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 Impressed Current 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 temporarily interrupted (instant-off). | ☐ **850 Off** |
| Structure tested exhibits at least 100mV of cathodic polarization. | ☐ **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. Impressed Current Rectifier Data

| Manufacturer | Model | Serial Number | Rated DC Output | | Initial Design or Lastly Recommended Output | |
|---|---|---|---|---|---|---|
| | | | Volts | Amps | Volts | Amps |

| Event | Date | Tap Setting | | DC Output | | Hour Meter | Comments |
|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | Volts | Amps | | |
| "As Found" | / / | | | | | | |
| "As Left" | / / | | | | | | |

## 8. Impressed Current Positive & Negative Circuit Measurements (Output Amperage)

*Complete if system is designed to report on measurements (e.g., individual lead wires for each anode are installed and measurement shunts are present).*

| Circuit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anode (+) | | | | | | | | | | | |
| Tank (-) | | | | | | | | | | | |

## 9. Description of Cathodic Protection System Repairs and/or Modifications

Provided 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 10.

☐ Additional anodes for an impressed current system *(attach corrosion expert's design).*

☐ Repairs or replacement of rectifier *(explain in "Remarks/Other" below).*

☐ Anode header cables repaired and/or replaced *(explain in "Remarks/Other" below).*

☐ Impressed current protected tanks/piping not electrically continuous *(explain in "Remarks/Other" below).*

| | |
|---|---|
| **Remarks/Other** | |

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| **Description of Cathodic Protection System Repairs and/or Modifications** *(continued from Section 9)* | |
|---|---|
| **Detailed Drawing** | |

**10. Impressed Current Cathodic Protection System Continuity Survey**

*Complete to document measurements of continuity on UST systems that are protected by impressed current cathodic protection systems.*

| **Structure "A"[1]** | **Structure "B"[2]** | **Structure "A" Fixed Remote Instant Off Voltage[3]** | **Structure "B" Fixed Remote Instant Off Voltage[4]** | **Point-to-Point Voltage Difference[5]** | **Isolated / Continuous / Inconclusive[6]** |
|---|---|---|---|---|---|
| Plus Tank Bottom | Plus Steel Line @ STP | -915 mV | -908 mV | | Inconclusive |
| Plus Tank Bottom | Plus Steel Line @ STP | | | 1 mV | Continuous |
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| **Comments** | |
|---|---|

[1] Describe the cathodically protected structure being demonstrated as isolated from unprotected structures (e.g. plus tank bottom).
[2] Describe the "other" protected structure being demonstrated as continuous (e.g. plus steel 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 protected structure "B" in millivolts (e.g. -908 mV).
[5] Record the voltage difference observed between structure "A" and "B" when conducting point-to-point testing (e.g. 1 mV).
[6] Document whether the test (fixed cell and/or point-to-point) indicated the protected structure was isolated, continuous or inconclusive.

**AI** _____

## 11. Impressed Current Cathodic Protection System Survey

*Use this section to document a survey of an impressed current cathodic protection system by obtaining structure-to-soil potential measurements.*

| Location Code[7] | Structure[8] | Contact Point[9] | Local Reference Cell Placement[10] | On Voltage[11] | Instant Off Voltage[12] | Ending Voltage[13] | Voltage Change[14] | Pass / Fail[15] |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 100 mV Polarization | | |
| Example 1 | Plus Tank | Tank Bottom | Soil @ UNL tank STP Manway | -1070 mV | -875 mV | | | Pass |
| Example 2 | Diesel Piping | Dispenser 7/8 | Soil @ DSL tank Manway | -810 mV | -680 mV | -575 mV | 105 mV | Pass |
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| 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, diesel piping, flex connector, etc.).
[9] Describe where contact with the structure that is being tested is made (e.g. plus tank bottom, diesel piping @ dispenser 7/8, etc.)
[10] Describe the exact location where the reference electrode is placed for each measurement (e.g. soil @ UNL tank STP manway, soil @ DSL tank manway, etc.).
[11] Record the structure-to-soil potential observed with the current applied (e.g. -1070 mV).
[12] Record the structure-to-soil potential observed with the current is interrupted (e.g. -875 mV).
[13] 100 mV Polarization test only – Record the voltage observed at the end of the test period (e.g. 575 mV).
[14] 100 mV Polarization test only – Subtract the final voltage from the instant off voltage (e.g. 680- mV – 575 mV = 105 mV).
[15] Indicate if the tested structure passed or failed one of the two acceptable criteria (850 instant off or 100 mV polarization) based on interpretation of the data.

GENERAL INSTRUCTIONS
**UST Impressed Current Cathodic Protection Evaluation**

Instructions provided are for the DWM 4227, UST Impressed Current 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 4227 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.

C. **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.

D. **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.

II. Structure-to-Soil Test Procedure

1. Inspect rectifier for proper operation and document necessary information. This includes measurement of output voltage/amperage with a multimeter (do not rely on rectifier gauges) and measurement of individual anode circuits, if installation allows such. Record all necessary information under Section 7 and 8 of the UST Impressed Current Cathodic Protection System Evaluation, DWM 4227.
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 one (1) measurement must be taken for each tank, preferably the test point is usually the center of the tank. Piping normally requires measurement at each end of the pipe.
    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.
5. Connect voltmeter positive lead to structure that is to be tested.
    a) Ensure good metal-to-metal contact is made between the test lead clip/probe and the structure.
    b) Ensure no corrosion exists where the test lead makes contact with the structure.
    c) Ensure your body does not come into contact with the electrical connections.
    d) Ensure test leads are not submerged in any standing water.
    e) Ensure test lead insulation is in good condition.
6. Obtain voltage potential with the protective current applied and record in the on column on the UST Impressed Current Cathodic Protection System Evaluation, DWM 4227.
7. Without moving reference electrode from the position it was in during Step 6 above, obtain voltage potential with the protective current temporarily interrupted and record in the instant off column on the UST Impressed Current Cathodic Protection System Evaluation, DWM 4227.
8. The instant off potential is the second value 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.
9. In order to obtain instant off potentials, a current interrupter or a second person is necessary. If a current interrupter is not available, have the second person turn the power switch off at the rectifier for three (3) seconds and then back on for fifteen (15) seconds. Repeat this procedure until an accurate instant off reading has been obtained.
10. Conduct a 100mV polarization decay if unable to obtain an instant off potential of -850mV or more negative in Step 7 above. While not a requirement of this form, consideration should be given to adjusting the rectifier output until an instant off potential of -85 mV is achieved or the maximum safe output is reached. It is only necessary to conduct 100mV polarization where the lowest (most positive) instant off potential is observed on the UST system.
11. 100mV of polarization is determined by leaving the power interrupted on the structure until a change of at least 100mV in the structure-to-soil potential is observed. In calculating the 100mV decay, the instant off potential obtained in Step 7 above is utilized as the starting point (e.g. if instant off equals -800mV, power must be left off until decayed to -700mV).
12. Calculate the voltage change by subtracting final (or ending) voltage from the instant off voltage and record these values in the appropriate columns on the UST Impressed Current Cathodic Protection System Evaluation, DWM 4227.
13. Data Interpretation
    a) If the instant off potential is -850mV or more negative, the 850 off criterion is satisfied and it is judged that adequate cathodic protection has been provided.
    b) If the instant off potential is more positive than -850mV, the tank may or may not be adequately protected and a 100mV polarization test is necessary.
    c) If the structure exhibits more than 100mV polarization, the 100mV polarization criterion is met and it is judged that adequate cathodic protection has been provided. If unable to meet either the 850 instant off or 100mV polarization criteria, it is judged that adequate cathodic protection has not been provided and repairs/modification are indicated. Alternatively, a person qualified as a corrosion expert could evaluate/conduct the survey and determine that cathodic protection is adequate based on their interpretation.

**Generalized Interpretation of Structure-to-Soil Potential Measurements (Voltages) Obtained on Impressed Current Cathodic Protection Systems**

| Voltage (mV) "On" | Generalized Interpretation* |
|---|---|
| **Any Positive Voltage or 0 to -100 "On" or "Off"** | Can indicate the structure attempted to be measured is not bonded to the impressed current system (conduct continuity testing). Stray current could be affecting the protected structure Consult a corrosion expert. Positive and negative wires could be reversed (negative must be to protected structure and positive to anode). Test leads are reversed (positive lead must contact structure and negative lead must be connected to reference electrode). Could indicate the measurement is for the potential of a copper wire. |
| **-101 to -399 "On" or "Off"** | Try again. A reading in this range is not normally seen on an underground steel structure. Could indicate that steel structure is electrically connected to a significant amount of a more noble metal (e.g., copper). Very corroded low carbon steel may also be indicated. |
| **-400 to -599 "On" or "Off"** | Usually means the steel structure has no cathodic protection. Existing impressed current anodes could be completely "burned out". Continuity of anode lead wires (positive circuit) could be broken. Negative bonds on the protected structures may be broken or nonexistent. |
| **-600 to -849 "On" or "Off"** | Usually means the steel structure has some protection, but for whatever reason, something is causing a low reading that may indicate adequate cathodic protection has not been provided. The impressed current system may be trying to protect a structure that requires more current than it can produce (rectifier output too small). The impressed current system may not be capable of effectively distributing the required current to all parts of the structure it is trying to protect (not enough anodes, anodes improperly installed, soil resistivity too high). The steel structure that is intended to be protected may not be electrically continuous with the other metallic structures under protection (conduct continuity testing). The environmental conditions may not be favorable at the time the attempt to obtain the reading. Retest during the next ninety (90) days. |
| **-850 or More Negative "On"** | Steel structure may or may not be adequately protected. Usually indicates the impressed current system is providing current to the structure although the reading normally includes a large voltage (IR) drop. Because the flow of current through the soil causes a voltage drop, the on potential cannot be used to indicate adequate cathodic protection has been provided. Instant off potentials must be utilized to demonstrate cathodic protection. |
| **-850 or More Negative "Off"** | Steel structure protected by impressed current system meets regulatory requirements and cathodic protection is judged to be adequate. A potential measurement of -850mV or more negative with the protective current temporarily interrupted (850 off) is considered to be the best indicator that adequate cathodic protection has been provided. |
| **More Negative than -1220 "Off"** | Instant off potentials more negative than -1220mV are theoretically not possible. If observed an instant off potential more negative than -1220mV, suspect stray current is affecting the protected structure. Consult a corrosion expert immediately since stray current can cause a rapid corrosion failure of the protected structure. |
| **More Negative than -2000 "On"** | Usually means a high resistance exists in the ground bed that is causing a large voltage drop. This condition is normally evident by checking the rectifier output since the voltage is very high, but the amperage is relatively low. However, be cautious when abnormally high voltages are observed since this can have a detrimental effect on cathodically protected structures or the anodes may be rapidly depleted. Stray current may also be generated that can adversely affect other buried metallic structures such as waterlines and other utilities. Consult a corrosion expert whenever it is suspected that too much voltage is being generated. |
| **Variable "On" or "Off"** | If the voltmeter readings vary, suspect that stray current may be affecting the cathodically protected structure. Sometimes, the stray current can cause a pattern to develop that is recognizable (e.g., 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 "On" or "Off"** | 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 there is a solid and clean metal-to-metal connection. Soil where the reference electrode is placed could be too dry. Add water to the soil or wait until a heavy rain occurs and try again. Petroleum contaminated soils may cause a high contact resistance. The tip of the reference electrode may need to be cleaned or replaced. |

*Site-specific conditions may produce differing interpretations.