

Improving Cathodic Protection Monitoring Data in the Time of IIoT and Big Data

Tony da Costa
Mobiltex Data Ltd.
3640 26th Street N.E.
Calgary, Alberta, T1Y 4T7
Canada

Matt Barrett
Mobiltex Data Ltd.
3640 26th Street N.E.
Calgary, Alberta, T1Y 4T7
Canada

ABSTRACT

This paper explores the advances in remote monitoring technology and the enhancements that can be made to ensure that pipeline integrity is maximized while operational efficiencies are optimized. Specifically focusing on the data that is generated by cathodic protection and pipeline integrity monitoring devices (e.g. rectifier monitoring), this paper explores how data analytics techniques, such as artificial intelligence and machine learning algorithms, can shine a light on historically 'dark' data, improving pipeline integrity operations and the safety of workers and the broader public. Examples of artificial intelligence and machine learning work, such as applying intelligent algorithms to data analysis streams, will be presented as means of reducing data overload while providing automated predictive failure analysis and optimization of cathodic protection systems.

Key words: Big data, data analytics, machine learning, cathodic protection, remote monitoring, pipeline integrity, dark data, intelligent algorithms, data overload, predictive failure, alarm optimization, seasonality, remote limits.

INTRODUCTION

Collecting large amounts of data is not a new idea in the cathodic protection industry. A myriad of data points are collected and stored each year for regulatory compliance purposes and for tracking operating performance. While the quality and quantity of data has improved over the years, influenced by increasingly automated data collection using remote monitoring devices, most data collected remains 'dark' – stored away in an unrelatable database for reference only if a specific need arises.¹

Monitoring Alarms

Even some data that is not dark, has become a problem. Since the introduction of remote monitoring technologies onto cathodic protection assets almost 20-years ago, operators have worked with technology vendors to develop alarms, often simple notifications via email or SMS that are triggered if a threshold has been breached on a pre-configured limit. Alarms have been a wonderful invention for the industry, ensuring that the right people are notified as soon as data, indicative of a potential problem, exists. Alarms have revolutionized how pipeline operators monitor their CP systems and have saved time and resources in the process. Alarms, however, are not perfect. If an alarm limit is poorly configured, it can become the root cause of a very challenging, and sometimes dangerous condition – alarm fatigue.

Before going deeper into alarm fatigue, however, it is important to look briefly at the various causes of an alarm. Changes in readings measurements can be indicative of both the state of the overall cathodic protection system (e.g. rectifier is supplying an adequate supply of voltage to the pipe), the performance of the cathodic protection system assets (e.g. the rectifier stops working), and the performance of the remote monitoring unit (RMU) in itself (e.g. the RMU fails to communicate). Alarms of the former category, the state or level of protection that the CP system is achieving, are also subject to seasonal and meteorological variations as well.

This diversity ensures that alarms could be classified into a variety of buckets, each with its own rank and signature in terms of priority and need for remedial action. A factor that greatly contributes to alarm fatigue is that in current operating systems, alarms are not often adequately classified and sorted, and thus appear as a foreboding wall of homogeneous problems.

Alarm Fatigue

An operator or technician develops alarm fatigue when the volume of alarms generated by the remote monitoring system becomes overwhelming, ceases to compute with known operating conditions, or is based on too many false positives. Homogeneity of alarms with respect to the root causes is also a contributing factor, as described previously.

When an operator or a technician develops alarm fatigue, the first thing that they will do is to adjust the limits of the device, essentially the threshold value at which a measured reading is higher, or lower (depending if Upper or Lower limit) must surpass to necessitate that an alarm condition is classified, and an alarm notification is circulated. However, this widening of limits, driven only by the desire to reduce the amount of alarms generated, is a dangerous precedent. Limits that are established for the purpose of avoiding an alarm calls into question the purpose of remote monitoring systems. For a manufacturer of remote monitoring devices, alarm fatigue is a dangerous precursor to an environment of mistrust in the values that the remote monitoring program has collected. If left unaddressed the seeds of doubt, with respect to the return on investment that has been made, will soon grow from seedling into sapling.

Isolating the Effect of Seasonality

Nascent developments in data analytics can help shine a light into this topic, helping to automate the setting of remote limits and alarm thresholds and to provide flexibility for systemic variations that may occur throughout the year. Machine learning algorithms can be developed to recognize patterns in

historical readings in relation to other operation or relatable data – such as soil type, seasonality and precipitation – ultimately providing prescriptive insights into what future thresholds at which limits should be set to provide an optimal feedback and security layer. Alarm optimization can play a vital role in the long-term success of cathodic protection engineers and pipeline operators in keeping their critical assets, and the safety of the public, well protected and in an efficient manner.

EXPERIMENTAL PROCEDURE

Data from impressed current cathodic protection (ICPP) rectifiers considered for this work has been collected for more than 12 years. The most typical setup involves a RMU installed on a transformer rectifier (Figure 1). The most common of these rectifiers provide a near constant voltage output, with output controlled by manually configuring taps to set the desired voltage. The RMU is configured to take periodic readings of the electrical features of the system, to ensure the pipe is sufficiently protected from corrosion. These readings are then transmitted by satellite or cell network and are stored in a secure database.

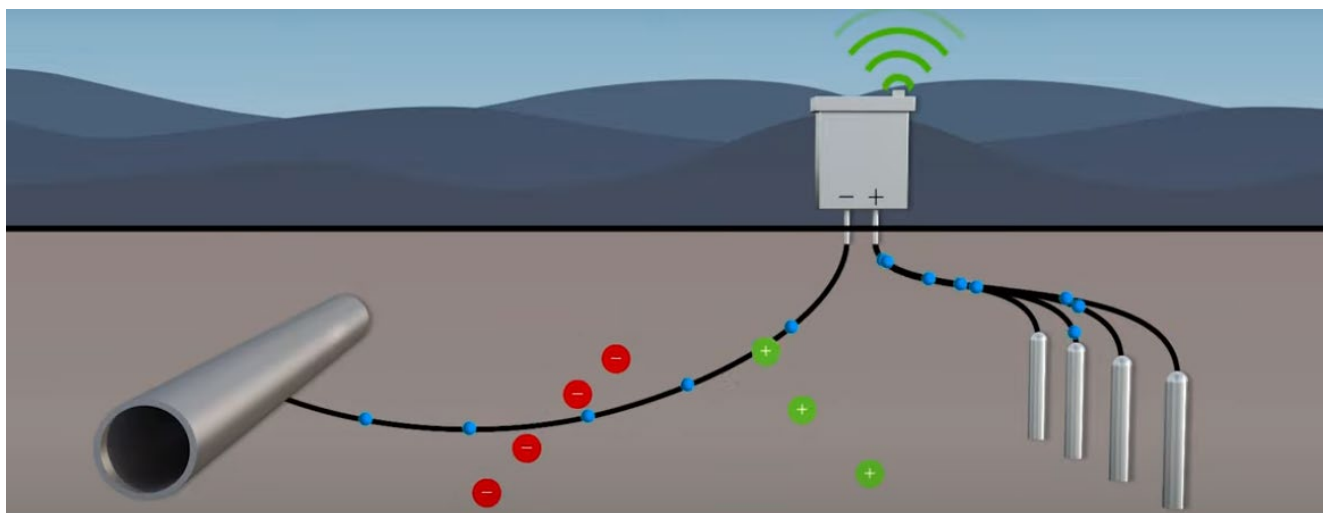


Figure 1: An impressed current corrosion protection system. A buried pipeline (bottom left) is connected by wire to a rectifier (top right) which is connected to buried anodes (bottom right). The rectifier drives a current into the pipeline through the soil. A remote monitoring unit is mounted to the rectifier housing, periodically measuring electrical features and transmitting data.

A common RMU setup records the DC voltage and the DC current of the cathodic protection system. The electrical current in a rectifier system travels through the soil to complete the circuit. In many rectifier setups, seasonal variation in the voltage and current readings is observed. This variation can be attributed to seasonal changes in soil resistivity.² An example is shown in Figure 2.

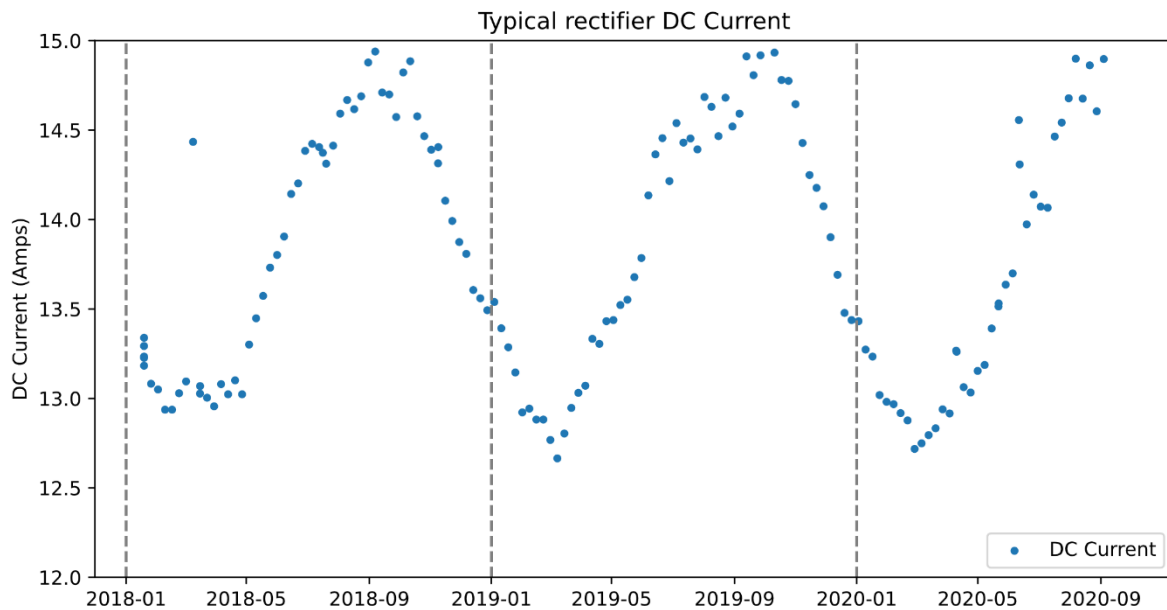


Figure 2: Seasonal variation in DC current

To better protect pipeline assets from corrosion, and to ensure that alerts do not become overwhelming, seasonally adjusted limits are proposed. This approach would work in two phases.

- 1) **Predicted thresholds:** Upon installation of a new RMU, a machine learning algorithm suggests an alert threshold. This suggested range is based on publicly available soil and temperature classifications specific to the rectifier's location, as well as features describing the pipeline and cathodic protection system.
- 2) **Rectifier specific thresholds:** In the weeks and months after an RMU is activated, as readings are captured and a location specific dataset is constructed, the alert threshold becomes more focused and specific to the rectifier being monitored.

Predicted thresholds

Resistivity of the soil in the ICCP rectifier system is not constant. Throughout the year, changes in temperature, precipitation and evaporation all play a role in changing soil resistivity.³ For a rectifier with fixed voltage output, the current will be inversely proportional to the resistivity of the rectifier-anode system, calculated using Ohm's law. The system includes many components, but the fluctuations which have been observed can be primarily attributed to seasonal changes of soil resistivity. The voltage divided by the current can be expressed as the system resistance, which fits quite well to a sine function, with a fixed period of one year.

$$y = A \cos(2\pi x - \varphi) + y_o \quad (1)$$

In Equation 1, A is the amplitude of the annual variation in resistance, φ represents the date shift of the maximum resistance, and y_o is the average resistance. A cosine function was chosen instead of a sine function for simplicity of interpretation of the offset, the parameter φ in a cosine function will indicate the maximum amplitude, or the calendar date with the highest resistance. An example of the cosine fit is shown in Figure 3.