RECOMMENDED PRACTICE FOR THE ADDITION OF SUPPLEMENTAL ANODES TO STI-P3® USTs

R972

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1.0 INTRODUCTION

1.1 On occasion, tank owners of sti-P3® tanks find that the cathodic protection readings are more positive than the NACE recommended -850 millivolt criteria. In this case, the cathodic protection system must be supplemented so that the tank continues to be protected from corrosion.

1.2 The addition of supplemental anodes can bring the tank potential more negative than the recommended -850 millivolt criteria. It does not, however, change the period of the manufacturer warranty on the tank.

1.3 This recommended practice (RP) was prepared under the direction of James B. Bushman, P.E., registered Professional Corrosion Engineer and Principal Corrosion Consultant for Bushman & Associates, Inc., P.O. Box 425, Medina, OH 44256, USA.

2.0 SCOPE

2.1 The tanks which are considered in this RP are shop fabricated steel storage tanks built according to the sti-P3® standard.

2.2 Tanks must be verified, through STI, that they are sti-P3® tanks.

2.3 This RP contains information regarding the number, size and type of anodes which may be used to supplement the cathodic protection of an sti-P3® tank, the installation of the anodes, the installation of test stations, and methods for verifying the proper operation of the anodes after installation.

2.4 The installation and testing of the cathodic protection system shall be performed by a qualified installer and tester. The qualified installer and tester shall be as defined by the applicable Federal, State, and Local regulations.

2.5 This RP only applies to tanks that require no more than 30 milliamps of current to bring the tank to protected levels. (See Section 8). If the current requirement is more than 30 milliamps, contact the Steel Tank Institute or a qualified corrosion consultant, as defined by the applicable Federal, State, and Local regulations.

2.6 Procedures for cathodic protection testing, verification of electrical isolation and measurement of supplemental protective current required are also included in this RP.

3.0 DEFINITIONS

Cathodic Protection (CP) - A technique to reduce (or eliminate) the corrosion of a metal surface (the exterior metal surfaces of underground storage tank (UST) in contact with the earth or tank backfill as used in this RP) by making that surface the cathode of an electrochemical cell.

Electrical Isolation - The condition of being electrically separated from other metallic structures or the environment. For the purposes of this RP, it shall mean that the sti-P3® underground storage tank(s) is electrically separated (no metal-to-metal contact) from all other buried metallic structures.
**Electrolyte** - A chemical substance containing ions that migrate in an electric field. For the purposes of this RP, electrolyte refers to the soil or liquid adjacent to and in contact with a buried or submerged metallic UST system, including the moisture and other chemicals contained in therein.

**Galvanic Anode** - A metal that provides sacrificial protection to another metal that is more noble when electrically coupled in an electrolyte. This type of anode is the electron source in one type of cathodic protection. For the purposes of this RP, the supplementary galvanic anode shall mean a high potential magnesium alloy anode ingot, prepackaged in selected backfill consisting of 75% gypsum, 20% bentonite, and 5% sodium sulfate.

**IR Drop** - The voltage drop through a resistance resulting from current flow through the resistance in accordance with Ohm’s Law (V = I x R).

**Reference Electrode** - An electrode whose open-circuit potential is constant under similar conditions of measurement, which is used for measuring the relative potentials of other electrodes. For the purposes of this RP, this shall mean a calibrated saturated copper-copper sulfate reference electrode (CSE).

**Soil Resistivity** - The property of the soil that is directly proportional to the soil’s resistance to electric current flow. For the purposes of this RP, it is the average soil resistivity measured using the Wenner Four-Pin method. The value so measured is expressed as the “average resistivity of the soil as measured to a depth equal to the pin spacing and is normally recorded in ohm-centimeters”.

**Structure Instant-Off Potential** - It is the structure-to-electrolyte potential reading obtained immediately after interruption of all CP system current flow. For the purposes of this RP, it is the second reading displayed on the digital voltmeter immediately after interruption of the test CP system current when measuring the potential on an sti-P3® tank during current requirement testing.

**Structure-to-Electrolyte Potential (also tank-to-soil potential or tank-to-electrolyte potential)** - The potential difference between a buried metallic structure and the electrolyte that is measured with a reference electrode (CSE as used in this RP) in contact with the electrolyte. For this RP, it is generally the voltage difference between the tank and the soil.

### 4.0 EQUIPMENT REQUIREMENTS

4.1 The following equipment is required for the tank testing procedures discussed in this recommended procedure.

- 2 - Portable copper-copper sulfate reference electrodes (1 is a calibrated reference electrode and is never to be used in the field.)
- 2 - Digital Multimeters capable of measuring DC Volts and DC Amps (minimum 10 megaohm internal resistance). (The second multimeter is required if current requirement testing is performed.)
1 - Portable 12 volt battery or battery from your vehicle
1 - Temporary anode (uncoated steel rebar or pipe, uncoated long screwdriver, etc.)
1 - Nilsson Model 400 Four-Pin Soil Resistivity Meter and pins
• Enough test wires and connectors to perform all testing

5.0 REFERENCE ELECTRODE USE, CARE & MAINTENANCE

5.1 Proper maintenance of the reference electrode is crucial to accurate tank-to-soil potential readings. Be sure that only distilled water is used in the reference electrode, and that it is typically two-thirds full of solution. The reference electrode should always have a quantity of undissolved copper sulfate crystals present in the solution to assure that the solution is saturated. The solution should always be azure blue and clear since contaminants can make the solution cloudy. If the solution is cloudy, compare the reference cell to a calibrated reference cell. If the difference between the reference cells is more than 10 millivolts, then the cloudy reference cell should be reconditioned.

5.2 Proper use of the reference electrode is as important as proper maintenance. Reference electrode placement can have varying effects on the accuracy of the tank-to-soil potential reading. Never place the reference cell in frozen or frosted soil, soil contaminated by hydrocarbon product, or any area above the tank which is shielded from the anode current, such as a containment sump, etc. Never place the reference cell on top of concrete since this can introduce substantial errors in the measurement.

5.3 If it is suspected that one of the conditions identified in Section 5.2 is present, place the reference electrode remote from the tank, in accordance with Section 6.3.

5.4 When inserting the reference electrode porous tip in the soil, assure good contact between the soil and the tip by twisting the electrode while inserting. Adding water to dampen the soil at the contact point will help provide good contact.

5.5 The meter connections for a standard commercial volt meter are; the positive (+) lead is connected to the tank, and the negative (-) lead is connected to the reference electrode. Set the meter to the autoscaling DC volts or manually set the meter to 2 volts DC or the next lowest available DC setting above 2 volts. If stable, record the reading.

5.6 If the readings are not stable, check all of the connections to ensure they are secure. If all connections are good, there may be stray currents in the area affecting the readings. If the reading continues to fluctuate, contact a cathodic protection specialist to determine if stray current is affecting the tank.
5.7 When conditions at the reference electrode location are suspected of affecting the reading accuracy, see Section 5.2. If necessary, the reference electrode should be relocated or the soil dampened. In some instances it may be necessary to place the reference electrode in native soil outside of the tank excavation. Accurately record both the reading and the location of the reference electrode.

6.0 TANK TESTING PROCEDURE

With a cathodically protected sti-P3® tank, the test methods require tank-to-soil potential measurements with respect to a permanently buried or portable copper/copper sulfate reference electrode placed in contact with the soil over the tank or remote from the tank. In addition, tank continuity and tank current requirement tests may be performed to obtain additional information about the cathodic protection system.

6.1 OVER THE TANK POTENTIAL READINGS

6.1.1 Place a portable copper/copper sulfate reference electrode in the soil over the top midpoint (or as near as possible) of the tank. For paved locations, soil can sometimes be found around vapor recovery units, automatic tank gauge riser, or other areas above the tank top. Check the soil for hydrocarbon or other contamination. If there is no contamination in the soil, place the reference cell in the soil, ensuring good contact is made between the soil and the porous tip by twisting the electrode while inserting. Pour water around the reference cell to help provide good electrical contact. If hydrocarbons are present, take remote reading as per section 6.3

6.1.2 Make the appropriate tank connection by either connection to the wire connected to the tank (PP2) or making a metallic connection to an exposed portion of the tank or by inserting a test lead down through the fill pipe and contacting the tank bottom.

6.1.3 Turn on the voltmeter to the 2 volt DC scale. Connect the negative test lead of the voltmeter to the reference cell. Connect the positive test lead of the voltmeter to the tank structure connection. Record the reading on the voltmeter.

6.1.4 Where the tank reading is more positive than -850 millivolts, perform the testing in Section 7 and 8.

6.1.5 A reading of -850 millivolts, or more negative, with respect to a copper/copper sulfate reference electrode is considered verification of adequate cathodic protection.

6.2 PERMANENT REFERENCE CELL READINGS

6.2.1 If a PP4 monitoring system is being used, then turn on the voltmeter to the 2 volt DC scale. Touch the negative test lead of the voltmeter to the contact for the reference cell, which is in the center of the PP4 test station marked with a “C”. Touch the positive test lead of the voltmeter to the tank structure connection contact, which is the numbered contact marked with either “1, 2, 3, or 4.” Accurately record the reading on the voltmeter.

6.2.2 The tank reading should be more negative than -850 millivolts. If the reading is more positive than -850 millivolts, perform the testing in Sections 7 and 8.
6.3 Remote Potential Readings

6.3.1 Place the reference cell in soil, approximately 30 feet (9.14 m) or more away from the tank. Try to place the reference cell in a place where there will be no metallic structures in between the tank and the reference cell. Connect the negative lead of the voltmeter to the reference cell. Connect the positive test lead of the voltmeter to the tank structure connection. Turn on the voltmeter to the 2 volt DC scale. Record the reading on the voltmeter.

6.3.2 The tank reading should be more negative than -850 millivolts. If the reading is more positive than -850 millivolts, perform the testing in Sections 7 and 8.

7.0 ELECTRICAL ISOLATION TESTING

7.1 In order to adequately cathodically protect the sti-P3® tanks, it is important that the tank be electrically isolated from metallic objects such as riser pipes, conduit, submersible pumps, leak detection equipment and any metallic piping. If a tank is not electrically isolated, this may be the cause for low cathodic protection measurements.

7.2 To check that there is no electrical circuit from the tank to the piping and other underground metallic structures, one test method is the Fixed Cell/Moving Ground test. This test method is detailed in sections 7.2.1-7.2.5.

7.2.1 The Fixed Cell/Moving Ground test method is a reliable means of verifying that the tank is isolated from all other buried metallic structures. The equipment requirements to properly perform the procedure include; a copper/copper sulfate reference electrode, a high impedance digital volt meter, and test leads of adequate length to reach structures adjacent to the tank.

7.2.2 Test any visible metallic object that is attached to the tank. Place the reference electrode in a location remote to the tank excavation. This location shall be at least 30 feet (9.14 m) away. Obtain a tank-to-soil potential reading for the tank using the procedure in Section 6.

7.2.3 Do not move the reference electrode from the selected position until the conclusion of this test procedure. Disconnect the meter lead from the tank structure connection.

7.2.4 Touch the positive (+) meter lead to all metallic objects that could possibly have continuity to the tank. These would include riser pipes, conduit, submersible pumps, leak detection equipment, electrical ground, and any metallic piping.

7.2.5 If a reading obtained from 7.2.4 above, or any other metallic object tested, is within 10 millivolts of the remote tank potential reading obtained in 7.2.2, that item may have continuity to the tank.

7.3 If an electrical short, i.e. continuity, is found between the tank and another object, move on to the current requirement test described in Section 8.0.

8.0 CURRENT REQUIREMENT TEST

8.1 The current requirement test procedure, for the purpose of this RP, will be used to determine if this RP is suitable for the tank being tested. Given that each tank is electrically isolated, the current requirement test is specific to one tank and must be performed on each tank that does not meet the -850 millivolt criteria.
8.1.1 If the current required is less than 30 milliamps, no further isolation testing is required. However, if the current required is greater than 30 milliamps, further isolation testing may be required.

8.2 The following connections shall be made, as directed in Paragraph 8.3, prior to beginning the test procedure. (See Figure 8.2.)

8.2.1 Negative (-) battery terminal to positive (+) lead of ammeter (multimeter)
8.2.2 Positive (+) battery terminal to the temporary anode
8.2.3 Negative (-) lead of voltmeter for tank potential to reference electrode
8.2.4 Positive (+) lead of voltmeter for tank potential to first tank connection
8.2.5 Negative (-) lead of ammeter (multimeter) to second tank connection - Setting ammeter to 200 mA, or lowest amp scale

8.3 Obtain a remote tank-to-soil potential measurement for the tank(s) before applying current.

8.3.1 Place reference electrode in remote soil at a location at least 30 feet (9.14 m) away from the tank end. Do not place reference electrode on pavement. (See Section 5.)
8.3.2 Take initial tank-to-soil potential measurements using the method described in Section 6.1 and 6.2 and record data.
8.3.3 Make battery connections to impress current through temporary anode. (See Figure 8.2.)
8.3.4 The temporary anode shall be located 100 feet (30.48 m) away from the tank on the end opposite the reference electrode location. Slowly insert the temporary anode into ground until a 1 milliampere reading is registered on ammeter.
8.3.5 Because an external power source is used during this test and the voltage applied by these systems is greater than normally supplied by an sti-P3 tank, “Instant Off” potentials readings must be obtained.
8.3.6 To obtain an “Instant Off” potential reading, apply the selected current for 1 minute. The current is turned off by disconnecting one of the current leads to the battery, while continuing to observe the voltmeter. Read and record the second reading displayed on the voltmeter after disconnecting current leads. If any difficulty occurs in obtaining this reading, reconnect the current lead and allow the test current to flow for at least an additional 30 seconds before interrupting the current again. Then repeat the “Instant Off” reading.
8.3.7 Insert temporary anode slightly deeper into soil and record the increase of current as measured on the ammeter.
8.3.8 Note new tank-to-soil potential measurement and record current and tank potential data.
8.3.9 Repeat this process until an “Instant Off” potential is between -850 and -1050 millivolts.
8.3.10 Record the final current measurement as shown on the ammeter as required to achieve the requirements of 8.3.9. This is the current requirement.
FIGURE 8.2
CURRENT REQUIREMENT TEST SETUP
8.4 For current requirements less than 30 milliamperes (0.030 amperes) the use of sacrificial anodes to extend the life of the cathodic protection system is feasible. Current requirements greater than 30 milliamperes might indicate a continuity problem which may not be easily identified, such as hold down straps, and can shorten the life of a sacrificial anode. In such situations, verification of the tank system as an sti-P3® is suggested. If the current requirement exceeds 30 milliamperes contact Steel Tank Institute or a qualified corrosion consultant, as defined by the applicable Federal, State, and Local regulations.

8.5 **SOIL RESISTIVITY TEST**

8.5.1 Soil resistivity may either be obtained by direct measurement at the UST site or by contacting the local gas utility, who may have soil resistivity data for the UST site area.

8.5.2 Direct measurement of soil resistivity is accomplished using the Wenner Four Pin method.

8.5.3 Figure 8.5.3 depicts the measurement being taken using the Nilsson model 400 soil resistivity meter, but any equivalent instrument specifically designed for performing this test may be used.

8.5.4 Follow the instructions given in the instrument's manual or the tester may refer to ASTM Test Method G57-95 “Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method”. Compare this against above to determine differences.

8.5.5 The measurement shall be made using a pin spacing at least equal to or up to 5 feet (1.52 m) greater than the tank bottom depth.

8.5.5.1 The depth that the measurement is taken at is determined by the distance between the pin spacing.

8.5.5.2 Example: If the tank is 8 feet (2.44 m) in diameter and is buried to a depth of 3 feet (0.91 m) below grade, the pins should be spaced between 11 feet (3.35 m) and 16 feet (4.88 m) apart. Typically the pins would be spaced at 15 feet (4.57 m) apart.

8.5.6 The soil resistivity measuring pins shall be placed either parallel or perpendicular to the UST but shall be no closer than 20 feet (6.10 m) of the nearest UST as measured from the tank center line or tank head, which ever is greater.

8.5.7 The pins should not be placed over any metallic piping or other buried metal structure. If the only soil area available does not meet the criteria of 1.6, then readings shall be taken at three different locations. All three readings shall be taken at the same pin spacing, as determined by the tank bottom depth (Paragraph 8.4.5.2). Use the average of the three readings to determine the number and size of anodes (Table9.1.1).
FIGURE 8.5.3
SOIL RESISTIVITY TEST SETUP

NOTES:
1. Pins should only be inserted as deep as necessary to obtain a reading with instrument. Additional depth can cause reading inaccuracy and makes later pin removal more difficult.

2. Make measurement with specialty meter designed for this purpose. Current applied between outer pins (from terminals C1 & C2) supplies these instruments is usually 97 Hz AC eliminating measurement inaccuracy caused by inst D C or 60 Hz AC earth currents.

3. The basic Wenner Formula computes the average Resistivity ($\rho$) of a Hemi-Cylinder of Earth whose radius (depth) is equal to the Pin Spacing (pin spacing can be any uniform amount).

4. Wenner Formula: $\rho = 2 \times 3.14 \times a \times R$ where:
   - $\rho$ = resistivity in ohm cm
   - $a$ = pin spacing in centimeters
   - $R$ = resistance measured with meter based on AC current flow between outer pins (C1 & C2), the resultant voltage (potential) drop between the inner pins (P1 & P2) and the meter which converts these values to based on Ohms Law where $R = \frac{E_1}{(P1 \cdot P2)/(C1 \cdot C2)}$.

   Note: If a pin spacing of 5 feet 3 inches is used, $2 \times 3.14 \times 2.54 \text{ cm} \times 12 \text{ inches} \times 5.25 \times \frac{\text{inches}}{\text{feet}} = 1000 \times R$.
   Similarly, if a pin spacing of 10 feet 3 inches gives an $R$ multiplier of 2000.
   - and a pin spacing of 15 feet 9 inches gives an $R$ multiplier of 3000

<table>
<thead>
<tr>
<th>Constant</th>
<th>Multiplier</th>
<th>Pin Spacing Pt</th>
<th>Pin Spacing Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>191.5</td>
<td>500</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>191.5</td>
<td>1000</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>191.5</td>
<td>1500</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>191.5</td>
<td>2000</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>191.5</td>
<td>2500</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>191.5</td>
<td>3000</td>
<td>15</td>
<td>8</td>
</tr>
</tbody>
</table>
8.5.8 The Wenner four pin method uses the following formula:

\[
\rho = 191.5 \times a \times R
\]

where:
- \(\rho\) = average soil resistivity in ohm-centimeters measured to a depth equal to the spacing between pins
- 191.5 = constant to convert formula where pin spacing is measured in feet and resultant resistivity is expressed in ohm-centimeters.
- \(a\) = pin spacing in feet
- \(R\) = meter reading when using Nilsson Model 400 = balance dial reading x multiplier dial reading or equal AC Soil Resistivity Meter as measured in ohms (alternatively if using DC method = \(E/I\))

9.0 DETERMINING THE AMOUNT OF SUPPLEMENTAL ANODES NEEDED

9.1 ANODE REQUIREMENT

9.1.1 Except for special circumstances, the preferred anode for use as a field supplement to cathodic protection is magnesium due to its higher driving potential. Install the quantity of anodes as defined in Table 9.1.1.

9.1.2 If the soil or excavation soil is suspected of having a resistance lower than 1500 ohm-cm the use of zinc anodes will promote longer anode life. For zinc anode requirements per the sti-P3® specification contact the Steel Tank Institute.

9.1.3 Table 9.1.1 is based on using a wired-on, high potential magnesium alloy type anode, pre-packaged in a special anode grade backfill. It is also based on a current requirement of 30 milliamps or less.

<table>
<thead>
<tr>
<th>SOIL RESISTIVITY (OHM-CM)</th>
<th>TOTAL ANODE WEIGHT REQ’D (LBS)</th>
<th>NO. OF ANODES &amp; SIZE OF EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,500-4,000</td>
<td>64 (29.03 kg)</td>
<td>2 ea. 32 lbs (14.51 kg)</td>
</tr>
<tr>
<td>4,001-10,000</td>
<td>34 (15.42 kg)</td>
<td>2 ea. 17 lbs (7.71 kg)</td>
</tr>
<tr>
<td>10,001-20,000</td>
<td>40 (18.14 kg)</td>
<td>2 ea. 20 lbs (9.07 kg)</td>
</tr>
<tr>
<td>20,001-30,000</td>
<td>60 (27.22 kg)</td>
<td>3 ea. 20 lbs (9.07 kg)</td>
</tr>
<tr>
<td>30,001-40,000</td>
<td>80 (36.29 kg)</td>
<td>4 ea. 20 lbs (9.07 kg)</td>
</tr>
</tbody>
</table>
9.1.4 A minimum of two (2) anodes are required for each tank. The types of magnesium anodes for this table are 17 pound (7.71 kg) (17D3 Type), 20 pound (9.07 kg) (20D2 Type), or 32 pound (14.51 kg) (32D5 Type) sizes.

10.0 ANODE HANDLING AND INSTALLATION

10.1 The key to the efficient operation of any system is the proper installation of the system components. Proper field procedures used during the installation will help ensure long term performance of the additional anodes.

10.2 The key components in a galvanic protection system are galvanic anodes, lead wires, wire connections, and test stations.

10.3 Handle the anode carefully. Do not lift by, or pull on the anode wire. Do not handle using end of bag. Carry the anode by cradling in both hands. Avoid deformation and damage to the cotton bag and subsequent loss of fill material.

10.4 Galvanic anodes should be prepackaged in select backfill. The anodes will have a #12 solid lead wire connected at the factory.

10.5 The anodes shall be placed as shown in Figure 10.5. There shall be a minimum 18 inches (0.46 m) between the tank head and the anode(s) and a minimum of 5 feet (1.52 m) between anodes.

10.6 It is recommended that the top of the anodes be installed within 1 foot (0.30 m) of the tank bottom depth.

10.6.1 For example, if the tank had a 10 foot (3.05 m) diameter and has a 3 foot (0.91 m) burial depth, the bottom of the tank would be at 13 feet (3.96 m) from grade. The anode would be buried to a depth of 12 to 14 feet (3.66-4.27 m). If the anode is placed horizontally, it would be 12 to 14 feet (3.66-4.27 m) deep. If the anode is placed vertically, the anode has to be placed deep enough so that the top of the anode was 12 feet (3.66 m) deep or greater. The length of the anode must be considered. If the anode is 3 feet (0.91 m) long, then auger a hole to a minimum of 15 feet (4.57 m), maximum of 17 feet (5.18 m). (See Figure 10.5.)

10.7 Anodes are sometimes shipped in water-proof paper or plastic bags. These bags must be removed prior to installation. The cloth bag containing the special fill material must be left intact both during and after installation.

10.8 When lowering an anode into an excavation, use a rope tied around the anode. Do not drop the anode or attempt to lower it by the lead wire.

10.9 Prior to backfilling, thorough watering of the anode(s) in place will activate it more quickly so that evaluation of the installation can be done immediately after backfilling and connection is complete.

11.0 ELECTRICAL CONNECTIONS

11.1 The importance of excellent electrical connections cannot be overemphasized. The galvanic system relies upon the flow of very small currents which must have proper connections in order to operate. These small potentials cannot overcome the resistance in a poor electrical wire connection or one that becomes poor because proper precautions were not taken to preserve it from contamination and a consequential build-up of resistance to the current.
FIGURE 10.5
PLACEMENT OF SUPPLEMENTAL ANODES AROUND TANK
11.2 **Should combustible vapors exist, do not use a thermite welding procedure. Instead, mechanical methods of tank connection must be employed.** Make a mechanical connection to the tank at the lift lug(s). An air drill may be utilized to provide a hole in a lifting lug where hardware can be attached to hold the lead wire. See Figure 11.2. A lug type connector is very effective for clamping the wire.

11.3 Always install the connection so that there is slack in the lead wire. The tank and soil may settle or move over time which could cause a strain to be placed on the wire, possibly causing it to break.

11.4 Prior to making any connection, clean the tank surface and the wire connector to ensure a good long term electrical bond. Some roughing of the surface may be required.

11.5 Each wire connection to the tank shall be coated to insure the connection is waterproof. The coating material must also be compatible with the tank.

11.6 Wire splices are to be avoided and all precautions shall be taken to furnish plenty of wire so that splices will not be required in the field. However, in the event splicing is unavoidable, provide a soldered “Western Union” splice sealed with a mastic filled, heat shrinkable tube designed for use “in-line” underground splices. The spliced wires must be insulated from the ground and sealed from moisture.

### 12.0 TEST STATION INSTALLATION

12.1 To monitor a galvanic cathodic protection system, test stations which permit IR drop compensated reading are required. There should be at least one test lead available for each tank. Often, a single test station is used as a common point for monitoring all of the tanks at a particular site.

12.2 Cathodic protection test stations should be clearly marked, readily accessible, and located away from the heavy traffic patterns at the site. They typically include a structure lead wire connected directly to the tank and allow for placement of a reference electrode in the soil adjacent to the tank.

12.3 The test station may incorporate a buried reference electrode to aid in consistent monitoring of the galvanic system.

12.4 Some test stations will allow for the measurement of the anode current output. This type of test station includes a calibrated resistor called a shunt. The shunt is located in line between the anode and the tank. A separate structure lead should be provided with this test station for use when obtaining a tank-to-soil potential.
FIGURE 11.2
ANODE/TEST STATION LEAD WIRE ATTACHMENT TO LIFT LUG
13.0 VERIFICATION OF SYSTEM OPERATION

13.1 Once the final anode connections have been completed and the anode has been backfilled, verification of the system operation is possible. Verification can be accomplished by performing the tank-to-soil potential reading per Section 6.0.

13.2 After correct operation of the system has been verified, fill out the record keeping form completely. See Figure 13.2. Once completed, place this form with the other tank cathodic protection records at the tank site.

14.0 DISCLAIMER

14.1 This RP is available for general use by those interested. Every effort has been made to ensure that the information contained within this RP is accurate and reliable. However, neither STI nor its corrosion consultant shall be held liable in any way for loss or damage resulting from such use or for violation of any federal, state, or municipal regulation with which it may conflict.

14.2 This may be revised or withdrawn at any time without prior written notice. This does not necessarily address all of the applicable health and safety risks and precautions with respect to particular materials, conditions, or procedures. Information concerning safety and health risks and precautions should be obtained from the applicable standards, regulations, suppliers of materials, or material safety data sheets.
Date Anodes Added:

INSTALLER INFORMATION
Name: Company:
Address: Phone:

Before Anode Installation:
Indicate Location and Value of All Potential Readings

Tank is Isolated from Other Metallic Structures: □
Current Requirement Measurement (mA):
Soil Resistivity:
Number of Anodes Installed:
Weight of Each Anode:

After Anode Installation:
Indicate Location and Value of All Potential Readings

Indicate Placement of Anodes on the Tank:

Signature: Date:

FIGURE 13.2
Record Keeping Form When Adding Anodes to sti-P3® Tanks
APPENDIX A

DESCRIPTION OF PP2, PP4, AND IR DROP COMPENSATED TEST STATIONS

PP2, which stands for Protection Prover 2, is an insulated wire electrically connected to the tank via a mounting plate. This system is provided on most sti-P3® tanks. The installation of the PP2 to the tank is the responsibility of the tank manufacturer. When the tank is installed, the installer has the responsibility of bringing this PP2 wire up to surface grade into one of the openings in the concrete. In the past, these wires used to be brought up coiled around the outside of the fill pipe. However, since the requirement of spill containment, the wire is typically brought into an unused opening of the tank concrete cover. In this location, the cathodic protection tester can place the reference cell in the backfill in this hole and connect the multimeter in the same place. The PP2 wire, once confirmed that it is still continuous with the structure, is an excellent source to connect the supplemental anodes to the structure. Once the PP2 wire and the supplemental anode wires are brought to the surface, they should be connected inside of an IR Drop Compensated Test Station.

PP4, which stands for Protection Prover 4, is a system incorporating a buried reference cell and 2-4 wire leads that terminate in a test station head. The 2-4 wires are connected to the PP2 wires from 2-4 sti-P3® tanks. This system utilizes a buried reference cell which is buried beneath the tanks and measures the electrochemical potential differences at the most susceptible area of the tank, the bottom. It also ensures that the reference cell placement variable is constant for each measurement. Measurements using this system can be performed by the tank owner at anytime by taking the voltmeter and connecting the test leads to the PP4 test station metallic contacts.

IR Drop Compensated Test Stations have several components. They have test terminals, structure wires, anode wires, and sometimes buried reference cell wires. The structure leads can be connected to the anode leads directly at the terminal or they can be connected via a low resistance shunt. The test station allows the cathodic protection tester to take “Instant On” readings, “Instant Off” readings, voltage drop across the known resistance value of the shunt to calculate current output of the anodes, as well as anode potential readings. The test station should be shielded or sealed off as best as possible from moisture ingress. This will reduce the amount of corrosion resistance introduced into the cathodic protection system. These test stations can be used with the PP2 system and the buried reference cells from the PP4 system.
REFERENCES

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

STI R821
“Steel Tank Institute Installation Instructions for sti-P3®”

NACE, International RP 0285
“Corrosion Control of Underground Storage Tank Systems by Cathodic Protection”

Petroleum Equipment Institute RP100
“Recommended Practices for Installation of Underground Liquid Storage Systems”

ASTM G57-95a,
“Method for Field Measurement of Soil Resistivity Using the Wenner Four-PIN Method”