FACTORS THAT CAN AFFECT CATHODIC PROTECTION TESTING OF GALVANIC SYSTEMS FOR UNDERGROUND STORAGE TANKS

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OUTLINE

Problem:

Cathodic protection criteria and test methods, originally written and accepted for buried or submerged metallic pipelines, have been applied in recent years as criteria for pre-engineered galvanic cathodic protection systems (PEGCP) on steel underground storage tanks (USTs). Both the corrosion and steel tank industries have accepted methods which are based on pipeline experience and technology. Not until 1988 was there any mandate to test tanks for adequate cathodic protection. As a result, there was a lack of documented test results (through a large database of statistics) to authenticate pipeline testing practices and cathodic protection criteria as it relates to corrosion control effectiveness for PEGCP steel UST's.

Solution:

Field research has resulted in the identification of conditions that can affect the accuracy of test methods currently used.

Analysis of all cathodic protection testing parameters has confirmed that there are site specific factors which give misleading indications that a PEGCP system on a steel UST is not protecting against corrosion or that the structure is corroding. The U.S. Environmental Protection Agency regulation references a recommended practice of the National Association of Corrosion Engineers (NACE) as an acceptable code of practice for cathodic protection criteria. It states that the cathodic protection potential of the buried steel structure must be -850 millivolts (mV) or more negative to assure proper corrosion control for a buried steel structure. Those factors, when properly recognized and identified, will assist the corrosion technician in proper testing and interpretation of test results. To date, results of extensive research shows that in some extreme cases a corrosion protection field test data analysis should take more than one structure to soil potential performed over the tank into account. Additional cathodic protection potentials should be obtained with the reference cell in a remote location.

A remote reference cell location is one where the reference cell is not placed near or over other metallic structures, but placed away from the tank. This reference cell location is preferable because it reduces the possibility of the cathodic protection test being affected by the influence of local action corrosion cells from other metallic structures such as nearby piping, conduit, or manway housings which could affect the accuracy of PEGCP system tests. This test will verify that the anodes are functioning, and that protective current is being applied.

Background:

Various types of cathodic protection have been used for many years to control corrosion of buried and submerged metallic structures. One method relies on energy supplied by direct connection of the metallic structure, like a steel tank, to a galvanically more active metal, like zinc or magnesium. Another type of cathodic protection uses the energy supplied by an external a.c. power supply which is converted to d.c. energy and then impressed on the UST system.

These types of corrosion control have proven to be highly effective when used on buried metallic pipelines. The National Association of Corrosion Engineers has devoted a great amount of effort in identifying and documenting test procedures as well as several criteria for evaluating the level of protection provided. These testing criteria are based on their application to buried metallic piping of various types using both methods of cathodic protection.

After more than twenty years in the marketplace, corrosion technicians and engineers are still learning that differences exist between the structures, pipelines and UST's, not only in cathodic protection design, but also in testing and operation of the cathodic protection system. Unfortunately, few studies until now have focused on the unique characteristics of PEGCP FOR STEEL UST's.

As part of a program begun in 1988, field data and cathodic protection test reports for these USTs are continuously evaluated. This has provided answers to several questions concerning results for cathodic protection testing of PEGCP UST's. It has been found that the inability to measure a tank to soil potential value of at least -850 mV (CSE) does not always mean that the tank cathodic protection system is failing to perform as designed. Interpretation of these measurements has led to many false assumptions of an "unprotected" status which often leads to a conclusion that the tank is corroding catastrophically. However, further evaluation of test results plus all basic variables about the UST site would conclude whether the anodes are functioning and corrosion has been effectively mitigated.

A detailed study has identified some primary factors which can contribute to low cathodic protection measurements on <u>properly installed</u> PEGCP STEEL UST's including:

1) Extremely dry surface soil conditions during the time of the test.
2) Frozen soil conditions at the reference cell location.
3) Metallic manway or containment sump filled with water.
4) Fabric membranes and tank appurtenances which shield the reference cell from measuring the PEGCP UST potential.
5) Elevated or sloping excavation design.
6) Non-conductive, hydrocarbon saturated, soil near the tank or soil access testing location.
7) Measurements made with the reference electrode placed in contact with asphalt or concrete.

The most common cause of a low potential measurement for a properly installed tank is the tank environment being in an extremely dry condition at the time of testing.

This paper will discuss this cause with emphasis directed on the evidence and results, and includes a suggestion for a corrective action plan.

Tank Surroundings:

As a preface, it should be noted that a database has been established by VeriTank, a company which specializes in cathodic protection testing of PEGCP STEEL UST's, of approximately 34,000 individual tank cathodic protection reports. About 92% of those tank-anode readings meet the NACE -850 mV (CSE) criteria. The purpose here is to shed light on common situations where non-conforming readings are taken, which can be easily resolved.

A lack of moisture in the excavation due to low water table, combined with the moisture drawing backfill properties of the tank, can result in cathodic protection levels less negative than -850 mV (CSE). This usually does not require the addition of anodes or worse, excavation of the UST.

Properly installed PEGCP STEEL UST's are backfilled with specified materials. These specified materials include either clean washed sand, pea gravel, or #8 crushed stone. These materials provide excellent structural support for the tank during its service, while assuring that rocks, debris and trash do not contact the tank.

The specified backfill allows water migration to occur through the excavation. Water or moisture present in the native soil around the excavation can easily move into this more porous material. When this occurs, a conductive (as well as corrosive) environment is present in the tank excavation.

This ease of water migration also allows, in arid conditions, moisture to move away from the tank in the excavation resulting in an extremely dry high-resistance environment. Thorough review of backfill conditions or surroundings, in addition to monitoring during maintenance or after construction, can aid in evaluating the effectiveness of the corrosion protection when insufficient readings are obtained.

Evidence:

Many cathodic protection tests of pre-engineered tanks are conducted during months when weather conditions are mild or warm. Seasonally, this period is often accompanied by weather with relatively little precipitation. About 5% of these tests provide results indicating the cathodic protection level does not meet the -850 mV (CSE) criteria for corrosion control as established by NACE.

Further evaluation for some of these tanks has been made possible by cooperation between the manufacturer, distributor, contractor, or specifying engineer. The follow-up investigation and/or testing has indicated specific conditions which are similar from one case to another.

The predominant condition which is similar from one occurrence to another is the presence of a backfill condition that exhibits a high resistance to cathodic protection current flow. This condition is caused by excessively dry backfill material. It can occur at the time of installation when backfill is dry and prior to groundwater accumulation or rainfall percolation toward the tank bedding where anodes are located. It can also occur as a result of excavation location, or configuration.

During the spring of 1991, Corrpro Companies performed special field testing on nine (9) UST sites in Ohio and Wisconsin on which conventional testing indicated low protection values. The testing and site evaluations included resistivity measurements, and cathodic protection potentials recorded at various levels in the backfill material. Soil boring in the excavation backfill allowed these tests to be performed at one (1) foot intervals from grade to a distance of 2' below the bottom of the UST. The data obtained proves that a dry backfill condition can exist in a stratified layer in the upper portion of the excavation.

The obligation of the corrosion consultant or cathodic protection tester goes beyond recommending the addition of anodes as a cure-all for "unprotected" cathodic protection test results. Just as corrosion control is based on the economic feasibility of the lifetime service for a structure, so should the recommendation for corrective action.

This requires a more comprehensive evaluation of the data. During this evaluation, consideration is given to the month in which the test is performed and the performance of additional potential measurements on the tank.

In most of these cases the potential measured is within a range of -849 mV to -650 mV. As much information as possible should be obtained from someone familiar with the installation (contractor, distributor, etc.) concerning the site configuration.

The possibility of a dry condition and low water table level during the months preceding and at the actual time of the cathodic protection test should be discussed.

A high percentage of the questionable test results are found in areas that have experienced extended periods of time without significant amounts of rainfall. This information is correlated with more recent testing of soil resistivity, and cathodic protection measurement levels to help identify the cause of the reading. When ground water monitoring wells are available, a visual observation of the monitoring well is suggested to determine the level during testing.

In some cases, results of temporary impressed current tests are also utilized to provide additional data. During this test, a D.C. voltage is forced through the excavation with the use of a temporary anode rod(s), and a 12 volt lantern battery. This test measures the amount of current in milliamperes required to shift the negative potential on the tank to a protected level by connecting an ammeter in series with the tank test connection. The amount of current applied is controlled by adjusting the depth of the temporary anode. A record is made of the shift in tank potential at several (usually increasing) levels of applied current.

Tanks that are buried in excessively dry backfill conditions typically require a small amount of current (less than 15 mV) to meet or exceed the specified level of cathodic protection required by the NACE minimum -850 mV (CSE) criteria. However, a small amount of current such as this is not indicative of defective anodes, anodes with plastic bags not removed, excessive coating damage, or tank electrical shorts to piping and conduit.

Recommendations:

Occasionally an owner will express concern about meeting cathodic protection regulations. Some regulatory officials with limited cathodic protection knowledge may question the tanks ability to resist corrosion. These types of inquiries necessitate a recommendation for additional action.

A recommendation may be possible when the previously detailed test data and visual information concerning the tank environment is available.

When steel USTs equipped with pre-engineered galvanic cathodic protection at the time of manufacture have been tested and are not meeting the required criteria for cathodic protection (-850 mV) (CSE) and, the data and conditions indicate prolonged or excessive dryness in the excavation, the following are recommended actions:

1) No immediate corrective action is necessary by the owner or installation contractor if the tank has been installed properly. Proper installation is verified by measuring continuity between the tank structure and other tank appurtenances or metallic structures in the excavation. Test results that fail to meet corrosion protection criteria do not mean that corrosion is occurring or that the cathodic protection system is not operational. It may simply mean that the anodes have not been activated due to a non-conductive electrolyte or backfill.
2) The owner should forgo the addition of anodes or excavation of the tank until backfill conditions can be considered a conductive environment (adequate moisture present) and all other possibilities are exhausted. This may be accomplished by flooding the excavation with water.
3) When backfill conditions are changed to a conductive environment, a cathodic protection test should be performed to verify the -850 mV (CSE) criteria is obtained.

These recommendations are based on the following:

1) Proof of the effect that water table has on the cathodic protection test results.
2) Analysis of all available data concerning tank location and surroundings and their effect on cathodic protection testing.
3) Review of statistical data for these occurrences.

Results:

A file has been compiled which contains reports and data that document the effect of dry backfill conditions on galvanic cathodic protection systems for steel underground storage tanks.

Some reports indicate a pattern of cathodic protection test results as they are related to the available water table at the time of testing (changes in backfill moisture content over time).

Other reports show how protection levels improve when backfill conditions become wet, either by rainfall, run-off, or intentional flooding of the excavation backfill. It should be noted that this can occur in all areas of the nation.

From a corrosion control technology standpoint, assuming the tank is properly installed, a cathodic protection test result not meeting the minimum -850 mV (CSE) criteria during a period of dry backfill conditions does not mean that the cathodic protection system is defective or of an inadequate design.

It does indicate the tank backfill material may not be an adequately conductive environment at the time of testing. Although the non-conductive backfill material prevents accurate measurement of the current from the anode, this dry condition also does not promote corrosion.

Several state environmental agencies and major tank buyers are accepting these recommendations by allowing a re-test of suspect tanks when conditions are more favorable for corrosion to occur.

Conclusion:

Additional emphasis by the industry on continuing research and further substantiation of these findings may provide information that will allow NACE to re-evaluate the cathodic protection test requirements and procedures for PEGCP STEEL UST's.

During testing, the possibility of influence from additional factors such as a dry excavation should be accounted for.

A single tank potential when the reference cell is placed over the tank that results in a lack of measurable current, and one of the previously mentioned factors is possible, should not be the limit of the data acquired to determine the protection level of a pre-engineered galvanic cathodic protection system.

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