Test Stations and Pipe-to-Soil Potential Measurements

Period #7

Practical Applications Course
2017
Introduction

- Test Stations
- Wire Connection to Pipe
- Pipe-to-Soil (P/S) Potential Measurements
- Criteria of Cathodic Protection (CP)
Test Stations

• Above Grade
  – Preferred but many for ease of locating and access
  – Preventing damage to wires
  – Conduit Type
  – Lexan Plastic posts
  – Terminal Blocks
  – Occasionally damaged by traffic or hunters
Test Stations

• At Grade
  – Similar to curb boxes
  – Wires coiled – some with terminal blocks
  – Better for esthetics
  – Easily lost or damaged
  – Need accurate measurements
Color Coding Wires

• Color codes help identify what each wire is connected (Follow company standards)
• Improves future monitoring by adding quick identification of the wire to test
• Technicians aren’t happy when the standard is not followed
Connecting Wires

• Thermit Welding
  – Surface preparation
  – Prepare the wire(s)
  – Prepare the welder mold – Make sure the mold is dry
  – Making the connection
  – Correctly identify the connection by following the color code
Safety While Thermite Welding

• Pipe surface must be clean and dry
• Welder Mold must be dry
• The atmosphere is gas free
• Wear the proper PPE
  – Glasses
  – Gloves
  – Boots
Prevent Backfill Damage to Wires

• Backfill settles after construction

• Leave extra wire coiled in test station (about two feet)

• Careful not to damage the wires with shovels or equipment
Test Station Usage

- Standard Test Stations
- Galvanic Anode Test Stations
- Buried Isolation Joint Test Station
- Foreign Line Crossing
- Current Flow Test Station
- Buried Reference Electrodes
Standard Test Station

• Two Wires
  – Inexpensive
  – If one fails you have a second
  – Future testing
Galvanic Anode Test Station

• Sacrificial Anode(s) attached through a test station

• Three wires usually attached to the pipe
  – Two serve as test wires
  – One used to connect anode at terminal block
  – Shunt can be installed to measure current output
Buried Isolation Joint

- Two wires attached to each side of a buried isolation joint
  - Follow color code

- Used to test the effectiveness of the isolation joint
Foreign Line Crossing

• Test leads are attached to another pipeline or facility on which you are not working

• Three wires attached to each pipeline
  – Note: Do not attach wires to another company’s facility without their approval and representative present

• Follow color code
Current Flow Test Station

- Used on transmission lines to measure direction and magnitude of current flow
- Also called IR Drop Test Stations
- Used to evaluate coating condition and CP effectiveness
Buried Reference Electrode Test Station

- Buried reference electrode attached through the test station
- Can be placed close to the pipe allowing for a more accurate reading
- Must be inspected periodically to validate calibration
Pipe-to-Soil Potential Measurements

- Volt Meters (multimeters)
- Lead Wires
- Reference Electrodes
- Placement of Electrode
- Electrolyte Contact
- Sign Convention
Pipe-To-Soil Measurements

- Used to determine the effectiveness of CP
- Locate stray current
- Check for shorts. Electrical isolation, electrical continuity
- Taken with CP
  - ON
  - Off
  - Cycling
  - Native State
Components to take a P/S Reading

- Volt Meter
- Lead Wires
- Reference Electrodes
- Electrolyte
- Pipeline or Structure
Voltmeters

• Available in various types
  – Digital
    • Numerical read-out
  – Analog (D’ Arsonval movement)
    • Moving needle
  – Computerized Data Logger
    • Computer chip stores the readings
    • Can collect other data
      – GPS
  – Must be high input resistance (10 megohoms or more)

See next slide for examples of voltmeters
Common Voltmeters used for CP
Lead Wires

• Connections Secure
  – To the Structure
  – Low Resistance
  – Tight Connections

• Loose connections
  – High Resistance
  – Unstable or incorrect reading

• Contact point
  – Clean
  – Electrically continuous
Lab 9 – Poor Test Lead Connection

• Connect test lead to the coated riser of the coated pipe and take P/S Reading ______________
• Compare that reading to a good reading
Reference Electrodes (half cells)

• Two Common Types
  – Copper Sulfate
  – Silver-Silver Chloride

• Temperature sensitive
• Contaminant free
• Saturated solution

• Reference electrodes are also called half-cells:
  – form one-half of an electrical cell
    • pipeline being the other half of the cell
Copper Sulfate Reference Electrode

- Come in various sizes and types
- Most commonly used for pipeline work
- Temperature sensitive
- Do not leave in direct sunlight for long periods of time or subjected to high temperatures
  - cover it from direct sunlight
  - overheating will cause a voltage shift in the potential readings
  - may cause it to leak or become unsaturated
Half Cells

2A Pencil
8A Flat Tip
6A Flat Tip
6B Pointed Tip
8B Pointed Tip
3A Flat Bottom
W7 Waterproof connector
DBA Direct burial
Silver-Silver Chloride Reference Electrodes

• Silver-silver chloride (AgAgCl)
  – Used in salt water
  – AgAgCl electrodes are used for testing submerged pipelines and other structures
Placement of Electrodes

• Important for accurate readings
• Directly over the pipeline
  – The closer the better
• Good electrolyte contact
• Do not place the electrode over an anode
  – get readings in between anodes whenever possible
  – don’t take readings directly at test stations that have an anode connected through them
  – do not place the electrode near the anode when testing service lines that have anodes attached to them
  – get the reading somewhat remote from the anode
    • readings over an anode will yield an erroneous reading because of the voltage (IR) drop
• Close to the pipeline as possible without touching it
Lab 10 – Placement of Reference Electrode

• Connect magnesium anode to coated pipe
• Take P/S reading with reference cell placed at opposite end of the coating holiday (coating flaw) ________
• Move reference cell by the coating holiday and take P/S_____________
Good Electrolyte Contact

- Good contact between the half-cell and the electrolyte
- Wetting the electrolyte with water can help improve contact
  - A wet sponge can also be used
  - The “Fat Boy” electrode
- Issues with taking readings through concrete or asphalt surfaces
- Get the tip through the top layers of the soil for better contact.
  - Good contact; potential readings will settle down
- Gravel or stones
  - may have to scrape away a couple of inches to get to the soil underneath
  - may need to install a tube through the stone to get to the soil
- Landscaping may have plastic for drainage or architectural effects with mulch or stone
  - puncture the plastic and get the electrode down to the soil or use a tube to get through the plastic
Lab 11 – Electrolyte Contact

1. Take the paper cup and fill it with water (simulates poor contact with electrolyte)
2. Place the paper cup in the tub
3. Take the P/S reading by placing the half-cell in the cup ________________
4. Take P/S reading by placing half-cell in the tub ________________
# Sign Convention

<table>
<thead>
<tr>
<th>Voltmeter (-) Lug</th>
<th>Voltmeter (+) Lug</th>
<th>Sign Convention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline</td>
<td>Electrode</td>
<td>0.850</td>
</tr>
<tr>
<td>Electrode</td>
<td>Pipeline</td>
<td>-0.850</td>
</tr>
</tbody>
</table>
Sign Convention (continued)

- Pipeline connected to the voltmeter (-) and your half-cell is connected to the voltmeter (+), the value would read +VDC.
- Pipeline connected to the voltmeter (+) and your half cell is connected to the voltmeter (-) the value would be -0.850 VDC.
- Either case is correct.
- **Must** track the polarity.
Sign Convention (continued)

- P/S readings are considered negative relative to the reference electrode
  - common cathodic protection criterion for a steel pipeline is -0.850 VDC referenced to CS
  - depending on your requirements, equipment and preference, your meter can read a -0.850 VDC or +0.850 Volts DC
- The reason why pipe-to-soil potentials are considered negative
  - Measurements are made to the CSE
  - Referring back to Table 1-1, note that there is a zero point when metal potentials are measured with reference to copper
  - Some metals are more negative than copper and some more positive
Sign Convention (continued)

• With underground structures
  – negative to earth when it is picking up current
  – positive to earth when discharging current
  – structure potential increases when CP is applied
  – it is negative to earth; said to increase negatively
  – common galvanic anode materials; the potential of the steel becomes more negative

• Most corrosion personnel connect digital voltmeters (+) to the pipeline and (-) to the CSE so that the meter shows a (-) reading
Criteria of Cathodic Protection

• There are several criteria

• Two most common
  – Pipe-to-Soil Potential of at least -0.85 Volts With Respect to a Copper-Copper Sulfate Reference Electrode
    • Measured with Cathodic Protection Applied
    • Measured with Cathodic Protection Off
  – 100mV (0.1) Volts Polarization
Effect of Voltage (IR) Drop

• Ohm’s Law defines the relationship among the three electrical quantities, voltage (E), current (I) and Resistance (R). Ohm’s Law states that voltage equals current times resistance, or E=IxR. Voltage is frequently referred to as simply IR.

• A voltage drop occurs whenever a current passes through a resistance

• The earth has resistance
  – Place the reference cell close to the pipe

• The voltage at the location of the electrode will be more negative than that at the location of the pipe
  – an erroneous reading, more negative than that the voltage at the pipeline
  – cathodic protection criteria require that the IR drop be “considered” in the reading; taking steps to obtain the most accurate, IR drop free data
-0.85 V With Respect to a Copper-Copper Sulfate Reference Electrode

• Commonly used criterion
• Applicable to steel and cast/ductile iron
• Useful on coated pipelines because of the relatively small current required to protect them
• Bare pipelines may require excessive current to polarize them up to this potential
• There are two versions of this criterion.
Measured with Cathodic Protection Applied

• Applicable to pipelines that have galvanic anodes connected directly to them
  – No way of disconnecting or interrupting the protective current
  – Consider IR Drop
Measured with Cathodic Protection Off

• Pipe-to-soil potential measurements taken with the cathodic protection current momentarily interrupted, or turned off
  – Usually easy to accomplish with impressed current systems
    • Interrupters
    • Also be done when galvanic systems are connected to the structure through a test station
• When the cathodic protection is off, there is no current flow in the earth and thus no IR drop (since voltage drop \[E = Ir\] [Ohm’s Law], if I=0, E must = 0)
  – These “off” readings are accurate measurements of the actual structure-to-soil potential
100mV (0.1) Volts Polarization

• Applicable to steel and cast/ductile iron as well as aluminum and copper
• Useful for steel structures that are poorly coated or bare and which would require an excessive amount of protective current to meet one of the -0.850V criteria
  – frequently used for well casings
• The 100mV (0.1V) polarization refers to the difference between
  – 1) the original, unprotected potential and the “off” potential after cathodic protection has been installed or:
  – 2) the difference between the “instant off” potential and a potential reached after a period of depolarization
Lab 12 – CP Applied – Instant Off

1. Take P/S reading with magnesium anode attached to coated steel
2. Disconnect anode and note instant off reading
3. Polarization- Continue to observe the P/S reading as it decays
   1. After 30 seconds
   2. After one minute
   • Did you achieve the 100 mV shift?
Summary

• Test Stations
• Wire Connection to Pipe
• Pipe-to-Soil (P/S) Potential Measurements
• Criteria of Cathodic Protection (CP)
Questions