

Cathodic Protection Coupon Interpretation in Multiple Pipeline Corridors

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ABSTRACT

Pipeline operators are becoming more dependent on coupons for demonstrating adequate cathodic protection as the use of multi-line corridors has increased. In such complex right-of-way configurations, the pipelines are often bonded together for cathodic protection purposes. The presence of widely varying coating qualities and current requirements means that protection levels measured during test post or close interval potential surveys are mixed potentials influenced by all the pipelines in the corridor. Targeted assessment of an individual pipeline therefore becomes much more complicated, particularly when a pipeline is newly constructed and is situated amongst legacy operating assets. To help account for this, coupons are heavily relied on to accurately assess protection levels on a specific pipeline.

Literature and the NACE standard SP0104 indicate that correct interpretation of coupon measurements may require the use of non-metallic soil-access tubes and/or a nearby stationary reference electrode. In practice, it is not always possible to install soil-access tubes along with the coupons due to factors such as land use, coupon depth, etc. This paper considers the theoretical and experimental basis for the need for a soil-access tube or a close-coupled reference. The interpretation of coupon data for new pipelines is examined in light of coupon data recorded on a new transmission pipeline that shares a corridor with several older pipelines. Recommendations are provided.

Key words: coupons, equalization currents, IR-drop, long-line currents, monitoring port, multiple pipelines, multi-line corridors, multi-line right-of-way, soil-access tube

INTRODUCTION

Coupons are used to represent small coating defects on the pipeline and are being increasingly relied on for assessing cathodic protection (CP) and corrosion. NACE Standard SP0104-2014¹, which provides guidance on the use of coupons for CP monitoring, recognizes the possibility of errors in instant-off coupon potentials unless, “a reference electrode is located very close to the coupon or in a soil-access tube.”

A soil-access tube, known variously as a calibration port, monitoring port, reference tube or soil tube, is “a tube that is nonconductive and impermeable to moisture that can be used in conjunction with a coupon and can be filled with electrolyte.” It is used to move the measurement reference electrode *electrically* close to a coupon with the intention of minimizing or eliminating voltage gradients in the soil between a reference at grade and the coupon.²

Soil-access tubes, along with, “a close-coupled CP coupon and reference electrode [and] a concentric CP coupon and reference electrode” are the recognized methods in Section 4.3 of SP0104 to address cases where, “the magnitude of the IR drop is either not known, considered to be significant, or may change significantly.” However, there is an important limitation with using reference electrodes in Section 9.2.4: “The accuracy of any permanently buried stationary reference electrode should be verified periodically.” If a soil-access tube is required to measure accurate potentials on a coupon, then there is no reason that a soil-access tube would *not* also be required to measure accurate potentials on a reference electrode. Thus, the use of a stationary (i.e., buried) reference electrode as a replacement for a soil-access tube cannot be considered a good long-term solution, because it is not possible to verify the reference electrode potential without the use of a soil-access tube.

This paper analyzes how measurement errors arise and evaluates the need for soil-access tubes and/or nearby stationary reference electrodes in light of data from a recent pipeline installation in a multi-line corridor.

CONVENTIONAL COUPON DATA INTERPRETATION

Although coupons represent coating defects on pipelines that expose the pipeline steel to the soil electrolyte, the measured potential on a coupon is often different than the measured potential on the pipeline. This difference in potentials will be discussed in the coming sections as background for the requirement for soil-access tubes.

Pipe-to-Soil vs. Coupon Potentials

A 2001 PRCI⁽¹⁾ research project compared pipeline instant-off potentials measured with respect to an at-grade reference electrode to coupon potentials measured using soil-access tubes as shown in the unity plot in Figure 1.³

⁽¹⁾ Pipeline Research Council International (PRCI), 15059 Conference Center Drive, Suite 130, Chantilly, VA USA 20151

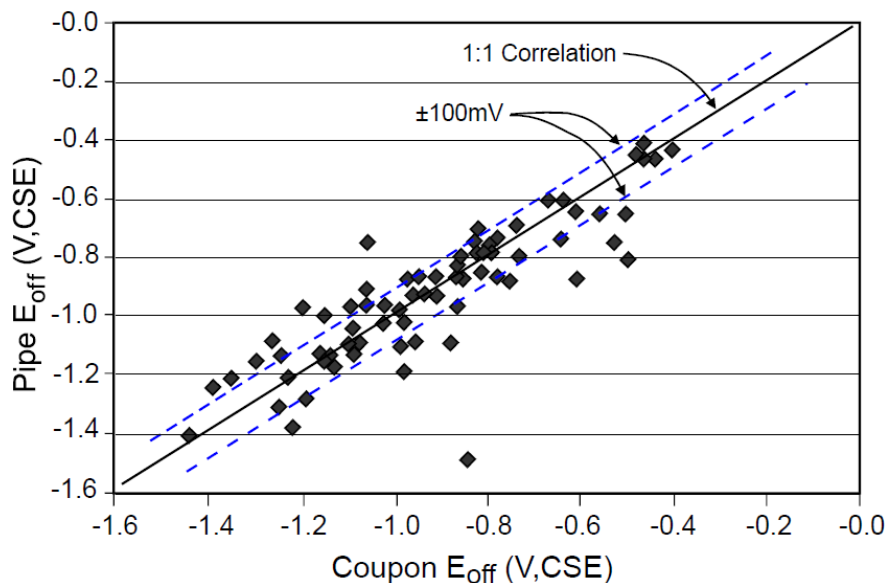


Figure 1: Pipe instant-off vs. disconnected coupon instant-off potentials.³

The correlation between the pipe instant-off potential and the disconnected coupon instant-off potential is relatively strong, and most potentials lie within the ± 100 mV band. However, there are also a significant number of points where the potential difference lies outside this band, with differences in excess of ± 200 mV common. In some cases, the coupons are more electronegative than the pipeline instant-off potentials, while in other cases the coupons are more electropositive than the instant-off potentials.

Thus, coupons are required to accurately determine protection levels, since the instant-off potential could be much more, or much less, electronegative than the true polarized potential. A corollary of this is that a significant difference between the coupon and the pipe instant-off potential measurements does not necessarily mean the coupon measurement is flawed because the pipeline potential is made up of many pipeline coating defects. In theory, the coupon is not intended to represent the instant-off potential or mixed potential of the pipeline, but rather the polarized potential of a singular holiday of a specific dimension at a defined location.

Requirement for Soil-Access Tubes

The same 2001 project considered the requirement for soil-access tubes, as shown in Figure 2, by comparing coupon potentials measured at-grade with and without soil-access tubes.

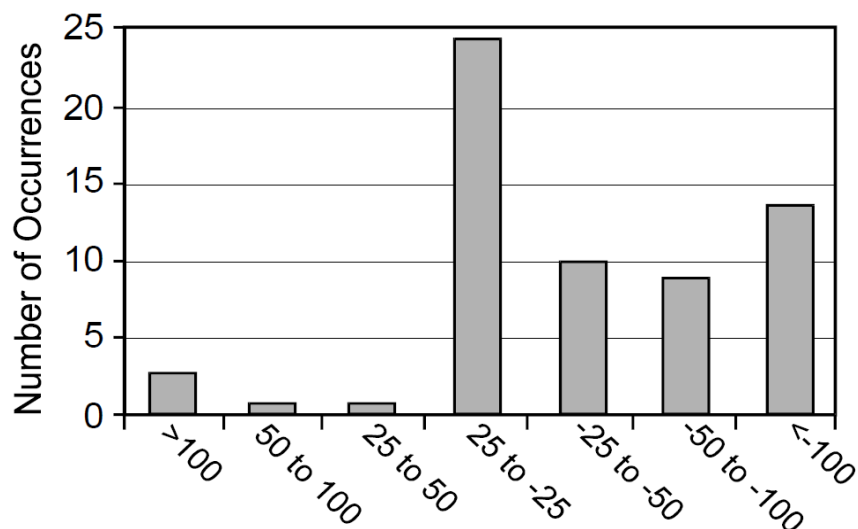


Figure 2: Difference between coupon-to-soil disconnected off-potential measured at grade and through the soil-access tube.³

For 38 of the 62 coupons, there was less than 25 mV difference between the measurements with and without soil-access tubes. However, there were some coupons with differences in excess of 100 mV and most of the differences were in the electronegative direction (i.e. the potential without the tube was more electronegative than the potential with the tube), meaning that in many cases measurements recorded without soil-access tubes would overstate the level of polarization. This resulted in a recommendation to include soil-access tubes when coupons are installed.

SP0104, while not mandating the use of soil-access tubes, generally adopts the recommendation of using soil-access tubes.

Proximity and Residual Gradients

Errors due to residual voltage gradients are most commonly associated with CP system operation (including groundbeds, sacrificial anodes and coating defects on cathodically-protected pipelines) plus stray currents. However, with the possible exception of stray currents, these gradients are localized. A rule of thumb for estimating this local distance (i.e. distance to remote earth) is 10-times the structure diameter; that is, for a 1-cm-diameter coating defect, remote earth would be approximately 10 cm away, as illustrated in Figure 1.⁴ Similarly, a shallow groundbed with a length of 100 m could be considered remote at approximately 1000 m.