Kentucky Department for Environmental Protection
Division of Waste Management
Underground Storage Tank Branch
300 Sower Boulevard, Second Floor – Frankfort KY 40601
(502) 564-5981

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DO NOT WRITE IN THIS SPACE

UST Galvanic Cathodic Protection Evaluation

1. UST Facility Information

Agency Interest Number (AI)			
UST Facility Name			
UST Facility Physical Address	Street Address:		
	City:	County:	Zip Code: -

2. Cathodic Protection Tester Evaluation *(mark only one)*

Date of Evaluation	/ /		
Reason for Evaluation *(mark only one)*	☐ New Install *(within 180 days)*	☐ Re-evaluation following repair / modification *(within 180 days)*	
	☐ Routine *(every 36 months)*	☐ Re-evaluation following a failure *(within 30 days)*	

All protected structures at this UST facility pass the cathodic protection system evaluation and it is judged that adequate cathodic protection has been provided to the UST system. Complete Section 4.	☐ **Pass**
One or more protected structure at this UST facility fail the cathodic protection system evaluation and it is judged that adequate cathodic protection has not been provided to the UST system. Complete Section 5.	☐ **Fail**
If the remote and the local potential readings do not both indicate the same test result on all protected structure (both pass or both fail), the cathodic protection system shall be re-evaluate and/or retested by a corrosion expert. Complete Section 3.	☐ **Inconclusive**

I certify that all the information provided on this document is true, accurate, and complete.

Cathodic Protection Tester Certification	*Printed*		**Date**	/ /
	Signature			
Certification Type *(mark all that apply)*	☐ NACE	☐ STI	☐ Other *(specify):*	
Certification	Number:	Expiration Date: / /		
Contact Information	Phone: ( ) -	Email:		
Company Name				

3. Corrosion Expert Evaluation *(mark only one)*

The evaluation shall 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 without following an acceptable industry code.

Date of Evaluation	/ /

All protected structures at this UST facility pass the cathodic protection system evaluation and it is judged that adequate cathodic protection has been provided to the UST system. Complete Section 4.	☐ **Pass**
One or more protected structure at this UST facility fail the cathodic protection system evaluation and it is judged that adequate cathodic protection has not been provided to the UST system. Complete Section 5.	☐ **Fail**

I certify that all the information provided on this document is true, accurate, and complete.

Corrosion Expert Certification	*Printed*		**Date**	/ /
	Signature			
	License #		**License Expiration Date**	/ /

AI _____

4. Applicable Evaluation Criteria *(mark all that apply)*

Structure-to-soil potential more negative than -850mV with respect to a $Cu/CuSO_4$ reference electrode with the protective current applied. Applicable to any galvanically protected structure.	☐ **850 On**
Structure-to-soil potential more negative than -850mV with respect to a $Cu/CuSO_4$ reference electrode with the protective current temporarily interrupted. Applicable to galvanic systems where anodes can be disconnected.	☐ **850 Off**
Structure tested exhibits at least 100mV of cathodic polarization. Applicable to galvanic systems where anodes can be disconnected.	☐ **100 mV Polarization**

5. Required Actions *(mark only one)*

Cathodic protection is adequate. No further action is necessary at this time. Next evaluation due 3 years from the date of this evaluation or if another reason listed in Section 2 (Reason for Evaluation) occurs.	☐ **None**
Cathodic protection may not be adequate. Re-evaluate during the next 90 days to determine if passing results can be achieved.	☐ **Re-evaluation**
Cathodic protection is not adequate. A repair or modification is necessary as soon as practical, but within the next 90 days.	☐ **Repair & Re-evaluation**
Next Cathodic Protection Evaluation shall be completed by	/ /

6. Description of Evaluated UST System

Tank	Product	Capacity *(gal)*	Tanks	Piping	Flex Connectors	
					STP	UDC
1						
2						
3						
4						
5						
6						

7. Description of Cathodic Protection System Repairs and/or Modifications

Provide detailed information about all modifications or repairs made to the cathodic protection system. Provide a detailed drawing below of the UST facility and cathodic protection systems. Sufficient detail shall 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. At a minimum indicate the following:

a) Tanks
b) Piping
c) Dispensers
d) Buildings and Streets
e) Anodes and Wires
f) Location of CP Test Stations
g) Each reference electrode placement (indicated by a code: 1, 2, T-1, T-2) corresponding with the appropriate line number in Section 9.

☐ Supplemental anodes for metallic pipe *(attach corrosion expert's design or documentation that industry standard was followed).*

☐ Supplemental anodes for a sti-P^{3} ® *tank (attach corrosion expert's design or documentation that industry standard was followed).*

☐ Galvanically protected tanks/piping not electrically isolated *(explain in "Remarks/Other" below).*

Remarks/Other	
Detailed Drawing	

AI _____

8. Galvanic (Sacrificial Anode) Cathodic Protection System Continuity Survey

Use this section to document measurements of continuity on UST systems that are protected by galvanic cathodic protection systems.

Structure "A"[1]	Structure "B"[2]	Structure "A" Fixed Remote Voltage[3]	Structure "B" Fixed Remote Voltage[4]	Point-to-Point Fixed Remote Voltage[5]	Isolated / Continuous / Inconclusive[6]
Premium Tank Bottom	Premium Tank Fill Riser	-921 mV	-915 mV		Inconclusive
Premium Tank Bottom	Premium Tank Fill Riser			17 mV	Isolated
Comments					

[1] Describe the cathodically protected structure being demonstrated as isolated from unprotected structures (e.g. premium tank bottom).
[2] Describe the unprotected structure being demonstrated as 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 (fixed cell and/or point-to-point) indicated the protected structure was isolated, continuous or inconclusive.

AI _____

9. Galvanic (Sacrificial Anode) Cathodic Protection System Survey

Use this section to document a survey of a galvanic cathodic protection system by obtaining structure-to-soil potential measurements.

Location Code[7]	Structure[8]	Contact Point[9]	Local Reference Cell Placement[10]	Local Voltage[11]	Remote Voltage[12]	Pass / Fail / Inconclusive[13]
Example 1	Plus Tank	Tank Bottom	Plus Tank STP Manway	-928 mV	-810 mV	Inconclusive
Example 2	Plus Piping	Dispenser 5/6	Under Dispenser 5/6	-890 mV	-885 mV	Pass

Comments	

If you have questions on how to fill out this form please contact the cabinet at (502) 564-5981 or visit our web site at http://waste.ky.gov/ust. For copies of UST facility records please visit http://eec.ky.gov/pages/openrecords.aspx or email EEC.KORA@ky.gov.

[7] 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.).
[8] Describe the structure that is being tested (e.g. plus tank, premium piping, flex connector, etc.).
[9] Describe where contact with the structure that is being tested is made (e.g. plus tank @ test lead, diesel piping @ dispenser 5/6, etc.)
[10] Describe the exact location where the reference electrode is placed for each "local" measurement (e.g. soil @ plus tank STP, soil @ dispenser 5/6, etc.).
[11] Record the structure-to-soil potential measured with the reference electrode place "local" in millivolts (e.g. -865 mV).
[12] Recorded the structure-to-soil potential measured with the reference electrode placed "remote" (copy voltage that was obtained during continuity survey).
[13] Indicate whether the tested structure passed or failed the -850 mV "on" criterion based on the interpretation of the test data.

GENERAL INSTRUCTIONS
UST Galvanic Cathodic Protection Evaluation

Instructions provided are for the DWM 4226, UST Galvanic Cathodic Protection Evaluation form. For any questions regarding any section of this form, please call the Division of Waste Management's Underground Storage Tank (UST) Branch. This form must be completed either by typing or by printing legibly with black ink.

Submit DWM 4226 form via mail, fax, or electronically:

Kentucky Department for Environmental Protection
Division of Waste Management
Underground Storage Tank Branch
300 Sower Boulevard, Second Floor
Frankfort, KY 40601
Phone: (502) 564-5981
Fax: (502) 564-0094
http://waste.ky.gov/UST

I. Continuity Testing Procedure

A. 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. Ensuring 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. The 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 direct current (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, product piping, flex connectors/swing joints, vent lines, electrical conduits, dispensers, utilities, etc.
7. Obtain voltage for each component and record on the continuity testing portion of the form DWM 4226 and DWM 4227.
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.

B. Fixed Cell – Moving Ground Data Interpretation

1. If two (2) or more structures exhibit potentials that vary by 2mV or less, the structures are considered to be electrically continuous.
2. If two (2) or more structures exhibit potentials that vary by 10mV or greater, the structures are considered to be electrically isolated.
3. If two (2) or more structures exhibit potentials that vary by more than 2mV, but less than 10mV, the result is inconclusive and further testing (point-to-point) is necessary.

II. 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 (1) voltmeter test lead to one (1) of the structures, for which continuity is being tested, and connect the other voltmeter test lead to the other structure that is being tested.
5. Record voltages observed on each of the two (2) structures that are being compared and record on the continuity testing portion of the form DWM 4226 and DWM 4227.

   Note: Testing with this method does not require a reference electrode. The two (2) 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.

B. Point-to-Point Data Interpretation

1. If the voltage difference observed between the two (2) structures is 1mV or less, this indicates the two (2) structures are considered to be electrically continuous with each other.
2. If the voltage difference observed between the two (2) structures is 10mV or greater, this indicates that the two (2) structures are considered to be electrically isolated from each other.
3. If the voltage difference observed between the two (2) structures is greater than 1mV but less than 10 mV, the result is inconclusive and further testing beyond the scope of this document is necessary.

III. Structure-to-Soil Test Procedure

1. Place voltmeter on 2 volt DC scale.
2. Connect voltmeter negative lead to reference electrode.
3. Place reference electrode in clean soil directly over the structure that is being tested to obtain local potential. At least one (1) local potential is required for each tank, preferably the test point is at the approximate midpoint along the centerline of the tank. Piping may require measurement at each end of the pipe and at the middle depending upon anode configuration.
    a) The reference electrode may not be placed on concrete or other paving materials.
    b) Ensure the reference electrode is placed in a vertical position (tip down).
    c) Ensure the soil where the reference electrode is placed is moist, add tap water if necessary.
    d) Ensure the soil where the reference electrode is placed is not contaminated with hydrocarbons.
    e) Ensure the reference electrode window is not exposed to direct sunlight.
4. Connect voltmeter positive lead to structure that is to be tested.
    a) If a test lead wire is utilized to make contact with the tested structure, ensure that continuity exists between the test lead wire and the structure. This may be accomplished by conducting a point-to-point continuity test.
    b) Ensure good metal-to-metal contact is made between the test lead clip/probe and the structure.
    c) Ensure no corrosion exists where the test lead makes contact with the structure.
    d) Ensure your body does not come into contact with the electrical connections.
    e) Ensure test leads are not submerged in any standing water.
    f) Ensure test lead insulation is in good condition.
    g) sti-P3® tanks
    h) If the test lead wire is not continuous or is not present, contact with the inside bottom of the tank is necessary. This may be accomplished by connecting the voltmeter lead wire to a test prod mounted onto the bottom of a wooden gauging stick and lowering the stick into the tank fill riser. Be sure that firm contact is made with the tank bottom. Care should be taken to ensure that any drop tube that may be installed in the tank does not prohibit contact with the tank bottom. If a metallic probe bar is utilized to contact the tank bottom, ensure that the probe bar does not contact the fill riser or any other metallic component of the UST system.
    i) 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 (both local and remote).
5. Obtain voltage and record in the local column on the galvanic cathodic protection system evaluation form DWM 4226.
6. Place reference electrode in clean soil remote from the protected structure.
7. Obtain voltage and record in the remote column on the galvanic cathodic protection system evaluation form DWM 4226. (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.)
8. Data Interpretation – refer to the Generalized Interpretation chart below.
    a) If both the local and the remote potential are –850mV or more negative, the 850 on criterion is satisfied and it is judged that adequate cathodic protection has been provided.
    b) If either the local or the remote potential is more positive than –850mV, the test result is inconclusive and further testing and/or repairs are necessary. Alternatively, a person qualified as a corrosion expert could evaluate/conduct the survey and declare a pass or fail based on their interpretation and professional judgment.

Generalized Interpretation of Structure-to-Soil Potential Measurements (Voltages) Obtained On Galvanic Cathodic Protection Systems

Voltage (mV) "On"	Generalized Interpretation*
Positive	Test leads are reversed (negative should be connected to the reference electrode and the positive should contact the structure being tested in order to observe negative voltages). Could indicate that stray current is affecting the structure. Consult with a corrosion expert.
0 to -100	Usually occurs when attempting to measure a structure that has a test lead that is not continuous with the tank. Since measuring the potential of a copper wire with reference to the copper-copper sulfate half-cell, the potential is zero or very near it. Disregard test lead and make direct contact with the protected structure.
-101 to -399	Try again. A reading in this range is not normally seen on an underground steel structure. Could indicate that steel structure is electrically connected to a significant amount of a more noble metal (e.g., copper). Very corroded low carbon steel may also be indicated.
-400 to -599	Steel structure does not meet regulatory requirements. Usually means the steel structure has no cathodic protection. Existing sacrificial anodes could be completely "burned out" or were never there to begin with.
-600 to -849	Steel structure does not meet regulatory requirements. Usually means that the steel structure has anodes but for whatever reason, something is causing a low reading that may indicate adequate cathodic protection has not been provided. The anodes may be trying to protect a structure that requires more current than they can produce. The protected steel structure may not be electrically isolated from all other metallic structures (conduct continuity testing). The environmental conditions may not be favorable at the time the attempt to obtain the reading. Retest during the next ninety (90) days to see if an acceptable reading can be obtained.
-850 to -1100	Steel structure protected by zinc anodes meets regulatory requirements and cathodic protection is judged to be adequate. Readings in this range are what would be expected on most sti-P_3® tanks that have not been modified and are reading "good" since nearly all come from the manufacturer with zinc anodes.
-850 to -1600	Steel structure protected by magnesium anodes meets regulatory requirements and cathodic protection is judged to be adequate. Readings in this range are what would typically be expected on steel piping that is reading "good" since magnesium anodes are generally installed on piping. Also, readings up to -1600mV on a sti-P3® tank that has been retrofitted or was supplied at the factory, with magnesium anodes.
More Negative -1100 with Zinc Anodes Only	Voltages more negative than -1100mV are theoretically not possible if there are only zinc anodes installed. If a reading more negative than -1100mV is obtained and the magnesium anodes are not present, suspect that stray current may be affecting the cathodically protected structure. A corrosion expert should be contacted immediately since stray current can cause a corrosion failure in a relatively short period oftime.
More Negative than -1600	Voltages more negative than -1600mV are theoretically not possible with any sacrificial anode cathodic protection system. If a reading more negative than -1600mV is obtained on any galvanic cathodic protection system, suspect that stray current may be affecting the cathodically protected structure. A corrosion expert must be contacted immediately since stray current can cause a corrosion failure in a relatively short period oftime.
Variable	If the voltmeter readings vary, suspect that stray current may be affecting the cathodically protected structure. Sometimes, the stray current can cause a pattern to develop that is recognizable. An example would be the on/off pattern of a nearby DC powered welding operation. A corrosion expert must be contacted immediately since stray current can cause a corrosion failure in a relatively short period of time.
Rapidly Fluctuating	If the voltmeter will not stabilize, it usually means there is a high electrical resistance somewhere. Check all lead wires and connections and make sure a solid and clean metal-to-metal connection is obtained. Soil where the reference electrode is placed could be too dry. Add water to the soil or wait until a heavy rain occurs and try again. Petroleum contaminated soils may cause a high contact resistance. The tip of the reference electrode may need to be cleaned or replaced.

*Site-specific conditions may produce differing interpretations.