# **Intermediate Course** Chapter 3 – Installation ICCP Systems

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**Appalachian Underground Corrosion Short Course** 

#### Why Are We Here?



- I passed Basic. I think.
- My boss sent me.
- My company offered to pay for it.
- This is my 2<sup>nd</sup> + time.
- I know the instructor and plan to heckle him during his presentation.
- The other class was full.
- I love ICCP Systems

### Chapter 3 Summary

- What is an impressed current cathodic protection system?
- Why impressed current?
- Types of ICCP systems.
- Types of power sources.
- Materials for ICCP systems.
- Site selection.
- Installation Methods.

#### Impressed Current CP System

• A cathodic protection system that utilizes an external source of DC power in order to force current flow onto a pipeline (or other structure).

- Mitigate the discharge of corrosion current from the structure to the electrolyte.
- Reducing loss of metal from the structure.

## Thank you Internet



## Why use ICCP instead of Galvanic?



- Soil Resistivity Issues
- Cost for increased coverage
- Cover areas that are not accessible

- Needs power
- Monitoring
- Interference

## Types of ICCP Anode Beds

Conventional - (Point)

Remote and perpendicular most common



#### **Conventional Anode Bed**

- Most common on pipelines
- Extended current distribution



- Normally installed perpendicular
- Can be drilled, trenched, directionally drilled
- Typically least expensive

- Requires additional right-of-way
- Can be subject to damage from 3<sup>rd</sup> party

## Types of ICCP Anode Beds

#### **Distributed**

Close and parallel, usually in plants, more subject to damage, more expensive than a remote ground bed



#### **Distributed Anode Bed**

- Localized application of current
- Plants, large diameter pipe, terminals, tanks
- Less stray current
- Should loop the header cable

- Close proximity requires care during installation
- Most susceptible to damage from plant/pipe maintenance
- More materials
- More expensive

#### Types of ICCP Anode Beds

#### Deep



#### Deep Anode Bed

- Becoming more popular
- Extended current distribution



- Pipelines, plants, terminals, tanks
- Requires less R/W
- Useful in high surface soil resistivities

- Less damage prone, but cannot be repaired
- Requires mud rotary or air drilling
- Possibly environmental concerns
- Most expensive

## Types of Power Supplies for ICCP Systems

- Rectifiers
- Solar Cells
- Thermoelectric Generators
- Engine Generator Sets
- Turbine Generator Sets
- Wind Powered Generators

## Rectifiers



#### • Converts AC to DC\*

1. Transformer to step down the AC

2. Rectifying element to convert the AC to DC

3. Cabinet

#### Rectifiers



- Single-phase or three-phase
- Air cooled or oil cooled
- Selenium stacks or silicon diodes
- Constant voltage or constant potential
- Meters, outlets, cup holders, landscaping

#### Rectifiers



#### Solar Cells

- Uses sunlight to maintain a charge on batteries.
- 1. Solar panels
- 2. Storage batteries
- 3. Control Cabinet



# Solar Cells



## Thermal Electric Generators TEGs



#### Engine – Generator Sets



#### **Turbine – Generator Sets**



### Wind Powered Generators



## **Anode Bed Materials**

- Anodes
  - Different types and uses
- Coke Breeze
- Cables
- Cable Connections
  - Structures
  - Above / below grade
- Cable Splices / Repairs



- Scrap Iron
- Graphite
- High Silicon Cast Iron
- Platinized Titanium
- Platinized Niobium / Tantalum
- Mixed Metal Oxide
- Magnetite

#### Scrap Iron

- Old pipelines / usually bare
- High consumption rates / not uniform



- Graphite
  - Brittle



- Mixed Metal Oxide
  - Most Common



- Mixed Metal Oxide Anodes
- Available in tubes and rods (standard)
- Wire and ribbon for sea water and tank bottoms
- Ribbon is also used for protecting poorly coated pipelines. Installed Parallel and may be in a sock.



- Platinum Anodes
  - Platinum provided on niobium wire
  - Used successfully in sea water
  - Usually applied to another cheaper metal like Titanium
  - Tend to break down if voltage at anode surface is >10V

#### Magnetite Anodes

- Popular in Europe, but rarely used in the US. Expensive
- High Silicon Cast Iron
  - Si 14.5% Cr 4.5%
  - Brittle

#### Coke Breeze

- Coke breeze is the typical backfill material used in impressed current CP systems.
- Used to lower anode resistance and increase anode life
- Metallurgical coke
  - Derived from heating coal (coking)
  - Most surface bed applications, requires tamping
- Petroleum coke
  - Higher quality, lower resistance, pumps easier for deep wells
  - More expensive

#### **Cables for ICCP**

#### • HMWPE – High Molecular Weight Polyethylene

- Outstanding dielectric strength and moisture resistance
- Resists corrosive chemicals





### **Cable Connections**

#### • Structures

• Exothermic Weld / Pin Braze / Mechanical



#### **Cable Connections**

#### • Cable to Cable

• Exothermic Weld / Compression / Split Bolt







## Cable Splices / Repairs

- Cable to Cable
- (+) Cables vs (-) Cables
- Copper Connectors
- Electrical tape / Splicing tape
- Kits 2 part epoxy or gels
- Cure before backfill

## Selecting an Anode Bed Site

- Soil Resistivity\*
  - Lower is better
- Soil Moisture
- Interference with foreign structures
- Power supply availability
- Accessibility for construction and maintenance
- Vandalism / Safety
- Site availability
- System midpoint



## Selecting an Anode Bed Site



### Selecting an Anode Bed Site

- Soil Moisture
- Electro-osmosis

 "When DC current is discharged to the soil from the anode, this current pushes the water away from the surface of the anode and could result in an increase of the anode bed resistance. In the case of the anode bed being installed in <u>high clay content soil</u>, the removal of moisture from the clay may seriously reduce the conductivity of the soil, possibly rendering the anode bed ineffective."

- <u>Surface Ground Beds</u>
- Can be installed horizontal or vertical\*
- Auger is usually best (vertical)
  - The depth of the auger hole is based on design calculations and the type of the anode.\*
- Backhoe / Trench (usually horizontal)
- Cokebreeze
- Warning tape

Loop system? Junction Boxes? Multiple Strings?



#### TYPICAL VERTICAL ANODE INSTALLATION

FIGURE 3-15





- <u>Deep Anode Bed</u>
- Requires Drill Rig
- Casing
- Individual anode leads
- Best if coke is pumped
- Must be vented
- Junction Box
- Seal Well



# Deep Well





# Deep Well





# Deep Well



#### Connection to the Pipe

- Exothermic weld method
- Uses graphite mold filled with copper oxide and aluminum
- Always wear gloves, boots, and safety googles
- Use UT to measure wall thickness before attempting weld



