Corrosion Basics

Understanding the basic principles and causes of corrosion

Close-Interval Potential Surveys

The principle of a close-interval potential survey (CIPS or CIS) is to record the pipe-to-soil (P/S) potential profile of a pipeline over its entire length by measuring potentials at intervals that do not significantly exceed the depth of the pipe (often ~1 m).

The negative terminal of a portable recording voltmeter is typically connected to the pipeline at a test point through a spool of thin copper wire. The positive terminal is usually connected to a pair of copper/copper sulfate ($Cu/CuSO_4$) reference electrode probes that are alternately positioned in the ground over the pipeline at regular intervals in "leapfrog" fashion. This polarity displays the pipeline potentials as positive.

The actual survey typically involves three distinct tasks: 1) locating and marking the pipeline with stakes or flags inserted at regular intervals, based on tape measurements or chaining; 2) data collection, including P/S potentials and notation of physical features along the right-of-way with global positioning system (GPS) coordinates collected separately for these features; and 3) clearing the right-of-way of survey wire and other materials. The field crew must be prepared to identify and repair breaks of the trailing copper wire; areas such as road crossings and stockyards may require the use of heavier, insulated wire that is resistant to breakage.

Because the potential of interest is at the structure-electrolyte boundary, it is important to consider possible voltage (IR) drop errors that result from the flow of current through the earth between the pipe surface and the reference electrode(s). One commonly used technique includes the synchronized interruption of cathodic protection (CP) current sources. The interruption plan must consider what groups of current sources influence different portions of a pipeline and should be interrupted during testing. This may include bonds and current sources belonging to other pipeline operators. Modern interrupters can be programmed to operate during a selected testing period each day and turn off in the conducting position overnight to minimize depolarization. It is a good practice to obtain potential waveforms at the start of a day's survey and throughout the day to confirm that interrupters remain synchronized and that no uninterrupted current sources influence the pipeline.

The CIS technique provides a complete P/S potential profile, indicating the status of CP levels. The interpretation of results, including the identification of defects, is relatively straightforward. The most useful graphical presentation of CIS data is to plot the "on" and "off" potentials together as separate profiles vs. distance. With the polarity convention described above, potentials are plotted as positive, with values nearer to the top of the page (typically the "on" potentials) actually being more negative (more protected). If a portion of the plot shows "off" potentials that are more negative than the corresponding "on" values, these "reverse shifts" indicate that operation of the interrupted current sources reduces CP levels locally. This condition must be explained or investigated. Localized dips in the potential profiles (to less negative values) may indicate the presence of a poor-quality coating or low-resistivity soils. The difference between the "on" and "off" potential values should also be noted. A reduction in this potential shift may also indicate a decrease in local P/S resistance or a problem with the distribution of protective current.

It may also be useful to complement the interrupted CIS with a "native" (depolarized) CIS; this data provides the opportunity to evaluate the 100 mV polarization CP criterion. The "native" survey may be conducted prior to the initial activation of the CP system for a new pipeline; however, the polarization criterion is more commonly applied for older piping with deteriorated coating. In that case, existing current sources must be turned off for a sufficient period to approximate full depolarization. When the "native" CIS data are plotted along with the interrupted data, the difference between the "off" and "native" profiles represents the level of polarization at each location.

Other applications and variations of the CIS technique are presented in NACE SP0207-2007, "Performing Close-Interval Potential Surveys and DC Surface Potential Gradient Surveys on Buried or Submerged Metallic Pipelines."

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