Introduction to Cathodic Protection and Testing

August 1, 2019
NEIWPCC Webinar

Steve Pollock
Technical Manager

Steel Tank Institute/Steel Plate Fabricators Association
What we will cover

• Degradation and corrosion
• Corrosion Control
  • Galvanic series
  • Corrosion cell
• History of steel tank corrosion protection
• UL 1746 – External Corrosion Protection for Steel Underground Storage Tank Systems
• Test Protocol
• Supplemental Anodes
Corrosion Control

Relative Energy Levels of Metals
Measured relative to a Cu/CuSO reference cell

Active (Corrodes Easily)
- Magnesium (-1600)
- Zinc (-1100)
- Aluminum (-1000)
- Steel (-600)
- Copper (+100)
- Carbon (+400)
- Silver (+500)
- Platinum (+900)
- Gold (+1200)

Passive (Stable)
Cathodic
Anodic
Corrosion Control

Corrosion Cell

Anode
Electrolyte
Cathode
DC Current Flow
Metallic Path
Corrosion Control

So if a buried steel tank is completely isolated from soil (like a sti-P3 tank) why are we concerned about corrosion?

• Steel is made up of many different “crystals”, each of which could have a different electropotential.

• The potential you measure is actually an average of all the steel “crystals” that make up a typical tank.
What is a sti-P3 tank?

• Pre-engineered factory fabricated cathodically protected steel tank with three modes of corrosion control

• 1 electrical isolation
• 2 external coatings
• 3 galvanic anodes
  a. weld-on anodes
Nature has endowed each metallic substance with a certain natural energy level or potential.

**GALVANIC ENERGY SERIES**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Energy Level (Volts)</th>
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</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>-1.7</td>
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<tr>
<td>Aluminum</td>
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<td>Zinc</td>
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<td>Silver</td>
<td>+0.4</td>
</tr>
<tr>
<td>Platinum</td>
<td>+0.9</td>
</tr>
<tr>
<td>Gold</td>
<td>+1.3</td>
</tr>
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</table>

DO NOT REMOVE CLOTH BAG OR CARDBOARD BOX AROUND ANODE

[I’LL JUST PULL THIS WHITE THING OFF SO THE TANK WILL FIT IN THE HOLE.]
Steel Tank Corrosion Control

- 1959 – bag wraps
- 1968 STI-LIFE
  - Steel with fiber reinforced plastic coating
  - Standard in effect for 5 years
  - Production specs, QC program
- 1969 – sti-P3
  - Coating improvements
  - Anode and bushing testing
- 1987 – ACT-100 (Association of Composite Tanks)
UL 1746 – designs and testing
• Tanks built to UL 58
• Part I Preengineered Cathodic Protection Systems
  • Components are: galvanic anodes; backfill material for anodes; insulating bushings and gaskets; dielectric coatings; pressure wire connectors; test station provision
• Part II Composite Tanks
  • Components are: steel tank; non-metallic external coating fabricated to at least 0.100”; nonmetallic caps for attachments
• Part III Jacketed Tanks
  • Components are: steel tank with a nonmetallic external FRP, polyurethane, polyurea or thermoplastic jacket; nonmetallic caps to cover external attachments; interstitial space providing minimum of 300 degrees of secondary containment centered at tank bottom and 100% containment at heads.
UL 1746 – designs and testing

• UL performance testing (not all inclusive)

• Components
  • Aging
  • Flexibility
  • Liquid compatibility
  • Environmental performance
  • Corrosion and permeation

• Completed tank
  • Impact
  • Lift lugs
  • Annulus
  • Holiday
Galvanic System Testing

Sti-P3 Tank to Soil potential

Voltmeter

Test Leads

Reference Cell

Connection to tank

TANK

30 ft
Pass/Fail Criteria for Galvanic Systems

• PASS: -850 mV or more negative for ON readings for local and two remote readings (true remote); OR
• PASS: -850 mV or more negative instant off readings for all recorded readings. This may apply to field-installed sacrificial anodes.
How to establish true remote

Keep moving reference cell away from tank until potential remains the same
Impressed Current System Testing

ICCP Structure to Soil Test

Voltmeter

Test Leads

Reference Cell

Connection to tank

TANK
Impressed current terms

- **Native Potential** - Potential measured before any CP has been applied

- **Static Potential** – Also called the depolarized potential...it is measured after CP has been interrupted and structure is allowed to depolarize completely

- **Polarized Potential** – Also called the instant off potential... the 2\textsuperscript{nd} number observed on digital voltmeter after rectifier power has been interrupted
Pass/Fail Criteria for Impressed Current Systems

• PASS: -850 mV DC or more negative for INSTANT OFF or 100mV shift readings at all three local test locations; OR

• FAIL: unable to obtain -850mV DC instant off or 100 mv shift at one or more local test points

• FAIL: continuity of protected structures cannot be established
No testing through asphalt or concrete cracks. Drill a hole to contact soil/backfill.
Continuity Testing

• Structures that are galvanically protected must be isolated from other metallic structures
  • troubleshooting
• With Impressed Current systems, all structures are bonded together (continuous)
  • Continuity is CRITICAL for Impressed Current systems
RP 972 Addition of Supplemental Anodes

- Main purpose is to provide a simple solution to bring sti-P3 tanks back to NACE criteria
- Conservative RP that gives step-by-step directions to contractors for adding supplemental anodes
- Must conduct current requirement test
- Provides option to hiring a CP Specialist
RP 972 Addition of Supplemental Anodes

- Current requirement result limited to 30 milliamps to bring tank back to -850 mV DC or more negative criteria
- Minimum of 2 anodes per tank
- Regulators should request the installer’s record keeping form for adding anodes
Thank you for your time!

Steve Pollock
Technical Manager STI/SPFA

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www.steeltank.com
NEIWPCC WEBINAR

Monitoring Impressed Current Cathodic Protection Systems

August 1, 2019

STORAGE TANK PROFESSIONALS

COMPLIANCE TESTING TRAINING CATHODIC PROTECTION

KEVIN HENDERSON CONSULTING, LLC
QUESTION

Why Is Monitoring of the Rectifier Required?

(It is not just to verify the AC power is on)
1. How is monitoring accomplished?

2. What does monitoring tell us?
   What am I looking for?

3. What happens as a result?
   What action(s) must be taken?

4. How can we make things better?
WHY IS MONITORING REQUIRED?

CP Testing required every three years

Galvanic Systems = O.K.

Impressed Current Systems = Not Cool!

- Way too many things can go wrong
- Waiting until the next test to find out could mean this
WHY IS MONITORING REQUIRED?

Impressed Current testing should be required annually but probably not going to happen

Instead - MONITORING is required to ensure system is operating correctly.

Monitoring frequency is 60 days
Should be 30 days (like most everything else)
WHY SHOULD WE PAY MORE ATTENTION TO MONITORING?

Generally Speaking

Oldest tanks = Impressed Current

Most Impressed Current systems installed in 1997 – 1998 (upgrading deadline)

Impressed Current systems are now 20+ years old

Tanks are now 25 – 50+ years old
WHY SHOULD WE PAY MORE ATTENTION TO MONITORING?

Not Going Away anytime soon

Most of these ancient tanks will be left in operation for the foreseeable future

Most are in operation at marginally profitable locations

Far too expensive to install a new UST system
(secondary containment/interstitial monitoring requirements)
HOW IS MONITORING ACCOMPLISHED?

Typically Involves Looking at Gauges and Recording:

- Volts
- Amps
- Hours
Verifying Gauges Are Accurate

Check accuracy of the rectifier voltmeter with portable multimeter
Check accuracy of the rectifier ammeter with portable multimeter

Requires simple calculation to figure amperage

\[22.0 \text{ mV} \times 0.2 \text{ amps/mV} = 4.40 \text{ amps}\]
Verifying Gauges Are Accurate

Clamp meters can read amperage directly.
## 60-DAY RECORD OF RECTIFIER OPERATION FOR IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM

- This form should 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, emperage and the number of hours indicated on the meter.
- Any significant variance should be reported to your corrosion professional so that any required and/or adjustments necessary can be made.

### I. USER OWNER

<table>
<thead>
<tr>
<th>NAME</th>
<th>Calks Pump - N - Shop</th>
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</thead>
<tbody>
<tr>
<td>ADDRESS</td>
<td>1075 Winchester Ave</td>
</tr>
<tr>
<td>City</td>
<td>Ashland</td>
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<tr>
<td>State</td>
<td>KY</td>
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### II. SITE INFORMATION

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<th>Super Test Feedback</th>
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<tr>
<td>ADDRESS</td>
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<tr>
<td>City</td>
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<tr>
<td>County</td>
<td>Clark</td>
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</table>

### XI. IMPRESSED CURRENT RECTIFIER DATA

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

| RECTIFIER MANUFACTURER | Brame Lachay |
| RECTIFIER MODEL | GSP47 |
| RATED DC OUTPUT | 30 VOLTS 12 AMPS |
| RECTIFIER SERIAL NUMBER | 974466 |

What is the "as designed" or "lastly recommended" rectifier output:

<table>
<thead>
<tr>
<th>DATE INSPECTED</th>
<th>RECTIFIER TURNED ON?</th>
<th>COARSE</th>
<th>FINE</th>
<th>VOLTS</th>
<th>AMPS</th>
<th>HOUR METER</th>
<th>INSPECTOR INITIALS</th>
<th>COMMENTS</th>
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<td>/</td>
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<td>/</td>
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<td>99133</td>
<td>DR</td>
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</tr>
</tbody>
</table>

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**NO SPECIFICATION OF WHAT AMPERAGE IS “NORMAL”**
Amp Range Recommended (no value given)

3.2 – 3.7 Amps = “Normal” Range

June 2017 = 3.2 amps

December 2018 = 0.3 amps

“Is Your System Running Properly”

YES - ?
How Many Amps are Required?

Depends on many factors – Should be specified by design engineer

RULE OF THUMB

One amp per 10,000 gallon bare steel tank {Coated tanks, (sti-P3 or ACT-100} typically require very little current)

If not specified, then look at voltage/amperage when last passing test was conducted
WHAT ARE THOSE GAUGES TELLING US?

Volts and Amps =
“Normal” Operation

Action = Routine monitoring/testing
WHAT ARE THOSE GAUGES TELLING US?

Zero Volts
(Not uncommon to indicate small voltage)
Zero Amps

Action = No Brainer!
WHAT ARE THOSE GAUGES TELLING US?

“Normal” Volts
(Not uncommon to be maxed out)

Zero Amps

Action = Respond ASAP
Only the Amperage Matters

It does not really matter what the voltage is but:

ZERO AMPS = ZERO CP
What is the Rectifier Log Telling Us?

**MINIMUM DESIGN AMPERAGE**

The output at the time of the last passing test was **4.3** amps  Date of Test: **09-12-2017**

The minimum output needed to provide adequate cathodic protection is: **3.5** amps.

Contact a qualified person to investigate if the observed amperage falls below this value.

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

**RECTIFIER INSPECTION LOG**

<table>
<thead>
<tr>
<th>DATE INSPECTED</th>
<th>ON / OFF</th>
<th>TAP SETTINGS</th>
<th>DC OUTPUT</th>
<th>HOUR METER</th>
<th>INSPECTOR INITIALS</th>
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</table>

- **Volts but no Amps**
- **Circuit is Open**
- **Voltage stays the same**
- **Sudden Loss of all amps**
- **Usually means all anode wires cut**
What is the Rectifier Log Telling Us?

Voltage stays the same but Amps falling

Voltage stays the same

Gradual Loss of amps

Usually means incremental failure of anodes

### Minimum Design Amperage

The output at the time of the last passing test was **4.3** amps Date of Test: **09-12-2017**

The minimum output needed to provide adequate cathodic protection is: **3.5** amps.

Contact a qualified person to investigate if the observed amperage falls below this value.

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

### Rectifier Inspection Log

<table>
<thead>
<tr>
<th>DATE INSPECTED</th>
<th>ON / OFF</th>
<th>TAP SETTINGS</th>
<th>DC OUTPUT</th>
<th>METER</th>
<th>INSPECTOR INITIALS</th>
<th>COMMENTS</th>
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<tr>
<td>01-12-18</td>
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<td>2 4</td>
<td>28 2.4</td>
<td>38408</td>
<td>KSH</td>
<td></td>
</tr>
</tbody>
</table>
If no minimum amperage is specified

Generally Accepted Rule of Thumb

20% of last passing test amperage

**EXAMPLE**

5.0 amps at last passing test

5.0 amps x 0.20 = 1.0 amps

5.0 – 1.0 = 4.0 amps

Minimum Amperage = 4.0
**RECTIFIER LOG - AS IT SHOULD BE**

**IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM**
**RECORD OF RECTIFIER OPERATION**

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

<table>
<thead>
<tr>
<th>UST OWNER</th>
<th>UST FACILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME: HMS Properties</td>
<td>NAME: 5 Star Mart</td>
</tr>
<tr>
<td>CITY: Gulfport</td>
<td>CITY: Long Beach</td>
</tr>
<tr>
<td>STATE: MS</td>
<td>STATE: MS</td>
</tr>
</tbody>
</table>

**RECTIFIER DATA**

| MANUFACTURER: WB Cathodic Services | RATED DC OUTPUT: 80 Volts 15 Amps |
| MODEL: UST8015H | SERIAL NUMBER: 02880149 |

**MINIMUM DESIGN AMPERAGE**

The output at the time of the last passing test was: **4.5** amps  
Date of Last Passing Test: **04-10-2019**

The minimum output needed to provide adequate cathodic protection is: **3.5** amps

Contact a qualified person to investigate if the observed amperage falls below the specified minimum value.  
Note: Relatively small variations in the rectifier amperage are normal. If there is no minimum amperage specified, contact a qualified person to investigate if the amperage output decreases by more than 20% from the last passing test.

**RECTIFIER INSPECTION LOG**

<table>
<thead>
<tr>
<th>DATE</th>
<th>TAP SETTINGS</th>
<th>DC OUTPUT</th>
<th>HOUR METER</th>
<th>INSPECTED BY</th>
<th>COMMENTS</th>
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<td>4.4</td>
<td>N.A.</td>
<td>K. Henderson</td>
</tr>
</tbody>
</table>
RECTIFIER LOG – 3 YEAR VERSION

Enough space for 3 years (30 day checks)

Details are nice but the AMPS are the only thing that really matters
How Can We Make Things Better?

**IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM**

**RECORD OF RECTIFIER OPERATION**

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

<table>
<thead>
<tr>
<th>UST OWNER</th>
<th>UST FACILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME:</td>
<td>NAME:</td>
</tr>
<tr>
<td>ADDRESS:</td>
<td>ADDRESS:</td>
</tr>
<tr>
<td>CITY:</td>
<td>STATE:</td>
</tr>
<tr>
<td></td>
<td>CITY:</td>
</tr>
<tr>
<td></td>
<td>STATE:</td>
</tr>
</tbody>
</table>

**RECTIFIER DATA**

<table>
<thead>
<tr>
<th>MANUFACTURER:</th>
<th>RATED DC OUTPUT:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>____ VOLTS ____ AMPS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MODEL:</th>
<th>SERIAL NUMBER:</th>
</tr>
</thead>
</table>

**MINIMUM DESIGN AMPERAGE**

The output at the time of the last passing test was ______ amps Date of Test: ________________

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

Contact a qualified person to investigate if the observed amperage falls below this value.

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

**RECTIFIER INSPECTION LOG**

<table>
<thead>
<tr>
<th>DATE INSPECTED</th>
<th>ON / OFF</th>
<th>TAP SETTINGS</th>
<th>DC OUTPUT</th>
<th>HOUR METER</th>
<th>INSPECTOR INITIALS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Want This Form?
Shoot Me An Email

Kevin4824@Comcast.net

KEVIN HENDERSON CONSULTING, LLC

Thanks For Your Time!
Cathodic Protection Test Report/Data, Is It Right?

Richard (Rick) Rogers - NACE Cathodic Protection Specialist #4394

UST Corrosion Management, Inc.

August 1, 2019
Today’s Discussion

- Approximately 25 minutes in length with some additional time for questions and answers.

Topics
- Is the test complete?
- Interpreting the data provided

Goal:
- Adequate information for you to make accurate determination on validity of test report
Differences between Sacrificial Anode and Impressed Current Cathodic Protection Systems

Sacrificial Anode Systems

1. Uses different type of metal connected to steel to create a DC current flow in a direction that protects the steel from corroding.
2. Sacrificial Anodes are limited in the amount of DC current they can produce, in turn limited in the amount of steel they can protect.
3. Sacrificial Anodes produce anywhere between approximately 2mA to 80mA per anode depending on the anode material, size of the anode, and the environment the anode is installed in.
4. A Sacrificial Anode life is strictly dependent on the size of the anode and how much current it produces.

Impressed Current Systems

1. Impressed Current Systems use anode materials that are highly resistant to corrosion but require an outside power source (typically a Rectifier) to create the DC current.
2. Typical ICCP Anode Manufacturers rate their anodes to have a 20 year life with up to 2.0A (2000mA) of current output per anode.
3. ICCP Systems can be designed to protect any size structure for a determined length of time because the unlimited external power source and high current outputs of individual anodes.
Sacrificial Anode Cathodic Protection System Report/Data

A Sacrificial Anode Cathodic Protection System resurvey report should include a minimum of information and test data.
1. Owner and Site Information including owner name and address and site name and address.
2. Tester Information including name, company employed with, any certification obtained that pertains to Steel Underground Storage Tank Cathodic Protection testing with certification number, expiration of certification, signature, and date.
3. Date test was performed.
4. Pass/Fail conclusion of Cathodic Protection Test clearly stated.
5. Date of next full system test required by.
Information and Test Data that should be included in a Sacrificial Anode Cathodic Protection System Report

Continued, Page 2

1. UST System description section including number of tanks, sizes of tanks, construction material of tanks, construction material of product lines, and if flex connectors are present and touching an electrolyte.
2. Continuity test data section including structures tested and the exact reading obtained on each structure.
3. Structure-to-Soil potential reading section including the structure tested, connection point for reading taken, location of reference cell at each test point location, local and remote potential readings (should show 2 remote readings on each structure), and conclusion (Pass, Fail, and possibly Inconclusive).
4. Site drawing showing layout of UST system, labeled tanks, labeled dispensers if readings taken at dispensers, and labeled reference cell test point locations.
You are looking to see that the tank(s) is some type of Galvanic (Sacrificial Anode) protected tank(s). If Flex Connectors are present, are they not touching soil or touching an electrolyte (soil and/or water) and protected by Sacrificial Anodes?
Most Sacrificial Anode (Galvanic) Systems will be tested using the fixed cell moving ground continuity test method because you should always take remote potential readings on the structure being tested. In the example above, you take the -961mV Unleaded 01 tank bottom reading minus the -572mV Unleaded 01 Fill Pipe reading which is 389mV difference. Based on the NACE criteria, these 2 structures are isolated from each other.
This example and the form layout is based on the current Steel Tank Institute Testing Guidelines. In Sacrificial Anode Systems, a tester should be taking local and remote readings on each structure. All local and remote readings must be -850mV or more negative to pass a system. If any reading is -849mV or more positive, then the result must be either Fail or Inconclusive. The Remote readings must be at true remote earth locations. If any potential reading in a Sacrificial Anode System is shown as approximately -200mV or around -1900mV, these readings are likely not real or a serious problem exists with the structure.
Site Drawing
Impressed Current Cathodic Protection System Report/Data

An Impressed Current Cathodic Protection System resurvey report should include a minimum of information and test data.
Information and Test Data that should be included in an Impressed Current Cathodic Protection System Report

Page 1

1. Owner and Site Information including owner name and address and site name and address.
2. Tester Information including name, company employed with, any certification obtained that pertains to Steel Underground Storage Tank Cathodic Protection testing with certification number, expiration of certification, signature, and date.
3. Date test was performed.
4. Pass/Fail conclusion of Cathodic Protection test clearly stated.
5. Date of next full system test required by.
Information and Test Data that should be included in an Impressed Current Cathodic Protection System Report

Continued, Page 2

1. UST System description including number of tanks, sizes of tanks, construction material of tanks, construction material of product lines, and if flex connectors are in the system and touching an electrolyte.

2. Rectifier information at a minimum including rectifier manufacturer, model number, serial number, rated DC outputs, tap settings, and meter readings.

3. Measured rectifier outputs, not meter readings. The meter readings should be included in the report.

4. The designed amperage output of the system or the amperage output during the last passing test of the system. It would also be good to include the recommended rectifier amperage output operating range.

5. Individual anode outputs if the system has the ability (anode junction box or individual anode cables) to measure the individual anode outputs.
1. Continuity test data section including structures tested and the exact reading obtained for each structure, not some rounded off number. Continuity testing on ICCP Systems will almost always be done as a Point-to-Point test method because of testing guidelines in NACE TM-0101-2012.

2. Local potential reading section including the structure tested, connection point for reading taken, location of reference cell at each test point location, “on” potential reading (a tester will never use this reading for any reason), instant off (polarized) reading, ending potential reading (depolarized or static) if 100mv polarization criteria used, voltage change (instant off reading minus ending voltage), and conclusion (Pass or Fail, no inconclusive allowed).

3. Site drawing showing layout of UST system, labeled tanks, labeled dispensers if readings taken at dispensers, labeled reference cell test point locations, rectifier location, anode junction box location if in the system, and anode and CP cable locations if known.
You want to estimate the approximate total amount of current needed to protect the steel structures (assuming they are bare steel). This example would be approximately 1.0A for the 10K, 0.6A for the 6K, and about 0.4A for the 4K. You would also add in about 0.2A for the Steel Piping for a total of 2.2A typically to protect all structures in this system at a minimum. Every site is unique but you can get a good estimate of the current output the rectifier should be producing at this site.
Rectifier Data

The main thing you are looking at in this section is the rectifier current output. Is the measured rectifier current output somewhere close to the estimated current output needed you calculated from the Tank and Piping Description Section? If the rectifier measured current output is significantly different than your estimated amount of current needed, this could indicate the system has been set to run at a current output outside of the engineered design current needed. It could also indicate a problem with the test as well.

This is useful information. Compare to current output in this report. The estimated current output for this system is 2.2A.

The rectifier measured current output should never exceed the rated rectifier current output.
First, you want to add up the outputs of every anode in the system and the total should be somewhere near the rectifier current output. If not, something is wrong. The rectifier current output in this example was 5.5A. The life of a single anode is strictly dependent on the amount of current that anode produces. In the example, there are 2 anodes producing significantly more than 1.0A. A 3’ X 5’ 3.0 MMO anode (LIDA Pack Canister) has a design life of approximately 20 years at 2.0A output. However, real world results have shown a slightly less anode life than 20 years at 2.0A output. Also, when you have an anode producing a higher amount of current, you can have the risk of polarizing the structure in the area of that anode to more than -1600mV. This should never be allowed to happen. Also look at the Description of Repairs section. Make sure the tester states exactly the repair work that was done as detailed as possible.
Impressed Current Continuity Test Data
Is This Right?

<table>
<thead>
<tr>
<th>STRUCTURE &quot;A&quot;</th>
<th>STRUCTURE &quot;B&quot;</th>
<th>POINT-TO-POINT VOLTAGE DIFFERENCE</th>
<th>ISOLATED CONTINUOUS/INCONCLUSIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Tank Bottom</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Regular STP Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Regular Fill Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Regular Vent Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Reg 100% Tank Bottom</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Regular 100% STP Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Regular 100% Fill Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Regular 100% Vent Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Premium Tank Bottom</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Premium Fill Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Premium STP Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Premium Vent Riser</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>MPD 1/2 Pipe Risers</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>MPD 3/4 Pipe Risers</td>
<td>Rectifier Negative</td>
<td>0 mV</td>
<td>Continuous</td>
</tr>
</tbody>
</table>

Almost always Point-to-Point Continuity test results in an Impressed Current System will not actually be 0.0mV to all structures tested but is possible. This could indicate the tester has rounded off all the readings or that the readings are not real.
### Impressed Current Continuity Test Data

### What You Should Expect To See

This is more typical of what you would expect to see in an Impressed Current System Point-to-Point Continuity test. This example is from a different test report than the examples in the Impressed Current section that were taken from a single test report.

<table>
<thead>
<tr>
<th>Structure “A”</th>
<th>Structure “B”</th>
<th>Point-to-Point mV Difference</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectifier Negative</td>
<td>Unleaded Tank Bottom</td>
<td>0.2mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Unleaded STP and Components</td>
<td>0.4mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Plus Tank Bottom</td>
<td>0.1mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Plus STP and Components</td>
<td>0.2mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Premium Tank Bottom</td>
<td>0.2mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Premium STP and Components</td>
<td>0.1mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Kerosene Tank Bottom</td>
<td>0.7mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Kerosene Vent Stack</td>
<td>0.5mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Steel Piping inside MPD 1-2</td>
<td>0.1mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Steel Piping inside MPD 3-4</td>
<td>0.2mV</td>
<td>Continuous</td>
</tr>
<tr>
<td>Rectifier Negative</td>
<td>Steel Piping inside Kerosene SPD</td>
<td>0.4mV</td>
<td>Continuous</td>
</tr>
</tbody>
</table>
Impressed Current Local Potential Readings

<table>
<thead>
<tr>
<th>LOCATION CODE</th>
<th>STRUCTURE</th>
<th>CONTACT POINT</th>
<th>REFERENCE CELL PLACEMENT</th>
<th>ON VOLTAGE</th>
<th>100 mV POLARIZATION VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Regular</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-2665</td>
<td>-1207</td>
</tr>
<tr>
<td>R2</td>
<td>Regular</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-2317</td>
<td>-1132</td>
</tr>
<tr>
<td>R3</td>
<td>Regular</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-2560</td>
<td>-1239</td>
</tr>
<tr>
<td>R1</td>
<td>Reg 100%</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-3370</td>
<td>-1490</td>
</tr>
<tr>
<td>R2</td>
<td>Reg 100%</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-1815</td>
<td>-761</td>
</tr>
<tr>
<td>R3</td>
<td>Reg 100%</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-2289</td>
<td>-1160</td>
</tr>
<tr>
<td>R1</td>
<td>Premium</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-2930</td>
<td>-1505</td>
</tr>
<tr>
<td>R2</td>
<td>Premium</td>
<td>Tank Bottom</td>
<td>Soil @ Tank Center</td>
<td>-2017</td>
<td>-1012</td>
</tr>
<tr>
<td>R3</td>
<td>Premium</td>
<td>Tank Bottom</td>
<td>Soil @ Tank End</td>
<td>-2360</td>
<td>-1180</td>
</tr>
<tr>
<td>R4</td>
<td>Regular</td>
<td>STP Riser</td>
<td>Soil @ Tank End</td>
<td>-2560</td>
<td>-1239</td>
</tr>
<tr>
<td>R4</td>
<td>Reg 100%</td>
<td>STP Riser</td>
<td>Soil @ Tank End</td>
<td>-2289</td>
<td>-1160</td>
</tr>
<tr>
<td>R4</td>
<td>Premium</td>
<td>STP Riser</td>
<td>Soil @ Tank End</td>
<td>-2360</td>
<td>-1180</td>
</tr>
<tr>
<td>R5</td>
<td>Regular</td>
<td>MPD 1/2 Pipe</td>
<td>Soil @ Dispenser</td>
<td>-2120</td>
<td>-1230</td>
</tr>
<tr>
<td>R5</td>
<td>Reg 100%</td>
<td>MPD 1/2 Pipe</td>
<td>Soil @ Dispenser</td>
<td>-2120</td>
<td>-1230</td>
</tr>
<tr>
<td>R5</td>
<td>Premium</td>
<td>MPD 1/2 Pipe</td>
<td>Soil @ Dispenser</td>
<td>-2120</td>
<td>-1230</td>
</tr>
<tr>
<td>R6</td>
<td>Regular</td>
<td>MPD 3/4 Pipe</td>
<td>Soil @ Dispenser</td>
<td>-1155</td>
<td>-920</td>
</tr>
<tr>
<td>R6</td>
<td>Reg 100%</td>
<td>MPD 3/4 Pipe</td>
<td>Soil @ Dispenser</td>
<td>-1155</td>
<td>-920</td>
</tr>
<tr>
<td>R6</td>
<td>Premium</td>
<td>MPD 3/4 Pipe</td>
<td>Soil @ Dispenser</td>
<td>-1155</td>
<td>-920</td>
</tr>
</tbody>
</table>

Based on the fact that a repair was just done to this system and it is running 5.5A (estimated 2.2A needed), I would question if the test was done immediately after the repairs were completed and/or with very little polarization time. There are 2 instant off potential readings around -1500mV. It is possible these readings could go to -1600mV or more negative after a period of polarization. There should never be an instant off potential reading more negative than -1600mV. If the test was done very soon after the repair was completed or the system turned on, I would request the tester return to the site and do another test after a significant period of polarization.
Impressed Current Local Potential Readings
Is this Right?

The “On” reading only in an Impressed Current System can never be used to pass or fail a Cathodic Protection test. The “On” reading is a totally false number and can never be used to determine pass or fail in an ICCP System. An Impressed Current System can only be evaluated using the Instant Off (Polarized) potential reading and Ending Voltage (depolarized or static) if trying to meet the 100mv Polarization Criteria.
Impressed Current Local Potential Readings
Is this Right?

<table>
<thead>
<tr>
<th>LOCATION CODE¹</th>
<th>STRUCTURE²</th>
<th>CONTACT POINT¹</th>
<th>REFERENCE CELL PLACEMENT¹</th>
<th>ON VOLTAGE²</th>
<th>INSTANT OFF VOLTAGE²</th>
<th>100 mV POLARIZATION ENDING VOLTAGE²</th>
<th>PASS / FAIL²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(example) T-1</td>
<td>PLUS TANK</td>
<td>TANK BOTTOM</td>
<td>SOIL @ REG. TANK STP MANWAY</td>
<td>-1070 mV</td>
<td>-875 mV</td>
<td></td>
<td>PASS</td>
</tr>
<tr>
<td>(example) P-2</td>
<td>DIESEL PIPING</td>
<td>DISPENSER 7/8</td>
<td>SOIL @ DIESEL TANK STP MANWAY</td>
<td>-810 mV</td>
<td>-680 mV</td>
<td></td>
<td>PASS</td>
</tr>
<tr>
<td>Reg Tank</td>
<td>Tank Bottom</td>
<td>In center at crack in concrete</td>
<td>-1234 mV</td>
<td>-1046 mV</td>
<td></td>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td>Reg Tank</td>
<td>Tank Bottom</td>
<td>On asp/conc crack at fill end</td>
<td>-2002 mV</td>
<td>-1214 mV</td>
<td></td>
<td></td>
<td>Pass</td>
</tr>
</tbody>
</table>

Local potential readings must never be taken with the reference cell placed on concrete, on asphalt, or on a crack in the pavement.
Impressed Current Local Potential Readings
Is this Right?

In an Impressed Current System, the “On” reading is never used to pass or fail a system for any reason. The “On” reading to a tester should never be used for any reason and means nothing to a tester. In turn, you never subtract the “Instant Off” reading from the “On” reading to determine the polarization.

The correct method to determine the amount of polarization and whether the 100mV polarization criteria was met is to subtract the “Ending Voltage (depolarized or static)” reading from the “Instant Off” reading. If the difference is at least 100mV or more, the readings at this test point pass.
Impressed Current Local Potential Readings

In an Impressed Current Cathodic Protection System, there must be at least 3 local potential test point locations (where the reference cell is placed) over each tank and at each end of Steel Product Lines. If there is 100’ of more between the test point reference cell locations for Steel Product Lines, you must take another reading with the reference cell placed in the middle of the 100’ distance and an additional test point location for each additional 50’.

In an Impressed Current System, all reference cell test point locations must pass either the NACE -850mV polarized potential (Instant Off) or 100mV polarization criteria for the system to pass.
There are a couple of things that are missing on this drawing that should be included. First, it does not show the location of the anode junction box. Most important, it does not show the location of the new 6 MMO anodes the tester says they just installed. Knowing the locations of the anodes is extremely important when evaluating the performance of an ICCP System.
Cathodic Protection Test Report/Data, Is It Right?

Presented by:

Richard (Rick) Rogers - NACE Cathodic Protection Specialist #4394
UST Corrosion Management, Inc.
August 1, 2019

If anyone has any questions or wants to discuss the presentation subject matter further, do not hesitate to email me at:

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or
RickRogers@USTCorrosion.com
Virginia’s Alternatives to Closure for Upgrading Violations
An Overview

Alicia Meadows
UST Compliance Coordinator
Virginia Department of Environmental Quality
August 1, 2019
Alternatives to Closure for Upgrading Violations

Created as a way to consistently handle situations where corrosion protection is present but not in compliance or information is unknown.
## Alternatives to Closure for Upgrading Violations – Decision Matrix

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Compliance Options other than closure</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bare or galvanized steel UST and/or underground piping known to have no lining or CP</td>
<td>None.</td>
<td>Must permanently close the unprotected steel structure and submit a closure assessment.</td>
</tr>
<tr>
<td>2. Bare steel UST with some form of CP upgrade (almost always impressed current) evident, but without documentation that an integrity assessment was properly accomplished and CP properly installed, or that the installed CP system was designed by a CP expert.</td>
<td>Owner must: (1) obtain TTT (case specifics may necessitate high level TTT); (2) perform a manned entry integrity assessment; (3) obtain corrosion expert certification of eligibility and system design; and (4) perform CP periodic testing (i.e., - 850 mV or 100mV shift test).</td>
<td>Site specific criteria provide for some RO discretion for the appropriate TTT method.</td>
</tr>
</tbody>
</table>

Six month and three year tests may have been performed, not performed, not documented, or are overdue. *(Includes cases where CP impressed current systems were turned off for more than 90 days.)*
Alternatives to Closure for Upgrading Violations – Decision Matrix

Bare or galvanized steel UST and or piping → No options → Must permanently close
Alternatives to Closure for Upgrading Violations – Decision Matrix

Tank owner wants to add lining to a cathodically protected tank.

- Lining may occur
- CP system MUST be maintained (tested, repaired when needed, etc.)
- Liner does not need to be maintained although encouraged
Alternatives to Closure for Upgrading Violations – Decision Matrix

Owner wants to add cathodic protection (CP) to a lined tank.

- Liner must pass lining inspection prior to adding CP.
- If liner fails, it must be repaired.
- If ineligible for repair then CP may not be added.
- Requires internal integrity assessment and CP expert certification.
Alternatives to Closure for Upgrading Violations – Decision Matrix

StiP-3 UST — Owner asserts tank is StiP-3 but has no proof.

- Require owner to physically demonstrate
- May rely on installation documentation, registration records, or a sworn affidavit
Alternatives to Closure for Upgrading Violations – Decision Matrix

StiP-3 UST with impressed current added-tank fails 100mV-shift test.

- CP expert required for modifications
- Tank must be modified according to NACE.