Impressed Current Cathodic Protection Installation

Period 3

Advanced Corrosion Course 2017
Course Objective

To familiarize corrosion personnel with a variety of types of impressed current ground beds, cathodic protection materials, and installation procedures.
Considerations for Installation

- Right-of-way
- AC power service
- Rectifiers
- Cables
- Types of ground beds
- Ground bed materials
- Electrical connections
Right-of-Way

- Is there space available for your design?
- Is there space for construction activities?
- Does the location have AC power?
- Are there other pipelines in the immediate area?
- Does normal land use jeopardize groundbed life?
- Can you afford the easement?
- Is the easement long-term?
- Is it accessible for maintenance?
AC Power Service

• Is power available?
• What type of service: above or below grade?
• Will power poles have to be added?
• Will new cable have to be trenched?
• Due to federal, state and local codes, a local licensed electrician should perform the work.
Rectifiers
Installation Tips

• Security
  – Does it need to be locked?
  – Does the location invite vandalism?
  – Is the unit well protected?
    • Bumpers or plow guards
    • Wattmeter shielded

• Install at approx. eye level to the user
• Ensure proper grounding
• Consider sizing rectifier after installing the ground bed to ensure proper sizing
• Install where easily accessible for maintenance
Rectifiers
Air Cooled – Constant Voltage

- Most common type used
- Economical
- Easy to maintain and replace components
- Convection air flow cools the components in the unit
Rectifiers
Oil-Cooled

• Used in extreme conditions
  – Dust
  – Salts in the air
  – Corrosive fumes
  – Excessive moisture
  – Excessive current demands
• Components are immersed in oil
• Can be made explosion-proof by adding correct fittings
  – Refineries
  – Chemical plants
  – Other explosive environments
• Need to drain water periodically
Rectifiers

Constant Current

• Special circuit that provides constant current output

• Used where the load resistances may change drastically
  – Wet to dry conditions
  – Also may be used to control stray current interference in dynamic environments
Rectifiers
Potential Controlled

• Monitors the structure-to-electrolyte potential (using PRC)
• Maintains predetermined P/S by adjusting rectifier output
• Used in special situations
  – Water storage tanks
  – Harbor structures
  – Structures subject to stray currents
  – Anywhere that a constant potential must be maintained
• Might be susceptible to lightening strikes
  • Circuit boards
Rectifiers
Solar Power Units

• Solar panels supply energy to storage batteries
• Sunlight is necessary occasionally
• Battery configuration can be large, costly, and vulnerable
• Vandalism is not uncommon
• Expensive initially, but may be significantly less than bringing in AC power
• Batteries require maintenance occasionally
Rectifiers
Thermoelectric

- Uses fuel (natural gas) from pipeline to create heat which is then turned into electric current
- No moving parts
- Requires modifications to the pipeline to get fuel
- Presents a burn hazard and must be secured from public
- Creates small amount of carbon emissions
Groundbed Anode Materials

• Many different anodes types available
• Some are made for specific applications (ex., harsh chemical environments, space restrictions, intense output demands)
• Some perform well in a wide variety of applications.
• Use what you are comfortable with
• Follow the manufacturer’s recommendations
Groundbed Anode Materials

• Graphite
  – Long history
  – Should not overt- drive them
  – Use backfill with them in soil
  – Brittle
  – Prone to damage in shipping
Groundbed Anode Materials

- High Silicon Cast Iron
  - Good electrical properties
  - Manufactured in many shapes and sizes
  - Good for service in harsh chemical environments
  - Brittle
  - Have a relatively slow consumption rate due to the formation of a silicon oxide film
Groundbed Anode Materials

Galvanic Anodes

- Not to be used in impressed current systems
- May be used to supplement impressed current systems
- Materials include magnesium, zinc and aluminum
- Variety of sizes, shapes and applications
- Low maintenance
- Poor coverage in some environments
Groundbed Anode Materials

• Mixed Metal Oxide Anodes (MMO’s)
  – Developed in Europe in early 1960’s
  – Consists of a titanium wire, mesh, or rod with an oxide film baked on
  – Favorable service life while providing current at very high density levels
  – Best performance when used in conjunction with backfill
Groundbed Anode Materials

• Advantages of MMO anodes
  – Lightweight and durable
  – Negligible consumption rates
  – High current density capability
  – Inert to acidic bi-products
  – Cost effective
Groundbed Anode Materials

Other Anode Materials

- Platinum Anodes
  - Platinum coated metal core

- Linear Anodes
  - Thin metallic ribbons (usually on titanium substrate)
  - Conductive polymer anodes (resembles electrical cable)

- Lead Silver Anodes
  - Sea water applications
Connections

Thermite Welds

• A thermal fusion bond of the conductor to the metallic medium and the metallic medium to the structure
• Inexpensive and durable
• Surface preparation (clean, dry and rough) is necessary for a secure and conductive connection
Connections
Thermite Welding

Use the correct mold for the surface
- Curved (large or small diameter)
- Flat

1. Wear appropriate PPE
2. Not for use in explosive environments
3. May need to preheat surface to remove moisture
4. Coat the weld adequately
Cable Connections

• Copper Crimps
  – Good compression between cables

• Split Bolts
  – Mild compression between cables

• Thermite welds
  – Conductive thermal bond between cables
Splice Coatings

- There are many methods:
  - Hand wrapping
  - Epoxy mold encapsulation
  - Shrink tubing and sleeves
  - Elastomer/urethane impregnated wrap
Connections

Splicing Tips

• Use as few as possible
• Use proper crimp size
• Eliminate voids or bubbles in coating materials
• Take your time
• Follow manufacturer’s recommendations
“Cathodic Protection Cable”

- Should be “Direct Burial Cable”
- Solid or stranded copper wire
- Rated for 600 volt service
- #4 or #2 AWG, 7 strand High Molecular Weight Polyethylene (HMWPE) is commonly used
- Different “jackets” are available for different applications and environments
- Dual jacketed HMWPE and Kynar or Halar for chlorine environments (typically deep anodes, and brackish or seawater)
- Specialty cable is relatively expensive
Cables

Installation Tips

• Select the appropriate size during design
• Bury it deep enough to limit third party damage
• Check insulation for nicks, cuts, or other damage
• Mark its location if possible
  – Burial tape
  – Above ground markers
  – Good as-built drawings
Types of Groundbeds

1. Conventional

2. Distributed

3. Vertically oriented (Deep, semi-deep or shallow)

4. Hybrid
Conventional Groundbed

- Anodes are located at remote earth to the structure
- Can be installed horizontally or vertically
- Used to influence broad areas of structure
- Can be used on coated or bare structures
- Relatively inexpensive and easy to install
- Particularly vulnerable to moisture variations in the soil (seasonal changes)
Conventional Groundbed
Installation Tips

• Use as few splices as possible
• Place anodes in moist soil
• Coke breeze decreases resistance to earth and prolongs groundbed life
• Consider looping the header cable
• Third party damage reduces with additional depth
Distributed Groundbed

- Anodes are installed along the pipeline
- Can be installed on either or both sides of the pipeline
- Can be used selectively
  - Shielded areas
  - Poorly coated areas
  - In congested areas
Distributed Groundbed
Installation Tips

• Locate the pipeline with a good instrument before installation
  – May need to use prod bar to verify
• Use extreme caution during excavations
• Ensure that the anodes and coke breeze do not contact structure
• Consider using augured holes for anode installation
Distributed Groundbed

- Reduces stray current interference
- Focuses CP current where it is needed
- Installation requires excavation near the structure
- Current attenuation problems on long anode strings
- Linear anode cable may be installed instead of anode rods
- Expensive
  - Large cables
  - Labor intensive
  - A lot of materials
  - May require a number of rectifiers
Vertically Installed Groundbed

- 0 – 20 ft deep = Shallow (installed w/ auger or drill rig)
- 20 – 50 ft deep = Semi-deep (likely will require drill rig, very good auger rigs can do drill to depth)
- More than 50 ft = Deep (requires drill rig)
- Anodes are lowered into a vertically drilled hole
Deep Groundbed
Installation Tips

• Hire an experienced and knowledgeable contractor for installation
• Vent the installation away from metallic structures (junction boxes and rectifier cases corrode due to chlorine gas generated at the anode)
• Good backfill installation process is extremely important
  – Pumping coke from the bottom (slow, thick, and steady)
• Protect the installation
  – Above ground appurtenance may require guards
    • Surface casing
    • Anode junction box
Deep Anode (sample design)
Deep Groundbed

Advantages and Disadvantages

1. Good current distribution
2. Fewer stray current interference problems
3. Small easement required
4. May have very long life
5. Less third party damage incidents
6. Can be expensive to install
7. Difficult to repair or replace
8. Environmental concerns (mud and cross contamination of aquifers)
9. May drill into hard rock or high pressure aquifers and have to abandon unfinished well
Hybrid Groundbed

• Combination of two or more ground beds working together
• Not necessarily the best configuration
• Could also be impressed and galvanic
• Usually results from add-ons and changing design factors
CONCLUSION

Impressed current groundbeds can provide many years of service (MAYBE EVEN UNTIL AFTER YOU RETIRE) when the proper materials are installed properly.