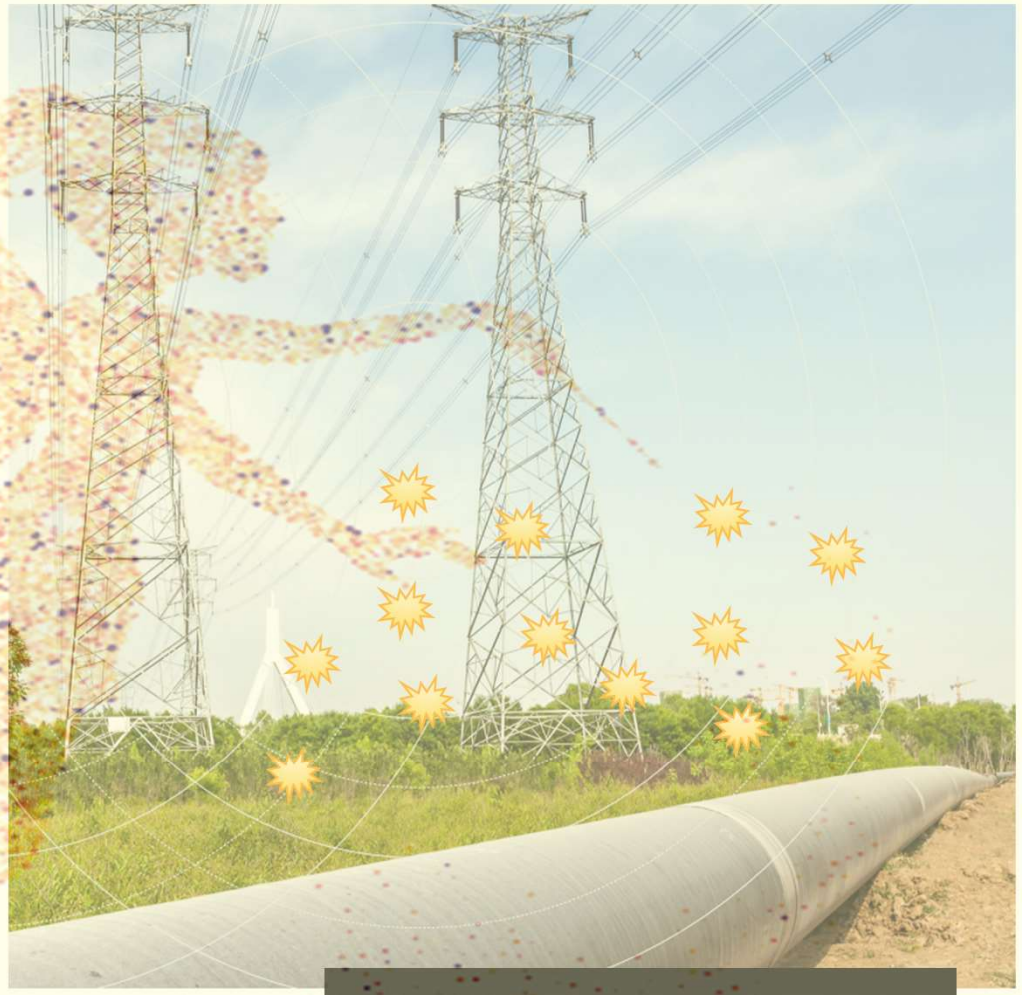
AC Corrosion

Magic Wonders



Lars Vendelbo Nielsen

MetriCorr

AMPP CHAPTER HOUSTON

AC Corrosion

The easiest way to avoid troubles

Lars Vendelbo Nielsen

September 10, 2024

AMPP CHAPTER HOUSTON

Today's Focus Points

- MetriCorr presentation
- A 1-minute re-visit of AC standard criteria
- AC modeling – spread resistance and soil resistivity - prediction of the AC current density
- The vicious circle of AC corrosion
  - Laboratory evidence
  - Field evidence
- Getting out of the circuit the easiest way

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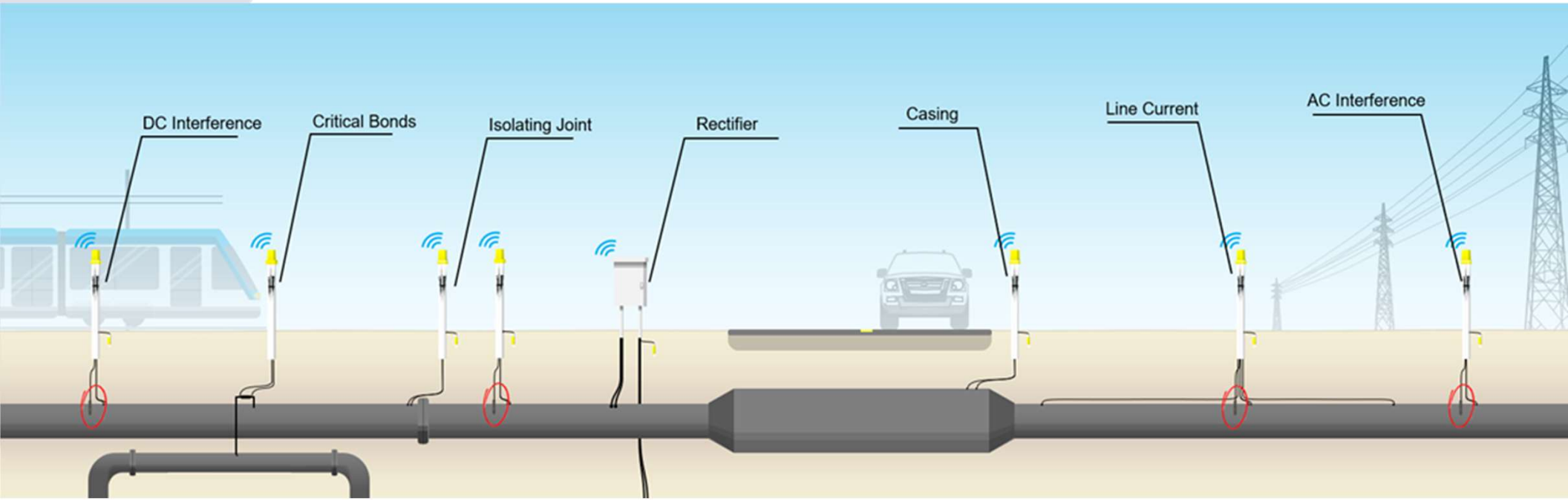
Rectifier & Test Station Monitoring



Corrosion Rate & Electrical Fingerprint Concept

Thickness Corrosion rate: ER probe

E_{ON}: Pipe vs. Ref

E_{IRfree} = Eon – J_{DC}*Rs

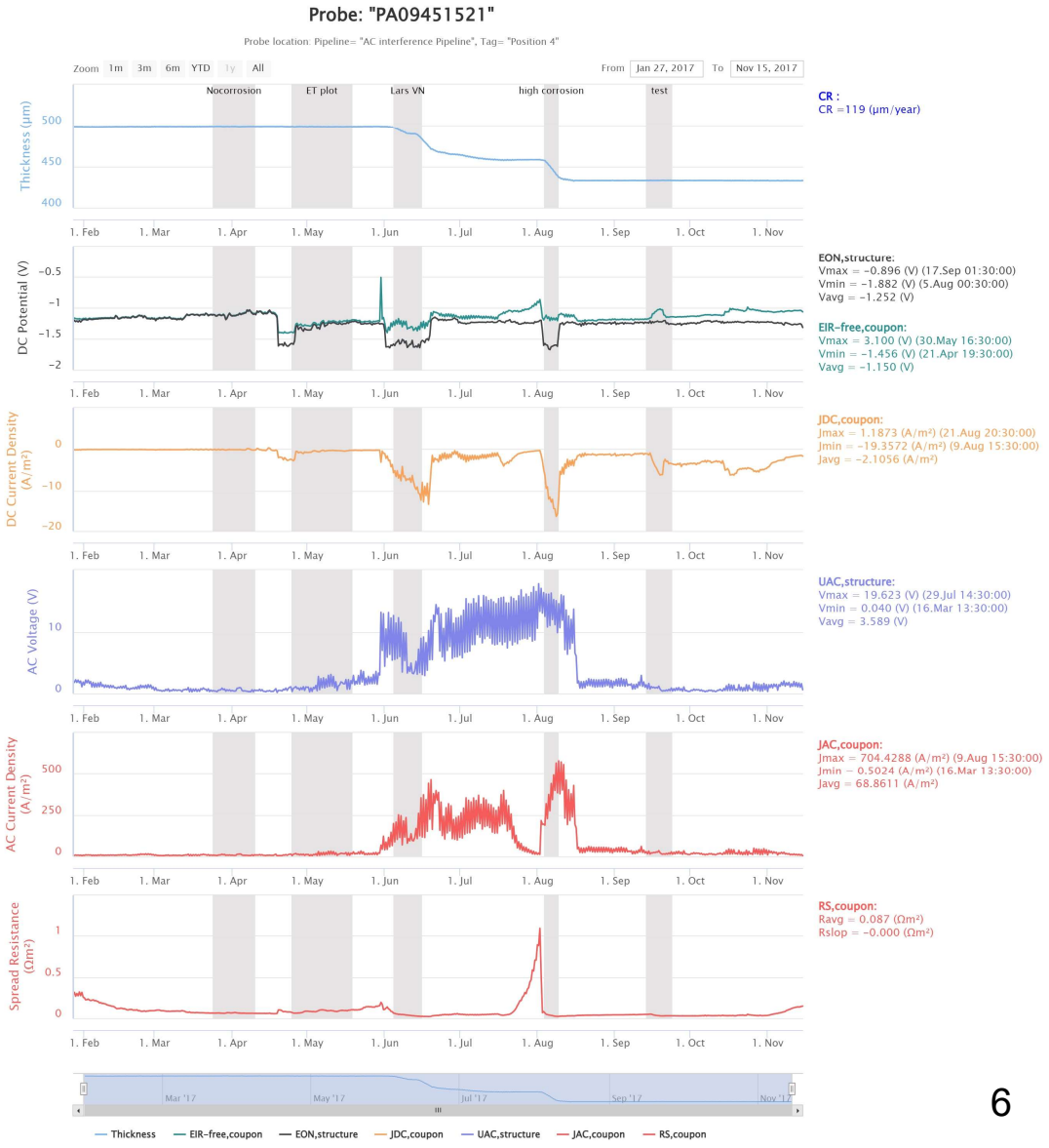
E_{OFF}: Probe vs. Ref

J_{DC}: Probe current density

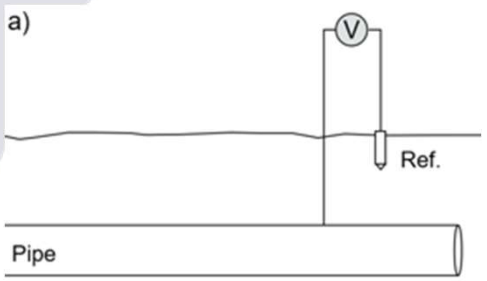
U_{AC}: Pipe vs. Ref

J_{AC}: Probe current density

$R_S = U_{AC}/J_{AC}$

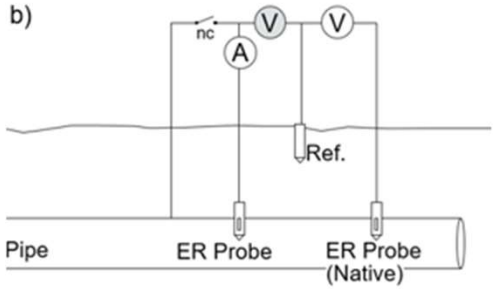


Rectifier & Test Point Monitoring



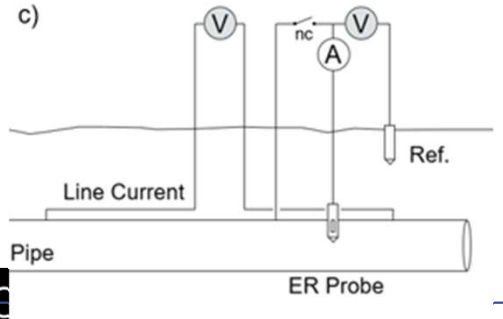
VL-100 MasterLink RMU Pack (Potential Test Station)

Item No.



ICL MasterLink RMU Pack (Corrosion Rate Test Station)

Item No.



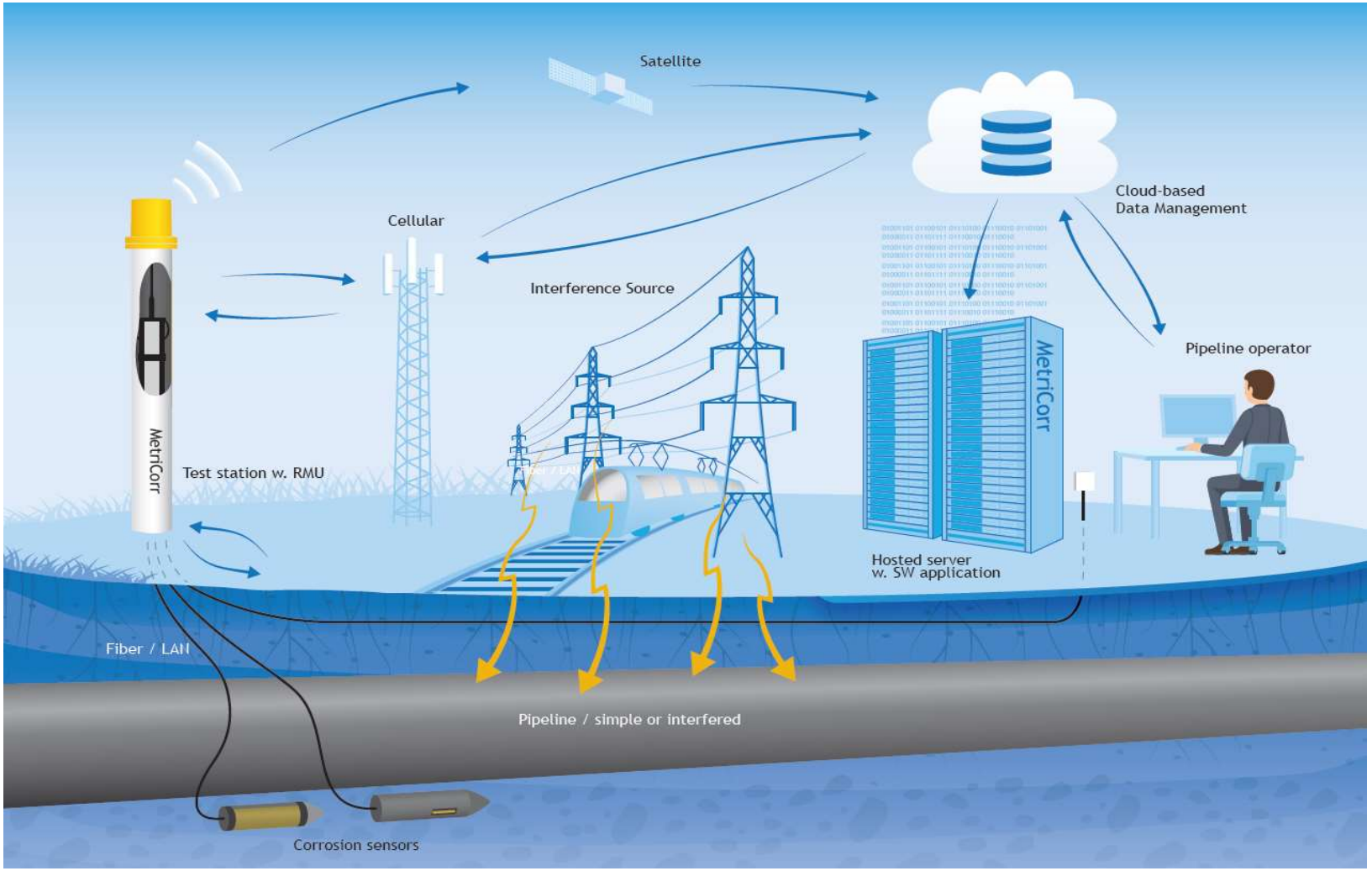
ICL-C MasterLink RMU Pack (Line Current & Corrosion Rate Test Station)

Item No.

Corrosion Rate & Electrical Fingerprint Concept

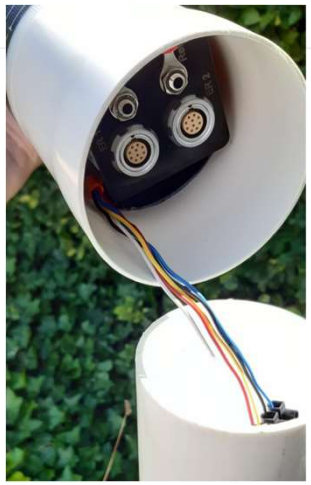
System Architecture

MetriCorr



Integrated Big Fink Solar Power Test Station

MetriCorr



Criteria

AC Criteria – NACE SP21424

6.1 **Corrosion Rate**: Effective control of AC corrosion can be shown by a documented corrosion rate less than 0.025 mm/year (1 mpy) which is a commonly used benchmark for effective external corrosion control....

6.2 **Current Density**: Unless effective AC corrosion control has been otherwise documented (6.1) the AC current density should not exceed a time-weighted average of

- 30 A/m^2 if DC current exceeds 1 A/m^2
- 100 A/m^2 if DC current is less than 1 A/m^2

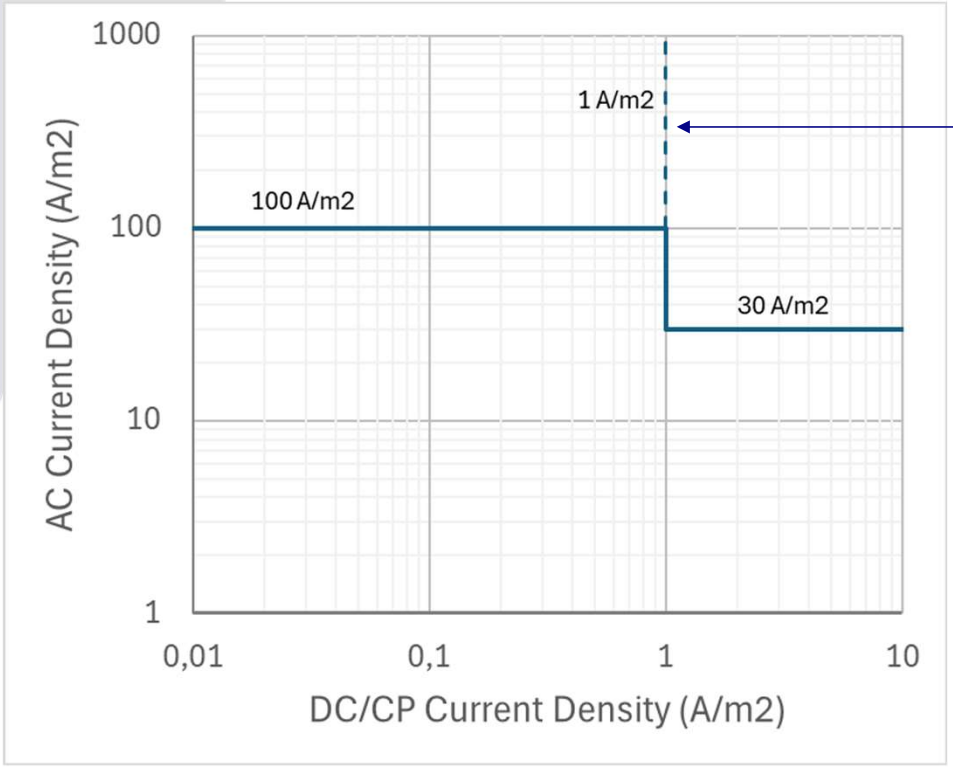
Current densities are measured on coupons.

6.3 **AC Voltage**: The AC voltage induced on a pipeline is the diving force for AC corrosion. The AC voltage should be mitigated to a level where the above current densities are met.

6.4 **Cathodic Polarization**: AC corrosion is inhibited by cathodic polarization The criteria given in NACE SP0169 shall be followed but the cathodic DC current densities given in 6.2 should be noted.

6.5 The above criteria shall be documented for a representative period of time, accounting for variations in influencing parameters.

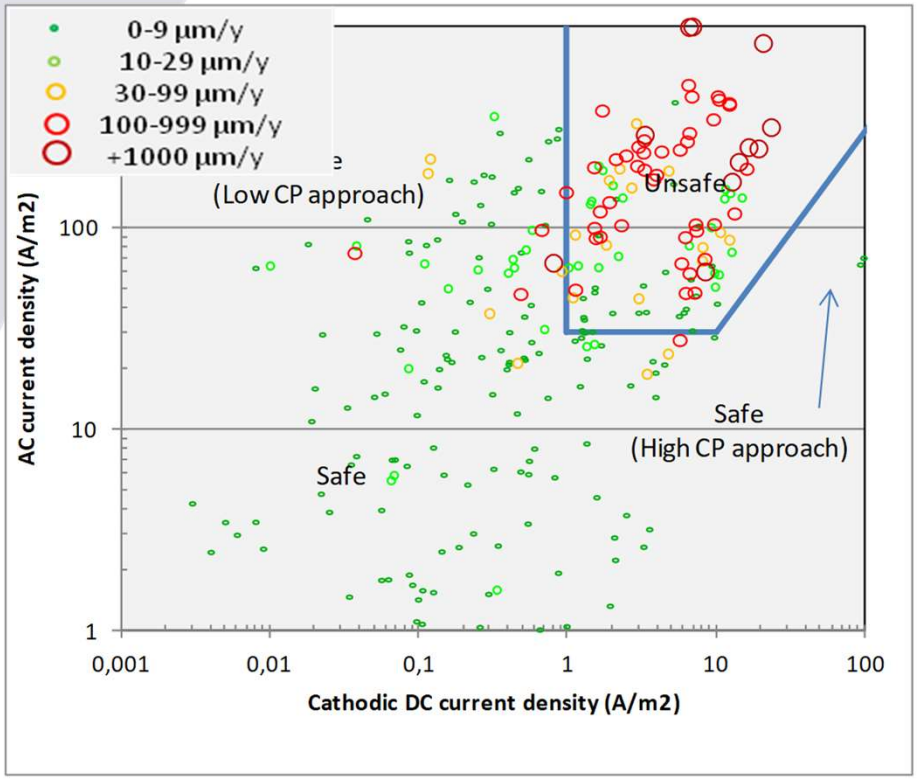
AC Criteria – SP21424



ISO 18086

Reason for 1 A/m2 DC?

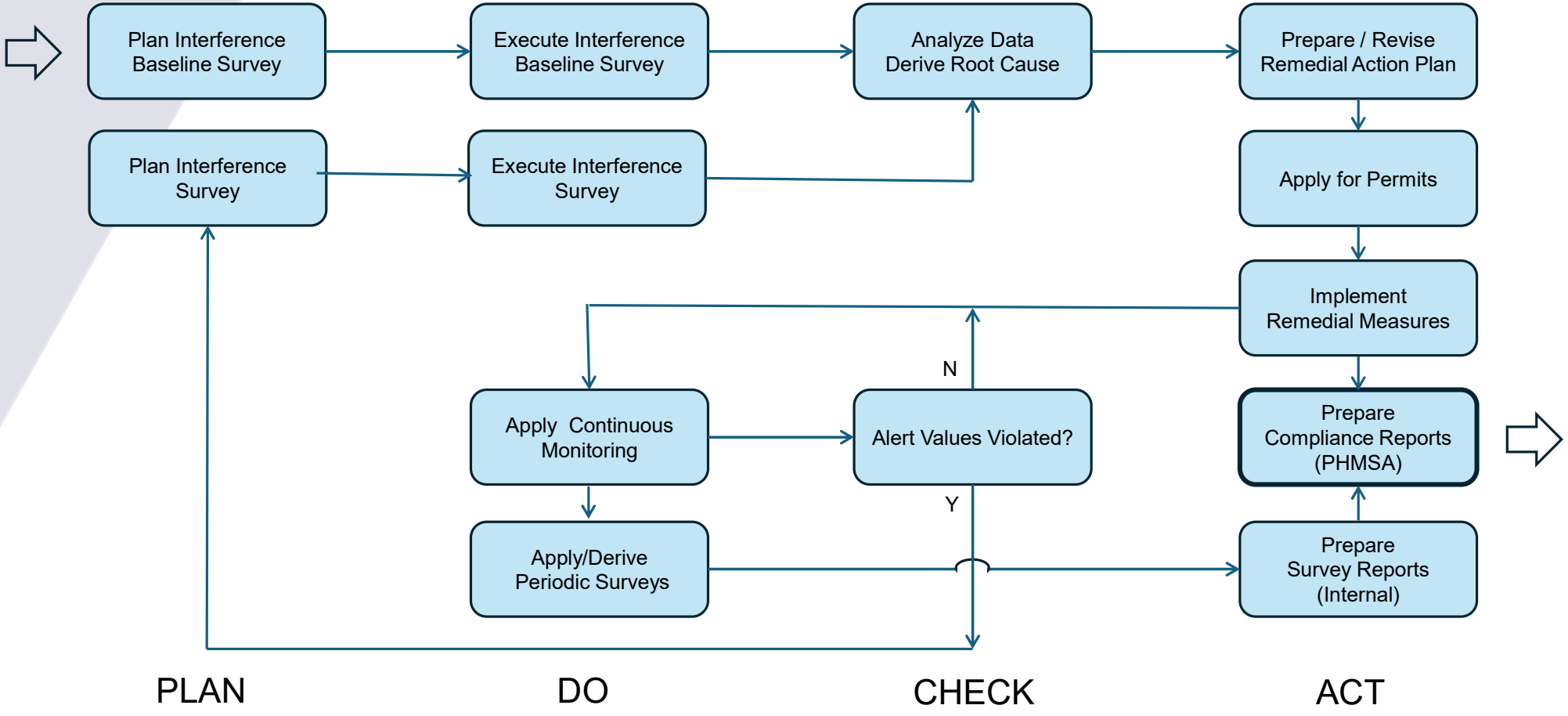
AC Criteria – SP21424



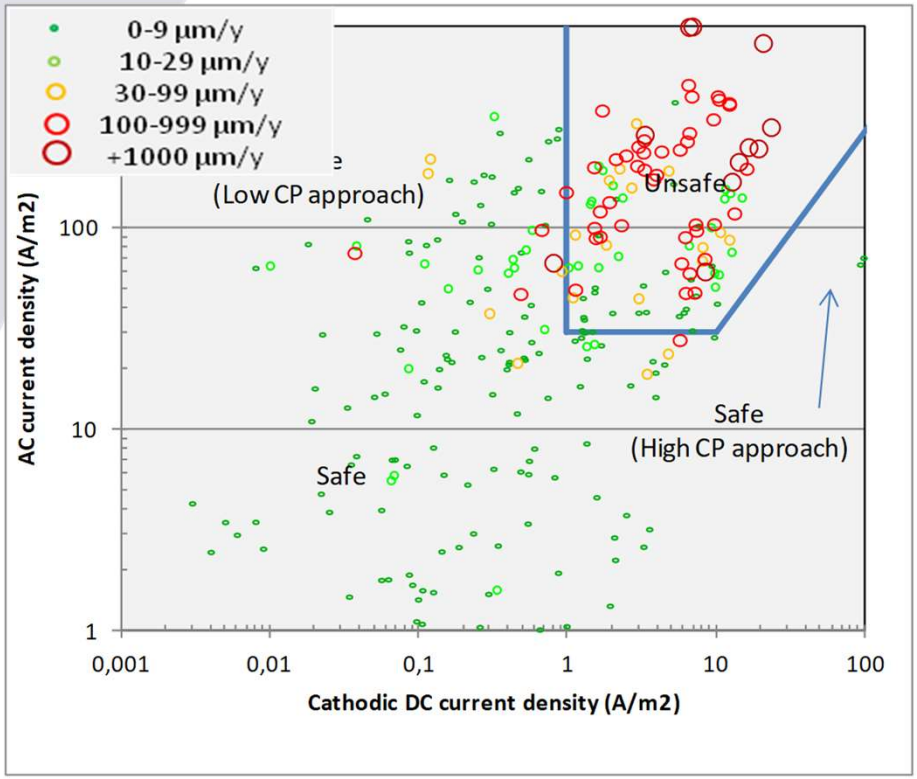
Reason for 1 A/m2 DC?

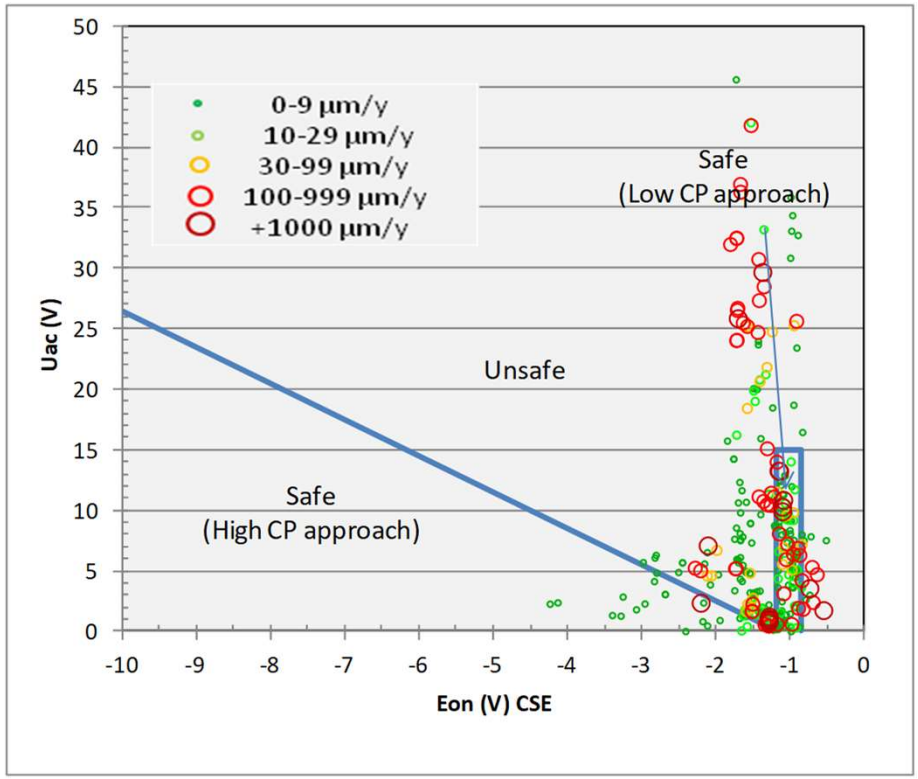
What does PHMSA Say?

PHMSA: 100Amps per meter squared – and then what?



AC Criteria – SP21424





Spread Resistance vs Soil Resistivity

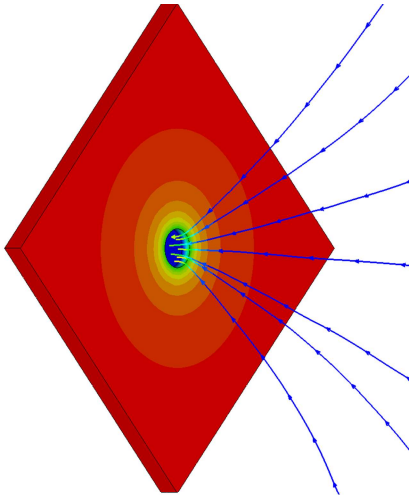
Spread Resistance vs Soil Resistivity

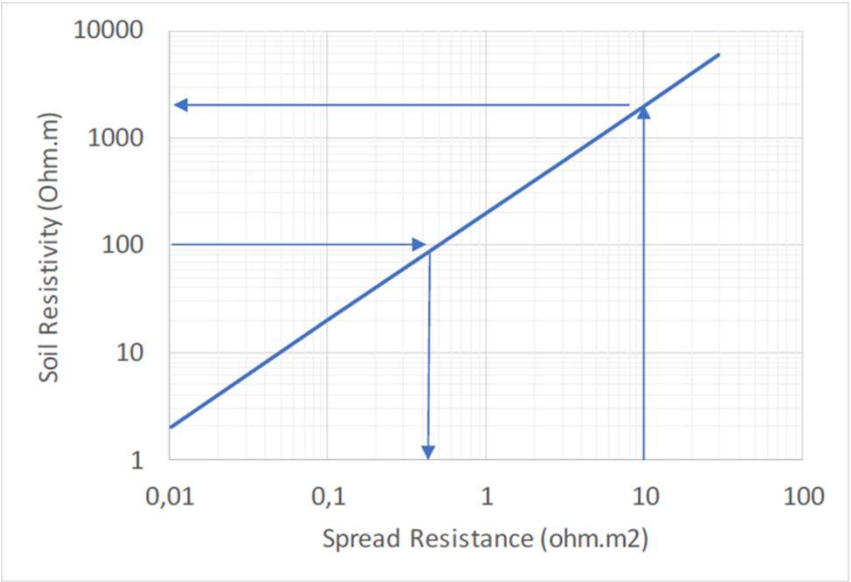
$$U_{AC}(V) = \frac{\rho_{soil}(\Omega \cdot m)}{2 \cdot d\,(m)} \cdot A\,(m^2) \cdot J_{AC}\,(A/m^2)$$

Spread Resistance vs Soil Resistivity

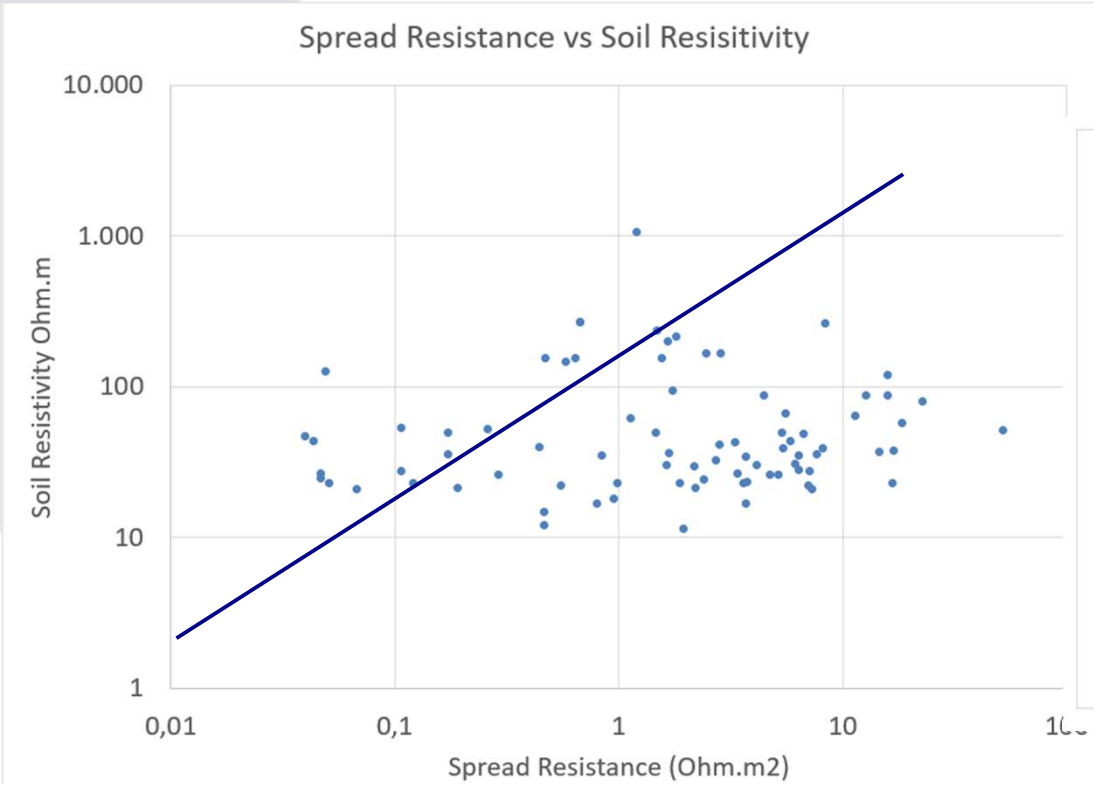
$$U_{AC}(V) = \frac{\rho_{soil}(\Omega \cdot m)}{2 \cdot d\,(m)} \cdot A\,(m^2) \cdot J_{AC}\,(A/m^2)$$

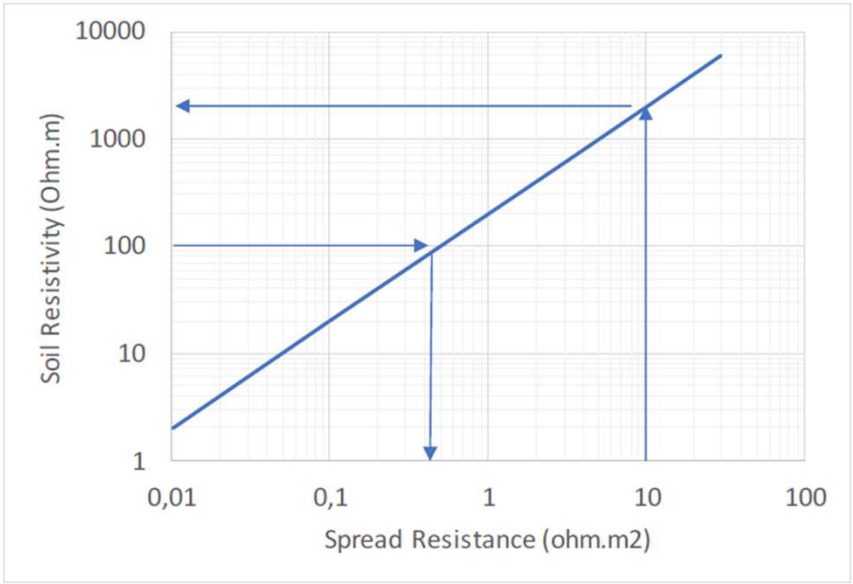
$$R_{spread}(ohm.\,m^2) = \frac{R_{soil}(ohm.\,m) \cdot A(m^2)}{2 \cdot d\,(m)}$$



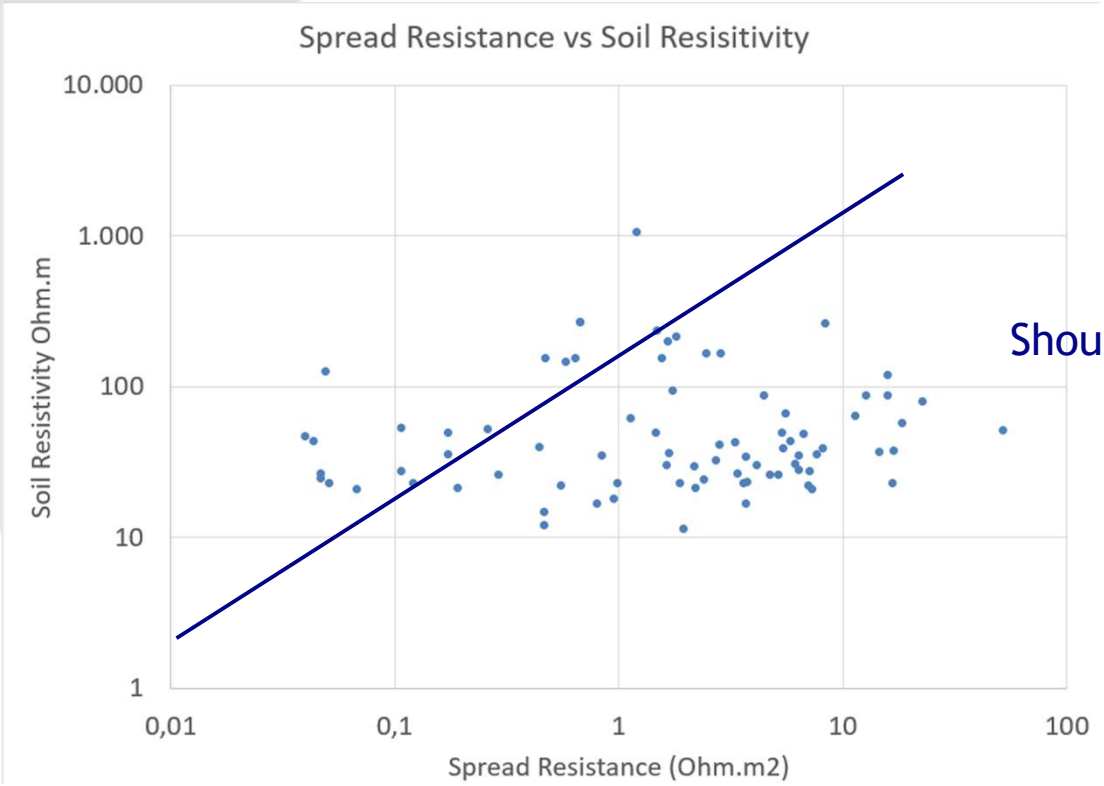


Spread Resistance vs Soil Resistivity





Spread Resistance vs Soil Resistivity

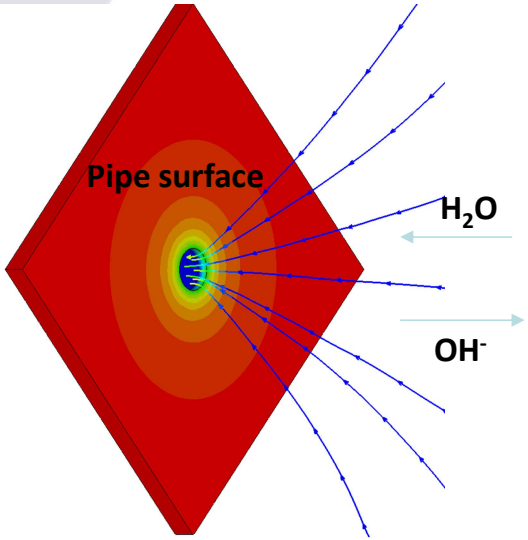


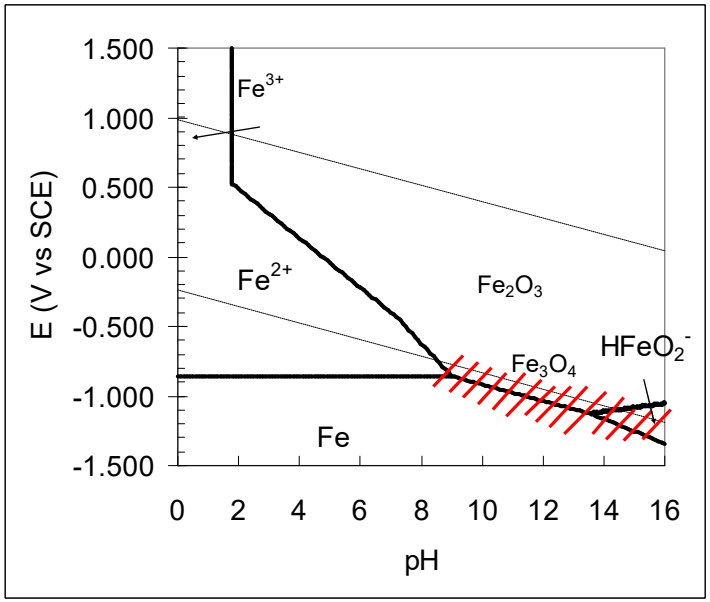
Should we disqualify AC current density modeling?

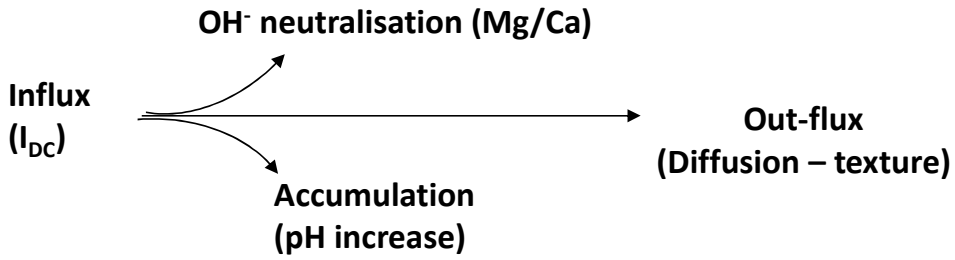
- Or should we disqualify coupons?

AC Corrosion Vicious Circle

AC Corrosion Vicious Circle

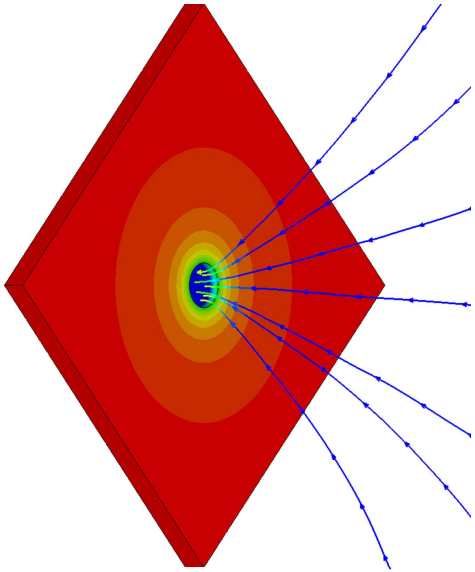


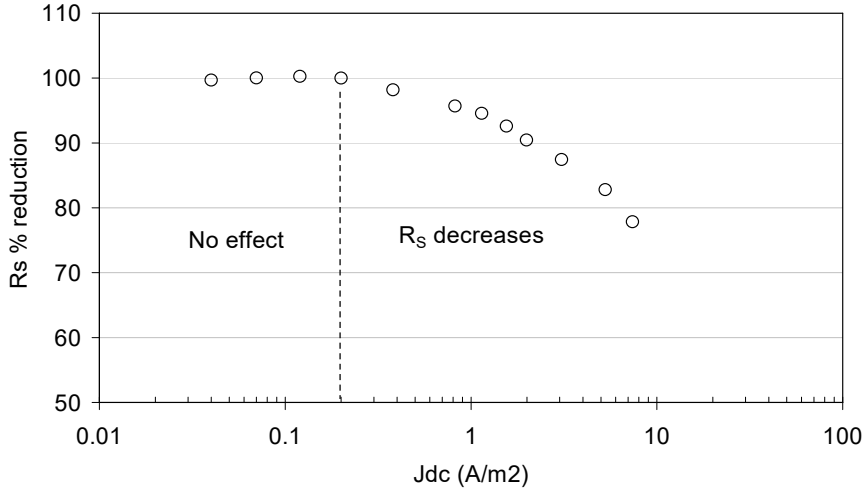




AC Corrosion Vicious Circle

$$U_{AC}(V) = \frac{\rho_{soil}(\Omega \cdot m)}{2 \cdot d\,(m)} \cdot A\,(m^2) \cdot J_{AC}\,(A/m^2)$$



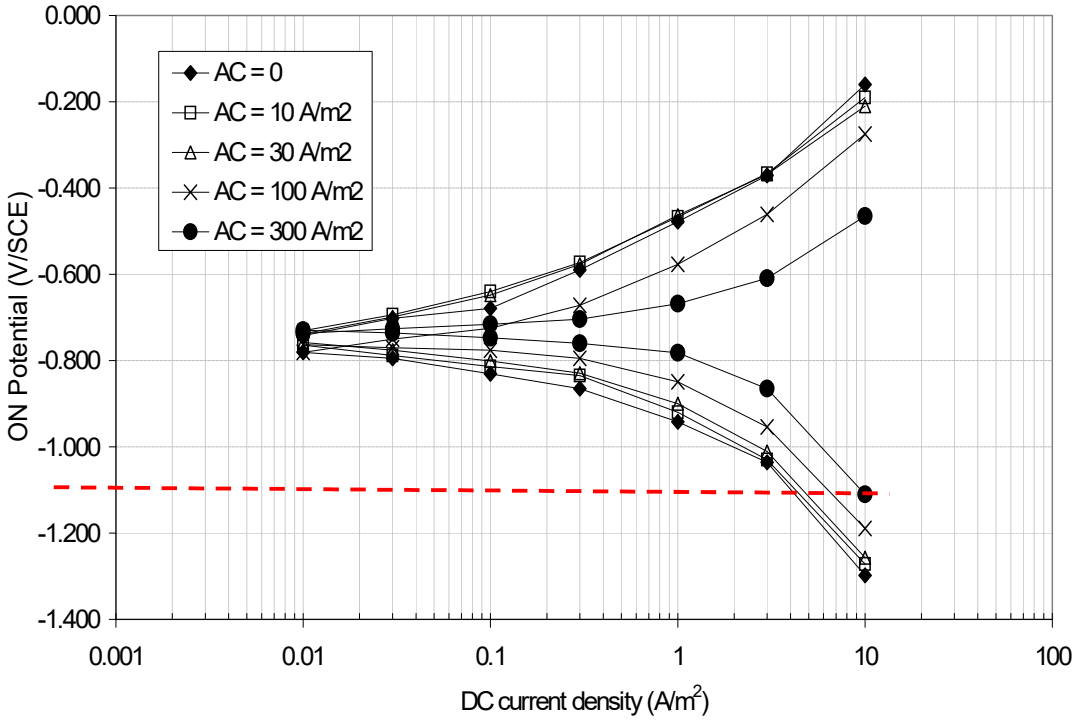


$$U_{AC}(V) = R_S \cdot (\Omega \cdot m^2) \cdot J_{AC}\,(A/m^2)$$

$$U = R \cdot I$$

$$E_{ON} - E_{IRfree} = I \cdot R_S$$

AC Corrosion Vicious Circle



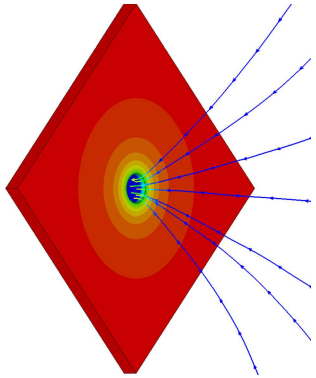
AC Corrosion Vicious Circle

Excessive CP

Small Coating Defect

Induced AC

Pre-requisites



Increased AC Current

Depolarization

"thorough mitigation"

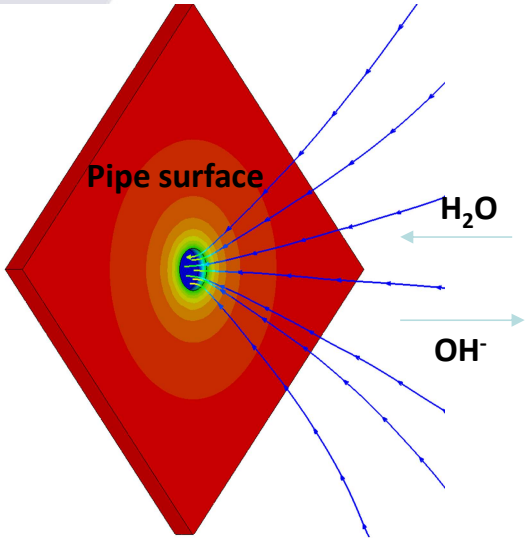
Excessive CP

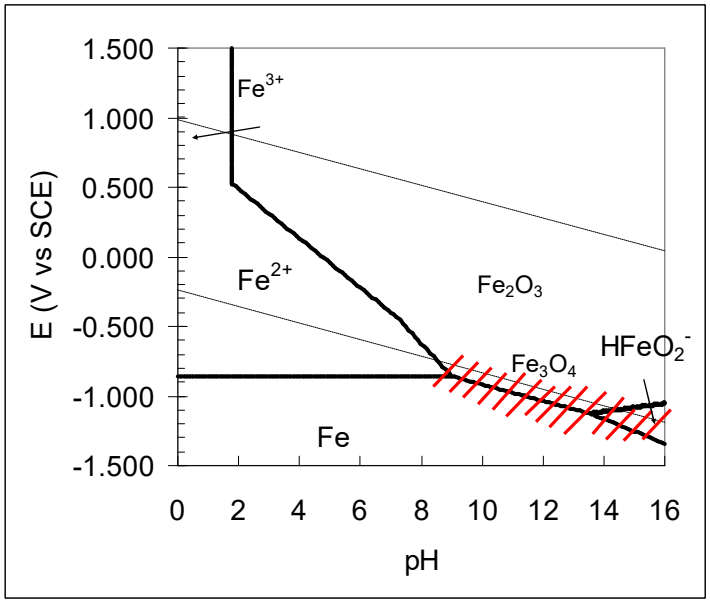
Alkalinity

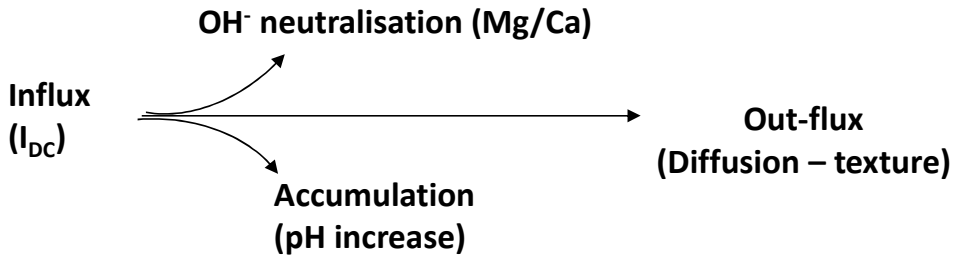
Reduced Spread Resistance

Ohm's law

AC Corrosion Vicious Circle



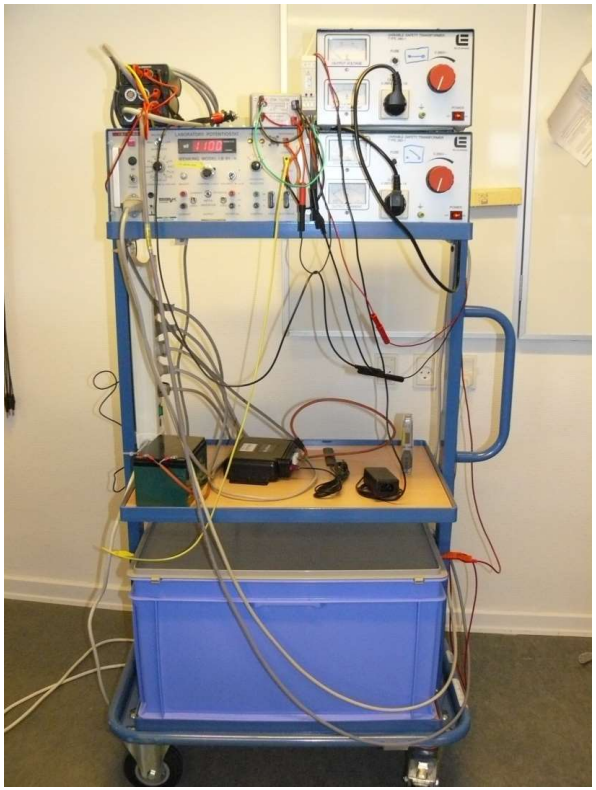


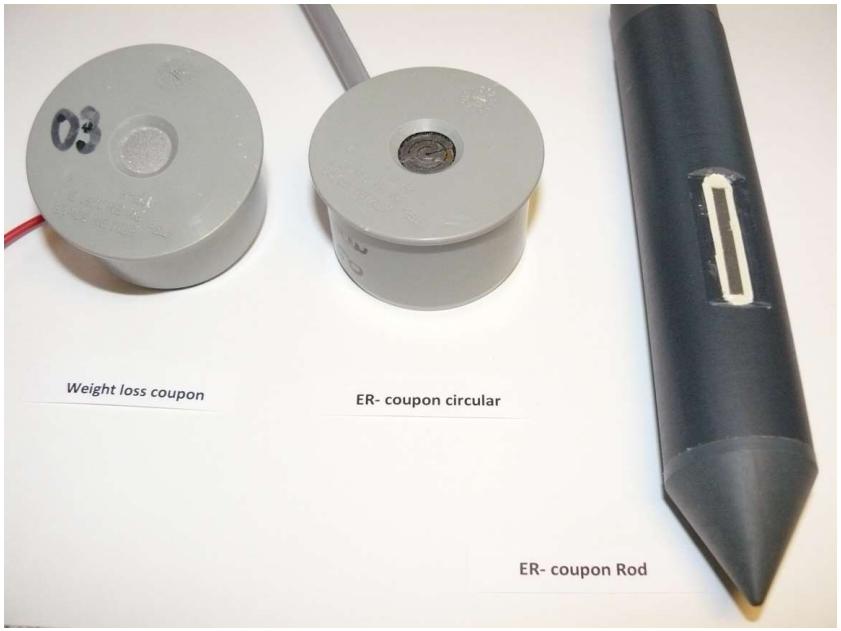


Laboratory Evidence

Laboratory Evidence

Corrosion rate,
DC Potential,
DC current density
AC voltage,
AC current density
Spread Resistance





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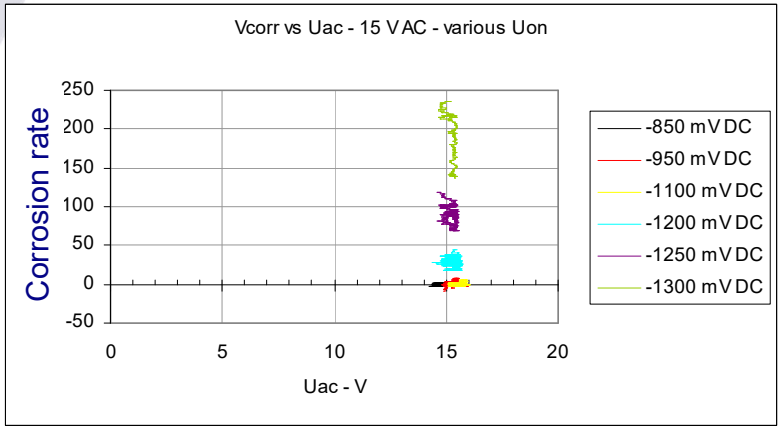
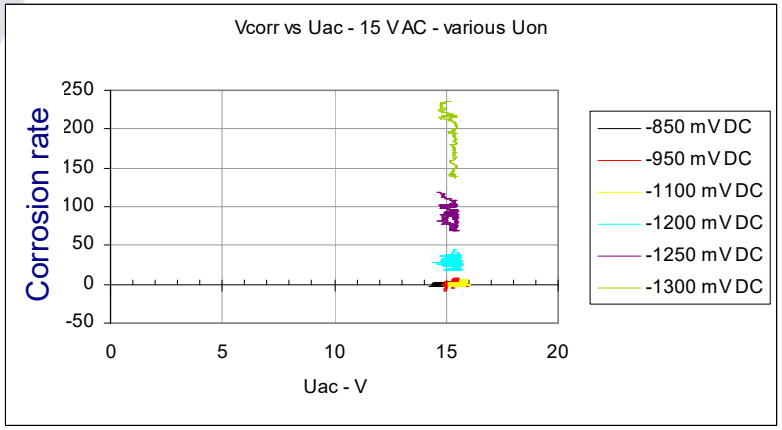
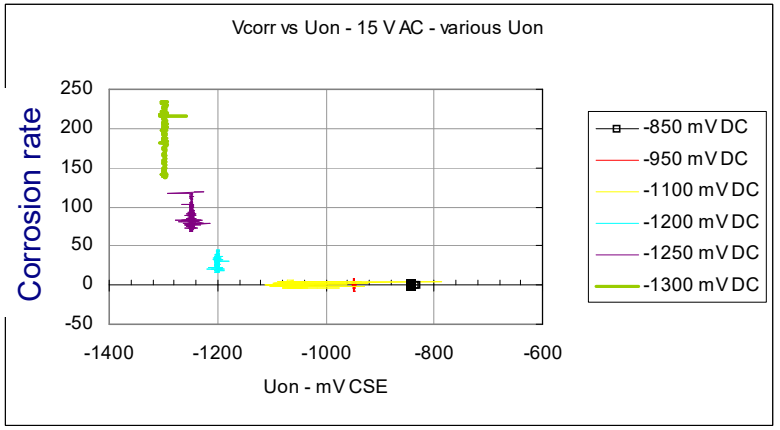


AC Corrosion – an effect of AC alone?

- Corrosion rate not particularly controlled by the AC voltage level

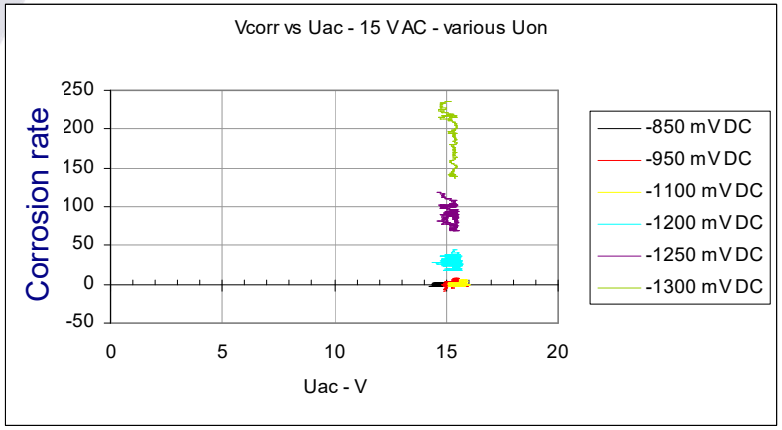
Laboratory Evidence

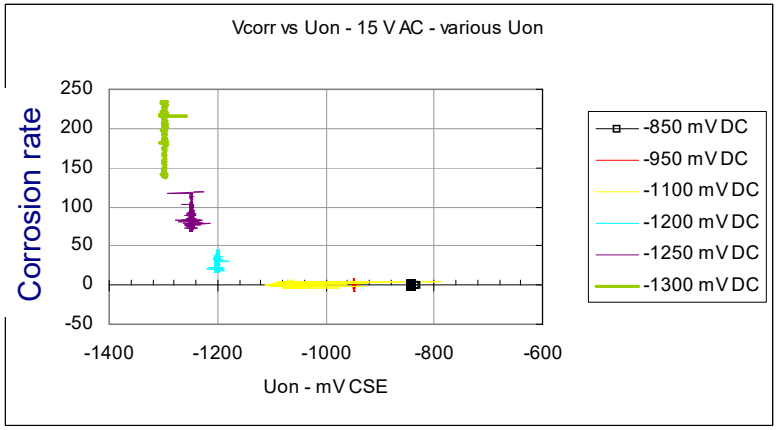


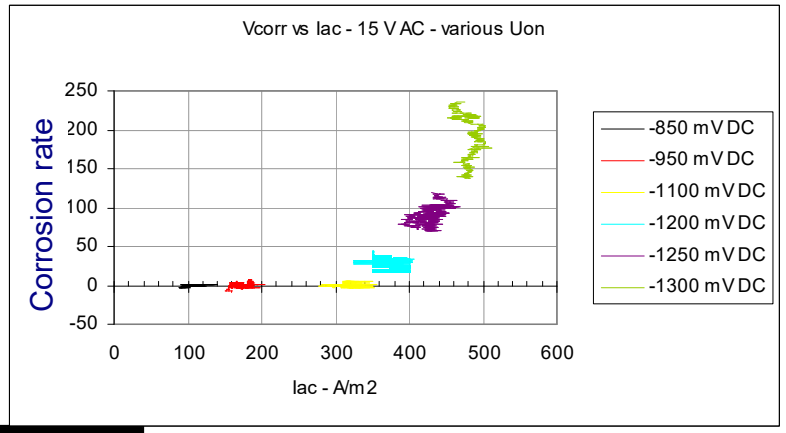


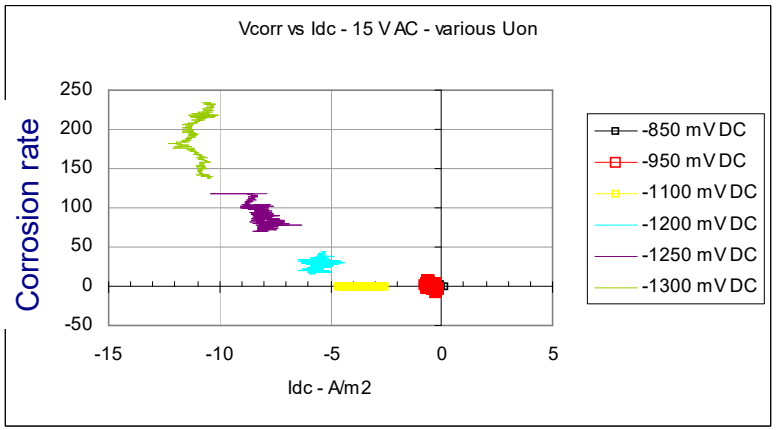
- Corrosion rate not particularly controlled by the AC voltage level
- DC – potentials have a high influence

Laboratory Evidence

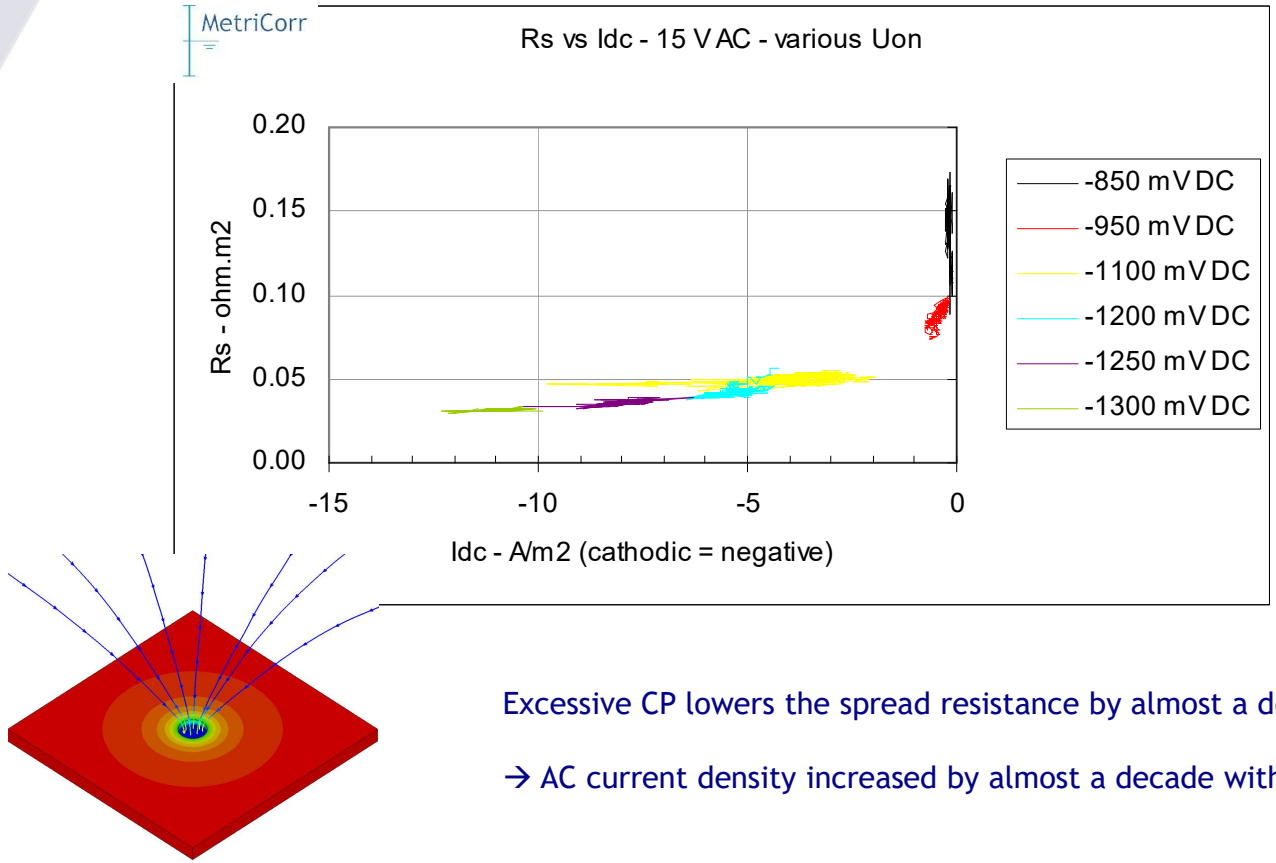








Laboratory Evidence



Excessive CP lowers the spread resistance by almost a decade

→ AC current density increased by almost a decade without increasing AC voltage

Field Evidence

Field Evidence

Thickness Corrosion rate: ER probe

E_{ON}: Pipe vs. Ref

$E_{IRfree} = Eon - J_{DC}*Rs$

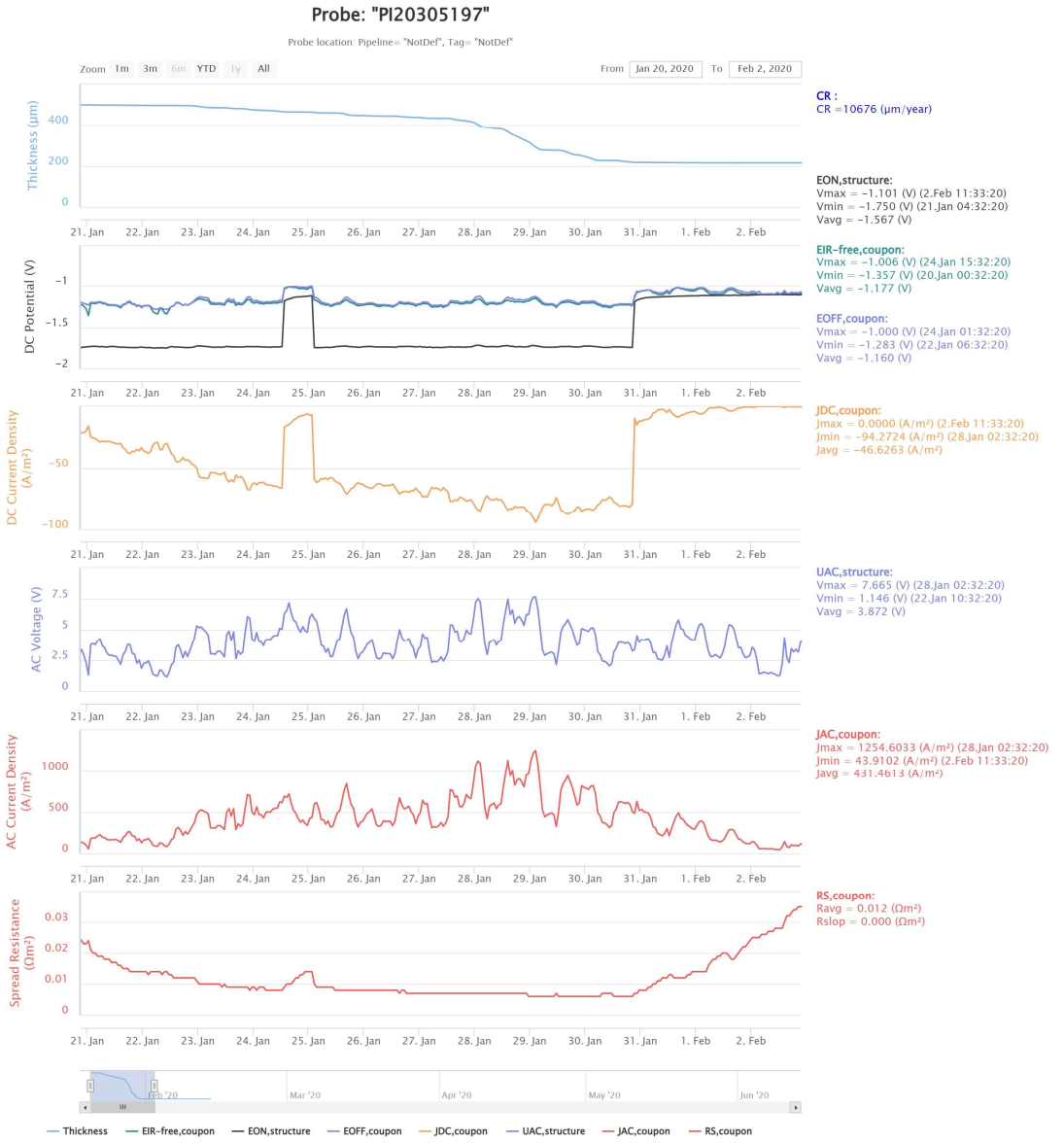
E_{OFF}: Probe vs. Ref

J_{DC}: Probe current density

U_{AC}: Pipe vs. Ref

J_{AC}: Probe current density

$R_S = U_{AC}/J_{AC}$



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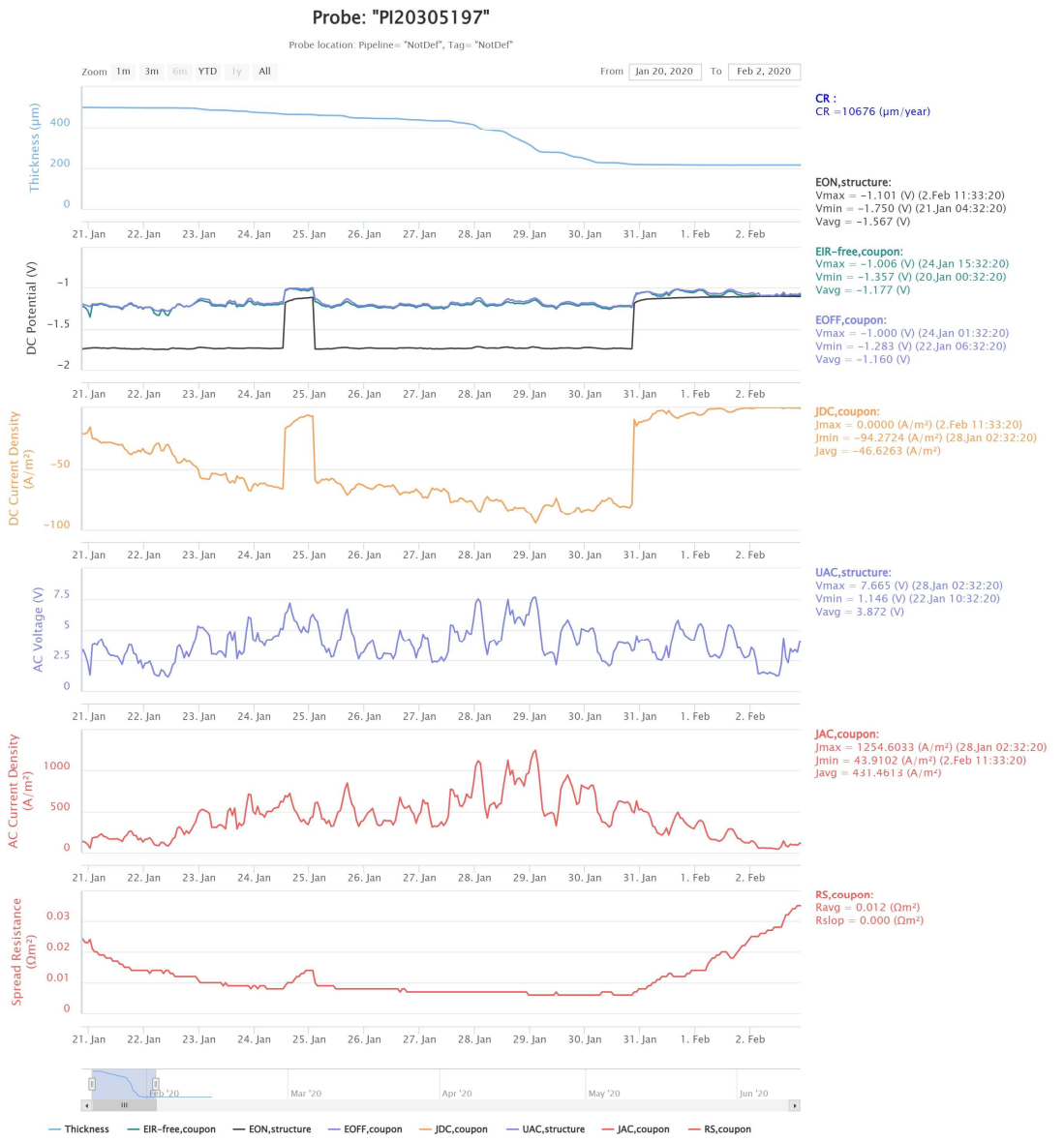
Field Evidence

Are AC and DC correlated?

Does DC control spread resistance?

Does Spread resistance control AC current density?

What is the easiest way to avoid “trouble”



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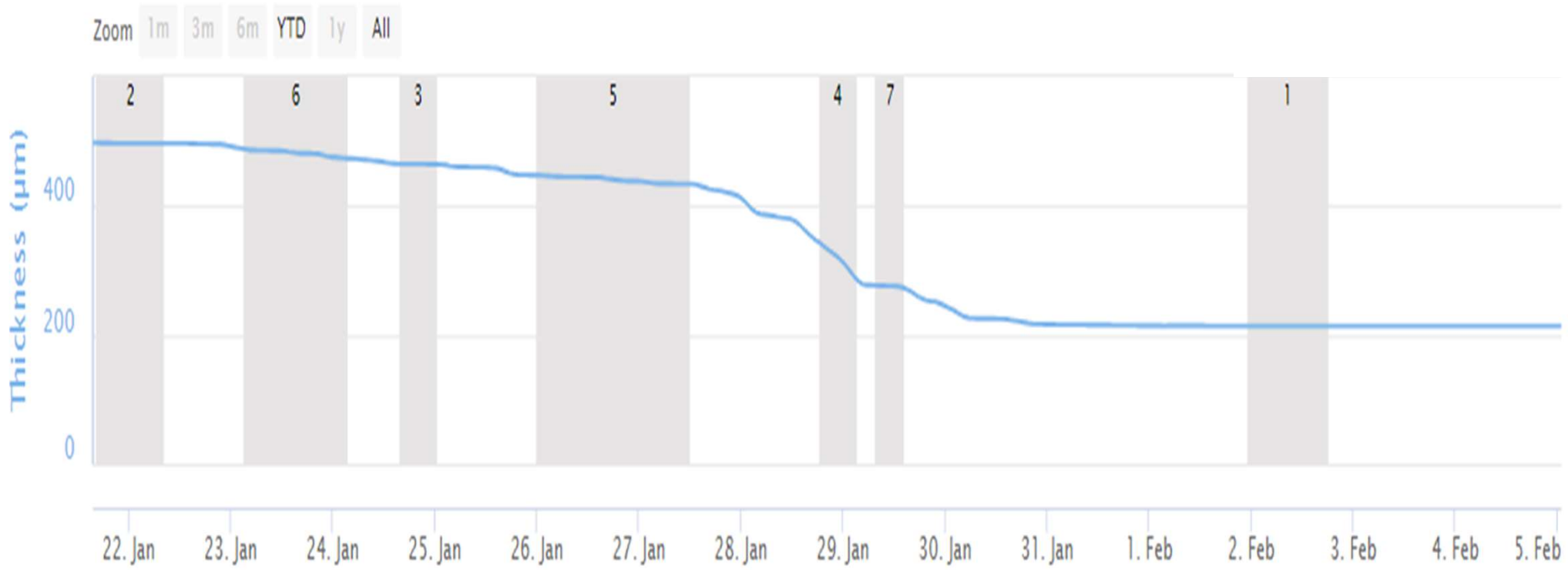
Field Evidence

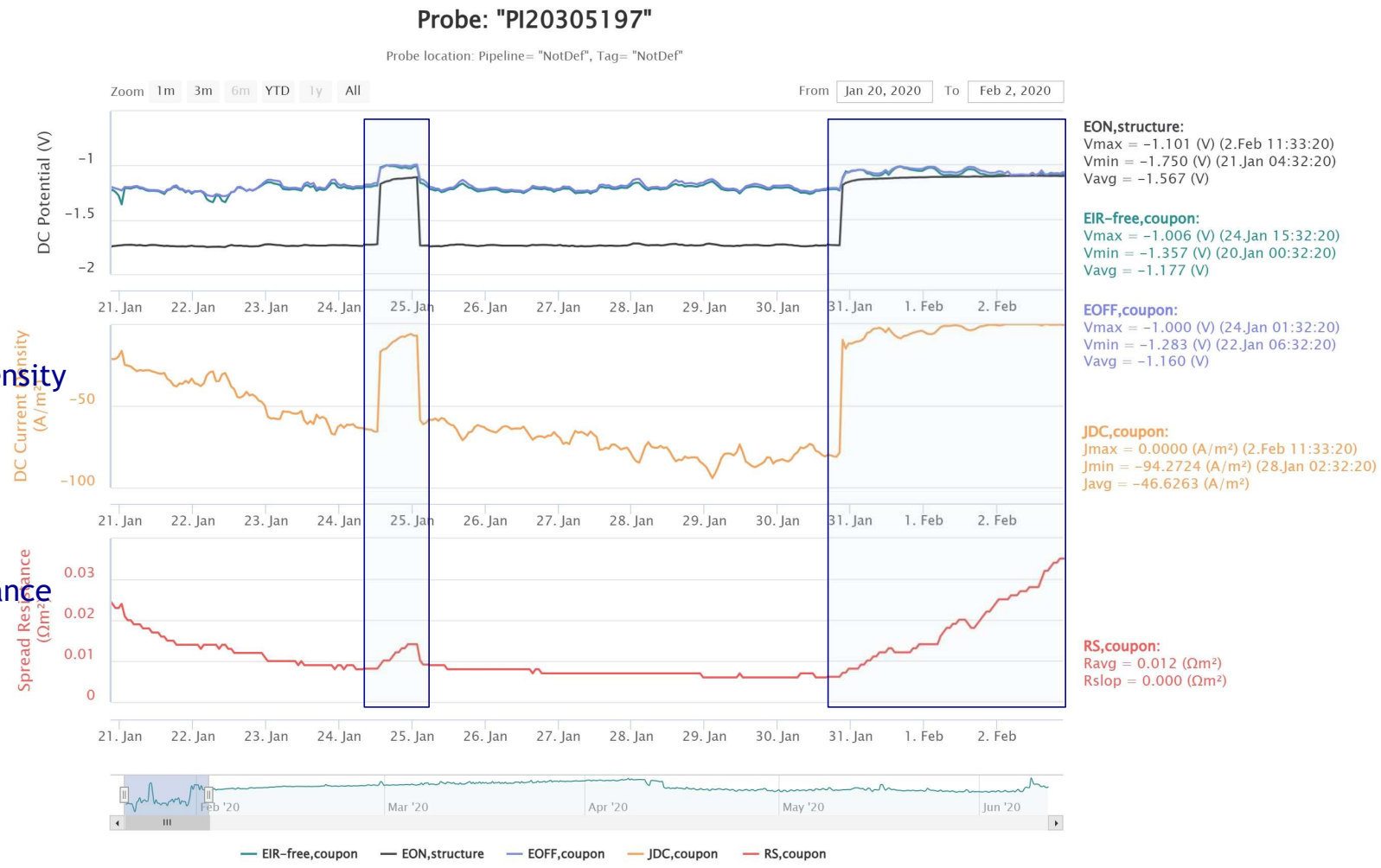


Field Evidence – CP Controls Spread Resistance

DC Potential

DC Current Density

Spread Resistance

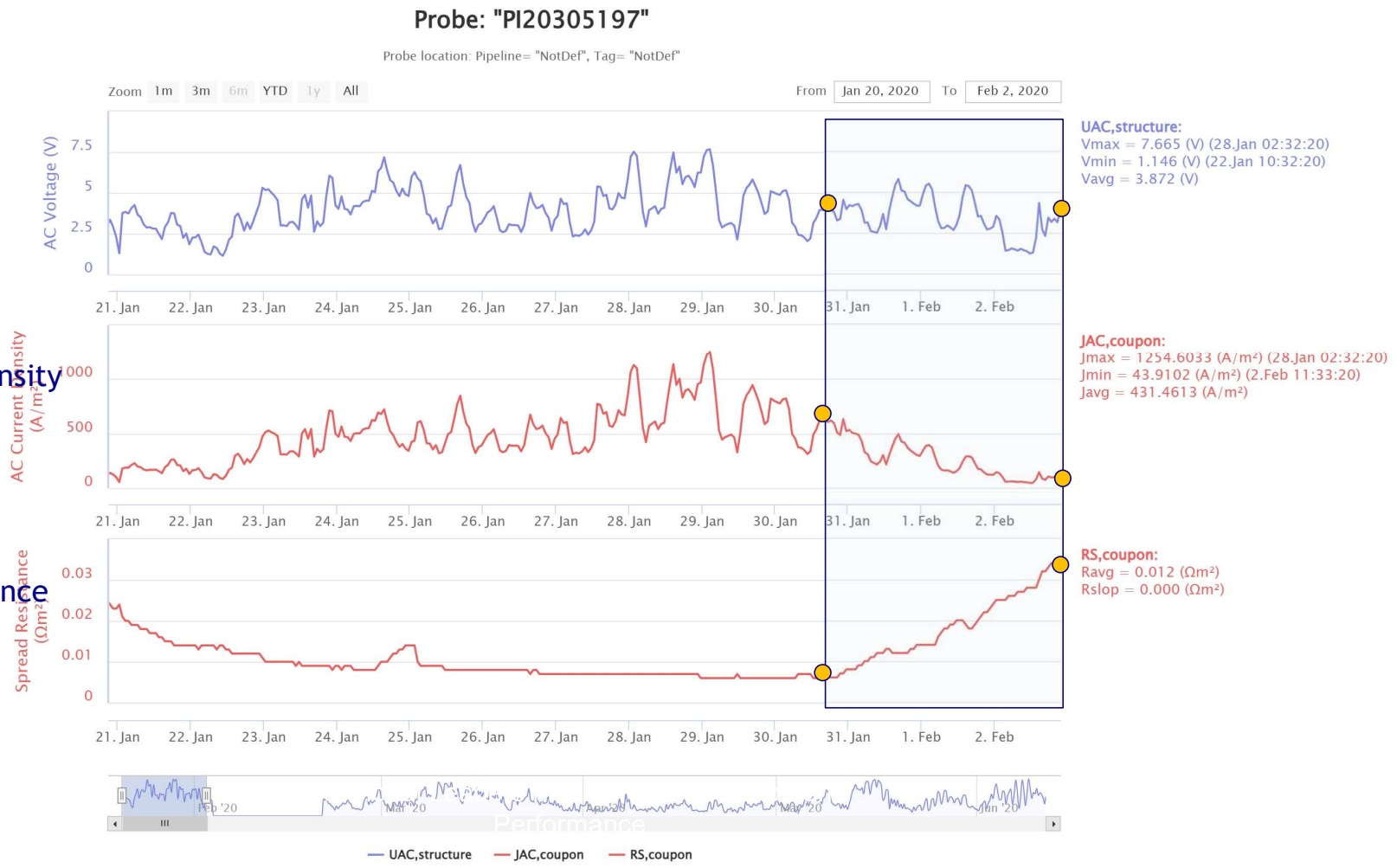


Field Evidence – Spread Resistance controls AC Current Density

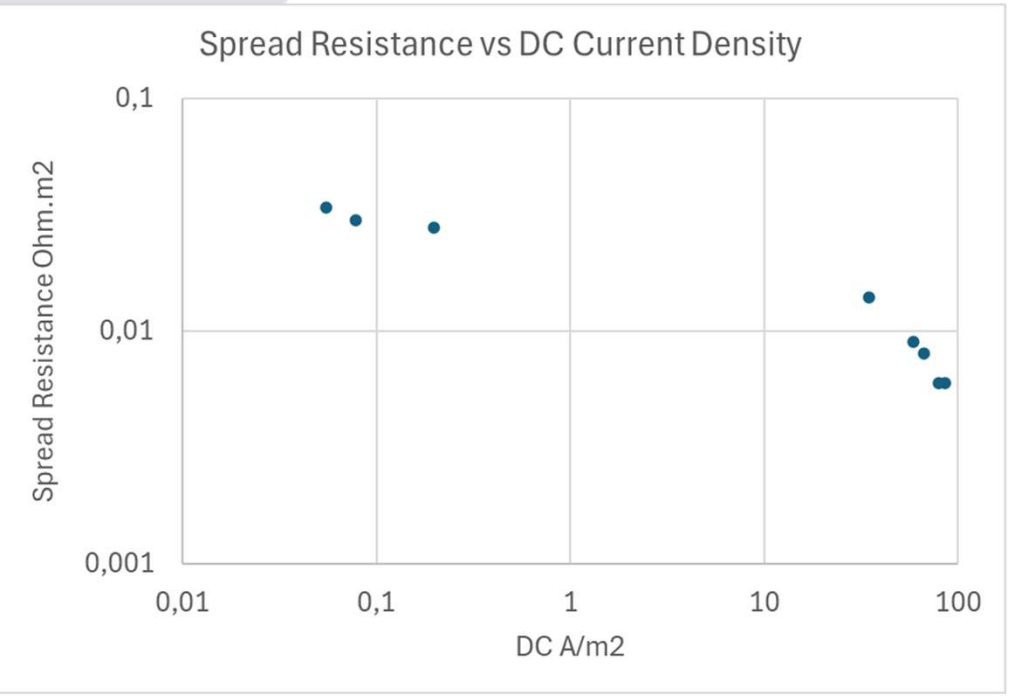
AC Voltage

AC Current Density

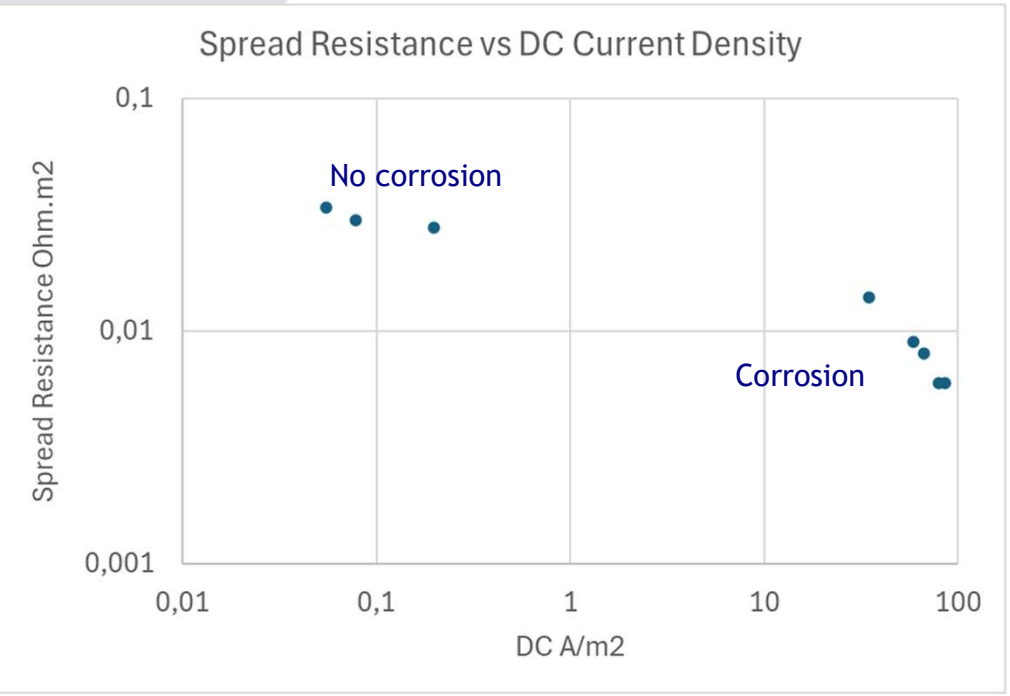
Spread Resistance

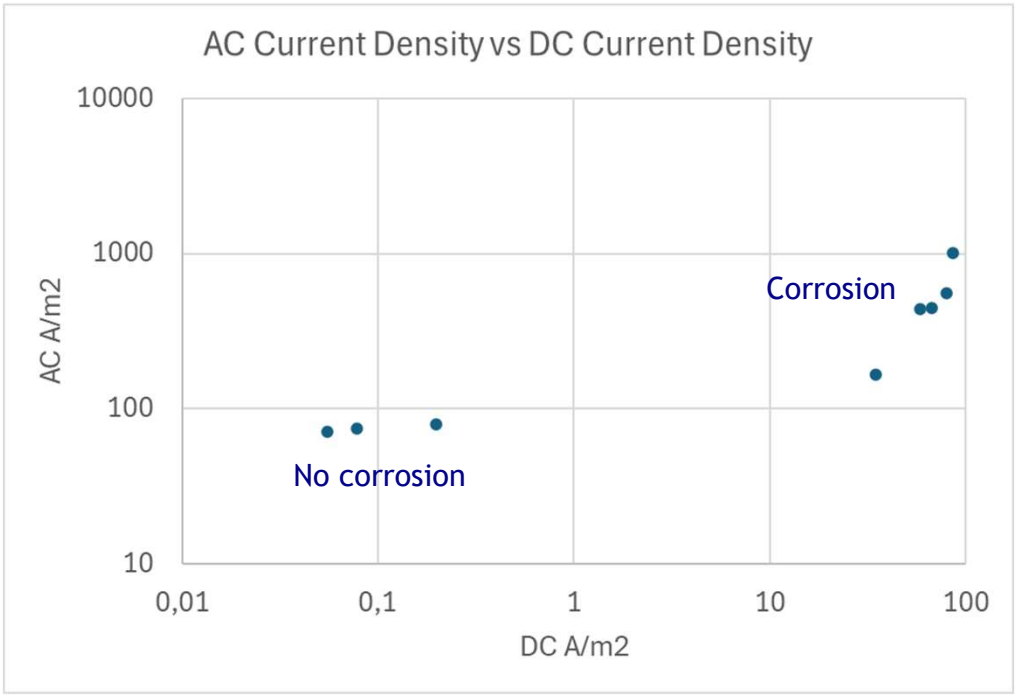


Field Evidence – Spread Resistance controls AC Current Density



Field Evidence – YOU control spread resistance, AC Current density and Corrosion Rates





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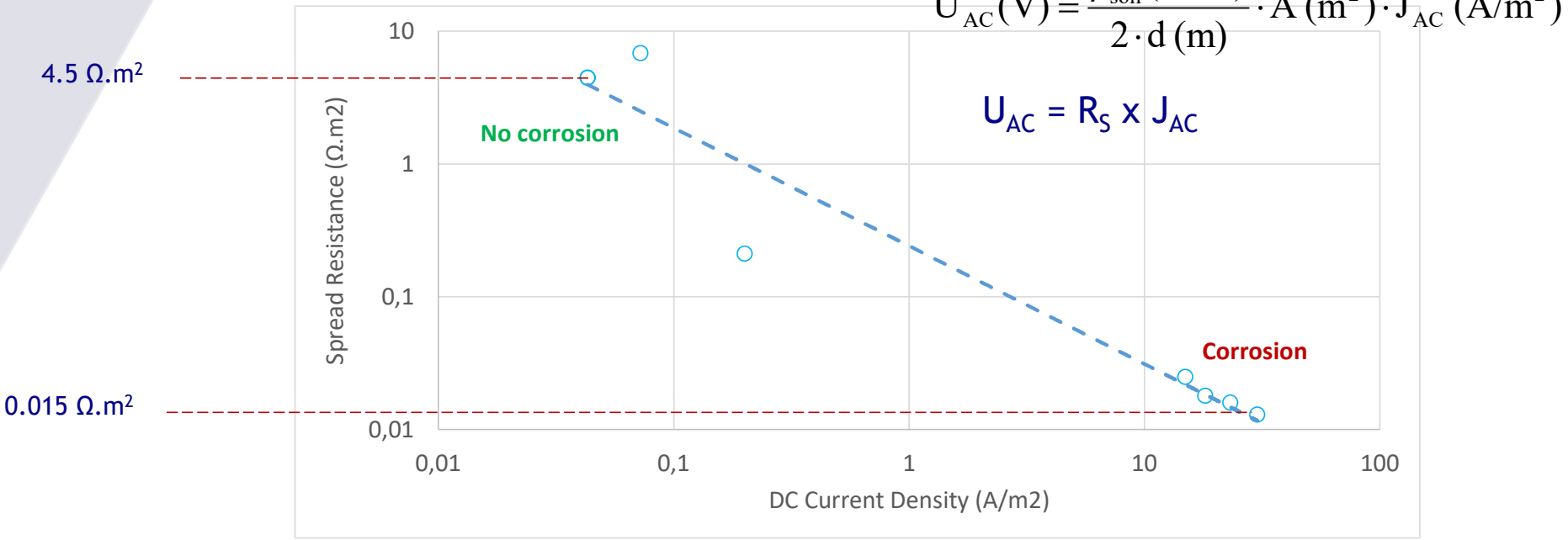
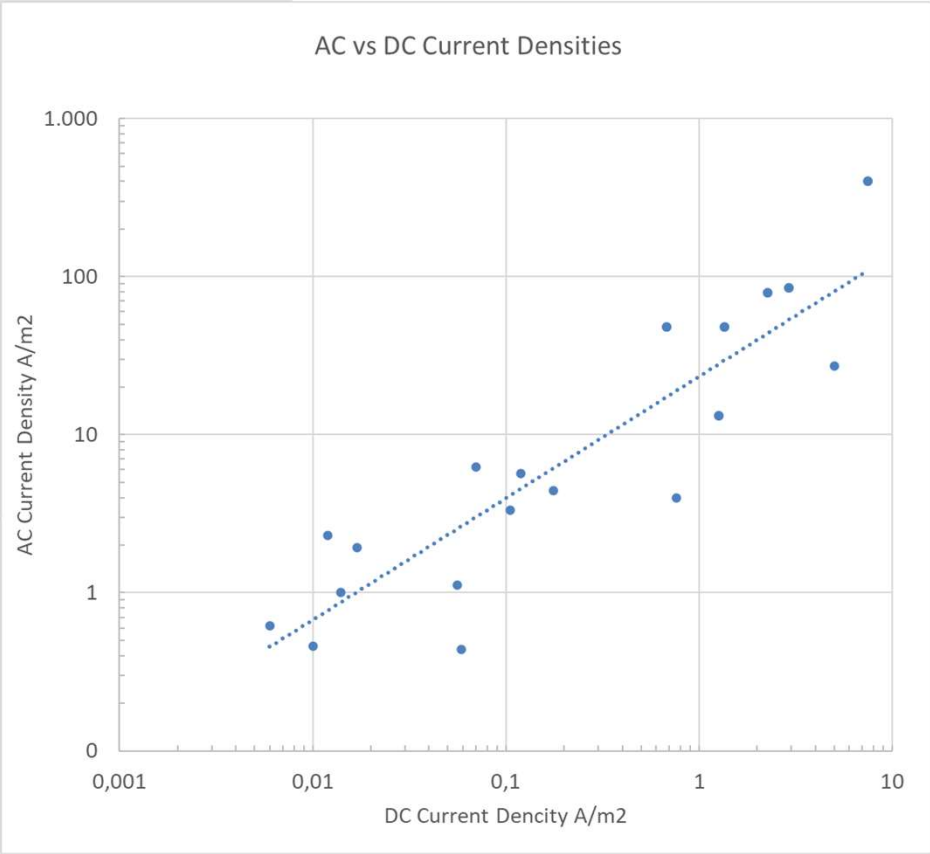
Field Evidence – YOU control spread resistance, AC Current density and Corrosion Rates

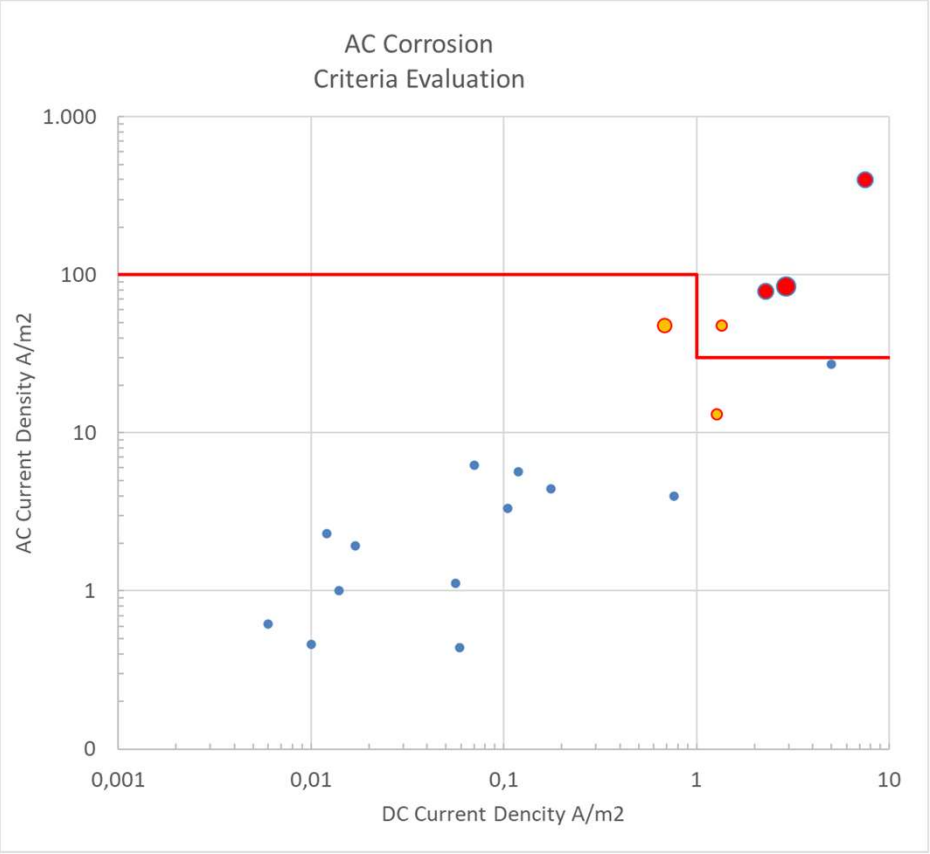
$$U_{AC}(V) = \frac{\rho_{soil}(\Omega \cdot m)}{2 \cdot d\,(m)} \cdot A\,(m^2) \cdot J_{AC}\,(A/m^2)$$



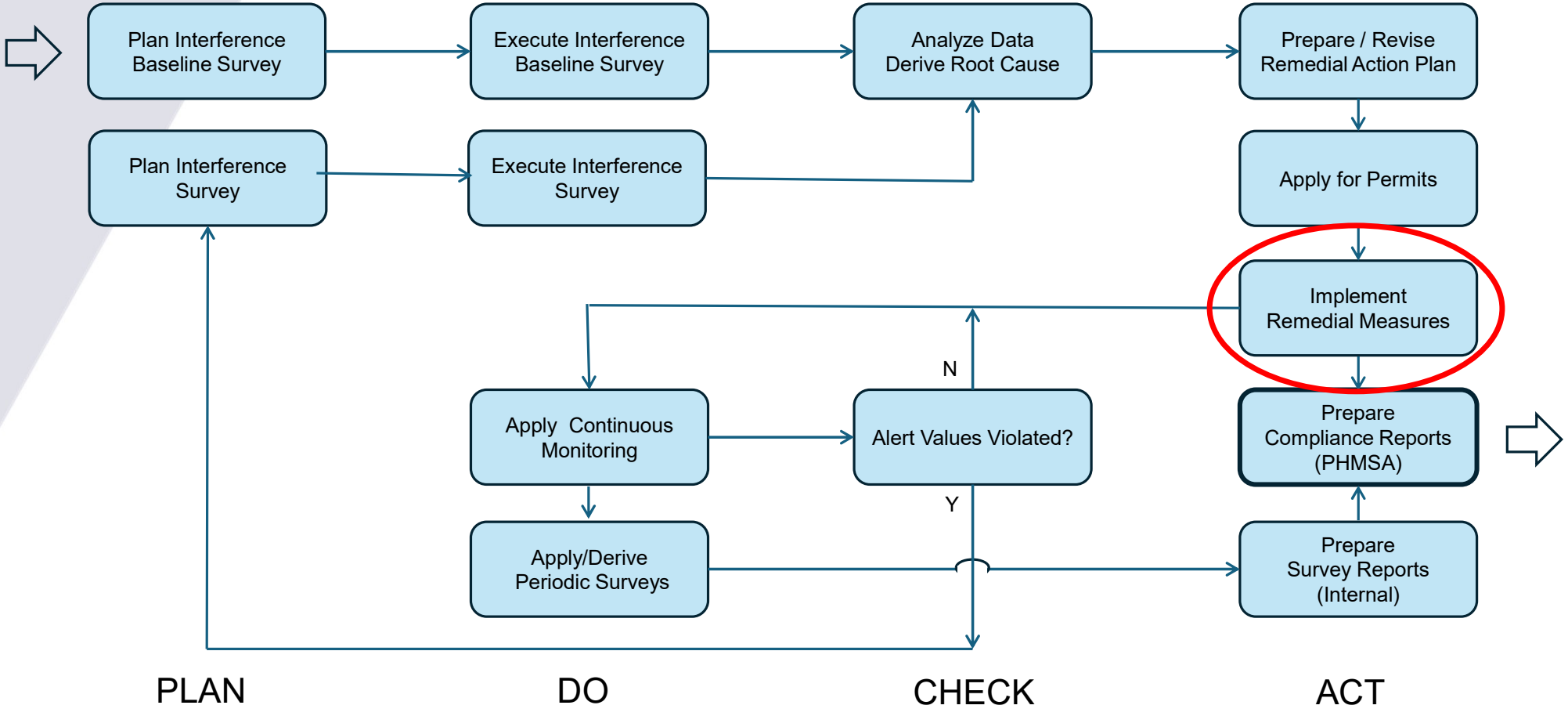
One extreme example → 350 times reduction in AC Current Density – just by reducing the CP level

Field Evidence – AC Corrosion Criteria Analysis





PHMSA: 100Amps per meter squared – and then what?



Thank you for attending!

Questions are welcome…

LVN@metricorr.com