

Stray And Telluric Current Correction Of Close Interval Potential Survey Data

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Abstract

A properly functioning cathodic protection system that provides adequate levels of cathodic protection current is the backbone of pipeline integrity. To adequately measure the effectiveness of a cathodic protection system, a close interval potential survey (CIPS) is a prerequisite. Direct current voltage gradient (DCVG) and alternating current voltage gradient (ACVG) surveys only delineate coating damage, they do not measure the effectiveness of cathodic protection. To adequately measure the level of cathodic protection on a pipeline, the structure-to-electrolyte potential must be measured at frequent intervals and the voltage drop due to the cathodic protection current flow through the soil must be considered, in the analysis of the measured potential.

With increasing population density and urbanization, stray currents from electrified transportation systems seriously affect pipelines. Direct current and low frequency AC traction systems can significantly affect the measured structure-to-electrolyte potential making interpretation of the results difficult if not impossible. With modern electronic survey equipment, the effect of dynamic stray currents on close interval structure-to-electrolyte potentials can be easily corrected.

Global Positioning System (GPS) synchronized current interrupters interrupt the cathodic protection current on a cyclic basis with very precise timing controlled by GPS satellite system. Survey equipment and stationary data loggers that also utilize the GPS timing signal to initiate measurement of the structure-to-electrolyte potential can be compared at each interval in time for the deviation from the average potential of each reading. This allows for correction of potential excursions due to stray or telluric currents.

By recording the precise time of each recorded reading, comparison can be made between the recorded rectifier ON and instant OFF potential of the close interval potential surveys and the recorded rectifier ON and instant OFF potential of the stationary

data loggers. The deviation from the mean value of both the rectifier ON and instant OFF values can be used to correct the close interval survey data.

Some pipelines are affected by telluric current, which often causes significant fluctuation in the structure-to-electrolyte potential. The same techniques as used for dynamic stray current can also be utilized for telluric current correction.



A CIPS Surveyor In The Mountains Introduction

There is increased awareness of corrosion and the need for cathodic protection of underground metallic pipelines to prevent leaks and preserve the environment. With increasing urbanization, stray current interference on pipelines is of major concern.

Both static stray current from foreign cathodic protection systems and other stationary sources of DC, as well as dynamic stray current from DC and low frequency AC traction systems can significantly corrode underground pipelines. Adequate cathodic protection levels and stray current mitigation systems must be maintained to ensure protection from corrosion.

Dynamic stray current principally originates from leakage of DC or low frequency AC current into the ground from electrified transit systems such as Figure No. 1. The current that leaks into the soil circuit will return to the traction substation via underground plant such as pipeline, water mains, cables, etc. Where the current flows onto a steel or iron underground pipe, it generally does not cause any damage, however where it leaves the pipe it can cause severe corrosion. In the case of lead, corrosion can occur at both the pickup and discharge locations.



Figure No. 1 Electrified Transit Vehicle

Telluric current is current that is induced on a pipe or cable due to fluctuations in the earth's magnetic field. Ionospheric disturbances generally due to sun spot activity cause the earth's magnetic field to wobble. This movement of the earth's magnetic field can induce current to flow on a pipe or cable. The effect is most pronounced in the northern and southern latitudes on pipelines that run principally north and south.

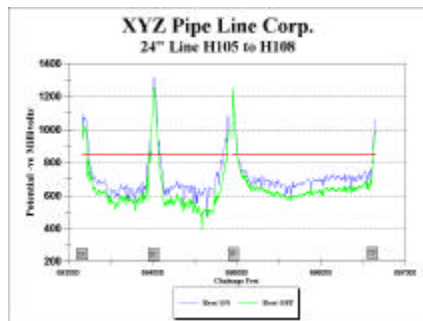


Figure No. 2 CIPS Survey Data

The corrosion engineer working in an environment where there are dynamic stray currents or telluric activity will have difficulty certifying that the piping system under his jurisdiction is adequately protected from corrosion. Measurement of the structure-to-electrolyte potential at test facilities or appurtenances on a pipeline only offer the corrosion engineer a snapshot of the level of protection on the pipeline system, but do not provide sufficient information for certification of the adequacy of the cathodic protection system. Figure No. 2 shows the results of a CIPS survey on a pipeline protected by an impressed current cathodic protection system, where sacrificial

anodes have been installed at test stations to supplement the level of cathodic protection. In this instance relying on test station survey data could result in corrosion of the pipeline in unprotected areas between test stations.

Close Interval Potential Surveys

A Close Interval Potential Survey allows for measurement of the structure-to-electrolyte potentials over a pipeline at close intervals 1 to 3 metres, (See Figure No. 3).



Figure No. 3 CIPS Surveyors

For a CIPS survey to be effective and provide accurate data to the corrosion engineer, the IR free potential must be accurately measured. The only effective method of measuring the adequacy of a cathodic protection system is to measure the IR free potential of the pipeline at sufficient locations such that the corrosion engineer can be confident that the gathered data is indicative of cathodic protection. With modern Global Positioning System (GPS) synchronised current



Figure No. 4 GPS Synchronised Current Interrupter

interrupters installed in all cathodic protection rectifiers that influence the survey area, the corrosion engineer can be confident that the recorded Instant OFF potential is the true IR free potential of the pipeline. Figure No. 4 shows a modern portable GPS synchronized current interrupter.

Modern close interval survey equipment equipped with a GPS engine can accurately measure the rectifier ON and IR free potential at each reading location. In addition to recording the Rectifier ON and Instant OFF potentials, the GPS equipped survey data logger can also record the Chainage, latitude, longitude, elevation and Coordinated Universal Time (UTC) of each reading. Figure No. 5 shows a modern CIPS survey data logger with GPS engine.



No. 5 GPS Synchronized Close Interval Survey Set

By utilising a GPS engine in the close interval survey equipment, the precise timing of the rectifier interruption is known and is used to initiate the measurement cycle. Since the time of the rectifier current interruption is known with great precision, the measurement of the instant OFF potential can be delayed by a programmed amount to allow for any inductive effects due to the interruption of the cathodic protection current, (See Figure No. 6).

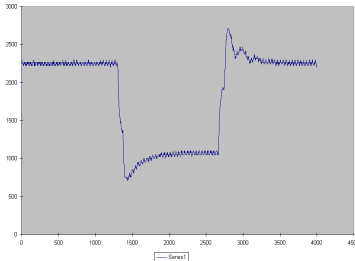


Figure No. 6 Waveform Captured by Survey Equipment

Stray and Telluric Correction

This improved method of stray and telluric current correction requires the installation of stationary data loggers on the pipeline under survey. Stray current and telluric current correction is accomplished by recording the rectifier ON and Instant OFF potential during each interruption cycle and time stamping each reading with the UTC time. Typically, stationary GPS synchronized data loggers such as the CATH-TECH™ Smart Logger are installed at 5 Km intervals on the section of pipeline under survey. Figure No. 7 shows a stationary GPS synchronized data logger. Figure No. 12 shows the effect of stray current and Figure No. 8 shows the effect of Telluric current on the pipe-to-soil potentials as recorded by a stationary logger.



Figure No. 7 GPS Synchronized Data Logger

Telluric Current Correction

With stationary data loggers recording the Rectifier ON and Instant OFF potential of the pipeline at each interruption cycle and stamping it with the UTC time, we now have a record of the effect of stray or telluric current on the structure-to-electrolyte potential of the pipeline at the Smart Logger locations. The mean value and the deviation from the mean value of each reading can easily be mathematically calculated using any spreadsheet program.

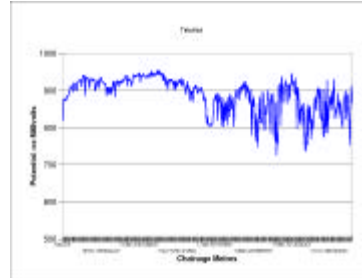


Figure No. 8 Telluric Current Effect on a Pipeline

The close interval survey instrument also time stamps each recorded rectifier ON and Instant OFF potential recorded during the close interval survey. Since the survey data is time stamped with the UTC time and the stationary logger data is also time stamped with the UTC time, a simple spreadsheet macro can add or subtract the deviation to correct the close interval survey data.

Although this method of correction of close interval survey data is not perfect, it nevertheless gives the corrosion engineer increased confidence in the effectiveness of close interval surveys in areas affected by stray or telluric current. Utilising GPS timed close interval potential survey data loggers and GPS synchronised stationary data loggers,



Figure No. 9 Effect Of Telluric Current on Close Interval Potential Data

accurate IR free potentials can be obtained at frequent intervals on a pipeline effected by stray or telluric current, provided all rectifiers that influence the pipeline in the survey area are synchronously interrupted.

Figure No. 9 depicts the effect of Telluric currents on the structure-to-electrolyte potential recorded during a close interval potential survey. Figure No. 10 is the companion stationary log of rectifier ON and OFF potentials recorded at a fixed location in the close interval survey area during the CIPS survey. Figure No. 11 shows the close interval potential survey data. Figure No. 9 shows the effect of telluric current on the depicted in Figure No. 9 after using the data in Figure No. 10 to correct the telluric deviations.

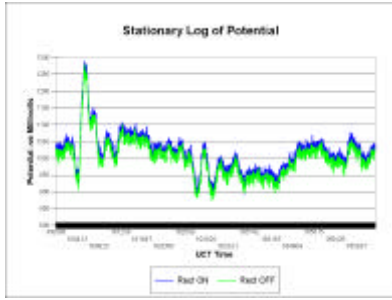


Figure No. 10 Stationary Log of Telluric Currents effect on the Potential of a Pipeline.

It is readily evident that time synchronized data can be used to compensate for stray and telluric deviations on close interval survey results.

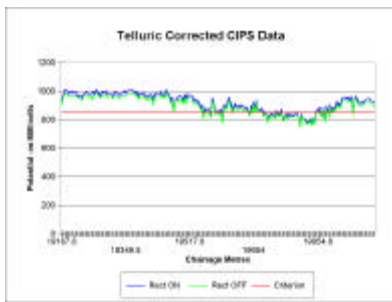


Figure No. 11 Telluric Corrected Close Interval Potential Data

Stray Current Correction

Most modern cities have electrified transit systems (See Figure No. 1). Due to the imperfect nature of the isolation of the track or power conductors associated with these electrified transit systems, stray currents leak into the soil circuit from the electrified transit system. Stray current from an electrified transit system is referred to as dynamic stray current because the magnitude and direction of current flow is continuously changing as traffic on the electrified transit system moves about. Figure No. 13 shows the fluctuation in the rectifier ON and OFF potentials due to dynamic stray current recorded by a stationary GPS data logger. The current, which leaks into the ground from the rails of an electrified transit system, must return to the source (Sub-Station) to complete the circuit. Underground plant such as water mains, pipelines, cables and other metallic conductors offer a low resistance path for dynamic stray current to follow in their return to the Sub-station.

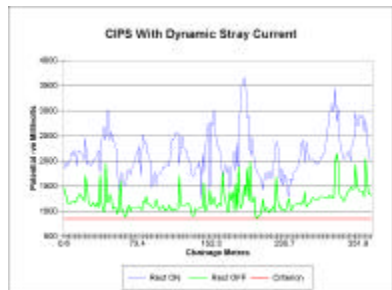


Figure No. 12 CIPS Survey Affected by Dynamic Stray Current

Figure No. 12 shows the effect of dynamic stray current from an electrified transit system on a close interval survey of coated steel pipeline. The potential excursions affect both the rectifier ON and rectifier OFF potentials and can vary in magnitude from a few millivolts to several volts. Figure No. 13 is a graph of the rectifier ON and Instant OFF potentials recorded by a stationary data logger, recording the ON and OFF potential of each rectifier interruption. The pipeline was affected by dynamic stray currents, which caused the fluctuation in the rectifier ON and OFF potential of the pipeline.

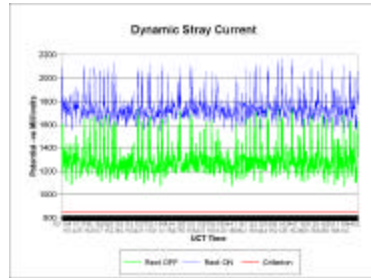


Figure No. 13 Structure-to-Electrolyte Potentials Recorded by a GPS Synchronized Stationary Data Logger

Figure No.14 shows the compensated results of a close interval potential survey on a pipeline affected by dynamic stray current. The original data in Figure No. 12 was compared to the data logged by the stationary data logger Figure No. 13 and using a Macro in Excel, compensation was applied to each reading according to the logged deviation from the norm at each interval in time.

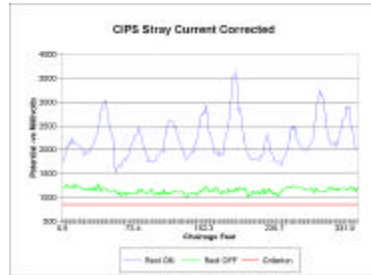


Figure No. 14 The Results of a Close Interval Potential Survey after Stray Current Correction

The peaks in the rectifier ON potentials evident in Figures No. 12 and 14 are not due to stray currents, but are due to a parallel distributed impressed current anode bed running parallel to the pipeline for approximately 500 metres. The pipeline shares a right-of-way with high voltage electrical power lines and is subject to both dynamic stray current and induced AC current.

Conclusion

By utilizing the Global Positioning System timing signal to provide high accuracy time stamping of all data, close interval potential survey data can be compensated for the effect of dynamic stray current and telluric currents. A simple formula is all that is needed in a spread sheet program to compare the time stamped close interval survey data to the time stamped potential deviation logged by the stationary GPS logger.