Installation of Galvanic Anodes

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Installation of Galvanic Anodes

• Brief Review of Fundamentals
• Normal Applications
• General Physical and Electrical Characteristics of Common Underground Galvanic Anodes
• Guidelines for Field Installations
The Galvanic Corrosion Cell

• The Galvanic Corrosion Cell Includes Four Basic Parts:
  1. An Anode
  2. A Cathode
  3. A Metallic Path between the Anode and the Cathode
  4. A Conducting Electrolyte

• There will be no corrosion unless current flows between the Anode and the Cathode.
The Galvanic Corrosion Cell

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Coatings and Electrical Isolation

• Holidays are Scrapes, Gouges, Pinholes, Rock Penetrations, etc.

• Holidays are expected in any coated pipeline.

• The result of Holidays are that a small area of pipeline becomes exposed and needs to be cathodically protected.

• Galvanic Systems could cathodically protect several hundred feet of a coated structure.
FIGURE 2-1

“OPEN CIRCUIT” ANODE IS NOT RECOGNIZED

ELECTROLYTIC PATH

CONDITION 1:
SWITCH OPEN IN MAGNESIUM ANODE CIRCUIT. NO CATHODIC PROTECTION. CORROSION CURRENT FLOW FROM ANODIC AREA TO CATHODIC AREA OF CORROSION CELL SHOWN BY LINES AND ARROWS. RETURN CIRCUIT THROUGH PIPE.

ELECTROLYTIC PATH

CONDITION 2:
SWITCH CLOSED IN MAGNESIUM ANODE CIRCUIT. CATHODIC PROTECTION APPLIED. CATHODIC PROTECTION CURRENT FLOW SHOWN BY LINES AND ARROWS. PREVIOUSLY ANODIC AREA HAS BECOME CATHODIC.

“CLOSED CIRCUIT” ANODE IS NOW RECOGNIZED

METALLIC PATH

BASIC CONCEPT OF CATHODIC PROTECTION WITH GALVANIC ANODES

FIGURE 2-1
# The Practical Galvanic Series

<table>
<thead>
<tr>
<th>Material</th>
<th>Potential*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PURE MAGNESIUM</td>
<td>-1.75</td>
</tr>
<tr>
<td>MAGNESIUM ALLOY</td>
<td>-1.60</td>
</tr>
<tr>
<td>ZINC</td>
<td>-1.10</td>
</tr>
<tr>
<td>ALUMINUM ALLOY</td>
<td>-1.00</td>
</tr>
<tr>
<td>MILD STEEL (NEW)</td>
<td>-0.70</td>
</tr>
<tr>
<td>MILD STEEL (OLD)</td>
<td>-0.50</td>
</tr>
<tr>
<td>CAST / DUCTILE IRON</td>
<td>-0.50</td>
</tr>
<tr>
<td>STAINLESS STEEL</td>
<td>-0.50 to + 0.10</td>
</tr>
<tr>
<td>COPPER, BRASS, BRONZE</td>
<td>-0.20</td>
</tr>
<tr>
<td>GOLD</td>
<td>+0.20</td>
</tr>
<tr>
<td>CARBON, GRAPHITE, COKE</td>
<td>+0.30</td>
</tr>
</tbody>
</table>

* Potentials with respect to saturated Cu-CuSO₄ electrode
Galvanic Anode Applications

• Small amounts of current required.
• Soil resistivity is relatively low.
• Constraints on the use of impressed current.
• ‘Hot Spot’ requirements.
• High voltage dissipation gap (or grounding cell)
Advantages of Galvanic Anode Systems

• No external power required
• Easy to install
• Maintenance requirements are low
• More economical
• Minimum of anodic interference
• Minimum right of way easement costs
• Anodes can be easily added, as needed
Disadvantages of Galvanic Anode Systems

• Limited driving potential
• Lower/limited current output
• Can be ineffective in high-resistivity environments
• Poorly coated structures require many anodes
• Not economical where large currents are required
• May not be effective in dynamic stray current areas
Distributed Galvanic CP System
Single Groundbed Galvanic CP System

- SERVICES
- ISOLATOR
- BONDED JOINTS
- COATED PIPE
- SECTIONALIZING ISOLATOR
- ANODE GROUNDDBED
Galvanic Anode Materials

• There metals are the most common galvanic anode materials:
  • Magnesium
  • Zinc
  • Aluminum
Magnesium Anodes

- Highest driving potential
- Many different shapes and sizes
- Generally used where soil resistivity is between 1,000 and 5,000 ohm-cm
### TABLE 2-1

**COMMON ALLOY SPECIFICATIONS - MAGNESIUM**

<table>
<thead>
<tr>
<th>Element</th>
<th>High Potential</th>
<th>Grade A</th>
<th>Grade B</th>
<th>Grade C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>0.010% max</td>
<td>5.3 to 6.7%</td>
<td>5.3 to 6.7%</td>
<td>5.0 to 7.0%</td>
</tr>
<tr>
<td>Mn</td>
<td>0.50 to 1.30%</td>
<td>0.15 to 0.70%</td>
<td>0.15 to 0.70%</td>
<td>0.15 to 0.70%</td>
</tr>
<tr>
<td>Zn</td>
<td>0</td>
<td>2.5 to 3.5%</td>
<td>2.5 to 3.5%</td>
<td>2.0 to 4.0%</td>
</tr>
<tr>
<td>Si</td>
<td>0.05 % max</td>
<td>0.10% max</td>
<td>0.30% max</td>
<td>0.30% max</td>
</tr>
<tr>
<td>Cu</td>
<td>0.02% max</td>
<td>0.02% max</td>
<td>0.05% max</td>
<td>0.10% max</td>
</tr>
<tr>
<td>Ni</td>
<td>0.001% max</td>
<td>0.002% max</td>
<td>0.003% max</td>
<td>0.003% max</td>
</tr>
<tr>
<td>Fe</td>
<td>0.03 % max</td>
<td>0.003% max</td>
<td>0.003% max</td>
<td>0.003% max</td>
</tr>
<tr>
<td>Other</td>
<td>0.05% each or</td>
<td>0.30 % max</td>
<td>0.30 % max</td>
<td>0.30 % max</td>
</tr>
<tr>
<td></td>
<td>0.30% max total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>Remainder</td>
<td>Remainder</td>
<td>Remainder</td>
<td>Remainder</td>
</tr>
<tr>
<td>Solution Potential</td>
<td>-1.80 V</td>
<td>-1.55 V</td>
<td>-1.55 V</td>
<td>-1.55 V</td>
</tr>
</tbody>
</table>
Zinc Anodes

• Many different shapes and sizes
• Perform best in low resistivity environments
  • <2,000 ohm-cm
• Examples of low resistivity environments?
  • Sea Water
  • Salt Marshes
Note: Cadmium is a known carcinogen and thus this alloy should not be used in Underground Applications.

TABLE 2-2

COMMON ALLOY SPECIFICATIONS - ZINC

<table>
<thead>
<tr>
<th></th>
<th>Zinc (Mil-A 18001)</th>
<th>Zinc (ASTM B418-67 Type II)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seawater Use</td>
<td>Underground Use</td>
</tr>
<tr>
<td>Element</td>
<td>Percent</td>
<td>Element</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.1 to 0.3%</td>
<td>Special high-grade Zinc</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.025 to 0.06%</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>0.005% max</td>
<td></td>
</tr>
<tr>
<td>Special high-grade zinc</td>
<td>Balance</td>
<td></td>
</tr>
<tr>
<td>Solution potential</td>
<td>-1.10 V</td>
<td>Solution potential</td>
</tr>
</tbody>
</table>

Zinc Anodes
- Gypsum
- Bentonite
- Sodium Sulfate
Note: None of these Aluminum Anode alloys work in Underground Applications – The anode will passivate and not deliver effective CP
Although this slide and in your Book indicate by the drawing To connect the anode directly To the pipe, Utilize an approved test station where you can...This Will allow the circuit to be Interrupted for survey & troubleshooting purposes
NOTES:

1. BARE ANODES WITH SEPARATE CHEMICAL BACKFILL MAY BE USED PER FIGURE 2-4.

2. MULTIPLE ANODE INSTALLATIONS MAY ALSO BE MADE WITH ALL ANODES BELOW PIPE BUT OTHERWISE IN GENERAL ACCORD WITH FIGURE 2-5.

3. IF NECESSARY, AUGER HOLE MAY BE ANGLED SLIGHTLY

TYPICAL INSTALLATION OF GALVANIC ANODES WHERE LATERAL SPACE IS LIMITED

FIGURE 2-3
TYPICAL INSTALLATION OF BARE GALVANIC ANODES WITH SEPARATE CHEMICAL BACKFILL

FIGURE 2-4
MULTIPLE INSTALLATION OF GALVANIC ANODES

FIGURE 2-5
Anode Lead Attachment

• Insulated lead wire from the anode may be connected by some form of an exothermic weld

• Ensures the long-term low resistance in the connection

• The copper metal nub at the point of connection must be thoroughly insulated with suitable coating material
B. EXPOSED THERMIT WELD (COPPER) ON CARBON STEEL: LARGE ANODE VS SMALL CATHODE, SLOW CORROSION RATE

EFFECT OF RELATIVE AREA OF ANODE TO CATHODE
NOTE: END OF CABLE SHOULD NOT PASS CENTER LINE OF MOLD.

MOLD POSITIONING

COAT WELD AREA WITH COLD-APPLIED BITUMEN TYPE COATING

THERMITE WELD, USE CHARGE AS SPECIFIED FOR SIZE OF WIRE AND PIPE.

COMPLETED WELD

THERMITE WELD
Brazing pin

- Ceramic Ferrule
- Cable lug for PinBrazing
- Silver capsule
- Special brazing alloy
- Special flux
- Brass

Melting Temperature 1200°F / 650°C

Only 5 microohms/brazed joint
Test Points

- Commonly referred to as test stations
- May be desired and/or required to permit periodic testing of galvanic anode performance
TYPICAL TEST POINT INSTALLATION

FIGURE 2-6
EPoxy Resin

Filler Hole

Anode Lead

Insulated Stranded Copper Cable

Plastic Mold

Cables Sealed to Mold with Tape Strips Supplied with Kit (3 Places)

Copper Compression Connector (or Alternates Below)

Split Bolt

Exothermic Weld

Alternate A

Alternate B
AWG NO. 8 STRANDED COPPER COLLECTOR WIRE.

COMPRESSION CONNECTOR

TAPER AND ROUGHEN WIRE INSULATION

2" MIN. (TYP.)

AWG NO. 12 SOLID COPPER WIRE

ELECTRICAL TAPE

SPlicing COMPOUND

TYPICAL ANODE SPlice
Bonding Strap As a Metallic Connection

Pipe
Anodes

8mA + Read
Current Direction Indicated on Amp Clamp
MAGNESIUM ANODE TEST STATION

Tag leads as shown
Std. 5" roadway box, upper section only with cover.

A WG No. 12 solid copper wire
Bonded pipe joint (Typ.)

Leave sufficient slack wire in box such that wires can be extended 12" above grade.

A WG No. 8 stranded copper wires
Thermite weld
Electrode

Note: Anode shall not come in contact with sand backfill

Proposed main with coating as specified on contract drawings
Magnesium anode

Sand backfill
Magnesium anode
Backfill with soil from ditch excavation

Section A-A
Plastic pipe, 5" I.D., 18" shaft length.

Available with 4, 5 or 7 terminals.

Heavy cast iron lids, both locking and non-locking, available.

One-inch extensions available whenever road resurfacing occurs.