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AC Interference Mitigation

Oil & Gas Pipeline Recommendations

Reconductoring & Voltage Uprating

Prepared: June 2026 | Authored by Joe Pikas

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Executive Summary

The reconductoring and voltage uprating of transmission lines from 345 kV to 700 kV significantly elevates alternating current (AC) interference risks for collocated oil and gas pipelines. By replacing aging steel-reinforced conductors with advanced composite-core designs, utilities can effectively double the ampacity of existing lines — without new tower construction — but the electromagnetic impact on neighboring buried infrastructure is far from simple.

This document presents a structured set of engineering recommendations to assess, mitigate, and monitor AC interference effects on steel pipelines operating within shared rights-of-way (ROW). Recommendations align with AMPP SP0177, SP21424, IEEE Std 80-2013, and INGAA/DNV GL guidelines.

> *Note: 700 kV is an IEC-standard transmission voltage class used in international markets. The North American equivalent voltage tier is 765 kV (extra-high voltage, EHV).*

KEY POINT

The driving variable for AC interference is line current — not voltage rating. Uprated 345 kV lines have been documented carrying up to 5,000 amps per circuit, far exceeding the 500–1,000 A loads that legacy mitigation systems were designed around.

1. Why the Risk Increases with Reconductoring

When transmission line current doubles, the surrounding electromagnetic field intensifies proportionally, increasing both the voltage and current induced on nearby pipelines. Three distinct coupling mechanisms are responsible:

- **Inductive Coupling:** Inductive (electromagnetic) coupling — the primary mechanism for long parallel collocations. AC currents in the transmission line conductors generate a time-varying magnetic field that induces longitudinal voltages along the pipeline.

- **Capacitive Coupling:** Capacitive coupling — electrostatic coupling relevant to above-grade metallic structures and workers near energized equipment during construction.
- **Resistive Coupling:** Resistive (conductive) coupling — occurs during fault events when large currents are discharged into the soil through tower footings, raising local ground potential and stressing pipeline coatings.

Field engineers near reconductored corridors have documented the following consequences for pipelines:

- Fault-induced voltage spikes exceeding safe touch potential thresholds
- Elevated steady-state touch potentials at valves and aboveground fittings
- Rapid cathodic protection (CP) system fluctuations and current drains
- Premature failure of isolation flanges and joints
- Through-wall AC corrosion in less than six months in high-risk scenarios

Importantly, reconductoring typically does not require new permits, and ROW agreements rarely compel utilities to notify collocated pipeline operators of line upgrades. Previously mitigated pipelines may now fall outside safe operating thresholds without any visible change to the physical corridor.

2. Severity Ranking & Screening Criteria

Before deploying detailed computational models, the following severity ranking table provides a rapid screening tool to prioritize corridors for urgent assessment. Any collocation scoring 'High' in two or more parameters should be treated as a priority intervention site.

Parameter	Low Risk	Medium Risk	High Risk
Separation Distance	> 500 ft	100–500 ft	< 100 ft
Phase Current (amps)	< 100 A	100–500 A	> 1,000 A
Soil Resistivity (ohm-cm)	> 30,000	2,500–30,000	< 2,500
Collocation Length	< 1,000 ft	1,000–5,000 ft	> 5,000 ft
Crossing Angle	> 60°	30°–60°	< 30°

Note: These rankings assess the likelihood of significant interference. Consequence factors — pipeline diameter, product type, proximity to population centers — must also be considered in an overall risk assessment.

3. Re-Assess and Remodel AC Interference

The first and most critical step following a reconductoring or voltage uprating event is to invalidate and rerun all existing AC interference models for affected corridors.

3.1 Computational Modeling

- **Software:** Use AC Mitigation PowerTool (ACPT) to predict induced voltages and current densities.
- **Current Profiles:** Input updated utility current profiles — both normal operating and peak current loading — not the historical values from the original mitigation design.
- **Field Validation:** Validate model outputs with field measurements (pipe-to-soil potentials, AC voltage surveys) before finalizing mitigation designs.
- **Harmonics:** Account for harmonics introduced by inverter-based renewable generation connected to the uprated line, which can complicate interference patterns beyond simple 60 Hz modeling.

3.2 Key Modeling Parameters

- Soil resistivity profile along the full collocation length (measured in ohm-cm)
- Actual phase currents under normal, peak, and N-1 emergency loading conditions
- Pipeline diameter, wall thickness, coating type, and estimated coating resistance
- Depth of cover and burial depth of the pipeline
- Collocation length, separation distance, and angle of crossing
- Tower footing resistance values for fault coupling calculations
- Location of all above-grade appurtenances (valves, meters, test stations)

4. Grounding Systems

Grounding is the fundamental active mitigation measure for induced AC voltages. The goal is to provide a low-resistance path to earth that diverts induced current away from the pipeline and limits the voltage that accumulates along the pipe wall.

4.1 Horizontal Ground Wires

A continuous buried horizontal conductor installed parallel to the pipeline provides distributed grounding along the full collocation length.

- Use bare copper wire buried at the same depth as the pipeline, parallel and within 3–5 ft of the pipe centerline.
- Bond the mitigation wire to the pipeline at specified intervals — intervals should not exceed one-fourth of the pipeline propagation length for effective interference.
- Copper cable is preferred in low-resistivity soils or higher-resistivity environments.
- For longer collocations (> 5,000 ft), install two parallel mitigation wires — one on each side of the pipeline — to achieve the grounding resistance required by modeling.

4.2 Deep Anode Beds

At locations where induced voltage reaches a local maximum (voltage peaks), surface grounding is often insufficient. Deep anode ground beds penetrate below the high-resistivity surface layer to reach lower-resistivity strata.

- Install deep anodes at each identified voltage peak along the collocation. A good ground at these locations will reduce the local voltage distribution.
- Ensure grounding resistance is at least 2 ohms lower than the pipeline mitigation characteristic impedance for effective voltage reduction.
- Grounding resistance that exceeds the pipeline characteristic impedance provides no effective AC mitigation — do not proceed without engineering verification.

4.3 Spacing and Mutual Coupling

- Minimum spacing between discrete ground installations should be 3–4 times the physical length of the ground electrode to minimize mutual coupling between adjacent grounds.
- Maximum spacing is determined by the required mitigation resistance profile from the CDEGS model.

5. DC Decouplers / Solid-State Decouplers (SSDs)

Solid-state decouplers (SSDs) — also referred to as polarization cell replacements (PCRs) — are essential interface devices that allow AC interference currents to discharge safely to ground while preserving the DC cathodic protection (CP) system on the pipeline.

- SSDs act as a selective AC-pass, DC-block gate: dangerous induced AC flows safely to the grounding system, while the DC cathodic protection current remains on the pipe.
- Install SSDs at all isolation flanges, valve stations, meter stations, and any aboveground pipeline facility within the interference zone.
- For pipelines with high-efficiency coatings (FBE, 3LPE), the number of coating holidays is lower, but any defect concentrates AC current discharge — making decoupler grounding of these points even more critical.
- Specify SSDs rated for the actual fault current magnitudes expected from the uprated line, including N-1 emergency scenarios. Legacy decouplers may be undersized.
- Verify SSD performance annually and after any known fault event on the transmission line.

CAUTION

Polarization cells (KOH type) are an older technology and require regular electrolyte maintenance. Solid-state decouplers are recommended for new installations due to their maintenance-free operation and consistent performance across a wide operating range.

6. Gradient Control Mats at Surface Facilities

Aboveground pipeline facilities — valves, meter stations, pig launchers/receivers, and test stations — create touch and step potential hazards when AC is induced on the pipeline. A worker contacting a valve stem while standing on the ground can experience the full pipe-to-soil voltage differential as an electric shock.

Gradient control mats eliminate this hazard by equalizing the voltage under a worker's feet with the voltage on the pipe.

6.1 Design and Installation

- Install interconnected bare copper conductor grids and ground rods around all aboveground appurtenances in the interference zone.
- The mat must extend a minimum of 3 ft beyond the operator's normal working position in all directions.
- Bury the copper grid at 4–6 inches depth to provide effective gradient control at the surface.
- Connect the mat to the pipeline through a solid-state decoupler to maintain DC isolation of the CP system while maintaining AC equipotential.

- Use dead-front (enclosed) test station designs to eliminate exposed energized wire terminals accessible to the public or untrained personnel.

6.2 Verification

- After installation, measure touch and step voltages with a calibrated meter under simulated load conditions.
- Verify compliance with **AMPP SP0177 limits** (**typically < 15 V AC touch potential at occupied facilities, < 50 V for unattended locations**).
- Gradient mat performance must be re-verified after any transmission line reconductoring or reconfiguration affecting the corridor.

7. Fault Shielding

During a transmission line fault, large currents are discharged through the tower footing into the surrounding soil. If a pipeline is within the zone of influence, the resulting ground potential rise (GPR) can damage pipeline coatings and — in extreme cases — cause direct arcing from the soil to the pipe.

- Install a shielding conductor (bare copper) between the tower footing and the pipeline along the full length of close-separation collocation (< 100 ft).
- Bond the shielding conductor to the pipeline at each tower location, connecting through a solid-state decoupler to maintain CP integrity.
- The shielding conductor provides a low-resistance path to earth that intercepts the fault current before it reaches the pipeline coating.
- Confirm tower footing resistance values with the utility during the reconductoring project — new substation fault levels may be significantly higher than original design values.
- For pipelines within 100 ft of a tower footing, perform detailed fault coupling analysis as part of the updated AC Mitigation PowerTool model.

8. Pipeline Route and Corridor Optimization

Where new pipeline segments are being planned, or where existing segments are being rerouted, the following corridor design recommendations reduce inherent AC interference exposure before any active mitigation is required.

- **Separation Distance:** Maximize separation distance from transmission line conductors - target over 500 ft where practical. Interference severity drops beyond this threshold.

- **Crossing Angle:** Negotiate crossing angles greater than 60 degrees with the transmission owner. Near-parallel crossings (< 30 degrees) behave similarly to collocations and carry equivalent inductive coupling risk.
- **Phase Sequencing:** Request optimal phase arrangement from the utility — a transposed or optimally phased conductor configuration can reduce the net magnetic field in the pipeline corridor without any physical pipeline changes.
- **ROW Positioning:** Where technically feasible, route the pipeline on the opposite side of the ROW from the transmission structure to maximize effective separation.
- **Contract Provisions:** For new joint-use corridor agreements, include a contractual requirement for the utility to provide AC interference modeling data prior to any line uprating or reconductoring within the shared corridor.

9. Pipeline Coating Considerations

High-performance coatings — Fusion Bonded Epoxy (FBE), three-layer polyethylene (3LPE), and dual-layer epoxy — significantly reduce the number of coating holidays. This is beneficial for general corrosion protection but creates a specific AC interference risk that must be understood and addressed.

IMPORTANT

Better coatings concentrate all induced AC current discharge at fewer defect points. This dramatically increases the local AC current density at each holiday, accelerating AC corrosion at those locations. AC corrosion monitoring and tight grounding intervals are therefore MORE critical for modern-coated pipelines than for older coal tar or tape-wrapped lines.

- For FBE-coated pipelines in AC interference zones, install AC current density coupons (measurement coupons) at locations identified by modeling as potential AC discharge points.
- Maintain AC current density at coating holidays below **30 A/m² per AMPP SP21424** to prevent AC-accelerated corrosion.
- Increase grounding density (shorter intervals between pipe bonds) for high-efficiency coated pipelines — the higher characteristic impedance of these lines requires closer-spaced grounding to achieve equivalent interference reduction.
- Where older pipeline segments with degraded or disbonded coatings exist within a reconductored corridor, prioritize these for immediate AC interference re-assessment, as coating defect density is high and unpredictable.

10. Enhanced Monitoring Programs

AC interference from reconductored lines is inherently dynamic — it fluctuates with grid loading, renewable generation dispatch, time of day, and seasonal demand patterns. Traditional annual close-interval survey (CIS) or spot pipe-to-soil potential measurements capture only a single point in time and will miss transient voltage events that can cause corrosion or safety incidents.

10.1 Continuous Remote Monitoring

- Deploy smart test stations with integrated data loggers at all high-risk locations identified by modeling.
- Configure loggers to record pipe-to-soil AC voltage, DC potential, and AC current density at minimum 15-minute intervals; 1-minute intervals at critical locations.
- Set automated alert thresholds: greater than 15 V AC at attended facilities; greater than 50 V AC at unattended locations; greater than 30 A/m^2 AC current density at coupons.
- Transmit data via cellular or satellite to a central monitoring dashboard accessible to both pipeline integrity and CP maintenance teams.

10.2 AC Current Density Coupons

- Install buried steel coupons at the same depth and coating condition as the pipeline at locations of predicted maximum AC current discharge.
- Measure both AC current density and DC pipe-to-soil potential simultaneously at each coupon to assess the effectiveness of the CP system under interference conditions.
- Coupon measurements should be collected at minimum quarterly, or monthly in high-risk zones following a line reconductoring event.

10.3 Post-Fault Inspection Protocol

- Following any confirmed fault event on a collocated transmission line, conduct an immediate AC voltage survey of the affected pipeline segment.
- Inspect isolation flanges and solid-state decouplers for damage — fault currents can exceed device ratings even in professionally designed systems.
- Conduct close-interval survey within 90 days of a major fault event to identify any coating damage caused by ground potential rise.

11. Cross-Sector Coordination

The absence of regulatory alignment between the pipeline and electric utility sectors is one of the most significant vulnerabilities in managing AC interference from uprated transmission lines. Both sectors operate under separate regulatory frameworks and have limited formal mechanisms for cross-sector notification.

11.1 Recommended Protocols

- **Notification:** Establish formal notification protocols with each transmission owner operating lines within shared ROW corridors. Request a minimum of 90 days of advance notice prior to any reconductoring, line uprating, or substation expansion that could affect current magnitudes.
- **Data Sharing:** Request updated phase current profiles and fault modeling assumptions from the utility at the start of any reconductoring project. AC is the primary driver of interference — historical voltage ratings are insufficient.
- **Early Engagement:** Engage AC interference consultants and mitigation suppliers early in the project timeline. Reactive, post-installation mitigation work is significantly more expensive and disruptive than proactive design.
- **Working Group:** Establish a cross-sector working group or joint technical committee for each shared corridor. Include pipeline integrity, cathodic protection, utility transmission engineering, and regulatory compliance representatives.
- **Documentation:** Document all coordination activities, data received, and mitigation decisions in a corridor-specific AC interference management plan that is updated whenever line conditions change.

11.2 Applicable Standards and References

- AMPP SP0177 — Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
- AMPP SP21424 — Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring
- IEEE Std 80-2013 — Guide for Safety in AC Substation Grounding (applicable to GPR and step/touch potential limits)
- INGAA/DNV GL Report 2015-04 — Criteria for Pipelines Co-Existing with Electric Power Lines
- NACE TM0497 — Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems
- CSA C22.3 No. 6 — Principles and Practices of Electrical Coordination Between Pipelines and Electric Supply Lines

12. Summary — Priority Risk & Action Matrix

The following matrix provides a rapid reference for prioritizing AC interference mitigation actions based on site-specific risk factors. Sites exhibiting multiple high-risk factors require immediate engineering assessment and should not await the next scheduled survey cycle.

Risk Factor	Recommended Action
Line current doubles/triples (reconductoring)	Re-model entire corridor; resize grounding systems
Parallel collocation > 5,000 ft	Install continuous copper wire with decouplers as specified
Separation distance < 100 ft	Fault shielding + DC decouplers mandatory
Aboveground facilities (valves, meters, pig traps)	Gradient control mats + solid-state decouplers at all locations
Soil resistivity < 2,500 ohm-cm	Deep anode grounding; accelerated corrosion monitoring
High-efficiency pipeline coating (FBE, 3LPE)	Increased coupon monitoring; dense grounding intervals
Crossing angle < 30 degrees	Treat as collocation; assess inductive coupling carefully
Emergency fault currents (new substation)	Validate legacy mitigation capacity; upgrade if needed

Disclaimer

This document presents engineering guidance based on industry-standard references and published field experience. Site-specific conditions vary significantly. All AC interference assessments and mitigation designs should be performed under the direction of a qualified corrosion engineer or cathodic protection specialist with specific experience in HVAC interference. This document does not replace detailed computational modeling, site surveys, or the professional judgment of a qualified practitioner.