Managing Electrical Interferences in Pipelines - A Practical and Cost-Effective Approach

Osvaldo Mejia[1], Nora Villamizar[2], Armando Lacera[3]

[1]Freelance consultant, [2]Penspen, [3]Promigas SA ESP

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1 ABSTRACT

The rapid expansion of AC/DC transmission networks, electrified transportation systems, and pipeline infrastructure has increased the spatial overlap among these assets. This growing proximity, combined with rising power demand, elevates the likelihood of electrical interference on pipelines, particularly from AC sources which presents newer and more complex challenges compared to the better-understood effects of DC interference.

Because both AC and DC interference can pose safety hazards and accelerate pipeline deterioration, technical teams often default to immediate mitigation. However, mitigating electrical interferences is technically complex, capital intensive, and not always warranted. Moreover, the presence of electrical interference does not necessarily imply stray-current corrosion. Therefore, incorporating risk management principles into the detect–mitigate cycle can significantly improve decision-making by distinguishing conditions that require prompt mitigation from those that can be safely managed through monitoring. This highlights the need for a structured, defensible framework that aligns with business goals and risk acceptance standards to inform strategies for manging electrical interferences.

This paper addresses that need by proposing a management framework designed to keep the risk of electrical-interference-related failures within the As Low As Reasonably Practicable (ALARP) range by actively managing the probability component of the risk. The approach introduces a multi-tier framework that integrates industry-aligned technical criteria with business management principles to support consistent, transparent, and cost-effective decisions. By aligning technical rigor with risk management principles, the framework enables more strategic resource allocation while maintaining the safety and reliability of pipeline operations.

Key words:

AC interference, DC interference, electrical interference, ALARP, Stray-current corrosion

Disclaimer

The framework proposed in this work is currently in a proof-of-concept stage. Accordingly, the primary objective of this paper is to foster discussion and gather insights from the community to refine and strengthen the approach.

2 GLOSSARY

Stray current: Current flowing through paths other than the intended circuit. [1]

Stray-current corrosion: Corrosion resulting from stray current. [1]

Electrical interference: Any electrical disturbance on a metallic structure in contact with an electrolyte caused by stray current(s). [1]

Mitigation: Any means used to eliminate or reduce the physical effects of electrical interferences.

3 INTRODUCTION

Managing AC and DC electrical interferences on pipelines is inherently complex. It requires significant effort to identify its source, assess its severity, select an appropriate mitigation strategy, implement the solution, and verify its long-term performance. Because electrical interferences pose a safety hazard and can, in some cases, lead to rapid pipeline failure, operators often assign high priority to this threat independent of broader risk considerations. However, with continued expansion of shared right-of-way between pipelines and electrical networks, a growing proportion of pipelines are expected to experience some level of either interference.

Deploying mitigation systems to eliminate all instances of electrical interference becomes burdensome —not only due to cost, but also because of the technical challenges in ensuring adequate performance of cathodic protection (CP) systems. Moreover, considering that the presence of electrical interference does not necessarily imply active stray-current corrosion, a distinction that is particularly relevant for AC interference. Avoiding installation of unnecessary mitigation systems, therefore, provides both economic and technical benefits.

This work proposes a methodology that applies risk-management principles to determine when mitigating interference is warranted and when continued monitoring or an inspect-and-repair strategy are more appropriate. Although the decision-making examples in this paper illustrate the management of AC-induced interference, the methodology is equally applicable to DC interference scenarios.

The outcome of this dissertation underscores the need for an industry-standardized framework to support technical personnel in making consistent, defensible, risk-based decisions regarding the mitigation of electrical interferences on pipelines. The approach proposed here may serve as a basis for developing such a framework.

4 TECHNICAL BACKGROUND

ASTM/NACE [1] defines electrical interference as "*any electrical disturbance on a metallic structure in contact with an electrolyte caused by stray current(s)*." This definition encompasses a wide range of scenarios, from conditions that merely distort the pipe-to-soil potentials (e.g., telluric currents) to cases involving high corrosion rates at unmitigated discharge points of stray currents generated by DC traction systems, or even instantaneous failures resulting from resistive coupling during lightning events.

Importantly, the presence of electrical interference does not automatically imply stray-current corrosion, nor does it guarantee that the resulting increased probability of failure (PoF), if any, will drive the pipeline's risk above the operator's acceptance criteria. Therefore, incorporating a sound risk assessment element into the interference management process helps determine whether a given condition requires proactive mitigation or whether the risk can be managed trough monitoring or an inspect-and-repair strategy.

Stray-current corrosion may occur when unintended electrical current enters or leaves the pipeline through the surrounding electrolyte. This interaction may affect the pipeline in two principal ways:

- At current-entry locations, pipeline potentials may be driven outside normal control range, increasing likelihood of coating damage. In some cases, DC interference may cause coating disbondment which, depending on coating type, may shield the CP current and lead to corrosion of the underlying metal. [2]

- At current-exit locations, localized metal loss can occur. The overall corrosion rate at these locations may range from negligible to extremely high, depending on the discharge area, current density, and duty cycle.

Outside these current-exchange locations, pipeline's integrity remains unaffected, making this a highly localized damage mechanism [3]. Local remedial actions may, therefore, safely address the symptoms (i.e., repair the metal loss before it fails) without eliminating the root cause. Hence, if reliable inspection methods are available and inspection intervals can be confidently established, an inspect-and-repair strategy, in some instances, may be more cost effective than mitigation.

Safety considerations, however, must always be addressed [4] [5] [6]. Hence, any hazardous potential that poses personnel risks must be mitigated (e.g., through grounding mats at test stations), even if corrosion-related effects are managed through other strategies.

From a risk management perspective, existence of an active damage mechanism does not necessarily equate to an unacceptable condition, nor does it require same response for all locations. Risk management principles allow acceptable probability of failure (PoF) thresholds to vary based on the consequences associated with failure at each site [7].

For example, acceptability of a PoF of 1×10^{-4} for a pipeline segment subject to the societal risk criteria shown in Figure 1 depends on the expected consequences for the segment. If it traverses a sparsely populated area, where a failure would plausibly involve fewer than 10 potential fatalities, the PoF will typically lie within the As Low As Reasonably Practicable (ALARP) region (i.e., between the maximum tolerable and broadly acceptable thresholds), not requiring further reduction. Conversely, if the same probability applies to a segment laid in a densely populated area, that PoF will be considered intolerable and shall be reduced by at least one order of magnitude to fall within the ALARP zone. In the last case, if the dominant contributor to the PoF is stray-current corrosion, its mitigation becomes mandatory.

Within the ALARP zone, it is not necessary to further reduce the PoF if the mitigation costs are grossly disproportionate to the anticipated benefits. According to HSE guidance [7], this threshold is defined as a tenfold difference between cost and benefit. Consequently, a cost-benefit analysis should be employed to justify necessary actions [8]. However, such analyses can be complex and time-consuming, particularly for technical staff who may not be familiar with the methodology; these individuals would benefit from a standardized framework with built-in cost-benefit guidelines.

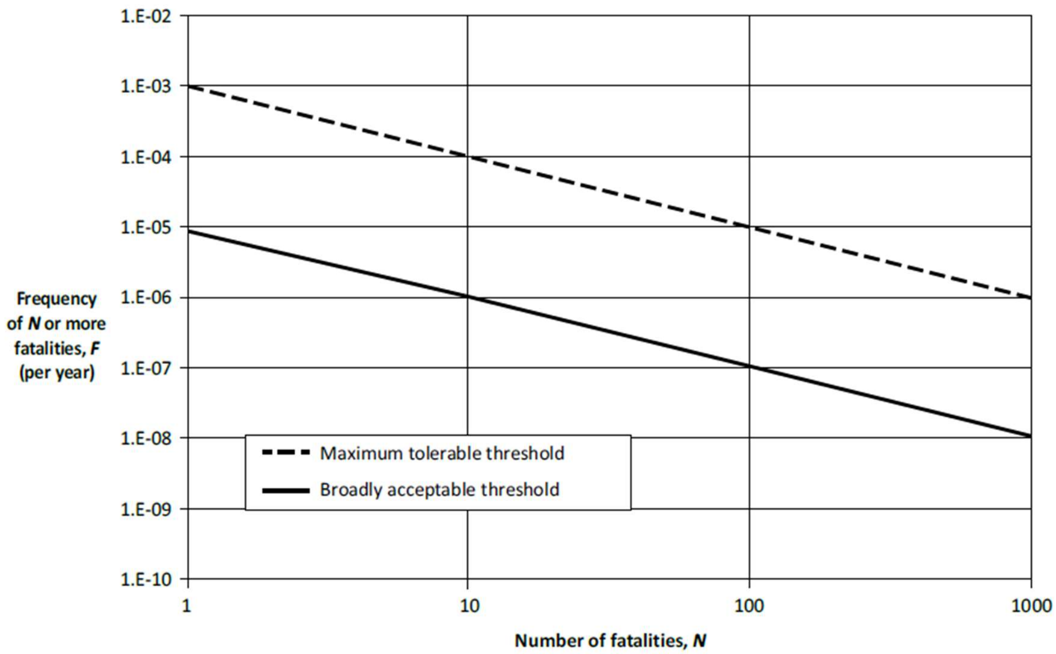

Figure 1. Societal Risk Criteria, Based on 1 km of Pipeline (source: CSA Z662:23)

On the other hand, risk-based inspection (RBI) philosophy demonstrates that the assessed probability of failure of an asset can be reduced by replacing conservative assumptions about its condition and deterioration rate with evidence from targeted inspections and monitoring [9]. In practice, this enables managing the risk in two complementary ways: (1) by removing epistemic uncertainty, yielding more defensible (and often less conservative) PoF estimates; and (2) by allowing implementation of a reliable inspect-and-repair approach. Consequently, because electrical-interference assessments are often conservative, an appropriately designed monitoring program can, to a meaningful extent, calibrate the PoF and focus mitigation where it adds the most value.

Building on these principles, the methodology proposed here considers end-to-end costs of addressing electrical interferences (from condition identification trough long term monitoring) ensuring that the level of effort invested remains within the ALARP region for the affected pipeline segment.

5 METHODOLOGY DESCRIPTION

To adapt this methodology for use by other operators, a quantitative risk assessment framework must be available or developed. This framework should define ALARP thresholds and provide a link between probability of failure, consequences of failure (in monetary units), and pipeline remaining life (RL)[1]. Figure 2 provides an example of such a framework.

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[1] Remaining life (RL), as used in this paper, refers to the estimated time for the segment to fail, based on corrosion growth predictions. It should not be confused with the time between failures derived from the PoF. For example, a new pipeline may have a RL of less than 100 year when calculated using the design corrosion rate, yet industry experience shows that its PoF may be on the order of 10^{-6}, corresponding to a statistical time between failures of 1 million years.

Warning: *All prescribed rules and quantitative or qualitative data discussed in the text or shown in the graphs and tables of this paper are fictitious examples intended solely to illustrate the methodology. Any operator wishing to implement the approach must establish its own rules aligned with its quantitative risk acceptance criteria, including specific PoF reduction targets over defined timeframe[2].*

Figure 2. Quantitative Risk Assessment Framework

In alignment with UKOPA TBN 022 [10], the proposed methodology introduces a multi-tier framework (Figure 3) that integrates technical criteria with business management principles to support decision-making throughout the threat's managing process. The methodology prescribes risk-based rules for determining the necessary levels of inspection, assessment, mitigation, and monitoring (Table 1 to Table 4) for pipeline segments affected by electrical interference.

It is important to note that standardized mitigation systems (

Table 3) apply only to straightforward interference scenarios[3]. More complex cases require a quantitative PoF calculation, including the design and costing of a customized mitigation system. However, the standardized data collection and monitoring tables remain applicable in these cases.

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[2] e.g., To reduce the PoF between 1 to 3 orders of magnitude (depending on the CoF) for a 20 Km pipeline over a 20-year period, assuming a 5-year in-line inspection frequency.

[3] For the purpose of Table 1 to Table 4**,** *straightforward conditions* are defined as pipeline segments less than 20Km in length with a single interfering AC source between isolation joints.

In all cases, the mitigation option must be compared against an inspect-and-repair strategy to justify the selected solution. The inspect-and-repair strategy should include inspection timing based on a conservative calculated RL or the quantitative PoF of the pipeline. The main elements of the methodology are described below:

5.1 Assessing Susceptibility to Electrical Interference

Assessing if there is a realistic possibility for the pipeline to be subject (i.e., susceptible) to electrical interferences is typically performed during the threat identification phase of the integrity management process. This assessment requires detailed knowledge of the pipeline's electrical environment, including the location and operational parameters of interference sources, pipeline's AC and DC pipe-to-soil potentials, and CP system performance [11].

Most of the data required for susceptibility assessment are typically collected through routine right-of-way patrols and CP monitoring activities mandated by local regulations or industry standards. Therefore, data gathering for susceptibility assessment does not add significant cost to the threat's management. However, the risk model must explicitly incorporate electrical interference mechanisms into its algorithm. If this is not the case, some investment in updating the risk assessment tools may be required.

Table 1 presents an illustrative ALARP-aligned monitoring strategy for gathering the data required for susceptibility assessment. An example susceptibility scoring model for AC-induced interference is provided at the end of this paper. For completeness, susceptibility models for AC/DC arcing and DC stray-current interference should also be developed.

5.2 Confirming Interference Occurrence

Confirming existence of electrical interference requires additional inspection and monitoring activities to identify affected locations and characterize corrosion dynamics, including corrosion rate (CR) and exchanged current density, magnitude, and duty cycle. For static interferences – such as that caused by a foreign CP system – this process is relatively simple and inexpensive. However, AC and dynamic DC interferences require more extensive and costly monitoring, often over several months [12].

For example, induced AC potentials vary with the load on the interfering system, which depends on power demand, which, in turn, depends on industrial activity (weekdays vs. weekends), and seasonal changes (e.g., winter vs. summer). A monitoring program that captures these variations throughout the year is essential for accurate characterization [11]. Similar considerations apply to DC interference from electrified transportation systems.

Additional monitoring activities may range from routine on/off AC and DC potential measurements at test posts to continuous logging of potentials and AC and DC current densities over extended periods at selected locations, and even periodic verification of the pipeline integrity. Following RBI principles, monitoring strategies should be guided by targeted PoF-reduction goals. Table 2 provides a fictitious ALARP-aligned monitoring strategy for confirming and sizing AC-induced interference.

5.3 Calculating Remaining Life

Given the relationship between CR, RL, and PoF, acceptability of the interference can be evaluated using the calculated RL. At this stage, the assessment should be based on conservative assumptions to ensure the system's safety until the next scheduled integrity inspection.

The CR may be determined from one or combination of sources, including external corrosion coupons, electrical resistance (ER) probes, in-line inspection (ILI) data, or derived from ongoing monitoring. To this purpose, UKOPA GPG 027 [11] provides guidance on determining CR from pipeline potentials and soil resistivity, while Zhou et al. [13] proposes a customizable method for calculating the RL for pipelines protected by CP and subject to AC corrosion.

When estimating RL, engineering judgment is essential to ensure conservativism and consistency with the CR source. For example, if the CR is established using ILI data and validated with ER probe measurements, it may be used directly. Conversely, if the CR is estimated from AC potential and soil resistivity alone, greater conservatism is required – for example, using the maximum recorded AC potential, the lowest measured soil resistivity along the pipeline, a 1 cm^2 coating defect, and a moderate current-exit duration.

5.4 Selecting / Designing Mitigation Systems

Designing effective mitigation systems for AC and dynamic DC interferences often require detailed and resource-intensive simulations. AC interference poses special challenges, because installing mitigation system at one location may accidentally increase interference elsewhere [3] [11]. Similarly, inadequate mitigation for dynamic DC interference can intensify its impact. Despite these complexities, operators with sufficient operational experience may, sometimes, define blueprint solutions for straightforward or recurring interference cases. When such expertise exists, the methodology allows the creation of standardized mitigation options.

Table 3 provides a fictional example of standardized mitigation systems for straightforward AC interference conditions. It is to note that, although standardized options reduce effort in identifying appropriate mitigation, they do not eliminate the need for detailed design and costing of the final solution.

For cases where standardized solutions are not applicable, a customized mitigation system shall be designed, usually requiring interference simulation. Accurate simulations require extensive data about the structures and their environment. Because collecting this information is time-consuming and expensive, simulations are often performed using limited, conservative inputs, which can lead to overly conservative results. Striking the right balance between data collection and acceptable conservatism is essential for ALARP-aligned threat management. Effective communication with the simulation provider is necessary to agree on the appropriate level of data required to meet accuracy requirements for the simulation.

5.5 Costing the Mitigation System

Installing a mitigation system is only part of the solution (and of its cost). Ensuring its long-term effectiveness requires a monitoring program capable of assessing its performance and identifying the need for corrective actions, if any. Selecting appropriate monitoring activities and frequencies is as important as the mitigation system itself, and these costs must be considered when evaluating ALARP compliance.

For customized solutions, the mitigation system shall be costed over its entire life cycle, including installation, maintenance, and monitoring. For standardized mitigation systems, its maintenance and monitoring cost against targeted reliability can be assessed in advance, allowing for prescribed monitoring strategies. A fictitious example of such a strategy is presented in Table 4.

5.6 Defining the Inspect-and-Repair Strategy

When defining the inspect-and-repair strategy, the approach must be based on either the calculated RL or the quantitative PoF. The inspection intervals should be deliberately conservative, considering accuracy of the assessment method, to ensure adequate safety margins. For example, assuming greater accuracy in PoF than in RL calculation, inspections may be scheduled at 50% of RL but 80% of the projected time to reach the PoF threshold.

Costing the inspect-and-repair strategy must include all associated expenses[4], including costs of the selected inspection method (e.g., ILI), supporting monitoring devices and activities required to ensure the strategy's safety, anticipated repairs, and personnel-safety protection systems. To ensure a fair comparison, the costing exercise shall be evaluated over the same timeframe as the design life of the alternative mitigation system.

5.7 Deciding Interference Management Strategy

Once an interference condition has been deemed unacceptable, the workflow described above enables decision-makers to compare the costs and benefits of alternative strategies, specifically mitigate versus inspect-and-repair approaches.

A monitoring-only approach is appropriate exclusively when the pipeline is susceptible to electrical interference, but its occurrence has not been confirmed through the required inspections and monitoring activities. Once interference has been demonstrated, the monitoring-only approach is no longer sufficient, and the decision space expands to the two active management strategies: mitigation or inspect-and-repair. These options become applicable only after the presence, characteristics, and potential impact of the interference have been verified.

However, the final decision should not rely solely on technical and economic factors. Business objectives, legal requirements, social impacts, and political context, must also be considered. For example, even if an interfered segment could be safely managed through inspect-and-repair, recent failure in the area due to unrelated causes may justify a more robust mitigation strategy.

Ultimately, decision-makers should apply sound engineering judgment, business acumen, and common sense to ensure that the chosen strategy aligns with the organization's current business environment and broader objectives.

6 Conclusions

As pipeline and electrical networks expand and converge, electrical interference is an increasing issue that requires attention from both pipeline operators technical and management personnel due to its potential for causing rapid pipeline failure. However, implementing mitigation systems to eliminate all instances of interference is neither technically necessary nor economically efficient. Instead, operators should manage this threat from a business risk management perspective that enables ALARP-based decision-making, ensuring both pipeline safety and responsible allocation of resources.

[4] Cost should only be accounted if they are not already part of the integrity-management or the interference-monitoring strategies.

Electrical interference may introduce personnel-safety hazard and pipeline integrity threat. Managing both aspects holistically is essential. Because of the damage caused by electrical interference is highly localized, an inspect-and-repair strategy may be viable in many cases, offering a cost-effective alternative to full mitigation.

The methodology proposed in this paper provides a technical and economic framework for decision-making in managing electrical interferences. It can be readily customized to any operator's risk management system, facilitating consistent business-oriented decisions while ensuring technical accuracy and regulation compliance.

7 RECOMMENDATIONS

The pipeline industry should strive to agree on a standardized framework that incorporates ALARP-based risk management concepts into electrical-interferences management. Such a framework would promote efficient resource allocation and improve consistency in addressing this threat.

8 USE OF ARTIFICIAL INTELLIGENCE

The authors acknowledge the use of Microsoft Copilot to enhance the clarity and organization of this paper. All ideas and conclusions presented herein are entirely the authors' own.

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10 TABLES AND GRAPHS

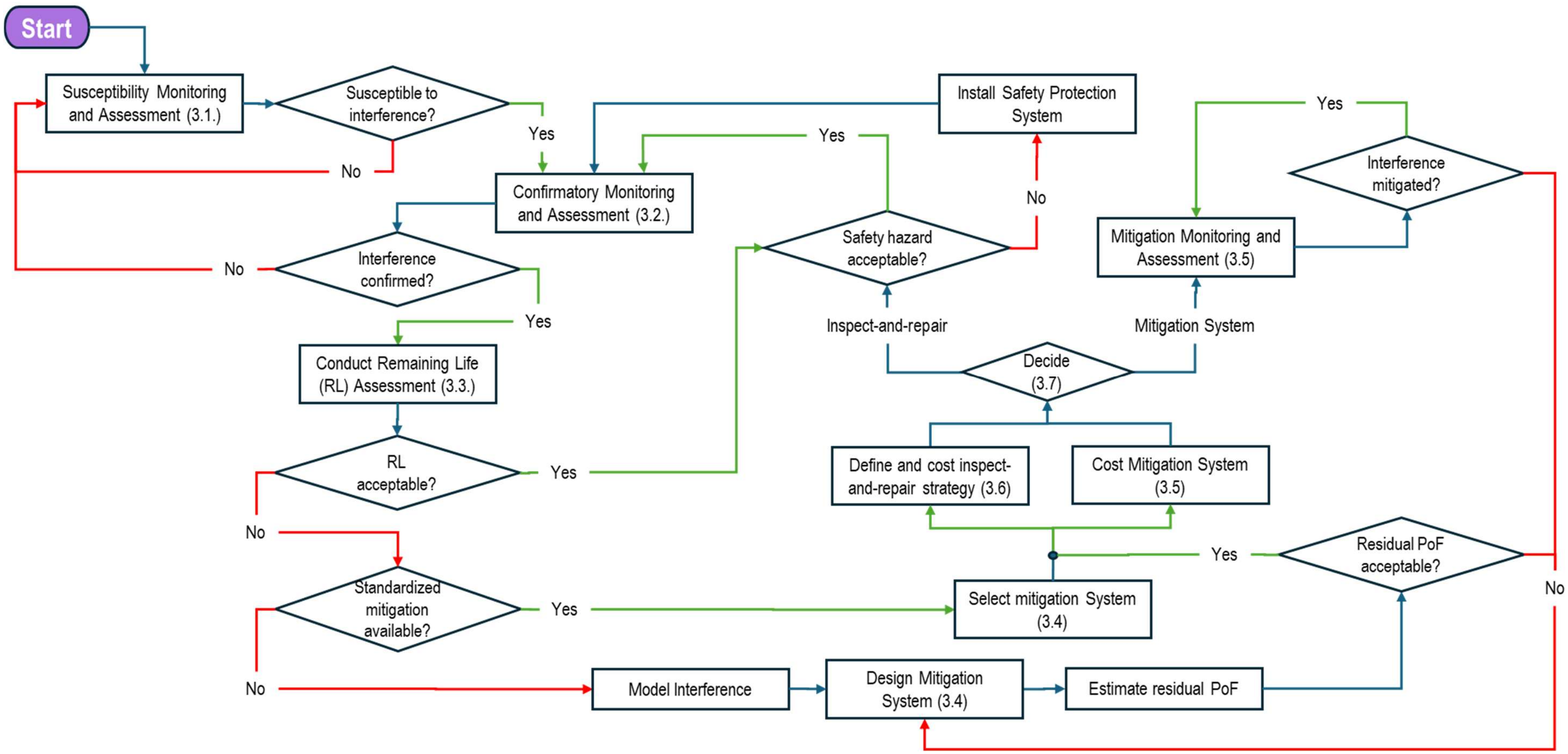

Figure 3. Methodology Implementation Flowchart

Table 1. ALARP Susceptibility Monitoring Plan (Illustrative example)

Monitoring Activity	Pipeline Criticality (e.g., Location Class) / Target PoF reduction			
	1 / 1x10-1	2 / 1x10-1	3 / 1x10-2	4 / 1x10-3
P/S On/Off (AC & DC) potential	((1)/1Km) / 6-M	((1)/1Km) / 3-M	((1)/1Km) / 2-M	((1)/1Km) / 2-M
Identification of interference sources	(1) / 3-Y (GIS search)	(1) / 3-Y (GIS search)	(1) / 1-Y (GIS & field search)	(1) / 1-Y (GIS & field search)
PCM	6-Y	6-Y	3-Y	3-Y
DCVG / ACVG	6-Y	6-Y	3-Y	3-Y
CIPS	6-Y	6-Y	3-Y	3-Y
Soil resistivity measurement	((1)/1-Y) / 10-Y	(((1)/6-M))/1-Y) / 10-Y	((1)/3-M) / 5-Y	((1)/1-M) / 5-Y

Convention:

(Nestable (Number of measurements or sampling frequency)/Measurement duration or frequency) / Monitoring frequency

e.g.: ((1)/1Km) / 6-M = 1 datum per 1 Km every 6 months

(((1)/3-M))/1-Y) / 5-Y = 1 datum every 3 months during 1 year every five years

(((1)/1 min))/7-D) / 3-M = 1 datum every 1 minute during 7 continuous days, every 3 months

Table 2. ALARP Confirmatory Monitoring Plan (Illustrative example)

Monitoring Activity	Pipeline Criticality (e.g., Location Class) / Target PoF reduction			
	1 / 1x10-1	2 / 1x10-1	3 / 1x10-2	4 / 1x10-3
P/S On/Off (AC & DC) potential	(1) / 6-M	(((1)/1 min)/24-H) / 6-M	(((1)/1 min)/7-D) / 3-M	(((1)/5 s)/7-D) / 1-M Online
AC & DC current density (1 and 10 cm2 coupon)	(1) / 6-M	(((1)/1 min)/ 24-H) / 6-M	(((1)/1 min)/ 7-D) / 3-M	(((1)/5 s)/ 7-D) / 1-M Online
Corrosion rate (ER prove)	N/A	(((1)/5 s)/1 H) / 6-M	(((1)/5 s)/1 H) / 3-M	(((1)/5 s) /7-D)/ 1-M Online
ILI (metal loss tool)	5-Y	5-Y	5-Y	5-Y
Magnetic and electrical field measurement	((1)/1-Y) / 10-A	((1)/1-Y) / 5-Y	(1) / 1-Y	(1) / 1-Y

Table 3. Standardized Mitigation System Selection (Illustrative example)

Mitigation	Pipeline Criticality (e.g., Location Class) / Target PoF reduction			
	1 / 1x10-1	2 / 1x10-1	3 / 1x10-2	4 / 1x10-3
Install capacitors / DC decoupling device @ each end of the segment to couple to station grounding system	• Install dead front @ test posts • Install gradient control mats @ test posts and other aboveground appurtenances • Install 1 and 10 cm2 coupon or ER probe at locations of highest AC potentials			
Install grounding system @ major electrical discontinuities along the paralleling segment	Locations can be selected by experienced personnel		• Locations shall be selected through simulation • Install DC decoupling devices at each end of the segment	
Install mitigation wire @ major electrical discontinuities along the paralleling segment	• Locations can be selected by experienced personnel • Bare copper connected through decoupling device • Maximum length of wire: 200 m • Install as many parallel wires as necessary to achieve target AC potential		• Locations shall be selected through simulation • Ribbon of sacrificial anode material installed in select sacrificial anode backfill • Maximum length of ribbon: 150 m • Install as many parallel ribbons as necessary to achieve target AC potential • Install DC decoupling devices at each end of the segment	

Notes to Table 3:

1 and 10 cm2 coupon or ER probe shall be installed at each grounding system and mitigation wire location

Table 4. ALARP Mitigation Monitoring Plan (Illustrative example)

Monitoring Activity	Pipeline Criticality (e.g., Location Class) / Target PoF reduction			
	1 / 1x10-1	2 / 1x10-1	3 / 1x10-2	4 / 1x10-3
Inspection of decoupling devices	(1) / 6-M	(((1)/1 min)/24-H) / 6-M	(((1)/1 min)/7-D) / 3-M	(((1)/5 s)/7-D) / 1-M Online
Inspection of grounding systems	(1) / 6-M	(((1)/1 min)/24-H) / 6-M	(((1)/1 min)/7-D) / 3-M	(((1)/5 s)/7-D) / 1-M Online
Inspection of mitigation wire system	(1) / 6-M	(((1)/1 min)/24-H) / 6-M	(((1)/1 min)/7-D) / 3-M	(((1)/5 s)/7-D) / 1-M Online
AC & DC current density (1 and 10 cm2 coupon)	(1) / 6-M	(((1)/1 min)/ 24-H) / 6-M	(((1)/1 min)/ 7-D) / 3-M	(((1)/5 s)/ 7-D) / 1-M Online
Corrosion rate (ER prove)	(((1)/5 s)/1 H) / 6-M	(((1)/5 s)/1 H) / 6-M	(((1)/5 s)/1 H) / 3-M	(((1)/5 s) /7-D)/ 1-M Online
ILI (metal loss tool)	5-Y	5-Y	5-Y	5-Y

Notes to Table 4:

These activities are in addition to activities listed in Table 1

11 SUSCEPTIBILITY MODEL FOR AC INDUCED INTERFERENCE

The proposed susceptibility model is a relativistic scoring model in which each variable is assigned a weight and each range of possible values is assigned a score. The weight reflects the relative influence of the variable on the likelihood of interference, while the score reflects the severity of the condition represented by that variable.

Each variable can receive a score between 0 and 5, where 5 indicates the highest likelihood of the threat materializing and 0 indicates that the threat is ruled out. Each variable is also assigned a weight between 0 and 1, with the restriction that the sum of weights shall be equal to 1.

The final susceptibility of a segment is calculated using the following equation:

$$S = \sum_{i=1}^{n} w_i * \frac{P_i}{5}$$

$$\sum_{i=1}^{n} w_i == 1$$

Where:

S = Segment's susceptibility

n = Number of variables participating in the susceptibility model

w_i = Weight of variable i

P_i = Score of variable i

According to the mathematical logic, the susceptibility of the segment can take values between 0 and 5, whose qualitative evaluation can be understood according to the following table:

Table 5 - 1 Qualitative Evaluation of Segment Susceptibility

Susceptibility	Equivalence
[4 – 5]	Very high
[3 – 4)	High
[2 – 3)	Medium
[1 – 2)	Low
(0 – 1)	Negligible

Segments with susceptibility score of less than 2, should be considered as not susceptible to the damage mechanism evaluated.

Susceptibility to AC interference (inductive coupling):

Resistivity Ranking (w = 1/6)

Soil Resistivity, ρ (Ohm-cm)	Score
ρ < 2500	5
2500 ≤ ρ < 10000	4
10000 ≤ ρ < 30000	2
ρ ≥ 30000	1

Pipeline AC Potential Ranking (w = 1/6)

Potential AC, PAC (V AC)	Score
PAC > 4	5
1 < PAC ≤ 4	3
0 < PAC ≤ 1	1
PAC = 0	0

Structures Separation Ranking (w = 1/6)

Distance to Interference Source, D (m)	Score
D < 30	5
30 ≤ D < 150	3
150 ≤ D < 300	2
D ≥ 300	0

AC Current Ranking (w = 1/6)

Corriente Transported by the Interference Source, I_{AC} (A)	Score
I_{AC} > 1000	5
500 < I_{AC} ≤ 1000	4
250 < I_{AC} ≤ 500	3
100 < I_{AC} ≤ 250	2
I_{AC} ≤ 100	1

Length of Parallelism Ranking (w = 1/6)

Length of Parallelism, L (m)	Score
L > 5000	5
1000 < L ≤ 5000	3
L ≤ 1000	1

Crossing Angle Ranking (w = 1/6)

Crossing Angle, θ (°)	Score
θ < 30º	5
30º ≤ θ < 60º	3
θ ≥ 60º	1
No crossing	0