Leak Prevention

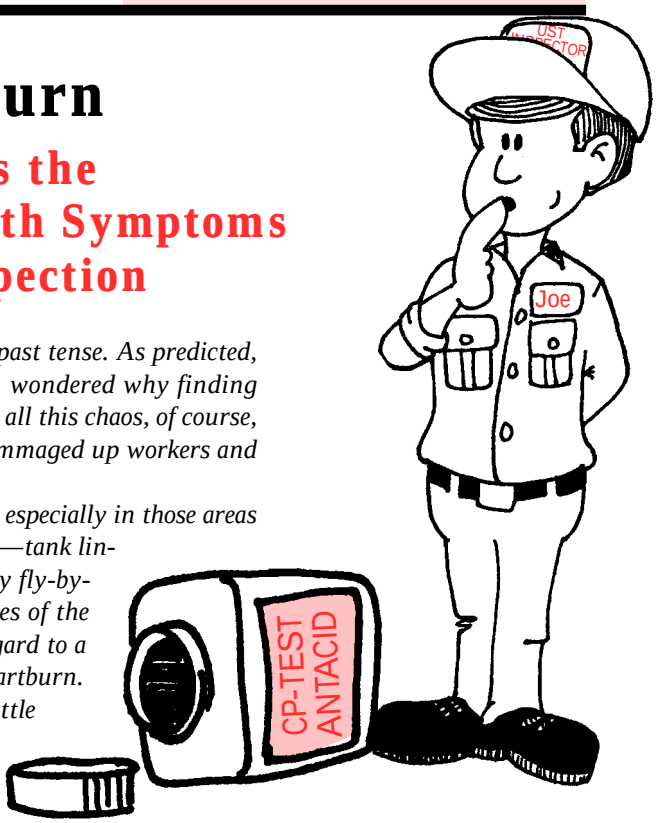
Tank-nically Speaking

by Marcel Moreau

Marcel Moreau is a nationally recognized petroleum storage specialist whose column, ***Tank-nically Speaking****, is a regular feature of* LUSTLine**.** *As always, we welcome your comments and questions. If there are technical issues that you would like to have Marcel discuss, let us know.*

Combatting CP-Test Heartburn

A Thoroughly Documented CP Test Is the Recommended Antacid for Coping with Symptoms Associated with the Common CP Inspection



After 10 long years, the '98 deadline can finally be talked about in the past tense. As predicted, many storage system owners waited 'til the end was nigh and then wondered why finding people to do the work was like looking for water in the desert. Amidst all this chaos, of course, were the entrepreneurs who, upon seeing financial opportunity knocking, rummaged up workers and provided the "services" needed to meet tank owner demands.

The result is that a lot of shoddy tank work has been done in recent years, especially in those areas of the tank upgrade market that are attractive to tank owners on tight budgets—tank lining and cathodic protection (CP). Although the potential problems created by fly-by-night lining contractors may be buried and hidden from the inquisitive eyes of the typical UST inspector, there are some things that inspectors can see with regard to a cathodic protection retrofit—things that can give an inspector pause, if not heartburn.

Unfortunately, no matter how poor the workmanship, an inspector has little to say about the cathodic protection installation, as long as it has been blessed by a legitimate "corrosion expert" as defined in the rules and explained in EPA memos. (Refer to LUSTLine *#23 for a description of qualified personnel.)*

What Constitutes an Acceptable CP Test?

I do believe, however, that the regulatory inspector has some say when it comes time to evaluate the performance of a cathodic protection system by conducting the initial CP test or the triennial CP test. Here's how:

The federal rule (40 CFR 280.31(b)(2)) contains no specific CP test criteria; it defers instead to industry standards such as NACE RP0285, "Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems." (The current edition of this document, RP0285-95, has a slightly different title, "Standard Recommended Practice—Corrosion Control of Underground Storage Tank Systems by Cathodic Protection.")

This NACE standard and others that I have reviewed describe specific testing criteria and methodologies for making measurements but provide precious little guidance about what constitutes an adequate CP test. There are no specifications concerning how many measurements should be made or how thoroughly a CP tester should investigate a system. These types of decisions are apparently left to the discretion of the tester, leaving the door wide open for some testers to be thorough and others to be quick.

Because the requirements for a CP test are not specifically spelled out in the federal regulations or industry standards, it seems appropriate for regulators to fill the void and set a minimum standard for what constitutes an acceptable CP test. The folks in EPA Region 4 did just that; they developed a standardized form to be used when documenting the results of a CP test of an UST system.

What data should be recorded during a CP test and why are these data important? A properly conducted and documented CP test will determine whether a CP system is adequately protecting its associated storage system. If the storage system is not protected, then all of the blessings of a CP expert are moot, and the system must be made to work.

A thorough, properly documented CP test should enable a knowledgeable reviewer to answer three questions about an UST system:

- ***Are sufficient data presented in the test report to evaluate the test results?***
- ***Were a sufficient number of appropriate measurements conducted during the test to fully evaluate the storage system?***
- ***Were appropriate CP test criteria used to arrive at a pass or fail test result?***

Let's review each of these questions. But first, some caveats. To keep the

following discussion from becoming an epic, I have limited the scope to the "typical" underground storage system at the "typical" convenience store or service station. I am assuming that the reader understands the mechanics of making CP measurements (See *LUSTLine* #25, "Testing Cathodic Protection Systems," for a refresher) and has some knowledge of CP principles. While I believe the discussion that follows is generally applicable to most storage systems, no doubt valid exceptions exist to the information and opinions presented.

Are Sufficient Data Presented in the Test Report to Evaluate the Test Results?

All too many CP test reports merely indicate that on a certain day a certain facility was tested and that the storage system(s) "passed." In some cases, a number may be added (e.g., "-0.911 volt—pass"). In some cases, especially where the monitoring results are less favorable, a number (e.g., "-0.777"), without even a pass or fail conclusion, is the extent of the test documentation.

Such results are incapable of being evaluated, because there is nothing to evaluate. Simply not enough information is presented to determine whether the second and third questions listed earlier have been adequately answered.

My criterion for an adequately documented CP test is simple: There should be sufficient documentation so that any knowledgeable CP tester should be able to return to the facility and make the same measurements in the same places.

This criterion means that there should be fairly exact descriptions of where the reference cell was located, where connections were made to the cathodically protected structure, and what types of measurements (e.g., continuity, current-on, instant-off, polarization change) were conducted. There should also be a pass/fail conclusion and a statement describing which CP criterion was used to reach the pass/fail conclusion for the test results.

Such detailed documentation is critical to a long-term understanding of what is happening to a CP system. If performance of a system is to be compared from one CP test to the next, all CP tests must be conducted in the same way. A remote "current-on" reading cannot be compared to a tank-top "current-off" reading. A reading where the reference cell comes in contact with soil cannot be compared to a reading where the reference cell is placed on concrete. Unless measurements are made in a nearly identical fashion each time a CP system is evaluated, comparison of CP test measurements conducted at different times is meaningless.

Because the requirements for a CP test are not specifically spelled out in the federal regulations or industry standards, it seems appropriate for regulators to fill the void and set a minimum standard for what constitutes an acceptable CP test.

Were a Sufficient Number of Appropriate Measurements Conducted to Adequately Assess the CP System?

I have monitored many systems, both impressed current and galvanic, where portions of a tank met acceptable criteria for cathodic protection, but other portions of the same tank did not. Cathodic protection is not an all-or-nothing phenomenon. It is the rule, rather than the exception, that different portions of a storage system will have different levels of protection, depending on distance from the anodes, areas of localized coating damage, variations in moisture content of the backfill around the storage system, and a host of other variables.

Therefore, it seems unreasonable to accept a single measurement with a reference cell in a single location as evidence that a storage system is adequately protected. Yet many CP test reports contain a single number for a tank. In some cases, tests of galvanic CP systems are conducted by moving the reference cell around until a "passing" reading can be obtained—regardless of whether the reading is local or remote, on concrete, or on the metal ring of a manway. Once this "passing" number is found, all other readings are discarded.

The UST rules require that all portions of a storage system that routinely contain product and that come in contact with the soil be adequately protected against corrosion. Thus a storage system must be thoroughly evaluated to ascertain that all portions of the tank and piping are protected—not just the end that happens to be close to a working anode.

In my opinion, voltage measurements for a standard-sized motor fuel tank should be made with the reference cell in at least three locations: one with the reference cell at one end of the tank, one on the other end, and one in the middle. The reference cell should be placed as close as possible to the top centerline of the tank. If the tank is completely covered by concrete or asphalt, then holes should be drilled into the concrete or test stations installed to provide access to the soil for placement of the reference cell.

Voltage measurements fall into two categories: current-on and current-off. Current-on measurements are conducted with the protective current applied (i.e., with the sacrificial anodes connected or the rectifier power turned on). Current-off measurements are conducted with the protective current turned off (i.e., with the sacrificial anodes disconnected or the rectifier power turned off).

Current-on measurements are the only option possible for virtually all galvanic systems installed on storage tanks, because the anodes are permanently attached. Both current-on and current-off measurements should be conducted for impressed current systems. The current-on measurements indicate the distribution of current on the structure and where the weak spots in terms of protection may be located.

The current-off (instant-off) measurements indicate whether the 0.85 volt current-off criterion has been met or what the starting point for the 100 millivolt polarization decay measurement is. If the 0.85 volt current-off criterion is not met, then voltage readings tracking the polarization decay should also be conducted and recorded, unless native potential readings are available to establish that the 100 millivolt polarization change criterion has been met.

Galvanic and impressed current systems should also include a conti-

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nuity survey to establish that components, such as tank fittings, risers, and vents, are either isolated (galvanic systems) or continuous (impressed current systems). (See *LUSTLine* #25, "Testing Cathodic Protection Systems," for information on how to conduct a continuity measurement.)

Were Appropriate CP Test Criteria Used to Arrive at a Pass or Fail Test Result?

The appropriateness of CP criteria is one of the more prominent hot buttons among CP professionals. (For a great compilation of the CP criteria literature, see the 500-page NACE publication, "Cathodic Protection Criteria—A Literature Survey," published in 1989.) The 1995 edition of NACE Standard RP0285, "Standard Recommended Practice—Corrosion Control of Underground Storage Tank Systems by Cathodic Protection," contains three acceptable criteria for cathodic protection:

- **0.85 volt (850 millivolts) current-on,** defined as follows:

  A negative (cathodic) potential of at least 850 mV with the cathodic protection applied. The potential is measured with respect to a saturated copper/copper sulfate reference electrode contacting the electrolyte. Voltage drops other than those across the structure/electrolyte boundary must be considered for valid interpretation of this voltage measurement.

- **0.85 volt (850 mV) current-off,** defined as follows:

  A negative polarized potential of at least 850 mV relative to a saturated copper/copper sulfate reference electrode.

- **0.1 volt (100 mV) of polarization change,** defined as follows:

  A minimum of 100 mV of cathodic polarization. The formation or decay of polarization can be used to satisfy this criterion.

My criterion for an adequately documented CP test is simple: There should be sufficient documentation so that any knowledgeable CP tester should be able to return to the facility and make the same measurements in the same places.

What About the Criteria?

While the 0.85 volt current-on criterion is one of the most commonly used, it is also by far the most commonly abused. This criterion is most appropriate for use in structures where there is little current flowing through the soil (the meaning of the last sentence of the criterion), which, in most cases, means structures that are very well coated.

Application of this criterion to structures that are essentially bare (e.g., asphalt coated), whether the system has been equipped with galvanic or impressed current CP, in most cases will produce apparently "passing" results that are seriously in error. This criterion should be limited to well-coated, galvanically protected structures, such as STI P3 tanks. It is inappropriate for impressed current systems.

The -0.85 volt current-off criterion is simple and can be used on any cathodically protected structure, coated or uncoated, where it is possible to interrupt the protective current, either by temporarily disconnecting the anodes (galvanic systems) or temporarily turning off the rectifier (impressed current systems). If the potential (voltage) of the structure is -0.85 volt or greater (more negative) immediately after the pro-

CP-TESTING MEASUREMENTS	GALVANIC WELL COATED	GALVANIC POORLY COATED	IMPRESSED CURRENT
Current-on readings with reference cell in at least three locations: both ends and middle of the tank. For piping, reference cell at both ends and every 10 feet along the piping run.	X	X	X
Current-off readings with reference cell in three locations: both ends and middle of the tank. For piping, reference cell at both ends and every 10 feet along the piping run.		X	X
Continuity testing for all metallic components connected to the tank or piping, including fill pipes, vent lines, automatic tank gauge risers, electrical conduit, etc.	X	X	X
Impressed current systems may also need to be evaluated for possible effects on adjacent structures, such as metallic natural gas lines or water lines. This step would involve checking for continuity and comparing current-on and current-off potentials on the adjacent structures.			X
Impressed current system test documentation to include the voltage and amperage output of the rectifier.			X
To pass, the 0.85 volt current-on criterion must be met at all reference cell locations along the length of the tank.	X		
To pass, the 0.85 volt current-off or 100 mV polarization change criterion must be met at all reference cell locations along the length of the tank.		X	X
CP tests should be sufficiently documented so that any knowledgeable person can make the same measurements in the same places. At a minimum, the CP test report should include a site sketch, the reference cell locations, structure connections, voltmeter readings, type of measurement (e.g., continuity, current-on, instant-off), the criterion used to evaluate the storage system, and the conclusions (i.e., protected or not protected against corrosion).	X	X	X

tective current is interrupted, the criterion is met.

The -0.85 volt current-off criterion is rarely relevant to galvanic systems because, in most cases, the anodes cannot be disconnected. It can be applied to impressed current systems. In my experience, however, this criterion is rarely met on all portions of a storage system.

Like the -0.85 volt current-off criterion, the 100 millivolt polarization change criterion is suitable for any cathodically protected structure, coated or uncoated, as long as the protective current can be interrupted. The application of this criterion in the field is somewhat more involved. Just as for the -0.85 volt current-off criterion, the protective current is interrupted to obtain an instant-off or polarized potential, but the potential that is measured must then be compared with the potential of the structure prior to the application of any CP (the "native" or "freely corroding" potential). The polarized potential must be 100 mV different from the native potential.

If the native potential is known, this comparison is quick and simple. This statement assumes, though, that the native potential has not changed over time—an assumption that is more likely to be true if the moisture conditions around the storage system were similar at the time of the CP test measurement and at the time when the native potential measurement was made.

If the native potential is not known, then the polarization on the structure must be allowed to decay, a process that can take from minutes to as much as a day. This step can make this criterion expensive and inconvenient to implement.

Note that this criterion has nothing to do with -0.85 volt and that storage systems with instant-off readings well below -0.85 volt can still pass.

In a Nutshell

My suggestions for the types of measurements that should be conducted and documented when evaluating various types of CP systems are described in the chart on page 10.

So these are my thoughts...What are yours? ■