CP SYSTEM DESIGN

Fundamentals, Tools, and Best Practices

LAKE SUPERIOR CONSULTING

TODAY'S PRESENTER

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AGENDA

WHAT IS CP?

A method used to control corrosion on metallic structures ⓘ

+ Coating is first line of defense

+ Degradation and defects are inevitable

+ CP systems are used to make structures the cathode of an electrochemical cell

Anodes + Cables + Power

WHY CP DESIGN MATTERS

BENEFITS

- ✓ Effective protection
- ✓ Extended Asset Life
- ✓ Optimized performance and energy usage
- ✓ Safety

RISKS WITHOUT CP DESIGN

- ✗ Under or over protection
- ✗ Stray current interference
- ✗ Coating damage or uneven distribution
- ✗ Premature equipment failure

CP DESIGN PROCESS

- Current Requirement

- Soil Resistivity

- Anode Selection

- Constructability & Environment

- Monitoring

THEORETICAL

Structure Surface Area

Coating Quality

Current Density Required to Mitigate Corrosion

BEST PRACTICES

- Use in conjunction with field testing methods

- Add conservatism

- Account for future increased demand

DOWNFALLS

- Hard to account for coating variance or shorts

- Other guesswork

FIELD TESTING

BEST PRACTICES

- Ensure proper placement of temporary ground

- Allow time for sufficient polarization

- Use IR Free measurements if possible

- Validate remote earth prior to test

DOWNFALLS

- Difficult to test when dealing with space constraints

- Minimal current output in dry areas

ELECTROLYTE RESISTIVITY

FIELD TESTING

Considers the resistivity near the structure as well as the location of the proposed CP system.

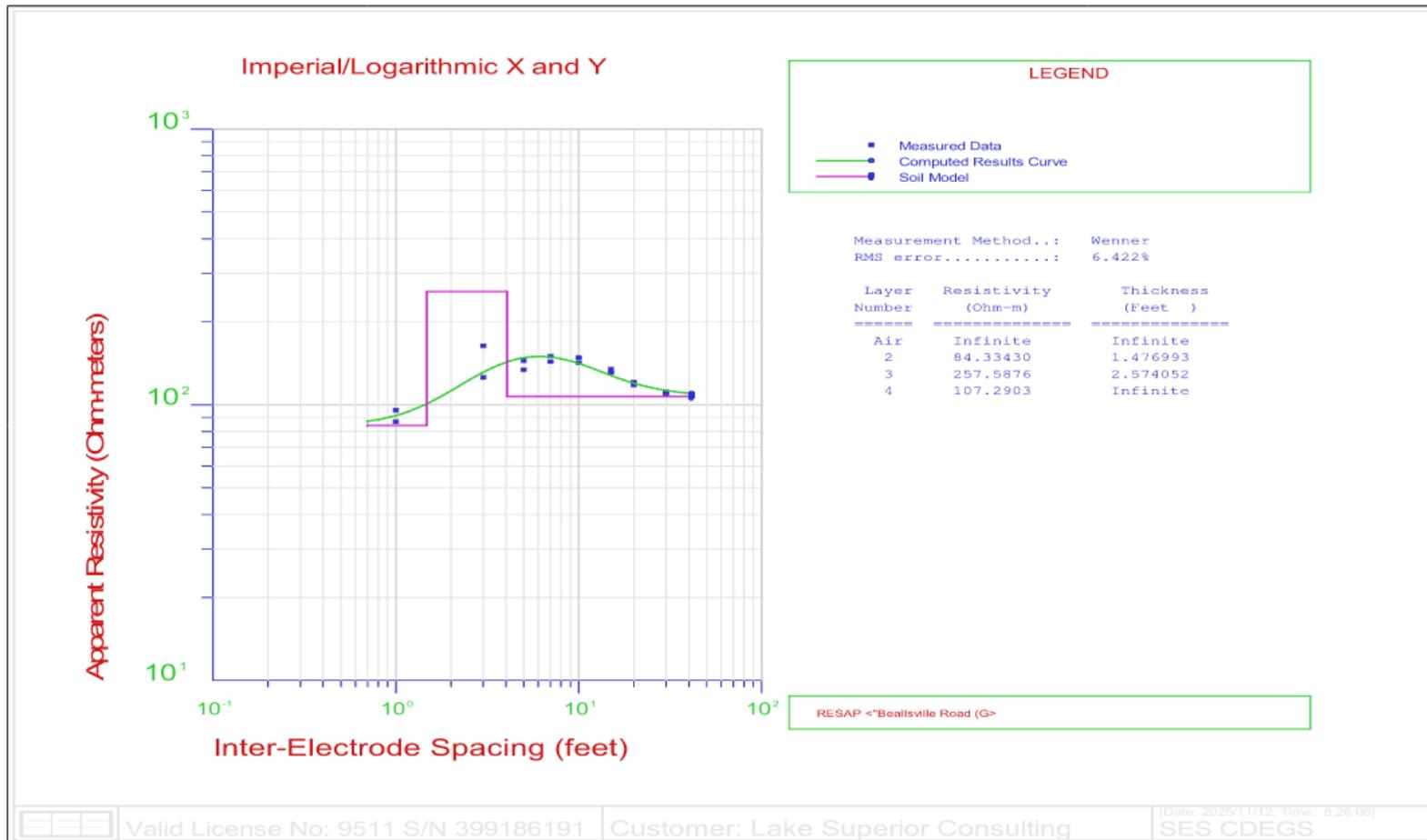| HIGH RESISTIVITY	resistance to current flow	good for corrosion but bad for CP system performance
LOW RESISTIVITY	ease in current flow	bad for corrosion but ideal for CP system performance

ELECTROLYTE RESISTIVITY
BEST PRACTICES & DOWNFALLS

BEST PRACTICES

- Soil Modelling

- Test near proposed groundbed location

- Avoid parallel metallic structures

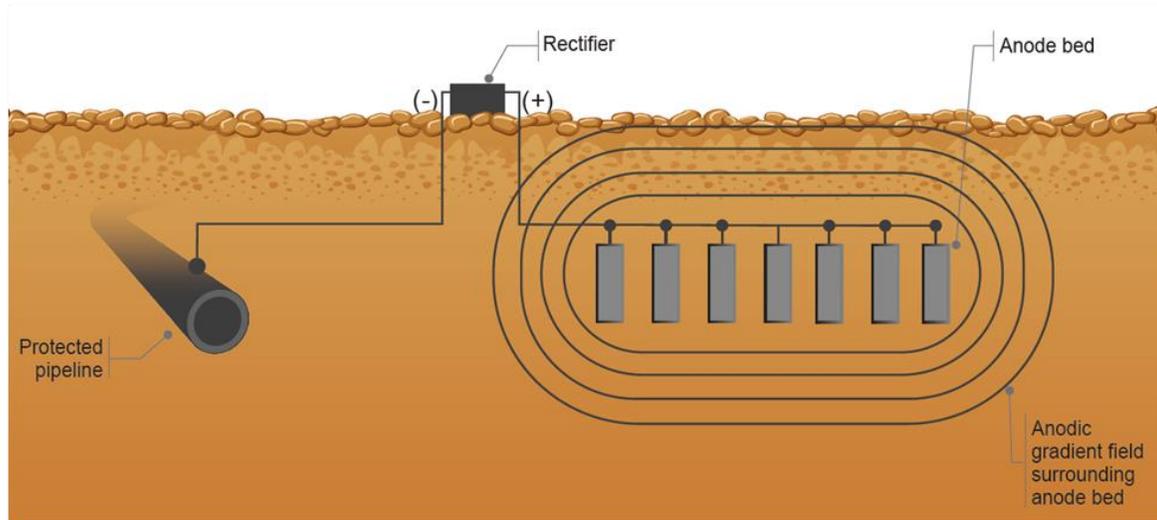- Document environmental conditions during test

DOWNFALLS

- Difficult to test in congested areas

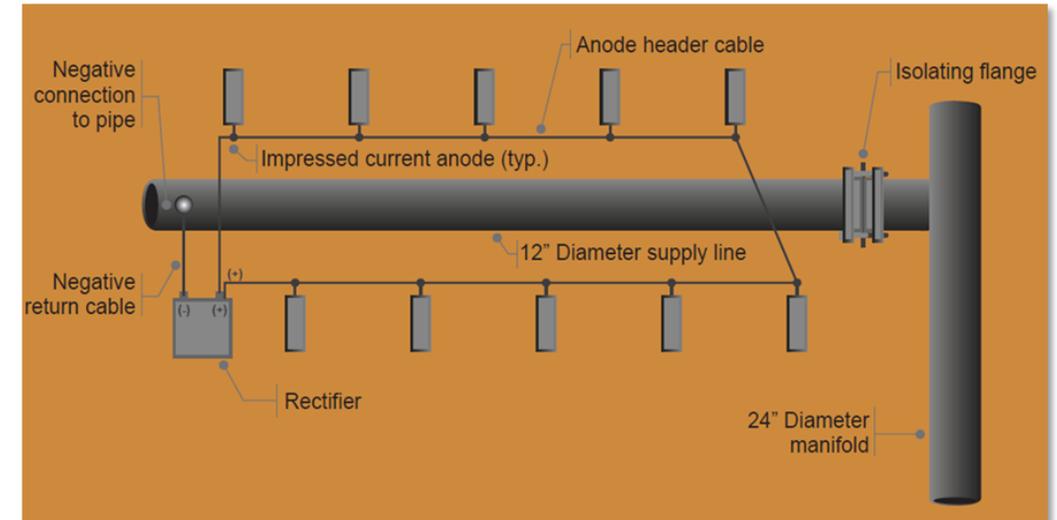- Difficult to identify some geologic features

CP SYSTEM TYPES

Remote

+ Surface (conventional)

+ Deep well

+ Electrically "remote" from pipeline

Distributed

+ Close to the structure

+ Linear anode systems

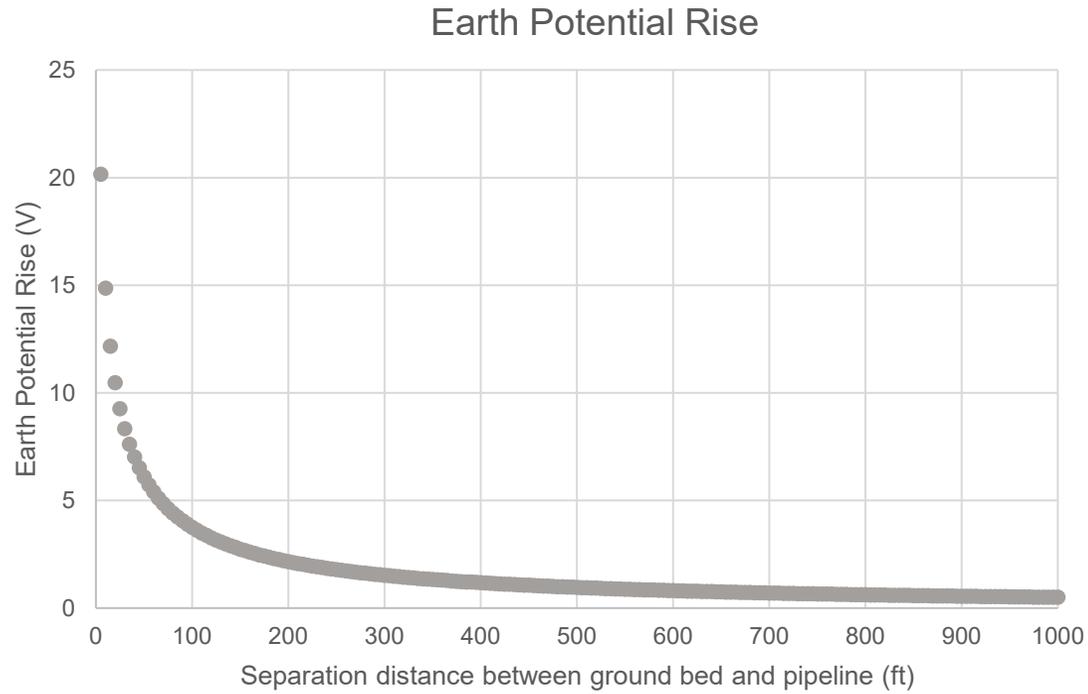+ Spacing important for current distribution

GROUNDBED CALCULATIONS

+ Remote Earth & Current Distribution
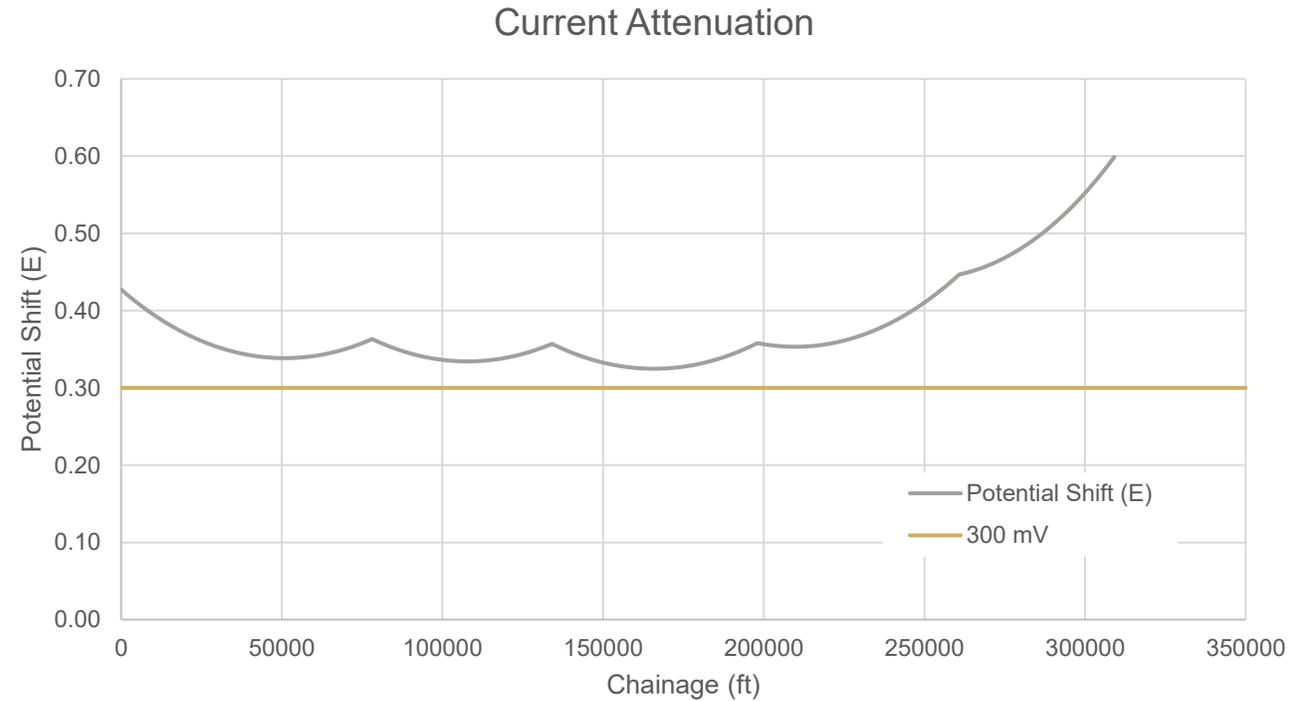
+ Current Attenuation

+ Circuit Resistance

+ System Life

GROUNDBED CALCULATIONS – POTENTIAL RISE

Calculating Remote Earth

Current Attenuation & Distribution

Earth Potential Rise

Current Attenuation

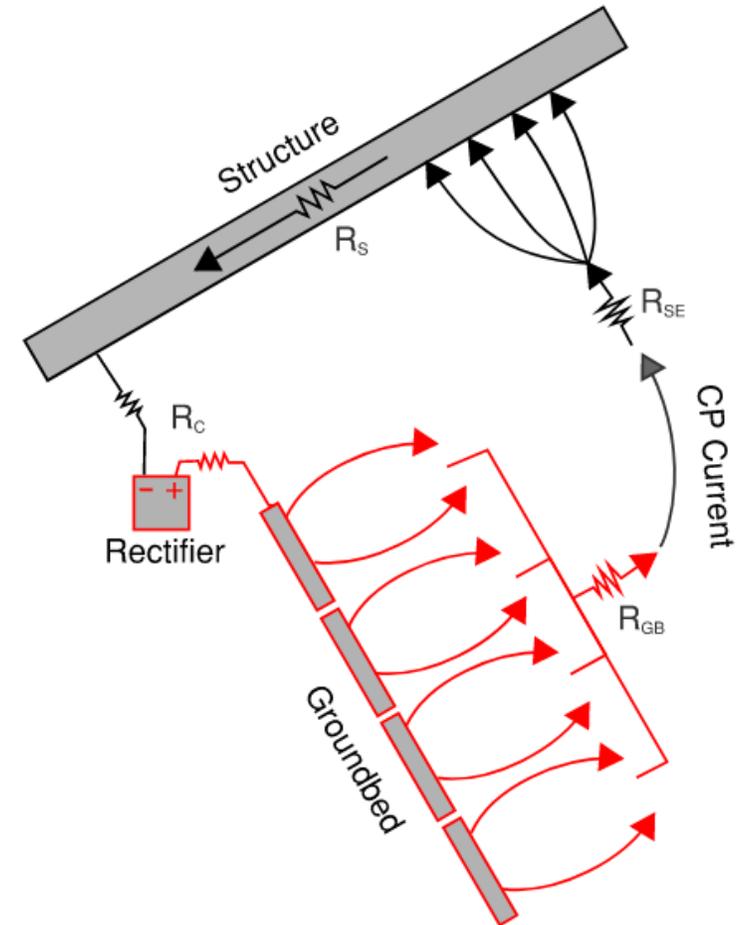# GROUNDBED CALCULATIONS – CIRCUIT RESISTANCE

Circuit Resistance

R_{GB} | Anode/groundbed resistance to earth

R_{SE} | Structure resistance to earth

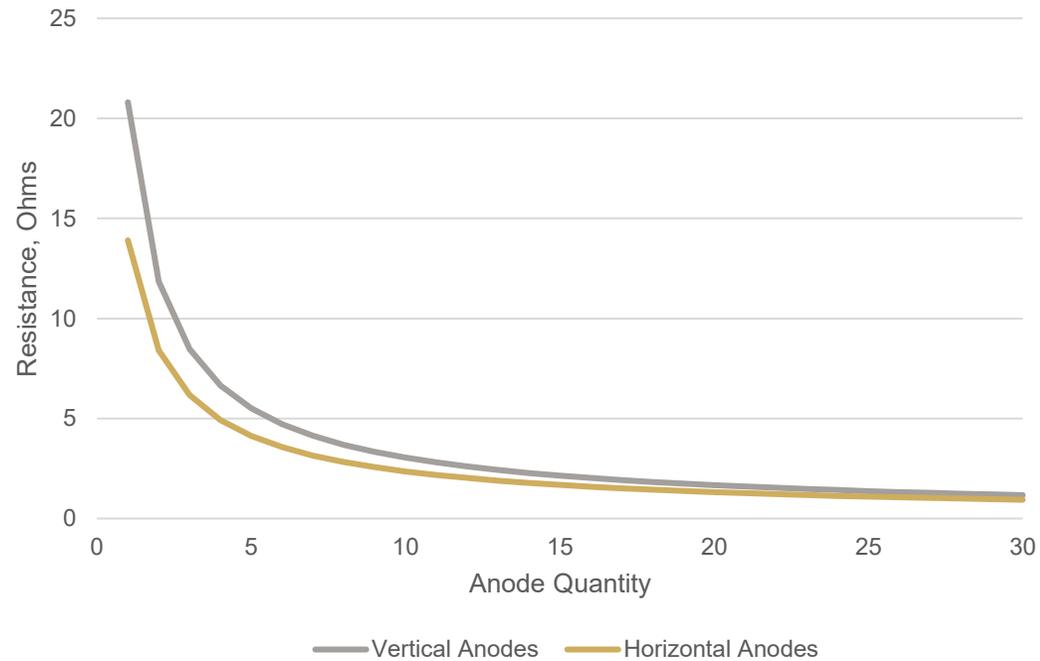R_S | Structure resistance

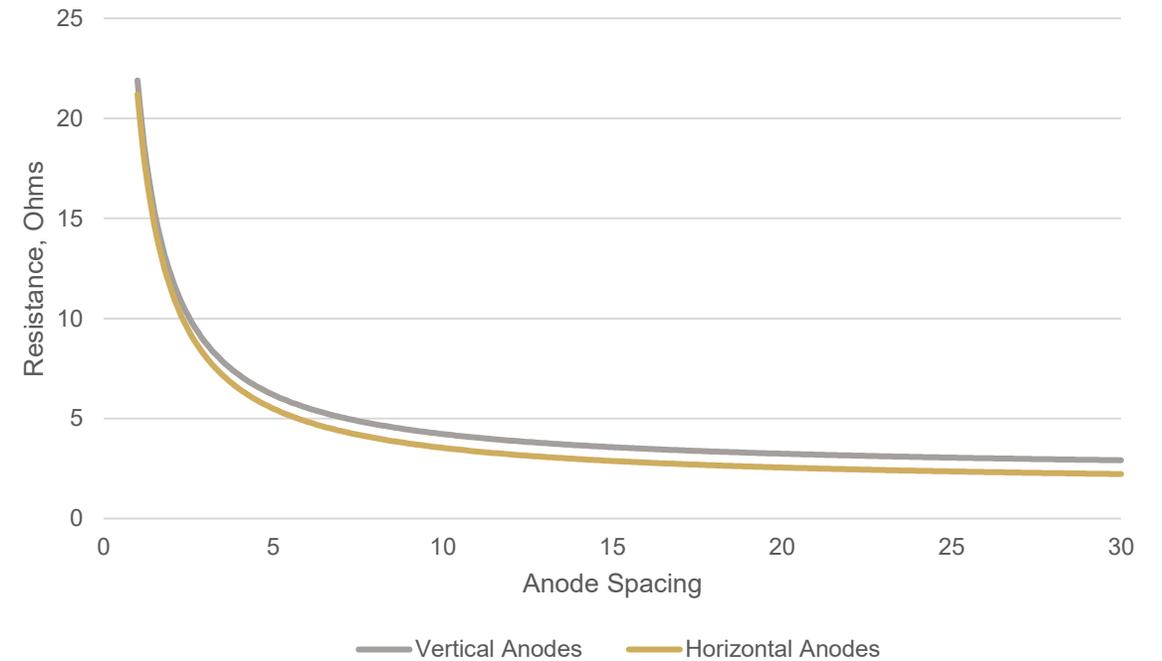R_C | Cable Resistance

$$R_{circuit} = R_{GB} + R_{SE} + R_S + R_C$$

GROUNDBED CALCULATIONS – CIRCUIT RESISTANCE

Anode Quantity Effect on Groundbed Resistance

Anode Spacing Effect on Groundbed Resistance

GROUNDBED CALCULATIONS – SYSTEM LIFE

ANODE TYPE	LIFE SPAN DRIVER	KEY LIMITATION
Sacrificial	Mass consumed by current	Anode Depletion
Dimensionally Stable	Coating current density	Coating Degradation

BEST PRACTICES

- Use conservatism for efficiency, current output, and utilization.

- Specify backfill specific to the type of anode to improve current density

DOWNFALLS

- These calculations do not account for some other factors that may result in system failure

CONSTRUCTABILITY

Primary constructability concerns reviewed:

Geography

+ Site access, steep slopes, material storage

+ Depth of water & bedrock

Space Constraints

+ Room for anode and cable installation

AC Power

+ Access to existing AC service

+ Alternative sources (TEGs, solar, etc.)

ELECTRICAL SHIELDING

+ Current is blocked or "shielded" from the intended source

  o Bulk object with high resistivity located between the anode and intended structure (ex. Concrete Supports)

  o Anode is located closely to a noble metal or bare structure.
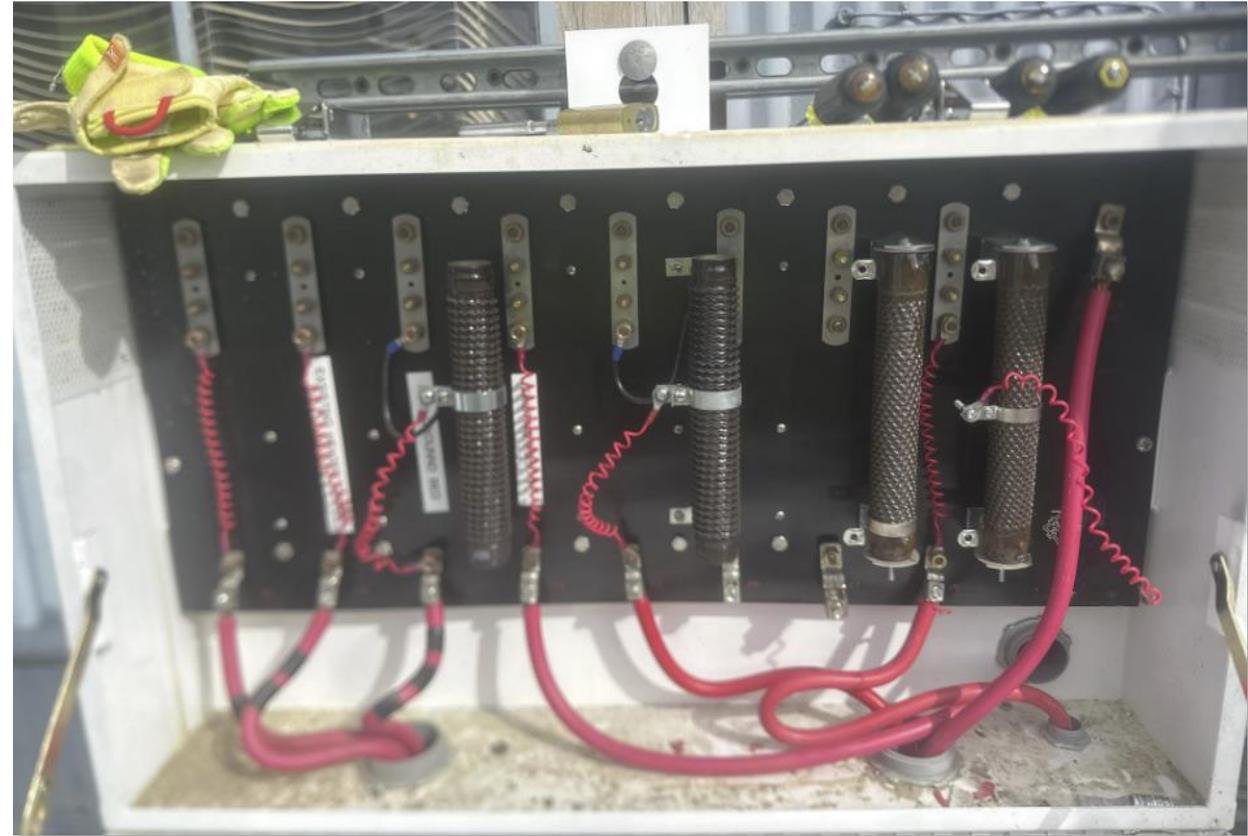
+ Anode placement is key to avoid this issue
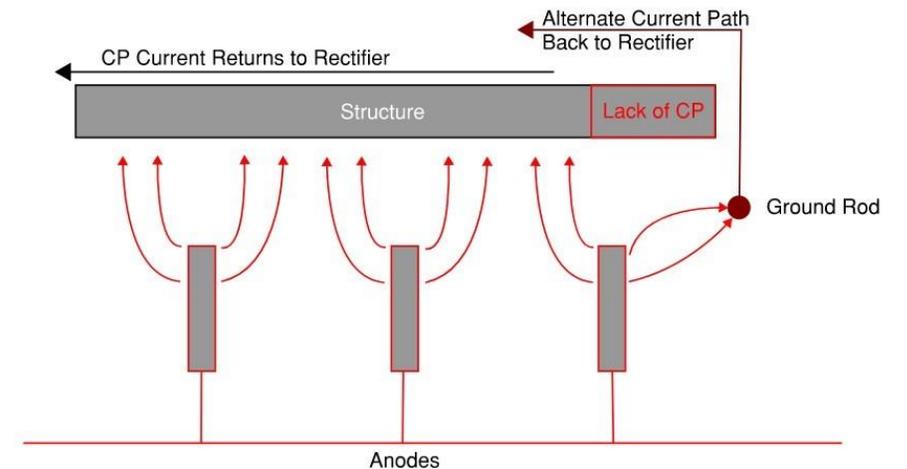
MONITORING COMPONENTS

CP System Monitoring & Best Practices

+ Looped cable systems

+ Above grade terminations

+ Junction boxes with provisions for resistors to be added

+ RMUs

QUESTIONS

Contact Information

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