AC Mitigation
Solutions to an On-Going Issue

Charlie Poore
NACE Senior Corrosion Technologist #53904

AC Interference

• One of the most pressing issues we face today in the corrosion industry
• Increasingly congested ROW’s – collocated power lines
• Higher Voltages
• Pipeline coatings and application techniques have improved vastly over the past decade
• Less frequent holiday locations –
  smaller holiday size = higher current discharge
AC Interference

- Variable current discharges based on power line energy demand
- Mitigation electrode may traverse many difference soil resistivity’s and corrosive environments
- Electrodes need to function in all environments, for long periods of time
AC Interference is Widespread Across our Operating Systems

- Houston, TX – DOW pipelines
  - 51 pipelines inside corridor
  - 230kV-500kV overhead lines

- El Paso, TX - Nustar
  - El Paso Electric to install 130kV system in ROW

- Farmington, NM – Tri-State
  - Proposed 130kV line
  - 41 potential pipeline crossings

PRACTICAL EXAMPLE
AC MITIGATION TOOLS

- DIFFERENT SOFTWARE PROGRAMS
- SOIL RESISTIVITY TESTING
- SOIL CONDITIONS
- LOAD INFORMATION FROM POWER COMPANIES
- COATINGS/CONDITION OF PIPE
- WEATHER
- FUTURE DEMANDS

AC Mitigation Modeling is a Snapshot in Time

- Modeling today is based on current conditions
  - loads, coating requirements

- AC Mitigation needs will change over time as conditions, loads and requirements change
CDEGS Modeling of AC Mitigation Electrodes

- Powerful software for examining ground resistivity and current dissipation characteristics
- Ability to model custom designs and situations
- On-site resistivity testing completed to provide accurate models

AC MITIGATION MATERIALS

- BARE COPPER CABLE
- COPPER ENCASED IN COKE BREEZE
- COPPER ENCASED IN CONDUCTIVE CONCRETE
- SOCK ELECTRODE-typically copper wire with some type of backfill
- ZINC RIBBON
BARE COPPER

SOCK ELECTRODE
SOCK ELECTRODE

ZINC RIBBON
Material issues to consider

- BARE COPPER CABLE-subject to corrosion, theft
- COKE BREEZE-issues of moving water/environmental concern
- CONDUCTIVE CONCRETE-dirty installation-requires specialized equipment
- SOCK ELECTRODE- splicing, damage to sock during installation process
- Zinc-soil or environmental issues that may effect its performance

INSTALATION METHODS

- Trenching
- Vibratory Plowing
- Horizontal drilling
- Directional drilling
- Point Drain
TRENCHING SOCK ELECTRODE

ZINC RIBBON PLOW INSTALATION
TRENCHING / PLOWING INSTALLATION

- Company SOP—can you place over top of existing pipe?
- Is trenching/vibratory plowing allowed?
- Room in the ROW?
- Product in pipeline—Hazardous/Explosive?
- Time frame—during or after Construction

DIRECTIONAL BORING INSTALLATION

- Length of bore—determine size of cable
- Existing infrastructure
- Underground structures
- Geology
POINT DRAIN

Typically bare copper wire

Typically uses some type of backfill around copper wire—backfill-coke breeze or conductive concrete

Advantage—Space saving—Leaves row available for future projects/pipe lenses

Disadvantage—not as effective as horizontal footprint, may require more point drains to achieve mitigation

Space/drill rig access—Overhead HVAC lines
CDEGS MODELING RESULTS

ANALYTICAL LOOK AT DIFFERENT MITIGATION MATERIALS

CDEGS Modeling of AC Mitigation Electrodes – 100 ohm-m Soil

<table>
<thead>
<tr>
<th>100 ohm-m soil, 1000 ft length</th>
<th>Resistance to Ground (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/0 bare copper</td>
<td>0.8992</td>
</tr>
<tr>
<td>Conductive Backfilled Electrode</td>
<td>0.8195</td>
</tr>
<tr>
<td>Zinc ribbon 7/8 x 5/8&quot;</td>
<td>0.8114</td>
</tr>
<tr>
<td>1/0 Copper, 6&quot;x6&quot; Conductive Column</td>
<td>0.7344</td>
</tr>
</tbody>
</table>

- Size matters—typically larger footprint lower resistance
- Conductive backfilled conductors are capacitive in nature – providing excellent surge dissipation characteristics
CDEGS Modeling of AC Mitigation Electrodes – 1000 ohm-m Soil

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Resistance to Ground (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/0 bare copper</td>
<td>8.5797</td>
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<tr>
<td>Conductive Backfilled Electrode</td>
<td>7.7761</td>
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<tr>
<td>Zinc ribbon 7/8 x 5/8&quot;</td>
<td>7.9096</td>
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<tr>
<td>1/0 Copper, 6&quot;x6&quot; Conductive Column</td>
<td>6.9165</td>
</tr>
</tbody>
</table>

- Difference in resistance to ground between conductive backfilled conductor and Zinc negligible
- Size of cable in sock does not play significant role in resistance to ground—overall “footprint” that is modeled

Charlie Poore  
Senior Corrosion Technologist #53904  
505-250-7481  
Charlie.poore@mesaproducts.com