STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF UNDERGROUND STORAGE TANKS

~~COMPLIANCE GUIDANCE DOCUMENT - 109~~TECHNICAL CHAPTER 4.1

EFFECTIVE DATE - ~~July 29, 1996~~TBD
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~~REQUIREMENTS FOR CORROSION PROTECTION~~

PURPOSE

The purpose of this ~~guidance document~~technical chapter is to assist ~~tank owners and operators,~~ service providers and Division of Underground Storage Tanks (Division) staff in understanding the requirements for Underground Storage Tank (UST) system corrosion protection design, construction, operation/maintenance, repair, testing, and recordkeeping. Evaluating the performance of these systems, whether during operational inspections by the State or during the periodically required testing by vendors, has resulted in some inconsistencies in understanding and application of testing practices. State policies and regulations have historically deferred to industry standards without specifics in regard to inspection and testing practices. A primary goal of this ~~guidance document~~technical chapter is to standardize the performance evaluation of these systems by detailing specific policies and guidelines that will create a uniformity of understanding and consistency of practice among Division inspectors, testers, and ~~the tank owner/operators~~service providers.

This ~~Guidance Document~~technical chapter contains the current policy of the Division based on the statute and regulations governing the Tennessee Petroleum Underground Storage Tank program. This document supersedes all previously published versions. The most current version of this ~~guidance document~~technical chapter will be posted and always available on the Division's website.

AUTHORITY

All rules referred to in this ~~CGD~~ technical chapter are contained in Chapter ~~1200-1-15~~0400-18-01 and are available on the Division of Underground Storage Tanks website at http://www.tn.gov/sos/rules/0400/0400-18/0400-18-01.20120307.pdf ~~http://www.tn.gov/sos/rules/1200/1200-01/1200-01-15.20110202.pdf~~

~~The UST Board is currently revising its rules to renumber them following chapters assigned to the Department of Environment and Conservation. The new chapter will be 0400-18-01 when the renumbering is adopted and a link to the renumbered chapter will be on the Division's website referenced above.~~

APPLICABILITY

Rule .02(4)(c)1. requires that all corrosion protection systems must be designed, constructed, operated, and maintained to continuously provide corrosion protection to the metal components of that portion of the tank and piping that "routinely contains petroleum" **and is in contact with the ground and/or any liquid**. These components include:

1. Any bare steel (no dielectric coating) tanks or piping*

2. STI-P3® tank systems which original anodes have become depleted
3. All below-grade piping (including piping that is partially above-grade if continuous with below grade piping) **including remote fill piping**
4. Metal flexible connectors
5. Any tank or piping with a coating that is determined not to be acceptable by the Division as a "suitable dielectric coating" (Note: dielectric coatings alone are not adequate corrosion protection)*
6. Tank systems constructed with suitable dielectric coatings (such as fiberglass or urethane, ACT-100® tanks) that a corrosion expert requires to be bonded into the same cathodic protection system of other tanks within or near the same tankhold.
7. Submersible Turbine Pump (STP) heads (if in contact with soil and/or any liquid)
8. Or, any other system component that could potentially cause a release of petroleum into the environment as a result of corrosion failure (such as manifold piping or siphon assist tubing for manifolded tanks).

* This only applies to tank systems that were required to be upgraded by the Federal deadline of December 1998 (Tennessee, December 1999). **Existing tank systems and piping currently in operation that did not meet the upgrading requirements by these dates cannot be upgraded and are considered substandard and shall be immediately and permanently closed by removal or closure-in-place as required by rule .07(2).**

Components of the tank system in contact with the ground and/or liquid that do not require corrosion protection because they do not "routinely contain petroleum" include:

1. Automatic Tank Gauge (ATG) risers
2. Vapor recovery risers
3. Fill risers, **but only if the fill riser is fitted with a drop tube**. See rule .02(4)(b)5. **If there is no drop tube, the fill riser must be corrosion protected**
4. Vent lines
5. The ~~Submersible Turbine Pump (~~STP~~)~~ riser
6. Interstitial Monitoring risers or any other riser not routinely containing petroleum

REQUIREMENTS

CORROSION SYSTEM DESIGN AND CONSTRUCTION

A **Corrosion Expert** must design all "field installed" corrosion protection systems as required by rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii). (Field Installed systems include the original or subsequent installation of anodes or modification to a galvanic corrosion protection system or an Impressed Current System.) This does **not** include anodes installed on isolated flexible connectors that may be in STP sumps or under dispensers. Documentation that the cathodic protection system is designed by a Corrosion Expert as required by rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii) must be maintained by the owner and/or operator for inspection by the Division.

CORROSION EXPERT

Corrosion Expert is defined in rule .01(4) and means a person who, by reason of thorough knowledge of the physical sciences and the principles of engineering and mathematics acquired by 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 must submit documentation for review by the Division that they have accreditation or certification as a Corrosion Specialist or Cathodic Protection Specialist by the National Association of Corrosion Engineers (NACE). If it is determined by the Division

that a person has sufficient experience and education to be qualified to take responsible charge in corrosion control of buried or submerged metal piping systems and metal tanks, then that person shall be classified by the Division as a Corrosion Expert.

To date, the Division has not made any determinations regarding who is qualified to be a Corrosion Expert. Refer to EPA's requirements for corrosion experts.

Situations requiring Corrosion Expert review:

1. Design of Field-Installed Cathodic Protection Systems.
2. Any modification (including repairs) of the Cathodic Protection System, such as addition of supplemental anodes or other changes in the design or construction of the Cathodic Protection System.
3. Review of Cathodic Protection System test results indicating anomalies, such as: if stray currents are affecting metallic structures, inconclusive CP test results, and any other system test results that the Division determines to require additional expert review.

CATHODIC PROTECTION TESTER

A **Cathodic Protection Tester** is defined in rule .01(4) and means a person who can demonstrate an understanding of the principles and measurements of all common types of cathodic protection systems as applied to buried or submerged metal piping systems and metal tanks. At a minimum, such persons must 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.

Testing cathodic protection systems is not required to be performed by a Corrosion Expert to comply with rule .02(4)(c)2. The Division requires that all cathodic protection testing performed by a person meeting the qualifications of a **Cathodic Protection Tester**. All testing must be conducted in accordance with the guidelines as detailed in this ~~Compliance Guidance Document~~technical chapter and all results shall be recorded on the official Tennessee Cathodic Protection Testing Survey F~~f~~orms (CN-1140 and CN-1309) as required by rule .02(4)(c)2.(iii) and .03(2)(b)2 .

GENERAL DESIGN AND CONSTRUCTION OF TANKS

Tanks must be properly designed and constructed as required by rule .02(4)(a), so that any portion underground that routinely contains petroleum and is in contact with the ground and/or liquid is protected from corrosion by **one** of the following:

1) **Fiberglass-**Tank is constructed of fiberglass-reinforced plastic-rule .02(4)(a)1.

2) **Steel tank with Cathodic Protection-**Tank is constructed of steel and is protected from corrosion by a cathodic protection system (either galvanic cathodic protection or impressed current cathodic protection)-rule .02(4)(a)2.

3) **Composite (Clad**)-Tank is constructed of a steel-fiberglass-reinforced-plastic composite-rule .02(4)(a)4.

4) **Jacketed-**Tank is constructed with a fiberglass-reinforced plastic jacket, which has an interstitial space between the inner tank and the outer jacket-rule .02(4)(a)4.

5) The tank is constructed of metal without additional corrosion protection measures provided that the tank is installed at a site that is determined by a corrosion expert not to be corrosive enough to cause it to have a release due to corrosion during its operational life.-rule .02(4)(a)5.

6) The tank construction and corrosion protection are determined by the Division to be designed to prevent the release of any petroleum in a manner that is no less protective than any of the previously mentioned methods of corrosion protection.-rule .02(4)(a)6.

GENERAL DESIGN AND CONSTRUCTION OF PIPING

Piping must be properly designed and constructed, as required by rule .02(4)(b), so that any portion that routinely contains petroleum and is in contact with the ground and/or liquid is protected from corrosion by **one** of the following methods:

1) Non-metallic (rigid or flexible)

a. If installed on or after November 1, 2005, shall meet or exceed the Standard for Safety established by Underwriters Laboratory in UL 971 - "Non-Metallic Underground Piping for Flammable Liquids", July 1, 2005. This requirement shall apply to all new and/or replacement piping.-rule .02(4)(b)1.(i)

b. Pipe marking or labeling shall comply with the Underwriters Laboratory standard as outlined in Division rules.-rule .02(4)(b)1.(ii)

2) Metallic

a. Dielectrically coated piping: Piping coated with a suitable dielectric material and has cathodic protection.-rule .02(4)(b)2.(i)

b. Bare steel with cathodic protection system: Bare steel piping to which a galvanic or impressed current system has been added.-rule .02(4)(b)2.(ii)

c. Isolation: Metallic piping **that is never in contact with the ground and/or liquid** (such as rubber boots acceptable to the Division, excavation of all soil or earthen material that exposes the entire length of the piping, or installation of any containment device that isolates the piping from the ground and/or liquids).-rule .02(4)(b)4.

d. The piping is constructed of metal without additional corrosion protection measures provided that the piping is installed at a site that is determined by a corrosion expert not to be corrosive enough to cause it to have a release due to corrosion during its operational life.-rule .02(4)(b)3.(i)

e. The piping construction and corrosion protection are determined by the Division to be designed to prevent the release of any petroleum in a manner that is no less protective than any of the previously mentioned methods of corrosion protection. -rule .02(4)(b)4.

METHODS OF CORROSION PROTECTION

There are three acceptable methods available to meet corrosion protection requirements: Galvanic CP Systems, Impressed Current CP Systems, and Internal Lining of tanks. Metals corrode naturally by the loss of electrons from the surface of the metallic components out into the surrounding soil. Corrosion protection systems reverse this flow of electrons inhibiting the natural process. Galvanic Systems are "passive" corrosion protection systems that utilize anodes made of metals such as magnesium and zinc that corrode

instead of the tank or piping. Due to the difference of the innate electric potentials, a naturally occurring electric current flows from the anodes through moisture in the ground to the tank and/or piping resulting in the protection of the metal components. Impressed Current Systems utilize the same principle but with the addition of an external direct current of electricity applied to the system, which supplies the flow of electrons necessary to reverse the corrosion process.~~that causes the anodes to corrode instead of the tank or piping.~~

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1) **Galvanic Systems** are comprised of sacrificial anodes that were installed on the ends of the tank by the tank manufacturer such as sti-P3® tanks. These systems may include anodes which were added subsequent to installation such as supplemental anodes bonded to sti-P3® tanks when the original anodes have become depleted. Not only can these systems be installed to protect the tanks, but also steel piping which includes flexible connectors.

2) **Impressed Current Systems** are always "Field Installed" systems that are added subsequent to the original installation of the tank system. These systems are designed to protect previously unprotected steel tanks, tanks that the attached anodes (sti-P3® tanks) have become depleted, or tanks which were previously lined internally. These systems can be installed to protect the tanks as well as electrically continuous steel piping.

3) **Internal Lining.** Prior to December 22, 1999 tanks may have been protected from corrosion by lining the inside of the tank with an epoxy lining. This was accomplished by a manned entry into the tank by an already existing manway or by cutting an opening into the tank top. Lining a tank was one method that met the requirements for corrosion protection.

GALVANIC SYSTEMS

1) Design and Construction

Galvanic systems are also known as sacrificial anode systems because an anode (usually zinc or magnesium) corrodes instead of the metal structure. Because the anode corrodes instead of the metal it is protecting, the anode sacrifices 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 those tank components that are well coated with a dielectric material (sti-P3® tanks or fusion bonded epoxy coated steel piping) because the available current output of these systems is low. Attempts to protect large areas of uncoated tanks or long runs of piping is generally not practical because the useful life of the anodes is too short or the number of anodes needed is too great.

2) Operation and maintenance/inspection

All galvanic systems must be operated and maintained to continuously provide corrosion protection to the metal components of that portion of the tank, piping and underground ancillary equipment that routinely contains petroleum and is in contact with the ground and/or liquid. See rules .02(4)(a)2. and .02(4)(b)2. Since galvanic systems are "passive" corrosion protection systems, rule .02(4)(c)2.(i) requires only periodic testing every three years to determine if the system is operating properly and the anodes are supplying sufficient protection. There are usually no maintenance requirements for galvanic systems and are limited to repairs to such things as bonding wires for anodes that have been added subsequently to the original installation of the tanks. Due to the nature of construction of the original system or subsequently added anodes, there are no components of galvanic systems usually

requiring periodic inspection unless the anode bonding wiring is visible and/or accessible as described above.

3) Repairs

a. Repairs include but are not limited to the following: replacement of anode(s) if depleted, repair or replacement of damaged bonding wires, and repair/replacement of system components to achieve isolation. If anodes are added to a sti-P3® tank with depleted anodes, that constitutes a "Field Installation" and requires that the CP system be designed by a corrosion expert, according to rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii). All documents related to the repair and design approval by a Corrosion Expert must be maintained for the life of the system and transferred to any new owner of the system. See rules .02(4)(c)5.(iii) and .03(2)(d). All design and construction requirements shall comply with Steel Tank Institute's "Recommended Practice for the Addition of Supplemental Anodes to sti-P3® USTs" (R972) revised January 2006 (or later).

b. The Division will allow the addition of an impressed current system, that is designed by a corrosion expert as required by rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii), to a STI-P3 tank as a repair of the cathodic protection system when the anodes on a cathodically protected tank are depleted. A bare steel tank which never met the 1998 upgrade deadlines may not be upgraded by addition of an impressed current system. Records of this repair must be maintained for the operational life of the UST system as required by rules .02(7)(f) and transferred to any new owner as required by rule .03(2)(d).

c. Within six (6) months following a repair of a cathodically protected system, the system shall be tested in accordance with rule .02(7)(e) to ensure that it is operating properly and all results shall be recorded on the official Tennessee Cathodic Protection Testing Survey F~~f~~orms (CN-1140 and CN-1309) as required by rule .02(4)(c)2.(iii) and .03(2)(b)2 .

4) Testing

a. A Cathodic Protection Tester must inspect all galvanic systems for proper operation within six (6) months of installation and at least every three (3) years thereafter. The system must be functioning as designed and is effectively preventing corrosion. See rule .02(4)(c)2.

b. All UST systems to which sacrificial anodes have been added for the purpose of replacing or enhancing an existing galvanic system shall be tightness tested. The tightness test shall be conducted no later than six (6) months, but no sooner than three (3) months, following the addition of the anodes. See rules .02(4)(c)3. and .02(4)(c)5.(iii). Records must be transferred to any new owner as required by rule .03(2)(d).

c. Structures utilizing galvanic cathodic protection will be considered adequately protected according to the criterion in Section 8 of NACE TM0101 when "A negative (cathodic) potential of at least 850 mV with the cathodic protection applied. This potential is measured with respect to a saturated copper/copper sulfate reference electrode contacting the electrolyte. Voltage drops other than those across the structure to electrolyte boundary must be considered for valid interpretation of this measurement." This criterion is also known as "850 on" and is not applicable to impressed current systems.

NOTE: A Cathodic Protection Tester may no longer use a cathodic protection test wire (PP2®) or test station (PP4®) that was permanently installed during the original installation of tank system to obtain potential measurements during a cathodic protection test. This is because of continuity issues and unknown location of and/or deterioration of the originally installed reference cell resulting in incorrect potential readings. Also, the buried reference cell only represents the potential reading at one location at the bottom of the tank system and would not meet the testing protocol established by the Division of requiring three readings over the top of each tank.

5) Recordkeeping

Records must be maintained in accordance with the following:

a. The CP system is to be tested every three (3) years and the results of the last two (2) tests must be maintained and made available upon request by the Division. See rules .02(4)(c)5.(i) and .02(4)(c)2.

b. A record of the addition of sacrificial anodes to an existing Galvanic System must be retained for the remaining operational life of the underground storage tank system and such records must be transferred in accordance with Division rules at the time of ownership transfer. See rules .02(4)(c)5.(ii) and .03(2)(d).

c. The results of tightness testing required when sacrificial anodes have been added for the purpose of replacing or enhancing an existing Galvanic System must be retained for the remaining operational life of the underground storage tank system. Such records must be transferred in accordance with Division rules at the time of ownership transfer. See rules .02(4)(c)3., .02(4)(c)5.(iii) and .03(2)(d).

d. The results of any cathodic protection system repairs must be maintained for the operational life of the system. See rule .02(7)(f).

e. Records Transfer. Upon transfer of ownership, including, but not limited to, sale of the tank system, originals and/or copies of all documents required for recordkeeping of corrosion protection systems shall be transferred to the new owner of the tank system at the time of the ownership transfer. See rule .03(2)(d).

IMPRESSED CURRENT SYSTEMS

1) Design and construction

All Impressed Current Systems are "Field Installed" systems and thus required to be designed by a Corrosion Expert as required by rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii). All design and construction requirements shall comply with NACE Standards RP 0285 (latest revision) for tanks, and RP 0169 (latest revision) for piping.

2) Operation and maintenance/inspection

a. All Impressed Current Systems must be operated and maintained to continuously provide corrosion protection to the metal components of that portion of the tank, piping and underground ancillary equipment that routinely contains petroleum and is in contact with the ground and/or liquid. See rule .02(4)(c)1.

b. All Impressed Current Cathodic Protection Systems must be designed to allow determination of current operating status.

- The rectifier must be visually inspected every sixty days, noting that it is turned on and operating properly. See rule .02(4)(c)4.
- The results of these inspections must be recorded on the Impressed Current Cathodic Protection System 60-day Record of Rectifier Operation F~~f~~orm CN-1282. See rule .02(4)(c)4.
- The 60-day Rectifier Log entries shall include the date of inspection, Rectifier On/Off status, voltage output if available, amperage output, hour meter reading if available, name of person inspecting, and any applicable comments. See rule .02(4)(c)4.
- The last **three** visual inspection results (i.e., the last six (6) months) must be maintained by the owner and/or operator. See rule .02(4)(c)4 and .02(4)(c)5.(iv).

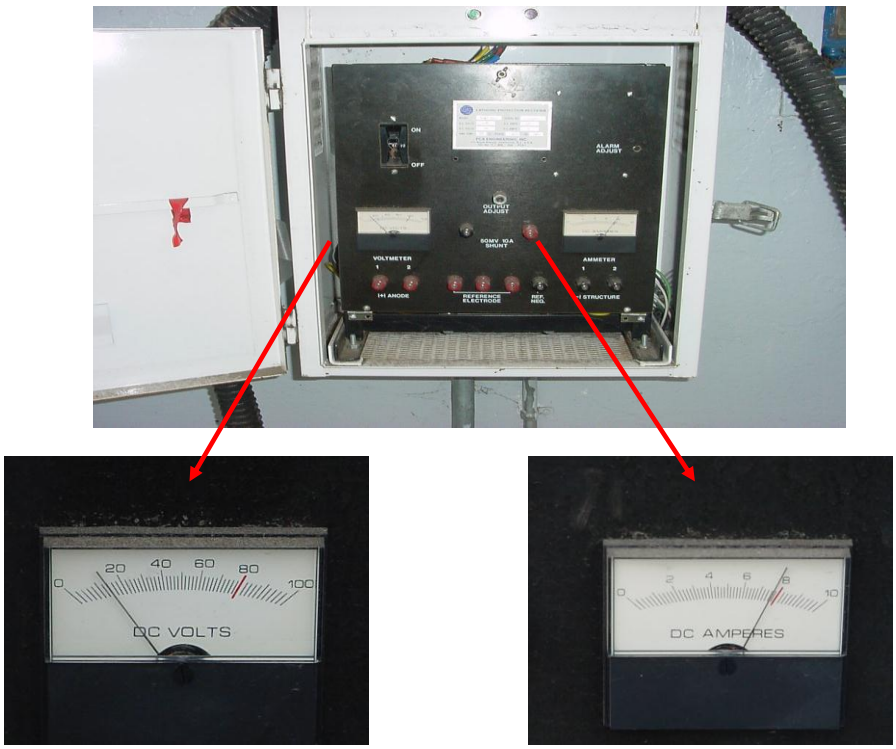
The following conditions are considered as <u>not</u> providing continuous corrosion protection as required by rules .02(4)(c)1.:

- the rectifier gauges either showing no voltage or current at all,
- the rectifier gauges showing voltage or current flow with the switch in the 'off' position,

- the rectifier gauge is spiked indicating the maximum voltage or current flow,
- rectifier logs show a current variance of more than 20% from reading to reading
- no electrical power **(Unless otherwise directed by the Division, in accordance with rule .02(4)(c)6.(i), UST systems with impressed current systems which have been turned off or inoperable for a period of less than twelve months, the tanks and lines shall be tightness tested with additional testing thereafter. In accordance with rule .02(4)(c)6.(ii), UST systems with impressed current systems which have been turned off or inoperable for a period of twelve months or more, the tanks shall be permanently closed.)**

A CP tester must determine the cause of the problem and restore the system to a satisfactory operating condition, and unless directed otherwise by the Division, conduct a test of the CP system to document that the system is protecting the tanks as required in rule .02(4)(c)6. This test will suffice for the post repair test required in the rule. The CP tester must engage the services of a corrosion expert when restoration of the CP system to proper operating condition requires any changes to its design as required by rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii).

This rectifier contains both an ammeter and voltmeter. To verify that the rectifier is on, these gauges should have values above zero. The readings do not tell you that the system is protecting the tanks and piping, it only indicates that the unit is operating.



3) Repairs

Rule .02(7) requires that owners and/or operators of UST systems shall ensure that repairs will prevent releases due to structural failure ***or corrosion*** as long as the UST system is used to store petroleum. Rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii) require that field installed cathodic protection systems for tanks and piping be designed by ***a corrosion expert***.

The Division has determined that to comply with rules .02(4)(a)2.(ii), .02(4)(b)2.(ii) and .02(7)(a) a corrosion expert must be either involved in the design and installation, approve, oversee, or sign off on all repairs made to cathodic protection systems that in any way affect the design of the system.

Repairs include, but are not limited to, the following list of activities:

1. Replacing anodes
2. Replacing rectifier
3. Adding anodes
4. Replacing broken rectifier components
5. Replacing broken ground wires or anode wires
6. Resolving continuity issues when problems identified and system does not pass
7. Adding additional structures to an existing CP system.

These activities require a retest of the CP system within 6 months following the repair to comply with rules .02(7)(e).

Activities listed below may be considered maintenance and do not require the approval of a corrosion expert under .02(4)(a)2.(ii), .02(4)(b)2.(ii) and .02(7)(a).:

Maintenance includes, but is not limited to, the following list of activities:

1. Routine CP testing
2. Turning rectifier on and off for testing.
3. Replacing blown fuse in rectifier
4. Reburying anode wires that have surfaced
5. Adjusting tap settings on rectifier to achieve protection after <u>fail</u> test result

4) Testing

a. A Cathodic Protection Tester must inspect all impressed current systems for proper operation within six (6) months of installation and at least every three (3) years thereafter. The system must be functioning as designed and is effectively preventing corrosion. See rule .02(4)(c)2.

b. All UST systems to which sacrificial anodes have been added for the purpose of replacing or enhancing an existing impressed current system shall be tightness tested. The tightness test shall be conducted no later than six (6) months, but no sooner than three (3) months, following the addition of the anodes. See rules .02(4)(c)3. and .02(4)(c)5.(iii). Records must be transferred to any new owner as required by rule .03(2)(d).

c. Structures utilizing impressed current cathodic protection will be considered adequately protected, as required by rules .02(4)(c)1. and 2. and .02(7), if they meet either:

i. The criterion in Section 9 of NACE TM0101: ~~when~~ a negative (cathodic) potential of at least 850 mV when the voltage drop from the applied protective current has been eliminated. This second meter reading is known as the "instant off" and is measured with the protective current interrupted when the power to the rectifier is cut off, or

ii. The criterion in Section 10 of NACE TM0101: when a minimum of 100 mV of cathodic polarization (either formation or decay) can be measured on the protected structures. When the current is interrupted, an "instant off" potential is recorded and the structure under cathodic protection is then allowed to depolarize until a change of at least 100 mV in potential is observed.

~~iii.~~ These potentials are measured with respect to a saturated copper/copper sulfate reference electrode contacting the electrolyte.

5) Recordkeeping

Records must be maintained in accordance with the following:

a. The CP system is to be tested every three (3) years and the results of the last two (2) tests must be maintained and made available upon request by the Division. See rule .02(4)(c)2.(i). and .02(4)(c)5.(i).

b. The results of the sixty (60) day rectifier inspection shall be recorded on the Impressed Current CP System 60 Day Record of Rectifier Operation Form CN-1282 and in accordance with rule .02(4)(c)2.(iii). The results of the last three sixty (60) day rectifier inspections must be retained for inspection by the Division. As required by rule .02(4)(c)5.(iv) and .03(2)(b)2.

c. The results of any cathodic protection system repairs must be retained for the remaining operational life of the underground storage tank system and such records must be transferred at the time of ownership transfer. See rule .02(7)(f) and .03(2)(d).

d. Documentation that the cathodic protection system is designed by a Corrosion Expert and that a Corrosion Expert was involved with repairs made to the system must be maintained by the owner and/or operator for inspection by the Division. See rules .02(4)(a)2.(ii), .02(4)(b)2.(ii), .02(7)(f), and .03(2)(b).

e. The results of tightness testing required when sacrificial anodes have been added for the purpose of replacing or enhancing an existing Impressed Current System must be retained for the remaining operational life of the underground storage tank system. See rule .02(4)(c)5.(ii) and .02(7)(f). Such records must be transferred in accordance with Division rules at the time of ownership transfer. See rule .02(4)(c)5.(ii) and .03(2)(d).

Rectifiers used on USTs are manually controlled for the most part. A Corrosion Expert will determine the amount of current necessary in the design to protect the structures and set the rectifier output accordingly at installation or during modification of the CP system as required by rules .02(4)(a)2.(ii) and .02(4)(b)2.(ii), and as outlined in the definition of Corrosion Expert in rule .01(4).

If the rectifier is equipped with a **voltmeter**, 60 day voltage readings made by tank owners should be fairly constant. The tank owner should record current (amps or milliamps) from an **ammeter**. The recorded current readings could vary if the anodes are buried shallow or there are wide seasonal variations in soil moisture content. If the anodes are buried at least 8 feet deep, then measured current output should remain fairly constant. **Any variation in current of more than 20% must be investigated and repaired.**

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CORROSION PROTECTION FOR FLEXIBLE (FLEX) CONNECTORS

Flex connectors are braided stainless steel fittings used to make connections from a product line to a dispenser or submersible pump. A braided steel mesh protects an interior plastic or non-metallic hose that carries petroleum. There are two different ways to protect flex connectors from corrosion: isolation and cathodic protection.

1) Isolation

Isolation means keeping a flex connector free from all contact with ground and/or water. If a sump can be kept free of water so that the flex connector is never exposed to soil and/ or water, then no further action is necessary under rule .02(4)(b). If the flex connector can come in contact with ground and/or water, then another means of achieving isolation, such as isolation boots, will be necessary to comply with rule .02(4)(b).

Isolation boots are plastic materials made for isolating flex connectors and are placed around the entire flex connector and secured. Isolation boots may be either one piece "sleeves" which slip over a flex connector and are secured at both ends with nylon zip ties, or stainless steel band clamps, also known as radiator clamps. Another design is a boot that is heat shrunk directly to a flex connector.
A third kind of isolation boot is a boot that is applied around the pipe and "zipped" or secured with nylon ties, or possibly Velcro fasteners. Tank owners using these "zip boots" must ensure that the flex connector does not come in contact with soil and/or water since it is not certain that the zip components remain fastened after installation. When boots show signs of degradation they must be replaced. Isolation boots must be secured at both ends and the tank owner must be able to document that **both ends** are secured in a manner that prevents the flex connector from coming in contact with soil or water to comply with rule .02(4)(b) and .02(4)(c)1. If this cannot be determined, cathodic protection must be added to comply with rule .02(4)(b)2. and .02(4)(c)1. Flex connectors which cannot be isolated from contact with soil or water are not corrosion protected, and cathodic protection is required if isolation cannot be achieved in accordance with rules .02(4)(b)2. and .02(4)(c)1.

One- piece Isolation boot

Zip boot

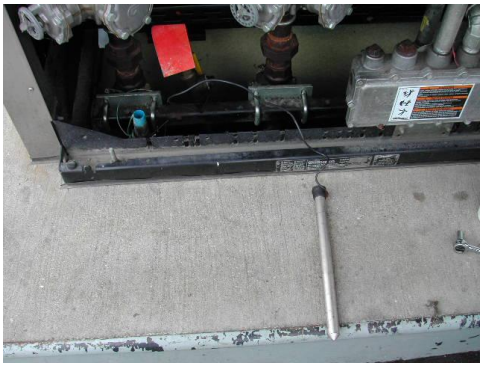
Following a limited study in 2001 by the Division, a decision was made not to approve the use of tape wraps alone to provide adequate corrosion protection to flex connectors and metallic piping components. See rule .02(4)(b)4. The study showed that exposure to hydrocarbons compromised the integrity of the rubberized tape material. Adhesive tapes provide some protection to metallic surfaces, but under direct burial conditions or exposure to water or other electrolyte, any exposed metal would be subject to corrosion even in the absence of petroleum. Another concern was a reduced likelihood of achieving proper installation under field application conditions, and no assurance that proper application techniques would be used by adequately trained individuals. Tape-wrapped flex connectors must also have a form of galvanic or impressed current cathodic protection, or the flex connector must be situated so that it is never exposed to soil and/or water in order to meet the requirements of rule .02(4)(b)2. and .02(4)(b)4.

2) Cathodic Protection

Sacrificial anodes may be attached to isolated flex connectors to achieve cathodic protection. A sacrificial anode is a less noble metal like zinc or magnesium alloys intentionally connected to form a galvanic cell with a more noble metal for the purpose of protecting the more noble metal from corrosion. Some flex connectors have a circular piece of anode material attached during manufacturing. If a factory designed anode is not present, cathodic protection can be added in the field. A spike anode (driving rod anode) is attached with a clamp, and then driven into the soil/backfill next to the piping. Sacrificial anodes can be connected to the flex connector at the submersible pump or under the dispenser. Also bracelet anodes can be attached with a U-bolt around the flex connector. In all cases the anodes must be in contact with backfill for the anode to work properly. Cathodic protection systems must be tested every three years as required by rule .02(4)(c)2.(i).

Driving rod anodes

Bracelet anode



Note that although this flex connector has a bracelet anode attached, it is ineffective in preventing corrosion. In order to work properly, the anode must be buried in soil.

Driving rod or bracelet anodes are designed to provide protection to a **single, isolated flex connector**. They are not designed to provide adequate protection for flex connectors which are electrically continuous with other structures such as the STP, impact valve, dispenser cabinet or other piping

components. If a driving rod or bracelet anode is used to provide cathodic protection to a flex connector the CP test must determine that the flex connector is isolated as required by rule .02(4)(c)2. Rule .02(4)(b)2.(ii) also requires a corrosion expert to design a field installed CP system (one driving rod anode will protect only one isolated flex connector). The Division issued a memo in October 2009 which said that adding a driving rod anode to a **single, isolated** flex connector does not require approval by a corrosion expert. **If the flex connector is electrically continuous with other flex connectors or other dispenser components, then documentation must be provided that a corrosion expert has determined that the galvanic CP system is adequate to protect the structures to which it is connected.**

In addition to corrosion, another factor contributing to failure of flex connectors is mechanical stresses-twisted, kinked, or installed with too much bend. The bend is determined by the length of the flexible portion, but manufacturers recommend that the bend radius should never exceed 90 degrees.

INTERNALLY LINED TANKS

One means of complying with the 1998 upgrade requirement was to install an epoxy liner inside a bare steel tank. National Leak Prevention Association (NLPA) Standard 631 describes procedures for lining underground storage tanks. If a tank was lined in accordance with NLPA 631, then the Division considers the tank to be upgraded. All lined tanks must be compatible with the product stored as required by .02(4)(a)3.(i)(II). Records of the lining installation must be maintained for the operational life of the tank as required by rule .02(4)(a)3.(i)(VI) and transferred to any new owners as required by rule .03(2)(d).

There are four possible combinations of lined tanks at a facility.

1. Bare steel tanks which have been internally lined.*
2. Bare steel tanks which have been lined and later added an impressed current CP system.
3. STI-p3 tanks which have been lined. These tanks may have been lined because the sacrificial anodes were depleted or for another reason.*
4. STI-p3 tanks which have been lined and later added an impressed current CP system.

*Tanks that meet this criteria shall have a cathodic protection system added by December 22, 2012 or be permanently closed as required by rule .02(4)(a)3.(v).

1) Internal lining inspections

The Division accepts two options for performing internal lining inspections required by rule .02(4)(a)3.(ii). The inspection may be performed utilizing a manned entry to inspect the tank lining in accordance with NLPA 631. The Division, in lieu of manned entry inspection, also permits the use of video cameras to inspect the internal lining so long as KWA protocol of assessing tank lining using video cameras is followed. At the time of issuance of this ~~guidance document~~technical chapter, the Division is only aware of three companies that perform video inspections in accordance with the aforementioned protocol. They are: Armor Shield of Kentucky located in Alexandria, KY; Tanknology located in Austin, TX; and Tank Tech located in Blodgett, MO.

2) For internally lined tanks without a CP system

a. Division rules require that tanks that were internally lined be inspected within ten (10) years of installation and every five (5) years thereafter to ensure that the tank lining is still performing in accordance with manufacturer's specification. See rule .02(4)(a)3.(ii).

b. Tank owners and/or operators, as required by rule .02(4)(a)3.(i)(VI), shall keep records that indicate when the tank lining was installed and records of the last internal lining inspection as required by rule .02(4)(a)3.(ii). If no records are available, then an internal lining inspection must be performed.

c. If the results of the lining inspection indicate a passing result, then the next internal inspection is due within five (5) years of the date of the last internal lining inspection as required by rule .02(4)(a)3.(ii). Internal lining inspection results must be retained until the next internal lining inspection.

d. If a tank that was upgraded by lining to meet the December 22, 1998 deadline is inspected and the results of the lining inspection indicate the lining has failed, and is not repairable, then the tank has reached the end of its operational life under rule .02(4)(a)3.(ii)(I). Substandard tanks must be permanently closed following the requirements of rule .07(2). Also, placing a substandard tank in temporary out-of-service status is not an option under rule .07(2).

e. If a tank that was upgraded by lining to meet the December 22, 1998 deadline is inspected and the results of the lining inspection indicate the lining has failed, and it is repairable, the tank owner must make a choice to repair the tank or not repair the tank.

   i. If the tank owner decides not to repair the tank, the tank has reached the end of its operational life under rule .02(4)(a)3.(ii)(I). Substandard tanks must be permanently closed following the requirements of rule .07(2). Also, placing a substandard tank in temporary out-of-service status is not an option under rule .07(2).

   ii. If a tank with a failed lining is not permanently closed as required under rule .07(2), the tank must be repaired, records of the repair must be maintained for the operational life of the UST system as required by rule .02(7)(f), and the repair records must be transferred to any new tank owner as required by .03(2)(d).

f. Please note that rule .02(4)(a)3.(v) requires that lined steel tanks without cathodic protection must be permanently closed by December 22, 2012; however, if the tank owner and/or operator wishes to continue use of these tanks, a cathodic protection system, designed by a corrosion expert as required by rule .02(4)(a)2.(ii) must be added before December 22, 2012. Tank integrity must be assessed before adding cathodic protection using the Ken Wilcox and Associates (KWA) recommended practice. See rule .02(4)(a)2.(v).

3) For internally lined tanks with a CP system

a. The tank owner and/or operator must have CP test records required by rule .02(4)(c)2.(ii), .02(4)(c)5.(i), and .03(2)(b)2. indicating the corrosion protection status. If the tank owner and/or operator does not have the CP records, then they must conduct a CP test as required by rule .02(4)(c)2.

b. The tank owner and/or operator shall have records which indicate when the tank lining was installed as required by rule .02(4)(a)3.(i)(VI) and .03(2)(d) and when the most recent internal lining inspection was performed as required by rule .02(4)(a)3.(ii) and .03(2)(d). The last date that a tank lining could be installed as an upgrade was December 22, 1999.

c. If the impressed current system was installed prior to the due date of the ten (10) year lining inspection required by rule .02(4)(a)3.(ii), then the tank owner and/or operator may use CP testing to verify the UST system is corrosion protected as required by rule .02(4)(c)2. a~~A~~nd

.02(4)(c)5.(i). Therefore, the tank owner and/or operator shall have records which indicate when the impressed current system was installed. If there are no CP installation records, then the Division will use the earliest reliable CP test date as the date of CP installation.

d. If the difference between the date of internal lining and addition of impressed current is more than 10 years, an internal lining inspection must be performed as required by rule .02(4)(a)3.(ii). (see section 2.e. above for failed lining).

e. An Impressed Current CP system must remain operational for the remaining life of the tank, as required by rule .02(4)(c)1. and records maintained as required by rule .02(4)(c)5. and .03(2).

*If the integrity of an UST was properly assessed before adding CP by one of the methods allowed by rule .02(4)(a)2.(v)(I) through (IV), periodic lining inspections are no longer required, only periodic CP tests as required by rule .02(4)(c)2.(i).

Tank integrity could have been assessed by performing a tank tightness test prior to and after the addition of a CP system (this method is no longer allowed for assessment), or by following the KWA recommended practices for assessing tank integrity. If CP was added to an UST for which the integrity was not properly assessed or records are not available, then a tank lining inspection must be performed under rules .02(4)(a)2.(v)(I) and (IV). If, however, cathodic protection is added to an UST whose integrity was not ensured, then periodic monitoring/inspection of both the cathodic protection system and lining is required. If the lining test fails, the lining must be repaired or the tank must be permanently closed as outlined in section 2.e. above.

For testing and recordkeeping of cathodic protection systems, refer to sections#4 and 5 under Galvanic Systems above.

4) Internal lining of tanks as a tank repair

If a tank meets any one of the construction standards in rule .02(4)(a)1. through 5., it may be repaired by lining. The Division will consider the lining or relining to be "in a manner that is no less protective", as allowed in rule .02(4)(a)6., as long as the tank is lined following the requirements of rule .02(4)(a)3. and .02(7)(a) and the record of the lining is maintained for the operational life of the UST system as required by rule .02(7)(f) and records of the lining are transferred to any new tank owner as required by rule .03(2)(d). Tank owners may also submit the lining records to the Division for retention in its files, and the Division will maintain the records following the requirements of rule .14(1).

Exception: If the tank is constructed of fiberglass, rule .02(7)(b) has the additional requirement mandating:

> "Repairs to fiberglass-reinforced plastic tanks shall be made by the manufacturer's authorized representatives or in accordance with the manufacturer's specifications."

Consequently, if the manufacturer of a fiberglass reinforced tank does not allow its tanks to be repaired by lining, rule .02(7)(b) would prevent lining as a repair.

The following conditions must be met for tank owners and/or operators using tank lining as a repair:

a. Prior to adding the internal lining, the tank integrity must first be assessed and determined to be structurally sound in accordance with NLPA Standard 631 and determined to be suitable for internal lining as required by rule .02(4)(a)3.(i)(III).

b. Rule .02(4)(a)3.(i)(IV) requires linings to be installed in accordance with manufacturer's instructions. The following standards are allowed by federal rule 40 CFR Part 280.33(a) and (b), and they may be used to comply with rule .02(4)(a)3.(i)(IV) and .02(4)(a)6.:

- National Leak Prevention Association Standard 631, Chapter 631, Chapter A-Entry, Cleaning, Interior Inspection, Repair, and Lining of Underground Storage Tanks
- National Leak Prevention Association Standard 631, Chapter D-Lining of Fiberglass Tanks for Compatibility & Repairs That Are Allowed

The NLPA standards are available at http://www.nlpa-online.org/standards.html and they include requirements like the ones listed below:

i. Internal tank linings must be installed in accordance with NLPA Standard 631 which requires an assessment of the tank shell after cleaning the tank and abrasive blasting of the tank interior. NLPA 631 contains specifications for testing for and repairing tank wall perforations. The procedures for assessing the tank shell in NPLA 631 must be followed and if it is determined the tank does not pass the assessment, the tank is not suitable for lining.
ii. The tank assessment must be done by a company trained and qualified to do this work, and tank lining must be installed in accordance with NLPA 631 and lining manufacturer's instructions, by a company trained and qualified to do tank lining.

c. Rule .02(7)(a) requires that repairs to UST systems be made to prevent releases due to structural failures or corrosion as long as the UST system is used to store petroleum. In accordance with rule .02(4)3., any tank lining must be installed to effectively prevent a release due to corrosion for the operational life of the system.

d. The Division asks to be given sufficient advance notice of the tank entry, cleaning, assessment, repair, and lining installation to have staff on site during every phase of the process. Complete documentation of the repair process is considered a tank repair record and must be maintained for the life of the system as required by rule .02(7)(f) and transferred to any new owner as required by rule .03(2)(d).

e. In order to comply with the "no less protective" standard in rule .02(4)(a)6., internal lining inspections within 10 years of lining and every 5 years thereafter are required for FRP tanks, fiberglass-coated steel tanks, or fiberglass-jacketed steel tanks if an internal lining is installed as a tank repair.

5) Lining and relining tanks to assure compatibility with alternative fuels

If a tank meets any one of the construction standards in rule .02(4)(a)1. through 5., it may be lined or relined to meet the compatibility requirements of rule .02(5). The Division will consider the lining or relining to be "in a manner that is no less protective", as allowed in rule .02(4)(a)6., as long as the tank is lined following the requirements of rule .02(4)(a)3. and .02(7)(a) and the record of the lining is maintained for the operational life of the UST system as required by rule .02(7)(f) and records of the lining are transferred to any new tank owner as required by rule .03(2)(d). If records are not maintained, the tank would be considered incompatible with alternative fuels~~substandard and should be permanently closed~~. Tank owners may also submit the lining records to the Division for

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retention in its files, and the Division will maintain the records following the requirements of rule .14(1).

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Historical Supporting CP Guidance

1. Fiberglass clad tanks with supplemental anodes

Fiberglass clad steel tanks are manufactured according to industry standard ACT-100, and are sufficiently corrosion protected to meet new tank standards without additional corrosion protection. In the mid-1990s some ACT-100 tanks were manufactured with a sacrificial anode as additional protection against incidental damage that might occur to the fiberglass coating during shipment or installation. In 1998 the Steel Tank Institute published a supplement to the installation instructions for ACT-100 tanks providing instructions for factory-attached and field-attached anodes.

EPA issued guidance in February 1999 concerning ACT-100 tanks that said:

> "These tanks are corrosion protected by an external cladding…. As long as the integrity of the cladding is maintained…monitoring of ACT-100 and ACT-100-U tanks with anodes should not be required.
>
> Periodic monitoring of cathodic protection systems is not required in the following cases:
> 1. When factory installed anodes are included with a new ACT-100 or ACT-100-U installation.
> 2. When field installed anodes are included with a new ACT-100 or ACT-100-U installation.
>
> Note: In cases where cathodic protection is retrofitted to a previously installed ACT-100 or ACT-100-U tank, cathodic protection monitoring is required because the status of the cladding cannot be determined."

Tanks which meet ACT-100 or ACT-100-U specifications and have factory-installed anodes or had anodes installed <u>at the time of installation</u> will not be required to conduct periodic CP testing.

Fiberglass-clad tanks not meeting ACT-100 specifications, or which had an anode field-installed some time after the tank was installed will be required to conduct periodic CP testing.

2. Rule Interpretation Memo - October 30, 2001

"Do the UST regulations require corrosion protection of metal fill pipes?

<u>Conclusion</u>: Both the federal and the state regulations **require** corrosion protection of a fill pipe which is in contact with the soil unless the fill pipe is provided with a drop tube."

Link to full document is available on the Division's website.

3. Division Memo – March 8, 2006

Intended to address situations where unprotected sections of metallic piping systems were discovered.

> "There may be circumstances for which closure of portions of the substandard system may not be warranted and the application of corrosion protection or isolation should be allowed. The Division will take those cases under consideration and make determinations on a case-by-case basis. Some examples of allowable circumstances are:
>
> 1. Unprotected flex connectors may be protected by isolation or by adding cathodic protection.

2. Unprotected fill pipes may be protected by installing a drop tube or adding cathodic protection to the fill pipe.

3. Unprotected siphon bars on manifold tanks may be protected by adding cathodic protection.

Tank owners who upgraded tanks by adding impressed current prior to December 22, 1999, or had a passive cathodic protection system on tanks at the time of installation, may repair the cathodic protection system if it is not functioning properly. Any tank which was upgraded by adding an internal lining only, that subsequently fails to pass an internal inspection will be considered a substandard tank and must be replaced."

4. Compliance Issue Clarification - November 11, 2009

Guidance issued describing 'unusual operating conditions' when observing rectifiers on compliance inspections. "Unusual operating conditions were described to be:

- the meters either showing no voltage or current at all,
- the meters showing voltage or current flow when the switch is in the 'off' position,
- the meter indicator is spiked indicating the maximum voltage or current flow, or a dangerous level indicated on the meter,
- for those systems using red and green indicator lights, the appropriate indicator light is not green,
- Rectifier logs show a current variance of more than several amps

Directive given the inspectors: If you observe any of the above unusual operating conditions, note them in the inspection form. In the inspection follow up letter require the owner to have a CP tester determine the cause of the unusual operating condition and restore the system to a satisfactory operating condition, followed by a test of the CP system to document that the system is protecting the tanks. That test could suffice for the post repair test required in 1200-1-15-.02(7)(e). The CP tester should engage the services of a corrosion expert when and where necessary to restore the CP system to proper operating condition."

5. CP systems without continuously operating cathodic protection

"A rule addressing gaps in continuous cathodic protection became effective November 17, 2009. Rule 1200-1-15-.02(4)(c)6. states the following for impressed current systems which have failed to provide continuous protection for UST systems:

- For UST systems with impressed current systems which have been turned off or inoperable for a period of less than twelve (12) months, unless directed to do otherwise by the Division, the tanks and lines shall be tightness tested in accordance with subparagraphs (3)(c) and (4)(b) of rule 1200-01-15-.04. Another tightness test shall be conducted no later than six (6) months, but no sooner than three (3) months, following the return of the impressed current system to operation.
- For CP systems turned off or inoperable for more than 12 months, unless directed to do otherwise by the Division, the tanks shall be permanently closed."

REFERENCES

1. Guidelines for the Evaluation of Underground Storage Tank Cathodic Protection Systems. Mississippi Department of Environmental Quality, July 1, 2002

2. NACE Standard TM0101, NACE International

3. NACE Recommended Practice RP 0285- "Corrosion Control of Underground Storage Tank Systems by Cathodic Protection" NACE International

4. NACE Recommended Practice RP 0169- "Control of External Corrosion on Underground or Submerged Metallic Piping Systems" NACE International

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

6. Steel Tank Institute (STI) Recommended Practice R972 "Recommended Practice for the Installation of Supplemental Anodes for sti-P3® UST's" Steel Tank Institute

7. Steel Tank Institute (STI) Recommended Practice R051 "Cathodic Protection Testing Procedures for sti-P3® UST's" Steel Tank Institute

8. Technical Interpretation and Guidance Regarding the Combination of Cathodic Protection and Internal Lining, December 4, 1995 Environmental Protection Agency

APPENDICES-

1. Structure-to-Soil Test Procedure for Galvanic CP Systems
2. Continuity Testing Procedure for CP Systems
3. Structure-to-Soil Test Procedure for Impressed Current CP Systems
4. Impressed Current CP Testing Survey
5. Galvanic CP Testing Survey
6. Impressed Current CP System 60 Day Record of Rectifier Operation Form

APPENDIX 1

Mississippi Department of Environmental Quality, July 1, 2002

STRUCTURE-TO-SOIL TEST PROCEDURE FOR GALVANIC CATHODIC PROTECTION 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 three (3) local potentials are required for each tank - the preferred test points are the approximate midpoint and at each end of the tank along the centerline. Piping may require measurement at each end of the pipe. 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. 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.
   - 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.
   - 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-P3® 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 is installed in the tank does not prohibit contact with the tank bottom. If a metallic probe bar is used 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-P3® 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 at both local and remote earth locations.

1. Obtain voltage and record in the local column on the Tennessee Galvanic Cathodic Protection Survey Form (CN-1140).

2. Place reference electrode in clean soil at remote earth from the protected structure.

3. Obtain voltage and record in the remote column on CN-1140. (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 Cathodic Protection Testers

Pass- If both the local <u>and</u> the remote potential are –850 mV or more negative, the 850 on criterion is met and adequate cathodic protection has been demonstrated.

Fail - If both the local <u>and</u> the remote potential are more positive than –850 mV, the 850 on criterion is not met and adequate cathodic protection has been demonstrated.
If either the local <u>or</u> the remote potential is more positive than –850 mV, the test result is inconclusive and further testing and/or repairs are necessary.

<u>NOTE:</u> a person qualified as a **Corrosion Expert** may evaluate results of the survey or conduct the survey and declare a pass or fail based on their interpretation and professional judgment.

APPENDIX 2

Mississippi Department of Environmental Quality, July 1, 2002

CONTINUITY TESTING PROCEDURE FOR CATHODIC PROTECTION SYSTEMS (GALVANIC & IMPRESSED CURRENT)

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 cathodic protection 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 Tennessee cathodic protection survey 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 2 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 2 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, connect the other voltmeter test lead to the other structure that is being tested or the negative rectifier lead wire.
5. Record voltages observed on each of the two structures that are being compared and record on Tennessee cathodic protection survey form.

Testing with this method does not require a reference electrode. The two structures of interest are simply connected in parallel with the voltmeter and a determination made as to whether or not any potential difference exists between them.

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 is necessary.

APPENDIX 3

Mississippi Department of Environmental Quality, July 1, 2002

STRUCTURE-TO-SOIL TEST PROCEDURE FOR IMPRESSED CURRENT CATHODIC PROTECTION 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). Record all necessary information Tennessee Impressed Current Cathodic Protection Survey Form (CN-1139).

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 (3) measurements must be taken for each tank the preferred test points are the approximate midpoint and at each end of the tank along the centerline. Piping normally requires measurement at each end of the pipe.
   - 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 CN-1139.

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 CN-1139.
   - 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. It is only necessary to conduct 100 mV polarization when 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 CN-1139.

Data Interpretation for Cathodic Protection Testers

Pass – 1. If the instant off potential is 850 mV or more negative, the 850 off criterion is met and adequate cathodic protection has been demonstrated, or
2. If the structure exhibits more than 100 mV polarization, the 100 mV polarization criterion is met and adequate cathodic protection has been demonstrated

If the instant off potential is more positive than -850 mV, the tank may or may not be adequately protected and a 100 mV polarization test is necessary.

Fail - If neither the - 850 instant off nor the 100 mV polarization criteria are met, adequate cathodic protection has not been provided and repairs/modification will be necessary to achieve cathodic protection.

NOTE: a person qualified as a Corrosion Expert may evaluate results of the survey or conduct the survey and determine that cathodic protection is adequate based on their interpretation.

APPENDIX 4

IMPRESSED CURRENT CATHODIC PROTECTION TESTING SURVEY

(Modifications are made to these forms from time to time. Please check the Division's website for the most current version of the State's official form)

DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF UNDERGROUND STORAGE TANKS
4th Floor, L & C Tower
401 Church Street
Nashville, TN 37243

IMPRESSED CURRENT CATHODIC PROTECTION TESTING SURVEY

- **This form must be utilized to evaluate underground storage tank (UST) cathodic protection systems in the State of Tennessee.**
- **Access to the soil directly over the cathodically protected structure that is being evaluated must be provided.**

I. UST FACILITY		II. UST OWNER	
NAME:		NAME:	
FACILITY ID NUMBER:		COMPANY:	
ADDRESS:		ADDRESS:	
CITY:	COUNTY:	CITY:	STATE:

III. CP TESTER		
TESTER'S NAME:		COMPANY:
ADDRESS:		LIST CERTIFICATION, IF ANY:
CITY:	STATE:	PHONE NUMBER:

IV. REASON SURVEY WAS CONDUCTED (mark only one)

☐ **Routine - 3 year** ☐ **Routine – within 6 months of installation** ☐ **Re-survey after fail** ☐ **Re-survey after repair/modification**

Date next cathodic protection survey must be conducted by: _____ (required within 6 months of installation/repair, or every 3 years).

V. CATHODIC PROTECTION TESTER'S EVALUATION (mark only one)

☐ **PASS**	All protected structures at this facility pass the cathodic protection survey and it is judged that adequate cathodic protection has been provided to the UST system (indicate all applicable criteria by completion of Section VII).
☐ **FAIL**	One or more protected structures at this facility fail the cathodic protection survey and it is judged that adequate cathodic protection has not been provided to the UST system (complete Section VIII).
☐ **INCONCLUSIVE**	The cathodic protection survey of an impressed current system must be evaluated by a corrosion expert because it cannot be determined that the protected structures are continuous or other factors may be resulting in high readings (complete Section VI).

My signature below is affirmation that I have sufficient education and/or experience to meet the definition of cathodic protection tester in Tennessee Rule 1200-1-15-.01(4) [40 CFR 280.12], that I am competent to perform the tests indicated above, that test results on this form are a complete and truthful record of all testing at this location on the date shown, and that I am responsible for conclusions contained therein.

CP TESTER'S SIGNATURE: **DATE CP SURVEY PERFORMED:** _____

VI. CORROSION EXPERT'S EVALUATION (mark only one)

The survey must be conducted and/or evaluated by a corrosion expert when: a) supplemental anodes or other changes in the construction of the impressed current system are made; b) stray current may be affecting buried metallic structures or c) an inconclusive result was indicated in Section V.

☐ **PASS**	All protected structures at this facility pass the cathodic protection survey and it is judged that adequate cathodic protection has been provided to the UST system (indicate all criteria applicable by completion of Section VII).
☐ **FAIL**	One or more protected structures at this facility fail the cathodic protection survey and it is judged that adequate cathodic protection has not been provided to the UST system (indicate required action by completion of Section VIII).

CORROSION EXPERT'S NAME: **COMPANY NAME:**

NACE INTERNATIONAL CERTIFICATION? ☐ **Yes** ☐ **No** **NACE INTERNATIONAL CERTIFICATION NUMBER:**

My signature below is affirmation that I have sufficient education and/or experience to meet the definition of corrosion expert in Tennessee Rule 1200-1-15-.01(4) [40 CFR 280.12], that I am competent to perform the evaluation indicated above, and that I am responsible for its conclusions.

CORROSION EXPERT'S SIGNATURE: _____ **DATE:** _____

VII. CRITERIA APPLICABLE TO EVALUATION (mark all that apply)

☐ **850 OFF**	Structure-to-soil potential more negative than –850 mV with respect to a Cu/CuSO4 reference electrode with protective current temporarily interrupted (instant-off).
☐ **100 mV Polarization**	Structure(s) tested exhibit at least 100 mV of cathodic polarization.

VIII. ACTION REQUIRED AS A RESULT OF THIS EVALUATION (mark only one)

☐ **NONE**	**Cathodic protection is adequate.** No further action is necessary at this time. Test again by no later than the date specified in Section IV.
☐ **RETEST**	**Cathodic protection may not be adequate**. Retest to determine if passing results can be achieved.
☐ **REPAIR & RETEST**	**Cathodic protection is not adequate.** Repair/modification is necessary as soon as practical.

IX. DESCRIPTION OF UST SYSTEM

FACILITY NAME:	FACILITY ID NUMBER:

TANK #	PRODUCT	CAPACITY	TANK MATERIAL	PIPING MATERIAL	FLEX CONNECTORS / LOCATION
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

If metal flex connectors are present, are they corrosion protected?	☐ **YES** **Method:** ☐ **Isolation (booted)** ☐ **Isolation (contained in sump or no soil contact)** ☐ **Attached Anode**[1]
	☐ **NO** **Action taken:** _____

[1] If the flex connectors are protected by sacrificial anodes, test accordingly and include the data with this form.

X. IMPRESSED CURRENT RECTIFIER DATA (complete all applicable)

In order to conduct an effective evaluation of the cathodic protection system, a complete evaluation of rectifier operation is necessary.

RECTIFIER MANUFACTURER:	**RATED DC OUTPUT:** _____ **VOLTS** _____ **AMPS**
RECTIFIER MODEL:	**RECTIFIER SERIAL NUMBER:**

RECTIFIER OUTPUT AS INITIALLY DESIGNED OR LASTLY RECOMMENDED (if available): _____ **VOLTS** _____ **AMPS**

EVENT	DATE	TAP SETTINGS		DC OUTPUT		HOUR METER	COMMENTS
		COARSE	FINE	VOLTS	AMPS		
"AS FOUND"							
"AS LEFT"							

Check all that apply: ☐ single amp/voltmeter ☐ dual amp/voltmeter ☐ red/green indicator light

XI. IMPRESSED CURRENT POSITIVE & NEGATIVE CIRCUIT MEASUREMENTS (output amperage)

Complete if system design allows such measurements (i.e. individual lead wires for each anode are installed and measurement shunts are present).

CIRCUIT	1	2	3	4	5	6	7	8	8	10	TOTAL
ANODE (+)											
TANK (-)											

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

Complete if repairs or modifications to the cathodic protection system are made or are necessary. Certain repairs/modifications as explained in the text of the TDEC cathodic protection guidance document (CGD-109) are required to be designed and/or evaluated by a corrosion expert (completion of Section VI required). Attach corrosion experts calculations and diagram and have corrosion expert sign Section VI.

- ☐ Replacing or Adding anodes for an impressed current system (attach corrosion expert's design).
- ☐ Repairs or replacement of rectifer or non functional rectifier components (attach explanation).
- ☐ Broken anode header cables or ground wires repaired and/or replaced (attach explanation).
- ☐ Resolving continuity issues when problems identified and system does not pass (attach explanation).
- ☐ Adding additional structures to an existing CP system (attach corrosion expert's design).
- ☐ Other (attach corrosion expert's explanation).

XIII. UST FACILITY SITE DRAWING

Attach detailed drawing or use the space provided to draw a sketch of the UST and cathodic protection systems. Sufficient detail must be given in order to clearly indicate where the reference electrode was placed for each structure-to-soil potential that is recorded on the survey forms. Any pertinent data must also be included. At a minimum you should indicate the following: all tanks, piping, and dispensers; all buildings and streets; all anodes and wires; and location of rectifier. Each reference electrode placement must be indicated by a code (1,2, T-1,) corresponding with the appropriate line number in Section XIV. of this form.

AN EVALUATION OF THE CATHODIC PROTECTION SYSTEM IS NOT COMPLETE WITHOUT AN ACCEPTABLE SITE DRAWING.

XIV. IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM CONTINUITY SURVEY

- This section will be utilized to conduct measurements of continuity on UST systems that are protected by cathodic protection systems.
- When conducting a fixed cell - moving ground survey, the reference electrode must be placed in the soil at a remote earth location and left undisturbed.
- Conduct point-to-point test between any two structures for which the fixed cell - moving ground survey is inconclusive or indicates possible discontinuity.
- For impressed current systems, the protected structure must be continuous with all other protected structures in order to pass the continuity survey.

FACILITY NAME: | **FACILITY ID NUMBER:**

DESCRIBE LOCATION OF "FIXED REMOTE EARTH" REFERENCE ELECTRODE PLACEMENT:

STRUCTURE "A" [1]	STRUCTURE "B" [2]	STRUCTURE "A" [3] FIXED REMOTE VOLTAGE	STRUCTURE "B" [4] FIXED REMOTE VOLTAGE	POINT-TO-POINT [5] VOLTAGE DIFFERENCE	ISOLATED/ CONTINUOUS/ INCONCLUSIVE[6]
(example) *PLUS TANK BOTTOM*	(example) *PLUS STEEL PROD LINE @ STP*	(example) *-915 mV*	(example) *-908 mV*		(example) *INCONCLUSIVE*
(example) *PLUS TANK BOTTOM*	(example) *PLUS STEEL PROD LINE @ STP*			(example) *1 mV*	(example) *CONTINUOUS*

COMMENTS:

_____

_____

_____

[1] Describe the protected structure ("A") that you are attempting to demonstrate is continuous (e.g. plus tank bottom).

[2] Describe the "other" protected structure ("B") that you are attempting to demonstrate is continuous (e.g. plus steel product line @ STP).

[3] Record the fixed remote instant-off structure-to-soil potential of the protected structure ("A") in millivolts (e.g. –915 mV).

[4] Record the fixed remote instant-off structure-to-soil potential of the "other" protected structure ("B") in millivolts (e.g. –908 mV).

[5] Record the voltage difference observed between structure "A" and structure "B" when conducting "point-to-point" testing (e.g. 1 mV).

[6] Document whether the test indicated the protected structure was continuous (1 -2 mV), inconclusive (3 - 9 mV), or isolated (> 10 mV).

XV. IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM SURVEY

- This section will be utilized to conduct a survey of an impressed current cathodic protection system by obtaining structure-to-soil potential measurements.
- The reference electrode must be placed in soil directly over the tested structure and as far away from active anode as practical to obtain a valid structure-to-soil potential.
- Both on and instant off potentials must be measured for each structure that is intended to be under cathodic protection.
- All instant off potentials must be -850 mV or more negative or the 100 mV polarization criterion must be satisfied in order to pass.
- At least three readings shall be recorded over each tank, one reading at each dispenser, and mid points of steel product lines more than 100 feet in length.

FACILITY NAME: **FACILITY ID NUMBER:**

LOCATION CODE[1]	STRUCTURE[2]	CONTACT POINT[3]	REFERENCE CELL PLACEMENT[4]	ON VOLTAGE[5]	INSTANT OFF VOLTAGE[6]	100 mV POLARIZATION		PASS / FAIL[9]
						ENDING VOLTAGE[7]	VOLTAGE CHANGE[8]	
(example) 1	(example) PLUS TANK	(example) TANK BOTTOM	(example) SOIL @ REG. TANK STP	(example) -1070 mV	(example) -875 mV			(example) PASS
(example) 2	(example) PLUS	(example) DISPENSER 5/6	(example) UNDER DISPENSER 5/6	(example) -810 mV	(example) -680 mV	(example) -575 mV	(example) 105 mV	(example) PASS

COMMENTS:

_____

[1] Designate numerically or by code on the site drawing each "local" reference electrode placement (e.g. 1, 2, 3… T-1, T-2, P-1, P-2…etc.).

[2] Describe the structure that is being tested (e.g. plus tank; diesel piping; flex connector; etc.).

[3] Describe where the structure being tested is contacted by the test lead (e.g. plus tank bottom, diesel piping @ dispenser 7/8, etc).

[4] Describe exact location where reference electrode is placed for each measurement (e.g., soil @ regular tank STP, soil @ dispenser 5/6, etc.)

[5] Record the structure-to-soil potential observed with the current applied (e.g. –1070 mV).

[6] Record the structure-to-soil potential observed with the current is interrupted (e.g., -875 mV).

[7] (Applies to 100 mV polarization only) Record the voltage observed at the end of the test period (e.g., -575 mV)

[8] (Applies to 100 mV polarization only) Subtract the instant off voltage from the final voltage (e.g., -575 mV – [-680 mV] = 105 mV change)

[9] Indicate if the tested structure passed or failed one of the two acceptable criteria (<-850 mV instant off or >100 mV polarization).

APPENDIX 5

GALVANIC CATHODIC PROTECTION TESTING SURVEY

(Modifications are made to these forms from time to time. Please check the Division's website for the most current version of the State's official form)

DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF UNDERGROUND STORAGE TANKS
4th Floor, L & C Tower
401 Church Street
Nashville, TN 37243

GALVANIC CATHODIC PROTECTION TESTING SURVEY

- This form must be utilized to evaluate underground storage tank (UST) cathodic protection systems in the State of Tennessee.
- Access to the soil directly over the cathodically protected structure that is being evaluated must be provided.

I. UST FACILITY		II. UST OWNER	
NAME:		NAME:	
FACILITY ID NUMBER:		COMPANY:	
ADDRESS:		ADDRESS:	
CITY:	COUNTY:	CITY:	STATE:

III. CP TESTER		
TESTER'S NAME:		COMPANY:
ADDRESS:		LIST CERTIFICATION, IF ANY:
CITY:	STATE:	PHONE NUMBER:

IV. REASON SURVEY WAS CONDUCTED (mark only one)

☐ Routine - 3 year ☐ Routine – within 6 months of installation ☐ Re-survey after fail ☐ Re-survey after repair/modification

Date next cathodic protection survey must be conducted by: _____ (required within 6 months of installation/repair, or every 3 years).

V. CATHODIC PROTECTION TESTER'S EVALUATION (mark only one)

☐ **PASS**	All protected structures at this facility pass the cathodic protection survey and it is judged that adequate cathodic protection has been provided to the UST system (indicate all applicable criteria by completion of Section VII).
☐ **FAIL**	One or more protected structures at this facility fail the cathodic protection survey and it is judged that adequate cathodic protection has not been provided to the UST system (complete Section VIII).
☐ **INCONCLUSIVE**	If the remote and the local do not both indicate the same test result on all protected structures (i.e., both pass or both fail), then the result is inconclusive, and further evaluation by a corrosion expert is necessary (complete Section VI).

My signature below is affirmation that I have sufficient education and/or experience to meet the definition of cathodic protection tester in Tennessee Rule 1200-1-15-.01(4) [40 CFR 280.12], that I am competent to perform the tests indicated above, that test results on this form are a complete and truthful record of all testing at this location on the date shown, and that I am responsible for conclusions contained therein.

CP TESTER'S SIGNATURE: **DATE CP SURVEY PERFORMED:** _____

VI. CORROSION EXPERT'S EVALUATION (mark only one)

The survey must be conducted and/or evaluated by a corrosion expert when: a) an inconclusive is indicated for any protected structure since both the local and the remote structure-to-soil potentials do not result in the same outcome (both pass or both fail); b) repairs to galvanized or uncoated steel piping are conducted or c) supplemental anodes are added to the tanks and/or piping.

☐ **PASS**	All protected structures at this facility pass the cathodic protection survey and it is judged that adequate cathodic protection has been provided to the UST system (indicate all criteria applicable by completion of Section VII).
☐ **FAIL**	One or more protected structures at this facility fail the cathodic protection survey and it is judged that adequate cathodic protection has not been provided to the UST system (indicate required action by completion of Section VIII).

CORROSION EXPERT'S NAME: **COMPANY NAME:**

NACE INTERNATIONAL CERTIFICATION? ☐ **Yes** ☐ **No** **NACE INTERNATIONAL CERTIFICATION NUMBER:**

My signature below is affirmation that I have sufficient education and/or experience to meet the definition of corrosion expert in Tennessee Rule 1200-1-15-.01(4) [40 CFR 280.12], that I am competent to perform the evaluation indicated above, and that I am responsible for its conclusions.

CORROSION EXPERT'S SIGNATURE: _____ **DATE:** _____

VII. CRITERIA APPLICABLE TO EVALUATION (mark all that apply)

☐ **850 ON**	Structure-to-soil potential more negative than –850 mV with respect to a Cu/CuSO4 reference electrode with the protective current applied (applicable to any galvanically protected structure).
☐ **850 OFF**	Structure-to-soil potential more negative than –850 mV with respect to a Cu/CuSO4 reference electrode with protective current temporarily interrupted (applicable only to galvanic systems where the anodes can be disconnected).
☐ **100 mV Polarization**	Structure tested exhibits at least 100 mV of cathodic polarization (applicable to galvanic systems where the anodes can be temporarily disconnected).

VIII. ACTION REQUIRED AS A RESULT OF THIS EVALUATION (mark only one)

☐ **NONE**	**Cathodic protection is adequate.** No further action is necessary at this time. Test again by no later than the date specified in Section IV.
☐ **REPAIR & RETEST**	**Cathodic protection is not adequate.** Repair/modification is necessary as soon as practical.

IX. DESCRIPTION OF UST SYSTEM

FACILITY NAME:			FACILITY ID NUMBER:		
TANK #	**PRODUCT**	**CAPACITY**	**TANK MATERIAL**	**PIPING MATERIAL**	**FLEX CONNECTORS / LOCATION**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

If metal flex connectors are present, are they corrosion protected?	☐ **YES** **Method:** ☐ **Isolation (booted)** ☐ **Isolation (contained in sump or no soil contact)** ☐ **Attached Anode**[1]
	☐ **NO** **Action taken:** _____

[1] If the flex connectors are protected by sacrificial anodes, test accordingly and include the data with this form.

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

Complete if repairs or modifications to the cathodic protection system are made or are necessary. Certain repairs/modifications as explained in the text of the TDEC cathodic protection guidance document (CGD-109) are required to be designed and/or evaluated by a corrosion expert (completion of Section VI required).

☐ Adding supplemental anodes for a sti-P_3® tank (attach corrosion expert's design).

☐ Adding supplemental anodes for metallic pipe (attach corrosion expert's design).

☐ Resolving continuity issues when problems identified and system does not pass (attach explanation).

Remarks/Other: _____

_____

XI. UST FACILITY SITE DRAWING

AN EVALUATION OF THE CATHODIC PROTECTION SYSTEM IS NOT COMPLETE WITHOUT AN ACCEPTABLE SITE DRAWING.

Attach detailed drawing or use the space provided to draw a sketch of the UST and cathodic protection systems. At a minimum, indicate the following: all tanks, piping and dispensers, all buildings and streets, all anodes and wires: location of CP test stations, Each reference electrode placement must be indicated by a code (1, 2, T-1, corresponding with the appropriate line number in Section XIII. of this form.

XII. GALVANIC (SACRIFICIAL ANODE) CATHODIC PROTECTION SYSTEM CONTINUITY SURVEY

- This section will be utilized to conduct measurements of continuity on UST systems that are protected by cathodic protection systems.
- When conducting a fixed cell - moving ground survey, the reference electrode must be placed in the soil at a remote earth location and left undisturbed.
- Conduct point-to-point test between any two structures for which the fixed cell-moving ground survey is inconclusive or indicates possible continuity.
- For galvanic systems, the structure that is to be protected must be isolated from any other metallic structure in order to pass the continuity survey.

FACILITY NAME: | **FACILITY ID NUMBER:**

DESCRIBE LOCATION OF "FIXED REMOTE" REFERENCE ELECTRODE PLACEMENT:

STRUCTURE "A" [1]	STRUCTURE "B" [2]	STRUCTURE "A" [3] FIXED REMOTE VOLTAGE	STRUCTURE "B" [4] FIXED REMOTE VOLTAGE	POINT-TO-POINT [5] VOLTAGE DIFFERENCE	ISOLATED/ [6] CONTINUOUS/ INCONCLUSIVE
(example) *PREMIUM TANK BOTTOM*	(example) *PREMIUM TANK FILL RISER*	(example) *-921 mV*	(example) *-915 mV*		(example) *INCONCLUSIVE*
(example) *PREMIUM TANK BOTTOM*	(example) *PREMIUM TANK FILL RISER*			(example) *17 mV*	(example) *ISOLATED*

COMMENTS: _____

[1] Describe the cathodically protected structure that you are attempting to demonstrate is isolated from unprotected structures (e.g. prem. tank).

[2] Describe the unprotected structure that you are attempting to demonstrate is isolated from the protected structure (e.g. premium tank fill riser).

[3] Record the measured structure-to-soil potential of the cathodically protected structure {"A"} in millivolts (e.g. –921 mV).

[4] Record the measured structure-to-soil potential of the unprotected structure {"B"} in millivolts (e.g. –915 mV).

[5] Record the voltage observed between the protected and the unprotected structures when conducting point-to-point testing (e.g. 17 mV).

[6] Document whether the test indicated the protected structure was continuous (1 -2 mV), inconclusive (3 - 9 mV), or isolated (> 10 mV).

XIII. GALVANIC (SACRIFICIAL ANODE) CATHODIC PROTECTION SYSTEM SURVEY

- This section will be utilized to conduct a survey of a galvanic cathodic protection system by obtaining structure-to-soil potential measurements.
- The reference electrode must be placed in the soil directly over the tested structure (local) **and** at a remote earth location, at least 25-100 feet away from the structure.
- Local voltage measurements should be made over the middle and both ends end of each tank.
- All local and remote earth voltage readings must be –850 mV or more negative, in order for the structure to pass.
- Inconclusive is indicated when both the local and remote earth structure-to-soil potentials do not result in the same outcome (i.e., both pass or both fail).

FACILITY NAME: | **FACILITY ID NUMBER:**

DESCRIBE LOCATION OF REMOTE REFERENCE ELECTRODE PLACEMENT:

LOCATION CODE[1]	STRUCTURE [2]	CONTACT POINT [3]	LOCAL REFERENCE CELL PLACEMENT [4]	LOCAL VOLTAGE[5]	REMOTE VOLTAGE[6]	PASS / FAIL / INCONCLUSIVE[7]
(example) *1*	(example) *PLUS TANK*	(example) *TANK BOTTOM*	(example) *PLUS TANK STP MANWAY*	(example) *-928*	(example) *-810*	(example) *INCONCLUSIV*
(example) *2*	(example) *PLUS PIPING*	(example) *DISPENSER 5/6*	(example) *UNDER DISPENSER 5/6*	(example) *-890*	(example) *-885*	(example) *PASS*

COMMENTS: _____

_____

_____

[1] Designate numerically or by code on the site drawing each "local" reference electrode placement (e.g. 1, 2, 3… T-1, T-2, P-1, P-2…etc.).

[2] Describe the structure that is being tested (e.g. plus tank; premium piping; diesel submersible pump flex connector; etc.).

[3] Describe where contact with the structure being tested is made (e.g. plus tank @ test lead; diesel piping @ dispenser 5/6; pp4, etc).

[4] Describe exact location where reference electrode is placed for each "local" reading (e.g. soil @ plus tank STP; soil @ dispenser 5/6; etc.)

[5] Record the structure-to-soil potential measured with the reference electrode placed "local" in millivolts (e.g. –865 mV, -920 mV, etc.).

[6] Record the structure-to-soil potential measured with the reference electrode placed "remote" (copy voltage obtained during continuity survey).

[7] Indicate whether the tested structure passed or failed the –850 mV "on" criterion based on your interpretation of the test data.

APPENDIX 6

IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM
60-DAY RECORD OF RECTIFER OPERATION FORM

(Modifications are made to these forms from time to time. Please check the Division's website for the most current version of the State's official form)

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF UNDERGROUND STORAGE TANKS
www.tdec.net/ust

4th Floor L&C Tower
401 Church Street
Nashville, Tennessee 37243

IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM
60-DAY RECORD OF RECTIFER OPERATION

- This form may be utilized to document that the cathodic protection system rectifier is checked for operation at least once every 60 days.
- Checked for operation is taken to mean that it was confirmed the rectifier was receiving power and is "turned-on".
- If your rectifier is so equipped, you should also record the output voltage, amperage and the number of hours indicated on the meter.
- Any significant variance should be reported to your corrosion professional so that any repairs and/or adjustments necessary can be made.

UST OWNER		UST FACILITY	
NAME:		NAME:	ID #
ADDRESS:		ADDRESS:	
CITY:	STATE:	CITY:	COUNTY:

IMPRESSED CURRENT RECTIFIER DATA

Rectifier Manufacturer:	Rated DC Output: _____ VOLTS _____AMPS
Rectifier Model:	Rectifier Serial Number:

What is the 'as designed' or lastly recommended rectifier output? _____ VOLTS _____AMPS

60-DAY LOG OF RECTIFIER OPERATION

DATE INSPECTED	RECTIFIER TURNED ON?	TAP SETTINGS		DC OUTPUT		HOUR METER	INSPECTOR INITIALS	COMMENTS
		COARSE	FINE	VOLTS	AMPS			