GUIDELINES FOR THE EVALUATION OF UNDERGROUND STORAGE TANK CATHODIC PROTECTION SYSTEMS

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SECTION 1 – GENERAL INFORMATION

1.1 Introduction

The purpose of this document is to provide guidance for the evaluation of cathodic protection (CP) systems operating on underground storage tank (UST) systems in Louisiana. While conducting structure-to-soil potential surveys is the primary means of testing CP systems, other aspects related to the evaluation, installation, operation and repair of CP systems are also addressed in this document where necessary.

Evaluation of CP systems to ensure they are functioning as intended has proven to be one of the more problematic areas and has led to a great deal of confusion and various practices among individuals engaged in the field of CP. Because the applicable regulations contain no specific criteria and instead defer to industry standards, a large degree of latitude has historically been provided for interpretation of what constitutes an acceptable evaluation.

Because there are many factors that can affect CP there is no standard test method or simple approach that will work at every site that has a CP system in operation. The primary intent of this guideline is to ensure that anyone engaged in UST system CP in Louisiana understands what is required. The second focus of this guideline is to establish sufficient and consistent documentation in order to evaluate the results generated by a qualified CP tester or corrosion expert. To this end, forms for evaluating CP are available on the LDEQ website at www.deq.louisiana.gov/ust. Only qualified CP testers or corrosion experts can perform CP testing in Louisiana.

Some of the more important points established in this guidance document are:

- Access to the soil directly over the structure tested is required
- Both local and remote structure-to-soil potentials are required on galvanic systems
- Voltage drops must be considered and instant off potentials are required on all impressed current systems
- Continuity/isolation testing is required whenever a CP survey is conducted
- Under certain conditions, a corrosion expert must evaluate the CP survey
- Installation of any new metallic components that routinely contain product (with the exception of submersible turbine pumps) that are buried, partially buried, or installed in a non-water tight containment sump must be coated with a dielectric material and have cathodic protection installed
- Isolation boots alone are no longer acceptable as a means of isolating metallic components installed after the effective date of this document

Simply conducting a structure-to-soil potential survey does not adequately evaluate a CP system. Other considerations that may need to be addressed are outlined in the text of this document and include review of previous CP evaluations, continuity measurements, evaluation of rectifier operation, current distribution among an impressed current anode ground bed, consideration of voltage drops, assurance of wiring integrity, continuity bonds, as built drawings, and other considerations.

This guideline is not intended to replace any statute, rule, or regulatory requirement concerning the installation, repair, operation or testing of CP systems. It is intended to state the interpretation of the Louisiana Department of Environmental Quality with regard to the implementation of those rules and regulations applicable to UST CP systems.

SECTION 2 – REGULATIONS

2.1 Rules

The 1988 Federal and subsequent Louisiana UST regulations require that any component of a UST system (tank, piping, or other components) that routinely contain product and are in contact with soil, backfill or water are protected from corrosion. If the metallic UST component is in contact with soil, backfill or water, it must be cathodically protected. If it is cathodically protected it must also have been coated with a suitable dielectric material if the metallic component in question was installed on or after December 22, 1988.

The rules also require evaluation of all CP systems within six months of installation or repair and once every three years thereafter. The two general types of CP typically installed on UST systems are galvanic (sacrificial anode) and impressed current (rectifier) systems. Although not a regulatory requirement, evaluating impressed current systems on an annual basis should be considered because these types of systems are more susceptible to failure or may be in need of adjustment on a more frequent basis in order to provide adequate CP.

LDEQ adopted almost verbatim the federal UST rules found under Subtitle I of the Resource Conservation and Recovery Act. The federal rules are published in Chapter 40 Part 280 of the Code of Federal Regulation (“Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tank Systems”). See LAC 33:XI.Underground Storage Tanks for the Louisiana UST regulation. It should be noted that the LDEQ UST regulations may be revised in the future so always refer to the most up to date rules when reviewing UST regulations (www.deq.louisiana.gov). The regulations reference several industry codes and practices and a listing of these are in Appendix A of this document.

SECTION 3 – TYPES OF CATHODIC PROTECTION

3.1 General

The two types of CP typically installed on UST systems are galvanic (sacrificial anode) and impressed current systems. The principle involved in the theory of CP is beyond the scope of this document. Stated in the simplest terms, both of these types of CP attempt to reverse the flow of electric current away from the metal that is intended to be protected from corrosion. Both types of CP prevent electric current from leaving the protected structure by supplying an electrical charge in the form of direct current (DC) power sufficient to overcome any current that would otherwise leave the structure. How the required electrical current is provided is what differentiates the two types of CP.

3.2 Galvanic Systems

Galvanic systems are also known as sacrificial anode systems because an anode (usually zinc or magnesium) corrodes instead of the protected metal. Because the anode corrodes instead of the metal that it is protecting, the anode is said to sacrifice itself. Sacrificial anodes are connected directly to the structure to be protected by either welding or mechanical connection of lead wires.

Galvanic systems are generally limited to tank(s) and piping that are well coated with a dielectric material (sti-P_3® tanks, epoxy/aliphatic urethane coated tanks or fusion bonded epoxy coated steel piping) because the available current output of sacrificial anode systems is low and cannot protect large metallic surface areas. Attempts to protect long runs of uncoated piping or uncoated tanks is generally not practical because the useful life of the anodes is too short or the number of anodes needed is too great.

3.3 Impressed Current Systems

Impressed current systems, sometimes called rectifier systems, utilize an electrical device (a rectifier) to convert an external alternating current (AC) power source to the required DC power source. In this type of system, anodes are installed in the soil around the structure to be protected and the DC power is supplied to the anodes through buried wires. The power to the rectifier cannot be interrupted except when conducting maintenance or testing activities. A dedicated and protected circuit should be provided for the impressed current system so that the power cannot be inadvertently cut off.

In impressed current systems the protected structure is bonded to the DC power system to complete the electrical circuit. It is critical that the anodes are connected to the positive terminal and the protected structure to the negative terminal of the rectifier. Reversal of the lead wires will make the components of the tank system anodic and can cause a rapid failure of the tank system due to corrosion induced by the rectifier. In addition, it is critical that all wire connections and splices are well insulated. Any breaks in the wiring insulation will allow current to leave the wire at that point and a rapid failure of the wire can occur due to corrosion.

Impressed current systems are generally installed on bare steel tank systems that were installed prior to the effective date of the Federal UST regulations (December 22, 1988) since these tanks usually do not have a good dielectric coating. The level of CP provided by an impressed current system can be changed since the voltage produced by the rectifier can be adjusted. Because conditions that affect the level of CP needed are likely to change over time, adjustment of the rectifier is frequently necessary.

SECTION 4 – QUALIFICATIONS TO TEST CATHODIC PROTECTION SYSTEMS

4.1 Qualifications

In order to test CP systems in Louisiana, an individual must meet certain minimum qualifications. It is the intent of LDEQ that those individuals who meet the minimum qualifications perform testing in a manner that is consistent with this guidance document. Should an individual who meets the minimum qualifications as described below not possess the knowledge and expertise needed to properly evaluate a CP system, that individual is not acceptable to LDEQ to perform such an evaluation.

While it is not necessary to be an "expert" to test CP systems in most cases, the proper evaluation of the two types of CP systems requires differing levels of expertise. Impressed current systems are inherently more involved and require a higher level of understanding than galvanic systems. In addition, certain circumstances and conditions may exist that would preclude an individual from making an effective evaluation of a CP system without the assistance of someone who is more qualified.

Because the testing of impressed current systems is inherently more complicated, someone who is only minimally qualified as a "tester" should recognize that they may or may not be able to properly evaluate all CP systems. Galvanic CP systems that are operating as designed are normally straightforward and a lesser degree of expertise is needed to properly evaluate them. However, troubleshooting and/or repair of galvanic systems may require someone who has a higher level of expertise than a person who is only minimally qualified as a tester.

Cathodic protection tester and *corrosion expert* are defined in Appendix B. Scenarios that require a corrosion expert to either conduct or evaluate the CP survey are listed in Section 7.2 of this document. A listing of those individuals who meet the qualifications of a corrosion expert (certified as either a *corrosion specialist* or a *cathodic protection specialist*) can be found at the web site of NACE International (www.nace.org).

Listed below are the minimum qualifications necessary to test CP systems:

- Anyone who meets the definition of *cathodic protection tester* as found in LAC 33:XI.103 is recognized as qualified to test CP systems
- Anyone who holds a certification from a national association (e.g., NACE International, Steel Tank Institute, etc.) or organization that recognizes that person as a qualified CP tester (e.g., see www.steeltank.com for a complete list of Steel Tank Institute's certified testers)
- See Appendix N for US EPA's more thorough discussion on minimum qualifications for CP testers and corrosion experts

SECTION 5 – INSTALLATION/REPAIR OF CATHODIC PROTECTION SYSTEMS

5.1 Galvanic Systems

5.1.1 sti-P_3® Tanks

The galvanic sacrificial anodes of a sti-P_3® tank are factory installed with the tank. If the CP system of a sti-P_3® tank needs repair, or addition of supplemental anodes, any CP tester or corrosion expert may conduct such repairs provided any provisions of the tank manufacturer are met. The design requirements for the installation of additional sacrificial anodes to a sti-P_3® tank must be accomplished by a corrosion expert unless the provisions of the Steel Tank Institute "Recommended Practice for the Installation of Supplemental Anodes for sti-P_3® UST's", R972 are followed (http://www.steeltank.org). An evaluation of the CP system must be conducted within six months of the installation or within six months of a repair.

5.1.2 Non-factory Coated Tanks (non sti-P_3® Tanks)

Galvanic systems are not recommended for non-factory coated steel tanks (i.e. bare steel, asphalt coated, poorly coated, etc.) due to the higher current required for protecting them. Typically, an impressed current system is required to protect such a tank. A corrosion expert would have to evaluate the tank system to determine the best course of action to protect such a tank, and would have to design the CP system installed on such a tank. Non-factory coated steel tanks that have never had CP installed cannot be upgraded and must be permanently closed in accordance with LAC 33:XI.303.E.2 and 903.D.

5.1.3 Factory Coated Metallic Piping

Installation of sacrificial anodes to factory coated metallic piping (e.g., extruded polyethylene, fusion bonded epoxy) may be accomplished without the design of a corrosion expert provided the provisions of the Steel Tank Institute "Recommended Practice for Corrosion Protection of Underground Piping Networks Associated with Liquid Storage and Dispensing Systems", R892 are followed. As an alternative, the practices as described in the Petroleum Equipment Institute RP100, "Recommended Practices for the Installation of Underground Liquid Storage Systems" may also be followed when installing sacrificial anodes on factory coated piping.

5.1.4 Non-factory Coated Metallic Piping

The repair of a galvanic CP system installed on metallic piping that is not factory coated with a dielectric material may be accomplished by either a CP tester or corrosion expert. However, the design of a new or modified galvanic CP system must be accomplished by a corrosion expert. In addition, an evaluation of the CP system must be conducted within six months of the repair.

5.1.5 Metallic Piping Repair/Installation

Provided below are some general observations that are commonly applicable to questions that arise when attempting to meet the CP requirements on metallic piping and other metallic components of a typical UST system.

Protected Components (e.g., metallic piping, flexible connectors, nipples, elbows, tees, couplings, unions, ball valves, submersible turbine pump heads)

a. **Metallic piping and components installed or replaced before December 22, 1988 –** Metallic piping and components of a piping system that routinely contain product and that are in contact with the soil, backfill, or water were required to have been isolated from the soil, backfill, or water or have had a CP system installed by December 22, 1998.

b. **Metallic piping and components installed or replaced on or after December 22, 1988** – All metallic piping and components of a piping system that routinely contain product and that are in contact with the soil, backfill, or water were required to have been protected from corrosion at the time of installation. Corrosion protection should have been accomplished by either a) isolating the component from contact with the soil, backfill, or water or b) coating/wrapping with a suitable dielectric material and providing a CP system. Due to past industry standards and practices, adding dielectric coatings to cathodically protected metal flex connectors and other metallic components has never been practiced and is not required for metallic components installed prior to the effective date of this document.

Any isolation boot designed to isolate a metallic component from contact with the ground must also prevent water from contacting the component to prevent corrosion of the component. <u>Beginning with the effective date of this document, installation of any new metallic components that routinely contain product (with the exception of submersible turbine pumps) that are buried, partially buried, or installed in a non-water tight containment sump must be coated with a dielectric material and have CP installed.</u> Isolation boots alone are no longer acceptable as a means of isolating metallic components installed after the effective date of this document.

Corrosion expert design is required for galvanic CP systems on metallic piping in accordance with sections 5.1.4 and 5.1.5 above, but not required for galvanic CP systems on flexible connectors, nipples, elbows, tees, couplings, unions, ball valves, submersible turbine pump heads.

Unprotected Components – Metallic components of the UST system that do not require corrosion protection include tank vent lines, any type of tank riser pipe that does not routinely contain a regulated substance, tank hold down straps (unless manufacturer/local code requires it), and remote tank fill lines.

Repair – Some confusion exists over whether or not metallic piping that has failed can be repaired or must be replaced. "Repaired" as related to metal pipe involves the replacement of the section of pipe that has failed. The entire run of metal piping does not have to be replaced but the repair must consist of replacement of the section of pipe that has failed (LAC 33:XI.507.A.4). Only metal pipe that is factory coated with a dielectric material (e.g., extruded polyethylene, fusion bonded epoxy) can be used to replace the failed section of metal pipe regardless of whether the existing pipe is galvanized or coated steel. Under no circumstances is it allowable to install galvanized piping when it is intended to serve as a product transfer line. Because of the complexities that may be involved in the CP of galvanized steel piping, a corrosion expert must evaluate and/or conduct the CP survey after the repair. Replacement of a metal section of pipe with fiberglass pipe may require the CP system to be re-designed by a corrosion expert and the CP system re-tested to ensure that it operates properly and maintains proper continuity/isolation. After December 20, 2008, if greater than 25% of a piping run is repaired or replaced, the entire piping run must be replaced with secondarily contained piping with interstitial monitoring (LAC 33:XI.507.A.7).

Electrical Continuity – Dielectric unions are normally not installed if the piping is protected by an impressed current system. It is essential that all metallic piping, as well as all other buried metallic components that are within the field of influence of the impressed current system, is bonded to the negative circuit of the impressed current system if it is buried. It is better to electrically isolate any metallic portion of the UST system that is not buried or submerged in water from that portion that is buried or submerged in water.

Electrical Isolation – If metallic piping is galvanically protected, it is critical that effective electrical isolation be provided. Failure to isolate the protected piping will result in premature failure of the sacrificial anodes. Isolation can be difficult to achieve where cathodically protected piping is present under dispensers that have shear valves present. This is due to the requirement that the shear valve must be properly anchored to the island form. Particular care should be exercised in these instances to assure proper isolation. If possible, the dielectric union should be installed below the shear valve so that anchoring does not cause a continuity problem.

Screw Joints – Particular care should be taken when dealing with metallic piping that is mechanically coupled with threaded screw joints. Any threaded joint in a metallic piping material can serve as a break in the electrical continuity of the piping system. It has been established that threaded couple pipe joints can develop enough electrical resistivity over time to effectively isolate each section of a piping system, especially when joint tape or joint compounds are used. This is highly undesirable in a CP system and you should ensure that electrical continuity is present between any sections of piping that are intended to be protected. Jumper wires or welding may be necessary across each pipe couple in order to assure electrical continuity between each section of piping.

Containment Sumps – If metallic components of a piping system are installed within a containment sump that was installed prior to December 20, 2008, the sump should be maintained dry. If a sump contains water and you are unable to keep the water out, the metallic components must be protected from corrosion. The metallic components may have been protected by installing isolation boots (in the case of flex connectors) or sacrificial anodes. If protecting metal components within a containment sump, the anode must be installed within the sump. Do not place the anode outside of the sump. <u>Note that any cathodically protected component, except submersible turbine pumps, that are in contact</u>

with soil, backfill, or water installed after the effective date of this document must also be coated/wrapped with a suitable dielectric material.

All metallic components of a piping system that are located inside of containment sumps installed after December 20, 2008 and within containment sumps that are used for interstitial monitoring are not allowed to be in contact with soil, backfill or water. All containment sumps installed after December 20, 2008 (LAC 33:XI.303.D.4 and 5) and all containment sumps used for interstitial monitoring (LAC 33:XI.701.B.4) must be maintained free of liquid and debris. Adding CP to metallic components in these containments sumps is not allowed to meet the regulatory requirements.

"Mixed" Piping – In those instances where fiberglass reinforced plastic or flexible piping has been connected to an existing metallic pipe (e.g., to extend a fueling island), a CP test station or access to the soil where the two dissimilar materials were joined must be provided. This is necessary to effectively test the adequacy of CP operating on the metallic piping.

5.2 Impressed Current Systems

Anyone who is a CP contractor (tester or expert) may install and/or repair an impressed current system. Impressed current systems and impressed current system component reconfigurations must be designed by a corrosion expert.

Note: Some UST facilities contain mixed systems such as impressed current systems for some tanks/components alongside other sti-P_3® and/or composite tank systems at the facility. This makes "bonding" and "continuity" a critical issue. A corrosion expert must review all such complex site designs.

If an impressed current system repair only involves the replacement of like-kind existing components, a corrosion expert does not need to "sign-off" on such work. However, after any repair or alteration of the impressed current system is made, it must be tested for proper operation within six months of the repair. If the repair or alteration results in any of the conditions described in Section 7.2 of this document, the CP survey must be conducted/evaluated under the supervision of a corrosion expert.

5.2.1 Rectifier Adjustment

Anyone who is considered qualified as a CP tester may adjust the rectifier output/voltage of an impressed current system as long as it remains within the values set by the corrosion expert who designed the system. If the original CP design is not available, then a corrosion expert must evaluate the CP system to determine the operating range of the CP system. An evaluation of the CP system must be conducted whenever an adjustment to the rectifier is made. Before making any adjustments to the rectifier, the power must be turned off and both the AC and the DC circuit breakers opened.

It should be recognized that increasing the rectifier output could cause an increase in the potential for stray current to be generated that may have a detrimental effect on other buried metallic structures at the facility. Excessive rectifier output can also significantly shorten the life of the anode ground bed since the anodes will be consumed more quickly than necessary. In addition, care should also be taken to ensure that components of the rectifier do not become overheated (causing a potential fire hazard) as a result of increasing the output.

When evaluating the operation and output of a rectifier, it is important to make all measurements with a good quality multimeter. Do not rely on the output indicated by the voltmeter and/or ammeter that may be installed on the rectifier. Most rectifier meters are adjustable and you should make any adjustment that may be indicated by measurement with the portable multimeter.

The meters that are commonly built into rectifiers are usually not accurate and may even be frozen in a fixed position. If the indicator needle is frozen on the rectifier voltmeter/ammeter and cannot be freed, the meter should be replaced. If replacement is not accomplished immediately, it should be noted that the meter is not functioning so that an observer will be able to discern that the meter is inoperable.

For the reasons given above and other considerations, a person qualified as a corrosion expert must be consulted whenever the output is adjusted beyond the values set by the corrosion engineer, if no original CP design is available, or when repairs are made to the rectifier. The corrosion expert must also evaluate and sign off on the CP survey to assure that the system is functioning properly (see Section 7.2).

5.3 General Information Applicable to All Repairs

UST owners are required to submit a *UST System Installation, Renovation, Repair, and Upgrade Notification* form (UST-ENF-04) form to the department 30 days prior to making repairs to tanks, piping, spill and overfill prevention equipment, corrosion protection equipment, release detection equipment, or any other UST system component. If the repair is an emergency repair, the UST-ENF-04 form can be submitted within 30 days after completing the repair. Repairing a CP system immediately after a failed test is considered an emergency repair. UST owners are also required to submit an amended *Underground Storage Tank Registration and Technical Requirements Form* (UST-REG) within 30 days after completion of the repair if any changes of any items reflected on the previously submitted form has changed due to the repair. The corrosion expert’s design documentation for field-installed CP systems must be maintained by the UST owner or operator in accordance with LAC 33:XI.509.B.1.b.

SECTION 6 – CATHODIC PROTECTION TESTING

6.1 Equipment

Although the equipment required to test CP systems is relatively simple, it is very important that the equipment is maintained in good working order and is free of corrosion and contamination. The basic equipment includes a voltmeter/ammeter/multimeter, reference electrode, wires, clips and test probes.

It may also be necessary to have a current interrupter for impressed current systems when the power cannot be easily cut on and off at the rectifier. A clamp-on type ammeter can be useful when troubleshooting impressed current systems. Wire locators can help determine the location of buried anode lead wires and header cables. Hand tools to clean corrosion or dielectric coatings from the surface of the structure you are testing at the point of contact with lead wires/probes may also be necessary.

6.1.1 Voltmeter/Ammeter/Multimeter

A good quality voltmeter/ammeter/multimeter that has an adequate degree of accuracy is essential for testing CP due to the low voltage/current involved. Most "low end" voltmeters/ammeters are not capable of achieving results accurate enough to ensure reliable results and should not be used.

All testing of CP systems must be accomplished with a high internal resistance (impedance of 10 meg-ohms or greater) voltmeter that is properly maintained and periodically calibrated in accordance with the manufacturer's recommendations. It is important that the voltmeter has a high internal resistance in order to avoid introducing a large error when measuring structure-to-soil potentials. The voltmeter should be calibrated at least on an annual basis.

The voltmeter must have a high degree of sensitivity and must be placed in as low a scale as possible (normally the 2 volt DC scale works well) in order to accurately measure the small voltages associated with CP systems. All voltage measurements obtained should be recorded as millivolts (mV). For example, a reading of -1.23 volts should be recorded as -1230 mV; a reading of -.85 volts should be recorded as -850 mV.

Voltmeters that have a variable input resistance can be utilized to ensure that contact resistance between the reference electrode and the electrolyte has been evaluated as a source of error (voltage drop) in the observed structure-to-soil potential. This is accomplished by changing the input resistance and noting whether or not the voltage observed changes significantly. If no voltage change is observed when the input resistance is changed, it can be assumed that contact resistance is not causing an error in the structure-to-soil potential measurement.

An ammeter that has a very low internal resistance is necessary when testing impressed current systems in order to accurately determine the current output of the rectifier and/or individual circuits in the system. Generally, amperage should only be measured where calibrated measurement shunts are present. Alternatively, a "clamp-on" type ammeter may be utilized in those cases where shunts are not present.

The batteries in the portable voltmeter/ammeter/multimeter must also be in good condition. Batteries that are in poor condition can cause unintended errors. If there is any question about the condition of the batteries, they must be replaced.

6.1.2 Reference Electrode

A standard copper/copper sulfate reference electrode (also known as a half cell or reference cell) must be utilized in order to obtain structure-to-soil potentials. The reference electrode must be maintained in good working condition and must be placed in the soil in a vertical position when conducting a test.

On those sti-P_3® tanks that have a CP test station (e.g., PP2®, PP4®, etc.), a reference electrode is permanently buried in the tank pit. Since it is generally not possible to determine where the permanent reference electrode was installed on these types of systems or its calibration accuracy, it is also necessary to conduct structure-to-soil potential measurements in the conventional manner (i.e. with a portable reference electrode in the soil directly over the tank and at a remote placement). A tank may not be passed on the basis of a structure-to-soil potential obtained with a test station. Both the local and the remote potential obtained in the conventional manner must indicate that adequate CP has been provided regardless of what the test station indicates.

A permanent reference cell that does not require servicing is available. Maintenance of the non-permanent reference electrode is important for accurate results and includes the following:

1. The copper-sulfate solution inside the reference electrode should be clear. If the solution appears cloudy, this may indicate that the solution is contaminated and the reference electrode should be compared with the known standard as described in paragraph 5 below. Only use distilled water and new copper-sulfate crystals when replacing the solution. Excess copper-sulfate crystals must be present in order to assure a saturated solution. Under average conditions, it is usually a good idea to empty and replace the solution every 2 or 3 months.

2. The porous ceramic tip must be maintained moist at all times. If the tip is allowed to dry out, it may lose its porosity and a good low resistivity contact with the soil will not be possible. Periodic replacement of the tip may be necessary.

3. The copper rod inside the reference electrode should periodically be cleaned with non-metallic sandpaper. Do not use black metal oxide sandpaper, steel wool or any other metallic abrasive as this can cause the copper rod to become contaminated. If the copper rod becomes contaminated, clean the copper rod and replace the copper sulfate solution.

4. The copper-sulfate solution must be free of contamination or errors will be introduced in the readings you observe. If the reference electrode is submerged in water or placed in moist soils that are contaminated, it is likely that the solution will become contaminated.

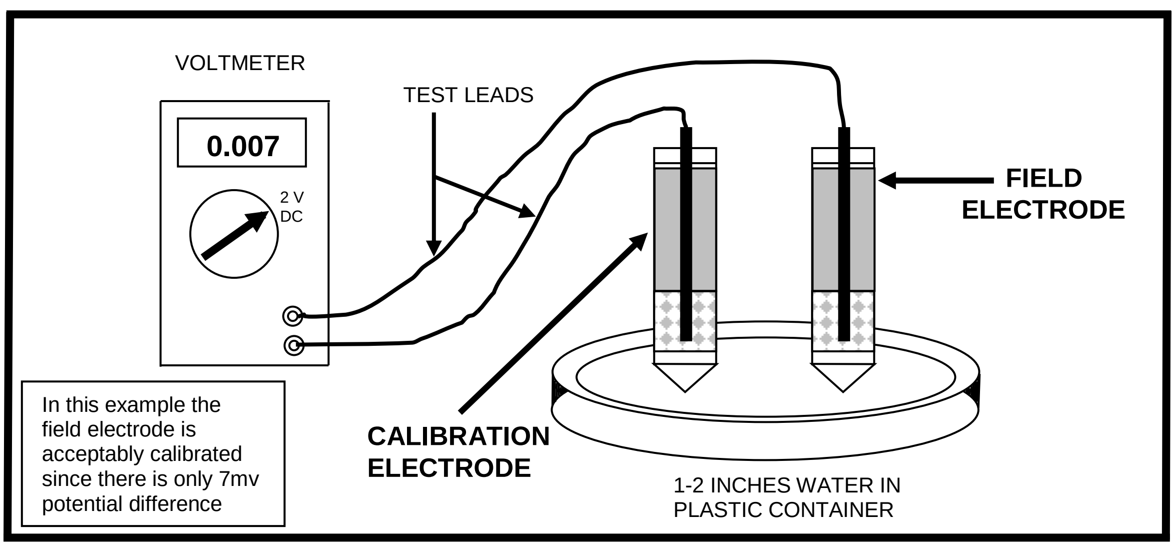
5. The reference electrode that is used in the field must be periodically calibrated. How often the reference electrode needs to be calibrated depends upon several different factors. Among the more important factors that should be considered are the frequency of use and the exposure of the reference electrode to contaminants. As a general rule, calibration should be checked once every week if the reference electrode is used daily. If the reference electrode is only periodically used, calibration should be checked prior to each use.

Calibration of the reference electrode is accomplished by comparing it with another reference electrode that has never been used in the field. The new reference electrode, that is to act as the calibration standard, should be properly set up with new copper sulfate solution. Consideration should be given to obtaining a reference electrode that is certified by the manufacturer to be properly calibrated for periodic calibration of the field electrode.

To calibrate the field electrode:

1. Place the voltmeter on the 2-volt DC scale (or lower) and connect the leads to the reference electrodes (Figure 1).
2. Place both the field electrode and the standard calibration electrode in a shallow nonmetallic container that has one to two inches of tap water in the bottom of it. Do not use distilled water. The reference electrodes must be placed vertically in the container with the ceramic tip of each submerged in the water.
3. Observe the potential measurement displayed on the voltmeter. If more than 10 mV potential exists between the two reference electrodes, the field reference electrode should be properly cleaned and refilled with new solution until the potential difference is 10 mV or less. If you are unable to achieve a 10 mV or less potential difference after cleaning/reconditioning, the field electrode must be discarded and a new one obtained.
4. In order to lessen the chance of cross contaminating the calibration electrode, you should leave the calibration electrode in the water for the shortest time necessary to complete the test.

Figure 1 – Illustration of Reference Electrode Calibration



6.1.3 Lead Wires/Test Probes/Miscellaneous

You should ensure that the insulation material of any lead wires is in good condition. Any clips or probes used to make contact with the structure to be tested must be clean and free of corrosion. A spool of suitable wire of sufficient length is necessary to conduct continuity and/or "remote earth" testing. It is usually necessary to have a probe that can be attached to the end of a tank gauging stick in order to contact the tank bottom since it is not uncommon for the test lead on sti-P_3® tanks to either be missing or discontinuous with the tank shell. A pair of locking pliers can sometimes be useful when attempting to get a solid connection.

6.2 Test Criteria

There are three test criteria that can be utilized to indicate if adequate CP is being provided to the structure being evaluated:

850 On – A structure-to-soil potential of -850 mV or more negative with the protective current applied. This is commonly referred to as "850 on" or the "on potential". This criterion is normally the only one available for galvanic systems (e.g., sti-P_3®) since the protective current usually cannot be interrupted.

Voltage drops (see Section 6.3) other than those across the structure to electrolyte boundary must be taken into consideration whenever this criterion is applied. Voltage drops may have a significant impact on the potentials observed when testing impressed current systems with the protective current applied. Therefore, the "850 on" criterion is not applicable to impressed current systems.

850 Off – A structure-to-soil potential of -850 mV or more negative with the protective current temporarily interrupted. This is commonly referred to as "850 off", "polarized potential" or "instant off potential". This criterion is applicable to impressed current and galvanic systems where the protective current can be interrupted. Caution must be exercised when testing impressed current systems to ensure that no active sacrificial anodes are also installed near the protected structure. If there are active anodes influencing the observed potential, the "850 off" criteria is not applicable unless the output current of these supplementary anodes is interrupted (e.g., use of an isolating test station).

The instant off potential is the second value that is observed on a digital voltmeter the instant the power is interrupted. The first number that appears immediately after power interruption must be disregarded. After the second number appears, a rapid decay (depolarization) of the structure will normally occur. Another common rule of thumb is to wait 2 ½ seconds after the power interruption and record the voltage value as the instant off potential. In order to obtain instant off potentials, a current interrupter or another person is necessary to assist the tester. If a current interrupter is not available, have the second person throw the power switch at the rectifier off for 3 seconds and then back on for 15 seconds. Repeat and plot this procedure until you are sure an accurate instant off reading has been obtained.

This criterion is considered by most to be the best indicator that adequate CP has been provided. Therefore, consideration should be given to adjusting the rectifier output upward until the "850 off" criterion has been met if this is feasible.

100 mV Polarization – A polarization voltage shift of at least 100 mV is commonly referred to as "100 mV polarization" or "100 mV shift". This criterion is applicable to galvanic and impressed current systems where the protective current can be temporarily interrupted and where the steel UST is not connected to a more noble metal such as copper or stainless steel or passivated steel in concrete. Current interruption is not typical for factory installed galvanic systems. Either the formation or the decay of at least 100 mV polarization may be used to evaluate adequate CP as long as they are not connected to these more noble metals.

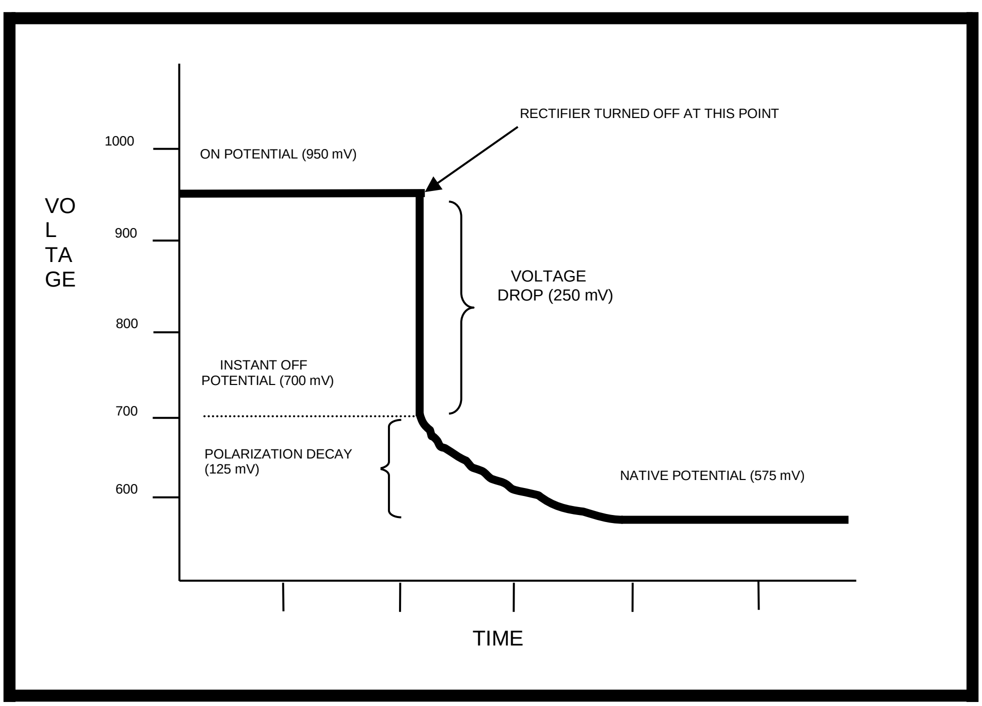
The “true” polarized potential may take a considerable length of time to effectively form on a structure that has had CP newly applied. If the protective current is interrupted on a metallic structure that has been under CP, the polarization will begin to decay nearly instantaneously. For this reason, it is important that the protective current not be interrupted for any significant length of time. Generally, not more than 24 hours should be allowed for the 100 mV depolarization to occur. On a well-coated structure complete depolarization may take as long as 60 to 90 days. Complete depolarization of uncoated structures will usually occur within 48 hours although it could take as long as 30 days.

The base reading from which to begin the measurement of the voltage shift is the instant off potential. Figure 2 illustrates an example of a structure that exhibits an on voltage of -950 mV. The instant off voltage is -700 mV. In order to meet the 100 mV polarization criteria, the structure-to-soil potential must decay to at least -600 mV (final voltage).

The use of native potentials to demonstrate the formation of 100 mV polarization is generally only applicable when a system is initially energized or is re-energized after a complete depolarization has occurred. This is because it is necessary to leave the reference electrode undisturbed (or returned to the exact position) between the time the native and the final voltage are obtained.

It is only necessary to conduct a 100 mV polarization test on that component of the UST system where the lowest (most positive) instant off structure-to-soil potential exists in order to demonstrate that the UST system meets this criterion. If the criterion is met at the test point where the potential is most positive, it can be assumed that it will be met at all other test locations.

Figure 2 – Graphic Representation of Voltage Drop in “ON” Potential



6.3 Voltage (IR) Drops

The effect voltage drops have must be considered whenever structure-to-soil potentials are obtained during the survey of a CP system. The concept of voltage drops is a difficult and controversial subject and a full discussion is beyond the scope of this document. However, stated in the simplest terms, a voltage drop may be thought of as any component of the total voltage measurement (potential) that causes an error.

The term IR drop is sometimes used and it is equivalent to voltage drop. IR drop is derived from Ohm's Law which states that V = IR. In this equation, V stands for voltage, I represents current (amperage) and R stands for resistance. Because the observed voltage is equal to the amperage (I) multiplied by the resistance (R) a voltage drop is commonly referred to as an IR drop. There are various sources of voltage drops and two of the more common are discussed below.

Current Flow – Whenever a current flows through a resistance, a voltage drop is necessarily created and will be included whenever a measurement of the electrical circuit is conducted. In order to effectively eliminate this voltage drop when testing impressed current systems, it is necessary to interrupt the protective current. The magnitude of the voltage drop obtained on impressed current systems is evaluated by conducting both on and instant off potential measurements.

To illustrate how this type of voltage drop contributes to the potential observed when measuring impressed current systems consider the following example. A potential of -950 mV is observed when the rectifier is on. A potential of -700mV is observed when the power is interrupted. Taking the absolute values (negative is dropped), the voltage drop component of the on potential is 250 mV (950 – 700 = 250). Figure 2 is a graphical representation of this voltage drop and also shows how the instant off potential will degrade over time until the native potential is reached.

Raised Earth – All active anodes will have a voltage gradient present in the soil around them producing a "raised earth effect". An abnormally high (more negative) potential will be observed if the reference electrode is within the voltage gradient of an active anode. The magnitude or area of influence of the voltage gradient is dependent predominantly on the voltage output of the anode and the resistance of the soil. Unfortunately, there is no "rule of thumb" guidance that can be given to determine how far away you must be from an anode in order to be outside the voltage gradient. If the potential is suspected to be affected by raised earth, it should be compared to a remote reading.

Because of the raised earth effect, it is necessary to place the reference electrode as far away from any active anode (and still be directly over the structure) when obtaining local potentials on galvanic systems. Since the protective current cannot typically be interrupted in galvanic systems, any effect this type of voltage drop may have is evaluated by placing the reference electrode remote. Placement of the reference electrode remote ensures that the reference electrode is not within the voltage gradient of an active anode. Since it is desirable to eliminate any effect voltage drops may have, it is necessary to obtain both local and remote structure-to-soil potentials on galvanic systems. Any effect raised earth may have when testing impressed current systems is eliminated by temporarily interrupting the power.

6.4 Stray Current

An unintended current that is affecting the structure you are trying to protect is referred to as a stray current. Stray currents can cause rapid corrosion failure of a buried metallic structure and are caused by an electric current flowing through the earth in an unintended path. If the metallic object you are trying to cathodically protect is buried near the path of the stray current, the current may “jump-on” the protected structure because it offers a lower resistance path for the current to flow. The affected structure will be cathodic where the stray current enters but will be highly anodic where the stray current returns to the earth. At the point where the current discharges, rapid corrosion of the structure intended to be protected will occur.

Although stray currents are relatively rare on UST systems, some common sources include:

- Railroad crossing signals (powered by batteries);
- Traffic signals that have induction type sensors buried in the pavement;
- Portable or fixed emergency power generators;
- Electrical railway systems such as streetcars or subways in urban areas;
- DC welding operations and other types of industrial machinery or processes that utilize DC power;
- Foreign CP systems protecting neighboring pipelines such as natural gas pipelines and buried metallic structures.

If unsteady readings are observed on the protected structure and it has been determined that it is not because of a bad electrical connection, it would be suspected that stray current is affecting the protected structure. In some cases, a pattern can be seen in the potential whereby it alternates between two relatively stable readings. These patterns can sometimes help to identify the source of the stray current. If it is suspected that stray current may be affecting the UST system, a thorough investigation must be conducted as soon as possible by a qualified corrosion expert since stray current can cause a rapid failure of the affected structure.

Cathodic Interference – When the impressed current system operating on the structure being protected causes an unintended current on some other nearby structure, this type of stray current is referred to as “cathodic interference”. Cathodic interference can cause a rapid failure of the water lines and other buried metallic structures at the facility where the CP system is operating. Observing an abnormally high (more negative) potential on a buried metallic structure would suggest that the impressed current system operating on the UST system is causing cathodic interference.

Instances where cathodic interference may be present include:

- copper water lines that are not bonded to the impressed current system and have a polarized potential of greater than -200 mV;
- metallic flex connectors associated with fiberglass reinforced plastic piping that have abnormally high (more negative) potentials and are not bonded to the impressed current system;

- sti-P3® tanks are buried at a facility where there is an impressed current system operating and are not bonded to the negative circuit. When the sti-P3® tanks have zinc anodes and a potential more negative than -1100 mV (more negative than -1600 mV in the case of magnesium anodes) is observed, it is likely that cathodic interference is occurring. Because of the potential for stray current to impact sti-P3® tanks, it is normally necessary to bond them into the impressed current system.

A corrosion expert must be consulted whenever cathodic interference is suspected in order to properly investigate and make any repairs/modifications that may be necessary.

6.5 Dissimilar Metals/Bimetallic Couples

The effect bimetallic couples may have must also be considered whenever structure-to-soil potentials are obtained during the survey of a CP system. The concept of dissimilar metals/bimetallic couples and the impact they can have on the proper evaluation of CP systems is a difficult and controversial subject and a full discussion is beyond the scope of this document. However, be aware that bimetallic couples may substantially influence the structure-to-soil potentials of a tank system to the extent that the 100 mV polarization criterion is not applicable. Because the validity of the 100 mV criterion may be suspect, consideration should be given to only utilizing the -850 mV instant off criterion when evaluating impressed current systems. A brief discussion follows.

Caution must be exercised when evaluating steel UST systems that have metals of lower electrochemical potential electrically connected to them. Typically, bimetallic couples are only of concern on impressed current systems (or shorted galvanic anode systems with supplementary impressed current) since those steel components protected by galvanic systems are electrically isolated from other metallic structures. Copper, stainless steel, and carbon steel rebar in concrete are all metals of lower potential that are commonly of concern. Sources of copper at UST facilities include the water service lines and the grounding system of the electrical power grid. Sources of stainless steel can include flex connectors and fittings. Sources of rebar in concrete can include deadman anchors and rebar in the concrete pad over the tank. Steel in concrete passivates and behaves electrochemically as if it were copper. Since the AC power supply to the submersible turbine pump should be continuous with the electrical service grounding system, which may in turn be continuous with the water lines, a significant amount of copper may be coupled to the steel UST system.

The effect this type of bimetallic couple has on the impressed current system can sometimes be clearly seen on those UST systems that store fuel for emergency power generators. Commonly these generator tank systems are installed with copper supply and return lines. When these tanks were retrofitted with an impressed current system, the copper lines were bonded into the CP system. In these instances, it is not uncommon to observe native structure-to-soil potentials on the UST system of -450 mV or more positive.

If the native structure-to-soil potential of the UST system is substantially lower than what would normally be expected, it is likely that a significant amount of copper is electrically bonded to the UST system. Typically, the expected native potential of a steel UST system should not be more positive than -500 mV.

To illustrate the effect of the copper-steel couple, consider the following example: A steel UST system that is coupled to copper has a native structure-to-soil potential of -300 mV with the bimetallic couple intact. If the copper couple is broken the UST system native potential is -600 mV. With the copper couple intact, the polarized (off) potential of the UST system is -450 mV. Although the voltage shift satisfies the 100 mV polarization criterion (from -300 mV to -450 mV), it is likely that the steel UST system is not adequately protected. This is because the UST system is not polarized at least 100 mV beyond the native potential of the steel. Since the true native potential of the steel UST system in this example is -600 mV, you would need to reach a polarized (instant off) potential of -700 mV or more negative.

Because the unaffected native potential of steel UST systems is generally not known, the application of the 100 mV polarization criterion would be inappropriate when there is a significant amount of copper (or other more noble metal) electrically continuous. For this reason, it is almost always mandatory to demonstrate that the UST system satisfies the 850 off criterion when evaluating a CP system that is or may be electrically connected to more noble metals such as copper or stainless steel or steel in concrete. If it does not pass, then the short must be cleared and/or a corrosion expert must evaluate the situation to resolve it.

6.6 Other Test Considerations

Various other factors can affect the accuracy of structure-to-soil potentials. Listed below are some of the more common factors:

Contact Resistance – In order to obtain an accurate structure-to-soil potential, a good (low resistivity) contact between the reference electrode and the soil must be made. Sometimes, the soil at the surface is too dry and water needs to be added in order to lower the resistance between the reference electrode and the soil. In addition, if the porous ceramic tip of the reference electrode becomes clogged or contaminated it should be replaced since this in itself can cause a high contact resistance.

Contaminated Soil – Ensure that the soil the reference electrode is placed in is free of contamination. Hydrocarbon contamination can cause a high resistance between the reference electrode and the soil.

Current Requirement Testing – When a current requirement test is conducted on galvanically protected tanks (refer to STI R972 for a description of this test), the affected structure can exhibit an elevated (more negative) structure-to-soil potential during the test and for a period of time after the test is completed. This is due to a temporary polarization of the tested structure which will dissipate over a period of time ranging from a few minutes to perhaps a few days depending on several different factors. Therefore, time sufficient for the temporary polarization of the affected structure to “drain-off” after a current requirement test is conducted must be allowed before an accurate structure-to-soil potential can be obtained. In addition, any potential measured with the battery connected should be disregarded as this measurement contains a large voltage drop. Only instant off voltages are meaningful when the battery is connected.

Drought Conditions – On occasion, it has been observed that structure-to-soil potentials can be improved by running water into the backfill material of the tank bed when extended periods of no rain have occurred. This practice serves to lower the resistance of the backfill material temporarily. However, this is not an acceptable practice for testing a CP system. A corrosion expert should evaluate the system and determine the repairs/modifications needed to obtain passing structure-to-soil potentials. Even in drought conditions a CP test must be passed. If a CP test fails, and it is believed to be from dry (high resistive) soil, the CP tester or corrosion expert may elect to re-survey the system at a later date (within 30 days of the fail) to see if site conditions improve. This may be done only if the continuity data suggests that all protected structures are isolated for galvanic systems and continuous for impressed current systems.

Electrical Shorts – When a substandard reading is observed on a galvanically protected system, it is common to find that some other metallic object is electrically connected to the protected structure. For instance, on sti-P_3® tanks, the nylon bushings installed in the tank bungs were sometimes removed when the various risers and other tank system components were installed or an electrical conduit was buried in contact with the tank shell.

Electromagnetic Interference – Overhead high voltage power lines, railroad crossing signals, airport radar systems and radio frequency transmitters (CB radios, cellular phones, etc.) can all cause an interference that will result in an inaccurate voltage reading.

Galvanized Metals – Buried metals that have a high electrochemical potential can also influence the voltage observed if the reference electrode is placed in close proximity to such metals. For instance, the steel of some of the manways that are installed to provide access to the tank appurtenances may be galvanized. If the reference electrode is placed in the soil of such a manway, an artificially high (more negative) potential may be observed. This is actually a raised earth effect although the galvanized metal is not acting to cathodically protect the buried structure of concern.

Parallel Circuits – Care should be taken to ensure that the person conducting the structure-to-soil testing does not allow their person to come into contact with the electrical components of the testing equipment. If the person touches the electrical connections, an error may be introduced due to the creation of a parallel circuit.

Pea Gravel – Because pea gravel or crushed stone typically has a very high electrical resistivity, it is necessary to ensure that it is saturated with water when attempting to measure structure-to-soil potentials with the reference electrode placed in the pea gravel. Use a voltmeter with an input impedance greater than 10M ohm for accurate data collection. Evaluate any effect high contact resistance may have by changing the input resistance of the voltmeter as described in Section 6.1.1. As an alternative way to evaluate the effect contact resistance may have, place the reference electrode remotely. If the remote reading is substantially more negative than the local, high resistance is indicated. Placement of a saturated sponge on the surface of the pea gravel may help overcome high contact resistance.

Photovoltaic Effect – It is known that sunlight striking the viewing window of a reference electrode can have an effect (as much as 50 mV) on the voltages observed when conducting testing. You should ensure that the viewing window of the reference electrode is kept out of direct sunlight. As an alternative, the viewing window can be covered with black electrical tape in order to prevent any sunlight from reaching the copper-copper sulfate solution.

Poor Connection – If the observed structure-to-soil potentials are unsteady and the voltmeter will not stabilize, you should suspect a bad connection somewhere. Ensure that all electrical connections are clean and tight and good contact is made between the test lead and the structure.

Shielding – Sometimes, a buried metallic structure that is between the reference electrode and the structure you are attempting to test will cause the reference electrode to be unable to "see" the structure you are testing. Shielding is commonly cited when low potentials are observed with the reference electrode placed locally over sti-P_3® tanks due to the various tank risers, pump heads, piping, electrical conduits and metallic manways that are typically located over the tank.

Temperature – The temperature of the reference electrode affects the voltages that are observed when conducting CP testing. You may need to make a correction to the observed potential in some extreme and/or marginal cases. The "standard" temperature is considered to be 77^{o} F. For every degree less than 77 add 0.5 mV to the observed voltage. For every degree above 77 subtract 0.5 mV from the observed voltage. To illustrate this, consider the following (in order to simplify the calculation, the negative sign is dropped from the structure-to-soil potential): A voltage of 845 mV is observed when the temperature is 57^{o} F. In this case the corrected voltage would then be 855 mV (20 ^{o} X 0.5 mV = 10 mV. Therefore: 845 mV + 10 mV = 855 mV).

6.7 Continuity Testing

When conducting an evaluation of a CP system, it is normally necessary to establish that the cathodically protected components of a UST system are either electrically isolated or electrically continuous depending on the type of CP system. Ohmmeters (continuity testers) such as those utilized to test automotive wiring circuits are not acceptable for use on buried metallic structures and should never be used for testing continuity of UST system components. The "fixed cell - moving ground" method and the "point-to-point" method are the two commonly utilized ways to test continuity and are discussed in more detail below.

Fixed Cell – Moving Ground Method – The most commonly accepted method of conducting a continuity survey is referred to as fixed cell – moving ground. In this method, the reference electrode is placed at a location remote from any of the cathodically protected structures. Potentials of all the metallic structures present at the site are then measured without moving the reference electrode (refer to Appendix E for a more complete description). Because the conditions found at the reference electrode/electrolyte interface can change over a short period of time (causing the observed potential to change), it is important to conduct this type of testing as quickly as possible.

When determining whether electrical continuity or isolation is provided, the following guidelines are generally accepted for fixed cell – moving ground surveys:

- If two or more structures exhibit potentials that vary by 1 mV or less, the structures are considered to be electrically continuous.
- If two or more structures exhibit potentials that vary by 10 mV or greater, the structures are considered to be electrically isolated.
- If two or more structures exhibit potentials that vary by more than 1 mV but less than 10 mV, the result is inconclusive and further testing (point-to-point) is necessary.

Point-to-Point Method – An easier and usually more accurate way to test continuity is the point-to-point method. This method is referred to as the point-to-point method, structure-to-structure method, or the potential difference technique. With this method, a reference electrode is not utilized. The two structures that are to be tested are simply touched with each lead of the voltmeter and the voltage difference (if any) is observed. For example, when trying to establish that electrical isolation exists between a tank and the fill riser associated with that tank, simply touch the fill riser with one of the voltmeter leads and the tank shell with the other voltmeter lead and observe the voltage difference.

When conducting point-to-point testing, any current that is flowing through the UST components can cause an inaccurate test result. Impressed current systems must be off when performing point-to-point testing. When conducting point to point testing on UST systems protected by an impressed current system, it is acceptable to make one connection point to the rectifier negative lead wire and the other to the structure being tested.

When determining whether electrical continuity or isolation is provided, the following guidelines are generally accepted for point-to-point surveys:

- If the voltage difference observed between the two structures is 1 mV or less, the two structures are considered to be electrically continuous with each other.
- If the voltage difference observed between the two structures is 10 mV or greater, the two structures are considered to be electrically isolated from each other.
- If the voltage difference observed between the two structures is greater than 1 mV but less than 10 mV, the result is inconclusive and further testing beyond the scope of this document is necessary.

6.7.1 Continuity Testing of Galvanic Systems

In order for sacrificial anodes to function efficiently, the protected component must be electrically isolated from any other metallic structures that may be connected to or in contact with the protected structure. This is generally accomplished through the use of dielectric bushings and unions and by making sure that no additional metallic structures come into contact with the protected structure.

On those systems where adequate CP has not been achieved, it is common to find that some unintended metallic structure is electrically continuous with the protected structure. Frequently, an electrical conduit is in contact with a sti-P_3® tank or the tank bung nylon bushings are missing or damaged. If metallic tank anchor straps were improperly installed, they will wear through the coating (e.g., epoxy/aliphatic urethane) on the tank over time and cause premature anode failure. With metallic piping, the shear valve anchoring bracket usually provides an electrical bond with the dispenser cabinet and all of the other metal connected to it. When this is the case, the anodes are trying to protect much more metal than intended and the life of the anodes is shortened.

6.7.2 Continuity Testing of Impressed Current Systems

Continuity testing of impressed current systems is always required to be conducted. In an impressed current system all components of the UST system must be electrically continuous for them to be protected. Various bonds may be required in order to ensure that continuity has been provided. Failure to establish continuity in an impressed current system can result in accelerated corrosion of the electrically isolated components.

Carefully check all bonds when evaluating an impressed current system as these are of critical importance. Commonly, tanks are bonded into the negative circuit by attachment to the tank vent lines above ground. Because of this, it is easy for the integrity of the bonds to be compromised. It is equally important to ensure that the positive lead wire(s) have continuity. Any break in the insulation or dielectric coating of the positive circuit will allow current to discharge from the break and cause rapid corrosion failure of the wire. This is why it is absolutely critical that all buried positive circuit splices are properly coated and insulated.

6.8 Reference Electrode Placement

6.8.1 General

Where the reference electrode is placed when taking structure-to-soil potential measurements is of critical importance. It is also essential that the exact location of the reference electrode placement be documented so that anyone could come back at a later date and reasonably duplicate the test. Reference electrode placement must be indicated by both written description and visually shown on a drawing of the tank system.

6.8.2 Local Placement

Placement of the reference electrode is considered local when it is contacting the soil directly over the structure that is being tested. As discussed in Section 6.3, consideration of any effect active anodes have (raised earth) must be considered when selecting the appropriate location for local placement.

In addition, shielding of the reference electrode by other buried metallic components may also need to be considered. For instance, it is necessary to ensure that the tip of the reference electrode is below the metallic skirting found on most manways. If the tip of the reference electrode is not below the metal skirt, it may be shielded from “seeing” the CP current.

Ideally, the tip of the reference electrode should be as close to the structure-to-soil interface as is practical in order to minimize the voltage drop present in the soil. In practice, about 6 inches of soil between the tip of the reference electrode and the structure being tested works well.

Note: Concrete has been shown to shift measured potentials through concrete by as much as 300 mV in either direction, thus valid readings cannot be taken over concrete or asphalt.

6.8.3 Remote Placement

The remote potential represents the average potential of the entire surface of the protected structure. The purpose of remote placement is to eliminate any effect that raised earth may be contributing to the measurement of the structure-to-soil potential and to overcome any effects shielding may have.

Placement of the reference electrode is considered remote when it is placed in the soil a certain distance away from the structure that is being tested. There are several different factors that determine the distance necessary in order to reach remote earth and a full discussion is beyond the scope of this document. However, a remote condition can normally be achieved when the reference electrode is placed between 25 and 100 feet away from any protected structure.

Depending on the conditions specific to the particular location where the cathodically protected structure is, the minimum distance to remote earth may be considerably more than 25 feet. Therefore, it is important that you establish that the reference electrode is truly remote when obtaining a structure-to-soil potential. In order to ensure that remote earth has been achieved, place the reference electrode at least 25 feet away from the protected structure and observe the potential. Move the reference electrode out away from the protected structure another 10 feet or so and observe the potential. If there is no significant difference in the two potentials, it can be assumed that remote earth has been achieved. If there is a significant difference, continue moving the reference electrode out away from the protected structure until no significant difference is observed.

When selecting a location to place the reference electrode to establish remote earth, it is essential that there are no other cathodically protected structures (e.g., natural gas lines) in proximity to the reference electrode. Foreign cathodically protected structures can cause an abnormally high (more negative) potential that is not indicative of the remote potential of the structure being measured. It is also important that there are no other buried metallic structures in the vicinity of the reference electrode. Any metallic structure buried near the reference electrode could possibly affect the structure-to-soil potential.

In addition to the above considerations, attempt to select the remote placement such that the reference electrode can “see” the structure being tested. This means that there should not be any buried metallic structure between the remote reference electrode placement and the protected structure. If you suspect that shielding may be affecting the observed potential, place the reference electrode away from the protected structure in a different direction.

6.8.4 Galvanic Placement and Number of Test Points

All galvanic CP systems shall be tested with at least three placements of the reference electrode with one of those placements taken locally and two taken remotely. This approach is only valid for electrically isolated USTs which are protected with galvanic anodes directly attached to the UST (e.g., sti-P3® tanks).

Typically, galvanic systems are tested using the 850 on criterion. In order to pass the structure-to-soil survey, both the local and the remote potentials must be more negative than -850 mV. If the anodes can be disconnected, either the 850 off or the 100 mV polarization decay criteria can be used to test a galvanic system. If neither the local nor the remote potential satisfies one of the CP criteria, the structure fails the test. If one of the potentials indicates adequate CP but the other does not, the result of the test is inconclusive. If the test result is inconclusive, repairs must be made or a corrosion expert must evaluate the data and/or conduct further testing to declare either pass or fail.

Although it may be common practice for some testers/experts to take three local readings over the tank/piping and no remote reading, this does not meet this guidance requirement. The remote potential may provide additional information by which to evaluate the CP system. However, the structure may not be passed based on the remote potential itself. In all circumstances, the potential obtained with the reference electrode placed locally must indicate that adequate CP has been provided. (Remember that petroleum contaminated soils can alter reference cell readings so space-out the test locations in clean soils over the tank to avoid problems.)

6.8.5 Impressed Current Placement and Number of Test Points

Impressed current systems shall be tested with the reference electrode placed locally at a minimum of three locations. In order to pass the survey, all potentials obtained with the reference electrode placed locally must satisfy either the 850 off or the 100 mV polarization decay criteria. The tester should obtain structure to soil potentials from as many soil access points along the structure as is practical. If any of the potentials indicate that adequate CP has not been provided, the structure should be failed.

Although not required by this guidance, it may be useful to place the reference electrode remotely when testing an impressed current system. The remote potential may provide additional information by which to evaluate the CP system. However, the structure may not be passed based on the remote potential itself. In all circumstances, the potential obtained with the reference electrode placed locally must indicate that adequate CP has been provided.

Additionally, special circumstances may require that a remote potential be obtained when testing impressed current systems. For instance, if there are active sacrificial anodes buried in close proximity to the structure being tested, the local potential may be influenced by raised earth. The voltage drop caused by the sacrificial anodes would preclude the accurate measurement of the local structure-to-soil potential. If it is known that sacrificial anodes are impacting the potentials obtained locally, remote potentials must be obtained.

The remote potential obtained under these special circumstances must meet either the 850 off or the 100 mV polarization criteria in order for the tested structure to pass the survey. An explanation must be given in the "Remarks" of Section XII of the *Impressed Current Cathodic Protection System Evaluation* form (UST-CP-02) as to why the remote potential must be considered. The remote potentials must be indicated on the form by either designating remote (R1, R2, or a description) in the location column of Section XII.

6.9 Soil Access

All structure-to-soil potentials that are intended to satisfy one of the three acceptable criteria found in Section 6.2 must be obtained with the reference electrode placed in contact with the soil. The person conducting the evaluation must either confirm that soil access is available or make prior arrangements with the owner of the UST system to secure access.

Under no circumstances is it allowable to place the reference electrode on concrete, asphalt, or any other paving material to achieve satisfactory structure-to-soil potentials. Likewise, the practice of placing the reference electrode on a crack or expansion joint of concrete or asphalt paving is not recognized as an acceptable method of obtaining satisfactory structure-to-soil potentials. Placement of the reference electrode in an observation (monitoring) well or release detection device to obtain a passing reading is also not allowed. While it may be useful to obtain data by placing the reference electrode on a crack in the pavement or in an observation well, the structure-to-soil potentials obtained by such placement are not in themselves acceptable to demonstrate adequate CP (NACE Standard RP0285, "Standard Recommended Practice – Corrosion Control of Underground Storage Tank Systems by Cathodic Protection").

Access may be provided by drilling holes through the pavement or the installation of proper CP test stations. A practical way to provide soil access is to drill a ½ inch diameter hole in the pavement so that a "pencil" type reference electrode (3/8-inch diameter) can be inserted through the pavement and into the soil. Upon completion of the survey, the hole should be filled with a fuel resistant caulking material so that easy access can be provided at a later date. As an alternative, a two-inch hole could be drilled to allow use of a standard reference electrode. A short length of PVC pipe could be epoxied in the hole and plugged with a threaded cap.

Various CP test stations/manways are available for installation. Whenever, the pavement is reworked around an existing system, provisions for access to the soil must be made so that adequate CP testing may be accomplished.

6.10 Cathodic Protection Test Locations

Because there are many different possible tank and CP system configurations that may occur, it is not feasible to attempt to illustrate every situation that may exist. The examples given in the following sections are offered as representative of some typical scenarios to illustrate the general principles. It may sometimes be necessary to utilize judgement to apply the intent of this guidance document when circumstances arise that are not specifically addressed in this guidance document.

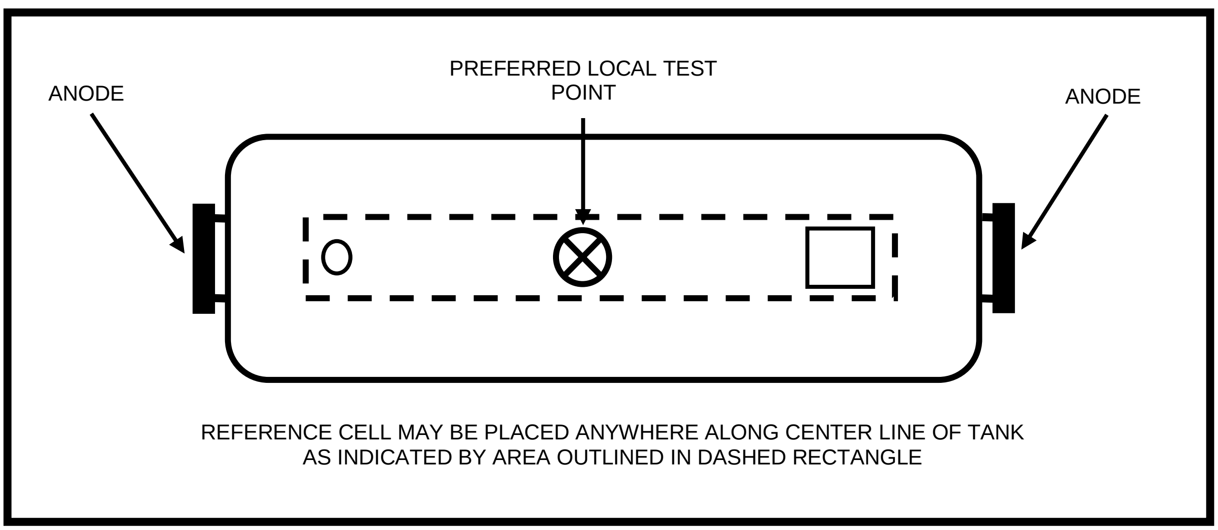
- All galvanic CP systems shall be tested with at least three placements of the reference electrode with one of those placements taken locally and two taken remotely.
- Impressed current systems shall be tested with the reference electrode placed locally over the structure in a minimum of three locations.

6.10.1 Galvanically Protected (sti-P3®) Tanks

All sti-P_3® tank CP systems shall be tested with at least three placements of the reference electrode with one of those placements taken locally and two taken remotely. Examples of appropriate locations to place the reference electrode locally would be in the soil near the one-third, mid-point, and/or two-thirds of the tank (Figure 3). However, if access to the soil is not available at the middle of the tank, the reference electrode may be placed at any point along the centerline of the tank but not directly over the anodes at each end of the tank.

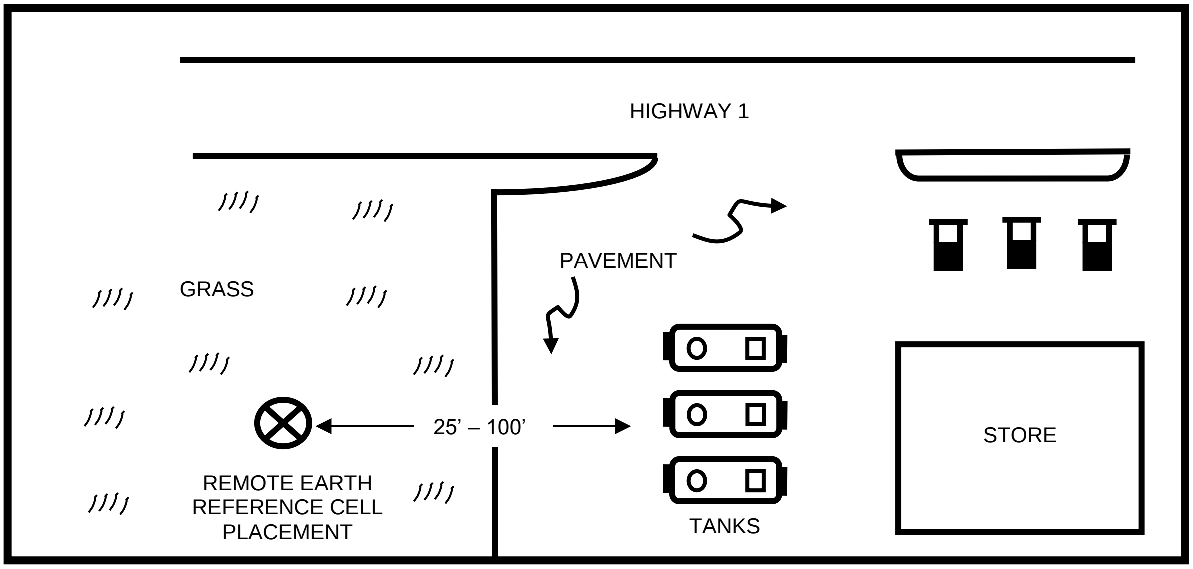
Caution should be exercised to ensure that there are no sacrificial anodes installed in the soil around the submersible pump manway to protect any steel piping that may be associated with the tank. If anodes are installed at the pump manway, the reference electrode must be placed in the soil near the opposite end of the tank. In addition to the local potential(s) described above, remote potential(s) must also be obtained. Remote generally means the reference electrode is placed in the soil at least 25 feet away and not more than 100 feet away from the tank you are measuring (Figure 4). Refer to Section 6.8.3 for a more complete discussion of remote reference electrode placement.

Figure 3 – Reference Electrode Placement for sti-P_3® Tanks



Care must be taken that the remote location is not in proximity to any other cathodically protected structure (e.g., natural gas lines) or directly over any other kind of buried metallic structure. The remote placement should be such that the reference electrode is aligned with the longitudinal axis of the tanks and can “see” the anodes. This orientation is desirable in order to prevent shielding.

Figure 4 – "Remote Earth" Reference Electrode Placement



6.10.2 Galvanically Protected Metallic Piping

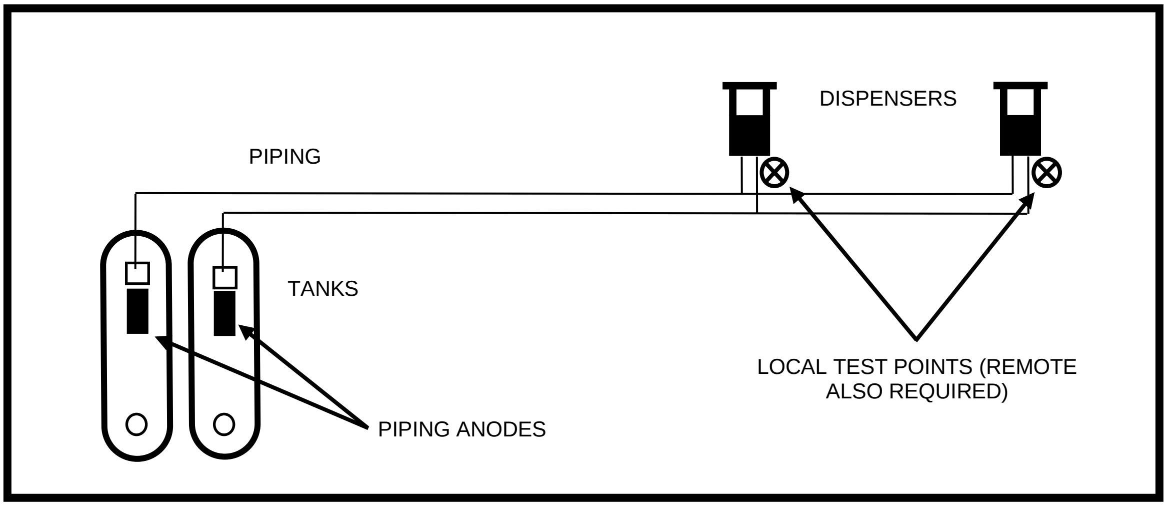
Both local and remote potentials are required on all galvanically protected metallic piping. When metallic piping is protected by sacrificial anodes, several different possibilities exist as to where to appropriately place the reference electrode to obtain local potentials. Knowing where the anodes that are protecting the piping are installed is of critical importance. When obtaining local potentials, the reference electrode must be placed in the soil directly over the pipe to be evaluated at each location.

When anodes are protecting piping components (flexible connectors, nipples, elbows, tees, couplings, unions, ball valves, submersible turbine pump heads), the reference electrode must be placed in the soil directly over the component to be evaluated at each location for the local potential measurements. Remote placement of the reference electrode is also necessary.

When anodes are protecting piping components (flexible connectors, nipples, elbows, tees, couplings, unions, ball valves, submersible turbine pump heads) that are located inside of containment sumps, the reference electrode must be placed inside of the containment sump. Remote placement of the reference electrode is not required in these instances.

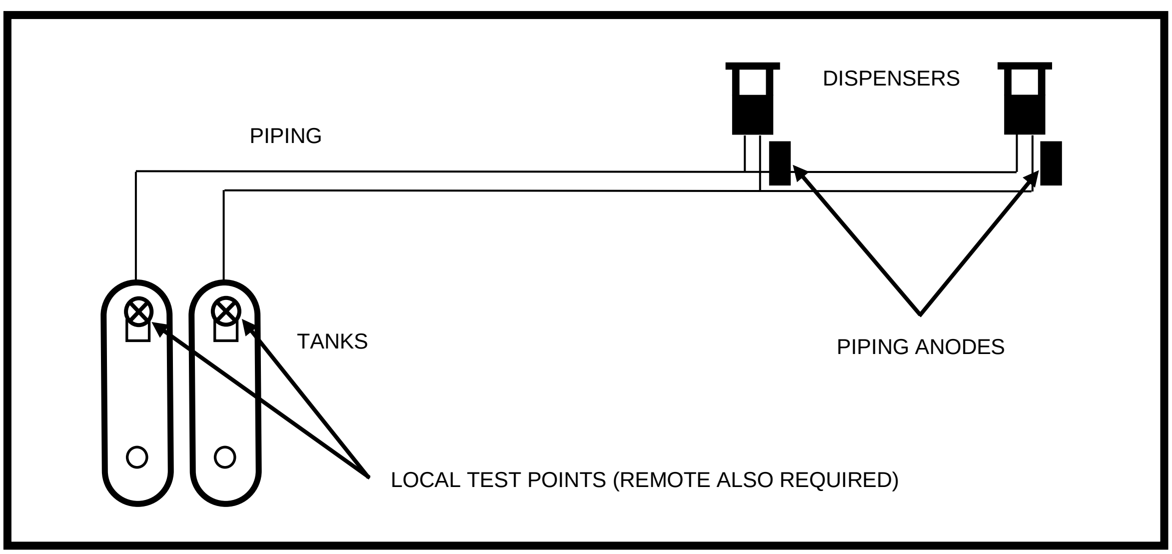
Because it is a common practice to bury piping anodes at the submersible pump manway of a tank, the appropriate location to place the reference electrode to obtain local potentials is at the dispensers (Figure 5). Remote placement of the reference electrode is also necessary.

Figure 5 – Local Reference Electrode Placement for Galvanically Protected Piping When Piping Anodes are at Tanks



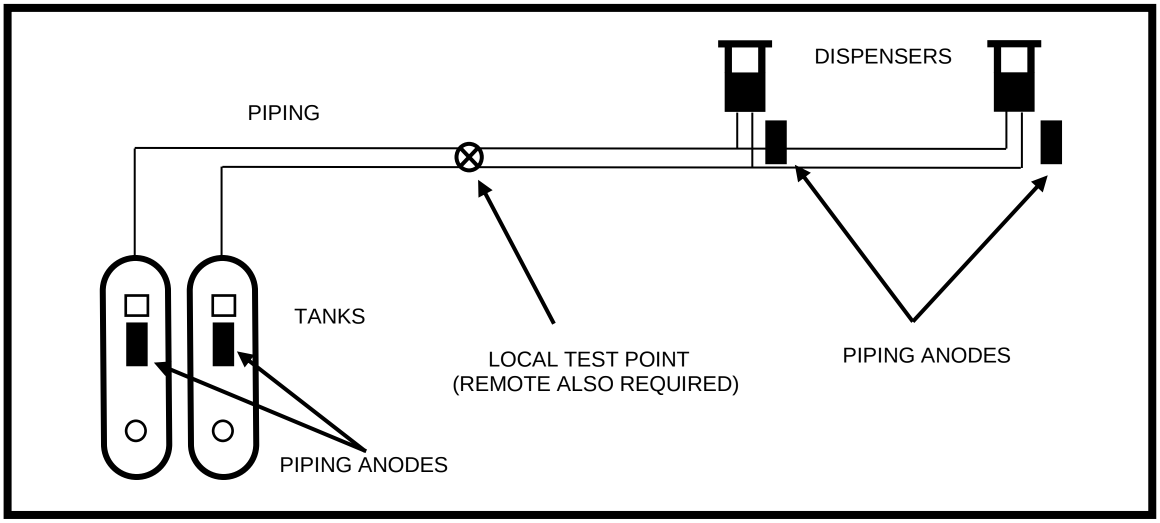
When the piping anodes are installed at the dispensers, the appropriate local reference electrode placement would be at the piping nearest the tanks (usually the submersible turbine pump manway) as shown in Figure 6. Remote placement of the reference electrode is also necessary.

Figure 6 – Local Reference Electrode Placement for Galvanically Protected Piping When Anodes are at Dispensers



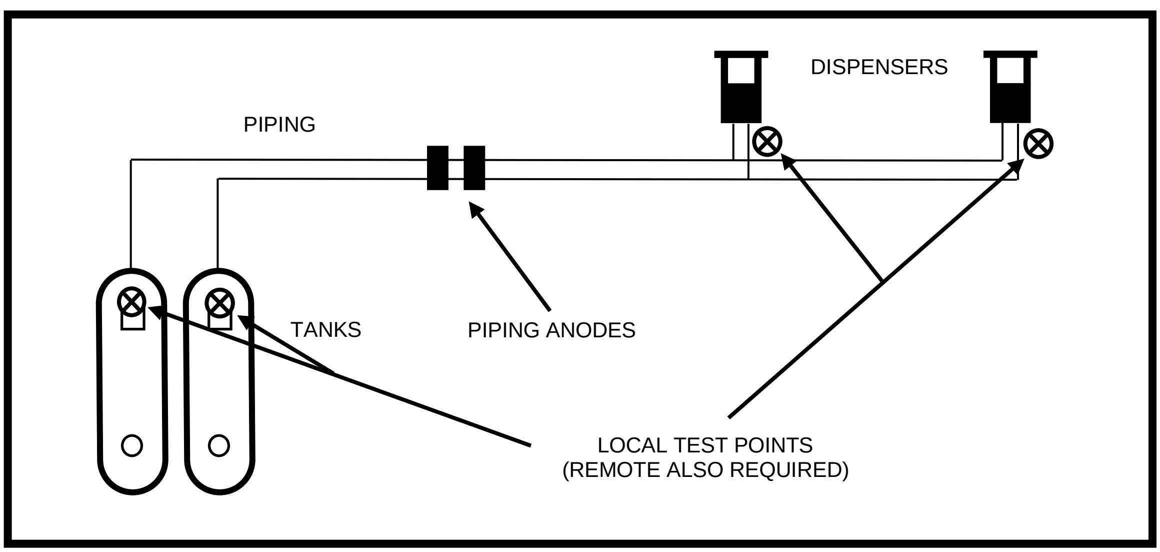
When the piping anodes are located at both the tanks and the dispensers, the reference electrode must be placed at the approximate center of the piping run to obtain local potentials (Figure 7). Remote placement of the reference electrode is also necessary.

Figure 7 – Local Reference Electrode Placement for Galvanically Protected Piping When Piping Anodes are at Both Ends of the Piping



When the anodes are installed at the center of the piping, or it is not known where the anodes are installed, the reference electrode must be placed at both the tank end of the piping and at each dispenser to obtain local potentials (Figure 8). Remote placement of the reference electrode is also necessary.

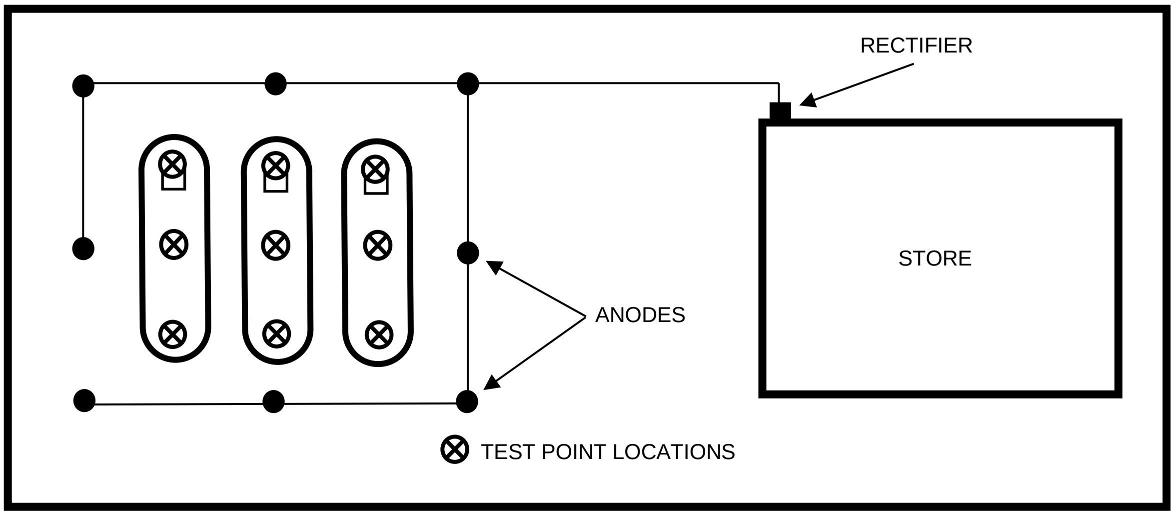
Figure 8 – Local Reference Electrode Placement for Galvanically Protected Piping When Anodes are Installed at Center of Piping or Location is Unknown



6.10.3 Tanks Protected by Impressed Current

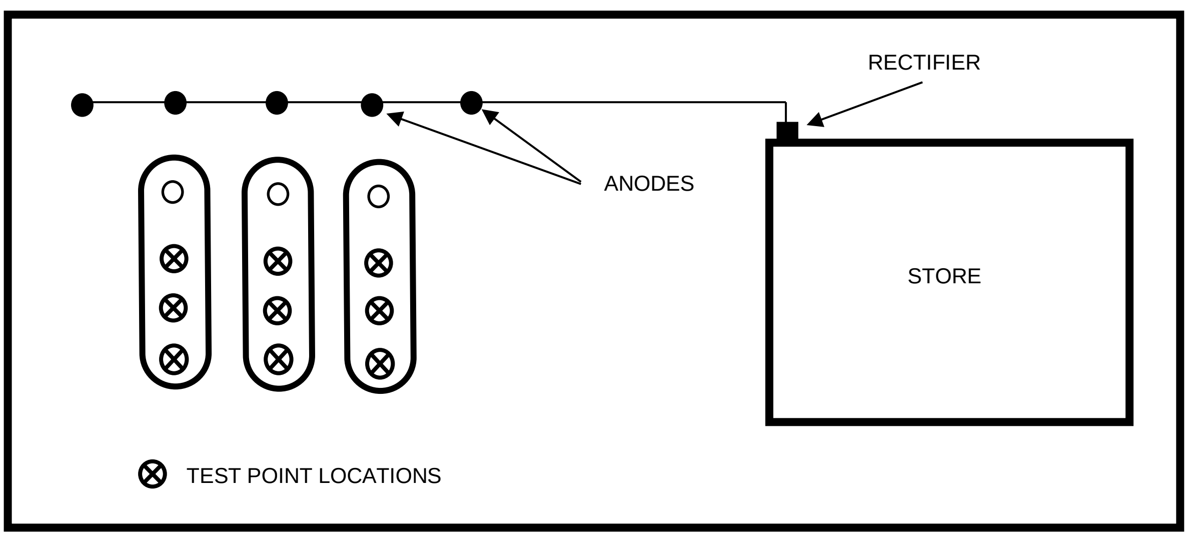
With impressed current systems, tank potentials (CP test readings) are required to be measured with the reference electrode placed locally in a minimum of three locations per tank. Where the location of the anodes is known and they are relatively evenly distributed about the tank bed, the appropriate location to place the reference electrode would be in the soil along the centerline of the tank (Figure 9). However, if access to the soil is not available at the middle of the tank, the reference electrode may be placed in the soil at any point along the centerline of the tank similar to that described in Section 6.10.1.

Figure 9 – Reference Electrode Placement for Tanks Protected by Impressed Current System When Anodes are Evenly Distributed



As with the evaluation of any CP system, the location of the anodes in relation to reference electrode placement can be of critical importance. When selecting the appropriate local placement, it is necessary to place the reference electrode at the point over the structure that is the most distant from any active anode due to the effects of attenuation. Attenuation of the CP current may occur whereby effective protection is not achieved at some point along a UST system. For instance, if all of the active anodes are along one side of a tank bed, current distribution and attenuation may prevent sufficient protective current from reaching the side of the tanks away from the anodes. The preferred placement of the reference electrode would be along the centerline of the tanks at the end opposite to that where the anodes are installed (Figure 10).

Figure 10 – Reference Electrode Placement for Tanks Protected by Impressed Current System When Anodes are Unevenly Distributed



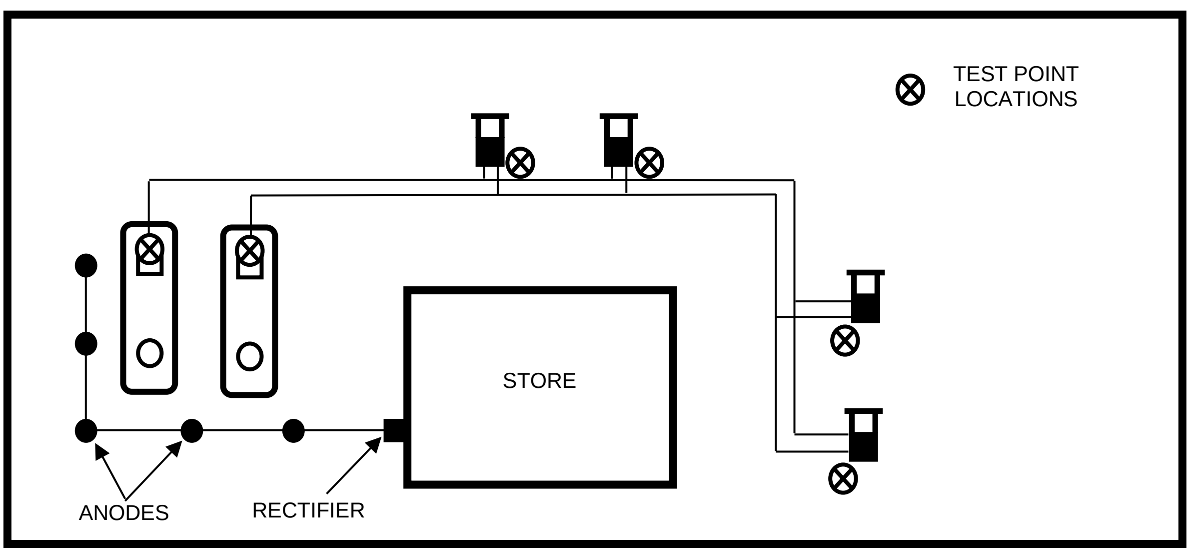
If the anode locations are unknown, at least three measurements are required along the centerline of the tank. Testing should be conducted at as many locations along the centerline of the tank as are available. Ensure that soil access is available at each end of the tank and in the middle, and record all three structure-to-soil potentials. If any one of the measured potentials does not meet one of the acceptable criteria, the structure should be failed.

In addition, if it is possible to measure the individual circuits in an impressed current system, a determination can be made as to which anodes are functional and how the current is distributed throughout the ground bed. How the current is distributed should be considered when choosing reference electrode placement when conducting a structure-to-soil potential survey. If for instance it is known that the majority of the rectifier output current is directed to only those anodes along one end of a tank bed, the reference electrode should be placed at the opposite end of the tank bed.

6.10.4 Piping Protected by Impressed Current

Due to the high degree of variability that exists in anode placement and piping configurations, structure-to-soil potentials must be obtained by placing the reference electrode at both the tank end of any piping and at each dispenser that is protected by impressed current (Figure 11). With impressed current CP systems, the local pipe potentials (CP test readings) shall be measured with the reference electrode placed locally and the impressed current system interrupted. Just as with any other type of CP system, knowing where the anodes that are protecting the piping are installed is of critical importance.

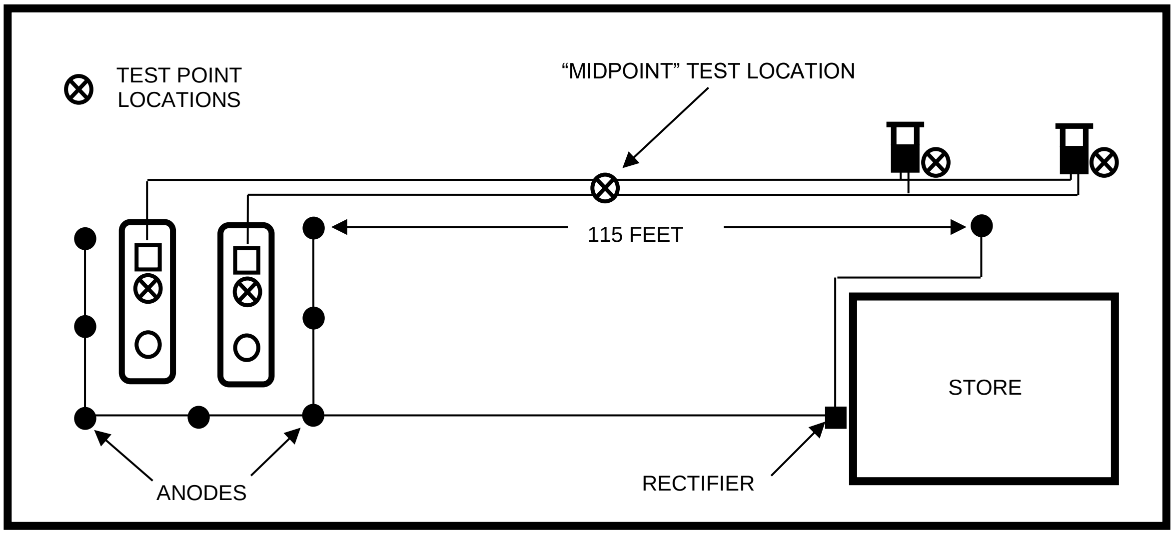
Figure 11 – Reference Electrode Placement for Metallic Piping Protected by Impressed Current System



6.10.5 "100 Foot Rule" for Piping

For both galvanic and impressed current systems, if more than 100 feet of piping exists between any two anodes, the reference electrode must also be placed at the midpoint between the two anodes that are separated by more than 100 feet (Figure 12). In addition, if it is not known where the piping anodes are located, there can be no more than 100 feet of piping between any two test points. This midpoint placement is in addition to any other reference electrode placement that may be required as noted above in Sections 6.10.1 through 6.10.4.

Figure 12 – "100 Foot Rule" for Metallic Piping Protected by Galvanic or Impressed Current System



SECTION 7 – DOCUMENTATION OF EVALUATION

7.1 Documentation

As with any kind of testing or work that is being performed at a UST facility, it is critical that proper documentation is made of all activities and test procedures. Without proper documentation, the evaluation of a CP system through the application of a structure-to-soil potential survey is of little value.

Although it has been previously stated, the exact location where the reference electrode was placed in order to obtain a passing structure-to-soil potential is of critical importance and cannot be overemphasized. For this reason, an exact description of where the reference electrode was placed for each structure-to-soil potential obtained during the survey is an absolute necessity. Failure to properly document reference electrode placement will result in the survey being deemed invalid.

Additionally, in order to effectively evaluate the survey of a CP system it is essential to be able to clearly understand how the survey was conducted. Likewise, when a re-survey of an existing system is being conducted it is important that the tester understands how the previous survey was conducted. Various methods of documentation may be necessary in order to clearly convey the procedures and survey results. In the sections that follow, some of the more critical aspects of documentation are discussed in more detail.

7.1.1 As Built Drawings

If any modification to the construction of the CP system is made (e.g., supplemental anodes) it is necessary to show the modification on a copy of the “as built” drawings. If no “as built” drawing is available, you must indicate the location of any anode addition on the site drawing that is constructed as part of the evaluation. Beginning with effective date of this document, dated “as built” drawings are required whenever a CP system is installed or substantially modified. The drawings should include: a) how many anodes were installed (number and size, e.g., 5 – 17 lb.); b) what type of anodes were installed (e.g., magnesium, zinc, etc.); c) where were the anodes installed; d) how deep were the anodes installed; e) what type of wire was used; f) how were the wires bonded, etc.

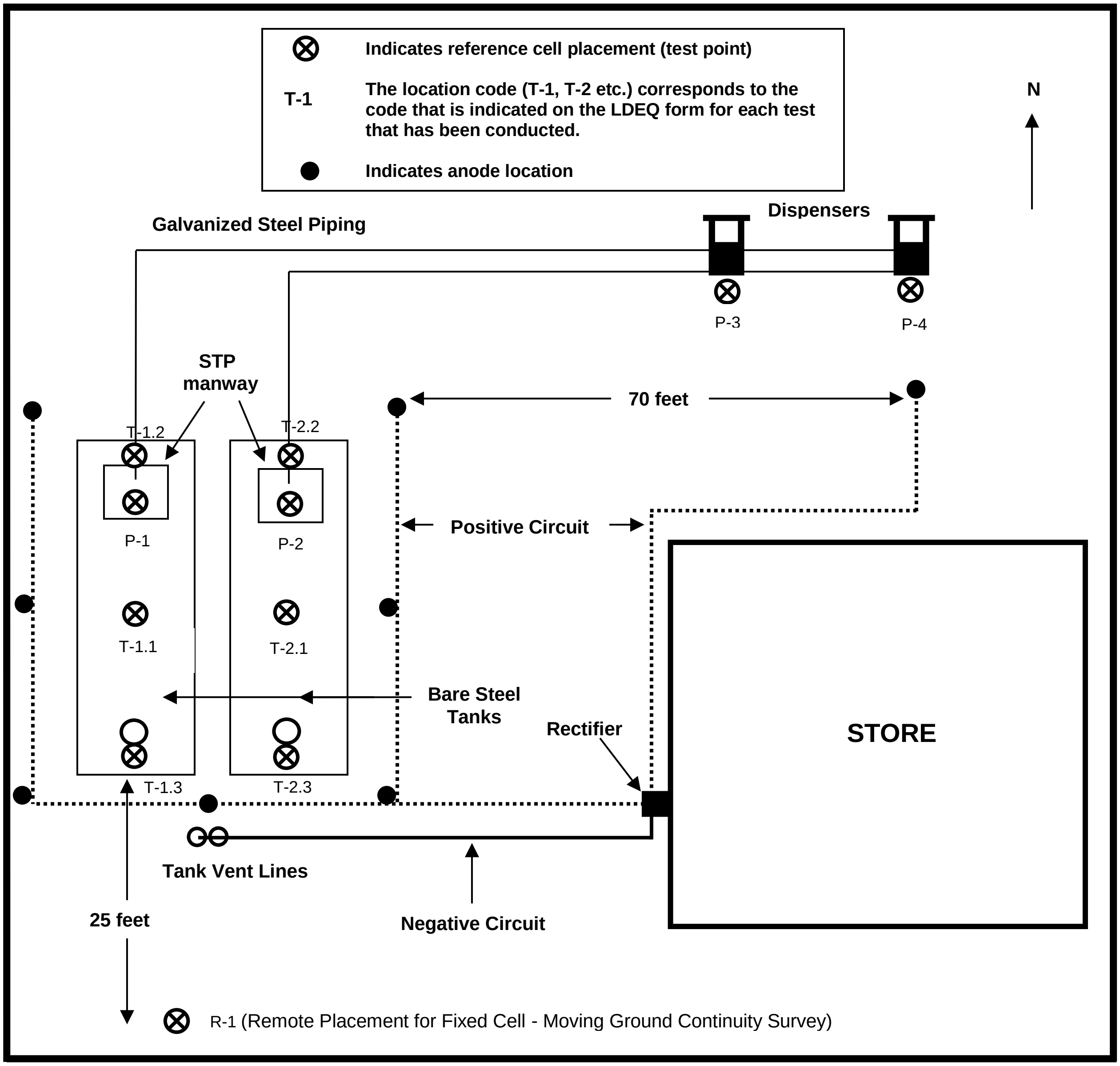
7.1.2 Site Drawing

Whenever a CP survey is conducted, a site drawing depicting the UST system, the CP system and any related features of the facility must be constructed. The CP contractor must indicate on the drawing where the reference electrode was placed for each of the structure-to-soil potentials utilized to obtain a passing evaluation. Figure 13 is an example of a site drawing that shows the type of information that is necessary to properly complete the evaluation.

While it is understood that the CP contractor will not always know where all of the pertinent components of the CP system may be buried, all that is known must be indicated. It is very important to show where the anodes are located on the site drawing. If it is not known where the anodes are buried, voltage gradients in the soil may help you determine the approximate location as described in the raised earth discussion of Section 6.3.

Should any modifications to the CP system be made, it is very important that such modifications be both visually indicated on the site drawing and a written narrative made that describes the work conducted. If “as built” drawings are available, it is acceptable to utilize these drawings for the purposes of meeting the requirements of this section. Any modifications or changes to the UST and/or CP systems that have been made since the construction of the “as built” drawings must be included.

Figure 13 – Example of a Site Diagram Constructed as Part of a UST System Cathodic Protection Survey



7.1.3 LDEQ UST Cathodic Protection Evaluation Forms

Whenever a CP survey is conducted in the State of Louisiana, the appropriate form(s) prescribed by LDEQ should be utilized to document the survey. If any forms besides the LDEQ forms are used, they must contain all of the information listed on the LDEQ forms. For galvanic systems, use form UST-CP-01, *Galvanic Cathodic Protection System Evaluation*. For impressed current systems use form UST-CP-02, *Impressed Current Cathodic Protection System Evaluation*. Examples of the forms are located in Appendices K and L. Please download the most recent versions of the forms from our web site at http://www.deq.louisiana.gov/ust. Use of the prescribed form(s) is not intended to limit other kinds of documentation that may be desirable in order to complete the evaluation. For instance, it may be necessary to provide photographs, or a written narrative describing various aspects of the evaluation or a repair/modification that are not captured by completion of the form(s) themselves.

7.1.4 Pass/Fail/Inconclusive

In order to assure uniformity in the manner in which CP evaluations are documented, the technician must determine a test result as prescribed in the LDEQ CP evaluation forms, UST-CP-01 and UST-CP-02. The terms “pass”, “fail” and “inconclusive” are utilized for this purpose. Therefore, it is necessary to clarify what these terms mean and their applicability as related to the evaluation of CP systems utilizing the LDEQ forms.

An evaluation conducted by an individual who is only qualified as a CP tester must result in one of three conclusions, pass, fail, or inconclusive. If the person conducting the evaluation is qualified as a corrosion expert, the evaluation must result in either pass or fail.

Galvanic Systems

Pass – The term “pass” in Section IV of the UST-CP-01 form means that the structure-to-soil potential survey indicates that all of the protected structures at a facility meet the 850 On criteria for both the local and remote test points, and that all protected structures are isolated from non-protected structures.

850 Instant Off or 100 mV Polarization Criteria – In certain cases, where it is possible to disconnect the anodes from the protected structure, it is possible to determine if a structure with sacrificial anodes is protected from corrosion based upon obtaining an instant off measurement and determining if the 100 mV polarization criteria has been met. This test should only be conducted by those familiar with the procedure.

Fail – The term “fail” in Section IV of the UST-CP-01 form means that the structure-to-soil potential survey indicates that there are one or more of the protected structures at a facility that do not meet the 850 On criteria for both local and remote test points.

Inconclusive – The term “inconclusive” as related to Section IV of the UST-CP-01 form means that a qualified CP tester is unable to conclusively evaluate the CP system to make a “pass” or “fail” determination (see chart below).

<table>
<tr><th colspan="2" rowspan="2">Galvanic Test Results</th><th colspan="2">Local Potentials
Meet 850 On Criteria</th><th colspan="2">Remote Potentials
Meet 850 On Criteria</th><th colspan="2">Continuity Results</th></tr>
<tr><th>Yes</th><th>No</th><th>Yes</th><th>No</th><th>Isolated</th><th>Continuous or Inconclusive</th></tr>
<tr><td rowspan="6">Section IV of UST-CP-01 Form</td><td>Pass</td><td>X</td><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td>Fail</td><td></td><td>X</td><td></td><td>X</td><td colspan="2">X or X</td></tr>
<tr><td rowspan="4">Inconclusive</td><td>X</td><td></td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td>X</td><td></td><td></td><td>X</td><td colspan="2">X or X</td></tr>
<tr><td></td><td>X</td><td>X</td><td></td><td colspan="2">X or X</td></tr>
<tr><td colspan="6">Stray current is suspected to be affecting the structure</td></tr>
</table>

Impressed Current Systems

Pass – The term "pass" in Section IV of the UST-CP-02 form means that the structure-to-soil potential survey indicates that all of the protected structures at a facility meet at least one of the 850 Instant Off or 100 mV Polarization criteria, and that all protected structures are electrically continuous.

Fail – The term "fail" in Section IV of the UST-CP-02 form means that the structure-to-soil potential survey indicates that there are one or more of the protected structures at a facility that do not meet the 850 Off or 100 mV Polarization criteria.

Inconclusive – The term "inconclusive" as related to Section IV of the UST-CP-02 form means that a qualified CP tester is unable to conclusively evaluate the CP system to make a "pass" or "fail" determination (see chart below).

<table>
<tr><th colspan="2" rowspan="2">Impressed Current System Test Results</th><th colspan="2">Instant Off
Meet 850 Off Criteria</th><th colspan="2">Polarization
Meet 100 mV Criteria</th><th colspan="2">Continuity Results</th></tr>
<tr><th>Yes</th><th>No</th><th>Yes</th><th>No</th><th>Isolated or Inconclusive</th><th>Continuous</th></tr>
<tr><td rowspan="6">Section IV of UST-CP-02 Form</td><td rowspan="2">Pass</td><td>X</td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td></td><td>X</td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td>Fail</td><td></td><td>X</td><td></td><td>X</td><td>X or</td><td>X</td></tr>
<tr><td rowspan="3">Inconclusive</td><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td></td><td>X</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="6">Stray current is suspected to be affecting the structure</td></tr>
</table>

7.2 Corrosion Expert's Evaluation

Because LDEQ allows individuals who may only have minimal training in the principles of CP conduct CP testing, there will be instances where the expertise of someone who is more qualified and better understands the principles involved will be necessary.

Some of the more obvious scenarios where a person with a level of expertise equivalent to a corrosion expert (LAC 33:XI.103 and Appendix B) is necessary are given below. If any of the conditions given below are met, a corrosion expert must evaluate the survey results obtained by a tester and/or conduct further testing and complete Section V of the UST-CP-01 or UST-CP-02 form. If the structure-to-soil potential survey is conducted by a person who is qualified as a corrosion expert, completion of Section V is all that is necessary.

A corrosion expert is required to evaluate and/or conduct the survey when:

1. An inconclusive is declared in section IV of either the UST-CP-01 or UST-CP-02 form.
2. It is known or suspected that stray current may be affecting the protected structure.
3. Adjustments to the rectifier current are made that are outside the original design specifications.
4. Supplemental anodes are added or other changes to the construction of an impressed current system are made.

5. To review a CP test when an impressed current system that was off for more than six months on a temporarily closed tank is restarted and passes a CP test.

Although not specifically listed above, it should be recognized that there might be additional circumstances that may arise that will require evaluation, and/or design by a corrosion expert.

7.3 What if the Evaluation Result is Fail?

The tester shall notify the tank owner if an evaluation of the CP system fails. Necessary repairs must be accomplished within 60 days of receipt of the "failed" evaluation. The tank owner/operator is responsible for ensuring that the CP system is maintained in a manner that will provide adequate CP to the UST system.

As it is recognized that many factors may cause a lower than desired voltage to be obtained during a structure-to-soil survey, there may be several different courses of action appropriate to resolve the "fail". For instance, it is not uncommon to simply retest a sti-P_3® tank that has failed a cathodic protection survey at a later date and achieve a passing result (e.g., after a dry period ends and when soil moisture levels are higher).

Therefore, a 30-day retesting period is allowed whenever a fail is obtained during which no action is necessary to repair or modify the CP system. This applies only to those galvanic and impressed current systems that appear to be in good working condition. If there are obvious problems with a system or the testers are unable to achieve a pass within the 30-day window, the tank owner must make any repairs and/or modifications that are necessary to achieve a pass. Repairs and/or modifications must be completed as soon as practical but no more than 60 days are allowed after the first failed CP test.

7.4 Impressed Current System Rectifier Inspections

Impressed current system rectifier inspections must take place at least once every 60 days. Inspection are required to ensure that the equipment is running properly (LAC 33:XI.503.A.3).

Whenever impressed current system rectifier inspections are conducted, the LDEQ *Impressed Current Cathodic Protection System Record of Rectifier Operation* form (UST-CP-03) should be utilized to document the inspections. If any form besides the LDEQ form is used, it must contain all of the information listed on the LDEQ form.

The minimum output (amperage value) that is required for the impressed current system to provide adequate protection must be listed on all impressed current system survey forms (UST-CP-02) for surveys conducted after the effective date of this document. This minimum amperage value must be listed on all impressed current system inspection forms if it available. If the amperage value falls below that value, the UST owner must have the system checked by CP tester or corrosion expert. If there is no minimum amperage specified, the UST owner must have the system checked by CP tester or corrosion expert if the amperage output decreases by more than 20% from the last passing test.

APPENDIX A
Industry Codes/Standards, References and Regulations

INDUSTRY CODES/STANDARDS

American Petroleum Institute (API) RP1632 “Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems”

American Petroleum Institute (API) RP1615 “Installation of Underground Petroleum Storage Systems”.

NACE International SP0169 “Control of External Corrosion on Underground or Submerged Metallic Piping Systems”

NACE International TM0101 “Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Tank Systems”

NACE International SP0285 “External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection”

Petroleum Equipment Institute (PEI) RP 100 “Recommended Practices for Installation of Underground Liquid Storage Systems”

Steel Tank Institute (STI) R892 “Recommended Practice for Corrosion Protection of Underground Piping Networks Associated with Liquid Storage and Dispensing Systems”

Steel Tank Institute (STI) R972 “Recommended Practice for the Addition of Supplemental Anodes for sti-P_3® UST's”

Steel Tank Institute (STI) R051 “Cathodic Protection Testing Procedures for sti-P_3® USTs”

REFERENCES

Department of Defense MIL-HDBK-1136 “Maintenance and Operation of Cathodic Protection Systems”

Department of Defense MIL-HDBK-1136/1 “Cathodic Protection Field Testing”

REGULATIONS

Federal - 40 CFR 280 “Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tank Systems”

State – LAC 33:XI.Underground Storage Tanks

APPENDIX B
Glossary

100 mV POLARIZATION – One of the three criteria that are commonly accepted as indicating adequate cathodic protection (CP) has been achieved. It is typically measured by interrupting the protective current on an impressed current system. When the current is interrupted, an "instant off" potential is recorded and the structure under CP is then allowed to depolarize until a change of at least 100 mV in potential is observed.

850 ON – One of the three criteria that are commonly accepted as indicating adequate CP has been achieved. It is measured with the protective current applied and is typically the only measurement possible with galvanic systems since the anodes cannot be disconnected. This criterion is not applicable to impressed current systems since a large portion of the "on" measurement can be comprised of a voltage drop when the protective current is applied.

850 OFF – One of the three criteria that are commonly accepted as indicating adequate CP has been achieved. It is measured with the protective current interrupted (either the power is cut off to the rectifier or the sacrificial anodes are disconnected). This criterion is considered by most to be the best indicator that adequate CP has been provided.

ANODE – The electrode of an electrochemical cell where oxidation (corrosion) occurs. With respect to CP, it can be thought of as the place where electrons leave the surface of a metal. Common galvanic anodes are zinc and magnesium.

AMPERE (AMP) – The basic unit of current flow in an electric circuit. Amperage can be thought of as "gallons per minute" in a water system.

AS BUILT DRAWINGS – Drawings that show how a system was actually installed in the field. Sometimes, unforeseen factors prevent the installation of a system as it was intended in the design drawings and this is why it is important to have detailed and accurate "as built" drawings.

ATTENUATION – The protective effects of CP current diminish as you move away from the source of the protective current. To illustrate this, on an impressed current system where the ground bed is installed only on one side of the tank bed, the end of the tanks away from the ground bed will receive less protective current than the side of the tanks closest to the anodes. Attenuation of protective current applies to galvanic systems as well.

CATHODE – The electrode of an electrochemical cell where reduction (and no corrosion) occurs. With respect to CP, it can be thought of as the place where current enters the surface of a metal.

CATHODIC PROTECTION – The technique of causing the entire surface of a metallic structure to become a cathode with respect to its external environment (soil). This is accomplished by supplying an electric current sufficient to overcome the tendency of naturally occurring electrical currents to leave the metallic structure.

CATHODIC PROTECTION EVALUATION – The interpretation of whether or not a CP system is providing sufficient corrosion protection. An evaluation incorporates all CP testing, surveys, rectifier operation/output measurements, consideration of voltage drops, condition of dielectric coatings, continuity, bond integrity, circuit integrity and any other factors or site specific conditions that may have an influence on the operation and effectiveness of a CP system.

CATHODIC PROTECTION SURVEY – Refers to the process whereby all of the structure-to-soil measurements necessary to contribute to the final evaluation of a system are obtained.

CATHODIC PROTECTION TEST – Refers to the process whereby only a single structure-to-soil measurement is obtained.

CATHODIC PROTECTION TESTER – A person who can demonstrate an understanding of the principles and measurements of all common types of CP systems as applied to buried or submerged metal piping and tank systems. At a minimum, such a person shall have education and experience in soil resistivity, stray current, structure-to-soil potential, and component electrical isolation measurements of buried metal piping and tank systems.

CONTINUITY – As related to CP, continuity means that two metallic structures are electrically continuous. With impressed current systems all protected structures must be continuous and this is normally accomplished through the use of wires referred to as continuity bonds.

CORROSION – The deterioration of a material (usually a metal) caused by an electro-chemical reaction with its environment. Corrosion of metals involves the flow of electrons (current) between an anode and a cathode. Corrosion will occur where the electrons leave the surface of a metal.

CORROSION EXPERT – A person who, by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics acquired through a professional education and related practical experience, is qualified to engage in the practice of corrosion control on buried or submerged metal piping systems and metal tanks. Such a person shall be accredited or certified as being qualified by the National Association of Corrosion Engineers (NACE) or be a registered professional engineer who has provided evidence to the satisfaction of the administrative authority documenting certification or licensing that includes education and experience in corrosion control of buried or submerged metal piping systems and metal tanks.

CURRENT REQUIREMENT TEST – A method of temporarily creating an impressed current CP system on a galvanically protected structure so that it can be determined how much protective current is necessary in order to achieve adequate CP. This is normally done by connecting a 12-volt battery to the structure to be tested and to a temporary anode.

DIELECTRIC MATERIAL – A coating that does not conduct electricity. Various coatings are utilized and some examples are the “fusion-bonded epoxy” found on factory coated steel piping and coal tar epoxies commonly found on sti-P_3® tanks.

DISTRIBUTED GROUND BED – Used to describe an anode configuration in which the anodes are more or less equally distributed around the metallic structure that is intended to be protected.

ELECTROLYTE – As related to UST CP systems, electrolyte refers to the soil and/or water surrounding the metallic structure that is under CP.

ELECTROMAGNETIC INTERFERENCE – As related to corrosion protection, it is an external electrical current that causes an error in a voltmeter measurement. Sources are commonly associated with high voltage AC power lines, radio frequency transmitters and airport radar systems.

FAIL – See Section 7.1.4.

FIELD INSTALLED – Refers to any impressed current system or sacrificial anode CP system that is installed at a pre-existing UST location or when sacrificial anodes are installed on metallic pipe in the field. Any CP system except for those associated with unmodified sti-P_3® tanks may be thought of as “field installed”.

FINAL POTENTIAL (VOLTAGE) – The voltage that is observed at the end of the depolarization period associated with the measurement of 100 mV polarization. The final voltage must be at least 100 mV less than the “instant off” voltage in order to meet the 100 mV polarization criterion for adequate CP.

FIXED CELL – MOVING GROUND – A technique for measuring continuity in a UST system whereby the reference electrode is placed in the soil at a location remote from the UST system and is left undisturbed (fixed cell) while potentials are measured on various parts of the UST system (moving ground).

GALVANIC (SACRIFICIAL) ANODE – A metal of high electro-potential (Appendix J) that is used to protect another metal. Zinc and magnesium are two metals that are commonly utilized in the protection of UST systems.

GALVANIC CATHODIC PROTECTION – A CP system that utilizes sacrificial anodes to provide the protective current. The anode will corrode (sacrifice itself) instead of the metal it is intended to protect. The anode provides a protective current (reverses the electron flow) because it has a higher electrochemical potential than the metal it is intended to protect. Galvanic systems are normally limited to the protection of well-coated structures because they have a very low driving potential.

IMPRESSED CURRENT ANODE – A metal that is utilized to deliver the current from a rectifier to the soil in order to protect the intended metallic structure. Impressed current anodes are commonly made of graphite, high silicon cast iron and “mixed-metal oxides” because the metal must be highly resistant to corrosion in order to have an acceptably long life span.

IMPRESSED CURRENT CATHODIC PROTECTION – A CP system in which the protective current is supplied by an external source (rectifier). The level of protective current that is delivered to the structure is adjustable and is much higher than that associated with galvanic anodes. For this reason, impressed current systems are utilized on those UST systems that are uncoated or require a high amount of protective current.

INCONCLUSIVE – See Section 7.1.4.

INSTANT OFF POTENTIAL (VOLTAGE) – The voltage that is observed momentarily after the power to an impressed current system is interrupted. It is used as the base line from which to begin calculating a 100 mV polarization. The second number that appears after the current is interrupted is considered the proper value to represent the instant off potential.

ISOLATION – As related to CP, isolation means that two metallic structures are electrically discontinuous. With galvanic systems a protected structure must be electrically isolated and this is normally accomplished through the use of nylon bushings and dielectric unions.

LOCAL POTENTIAL (VOLTAGE) – The structure-to-soil potential of a metallic structure that is measured with the reference electrode placed in the soil immediately over the protected structure.

NACE INTERNATIONAL – Acronym for National Association of Corrosion Engineers International.

NATIVE POTENTIAL (VOLTAGE) – The structure-to-soil potential of a metallic structure exhibited before any CP is applied.

ON POTENTIAL (VOLTAGE) – The structure-to-soil potential of a metallic structure that is measured with the protective current applied.

PARALLEL CIRCUIT – Can be caused by the person conducting the test making contact with a metallic part of the test leads or reference electrode when conducting structure-to-soil potential measurements. The creation of parallel paths must be avoided since inadvertent errors can be introduced.

PASS – See Section 7.1.4

PASSIVATION – When a metal undergoes passivation, an oxidation layer forms on the surface of the metal due to corrosion and can be defined as the loss of chemical reactivity. The oxidation layer acts as a coating and prevents or slows further corrosion of the metallic object since oxygen is prevented from reaching the underlying metal.

PHOTOVOLTAIC EFFECT – Sunlight striking the electrolyte solution in a copper-copper sulfate reference electrode can cause an error in the observed structure-to-soil potential and must be avoided.

POINT-TO-POINT – A technique for measuring continuity in a UST system whereby each lead of a voltmeter is connected to the two metallic structures of interest (negative lead to one structure and positive to the other). The voltage difference (if any) measured with the voltmeter connected in this manner indicates if continuity is present or not.

POLARIZATION – The change in the structure-to-soil potential of a metallic structure due to the application of a protective current. In this guidance document, polarization is considered to mean cathodic polarization - that is, the potential of the metal is shifted in the negative direction.

POLARIZED POTENTIAL – The structure-to-soil potential of a metallic structure that is observed after the protective current is applied and sufficient time has elapsed for the structure to completely polarize.

RAISED EARTH – Term used to describe the high voltage gradient found in the soil around an active impressed current or sacrificial anode. Placement of the reference electrode in proximity to an active anode will cause an abnormally high (more negative) structure-to-soil potential than would be present if the anode were not in close proximity.

RECTIFIER – A device utilized in impressed current systems that changes AC power to DC power.

REFERENCE ELECTRODE – Also referred to as a reference cell or a half-cell. A device whose electrochemical potential is constant that is used to measure the structure-to-soil potential of buried metallic structures. The potential that is observed on the buried metallic structure is relative to the potential of the reference electrode. The potential of a buried metallic structure would be zero if it were of the exact same composition as the reference electrode if all sources of measurement error were eliminated.

RESISTANCE – A measurement of the tendency of a substance to inhibit the flow of electrical current. Resistance in UST CP systems is generally meant to refer to the electrical properties of the backfill materials (soil).

REMOTE EARTH – The structure-to-soil potential of a metallic structure that is measured with the reference electrode placed in the soil at a point well away (remote) from the protected structure. Remote earth is generally thought of as at least 25 feet and not more than 100 feet away. Remote earth is established when the observed structure-to-soil potential does not significantly change no matter how far away the reference electrode is from the protected structure.

SACRIFICIAL ANODE – See Galvanic Anode.

SHIELDING – A structure that prevents or diverts an electrical current from reaching the desired location. Normally thought of as something that stops a reference electrode from being able to “see” the metallic structure on which you are attempting to measure a structure-to-soil potential.

sti-P_3® TANK – A steel tank manufactured to the standard created by the Steel Tank Institute that comes from the factory with a “pre-engineered” CP system. The “P3” means that the steel tank is protected in three ways: 1) a protective dielectric coating is factory applied; 2) sacrificial anodes (normally zinc) are factory installed on the tanks; and 3) dielectric bushings are installed to facilitate electrical isolation of the tank.

STRAY CURRENT – An electrical current that travels along an unintended path. Stray current is normally described as current from some external source that enters a protected metallic structure at one point that then exits at another point. The point where the stray current exits the protected structure can be subject to intense corrosion and failure may rapidly occur.

STRUCTURE-TO-SOIL POTENTIAL – Also known as “pipe-to-soil potential’ or “structure-to-electrolyte potential”. The difference in the potential of the surface of a buried metallic structure and the electrolyte (soil) that surrounds it with respect to a reference electrode in contact with the electrolyte (soil). Structure-to-soil potential can be thought of as the voltage difference between a buried metallic structure and the soil that it is buried in.

VOLTAGE – The basic unit of force in an electric circuit. Voltage can be thought of as “pounds per square inch pressure” in a water system.

VOLTAGE (IR) DROP – With respect to UST CP systems, voltage drops may be thought of as any voltage that causes an error in the observed structure-to-soil potential. Whenever a current is flowing through a resistance, a voltage drop is present and is part of the voltage measurement obtained.

APPENDIX C
Generalized Interpretation of Structure-to-Soil Potential Measurements (Voltages) Obtained on Galvanic CP Systems

Listed in this table are some generalized observations that can be applied to the interpretation of structure-to-soil potentials. Depending on the specific site conditions and other factors, differing interpretations are possible.

VOLTAGE (mV) "ON"	GENERALIZED INTERPRETATION
POSITIVE	Test leads are reversed (negative should be connected to the reference electrode and the positive should contact the structure you are testing in order to observe negative voltages). Could indicate that stray current is affecting the structure (consult with a corrosion expert).
0 to -100	Usually occurs when you are attempting to measure a structure that has a test lead that is not continuous with the tank. Because you are measuring the potential of a copper wire with reference to the copper-copper sulfate half-cell, the potential is zero or very near it. Disregard test lead and make direct contact with the protected structure.
-101 to -399	Try again – a reading in this range is not normally seen on an underground steel structure. Could indicate that steel structure is electrically connected to a significant amount of a more noble metal (e.g., copper). Very corroded low carbon steel may also be indicated.
-400 to -599	Steel structure does not meet regulatory requirements. Usually means that the steel structure has no CP. Existing sacrificial anodes could be completely "burned-out" or were never there to begin with.
-600 to -849	Steel structure does not meet regulatory requirements. Usually means that the steel structure has anodes but for whatever reason, something is causing a low reading that may indicate adequate CP has not been provided. The anodes may be trying to protect a structure that requires more current than they can produce. The protected steel structure may not be electrically isolated from all other metallic structures (conduct continuity testing). The environmental conditions may not be favorable at the time you are attempting to obtain the reading. Conduct 100 mV polarization decay test if possible. Retest within next 30 and/or repair during the next 60 days.
-850 to -1100	Steel structure protected by zinc anodes meets regulatory requirements and CP is judged to be adequate. Readings in this range are what you would expect on most sti-P_3® tanks that have not been modified and are reading "good" since nearly all come from the manufacturer with zinc anodes.
-850 to -1600	Steel structure protected by magnesium anodes meets regulatory requirements and CP is judged to be adequate. Readings in this range are what you would typically expect on steel piping that is reading "good" since magnesium anodes are generally installed on piping. You may also find readings up to -1600 mV on a sti-P_3® tank that has been retrofitted or was supplied at the factory with magnesium anodes.
MORE NEGATIVE THAN -1100 WITH ZINC ANODES ONLY	Voltages more negative than -1100 mV are theoretically not possible if there are only zinc anodes installed. If you have a reading more negative than -1100 mV and you are sure magnesium anodes are not present, you should suspect that stray current may be affecting the cathodically protected structure. A corrosion expert should be contacted immediately since stray current can cause a corrosion failure in a relatively short period of time.
MORE NEGATIVE THAN -1800	Voltages more negative than -1800 mV are theoretically not possible with any sacrificial anode CP system. If you have a reading more negative than -1800 mV on any galvanic CP system, you should suspect that stray current may be affecting the cathodically protected structure. A corrosion expert should be contacted immediately since stray current can cause a corrosion failure in a relatively short period of time.
VARIABLE	If the voltmeter readings vary you should suspect that stray current may be affecting the cathodically protected structure. Sometimes, the stray current can cause a pattern to develop that is recognizable. An example would be the on/off pattern of a nearby DC powered welding operation. A corrosion expert should be contacted immediately since stray current can cause a corrosion failure in a relatively short period of time.
RAPIDLY FLUCTUATING	If the voltmeter will not stabilize, it usually means that there is a high electrical resistance somewhere. Check all lead wires and connections and make sure that you are making a solid and clean metal to metal connection. Soil where the reference electrode is placed could be too dry. Add water to the soil or wait until a heavy rain occurs and try again. Petroleum contaminated soils may cause a high contact resistance. The tip of the reference electrode may need to be cleaned or replaced.

APPENDIX D
Generalized Interpretation of Structure-to-Soil Potential Measurements (Voltages) Obtained on Impressed Current Systems

Listed in this table are some generalized observations that can be applied to the interpretation of structure-to-soil potentials. Depending on the specific site conditions and other factors, differing interpretations are possible.	
VOLTAGE (mV)	**GENERALIZED INTERPRETATION**
ANY POSITIVE VOLTAGE OR 0 TO -100 "ON" or "OFF"	Can indicate that the structure you are attempting to measure is not bonded to the impressed current system (conduct continuity testing). Stray current could be affecting the protected structure (consult a corrosion expert). Positive and negative wires could be reversed (negative must be to protected structure and positive to anode). Test leads are reversed (positive lead should contact structure and negative lead should be connected to reference electrode). Could indicate that you are measuring the potential of a copper wire.
-101 to -399 "ON" or "OFF"	Try again – a reading in this range is not normally seen on an underground steel structure. Could indicate that steel structure is electrically connected to a significant amount of a more noble metal (e.g., copper). Very corroded low carbon steel may also be indicated.
-400 to -599 "ON" or "OFF"	Usually means that the steel structure has no CP. Existing impressed current anodes could be completely "burned-out". Continuity of anode lead wires (positive circuit) could be broken. Negative bonds on the protected structures may be broken or non-existent.
-600 to -849 "ON" or "OFF"	Usually means that the steel structure has some protection but something is causing a low reading that may indicate adequate CP has not been provided. The impressed current system may be trying to protect a structure that requires more current than it can produce (rectifier output too small). The impressed current system may not be capable of effectively distributing the required current to all parts of the structure you are trying to protect (not enough anodes, anodes improperly installed, soil resistivity too high). The steel structure that is intended to be protected may not be electrically continuous with the other metallic structures under protection (conduct continuity testing). The environmental conditions may not be favorable at the time you are attempting to obtain the reading. Conduct 100 mV polarization decay test. Retest within next 30 and/or repair during the next 60 days.
-850 or MORE NEGATIVE "ON"	Steel structure may or may not be adequately protected. Usually indicates that the impressed current system is providing current to the structure although the reading normally includes a large voltage (IR) drop. Because the flow of current through the soil causes a voltage drop, the on potential cannot be used to indicate that adequate CP has been provided. Instant off potentials must be utilized to demonstrate CP.
-850 or MORE NEGATIVE "OFF"	Steel structure protected by impressed current system meets regulatory requirements and CP is judged to be adequate. A potential measurement of -850 mV or more negative with the protective current temporarily interrupted (850 off) is considered to be the best indicator that adequate CP has been provided.
MORE NEGATIVE THAN -1220 mV "OFF"	Instant off potentials more negative than -1220 mV are theoretically not possible. If you observe an instant off potential more negative than -1220 mV, you should suspect stray current is affecting the protected structure. Consult a corrosion expert immediately since stray current can cause a rapid corrosion failure of the protected structure.
MORE NEGATIVE THAN -2000 "ON"	Usually means that a high resistance exists in the ground bed that is causing a large voltage drop. This condition is normally evident by checking the rectifier output since the voltage is very high but the amperage is relatively low. However, you should be cautious when abnormally high voltages are observed since this can have a detrimental effect on cathodically protected structures or the anodes may be rapidly depleted. Stray current may also be generated that can adversely affect other buried metallic structures such as water lines and other utilities. Consult a corrosion expert whenever it is suspected that too much voltage is being generated.
VARIABLE "ON" or "OFF"	If the voltmeter readings vary, you should suspect that stray current may be affecting the cathodically protected structure. Sometimes, the stray current can cause a pattern to develop that is recognizable. An example would be the on/off pattern of a nearby DC powered welding operation. A corrosion expert should be contacted immediately since stray current can cause a corrosion failure in a relatively short period of time.
RAPIDLY FLUCTUATING "ON" or "OFF"	If the voltmeter will not stabilize, it usually means that there is a high electrical resistance somewhere. Check all lead wires and connections and make sure that you are making a solid and clean metal to metal connection. Soil where the reference electrode is placed could be too dry. Add water to the soil or wait until a heavy rain occurs and try again. Petroleum contaminated soils may cause a high contact resistance. The tip of the reference electrode may need to be cleaned or replaced.

APPENDIX E
Continuity Testing Procedure for Galvanic/Impressed Current CP Systems

Fixed Cell – Moving Ground Continuity Test Procedure

1. Place reference electrode in contact with the soil at a location remote (25 – 100 feet) from all cathodically protected structures. You must ensure that the remote reference electrode placement is not in proximity to any other CP systems (e.g., natural gas pipelines) or directly over any buried metallic structure in order to minimize the chances of unwanted interference.
2. Be sure that reference electrode is firmly placed in moist soil and is not in contact with any vegetation.
3. Connect reference electrode to the negative terminal of voltmeter using a long spool of suitable wire.
4. Connect positive lead wire to voltmeter. This lead wire should have a sharp test prod (scratch awl or similar) in order to assure good contact with the metallic structures under test.
5. Place voltmeter on 2 volt DC scale.
6. Contact each buried metallic structure with the positive test lead without moving the reference electrode. Typical items that would be tested during a continuity survey include: all tanks, tank risers, submersible pump heads, piping, flex connectors/swing joints, vent lines, electrical conduits, dispensers, utilities, etc.
7. Obtain voltage for each component and record on LDEQ UST-CP-01 or UST-CP-02 form.
8. Voltages for each component that is tested must be obtained as quickly as possible since the observed potential can change over time. This is because the conditions in the soil where the reference electrode is placed can change over a relatively short period of time.

Fixed Cell – Moving Ground Data Interpretation

- If two or more structures exhibit potentials that vary by 1 mV or less, the structures are considered to be electrically continuous.
- If two or more structures exhibit potentials that vary by 10 mV or greater, the structures are considered to be electrically isolated.
- If two or more structures exhibit potentials that vary by more than 1 mV but less than 10 mV, the result is inconclusive and further testing (point-to-point) is necessary.

Point-to-Point Continuity Test Procedure

1. Turn off power to rectifier if testing an impressed current system. This is necessary to obtain accurate results.
2. Connect test leads to voltmeter. Both test leads should have a sharp test prod or suitable clip lead in order to make good contact with tested structures.
3. Place voltmeter on 2 volt (or lower) DC scale.
4. Connect one voltmeter test lead to one of the structures for which continuity is being tested and connect the other voltmeter test lead to the other structure that is being tested. For impressed current systems, one structure should be the rectifier negative lead wire.
5. Record voltages observed on each of the two structures that are being compared and record on LDEQ UST-CP-01 or UST-CP-02 form.

Point-to-Point Data Interpretation

- If the voltage difference observed between the two structures is 1 mV or less, this indicates that the two structures are considered to be electrically continuous with each other.
- If the voltage difference observed between the two structures is 10 mV or greater, this indicates that the two structures are considered to be electrically isolated from each other.
- If the voltage difference observed between the two structures is greater than 1mV but less than 10 mV, the result is inconclusive and further testing beyond the scope of this document is necessary.

APPENDIX F
Structure-to-Soil Test Procedure for Galvanic CP Systems

1. Place voltmeter on 2 volt DC scale.
2. Connect voltmeter negative lead to reference electrode.
3. Place reference electrode in clean soil directly over the structure that is being tested to obtain local potential. At least one local potential is required for each tank - the preferred test points are near the one-third, midpoint, and/or two-thirds sections of the tank along the centerline. Piping may require measurement at each end of the pipe and at the middle depending upon anode configuration (Section 6.10.2 of this guidance document).
    - The reference electrode may not be placed on concrete or other paving materials.
    - Ensure that the reference electrode is placed in a vertical position (tip down).
    - Ensure that the soil where the reference electrode is placed is moist – add tap water if necessary.
    - Ensure that the soil where the reference electrode is placed is not contaminated with hydrocarbons.
    - Ensure that the reference electrode window is not exposed to direct sunlight.
4. Connect voltmeter positive lead to structure that is to be tested.
    - If a test lead wire is utilized to make contact with the tested structure you must ensure that continuity exists between the test lead wire and the structure. This may be accomplished by conducting a point-to-point continuity test as described in Appendix E.
    - Ensure that good metal-to-metal contact is made between the test lead clip/probe and the structure.
    - Ensure that no corrosion exists where the test lead makes contact with the structure.
    - Ensure that your body does not come into contact with the electrical connections.
    - Ensure that test leads are not submerged in any standing water.
    - Ensure that test lead insulation is in good condition.
    - sti-P_3® tanks
        - If the test lead wire is not continuous or is not present, contact with the inside bottom of the tank is necessary. This may be accomplished by connecting the voltmeter lead wire to a test prod mounted onto the bottom of a wooden gauging stick and lowering the stick into the tank fill riser. Be sure that firm contact is made with the tank bottom. Care should be taken to ensure that any drop tube that may be installed in the tank does not prohibit contact with the tank bottom. If a metallic probe bar is utilized to contact the tank bottom, ensure that the probe bar does not contact the fill riser or any other metallic component of the UST system.
        - If a sti-P_3® tank is equipped with a PP4® test station, the PP4® test station is disregarded and potentials must be obtained with a portable reference electrode placed in the soil (both local and remote) as described in Section 6.10.1 of this guidance document.
5. Obtain voltage and record in the local column on the LDEQ UST-CP-01 form.
6. Place reference electrode in clean soil remote from the protected structure. At least two remote potentials are required. (Refer to Section 6.10.3 of this guidance document for a discussion of remote reference electrode placement.)
7. Obtain voltages and record in the remote columns on the LDEQ UST-CP-01 form. (Note: if the fixed cell-moving ground method was used to conduct continuity survey, the potential obtained during the continuity survey for each corresponding structure may be transposed to the appropriate column.)

Data Interpretation (for a more complete discussion refer to Appendix C and Section 7.1.4 of this guidance document)

- If both the local and the remote potentials are -850 mV or more negative, the 850 on criterion is satisfied and it is judged that adequate CP has been provided.
- If either one of the local or the remote potentials are more positive than -850 mV the test result is inconclusive and further testing and/or repairs are necessary. Alternatively, a person qualified as a corrosion expert could evaluate/conduct the survey and declare a pass or fail based on their interpretation and professional judgement.

APPENDIX G
Structure-to-Soil Test Procedure for Impressed Current Systems

1. Inspect rectifier for proper operation and document necessary information. This includes measurement of output voltage/amperage with a multimeter (do not rely on rectifier gauges) and measurement of individual anode circuits (if installation allows such). Record all necessary information under Section IX and X of LDEQ UST-CP-02 form.
2. Place voltmeter on 2 volt DC scale.
3. Connect voltmeter negative lead to reference electrode.
4. Place reference electrode in clean soil directly over the structure that is being tested. At least three measurements must be taken for each tank - the preferred test point is usually the center-line of the tank. Piping normally requires measurement at each end of the pipe (Section 6.10.3 and 6.10.4 of this guidance document for further explanation).
   - The reference electrode may not be placed on concrete or other paving materials.
   - Ensure that the reference electrode is placed in a vertical position (tip down).
   - Ensure that the soil where the reference electrode is placed is moist – add tap water if necessary.
   - Ensure that the soil where the reference electrode is placed is not contaminated with hydrocarbons.
   - Ensure that the reference electrode window is not exposed to direct sunlight.
5. Connect voltmeter positive lead to structure that is to be tested.
   - Ensure that good metal-to-metal contact is made between the test lead clip/probe and the structure.
   - Ensure that no corrosion exists where the test lead makes contact with the structure.
   - Ensure that your body does not come into contact with the electrical connections.
   - Ensure that test leads are not submerged in any standing water.
   - Ensure that test lead insulation is in good condition.
6. Obtain voltage potential with the protective current applied and record in the "on" column on the LDEQ UST-CP-02 form.
7. Without moving reference electrode from the position it was in during step 6 above, obtain voltage potential with the protective current temporarily interrupted and record in the "instant off" column on the LDEQ UST-CP-02 form.
   - The instant off potential is the 2nd value that is observed on a digital voltmeter the instant the power is interrupted. The first number that appears immediately after power interruption must be disregarded. After the second number appears, a rapid decay (depolarization) of the structure will normally occur.
   - In order to obtain instant off potentials, a current interrupter or a 2nd person is necessary. If a current interrupter is not available, have the second person throw the power switch at the rectifier off for 3 seconds and then back on for 15 seconds. Repeat this procedure until you are sure an accurate instant off reading has been obtained.
8. Conduct 100 mV polarization decay if you are unable to obtain an instant off potential of -850 mV or more negative in step 7 above. (Note: While not a requirement of this guidance document, consideration should be given to adjusting the rectifier output until an instant off potential of -850 mV is achieved or the maximum safe output is reached.) It is only necessary to conduct 100 mV polarization where the lowest (most positive) instant off potential is observed on the UST system.
   - 100 mV of polarization is determined by leaving the power interrupted on the structure until a change of at least 100 mV in the structure-to-soil potential is observed. In calculating the 100 mV decay, the instant off potential obtained in Step 7 above is utilized as the starting point (e.g., if instant off = -800 mV, power must be left off until decayed to -700 mV).
   - Calculate voltage change by subtracting final (or ending) voltage from the instant off voltage and record these values in the appropriate columns on the LDEQ UST-CP-02 form.

Data Interpretation (for a more complete discussion refer to Appendix D and Section 7.1.4 of this guidance document)

- If all of the instant off potentials are -850 mV or more negative, the 850 off criterion is satisfied and it is judged that adequate CP has been provided.
- If any of the instant off potentials are more positive than -850 mV, the tank may or may not be adequately protected and a 100 mV polarization test is necessary.
- If the structure exhibits more than 100 mV polarization, the 100 mV polarization criterion is met and it is judged that adequate CP has been provided.
- If you are unable to meet either the 850 instant off or the 100 mV polarization criteria, it is judged that adequate CP has not been provided and repairs/modification are indicated. Alternatively, a person qualified as a corrosion expert could evaluate/conduct the survey and determine that CP is adequate based on their interpretation.

APPENDIX H
Checklist for Galvanic CP System Survey and Completion of UST-CP-01 Form

☐	Identified UST owner, UST facility, CP tester, tester's qualifications and reason for survey (Sections I – IV).
☐	Described UST and CP system (Section VIII).
☐	Constructed site drawing depicting all pertinent components of the UST and CP systems at the facility.
☐	Reviewed any previous CP design/repair/testing data that may be available.
☐	Ensured soil access was available directly over each cathodically protected component at the facility (see Section 6.9 of these guidelines).
☐	Conducted continuity testing of all pertinent metallic components at the UST facility by the fixed remote – moving ground and/or the point-to-point method (Section X).
☐	Obtained appropriate number of local structure-to-soil potentials on every cathodically protected structure with the reference electrode placed in the soil directly over the structure under test (Section XI).
☐	Obtained at least two remote potentials for every cathodically protected structure to appropriate columns in Section XI.
☐	Indicated location (by code or other means) of reference electrode placement on site drawing for each structure-to-soil potential that was obtained during the survey.
☐	Described any repairs and/or modifications that were made to the CP system (Section IX).
☐	Indicated whether or not each protected structure met the -850mV on criteria for both the local and remote reference electrode placement by indicating pass/fail/inconclusive in the appropriate column in Section XI.
☐	If only qualified as a tester - indicated the results of the evaluation by marking either pass, fail or inconclusive in Section IV.
☐	If only qualified as a tester - marked inconclusive in Section IV if any of the conditions found in Section 7.2 of these guidelines were applicable to survey.
☐	If tester indicated inconclusive, either repairs were conducted or a corrosion expert evaluated/conducted the survey and completed Section V.
☐	If a corrosion expert conducted and/or evaluated the survey – indicated the results by marking either pass or fail in Section V.
☐	Indicated criteria that were applied to the evaluation in Section VI.
☐	Indicated action required as a result of the survey by marking either none, re-test, or repair and re-test in Section VII.
☐	Provided UST owner with any other type(s) of documentation that may be necessary in order to adequately describe the CP evaluation including the operating status and any repairs or recommendations and attached same to the UST-CP-01 form.

APPENDIX I
Checklist for Impressed Current System Survey and Completion of UST-CP-02 Form

☐	Identified UST owner, UST facility, CP tester, tester's qualifications and reason for survey (Sections I – IV).
☐	Described UST system and type of CP (Section VIII).
☐	Constructed site drawing depicting all pertinent components of the UST and CP systems at the facility.
☐	Reviewed any previous CP design/repair/testing data that may be available.
☐	Checked rectifier for proper operation and measured output voltage/amperage with portable multimeter and indicated all other pertinent information (Section IX).
☐	Measured current output of all positive and negative circuits if the system was designed to allow for such (Section IX).
☐	Ensured soil access was available directly over each cathodically protected component at the facility.
☐	Conducted continuity testing of all pertinent metallic components at the UST facility by the fixed remote – moving ground and/or point-to-point method (Section XI).
☐	Recorded native structure-to-soil potentials in appropriate column in Section XII if this data was available or the system had been down long enough for complete depolarization to occur.
☐	Obtained structure-to-soil potential on every cathodically protected structure with the reference electrode placed in the soil directly over the structure under test with the protective current applied (on) and recorded voltages in appropriate column in Section XII.
☐	Obtained appropriate number of structure-to-soil potentials on every cathodically protected structure without moving reference electrode from placement utilized to obtain on potential with the protective current temporarily interrupted (instant off) and recorded voltages in appropriate column in Section XII.
☐	Conducted 100 mV polarization test if all protected structures did not meet the -850 instant off criterion. Obtaining a 100 mV decay is only required on that component of the UST system that displays the lowest (most positive) instant off potential in order to demonstrate the criterion has been satisfied.
☐	Indicated location (by code or other means) of reference electrode placement on site drawing for each structure-to-soil potential that was obtained.
☐	Described any repairs and/or modifications that were made to the CP system (Section X).
☐	Indicated whether or not each protected structure met the -850mV instant off criteria and/or the 100 mV polarization criteria by indicating pass/fail in the appropriate column in Section XII.
☐	If only qualified as a tester - indicated the results of the evaluation by marking either pass, fail or inconclusive in Section IV.
☐	If only qualified as a tester - marked inconclusive in Section IV if any of the conditions found in Section 7.2 of these guidelines were applicable to the survey.
☐	If it was necessary for the tester to indicate inconclusive, a corrosion expert evaluated the data obtained by a tester and/or conducted his own testing (Section V).
☐	If a corrosion expert conducted evaluation – indicated the results by marking either pass or fail in Section V.
☐	Indicated criteria that were applied to the evaluation by completion of Section VI.
☐	Indicated action required as a result of the survey by marking either none, re-test, or repair and re-test in Section VII.
☐	Provided UST owner with any other type(s) of documentation that may be necessary in order to adequately describe the CP evaluation including the operating status and any repairs or recommendations and attached same to the UST-CP-02 form.

APPENDIX J
Typical Potential of Selected Metals

TYPICAL POTENTIAL OF SELECTED METALS	
The table below lists some common metals and their observed electrical potentials as measured with respect to a copper/copper sulfate reference electrode.	
METAL	**VOLTAGE (mV)**
Magnesium (commercially pure)	-1750
Magnesium (alloy found in typical CP anode)	-1600
Zinc (nearly 100% pure - as found in typical CP anode)	-1100
Aluminum (5% zinc alloy)	-1050
Aluminum (pure)	-800
Low Carbon Steel (new – clean & shiny)	-600 to -750
Low Carbon Steel (old – rusty)	-500 to -600
Stainless Steel (active - unpassivated)	-450 to -600
Cast Iron (not graphitized)	-500
Lead	-500
Low Carbon Steel in Concrete	-200
Brass, Bronze	-200
Stainless Steel (passivated)	50 to -250
Copper	0 to -200
High Silicone Cast Iron	-200
Carbon, Graphite	+300
Silver	+500
Platinum	+900
Gold	+1200

APPENDIX K
UST-CP-01, Galvanic Cathodic Protection System Evaluation Form

Please download the latest form from our web site at http://www.deq.louisiana.gov/UST

LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY
GALVANIC CATHODIC PROTECTION SYSTEM EVALUATION

- This form may be utilized to evaluate underground storage tank (UST) cathodic protection (CP) systems in Louisiana.
- A site drawing depicting the UST system must be attached to the evaluation form.

I. UST OWNER		II. UST FACILITY	
NAME:		NAME:	AI#
ADDRESS:		ADDRESS:	
CITY:	STATE:	CITY:	PARISH:

III. REASON SURVEY WAS CONDUCTED

☐ Routine - 3 year ☐ After Repair/Modification ☐ Within 6 months of Installation

IV. CATHODIC PROTECTION TESTER'S EVALUATION

☐ **PASS**	All protected structures at this facility pass the CP survey and the continuity survey indicates all protected structures are isolated
☐ **FAIL**	One or more protected structures at this facility fail the CP survey
☐ **INCONCLUSIVE**	Remote and local do not indicate the same test result on all protected structures (both pass or both fail), continuity survey indicates continuous or inconclusive results, or stray current is suspected to be affecting the structure
CP TESTER'S SIGNATURE:	DATE OF CP SURVEY:

CP TESTER	CP TESTER'S QUALIFICATIONS
TESTER'S NAME:	NACE INTERNATIONAL CERTIFICATION NUMBER:
COMPANY NAME:	OTHER:
ADDRESS:	OTHER:

V. CORROSION EXPERT'S EVALUATION

☐ **PASS**	All protected structures at this facility have been judged to have adequate CP
☐ **FAIL**	One or more protected structures at this facility fail the CP survey and it is judged that adequate CP has not been provided to the UST system
CORROSION EXPERT'S NAME:	COMPANY NAME:
NACE INTERNATIONAL CERTIFICATION:	NACE INTERNATIONAL CERTIFICATION NUMBER:
CORROSION EXPERT'S SIGNATURE:	DATE:

VI. CRITERIA APPLICABLE TO EVALUATION

☐ **850 On**	Structure-to-soil potential more negative than –850 mV with respect to a $Cu/CuSO_4$ reference electrode with the protective current applied
☐ **850 Instant Off**	Structure-to-soil potential more negative than –850 mV with respect to a $Cu/CuSO_4$ reference electrode with protective current temporarily interrupted (all anodes disconnected)
☐ **100 mV Polarization**	Structure tested exhibits at least 100 mV of cathodic polarization

VII. ACTION REQUIRED AS A RESULT OF THIS EVALUATION

☐ **None**	Cathodic protection is adequate and no further action is necessary at this time
☐ **Retest**	Cathodic protection may not be adequate – Retest during next 30 days to achieve passing results
☐ **Repair & Retest**	Cathodic protection is not adequate - Repair within 60 days of first fail and retest after repair

The next "routine" test of the cathodic protection system must be conducted by no later than:

UST-CP-01 **Underground Storage Tank Division** **Revision 0 – 10/15/2020**

VIII. DESCRIPTION OF UST SYSTEM

STATUS	PRODUCT	CAPACITY	TANK MATERIAL	INSTALL	PIPE MATERIAL	INSTALL	STP CONT. SUMP	MPD CONT. SUMP

PIPING FLEX CONNECTORS

LOCATION	TYPE of CORROSION PROTECTION		LOCATION	TYPE of CORROSION PROTECTION

IX. DESCRIPTION OF CATHODIC PROTECTION SYSTEM REPAIRS AND/OR MODIFICATION

☐ Anodes added to sti-P_3® tank ☐ Anodes added to buried metallic pipe ☐ Anodes added to containment sumps

☐ Other (explain):

COMMENTS:

DESCRIPTION OF REPAIRS NEEDED:

RECOMMENDATIONS FOR CONTINUED OPERATION:

Page 2 of 3

X. CONTINUITY SURVEY

STRUCTURES TESTED		POINT-TO-POINT TEST	FIXED CELL-MOVING GROUND TEST			TEST RESULT
STRUCTURE “A”	STRUCTURE “B”	POINT-TO-POINT VOLTAGE DIFFERENCE (mV)	STRUCTURE “A” FIXED REMOTE VOLTAGE (mV)	STRUCTURE “B” FIXED REMOTE VOLTAGE (mV)	STRUCTURE “A” / “B” VOLTAGE DIFFERENCE(mv)	ISOLATED/ CONTINUOUS/ INCONCLUSIVE

REMARKS:

XI. STRUCTURE-TO-SOIL POTENTIAL SURVEY

LOCATION OF REMOTE REFERENCE CELL 1 (R1):

NOTE: All measurements recorded in millivolts (mV) unless noted

LOCATION OF REMOTE REFERENCE CELL 2 (R2):

Ending voltage(s) recorded after (elapsed time):

STRUCTURE	STRUCTURE CONTACT POINT	LOCATION OF LOCAL REFERENCE CELL	LOCAL/ON VOLTAGE	REMOTE 1 VOLTAGE	REMOTE 2 VOLTAGE	INSTANT OFF VOLT	ENDING VOLTAGE	VOLTAGE SHIFT	PASS/FAIL/ INCONCLUSIVE

REMARKS:

Page 3 of 3

APPENDIX L
UST-CP-02, Impressed Current Cathodic Protection System Evaluation Form

Please download the latest form from our web site at http://www.deq.louisiana.gov/UST

LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY
IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM EVALUATION

- This form may be utilized to evaluate underground storage tank (UST) impressed current CP systems in Louisiana.
- A site drawing depicting the UST system must be attached to the evaluation form.

I. UST OWNER		II. UST FACILITY	
NAME:		NAME:	AI #
ADDRESS:		ADDRESS:	
CITY:	STATE:	CITY:	PARISH:

III. REASON SURVEY WAS CONDUCTED

☐ Routine - 3 year ☐ After Repair/Modification ☐ Within 6 months of Installation

IV. CATHODIC PROTECTION TESTER'S EVALUATION

☐ **PASS**	All protected structures at this facility pass the CP survey and continuity survey indicates all protected structures are continuous
☐ **FAIL**	One or more protected structures at this facility fail the CP survey
☐ **INCONCLUSIVE**	Continuity survey indicates isolated or inconclusive results, or stray current is suspected to be affecting the structure

CP TESTER'S SIGNATURE:	DATE OF CP SURVEY:
CP TESTER	**CP TESTER'S QUALIFICATIONS**
TESTER'S NAME:	NACE INTERNATIONAL CERTIFICATION NUMBER:
COMPANY NAME:	OTHER:
ADDRESS:	OTHER:

V. CORROSION EXPERT'S EVALUATION

☐ **PASS**	All protected structures at this facility have been judged to have adequate CP
☐ **FAIL**	One or more protected structures at this facility fail the CP survey and it is judged that adequate CP has not been provided to the UST system

CORROSION EXPERT'S NAME:	COMPANY NAME:
NACE INTERNATIONAL CERTIFICATION:	NACE INTERNATIONAL CERTIFICATION NUMBER:
CORROSION EXPERT'S SIGNATURE:	DATE:

VI. CRITERIA APPLICABLE TO EVALUATION

☐ **850 Instant Off**	Structure-to-soil potential more negative than –850 mV with respect to a $Cu/CuSO_4$ reference electrode with protective current temporarily interrupted (rectifier turned off)
☐ **100 mV Polarization**	Structure tested exhibits at least 100 mV of cathodic polarization

VII. ACTION REQUIRED AS A RESULT OF THIS EVALUATION

☐ **Routine Monitoring**	Cathodic protection is adequate – Monitor the rectifier every 60 days to ensure continued satisfactory operation
☐ **Retest**	Cathodic protection may not be adequate – Retest during next 30 days to achieve passing results
☐ **Repair & Retest**	Cathodic protection is not adequate - Repair within 60 days of first fail and retest after repair

If the rectifier amperage falls below amps during routine monitoring – Contact a qualified person to investigate

The next "routine" test of the cathodic protection system must be conducted by no later than:

UST-CP-02 **Underground Storage Tank Division** **Revision 0 – 10/15/2020**

VIII. DESCRIPTION OF UST SYSTEM

STATUS	PRODUCT	CAPACITY	TANK MATERIAL	INSTALL	PIPE MATERIAL	INSTALL	STP SUMP	MPD SUMP

PIPING FLEX CONNECTORS

LOCATION	TYPE of CORROSION PROTECTION		LOCATION	TYPE of CORROSION PROTECTION

IX. IMPRESSED CURRENT RECTIFIER DATA

RECTIFIER MANUFACTURER:	MODEL:	SERIAL #:
RATED DC OUTPUT: Volts Amps	RECTIFIER SHUNT: mV = Amps	SHUNT FACTOR = Amps/mV

AS FOUND

TAP SETTINGS OR RHEOSTAT %			DC OUTPUT				HOUR METER
COARSE	FINE	RHEOSTAT	INDICATED VOLTS	INDICATED AMPS	MEASURED VOLTS	MEASURED AMPERAGE	
						(Shunt Voltage = mV)	

POSITIVE AND NEGATIVE CIRCUIT MEASUREMENTS (Amps) — Anode Shunt Size = 0.01 Ω

CIRCUIT	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
ANODE (+)													Amps
STRUCTURE (-)													Amps

☐ Mark this box if rectifier was not changed from the "As Found" settings

AS LEFT

TAP SETTINGS OR RHEOSTAT %			DC OUTPUT				HOUR METER
COARSE	FINE	RHEOSTAT	INDICATED VOLTS	INDICATED AMPS	MEASURED VOLTS	MEASURED AMPERAGE	
						(Shunt Voltage = mV)	

POSITIVE AND NEGATIVE CIRCUIT MEASUREMENTS (Amps) — Anode Shunt Size = 0.01 Ω

CIRCUIT	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
ANODE (+)													Amps
STRUCTURE (-)													Amps

X. DESCRIPTION OF CATHODIC PROTECTION SYSTEM REPAIRS AND/OR MODIFICATION

☐ Anode(s) replaced ☐ Anode wire(s) replaced ☐ Negative wire repaired/replaced

☐ Other (explain):

COMMENTS:

DESCRIPTION OF REPAIRS NEEDED:

RECOMMENDATIONS FOR CONTINUED OPERATION: Monitor and record the rectifier volts and amps with the appropriate form every 60 days

Take immediate action to have the system reevaluated by a qualifed person if monitoring indicates the rectifier amperage falls below amps

XI. CONTINUITY SURVEY						
STRUCTURES TESTED		POINT-TO-POINT TEST	FIXED CELL-MOVING GROUND TEST			TEST RESULT
STRUCTURE "A"	STRUCTURE "B"	POINT-TO-POINT VOLTAGE DIFFERENCE (mV)	STRUCTURE "A" FIXED REMOTE VOLTAGE (mV)	STRUCTURE "B" FIXED REMOTE VOLTAGE (mV)	STRUCTURE "A" / "B" VOLTAGE DIFFERENCE(mV)	ISOLATED/ CONTINUOUS/ INCONCLUSIVE
REMARKS:						

XII. STRUCTURE-TO-SOIL POTENTIAL SURVEY								
NOTE: All measurements recorded in millivolts (mV) unless otherwise noted								
STRUCTURE	STRUCTURE CONTACT POINT	LOCATION OF LOCAL REFERENCE CELL	ON VOLTAGE	INSTANT OFF VOLTAGE	STATIC VOLTAGE	VOLTAGE SHIFT	ELAPSED TIME	PASS/ FAIL
REMARKS:								
								Page 3 of 3

APPENDIX M
UST-CP-03, Impressed Current Cathodic Protection System Record of Rectifier Operation

Please download the latest form from our web site at http://www.deq.louisiana.gov/UST

IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM RECORD OF RECTIFIER OPERATION

This form may be utilized to document the proper operation of the rectifier (performed at least once every 60 days).
The CP tester or corrosion expert must specify the minimum amperage required to provide adequate cathodic protection.

UST OWNER		UST FACILITY			
NAME:		NAME:		I.D.#	
ADDRESS:		ADDRESS:			
CITY:	STATE:	CITY:		STATE:	MS

RECTIFIER DATA

MANUFACTURER:	RATED DC OUTPUT:	Volts	Amps
MODEL:	SERIAL NUMBER:		

MINIMUM DESIGN AMPERAGE

The output at the time of the last passing test was: amps	Date of Last Passing Test:

The minimum output needed to provide adequate cathodic protection is: ☐ amps

Contact a qualified person to investigate if the observed amperage falls below the specified minimum value

Note: Relatively small variations in the rectifier amperage (+ or -) are normal. If there is no minimum amperage specified, contact a qualified person to investigate if the amperage output decreases by more than 20% from the last passing test.

DATE INSPECTED	HOUR METER	DC OUTPUT		DATE INSPECTED	HOUR METER	DC OUTPUT		DATE INSPECTED	HOUR METER	DC OUTPUT	
		VOLTS	AMPS			VOLTS	AMPS			VOLTS	AMPS

Comments:

UST-CP-03	LDEQ - Underground Storage Tank Division	Revision 0 – 10/15/2020

APPENDIX N
US EPA Memo on Clarification of Corrosion Expert and Cathodic Protection Tester Qualifications

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

March 31, 2011

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

MEMORANDUM

SUBJECT: Update to the Regulatory Interpretation Request:
Clarification of "Corrosion Expert" and "Cathodic Protection Tester"

FROM: Carolyn Hoskinson, Director
Office of Underground Storage Tanks

TO: EPA UST/LUST Regional Program Managers
State UST Managers

This memorandum updates the Office of Underground Storage Tank's (OUST) April 16, 2001 memorandum titled ***Update to the Regulatory Interpretation Request: Clarification of "Corrosion Expert" and "Cathodic Protection Tester."*** Since OUST issued that memorandum, NACE International changed their certification categories. In particular, they added a new certification category, cathodic protection technologist.

The Environmental Protection Agency (EPA) believes the new certification category fits EPA's definition of cathodic protection tester (§ 280.12) but does not meet EPA's definition of corrosion expert (§ 280.12). We believe cathodic protection technologist does not meet the definition of corrosion expert because the skill assessment description contained in the NACE International literature requires only the design and installation of simplistic forms of galvanic and impressed current cathodic protection facilities. EPA believes cathodic protection systems at underground storage tank (UST) facilities can be complex and therefore, to be considered a corrosion expert, certifications must include skills to design complex cathodic protection systems. The attached table lists the NACE International certifications and shows where each certification fits into EPA's corrosion expert and cathodic protection tester definitions. This table updates the table provided in the April 16, 2001 memorandum which is available on EPA's website at: www.epa.gov/oust/compend/adn.htm (question 30).

As always, state agencies may impose requirements that are more stringent than the federal regulation. Owners and operators of UST facilities and members of the contracting community should confer with their state UST program offices to determine whether they interpret corrosion expert and cathodic protection tester definitions differently.

1

If you have any questions on this issue, please contact Paul Miller (703-603-7165 or miller.paul@epa.gov) of my staff. For information on NACE International's accreditation programs and descriptions of each certification category, please contact NACE International at (281) 228-6200 or visit their website at: www.nace.org.

Attachment

cc: Kim Ray, NACE International
Kathy Nam, OGC
OUST Regional Liaisons

Attachment: NACE International Certification Levels That Meet EPA's Definitions Of Corrosion Expert And Cathodic Protection Tester

<table>
<tr><th>EPA Definition (40 CFR Part 280.12)</th><th>NACE Certification</th></tr>
<tr><td rowspan="2">CORROSION EXPERT

EPA's definition requires NACE certification unless the person is a registered professional engineer (PE) with certification or licensing that includes education and experience in corrosion control of buried or submerged metal piping systems and metal tanks. Please check with state and local authorities to determine if their requirements are more stringent.</td><td>Corrosion Specialist</td></tr>
<tr><td>Cathodic Protection Specialist</td></tr>
<tr><td rowspan="6">CATHODIC PROTECTION TESTER

EPA's definition of cathodic protection tester does not require any specific certification; however, it does require education and experience in various corrosion areas. Persons holding these NACE certification levels are viewed by EPA as fully meeting regulatory requirements. Please check with state and local authorities to determine if their requirements are more stringent.

Note: Persons meeting EPA's definition of corrosion expert would also be considered as meeting EPA's definition of cathodic protection tester.</td><td>Cathodic Protection Technologist</td></tr>
<tr><td>Cathodic Protection Technician</td></tr>
<tr><td>Cathodic Protection Tester</td></tr>
<tr><td>Senior Corrosion Technologist</td></tr>
<tr><td>Corrosion Technologist</td></tr>
<tr><td>Corrosion Technician*</td></tr>
</table>

*Please note that NACE requires a *Corrosion Technician* performing as a CATHODIC PROTECTION TESTER be directly supervised by a *Corrosion Technologist, Senior Corrosion Technologist, Cathodic Protection Specialist,* or *Corrosion Specialist.*