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 him know at* **marcel.moreau@juno.com**

Continuous or Isolated? This Is the Question

When the testing of cathodically protected tanks is mentioned in regulatory circles (usually accompanied by some scratching of heads and sighs of frustration), the number that pops into the collective consciousness is the venerable -.85 volts. Most folks recognize that this number constitutes a "structure-to-soil" potential measurement—a measurement that is fundamental to evaluating whether a cathodic protection (CP) system is functioning properly. How to conduct and record structure-to-soil measurements has been the topic of previous "Tank-nically Speaking" articles. (See *LUSTLine* #25, "Testing Cathodic Protection Systems," and #32, "Combatting CP-Test Heartburn.")

A recent query from a perspicacious regulator, however, brought to my attention a much-neglected topic associated with the testing of cathodically protected tanks and piping—continuity. Or did he mean isolation? Hmm, what do we mean?

To say that two components of a cathodically protected structure are *electrically continuous* means that electrons are able to move freely between the two components. (In electrical terms, the resistance is low.) To say that two components of a cathodically protected structure are *electrically isolated* means that electrons are *not* able to move freely between the two components. (In electrical terms, the resistance is *very* high.)

Continuity/isolation problems are one of the most frequently found causes for the failure of both impressed and galvanic CP systems to perform properly. Electrical continuity/isolation is often the first measurement that is taken when a storage system fails a structure-to-soil cathodic protection test. But *how* you measure the continuity or isolation of a buried structure is the question at hand.

The first thing to remember is that the exact same procedures are used to measure both continuity and isolation. To determine whether the readings obtained on a particular cathodically protected structure are "good" or "bad," you must keep in mind whether you are testing an impressed or a galvanic CP system. Electrical continuity is a critical element in the design of impressed current cathodic protection systems, while its opposite, electrical isolation, is a critical element of commonly used galvanic cathodic protection systems.

Tools and Methods

The resistance (ohm meter) circuit of traditional multimeters used to measure voltage, amperage, and resistance is generally not suited for making electrical continuity/isolation measurements among the various buried metallic components of an underground storage system. Instead, continuity/isolation measurements are typically made with the same equipment and procedures used in structure-to-soil cathodic protection measurements.

To the casual observer, the measurement of continuity/isolation may appear identical to the structure-to-soil measurement. Likewise, because the results are recorded as voltages on the CP monitoring record, continuity/isolation measurements can be readily confused with structure-to-soil measurements unless they are properly identified.

To confuse matters even more, several methodologies may be used to evaluate the continuity/isolation of cathodically protected systems. The following are descriptions of three different methods for evaluating the electrical continuity/isolation of buried metallic structures:

1. FIXED REFERENCE, MOVING GROUND The theory here is that if two buried metallic structures are electrically continuous, they will both be at the same potential (voltage) relative to a stable reference.

Procedure

Place the copper/copper sulphate reference cell (CRC) in a fixed location, attach one of the voltmeter test leads to the CRC, and then make contact with the storage system or other components that you wish to evaluate (e.g., fill pipe, ATG riser, submersible pump, vent pipe, tank shell, building electrical ground) with the second voltmeter test lead. The critical elements in this procedure are: (a) the CRC must not budge (at all!) during the entire continuity/isolation testing procedure, and (b) the voltmeter test lead must make solid metal-to-metal contact with each component that is to be evaluated.

Tips

- It is good form to place the CRC at some distance from the structure(s) being evaluated, but I have had quite good luck placing the CRC in a central location near the storage systems being evaluated.
- Use a sharp probe on the voltmeter test lead to achieve metal-to-metal contact with the various storage system components. Do not touch the metallic components of the probe while making the measurement.
- Be sure the voltage on the storage system is stable. If you cannot get a good stable reading on your voltmeter, this test will be difficult to utilize. With an impressed current system, the rectifier may be on or off, but the rectifier should have been turned on or off a day or more before the continuity/isolation measurements are made.

Interpretation of Results

The actual voltage that is measured using this procedure is not important. The voltage will vary depending on the location of the CRC, but the purpose here is not to evaluate the structure-to-soil potential. The *only* factor being evaluated here is whether the voltage measurements made with the test lead contacting different storage system components are identical or nearly so (plus or minus a few millivolts) to one another.

Whether the voltmeter reads -1.4 volts or -.80 volts or -.43 volts is *not* relevant. What is relevant is the relationship of the various readings to one another. Readings from different storage system components of -.654 volts, -.655 volts and -.653 volts indicate that the three components are electrically continuous. Readings of -.654 volts, -.593 volts and -.730 volts indicate that the three components are electrically isolated from one another. Readings that are different from one another but not by much (e.g., -.654 volts, -.666 volts, -.648 volts) are inconclusive. Use test method #2, if possible, to tell for sure what is going on. Readings that are more than about 20 millivolts different from one another generally indicate that structures are electrically isolated.

2. CURRENT ON/CURRENT OFF POTENTIALS The theory here is that when the cathodic protection current is repeatedly turned on and then off, structure-to-soil potentials of the components that are electrically continuous with the CP system will show large variations in potential that follow the cycling of the CP current.

Procedure

The reference cell is placed in a fixed location, a voltmeter test lead is attached to the CRC, and the other voltmeter test lead is placed in contact with the various storage system components or building electrical ground, just as for the fixed-reference/moving-ground technique described above. Rather than making a single voltage measurement at each storage system component, however, the CP current is cycled on and off at intervals of five seconds or so, so that both current on and current off measurements can be recorded and compared.

Tips

- It is good form to place the CRC at some distance from the structure(s) being evaluated, but I have had good luck placing the CRC in a central location near the storage systems being evaluated.
- Use a sharp probe on the voltmeter test lead to achieve metal-to-metal contact with the various storage system components. Do not touch the metallic components of the probe while making the measurement.
- This method can only be used where the CP current can be conveniently turned on and off. The method could be applied to a CP system with permanently attached anodes, however, by installing a temporary CP system that can be turned on and off.

Interpretation of Results

As with the fixed-reference/moving-ground technique, the magnitude of the current on and current off readings is not important. What is important is that the current on and current off measurements for each location are approximately the same. In this case, however, there are two indicators of continuity—the current on and current off voltages *and* the shift in the voltage created by the cycling of the CP current. The current on and off voltages should be reasonably close, but they do not need to be identical. Continuity would still be indicated if the voltage shift from the current on to the current off condition was of a similar magnitude.

This technique is useful in identifying relatively high resistance connections that cause the readings in method #1 above to be 20 millivolts or more different. Despite relatively high resistances among the components, these connections still provide enough continuity so that a significant amount of CP current is flowing to the component being tested. If turning the CP current on and off has little effect on the potential of the component being tested, then it is likely that the structure is isolated from the CP system.

3. STRUCTURE-TO-STRUCTURE POTENTIAL The theory for this method is that if two buried metallic structures are electrically continuous, there will be no voltage difference between them.

Procedure

This procedure does not require a reference cell. The two leads of the voltmeter are connected to different components of the storage system or building electrical ground. If the two components are continuous, the voltage should be zero. Typically, one lead of the voltmeter is fixed to a single storage system component (e.g., a tank shell) and the other lead of the voltmeter is moved around to the different storage system components.

Tips

Be sure that the voltmeter test leads achieve metal-to-metal contact with the various storage system components. Do not touch the metallic components of the probe while making the measurement.

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Interpretation of Results

The interpretation of results for this method is essentially the same as for the fixed-reference/moving-ground method described above, except that continuity is indicated by a voltage of zero or a few millivolts between different components of the system. Voltage differences in the range of 10 to 20 millivolts are inconclusive, and procedure #2 above should be used to make a definitive determination of continuity or isolation. Voltage differences greater than about 20 millivolts generally indicate that the components are isolated.

Which Method to Use

As far as I can tell, all of these methods are valid (if done properly), and each may have advantages/disadvantages under certain circumstances. I can see where method #2 would be the most forgiving in terms of execution, as the other methods rely on relatively perfect connections of the voltmeter leads to the structure. In my experience, this can be difficult to achieve on a rusty riser. However, method #2 does require that the CP current be easily interrupted. This would be a problem for most galvanic systems and for impressed current systems where an extra person or an automatic current interruption device is not available.

When to Test for Continuity

I believe that continuity testing is essential for impressed current systems. I have seen too many such systems with continuity problems. Knowing the continuity status of a particular storage system component is a great help in interpreting the structure-to-soil potential measurements that are made using that component as the structure contact.

I would check the continuity status of any newly installed galvanic CP system. For a galvanic system that has been in service for awhile, I would check the continuity only if the system failed to meet criteria for cathodic protection. In my experience, galvanic systems that have been in service for a while and meet criteria are unlikely to have continuity problems. ■