AC Mitigation
Solutions to an On-Going Issue

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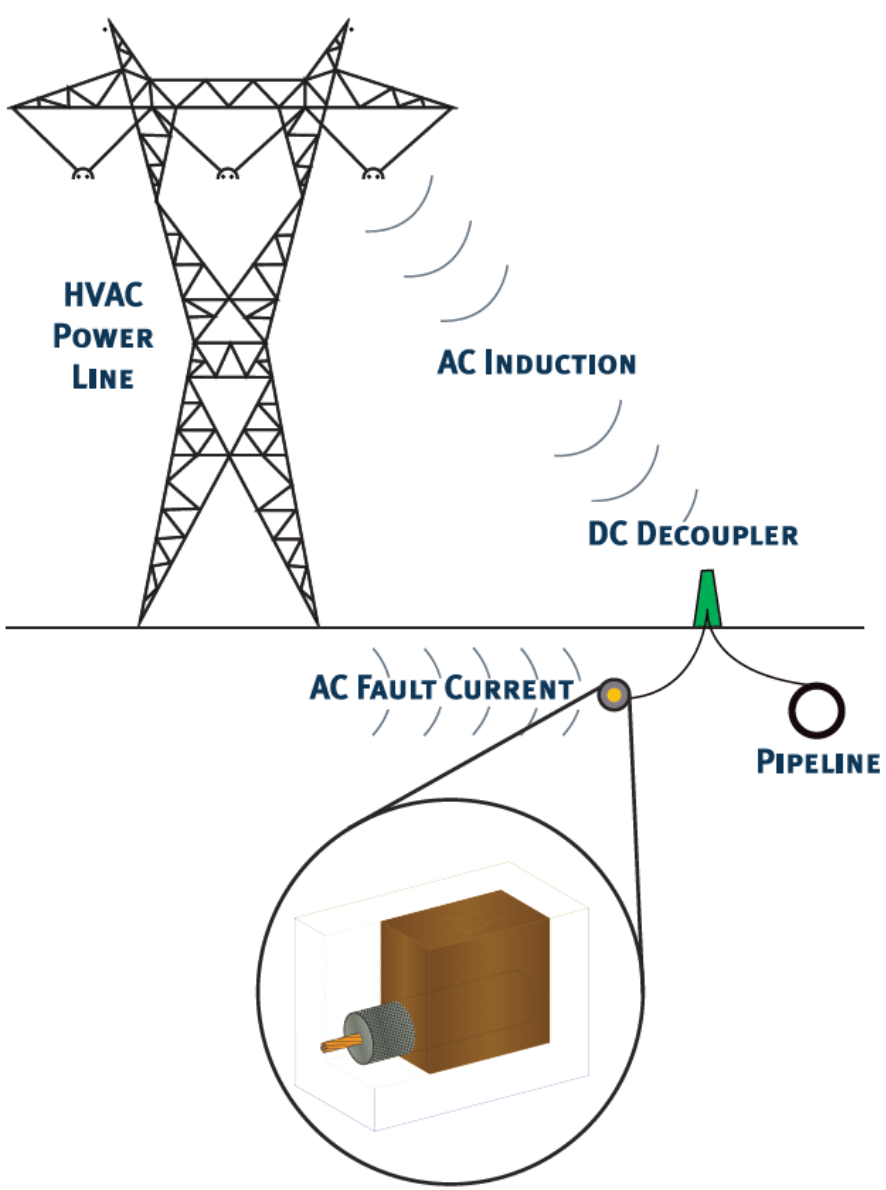
AC Interference

- 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

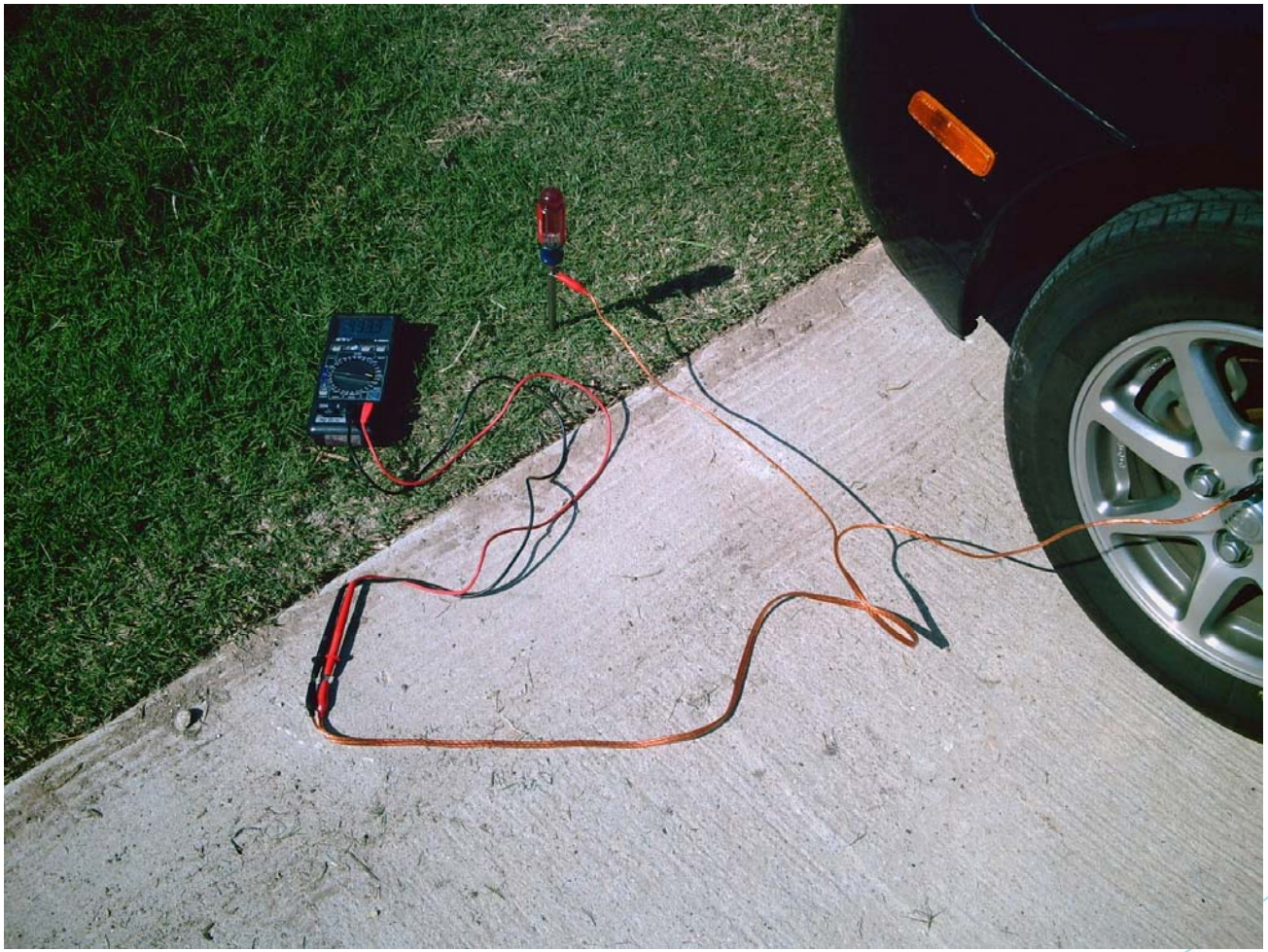


COMMON ROW TODAY

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

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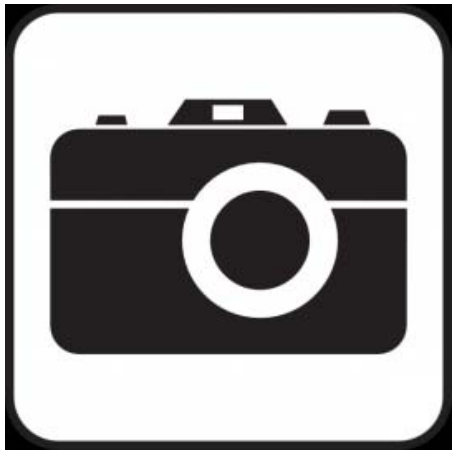
AC MITIGATION TOOLS

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

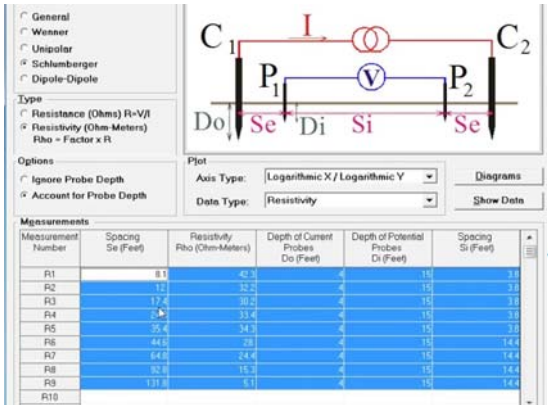
AC Mitigation Modeling is a Snapshot in Time

- 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

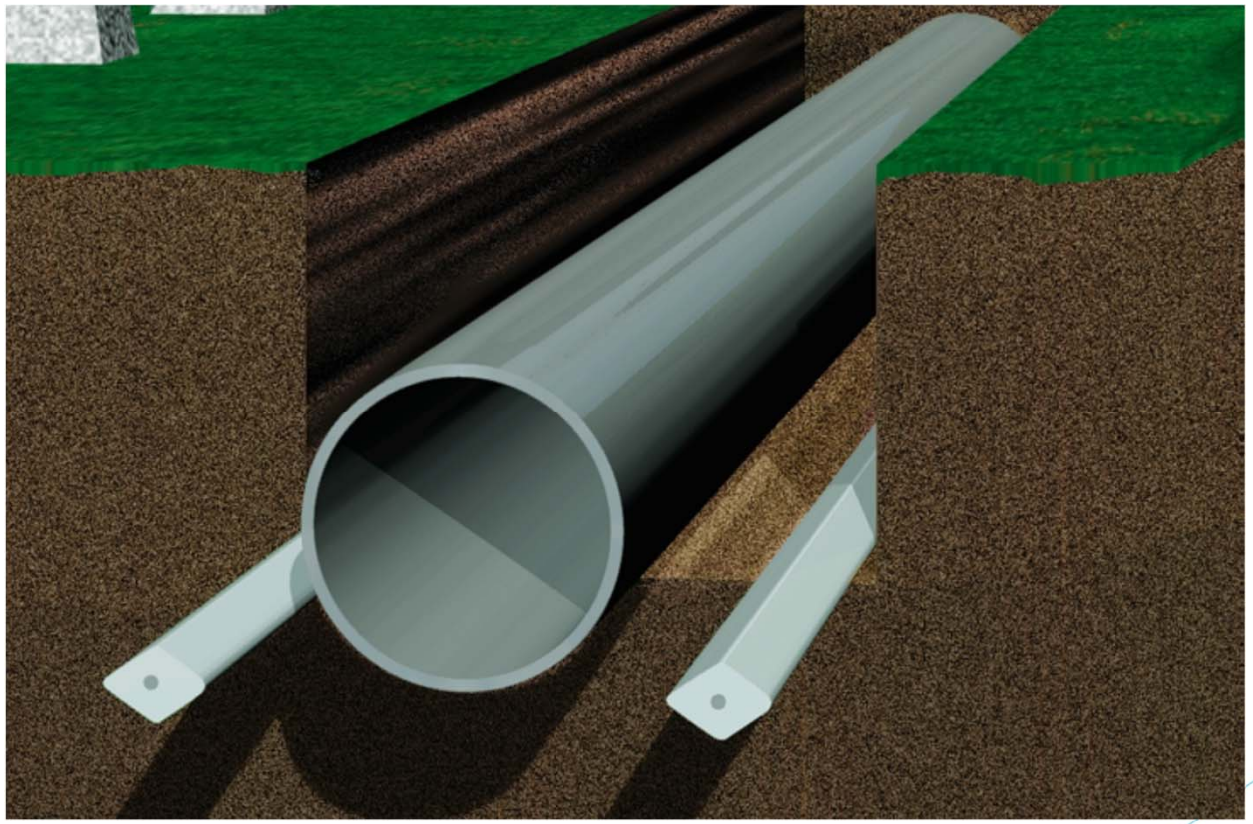
- BARE COPPER CABLE
- COPPER ENCASED IN COKE BREEZE
- COPPER ENCASED IN CONDUCTIVE CONCRETE
- SOCK ELECTRODE-typically copper wire with some type of backfill
- ZINC RIBBON

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

POINT DRAINS

- TYPICALLY BARE COPPER WIRE
- TYPICALLY USES SOME TYPE OF BACKFILL AROUND COPPER WIRE-BACKFILL-COKE BREEZE OR CONDUCTIVE CONCRETE
- ADVANTAGE-SPACE SAVING-LEAVES ROW AVAILIBLE FOR FUTURE PROJECTS/PIPELENES
- DISADVANTAGE-NOT AS EFECTIVE AS HOROZONTAL 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

100 ohm-m soil, 1000 ft length	
Conductor	Resistance to Ground (ohms)
1/0 bare copper	0.8992
Conductive Backfilled Electrode	0.8195
Zinc ribbon 7/8 x 5/8"	0.8114
1/0 Copper, 6"x6" Conductive Column	0.7344

- 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

1000 ohm-m soil, 1000 ft length	
Conductor	Resistance to Ground (ohms)
1/0 bare copper	8.5797
Conductive Backfilled Electrode	7.7761
Zinc ribbon 7/8 x 5/8"	7.9096
1/0 Copper, 6"x6" Conductive Column	6.9165

- 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

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CORROSION CONTROL + INTEGRITY

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