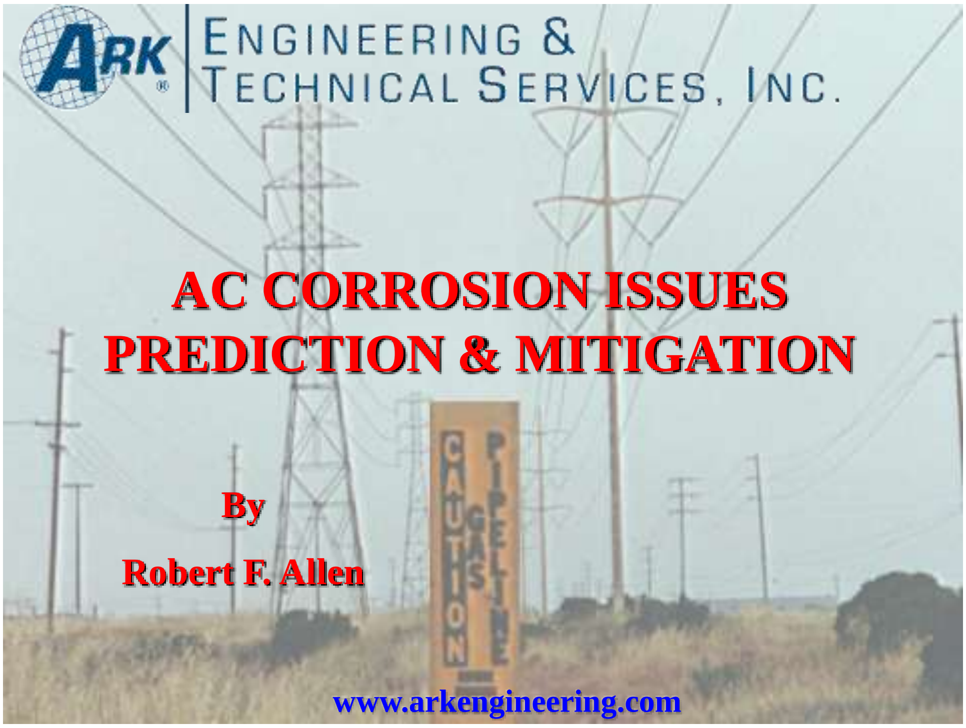
ARK
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AC CORROSION ISSUES
PREDICTION & MITIGATION
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Introduction

- Although not all aspects of the AC Corrosion mechanism have been fully clarified, experience has reached a level from which general guidelines have been developed.
- AC Corrosion Risk Assessment, AC corrosion mitigation , and AC corrosion monitoring.

Overview

- NACE - Task Group 430 – Issued a document titled: “Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring” in May 2018.
- NACE SP21424-2018
- This standard practice presents guidelines and procedures for use during risk assessment, mitigation, and monitoring.

NACE Standard SP21424-2018

- AC Corrosion on a cathodically protected underground pipeline is commonly the result of a combined action of the AC voltage, the CP conditions, a coating defect, and the chemical and physical conditions of the soil.
- If the AC component is removed or limited, the corrosion will be mitigated.

NACE Standard SP21424-2018

- AC Corrosion is also influenced by DC current. It can also be reduced by adjusting the DC component through the CP system.
- An AC Corrosion evaluation process includes an analysis to develop the following strategies:

Evaluation Process

- Analysis – Risk Assessment
- Mitigation Strategy
- Monitoring Strategy
- On-going monitoring to determine safe or unsafe conditions

- Used for new pipelines, new interference source, or existing pipelines

AC Interference vs. AC Corrosion

- Inductive and conductive effects as a result of AC current flowing in electric circuits.
- AC voltage and currents are induced upon the pipeline.
- Where these AC currents leave the pipeline through coating defects, they can cause AC corrosion effects.
- The intensity is measured in A/m2

AC Corrosion

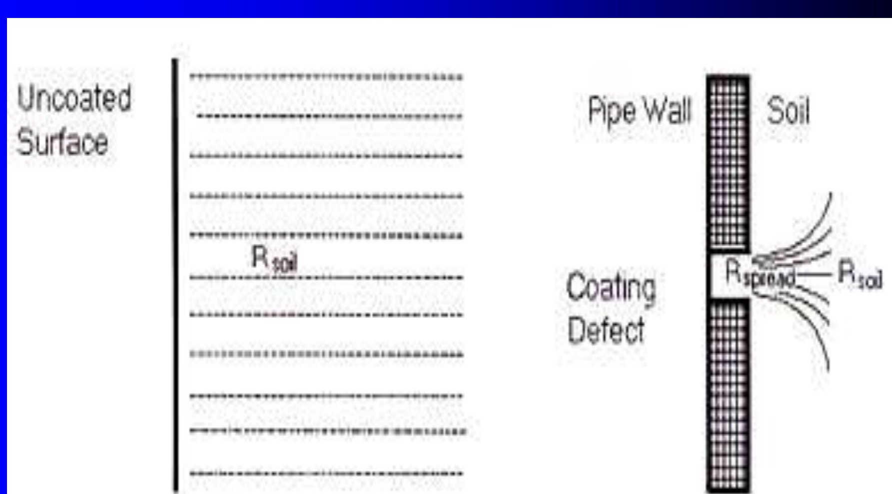
Overview

- Induced AC voltage may be a cause of corrosion at coating defects where AC current escapes the pipe.
- Small rather than large coating defects are susceptible to AC corrosion since the spread resistance (in Ω-m^2) associated with the defects increases with increasing area

Spread Resistance

- The spread resistance R_S is controlled by factors relating to the resistance of the soil, porosity, and geometric factors in the interface between the soil and the coating defect.
- Spread resistance is approximately the proportionality factor between AC voltage and AC density.

Spread Resistance



Spread Resistance

- A non-coated surface results in only a soil resistance value.
- A coated surface with a defect results in both soil resistance and spreading resistance values. A large IR drop develops near the vicinity of the pipe to soil interface where the coating defect is present.
- A geometrical spread effect is produced as a result of concentrated current flux lines.

Effect of Surface Area

- The surface area of the pipe at a coating holiday is important since the corrosion rate increases with increasing current density.
- Large holidays would have a lower current density than small holidays if both were exposed to the same soil conditions.

AC Corrosion Risks

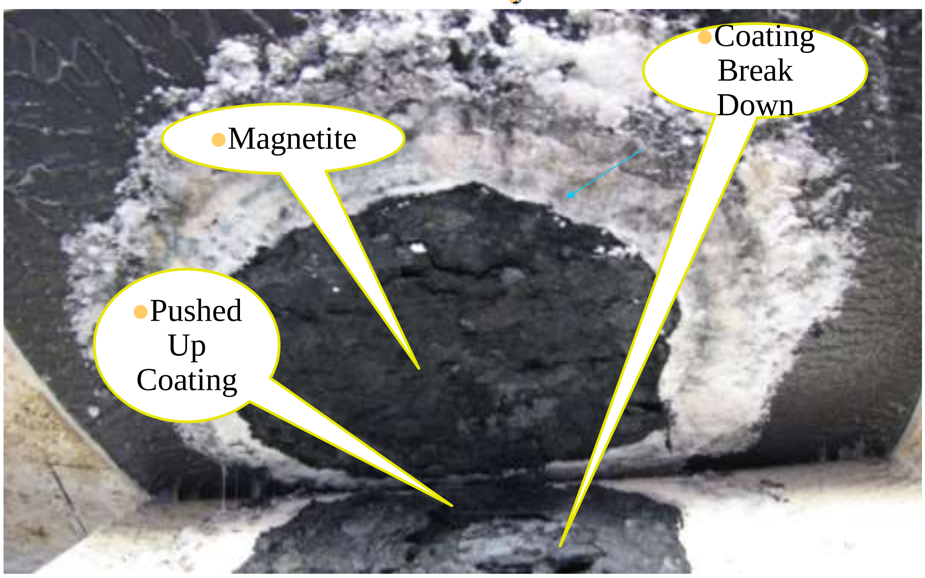
- The following factors increase AC corrosion risks:
- A low level of cathodic protection (low DC current density) with a high level of AC current density
- Small size coating defects
- Low soil resistivity

Signs of Coating Failure and AC Corrosion – Polyethylene Coating

Risk Assessment

- AC Corrosion Evaluation – If an AC Corrosion risk is present, then AC interference calculations (analysis), AC survey, evaluation of historic CP data and abnormalities, DC interference, ILI results, other relevant data should be reviewed.
- New AC circuits or DC interference sources may cause additional risk

AC Corrosion By Products



Risk Assessment

- New pipelines with interfering AC systems
- Pipeline Corrosion History Records may require re-evaluation in view of AC corrosion characteristics.
- AC Voltage measurements
- DC CP Potentials – Inadequate or Excessive
- Soil Resistivity Measurements

Risk Assessment

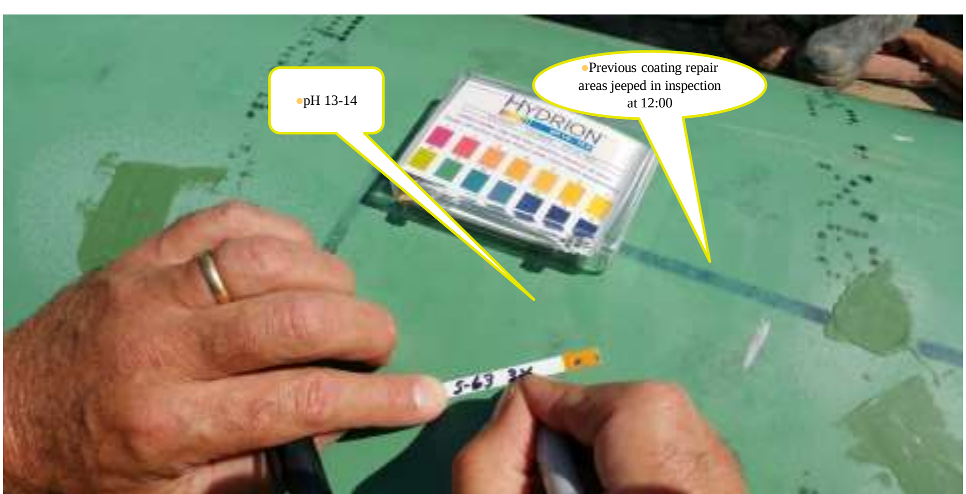
- Soil resistivity surveys – the spread resistance is influenced by the soil resistivity.
- The following soil resistivity parameters can be applied as a risk guideline:
- Below 25 Ω-m: very high risk
- Between 25 Ω-m and 100 Ω-m: high risk
- Between 100 Ω-m and 300 Ω-m: Medium

Circular Morphology

Risk Assessment

- DC Interference Effects
- Coupon or Corrosion Rate Probe Data – AC & CP Densities or Significant Corrosion Rates

AC Corrosion - pH is Always 13-14



Criteria

- AC Voltage – mitigated to a level where the current densities are met.
- AC Density – recommended not to exceed:

  30 A/m2 – if DC Density exceeds 1 A/m2

  100 A/m2 – if DC Density less than 1 A/m2
- Less than 0.025 mm/y corrosion rate using weight loss coupons or probes

Criteria

- Consecutive use of inspection tools may be used to quantify corrosion attacks
- AC and DC current densities are measured at coupons installed along the pipeline
- The above criteria should be documented for a representative period of time accounting for variations in the influencing parameters.

Research Studies

- AC Voltage required to produce a current density of $100 A/m^2$ in 1000 ohm-cm soil at a 1 cm^2 holiday:
- $i_{ac} = 8 V_{ac} / p \pi d$
- Where:

i_{ac} = ac current density (A/m^2)

V_{ac} = pipe ac voltage to remote earth (V)

p = soil resistivity (ohm-m)

Research Studies

- d = diameter of a circular holiday having a 1 cm^2 surface area = 0.0113 m

Then: for $i_{ac} = 100 A/m^2$ and p = 10 ohm-m

$$V_{ac} = \frac{100 A/m^2 \bullet 10 \text{ ohm-m} \bullet 3.14 \bullet 0.0113 m}{8}$$

V_{ac} = 4.4 V

Results

- The calculation indicates that CP protected pipelines subjected to AC voltages that are below the NACE recommended maximum safe level of 15 volts (NACE SP0177) can suffer from AC corrosion at holiday sites having a surface area of approximately 1 cm^2 in a soil resistivity of 3000 ohm-cm or less.

Mitigation

- AC Voltage Mitigation – Reference NACE Standard SP0177-2104
- CP System Condition – Create uniform polarized potentials along the pipeline and minimize voltage drops. Minimize the risk of inadequate CP and excessive CP.
- DC Interference effects – Reference NACE Standard SP0169

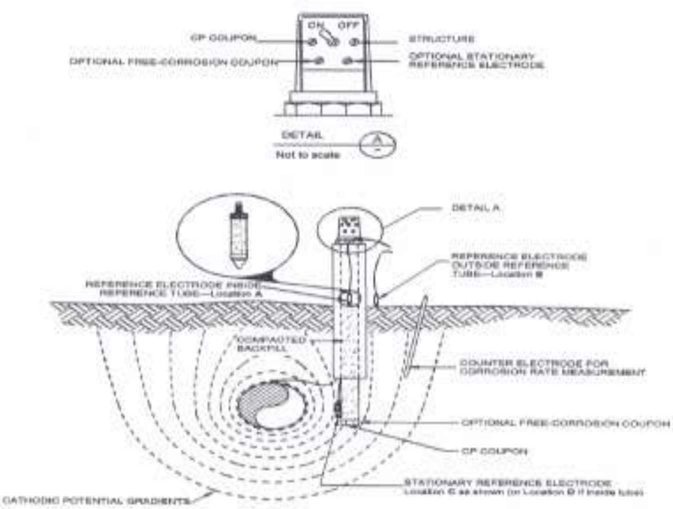
Other Factors

- Mitigation wire provides a benefit in the mitigation of AC corrosion. For a coating holiday located in the vicinity of the mitigation wire, the effective resistance of the holiday is increased due to the mutual resistance between the holiday and the mitigation wire, thereby reducing the AC current density at the holiday.

Monitoring Strategies

- Test Stations and Monitoring Locations – Selected where the risk analysis indicates a risk of AC corrosion:
- High AC voltages
- Low Soil Resistivity
- Excessive CP conditions or DC intf.
- Previous ILI or excavation locations
- Coupon or Probe locations of high values

Coupon Test Station



Monitoring Strategies

- Coupon Test Stations
- Corrosion Rate Measurements
- Data Loggers
- Remote Monitoring Units

Coupon T/S - DCD – Remote Monitor

Coupons or Probe Installation

- Coupon test stations or ER Probes are installed on the pipeline, at specific intervals to measure the DC potentials, AC potentials, and current densities.
- This test equipment provides the necessary data to assess the likelihood that AC interference is contributing to the observed corrosion.

Long Term Monitoring

- Monitoring AC corrosion is a dynamic process, to provide AC corrosion criteria information.
- This monitoring will determine safe or unsafe locations. Unsafe locations are areas where the parameters have been exceeded and require a renewed risk assessment analysis or a renewed mitigation strategy, in an iterative process.

Thank You!

Any Questions?