a persistent challenge in oilfield production systems due to multiphase flow, changing water cut, variable fluid chemistry, and intermittent water wetting of steel surfaces (1; 2). These conditions complicate corrosion monitoring and often limit the effectiveness of traditional techniques such as weight-loss coupons and electrochemical probes, which may require extended exposure periods or continuous electrolyte contact to provide meaningful results (3; 4).

Corrosion inhibitors are widely applied to mitigate metal loss; however, verifying inhibitor performance, optimizing dosage, and selecting appropriate chemistries under field conditions can be difficult. Laboratory screening provides useful comparative data, but field performance frequently varies due to site-specific operating environments (4). As a result, corrosion control programs are often adjusted based on indirect indicators or prolonged trial periods, increasing uncertainty and delaying corrective action (3).

Electrical Resistance (ER) probes offer a direct measurement of metal loss and do not require continuous aqueous contact, making them well suited for multiphase production systems (3; 5). When deployed under operating conditions, ER monitoring provides continuous corrosion rate trends that can be used to assess baseline corrosion behavior, evaluate inhibitor response, and support treatment decisions in near real time (5; 6).

This case study evaluates the application of ER probe monitoring across multiple producing wells with differing operating conditions and corrosion environments. ER data were used to support three practical corrosion management scenarios: confirmation of existing inhibitor performance, optimization of underperforming corrosion control programs, and comparative evaluation of inhibitor chemistries following establishment of baseline corrosion behavior. The objective was to demonstrate a field-deployable workflow for integrating ER measurements into corrosion inhibitor selection and program optimization, enabling data-driven decisions under site-specific operating conditions.

2 OVERVIEW OF ELECTRICAL RESISTANCE (ER) PROBE APPLICATION

Electrical Resistance (ER) probes were used in this case study to monitor corrosion behavior and evaluate corrosion inhibitor performance under field operating conditions. ER probes quantify corrosion by measuring the increase in electrical resistance of a metallic sensing element as material loss occurs over time (3; 5). As corrosion reduces the cross-sectional area of the element, its electrical resistance increases in proportion to metal loss, which is converted to a corrosion rate expressed as metal penetration per unit time (3).

ER technology was selected for this application because measurements do not require continuous electrolyte contact. This characteristic makes ER probes particularly suitable for the multiphase oilfield environment evaluated in this study, where water wetting can be intermittent and variable (4). The sensing element is directly exposed to the process stream, allowing corrosion trends to be monitored under actual flow, temperature, and fluid composition conditions encountered during inhibitor evaluation (5).

Modern ER probes incorporate temperature compensation and reference elements to reduce measurement drift and environmental effects (3). Although ER probes respond more slowly than electrochemical techniques during the initial stages of corrosion, they provide a direct measurement of cumulative metal loss (3). In this case study, this capability enabled reliable comparison of corrosion trends before and after inhibitor application, as well as differentiation between competing inhibitor chemistries over relatively short evaluation periods (6).

Limitations of ER probes include reduced sensitivity to highly localized corrosion and the requirement for sufficient exposure time to establish stable trends (3). These limitations were considered during interpretation of the data presented in this case study. When applied within these constraints, ER probes provided a practical and effective monitoring tool for corrosion inhibitor performance verification and product selection in the evaluated system.

3 FIELD DESCRIPTION AND MONITORING SETUP

This case study was conducted across multiple producing well locations with differing operating conditions and corrosion environments. The selected wells were representative of typical oilfield production systems, exhibiting variability in production rates, water cut, gas–liquid ratios, temperature, and produced water chemistry. These differences resulted in varying corrosion risk profiles and required site-specific evaluation of corrosion behavior and inhibitor performance.

The monitored wells differed in baseline corrosion behavior due to variations in fluid composition, flow regime, and corrosive species. Accordingly, corrosion control effectiveness was evaluated independently at each location rather than assuming uniform response across the field.

3.1 Monitoring Locations and Corrosion Environments

ER probes were installed at selected monitoring points within each well system to capture representative corrosion behavior under flowing conditions. Probe locations were chosen based on accessibility, exposure to multiphase flow, and relevance to corrosion risk, including wellhead piping, flowlines, and downstream production facility piping. Each installation exposed the sensing element to the local corrosion environment specific to that well.

3.2 ER Probe Configuration and Data Acquisition

Carbon steel ER probes were used at all monitoring locations to maintain consistency in corrosion rate measurement. Probes were connected to data logging systems configured to record corrosion data at regular intervals. Following installation, ER measurements were allowed to stabilize prior to interpretation or chemical intervention. Probe configuration and data acquisition settings were held constant throughout the evaluation period to ensure comparability across wells and treatment scenarios.

3.3 Operating Condition Variability and Data Interpretation

Because operating conditions varied between wells, ER data were interpreted within the context of each location's specific corrosion environment. Differences in baseline corrosion rate, inhibitor response time, and trend stability were evaluated relative to local conditions rather than compared directly on an absolute basis across all wells. This approach ensured observed changes in corrosion behavior reflected chemical intervention under site-specific conditions rather than environmental variability alone.

Table 1 provides a summary of key operating parameters and corrosion environments for the monitored wells.

Table 1: Summary of Well Operating Conditions and Corrosion Environments

Well ID	Artificial Lift Type	Oil Rate (BPD)	Water Cut (%)	Gas Rate (MSCFPD)	Temperature (°F)	Corrosion Environment Notes
A	Gas Lift	35	95	355	140	CO2
B	ESP	380	71	330	165	CO2
C	Flowing	430	33	1935	170	CO2
D	ESP	840	59	485	165	CO2
E	ESP	190	74	345	160	CO2
F	Gas Lift	414	78	438	170	CO2

4 BASELINE CORROSION BEHAVIOR

Baseline corrosion behavior was established using ER probe measurements prior to changes in corrosion inhibitor strategy. Depending on the evaluation scenario, baseline conditions were defined either under the existing inhibitor program (Scenarios 1 and 2) or during temporary suspension of inhibitor injection (Scenario 3).

For Scenarios 1 and 2, ER probes were installed while corrosion inhibitor programs were already in place, and data were allowed to stabilize before interpretation. The pre-intervention portions of Figures 1–5 represent baseline behavior under current treatment conditions. Low and stable corrosion rates were interpreted as acceptable corrosion control, while elevated or variable trends indicated inadequate or unstable performance and triggered further evaluation.

For Scenario 3, corrosion inhibitor injection was temporarily suspended to establish an untreated baseline prior to comparative testing. The pre-treatment portion of Figure 6 reflects baseline corrosion behavior representative of the system’s native corrosivity under prevailing operating conditions. This baseline provided the reference for subsequent assessment of inhibitor response and relative performance.

Baseline periods also captured natural variability associated with multiphase flow and operational fluctuations. These trends were considered during interpretation of post-treatment responses to ensure observed changes in corrosion rate were attributable to chemical intervention rather than normal process variation.

Establishing baseline corrosion behavior provided the reference framework for evaluating corrosion rate reduction, response time, and trend stability following inhibitor application, as presented in Section 5.

5 CORROSION INHIBITOR EVALUATION USING ER MONITORING

Electrical Resistance (ER) probe monitoring was used in this case study as a practical tool to evaluate corrosion inhibitor performance and support corrosion control decisions under field operating conditions. Three evaluation scenarios were applied depending on the initial corrosion behavior observed following probe installation.

5.1 Scenario 1: Verification of Existing Corrosion Inhibitor Performance

In the first scenario, ER probes were installed in systems where a corrosion inhibitor program was already in place. Corrosion rate data were collected to assess the effectiveness of the existing treatment under operating conditions.

Where ER-measured corrosion rates were observed to be low and stable, indicating acceptable corrosion control, no changes were made to the chemical program. In these cases, ER monitoring served as confirmation of ongoing inhibitor performance and provided quantitative validation of the existing corrosion mitigation strategy.

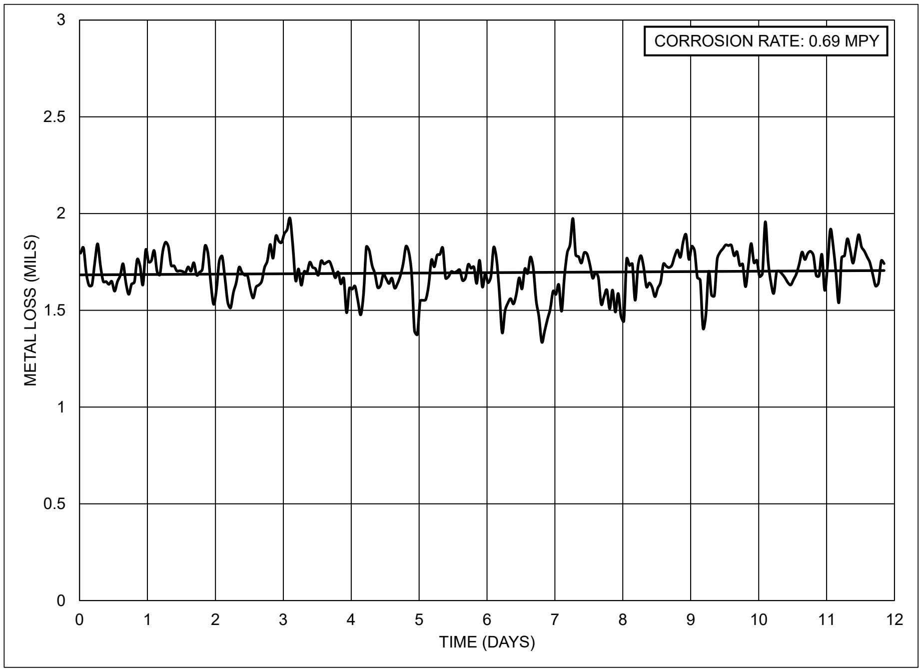

Figure 1:ER Probe Metal Loss vs Time – Well A

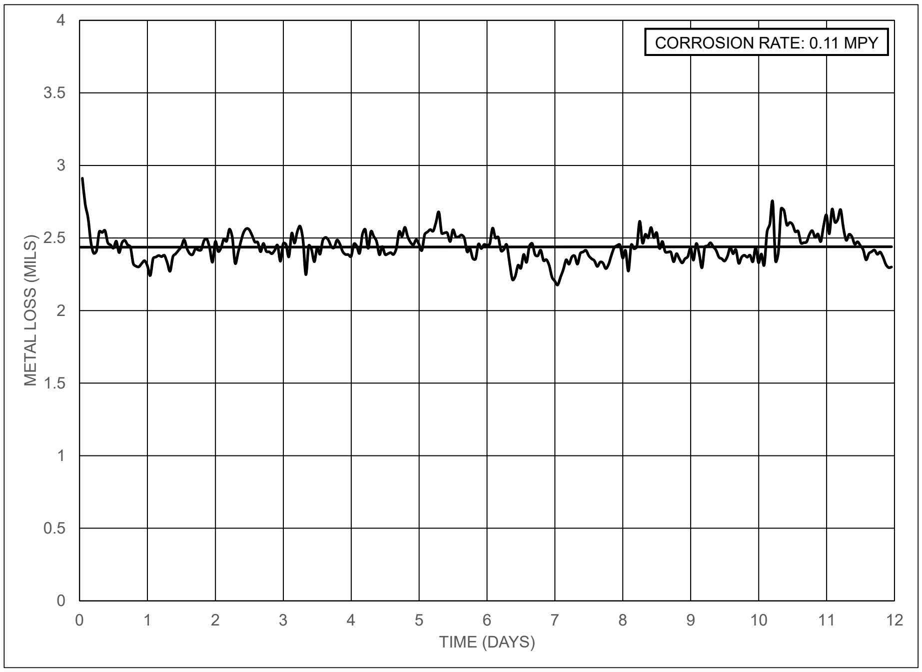

Figure 2: ER Probe Metal Loss vs Time – Well B

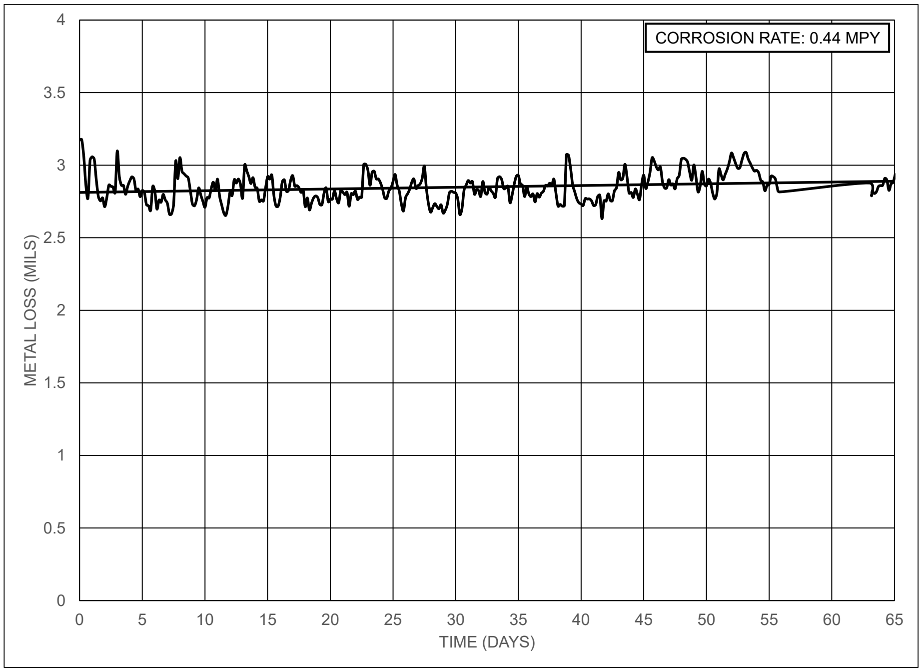

Figure 3: ER Probe Metal Loss vs Time – Well C

5.2 Scenario 2: Optimization of Inadequate Corrosion Control

In the second scenario, ER monitoring identified elevated or unstable corrosion rates despite ongoing inhibitor injection. When this behavior was observed, corrective actions were implemented, including increasing inhibitor dosage concentration, changing to an alternative inhibitor chemistry, or applying a combination of both approaches.

Subsequent ER data were used to evaluate changes in corrosion behavior following these adjustments. Reductions in corrosion rate and improved trend stability were interpreted as indicators of improved corrosion control under the evaluated conditions.

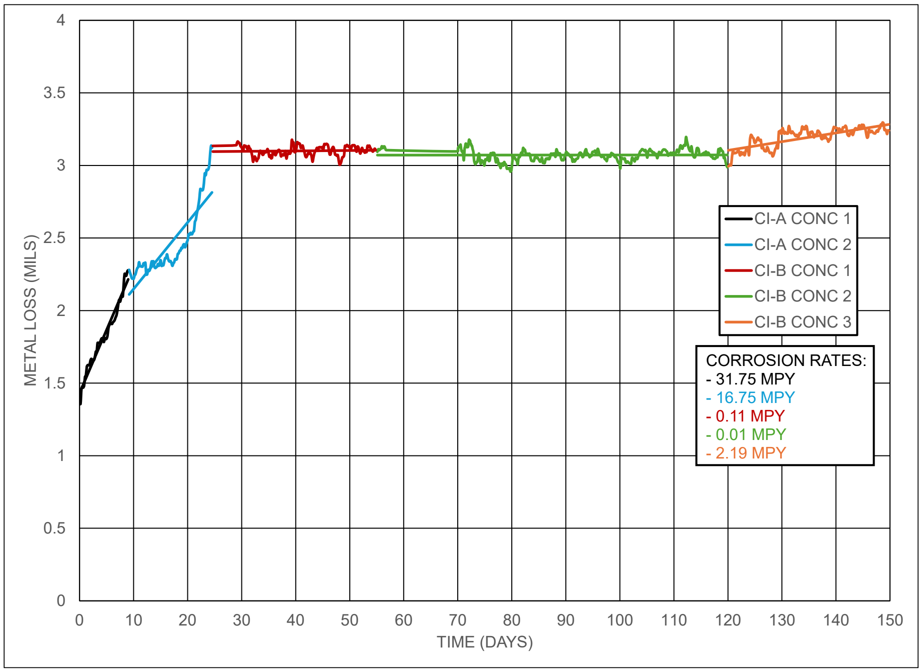

Figure 4: ER Probe Metal Loss vs Time – Well D

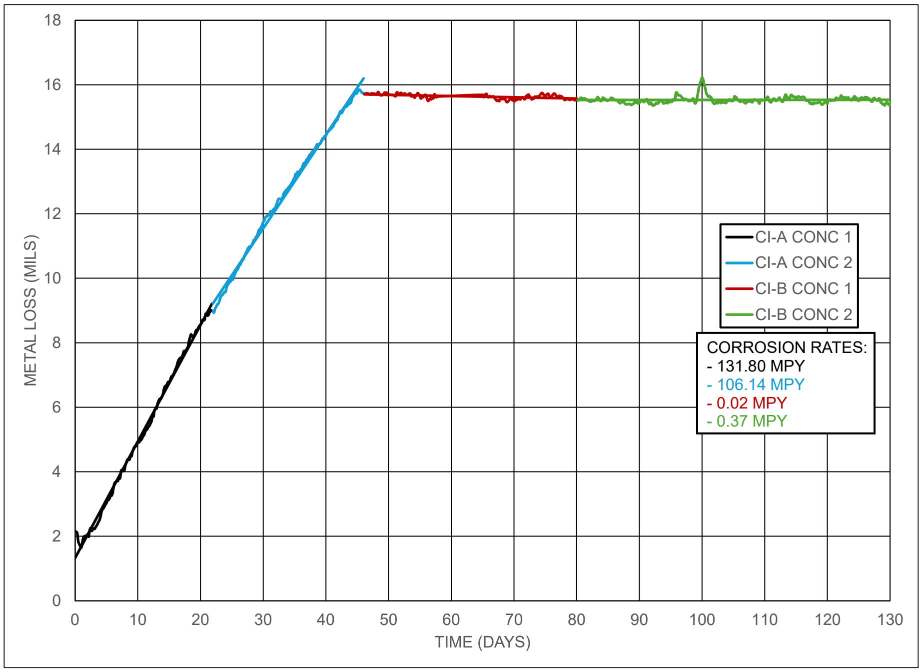

Figure 5: ER Probe Metal Loss vs Time – Well E

5.3 Scenario 3: Baseline Establishment and Comparative Inhibitor Evaluation

In the third scenario, an ER probe was deployed in a system where corrosion inhibitor injection was temporarily suspended to establish a baseline corrosion rate. After baseline conditions were documented, two corrosion inhibitors were evaluated sequentially at varying concentrations.

Changes in ER-measured corrosion rate following each treatment were compared to baseline behavior to assess relative performance. Differences in response time, magnitude of corrosion rate reduction, and stability of trends were used to inform product selection and dosage optimization.

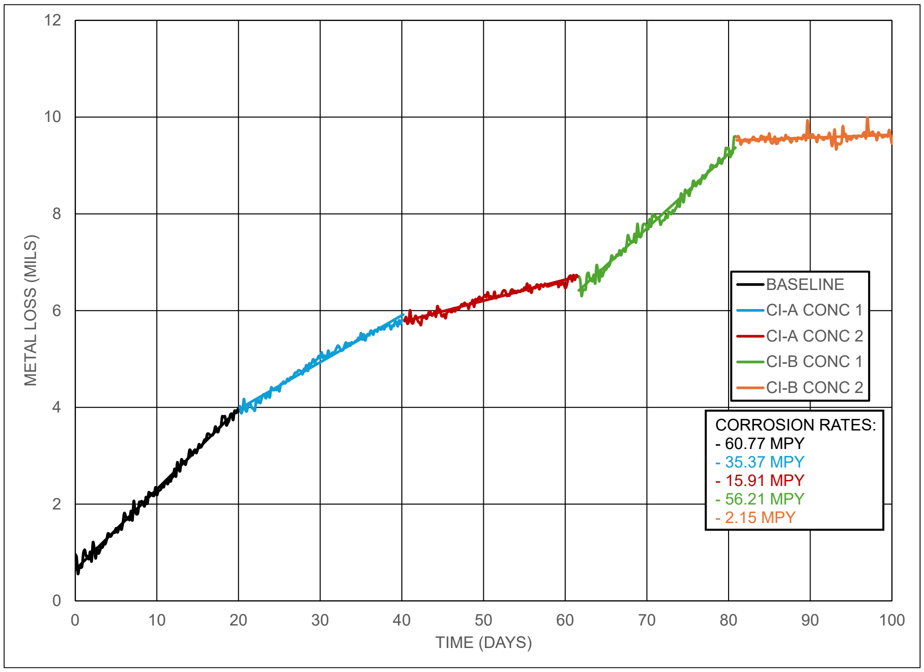

Figure 6: ER Probe Metal Loss vs Time – Well F

6 PRODUCT SELECTION AND PROGRAM OPTIMIZATION

ER probe monitoring provided field-based data to support corrosion inhibitor selection and optimization across the three evaluation scenarios. Changes in ER-measured corrosion rate, response time following chemical intervention, and trend stability were used to evaluate treatment effectiveness under site-specific operating conditions.

In Scenario 1, ER data indicated low and stable corrosion rates under the existing inhibitor program. No changes were made to product selection or dosage, and ER monitoring served as confirmation of acceptable corrosion control.

In Scenario 2, elevated or unstable corrosion rates prompted corrective actions, including increased inhibitor dosage, changes to alternative inhibitor chemistries, or both. Subsequent ER trends showing reduced corrosion rates and improved stability supported selection of optimized treatment conditions for continued operation.

In Scenario 3, baseline corrosion behavior was established in the absence of inhibitor injection, followed by sequential evaluation of two inhibitors at varying concentrations. Relative performance was assessed based on corrosion rate reduction, response time, and trend stability, informing selection of the preferred chemistry and dosage for field deployment.

Across all scenarios, ER-based evaluation enabled early identification of underperforming treatments and reduced reliance on extended trial durations. This approach supported more efficient chemical programs by aligning product selection and dosage optimization with observed corrosion behavior under actual operating conditions.

7 DISCUSSION AND LESSONS LEARNED

ER probe monitoring provided direct visibility into corrosion behavior under field operating conditions and supported corrosion control decisions across the three evaluation scenarios. Combined baseline and treatment response trends (Figures 1-5) demonstrate how ER probe monitoring differentiated effective and underperforming inhibitor programs within relatively short evaluation periods.

Establishing a stable baseline prior to chemical intervention was critical for interpreting ER responses. Both inhibitor-present and untreated baseline periods, corresponding to the pre-treatment portions of Figures 3-5, provided the necessary context to distinguish treatment effects from normal operational variability.

Inhibitor performance varied across wells with different operating conditions and corrosion environments (Figures 1-5), reinforcing the need for site-specific evaluation. ER monitoring indicated that treatment effectiveness was influenced by local fluid chemistry, flow regime, and water wetting behavior, highlighting limitations of laboratory screening alone for predicting field performance.

ER probes were particularly effective in multiphase systems where electrochemical techniques can be unreliable due to intermittent electrolyte contact. Continuous ER trends captured response time and stability following inhibitor application (Figures 1-5), providing insight not readily obtained from weight-loss coupons or discrete measurements.

Several practical lessons emerged. Variability associated with changing flow conditions necessitated evaluation of corrosion trends rather than individual data points. Additionally, because ER probes primarily reflect uniform metal loss, integration with complementary monitoring methods remains important where localized corrosion is a concern.

Overall, this case study showed that ER monitoring can be applied as a flexible field tool for corrosion inhibitor verification, optimization, and comparative evaluation when used within its known limitations. The observations emphasize the value of combining ER measurements with operational context and structured decision workflows to improve confidence in corrosion management decisions across diverse production environments.

8 CONCLUSIONS

This case study demonstrated the use of Electrical Resistance (ER) probe monitoring as a practical field tool for corrosion inhibitor evaluation, program optimization, and product selection across multiple well locations with differing operating conditions and corrosion environments.

ER monitoring supported three evaluation scenarios: confirmation of existing inhibitor performance, optimization of underperforming corrosion control programs, and comparative assessment of inhibitor chemistries following establishment of baseline corrosion behavior. In each scenario, ER-measured corrosion trends provided field-based feedback that informed treatment decisions under site-specific conditions.

Where existing inhibitor programs produced low and stable corrosion rates, ER monitoring confirmed acceptable corrosion control without changes to chemical formulation or dosage. In systems exhibiting elevated or unstable corrosion rates, ER data guided dosage adjustments and chemistry changes, with subsequent reductions in corrosion rate and improved trend stability observed following corrective actions. In comparative evaluations, ER probe monitoring differentiated inhibitor chemistries and concentrations based on response time, magnitude of corrosion rate reduction, and stability of protection.

Overall, ER-based evaluation reduced reliance on extended trial durations and laboratory screening alone by providing timely insight into corrosion behavior under actual operating conditions. Within the scope of this case study, ER probe monitoring provided a flexible framework for linking corrosion measurement to chemical program decisions across diverse production environments.

9 REFERENCES

1. de Waard, C. and Milliams, D.E. 1975. Carbonic Acid Corrosion of Steel. Paper 128 presented at CORROSION 1975, Toronto, Canada.

2. Nesic, S. 2007. Key Issues Related to Modelling of Internal Corrosion of Oil and Gas Pipelines. Paper 07655 presented at CORROSION 2007, Nashville, Tennessee, USA.

3. Schmitt, G. 2013. Application of Corrosion Monitoring Techniques in Oil and Gas Production. Paper NACE-2013-2524 presented at CORROSION 2013, Orlando, Florida, USA.

4. Kermani, M.B., Harrop, D., and Brown, B. 2016. Corrosion Monitoring in Multiphase Oil and Gas Production Systems. Paper NACE-2016-7854 presented at CORROSION 2016, Vancouver, Canada.

5. Shukla, P.K. 2019. Monitoring Effectiveness of Corrosion Control Using Electrical Resistance Probes. Paper NACE-2019-12933 presented at CORROSION 2019, Nashville, Tennessee, USA.

6. Mugongo, D. 2022. Field Application of Electrical Resistance Probes for Corrosion Inhibitor Performance Verification. Paper AMPP-2022-17601 presented at the AMPP Annual Conference & Expo, Nashville, Tennessee, USA.