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WHITE PAPER / CATHODIC PROTECTION DATA ANALYSIS

PATENT-PENDING DATA ANALYTICS APPLIED TO CIS AND RMU DATA DELIVERS MORE TARGETED AND EFFICIENT STRATEGIES FOR MAINTAINING AND IMPROVING THE PERFORMANCE OF CATHODIC PROTECTION SYSTEMS

This whitepaper provides a summary of AMPP Technical Paper 51323-19318-SG presented at 2023 AMPP Annual Conference

In this study, ground-breaking data analytics techniques are employed to combine high spatial resolution measurements from a Close Interval Survey (CIS) with year-round, daily Remote Monitoring Unit (RMU) measurements from nearby coupons. In effect, we create a "living" CIS profile, which updates in response to incoming RMU readings.

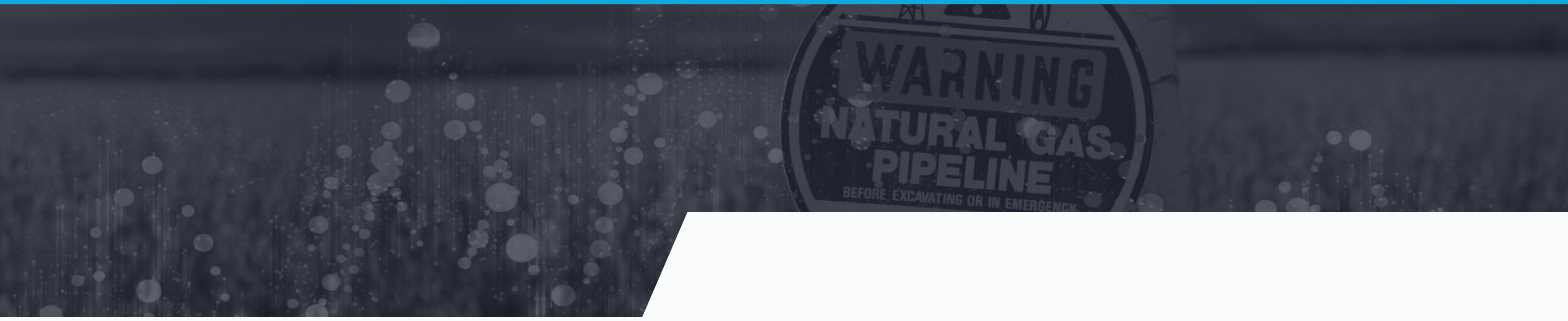
First, by comparing RMU and CIS measurements we aim to confirm the validity of the CIS readings, highlight any high-risk locations on the pipeline, and learn more about the influence of CP rectifiers at various distances along the pipeline (Figure 1 – *refer to original release: AMPP Paper 51323-19318-SG for all figure charts* LINK).

CIS and RMU technologies are essential for validating the safe operation of a cathodic protection (CP) system. CIS surveys on a pipeline are typically performed once every few years due to the high cost and time commitment of the process. However, they provide a high spatial resolution of measurements (Figure 2). RMUs installed at test posts with a typical spacing of multiple kilometers between units can be used to measure comparable electrical readings year-round without requiring a human to physically travel to each location.

Supplementing CIS measurements with RMU readings is becoming common practice in the cathodic protection industry. This paper presents various methods of combining these two data sources (Figure 3) and unlocking new insights that have not been readily available in the past. These techniques, methodologies, and interpretation of results (Figure 4) will help pipeline operators gain a better understanding of their CP systems.

The experimental procedure in this study focuses on a 114km segment of a 30.5 cm diameter coated steel pipeline running through a subtropical desert. The segment is part of an approximately 643 km pipeline, which was commissioned and put into operation in 2012. This segment has been cathodically protected by three rectifiers, which have been continuously monitored by remote monitoring units since 2012 (Figure 5). In addition, more than 30 coupons adjacent to the pipeline have been monitored since 2018 (Figure 6). One Close-Interval Survey (CIS) was performed in March 2021, resulting in 25,000 measurements of pipe-to-soil AC and DC potentials along the segment of interest collected over a two-week period (Figure 7).

In this study, the spatial and temporal relationships between CIS readings and coupon RMU readings are explored (Figure 8), particularly focusing on the rectifier "on" DC potential measurements. The approximate location of each coupon test station is determined, and statistics are gathered from the DC potential for the week prior to the start of the CIS survey (Figure 9). The average and standard deviation of each coupon's DC potential measurements are taken to be a proxy measurement of the nearby CIS. This value should represent the CIS measurement, with a calibration factor depending



on the specific setup, including coupon type and distance to the pipeline (Figure 10).

The hourly coupon RMU data may also be fit to a seasonality model (Figure 11), which simplifies the behavior into an equation that can be described by a few variables. A linear extrapolation between nearest test stations is made, as different test stations may experience different seasonal behavior (Figure 12). A projection of the CIS potential measurements is made into different times of the year, shifting the potentials up or down by a factor representing the seasonal changes on the nearby test stations (Figure 13). The projections are analyzed for any high-risk locations, for example, where the potential measurement is no longer meeting the regulatory requirements (Figure 14).

To test the validity of this approach, it will be necessary in the future to obtain a CIS survey at a different time of year (Figure 15), to see if the seasonal behavior observed at the coupons is representative of the seasonal changes that can be measured by CIS.

The combination of CIS measurements and coupon RMU measurements allows for a better understanding of the spatial and temporal variation in protection currents (Figure 16). Armed with this knowledge, a pipeline operator can optimize cathodic protection system operation by reducing or increasing protection currents at different times of the year. This will ensure that the pipeline's integrity is maintained, and the risk of corrosion is minimized (Figure 17).

Furthermore, the study demonstrates how the integration of CIS and RMU data can be visualized in various formats (Figure 18), which can aid pipeline operators and corrosion engineers in making more informed decisions about maintenance and mitigation activities. For instance, areas with consistently low or negative potentials can be flagged for further investigation and remedial action (Figure 19).

The data analysis techniques presented in this paper not only provide a comprehensive view of the pipeline's cathodic protection status but also open the door for further research and development in the field (Figure 20). Future work could focus on refining the models used in this study, incorporating additional factors such as soil resistivity, coating condition, and environmental factors (Figure 21). Moreover, machine learning algorithms could be employed to identify patterns and anomalies in the data more efficiently (Figure 22).

In summary, this study highlights the potential of combining high-resolution CIS measurements with continuous RMU measurements to gain a deeper understanding of cathodic protection systems on pipelines (Figure 23). By utilizing data analytics techniques, pipeline operators can optimize their CP systems and make more informed decisions about maintenance and mitigation strategies, ultimately ensuring the safe operation of the pipeline infrastructure (Figure 24).

This research provides a valuable contribution to the field of corrosion protection and pipeline integrity management. By effectively leveraging both CIS and RMU data, corrosion engineers and pipeline operators can develop more targeted and efficient strategies for maintaining and improving the performance of cathodic protection systems (Figure 25). This approach will lead to increased pipeline safety and longevity while reducing the overall costs and environmental impact associated with pipeline corrosion and failure (Figure 26).

REFERENCES: See AMPP Paper 51323-19318-SG : **LINK**

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1.844.689.3282 (844.MTX.DATA) | info@mobiltex.com | mobiltex.com

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