NEW TRENDS
in
AC & LIGHTNING MITIGATION

54th SIEO/NACE Winter Symposium

Sun Valley, ID

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Bass Engineering Company

AC Interference

Co-Location

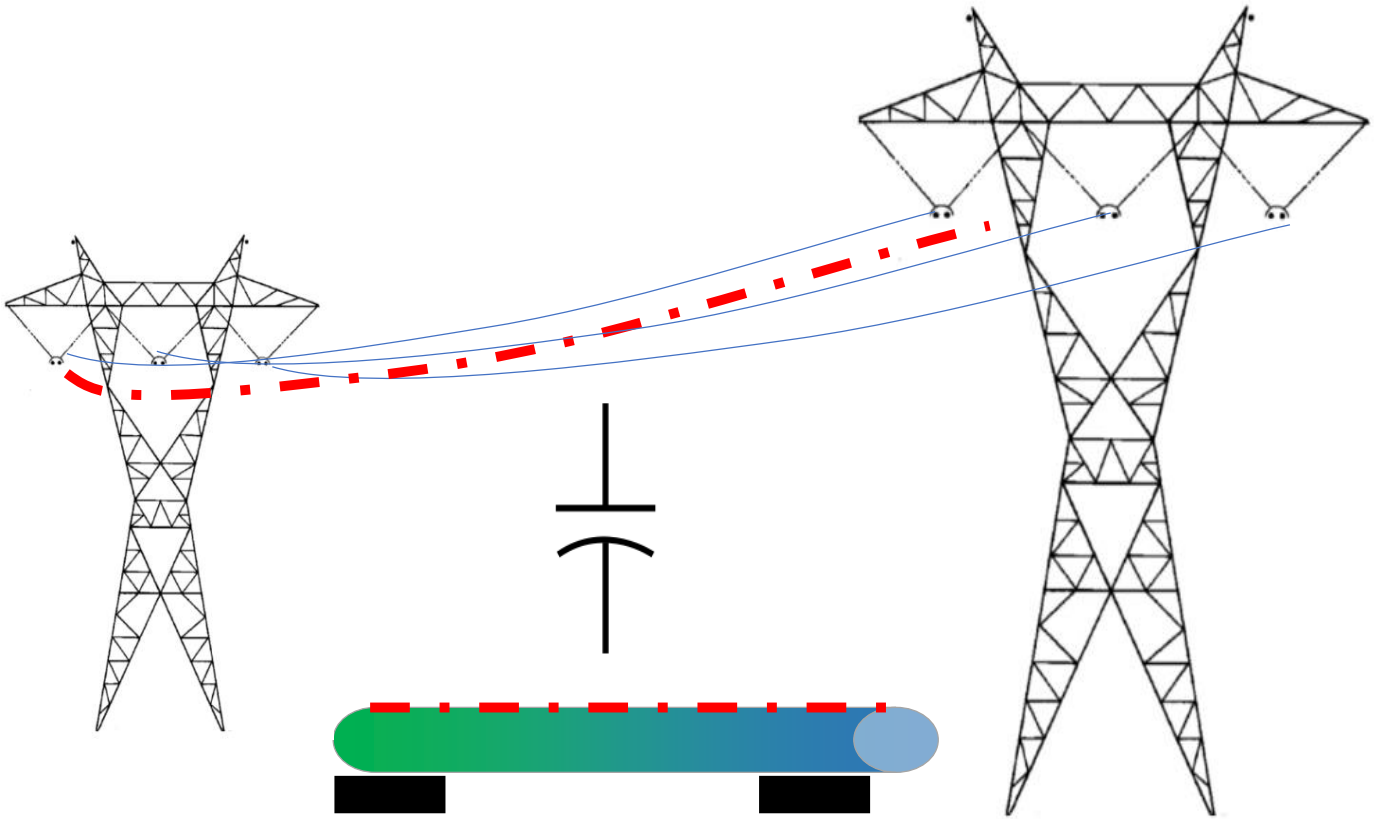
- Pipelines
- HVAC Power Systems

Creates Complex,

Electro-magnetic Interaction

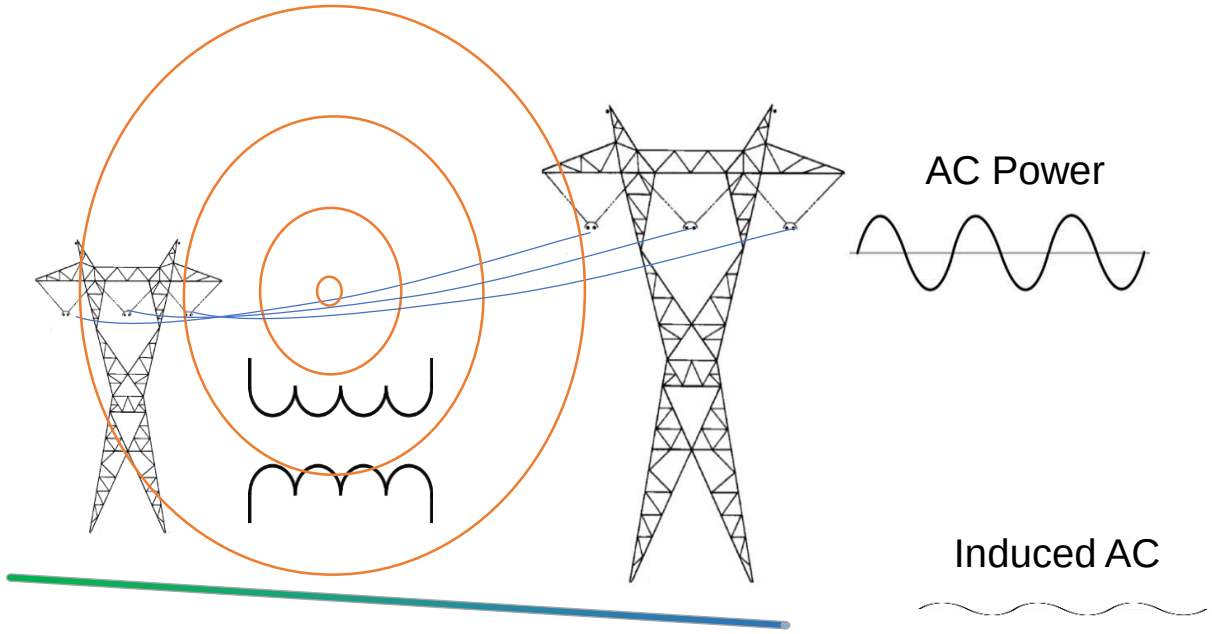
Capacitive Coupling

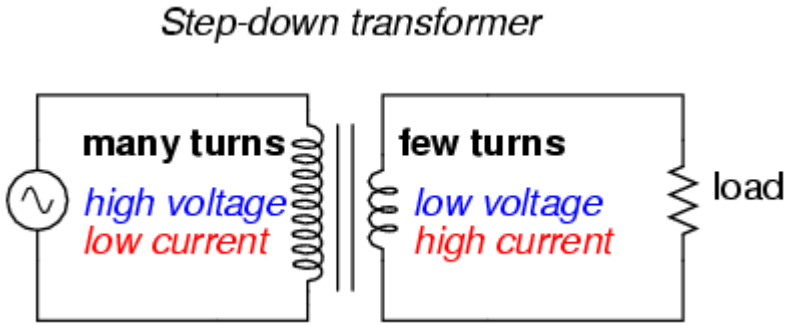
Electric Field Influence



Inductive Coupling

Magnetic Field Influence



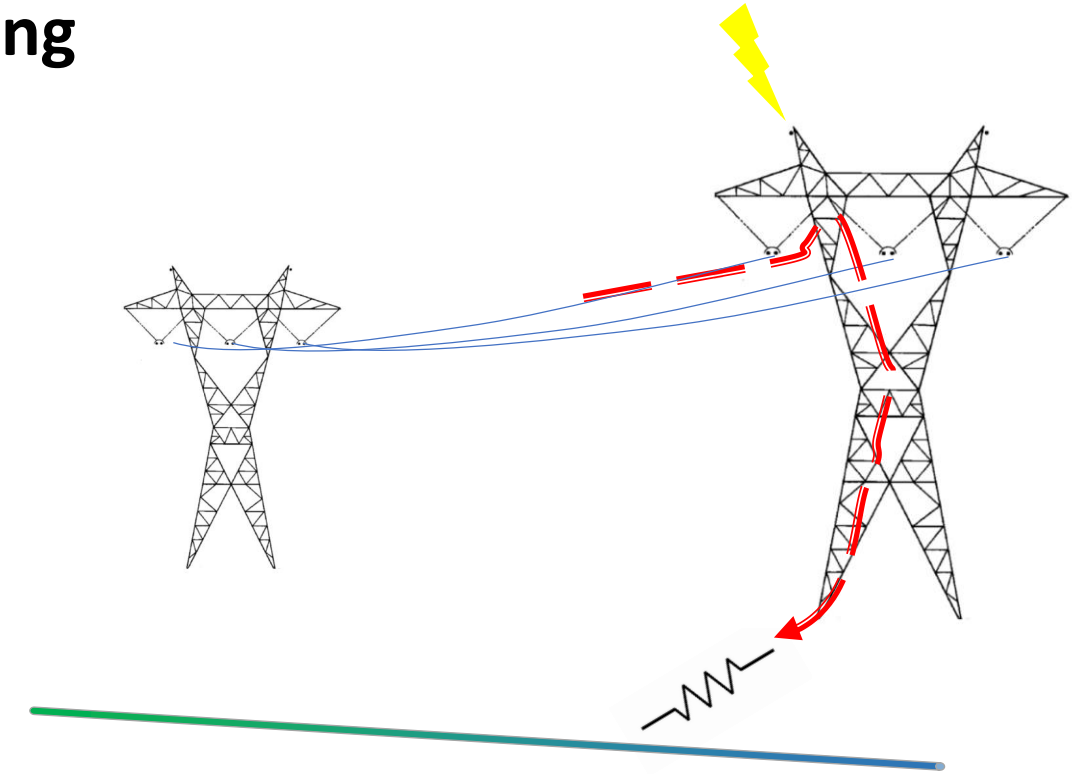


Resistive Coupling

Shared Conductive Path

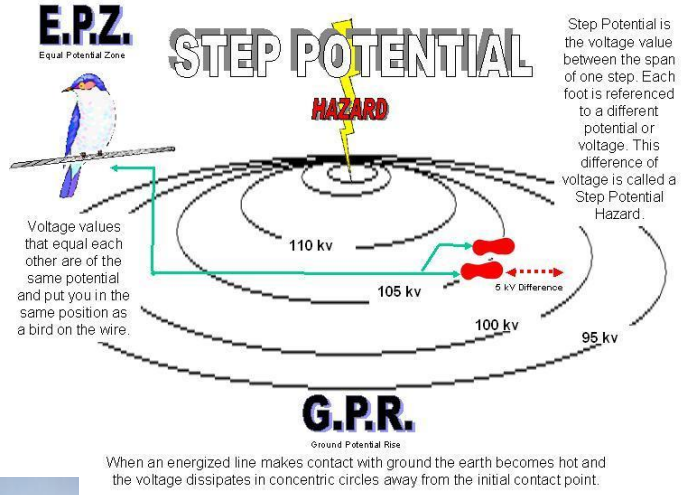
Fault or “Short-Circuit” HVAC Conditions

Lightning



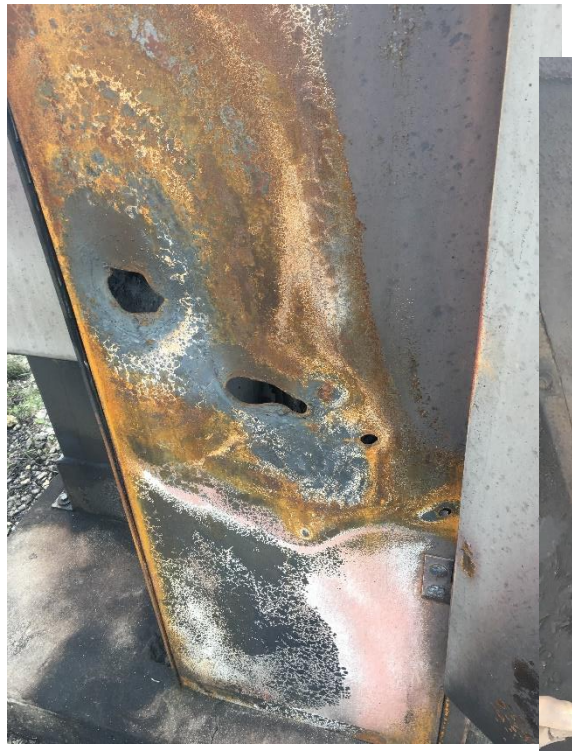
AC Interference = **Risk**

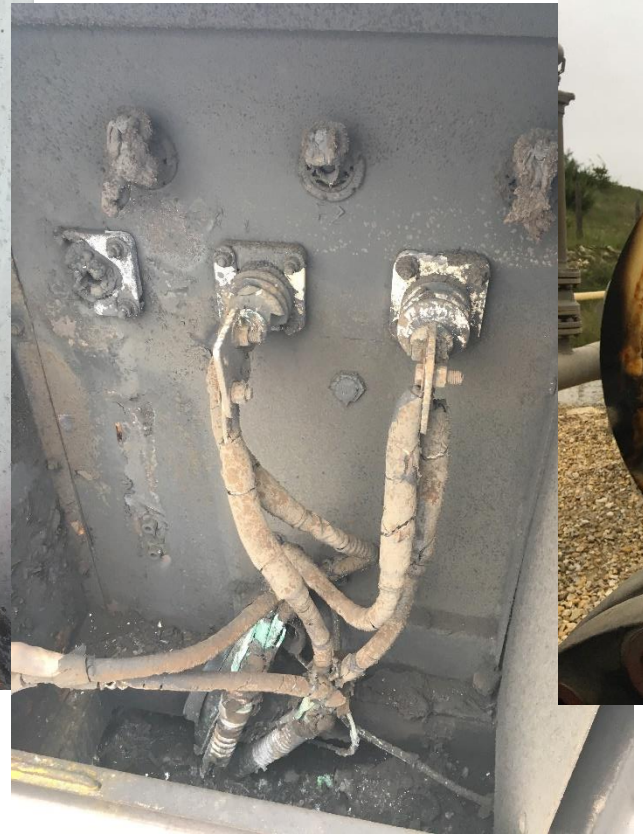
- **Personnel**
  - Step-Step Potential
  - Step-Touch Potential
- Pipeline Equipment
  - Metering
  - Electrical Isolation
- CP System
  - ICCP/GCP Damage
- Pipeline
  - AC Corrosion



Resistive Coupling

Fault or “Short-Circuit” HVAC Conditions





AC Corrosion Morphology

Tubercle

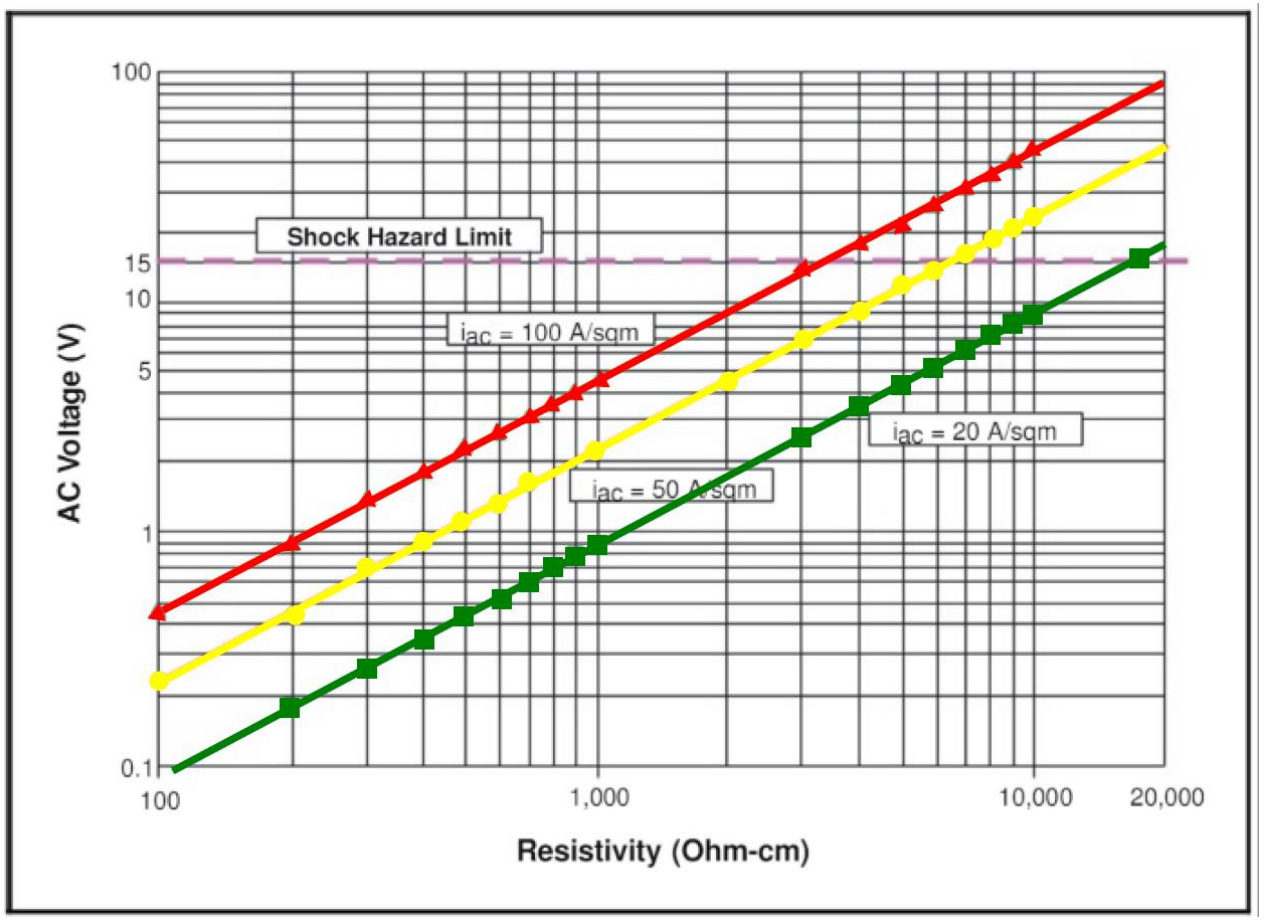
Coating Deformation

Pits Within Pits

AC Corrosion & AC Current Density

ACCD	AC Corrosion Risk
< 20 A/M^2	Low Risk
20-100 A/M^2	Medium Likelihood
> 100 A/M^2	Very High Likelihood

Expressed as a Function of AC Voltage & Soil Resistivity



Risk Factors

Multiple

Dynamic

Interactive

Geezzzz…Can I Get Some Help Here?

Federal Law

- 49 CFR 192.467 (f)
  - External Corrosion Control; Electrical Isolation
- 49 CFR 195.575 (e)
  - External Corrosion Control; Electrical Isolation
- 29 CFR 1910
- 29 CFR 1926

Yea…Not Really What I was Looking for….

NACE

- NACE SP0177-2014
  - Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
- NACE SP21424-2018
  - Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring
- AC Corrosion State-of-the-Art Report: Corrosion Rate, Mechanism, & Mitigation Requirements #35110
- NACE SP0104-2014
  - The Use of Coupons for Cathodic Protection Monitoring
- Technical Report on the Application & Interpretation of Data from External Coupons Used in the Evaluation of Cathodically Protected Metallic Structures #35201

Other

- Canadian Standard
  - CAN/CSA – C22.3 No. 6-13
    - Principles and Practices of Electrical Coordination Between Pipelines and Electric Supply Lines
- European Standard
  - BS EN 15280:2013
    - Evaluation of AC Corrosion Likelihood of Buried Pipelines Applicable to Cathodically Protected Pipelines
- Interstate Natural Gas Association of America (INGAA)
  - Criteria for Pipelines Co-existing with Electric Power Lines; 2015-04 Final Report
- National Electric Code (NEC), Article 250
  - Grounding & Bonding
- Institute of Electrical & Electronic Engineers (IEEE)
- PRCI
  - On-going Research; EC 6-2, EC 6-4

Confused?


Induced
Requirements
195
NACE
NEC
Corrosion
Modeling
INGAA
Spread
Impendance
Coupon
Voltage
Grounding
Lightning
AC
DC
Mitigation
RM4210
Standard
DOT
Current
Rate
capacitive
PHMSA
Powerline
Size
192
Resistance
European
Density
Neutral
TRITON
Mechanism

AC Interference Threat Risk Assessment

Apply Industry Risk Concepts

RECEPTOR

An object impacted by an abnormal event or failure.
Personnel, PL Assets, CP Systems

LOCATION

A position or site marked by some distinguishing feature.
Aboveground appurtenances, station numbers

MECHANISM

A natural or established process by which something takes place or is brought about.
Capacitive, Inductive & Resistive Coupling

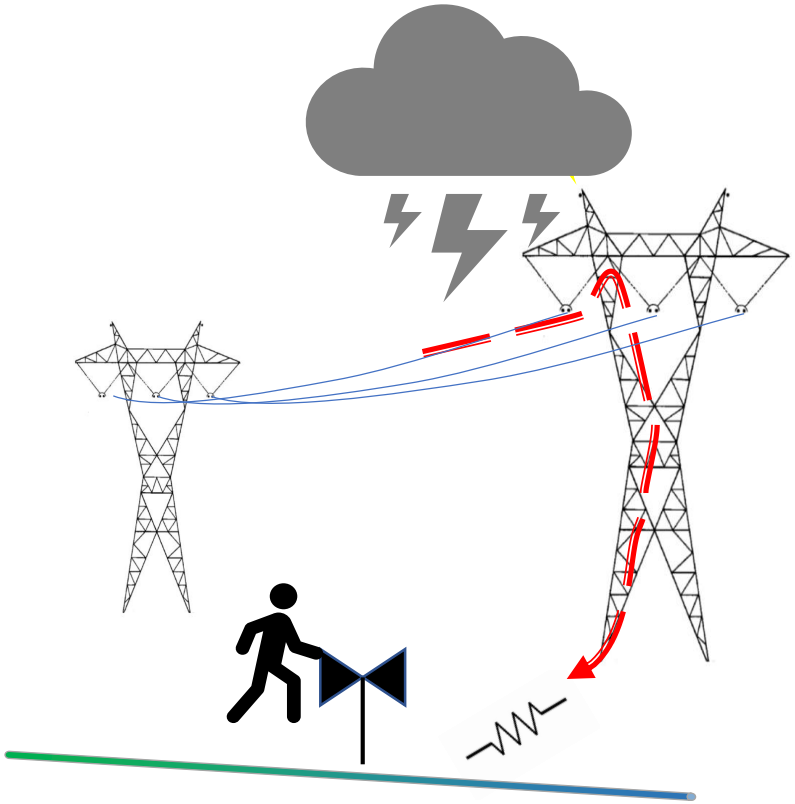
THREAT

An indication of something impending.
Elevated AC potentials, elevated AC current density, step/touch potentials

FACTOR

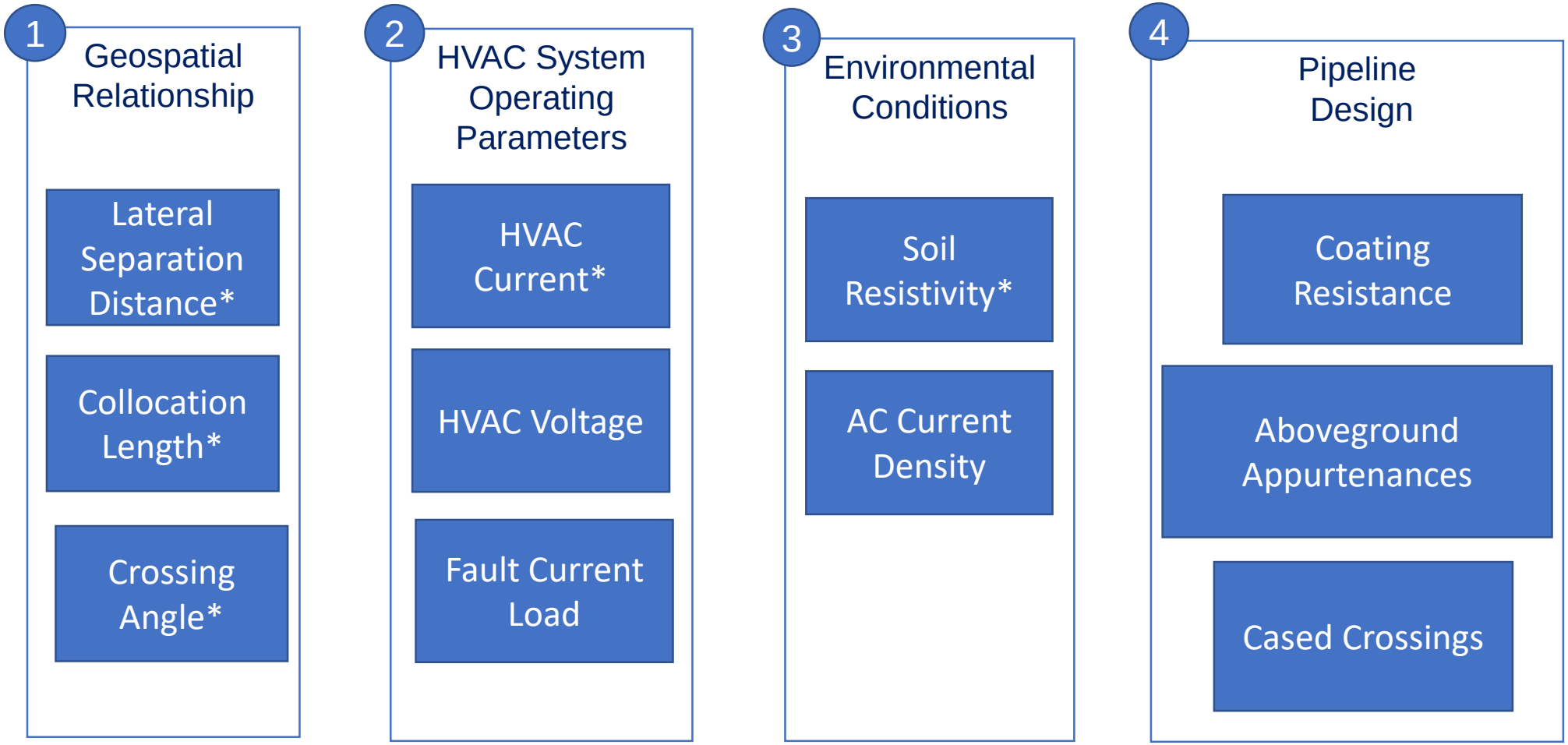
Something that actively contributes to the production of a result.
Lateral separation distance, co-location length, crossing angle, soil resistivity, HVAC current, etc.

Threat Risk Assessment; Resistive Coupling



RECEPTOR	Personnel Electrical Isolation
LOCATION	Valve setting; ID by station #
MECHANISM	Resistive Coupling
THREAT	Elevated AC potentials Step-touch potentials
FACTOR	Lateral separation distance Soil resistivity

AC Threat Risk Factors



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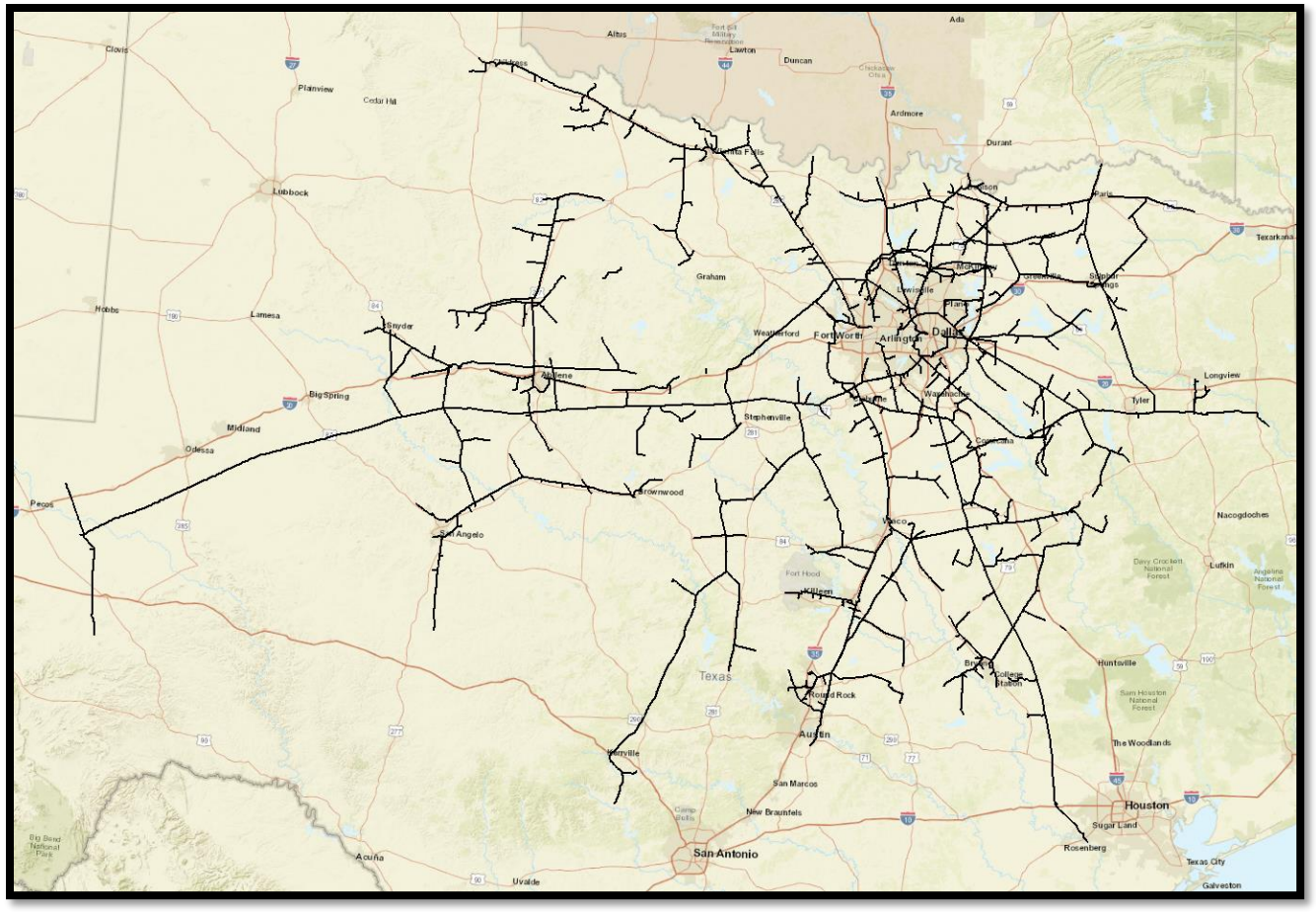
The INGAA Foundation, Inc.

Identify & Prioritize

Over 7,000 miles of transmission PL and large diameter distribution mains serving several rural and major metropolitan areas

Assets spread over six environmental geographies

Wide ranging pipe design and operating parameters

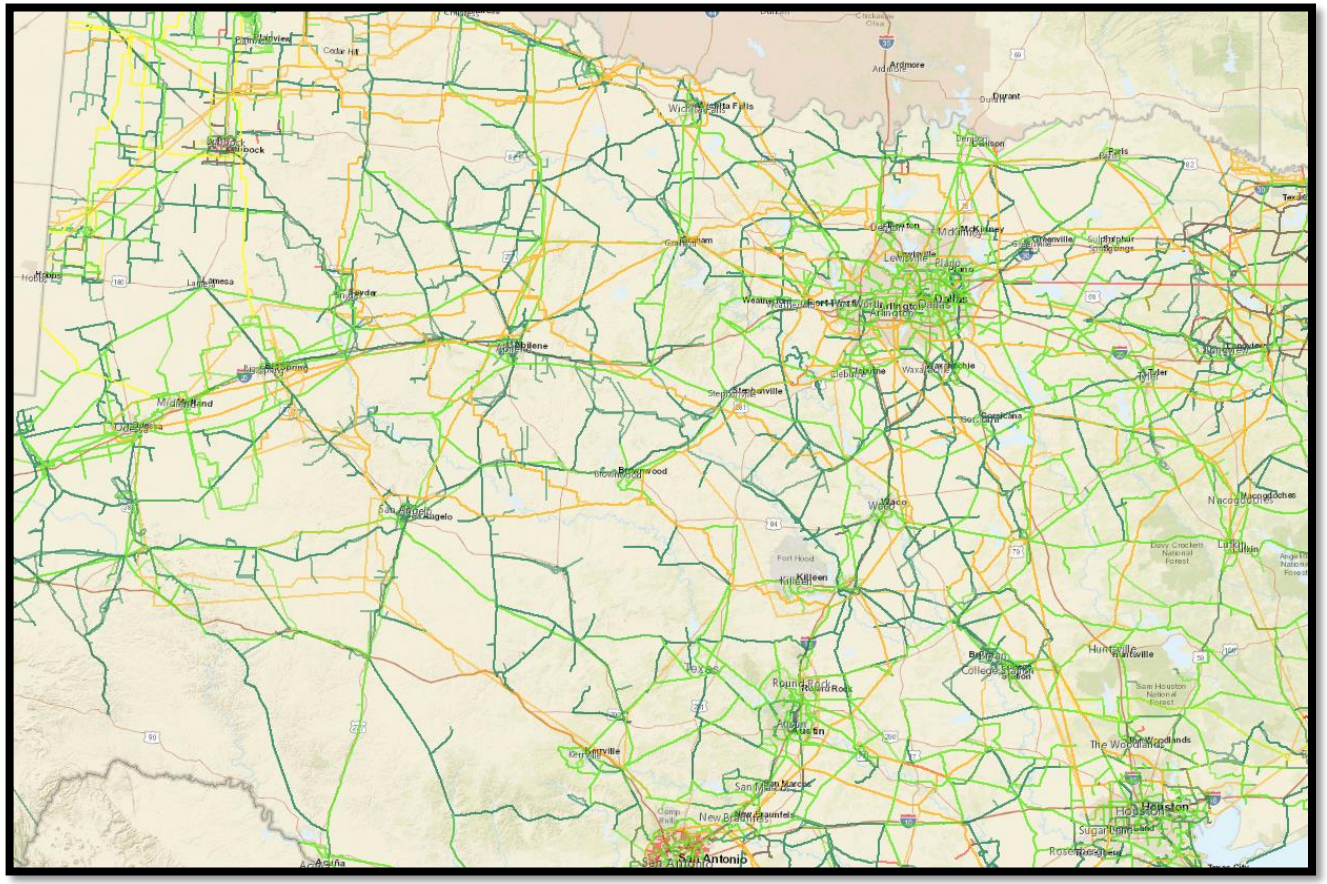


Analyze HVAC Data

Obtained **41,322** miles of HVAC centerline and operational data from Platts, PennWell, & RexTag

Converted Rated Voltage to AC Current

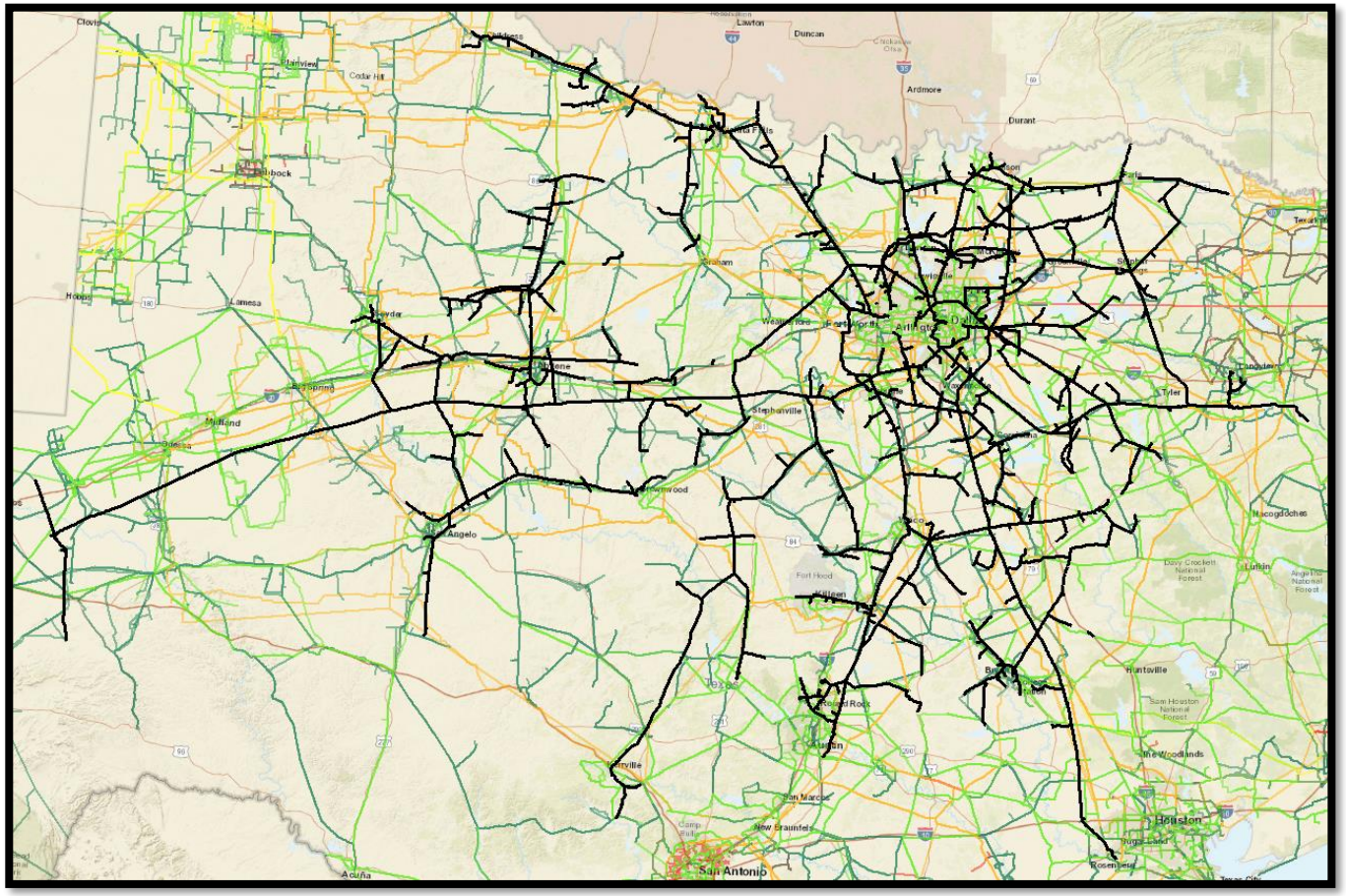
0-69 kV
70-138 kV
138-230 kV
231-345 kV
346-500 kV



Geospatial Analysis; PL & HVAC System

Utilize GIS tools to determine

- Lateral separation distance
- Co-location length
- Co-location angle
- Crossing angle

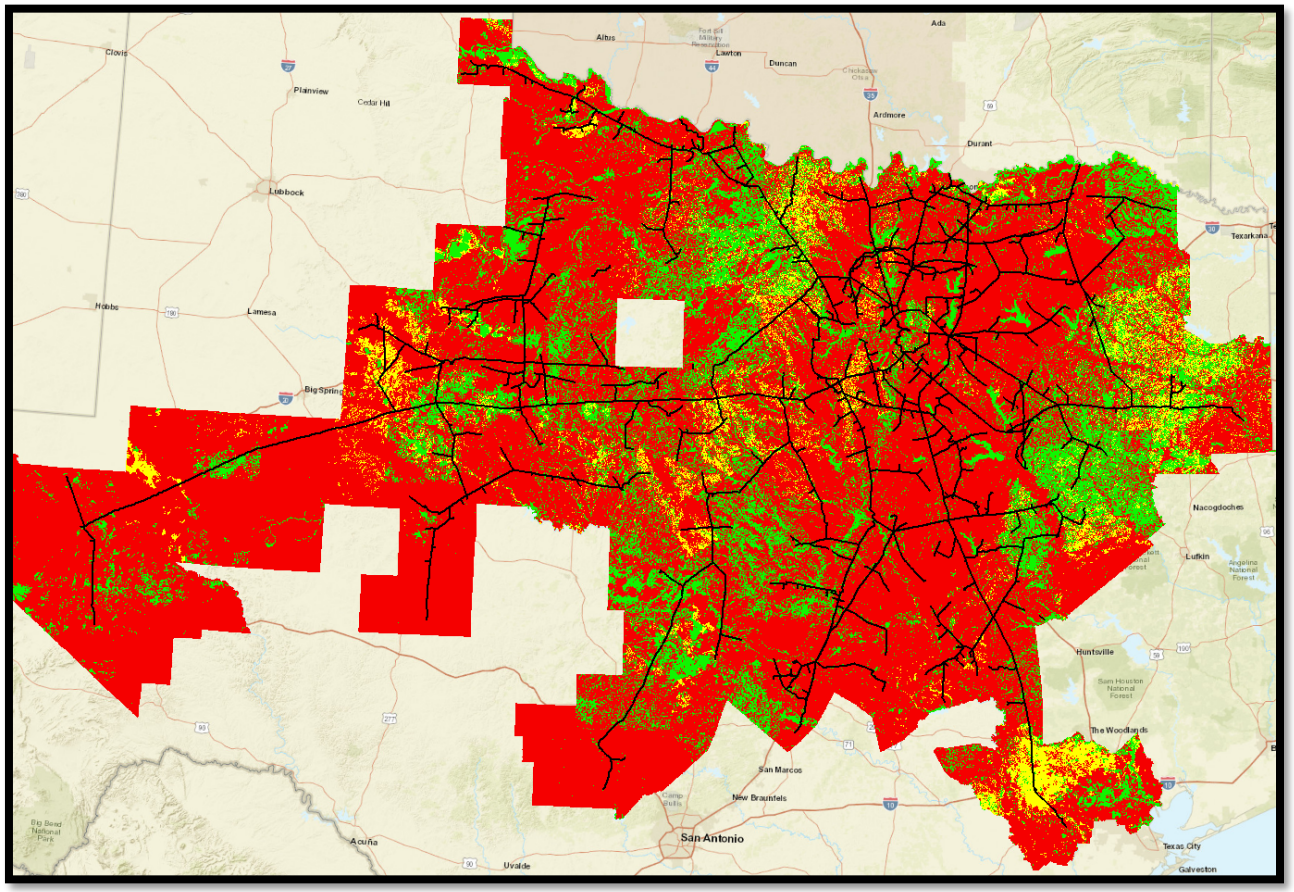


Geospatial Analysis; Soil Resistivity

Vast pipeline system spread across 6 geographical regions

Acquired USGS SSURGO soils data

Utilize UGIS tools to determine soil resistivity for co-location



AC Threat Risk Analysis

Import GIS Data into RIPL

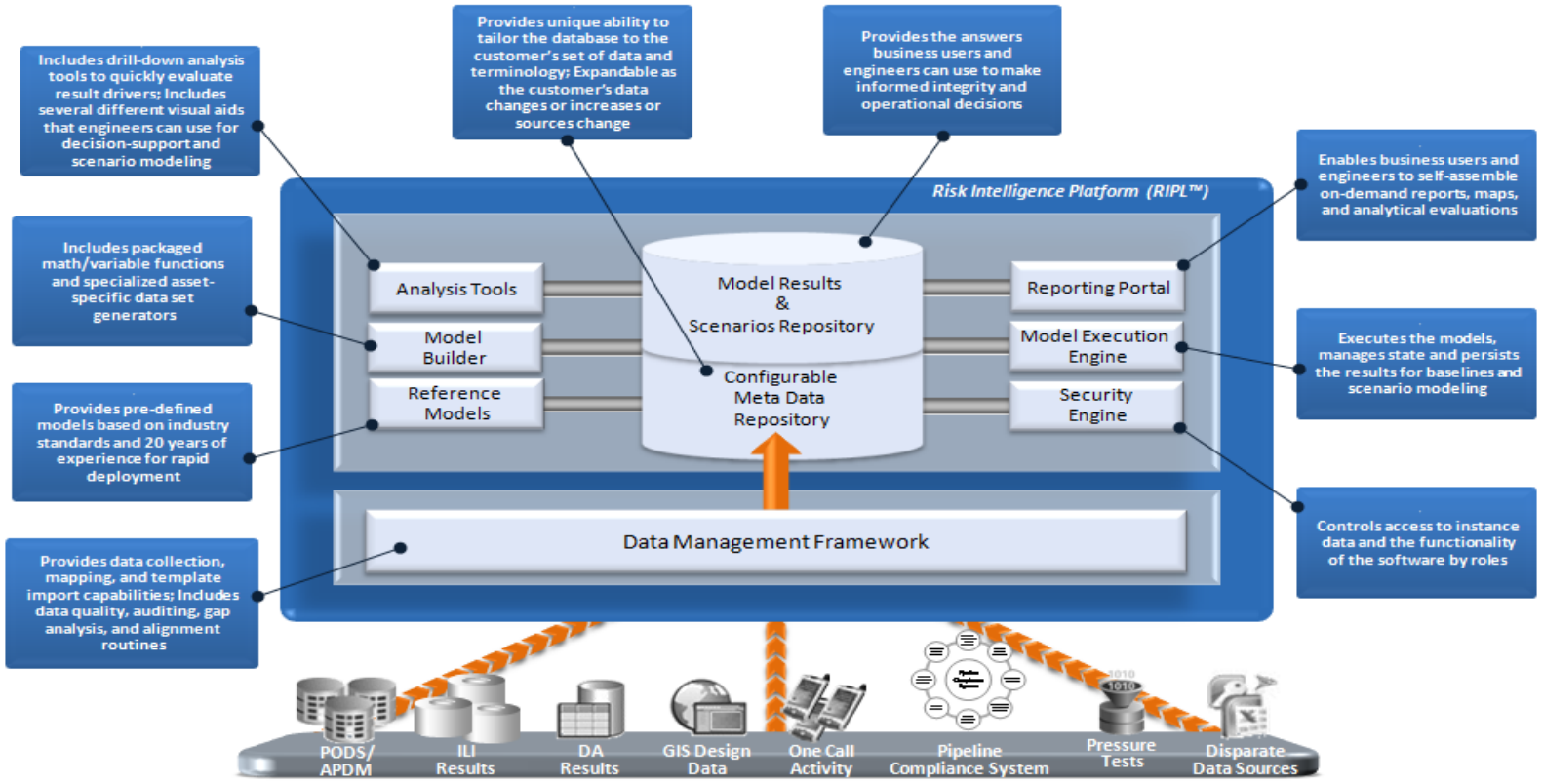
Separation Distance
Co-location Length
Co-location Angle
Crossing Angle
HVAC Voltage
HVAC Current
Soil Resistivity

Combined with Existing:

Pipe Coating Resistance

Create Threat Ranking

Analysis dynamically segmenting and ranking PL based on specific factors combined into a threat score



Engineered Field Analysis

- Differentiate above & below ground assets
  - Design gradient control mats
- Identify electrical isolation locations
  - Design decoupler installations
- Design engineered grounding system locations
  - Incorporate “natural” grounding
- Address lightning mitigation
- Address safe arc distance
  - Substations, guy anchors, etc.
- Incorporate AC mitigation system monitoring

AC & Lightning Mitigation Tools

- Engineering Controls
- Decoupling Devices
- Engineered Grounding Systems
- Gradient Control Mats
- Coupon Test Stations

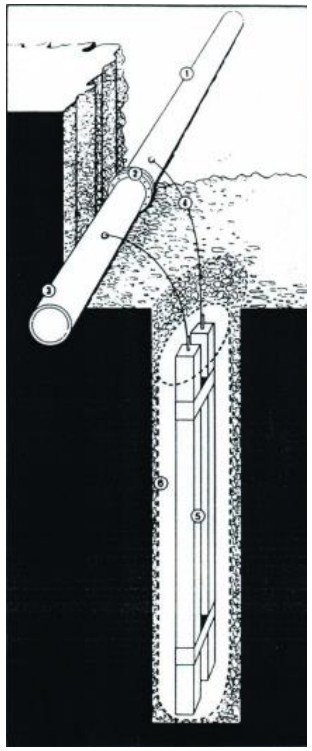
Signage


DANGER
Electrical hazard.


WARNING!
AC VOLTAGE MAY
BE PRESENT
ON THE FENCE
AND/OR
PIPELINE

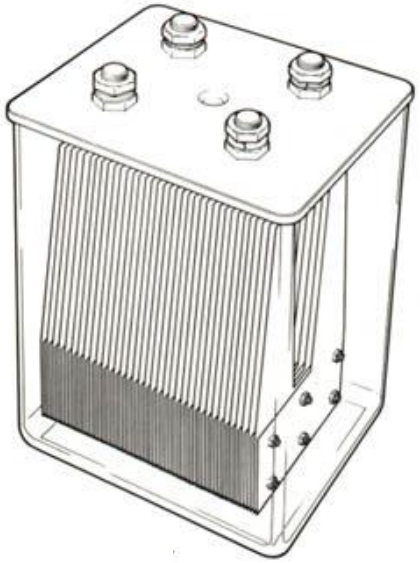
Dead Front Test Stations

Decoupling Devices



Zinc Anode Pair

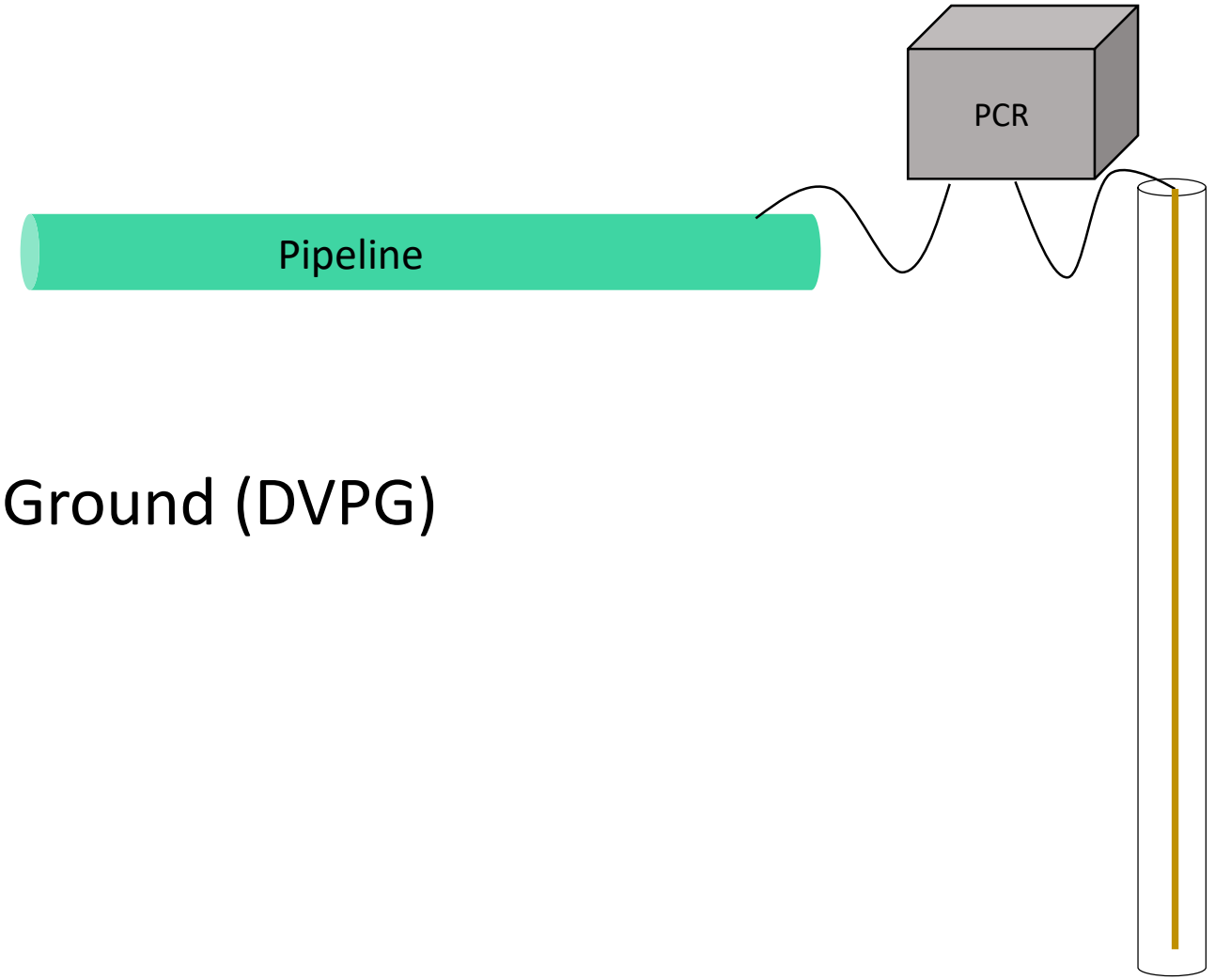
Polarization Cell



Polarization Cell Replacement (PCR)

Solid State Decoupler (SSD)

Engineered Grounding Systems

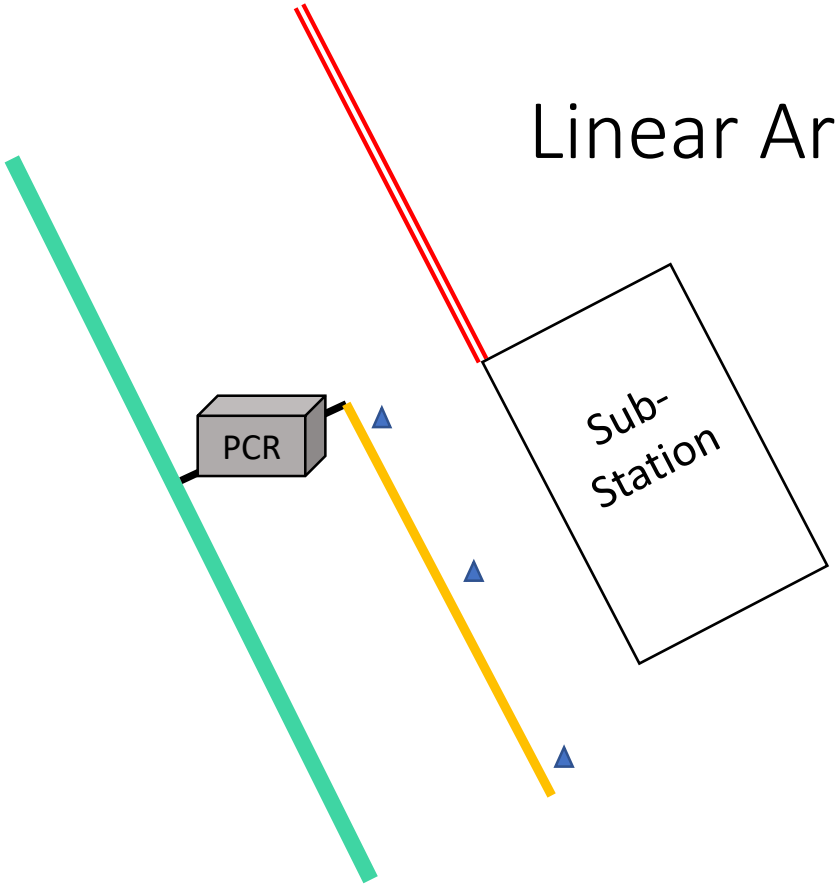


Deep Vertical Point Ground (DVPG)

Engineered Grounding Systems

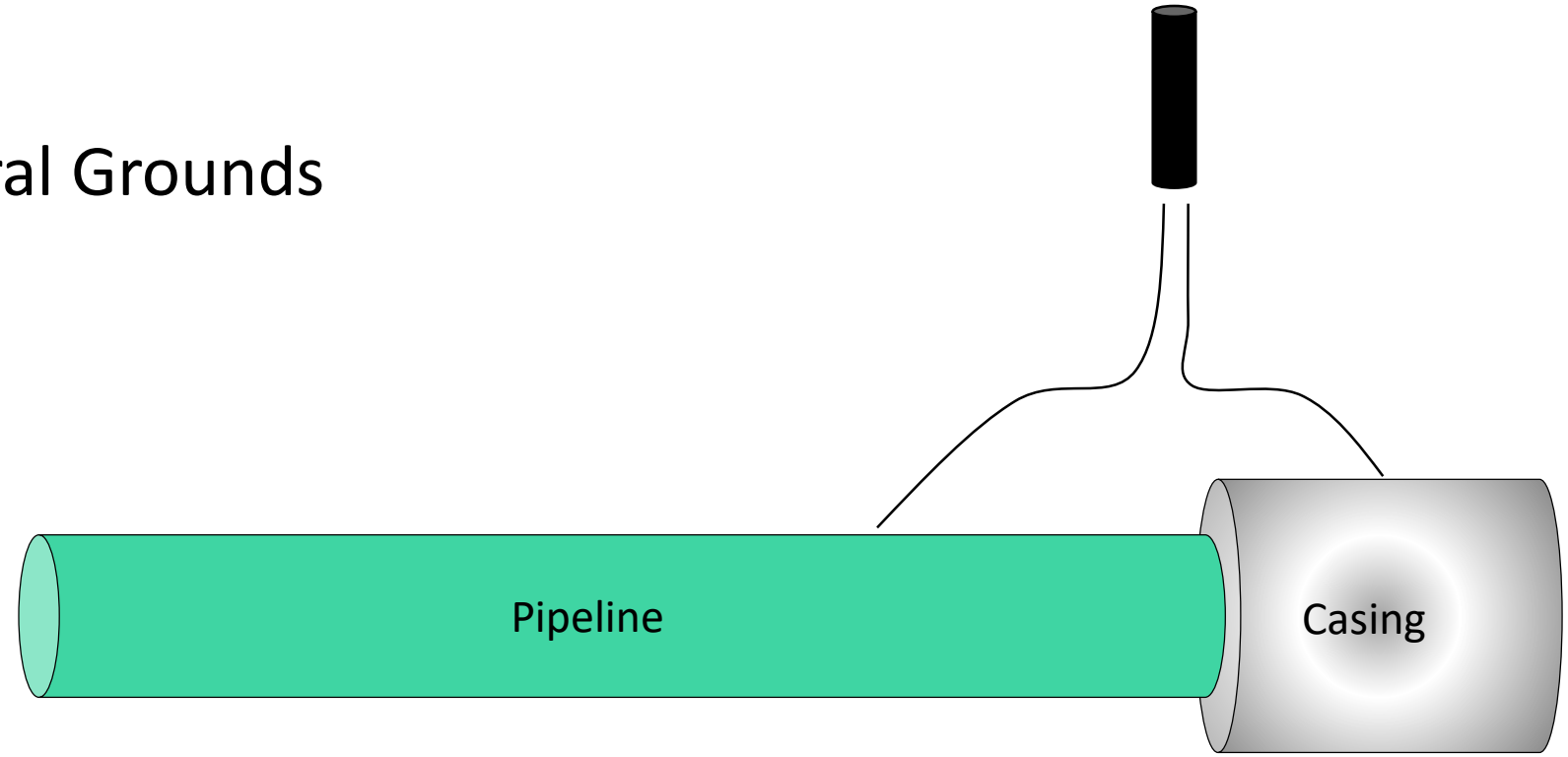
Linear Ground

Linear Array

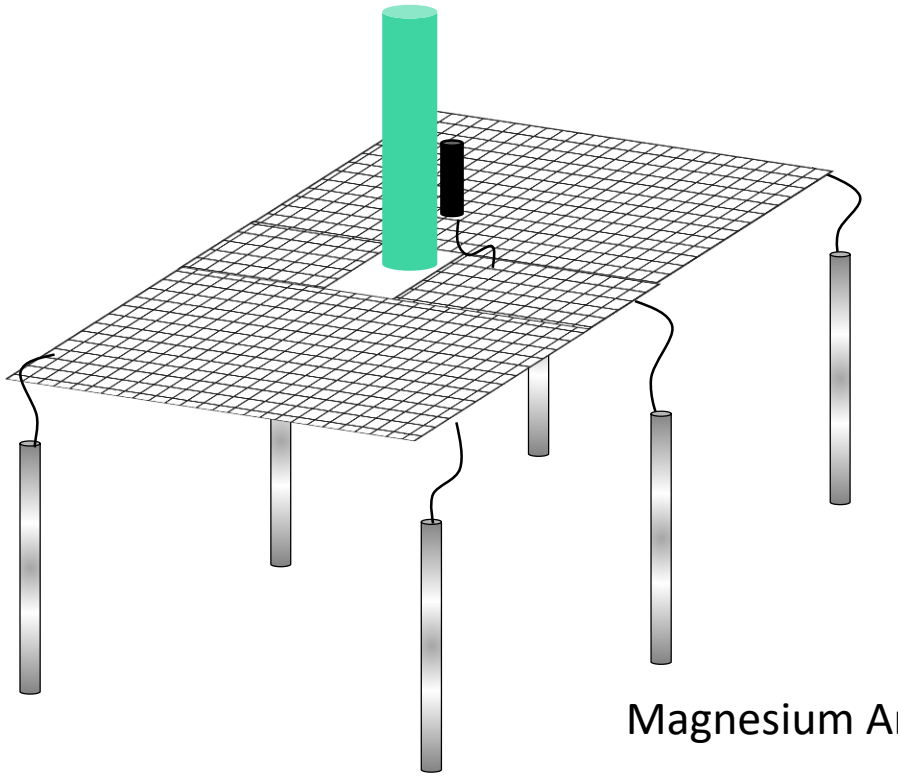


Engineered Grounding Systems

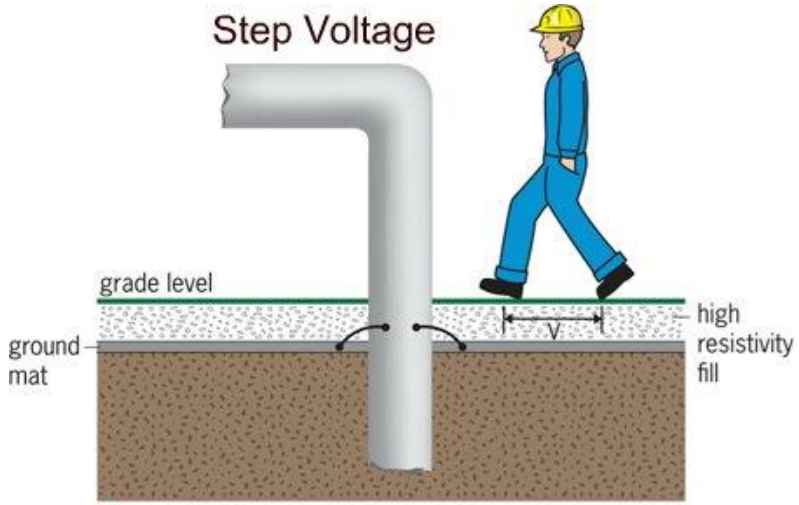
Natural Grounds

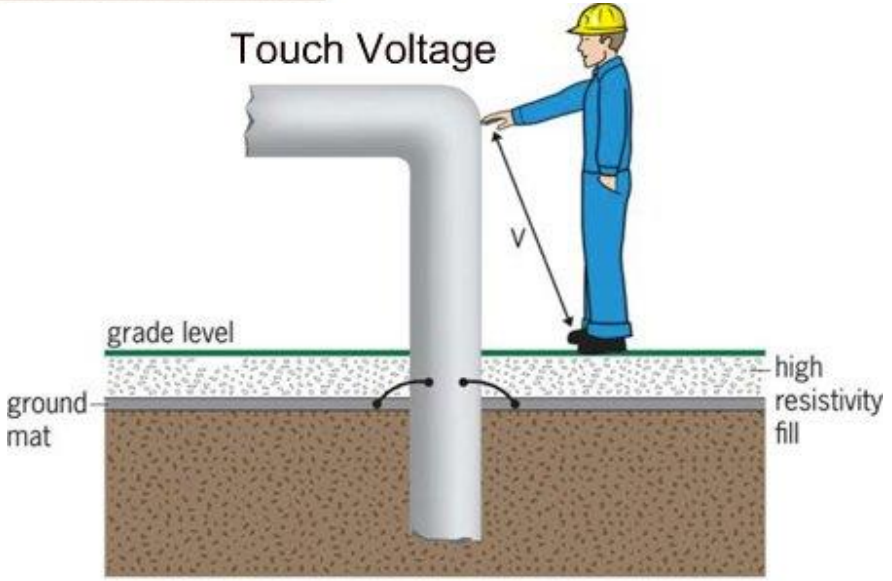


Gradient Control Mats



Magnesium Anode





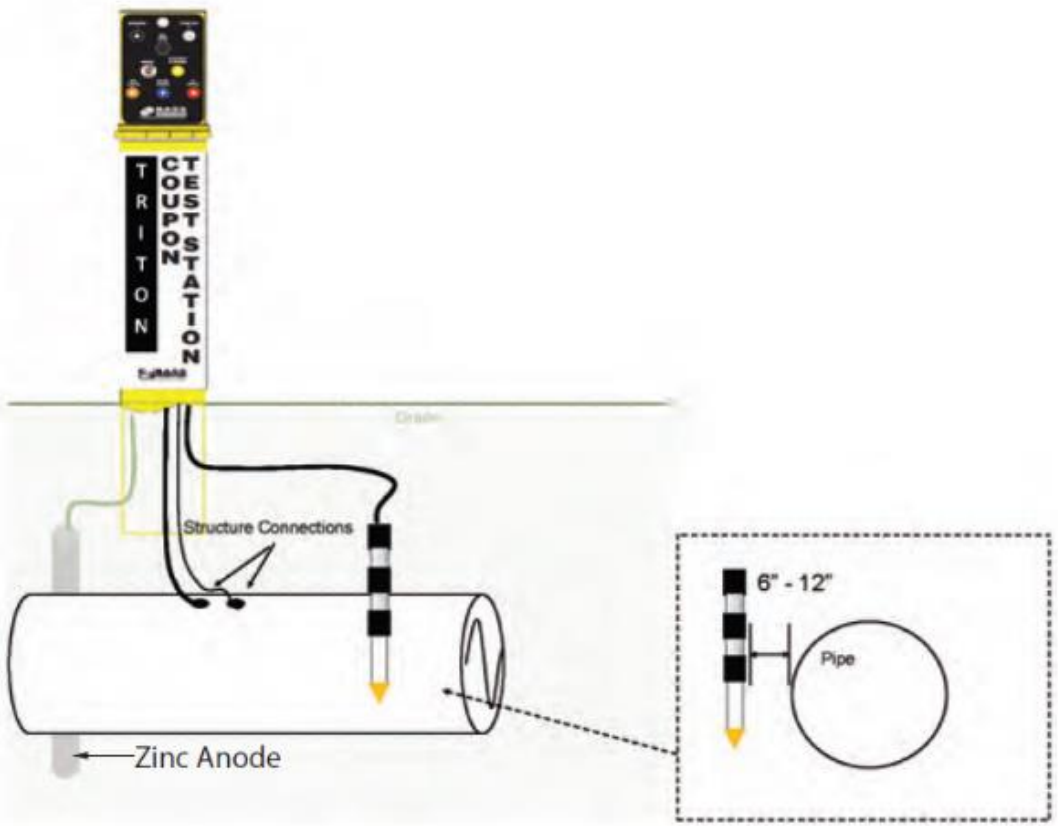
Gradient Control Mat Assembly

Exothermically Welded @ Seams on 18” Centers

Lead Length is Critical!

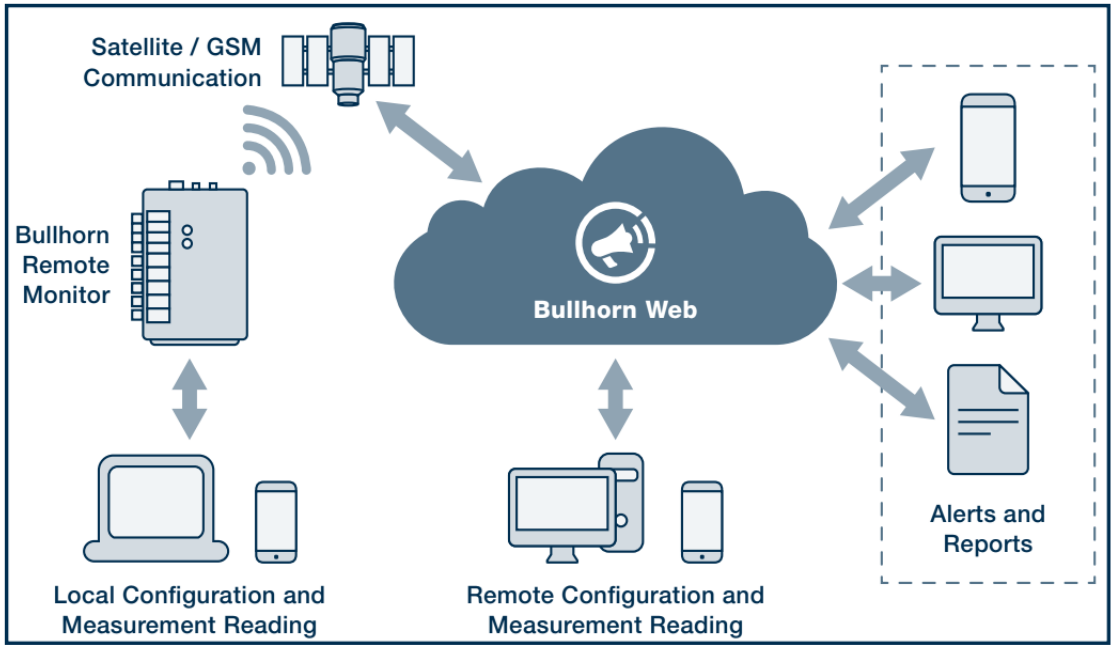
Pin Brazed Connections

Monitoring



- Measure PL AC & DC P/S Potentials
- Measure AC & DC Current
- Calculate PL AC & DC Current Density

Remote Monitoring w/ CTS



The RM4210 integrates with Bullhorn Web, allowing you to access your measurements or update configurations from nearly anywhere.

The Complete Package

- AC Threat Risk Analysis
  - Prioritize pipeline assets at risk
- Engineered Field Analysis
  - Gather critical field data
    - Soil resistance
    - Electrical isolation locations
    - Aboveground assets/security dimensions
    - Cased crossings
    - HVAC guyed anchors

Summary

- AC Interference is Complex
- Influenced by Design & Operating Conditions…Dynamic!
- Design Protocol
  - AC Threat Risk Analysis w/ Engineered Field Design
- Integrated ACLM Solution Using Multiple AC Mitigation Tools
- Monitor!!

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