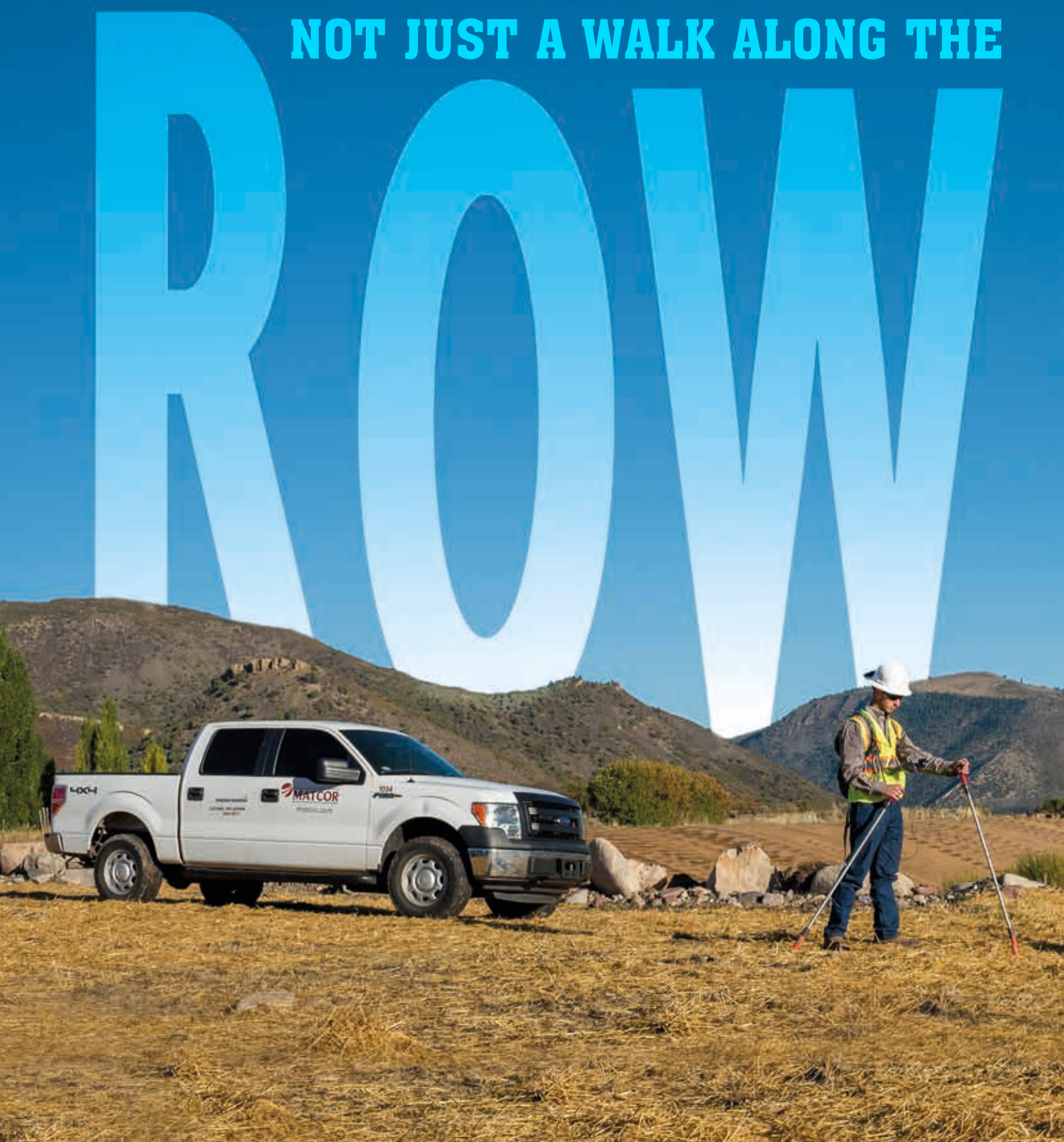
Figure 1. CIPS survey.



Ted Huck, MATCOR Inc., USA, highlights the importance of close interval potential surveys as a means of ensuring pipeline cathodic protection systems are operating to specified standards.

Perhaps you have seen a safety vest-wearing survey crew walking down a pipeline right-of-way (ROW) – a lead person walking in front with a pipe locator, and a second person following with a pair of poles and a backpack containing a spool that is trailing a long thin copper wire – and wondered what they were doing. Well, they are enjoying a nice walk along the pipeline ROW; collecting valuable information that is used to ensure the integrity of the pipeline they are walking.

This article is a primer on close interval potential surveys (CIPS). For those in the US, the 'P' is dropped and is referred to as CIS. Either way, this survey methodology is an invaluable assessment tool that is frequently mandated by pipeline regulatory authorities. This article describes the process of collecting the information and how that information is used as a tool to ensure a pipeline's integrity.

Any discussion of CIPS surveys should start with a basic understanding of what pipeline integrity means. Pipeline integrity represents the efforts by the pipeline owner to maintain their pipeline assets, and to ensure that the public is protected from the very serious consequences of pipeline failures. One of the primary threats to metallic pipelines is corrosion, indeed the United States' Department of Transportation's 'Pipeline Incident 20 Year Trends' reports corrosion as the second leading cause of all reported incidents behind material/weld/equipment failures, and ahead of mechanical damage from third parties (call before you dig). So, any discussion of assuring pipeline integrity has to address corrosion as a significant threat.

Current best practices to prevent metallic pipeline corrosion include a combination of coatings and cathodic protection (CP). Coatings provide the primary defence against corrosion by isolating the pipeline from the environment while CP provides a secondary level of corrosion prevention through the application of direct current (DC) current along the length of the pipeline. This CP current is intended to flow through the earth seeking out exposed metal defects, also known as voids or holidays, in the pipeline coating along the length of the pipeline. As current flows onto the exposed metal, the electrical potential of the metal shifts, becoming more negative as a result of the current application. This

potential shift changes the environment around the metal and inhibits the corrosion reaction as the steel structure is polarised. With sufficient polarisation, the corrosion rate for the metallic pipeline is reduced to virtually zero and the corrosion risk is eliminated.

Though the vast majority of pipelines are carbon steel and the technology is applicable for other metallic pipelines, for the purpose of this article, metallic and carbon steel are used interchangeably. Since pipeline operators utilise coatings and CP to prevent their carbon steel pipeline from corrosion damage that can adversely affect the integrity of their assets, they should be very interested in assessing the condition of the coating and the effectiveness of the CP system. One of the most effective tools to assess the effectiveness of a pipeline's CP system and the condition of the pipeline's coating system is the CIPS survey.

What does a CIPS survey do?

The goal of any CIPS survey is to measure the electrical potential of the steel pipeline along the length of the pipeline area being surveyed. As noted earlier, the goal of CP is to polarise those exposed areas along the pipeline that are not fully isolated from the environment by the coating system. If the coating system for a 10 km long, 12 in. dia. pipeline were 99% effective and only had 1% of holidays, there would be almost 96 m^2 of exposed steel along the length of pipeline. Each of these coating defects or holidays along the pipeline are potential corrosion sites unless the CP system is properly polarising the pipeline along its entire length.

While there are a variety of accepted criteria for what constitutes proper polarisation, the two most widely accepted are those detailed in NACE specifications – the criteria descriptions are simplified and apply to the majority of buried and submerged pipelines in typical ambient temperature environments, where the criteria may need to be adjusted for elevated operating temperatures and especially corrosive chemical environments.

The first is the -850 MV polarised potential criteria. NACE deems any pipeline that has a negative polarised potential of -850 MV to meet the criteria for effective CP. The second is to demonstrate that there is at least a -100 MV shift of the polarised structure from its native or depolarised potential. The data collected in the CIPS survey allows the pipeline operator to assess the polarised potential of the pipeline to ensure that it meets criteria and that the CP system is working effectively in conjunction with the coating system to prevent corrosion.

Figure 2. CIPS crew gathers potential data along pipeline ROW.

The CIPS survey can be conducted on buried or submerged pipelines. At regular intervals along the pipeline – typically every 2.5 ft (76 cm) – measurements are taken of the potential or voltage difference between the pipeline, and a reference electrode in contact with the soil or water. That is a technician with the two poles. Every step along the ROW one of the poles makes contact with the ground, and the technician pushes a button that submits data collected by the data logger in a backpack. The data collected during a close interval survey can be used to establish a baseline for CP on a new pipeline, or assess the performance and operation of existing underground pipeline CP systems. CIPS can also identify areas with insufficient CP and may detect large coating defects or holidays, however small defects may not be detected.

Keys to a successful CIPS survey

Selecting a qualified survey crew

Whether the CIPS survey is being performed by the pipeline operator's personnel or by a supplier that specialises in these surveys, the qualifications and experience of the survey crew are critical to collecting accurate data. When contracting the CIPS survey work key considerations should include: safety record, makeup of crew, whether crew members are full time employees or subcontractors, the type of equipment they have, engineering and IT support for data analysis and reporting, and turnaround time for reporting.

Many operators have started to specify that at least the crew leader must have NACE certification, that the crews must be full time employees and not subcontractors, and that a NACE CP or corrosion specialist must review and stamp the final report. One additional note on contracting CIPS surveys – some survey companies compensate the field crew based on miles per day. This model has led to data being collected quickly, but often not correctly as the crew rushes down the ROW. Many operators prefer to pay a fixed crew day rate to avoid the danger of pay-per-mile incentives.

Advanced planning

Before any survey, it is important to properly plan. Typical information required in advance of starting a CIPS survey includes historical survey data, rectifier output information, maps and alignment sheets detailing the pipeline, surrounding terrain and structures. Also helpful is information about any remediation done in the area, such as construction activity, additional pipelines or new power lines. Noting any changes or upgrades to the

cathodic protection system is critical. Has the system been upgraded, have rectifiers been replaced or ground beds or bonds added? Complete information greatly assists the CIPS crew in planning and implementing close interval survey work.

Select the CIPS type

CIPS surveys come in a variety of forms, including native potential, depolarised, on potential and instant off, or on-off interrupted potential that can be summarised into two basic groups:

- On potential and on-off interrupted potential surveys are used to determine if the -850 MV criteria is being achieved. These are the most common surveys and are often preferred because they typically require only a single pass over the ROW.
- Native potential and depolarised surveys establish a baseline for using the -100 MV shift criteria. This criteria requires survey data on the potential of the structure without CP applied and then survey data once the current is applied so that it is possible to confirm that a minimum shift of -100 MV has been achieved. Since the -100 MV shift criteria requires two data sets to measure the shift in potential they are often used only when the -850 MV criteria is not easily achieved.

Collect the CIPS data

Once the close interval survey method is determined, CIS crews gather data in the field with specialised equipment by walking the length of the pipeline being surveyed. A typical crew can effectively average about five miles per day in moderate terrain, although a variety of factors can affect the data collection rate.

For all CIPS surveys it is very important to identify all of the potential current sources that might impact the pipeline in the survey area. This would include the pipeline's CP systems and those CP sources that are in the same area and could potentially have an influence on the pipeline. There are a variety of other factors that can impact the quality and integrity of the data being collected. It is also quite important that the data being collected is properly tagged to a specific location. With today's sub-metre (and even sub-centimetre) GPS technology, almost all CIPS survey data is now tagged with a specific GPS location for every data point to facilitate data alignment.

CIPS data analysis and reporting

Close interval survey data and reports typically include regular daily or weekly field progress reports during the survey and complete data and final reports upon completion of the survey. Often the raw data collected needs to be processed by a data analyst to align the data sets and the GPS data and to eliminate spurious readings.

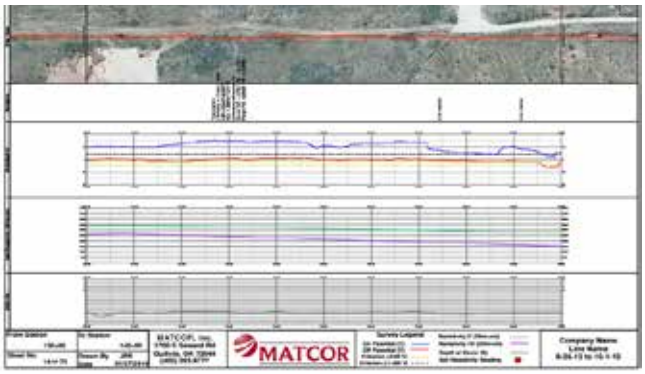


Figure 3. CIPS alignment sheet data presentation.

Final reports typically include the raw data set, the processed data, graphs/plots of the data, operating details of the CP system at the time the data was collected, ROW conditions, and any external effects on the pipeline by other sources. Good CIS data fits right into the pipeline GIS and compliance systems utilised by most operators. Final CIS reports may also include an engineering report that details the current status of the pipeline and any potential issues that may arise from the survey findings.

Other considerations

In some cases, CIPS surveys may be especially challenging or conditions may make it infeasible to collect data. This would include:

- Piping that is located especially deep where potential readings may not be accurate.
- Pipelines installed in rock bores or with casings where potential readings cannot be attained.
- Areas of coating disbondment that can provide false readings.
- Frozen soils, paved roadways and very dry, rocky soils that may not allow for accurate potential readings.
- Areas under the influence of telluric earth currents or DC transit interference.
- Congested plant environments with significant plant earthing or grounding networks.

These should be identified during the planning phase and alternative integrity assessment methods or tools may be required.

CIPS surveys are an effective and proven tool in the pipeline operator's integrity programme that can be used to assess the effectiveness of the pipeline's CP systems and to identify areas of corrosion risk. When performed on a regular basis they can be used to evaluate coating degradation and provide information on areas requiring additional supplemental CP.