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# AC Interference, AC Corrosion & AC Mitigation

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### ABSTRACT

This paper will discuss AC Interference, AC Corrosion and AC Mitigation. The paper will cover each subject, provide some solutions and recent research on AC corrosion. The AC interference discussion will be about the three types of AC interference that is encountered in the pipeline industry. Discussion about the how-why-where-when of AC interference. This will be a general discussion. The AC corrosion discussion will explain AC corrosion, when-where-how-why of its occurrence and what it looks like. Several photographs of AC corrosion will be presented. Finally AC mitigation will be discussed. This will cover various methods for mitigating AC including modeling for designing the mitigation system. Systems will go from simple to complex and a case history for a 42" natural gas pipeline will be included.

Keywords: AC Interference, AC Corrosion, AC Mitigation

### INTRODUCTION

AC Interference is a growing problem worldwide. More pipelines are being installed in powerline rights of way – ROW and more powerlines are being installed along pipeline ROW's. This is causing multiple issues on pipelines, primarily step and touch potentials greater than the suggested limits, AC faults causing coating damage and in some cases damage to the pipeline steel and an increase in the cases of AC corrosion. Luckily, AC interference can be controlled and mitigated. Mitigation can minimize or eliminate the step and touch issue, lower the probability of AC corrosion and mitigate the effects of a fault or lightning.

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Figure 1: Typical Pipeline ROW with Multiple Powerlines

### DISCUSSION

AC interference is not a new problem. It has been around since pipelines started to be installed near or next to powerlines. The problem is over the years the powerlines have gone to higher and higher voltages and the pipelines have gone to superior and high performing coatings. This combination has caused increased AC interference.

AC interference can be mitigated. Mitigation can be a very complex process and an expensive process. Lots of factors increase the complexity. Number of powerlines and the operating voltage of the powerlines. Number of pipelines in the ROW and the type and age of the coating. Pipeline geometry vs. the powerline geometry. All of these factors as well as lots of other supporting data get entered into the various AC mitigation programs and the mitigation design is created.

Multiple powerlines are an issue as they can be in phase or out of phase which can cause a greater influence/interference condition. Higher voltages or mixed voltages due to the multiple powerlines also increases the interference condition.

Mixed pipelines in the same ROW also cause increased modeling complexities and mitigation complexity. Having an older high loss/leaky coating and a high performance extremely high dielectric coating together in the ROW and adding AC mitigation is difficult due to the coating type's interaction.

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### **Types of AC Interference**

Conductive Coupling -- AC Fault Conditions



Relatively rare Short duration Generally due to weather (lightning and high winds)

Can cause structural failure, CP component damage, causes intense stressing of the pipeline coating and possibly the pipe wall



Figure 1B: Lightning/Surge Damage on a Pipeline Test Station

#### Electromagnetic Induction



A function of Line Current not Voltage Power transferred is:

- Proportional to line current \_
- Proportional to parallelism -
- Inversely proportional to separation distance \_

Can result in high voltages on long sections of pipeline even if the pipeline is grounded

Electrostatic Coupling or Capacitive Coupling



Pipe and Power line create a circuit of two capacitors in series.

A capacitor is a passive electronic component consisting of a pair of conductors separated by an insulator (air).

Can generate very high AC voltage levels – but there is not enough power to do much more than create an electrostatic shock.

Generally a nuisance, however can be an issue and grounding may be required.

### Longitudinal Electric Field – LEF

# The electric field resulting from the flow of current in the powerlines, which subsequently results in electromagnetically induced AC voltages in the pipeline, is commonly called the... Longitudinal Electric Field or LEF

Current through the HVAC lines generate a Longitudinal Electric Field (LEF) The separation between the phase conductors has a significant effect on the LEF and increases with separation

Bundled buried conductors have no separation and provide only a minimal effect on pipelines The arrangement of phases on multiple circuit HVAC lines can have a large impact on the LEF

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Powerline Geometry Effects the LEF – Powerline - Quadruple Vertical Circuit with Skywires

### **AC Mitigation**

AC Mitigation typically involves installation of one or more grounding devices to allow AC current to readily discharge off of the pipeline thus minimizing coating stress during fault conditions and reducing the inductive voltage levels to well below any threshold for personnel safety or AC induced corrosion.

AC Mitigation methods vary depending on the level of AC on the pipeline and multiple factors. The optimum method to design an AC Mitigation system is by modeling. Various modeling software is available to do the modeling. The software varies from the simple to the complex and again are able to model an AC Mitigation system from a simple mitigation design to a complex mitigation design.

Modeling involves gathering various data sets: AC field data on the pipelines Soil resistivity between 2.5 feet and 100 foot depths at varying depths Longitudinal electric field - LEFT measurements Power line operating data – normal load, peak load, fault current and trip time Pipeline data, coating type, pipe information, etc. & distances from powerline

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The data will be entered into the model and an AC Mitigation design will be generated. A typical AC Mitigation design will include: Mitigation material – length & quantity Decoupler type, quantity, installation method & installation schedule Grounding mats for valve sites, test stations and other appetences Commissioning plan

Modeling is a normally very complex process as multiple factors are involved and minor variations can cause a major change in the model. That is why it is extremely important to acquire all the necessary data and information to feed into the model to create an accurate and realistic model and design. Assumptions must be minimized to get an accurate result.

### **AC Corrosion**

AC Corrosion is a phenomena that has been accepted by most corrosion professionals and is being addressed now as a corrosion issue. AC corrosion is a current density problem, not an AC voltage issue. It is dependent on soil resistivity and the size of the coating holiday/flaw. A small coating holiday in a low resistance soil environment is a likely candidate for AC corrosion. Keep in mind that you need an AC current source so AC corrosion is typically limited to overhead AC power line OHAC influence on the pipeline.

AC Stray Current Corrosion:

- Ćharacterized by round morphology
  - Unique shapes and colors
  - Almost perfectly round
  - Smooth edges
  - Pimpled Pattern
  - Brown discoloration
  - Corrosion product is not soluble
  - pH Neutral to Elevated
  - AC Current Densities > 100A/meter

Research & field testing has found that the optimum coating holiday size for high AC Corrosion

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rates is between 1-3 cm coating holiday. AC Current density is the key consideration.

- ★ 0-20 A/m no corrosion
- ★ 20-100 A/m possible corrosion risk
- ★ Over 100 A/m<sup>2</sup> definite corrosion risk

AC Corrosion can be mitigated as part of a typical AC Mitigation system. The AC Mitigation system will offer a path for the AC current to discharge and lower the current density at the coating holidays/flaws. This will be included in the model and additional AC Mitigation may be required.

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Figure 2A: Typical AC Corrosion Pit



Figure 2B: Typical AC Corrosion Pit with corrosion products

### CONCLUSIONS

AC Interference can be mitigated with an AC Mitigation system.

The AC Mitigation system needs to be modeled using the appropriate AC Mitigation modeling software.

AC Corrosion can be a problem on when you have an AC Interference issue, very small coating holidays and low resistivity soil.

AC Corrosion can be mitigated using a properly modeled AC Mitigation system.

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### CASE STUDY – AC Mitigation System on a 42" Natural Gas Transmission Pipeline

The case study is an actual AC Mitigation design based on a model. The 42" pipeline is in a common ROW with other gas transmission pipeline s with coal tar enamel – CTE coating. The 42" line has fusion bonded epoxy – FBE coating. The powerline was a 380 KV line. The model required a single length of AC mitigation parallel to the pipeline, 5' off the pipeline and at pipe depth. The mitigation was installed between the pipeline and the powerline. The mitigation ran the length of the parallelism and was approximately 28,500 feet of #2 AWG copper cable installed inside a prepared backfill. Solid state decouplers were installed at approximately 1000 foot intervals and with an AC coupon test station installed at 2500 foot intervals.

The mitigation system was commissioned and all the decouplers were flowing current, the AC

potentials were all less than 3 volts and the AC coupons showed a current density less than 1 A/m. The installation was considered successful.



Figure 3: Installing AC Mitigation with Backhoe

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