Addressing Electromagnetic Interference Issues for Safe Transition to Net Zero Transmission Network and Clean Energy

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What is it?

Commonly known as "Electromagnetic field interference (EMI)/ AC interference/ Impressed Voltages (IV)/ Low frequency induction (LFI)".

A coupling of energy from an electrical source (such as an electrical power line) to a metallic conductor (such as a pipeline) which at low frequencies (in the range of power system frequencies) occurs in the form of three different mechanisms;

- Capacitive or electrostatic coupling (arising from the electric field and voltage source)
- Inductive or electromagnetic coupling (arising from the magnetic field and current source).
- Conductive or resistive coupling (arising from current flow through a connection with earth)

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Electromagnetic field Interference: Issues and Concerns

AC corrosion is the metal loss that occurs from AC current leaving a metallic pipeline at a point where there is a discontinuity in the protective coating that exposes the unprotected surface to the environment.

- Electrical shock hazards for people touching the exposed metallic utilities or metallic structures connected to them or simply standing near them. Such shock hazards are a concern during normal and fault conditions on the power lines.
- Damages to the pipeline coating due to excessive coating stress voltages during ground fault conditions on the power lines.
- Accelerated pipeline corrosion due to excessive AC leakage currents from pipeline coating defects (holidays), i.e., AC enhanced corrosion activities which is a concern during normal conditions on the power lines only.

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Why to carry out assessments ?

- **Aim # Safe system operation and work environment i.e., no system redundancy and no electric shock**

Electricity at Work Regulations (1989)

(i) ‘Regulation 8 of the electricity at work regulations stipulates that - Precautions shall be taken, either by earthing or other suitable means, to prevent danger arising when any conductor (other than a circuit conductor) which may reasonably foreseeably become charged as a result of either the use of a system, or a fault on a system, becomes so charged’.

(ii) Conductors which, although not part of a system, are within electrostatic or electromagnetic fields created by a system may be subject to this regulation. Appropriate precautions are necessary if the induced voltages or currents are large enough to give rise to danger’.

(iii) ‘A conductor shall be regarded as earthed when it is connected to the general mass of earth by conductors of sufficient strength and current carrying capability to discharge electrical energy to earth’.

See: https://www.hse.gov.uk/pUbns/priced/hsr25.pdf (Page 25)

Electromagnetic field interference assessment

- ✓ A system layout drawing /google earth files having pipeline and powerline with the following details;

- Pole/towers location (for OHL)
- Cable joints & terminations (for cable)
- Substations
- Pipelines routes
- CP Test points, Valves and Isolating joints
- Other metallic objects (railways, other pipelines etc.)

Main Data Requirement

Pipeline Construction/Installation:

i. Material
ii. Diameter
iii. Wall thickness
iv. Burial depth to centre line of pipeline
v. Length between isolating joints
vi. Soil resistivity along the route

Pipeline Coating/Cathodic Protection:

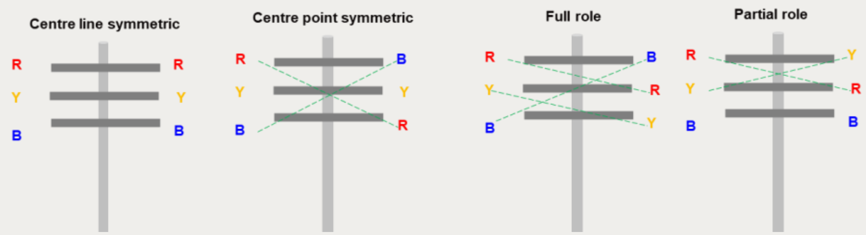
i. Coating type (e.g. fusion bonded epoxy, coal tar enamel etc)
ii. Coating resistance/resistivity
iii. Coating thickness
iv. Cathodic protection system/details of anode beds
v. Appurtenances (test posts, valves, offtakes and isolating joints/location of bonds)
vi. Existing earthing/surge protection details

Power Line Parameters

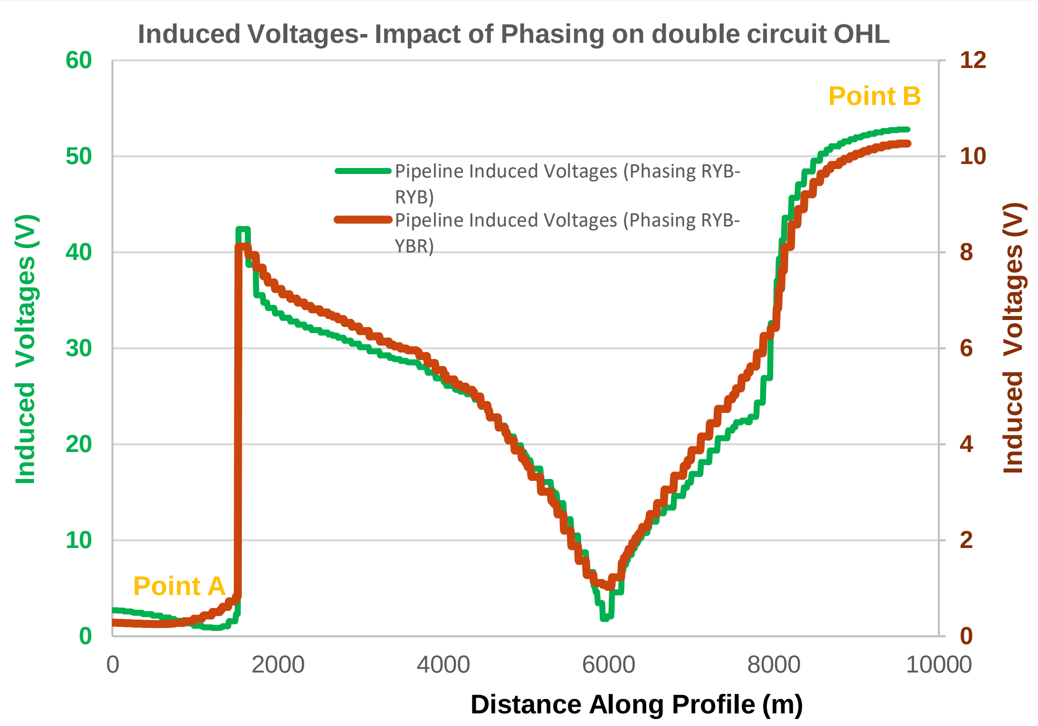
i. Operating Voltages
ii. Actual/rated load currents
iii. Tower Configurations/diagrams
iv. Phase and earth wire properties (manufacturer sheet)
v. Phasing diagram/transposition
vi. Tower footing resistance
vii. Substations earthing details
viii. Fault current data (phase to earth fault levels, fault clearing time)
ix. For cable circuits: cable cross-section/supplier data sheet, installation depth, installation arrangement flat or trefoil, buried in soil or installed in ducts and bonding arrangement

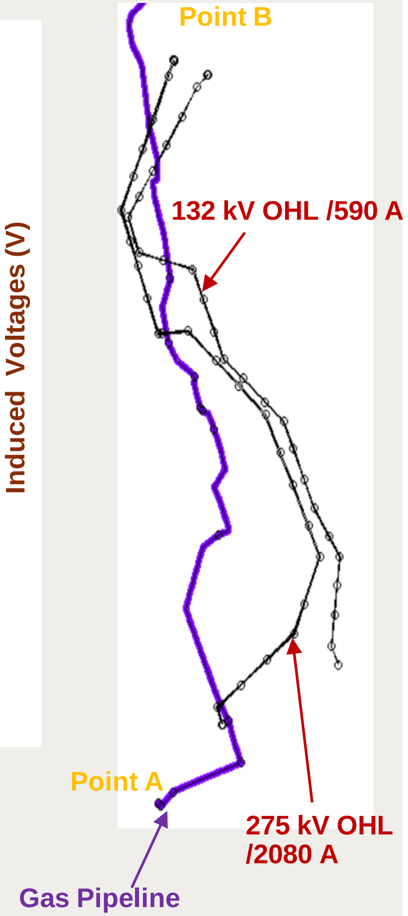
Electromagnetic field interference assessment

Data matters!, Let see how?



- A 9.61 km gas pipeline with coating resistance of 50,000 Ωm^2 and 2.2 mm thickness is buried 1.82 m below ground. In shared corridor there are two double circuit OHLs i) 132 kV and ii) 275 kV. The soil assumed is 100 Ωm.





1. Same phasing (RYB) both side of each double circuit OHL, maximum induced voltages on pipeline V_{max}= 52.78 V
2. Balanced phasing (RYB/BYR) on each double circuit OHL , maximum induced voltages on pipeline V_{max}= 10.26 V

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Electromagnetic field interference assessment

Another data example?

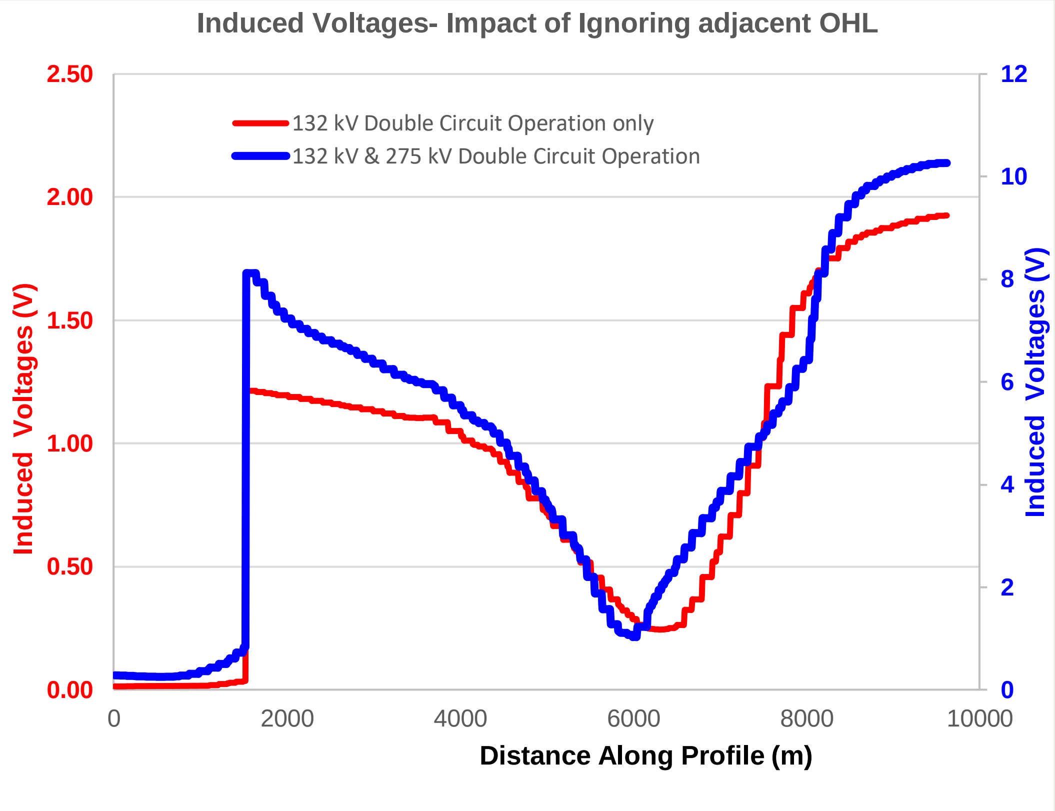
- A 9.61 km gas pipeline with coating resistance of 50,000 Ωm^2 and 2.2 mm thickness is buried 1.82 m below ground. In shared corridor there are two double circuit OHLs i) 132 kV and ii) 275 kV. Balanced phasing (RYB/BYR) on each double circuit OHL . The soil assumed is 100 Ωm.

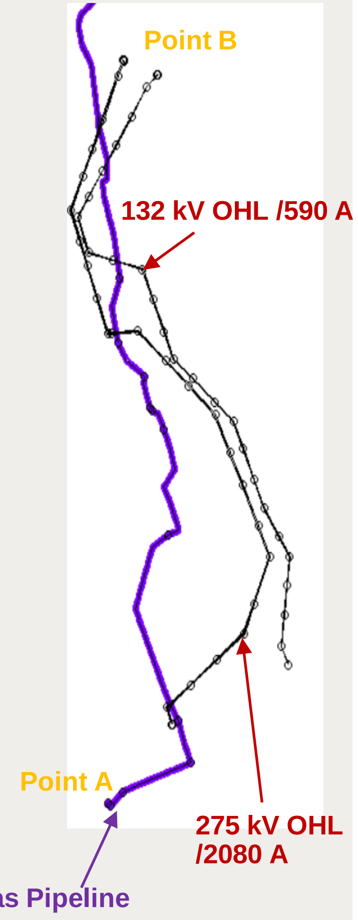
1. Only 132 kV OHL is included in model which is in scope as per client requirement, maximum induced voltages on pipeline

   V_{max}= 1.93 V

2. Both 132 kV and 275 kV included in model to calculate realistic results, maximum induced voltages on pipeline

   V_{max}= 10.26 V





Electromagnetic field interference assessment

Carry out an initial assessment based on BS EN 50443 or CIGRE guidelines.

“When there is a breach of so-called interference distance Typical 1,000 m in rural and 300 m in an urban area. For cable circuits 50 m in both rural and urban zone”

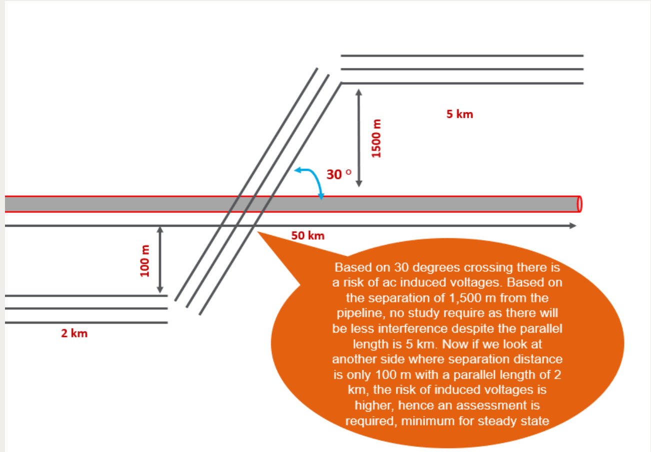
- **What else to look?**
  - **Powerline Current (Amps)**
  - **Crossing Angle (Degree)**
  - **Parallelism Length (Meters)**

Type of A.C. Power Systems	Areas	ρ (Ωm)	Interference Distance (m)*	
			Normal Operation	Fault Condition
Overhead	Rural	> 3,000	ρ/3	ρ
		≤ 3,000	1,000	3,000
Overhead	Urban	> 3,000	≥ 300	ρ/10
		≤ 3,000		≥ 300
Underground	all	all	50	50

* National rules, recommendations and guidelines determining other interference distances may be applied.

Hypothetical Example

A 132 kV OHL with 1,000 A load current crossing 50 km long 10” gas pipeline with 30 degree with some parallelism in rural area. Soil is assumed 100 ohm-m.



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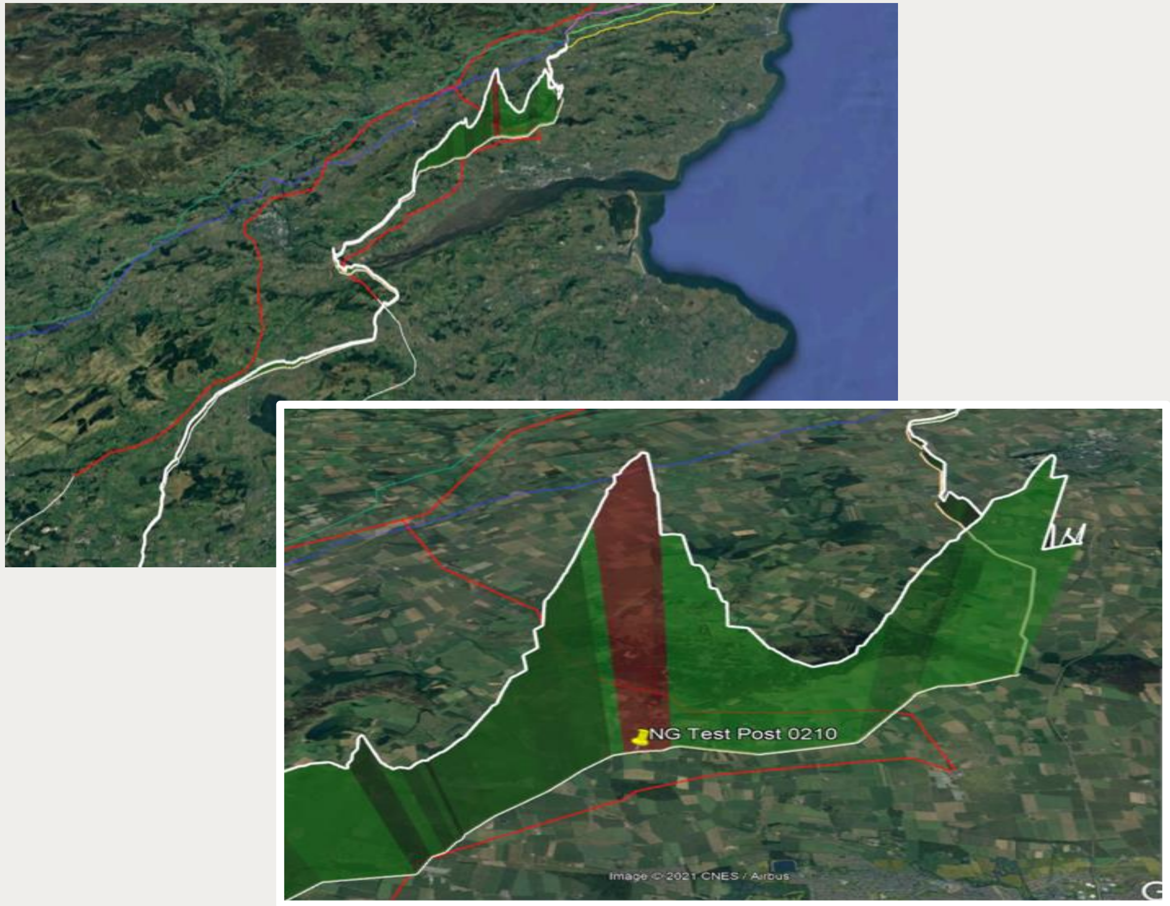
Electromagnetic field interference assessment

Need for computer simulation ?

- Fast and flexible
- Complex right-of-way configurations containing multi-circuit power line (OHL/cable) & multiple pipeline
- Compute the inductive, conductive, capacitive, and total interference levels simultaneously
- Multiple multilayer soil along the common utility route
- High accuracy
- Representation/identification of problematic areas



The limits below 15 V is GREEN area and above 15 V is RED shaded area

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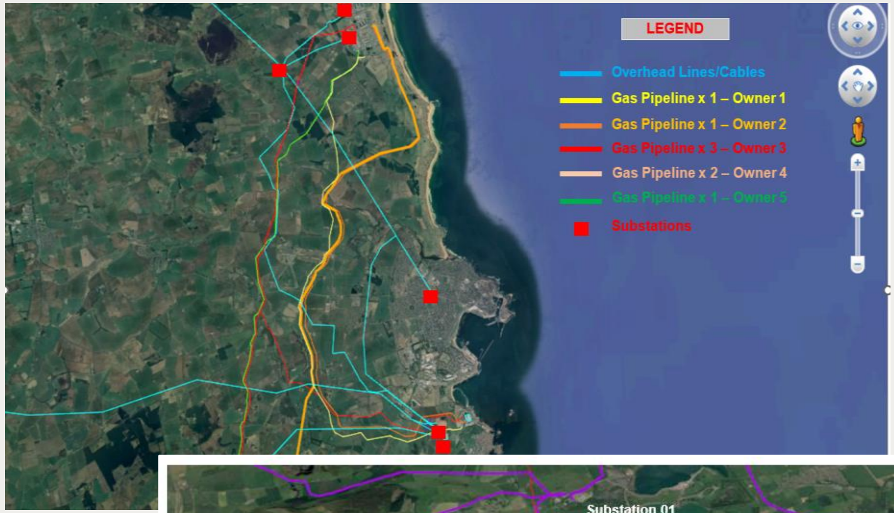
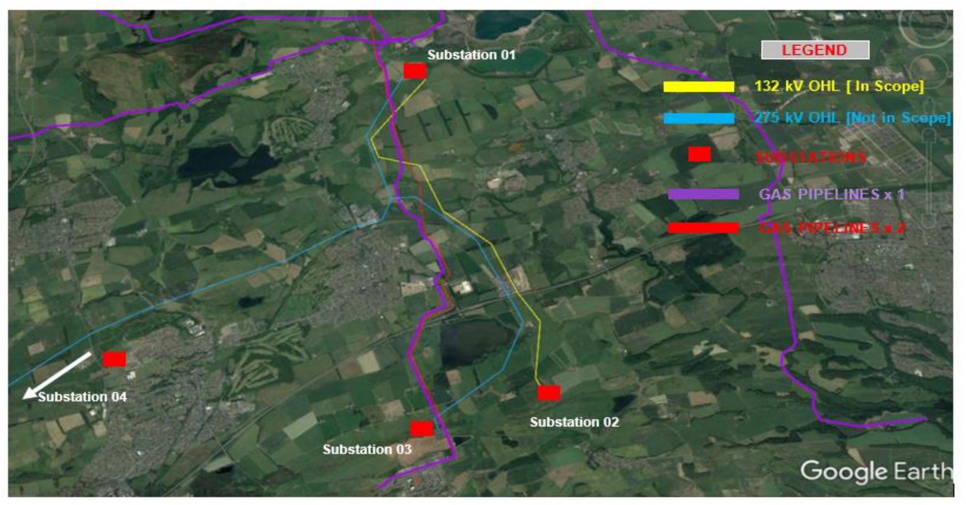
Electromagnetic field interference assessment

Projects raise different problems, typical are;

- Data collection from gas/power companies
- Land access for site measurements
- Other lines are not my scope
- Why do you need this all data, too much information!
- Can we assume worst-case?
- When are you digging near our pipeline?
- What does the results mean for me?





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Management/Mitigation of Electromagnetic field interference

Planning/FEED stage (Primary Control)

- Re-routing of a planned power line/relocation of substation/solar/wind/battery storage (increasing distance between pipeline and electrical assets). Similar approach can be adopted for new pipeline routes.
- Selecting overhead conductor configuration/phasing minimising the induction from the line/transposition of conductors.
- Utilising underground cable circuits instead overhead power line in shared corridor and placing OHL/cable interface points (sealing end compounds) away from pipelines.
- Fault level mitigation equipment within the substations to reduce risk during phase to earth fault conditions.

Development /Detailed design stage (Secondary Control)

- Run an initial assessment using so called interfering distances and if deemed necessary carryout software assessment
- Earthing (Zinc gradient control wires) of pipeline in line with pipeline company/national standards.
- Sensitivity analysis - future upgrades, extension to substations to accommodate renewable energy (wind farms/solar/battery storage)
- Maintaining records for future assessment

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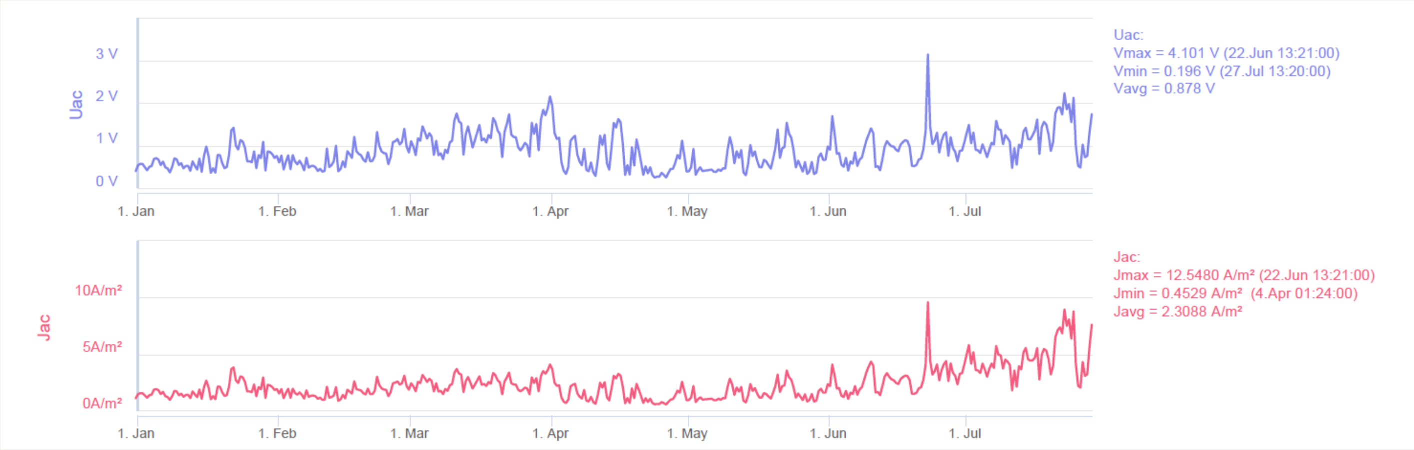
Management/Mitigation of Electromagnetic field interference

Operation & Maintenance Stage

- If it is important to validate a substation earthing and earth potential rise (EPR) profile for substation safety, then why not for a pipeline perspective ?
- Monitoring considerations : a communication path between powerline/pipeline operator to install/adjust the monitoring schedule.
- For historical installations – As part of the asset management, the pipeline companies shall carry out continuous monitoring and assess risk using national standards. Or wait for an accident?



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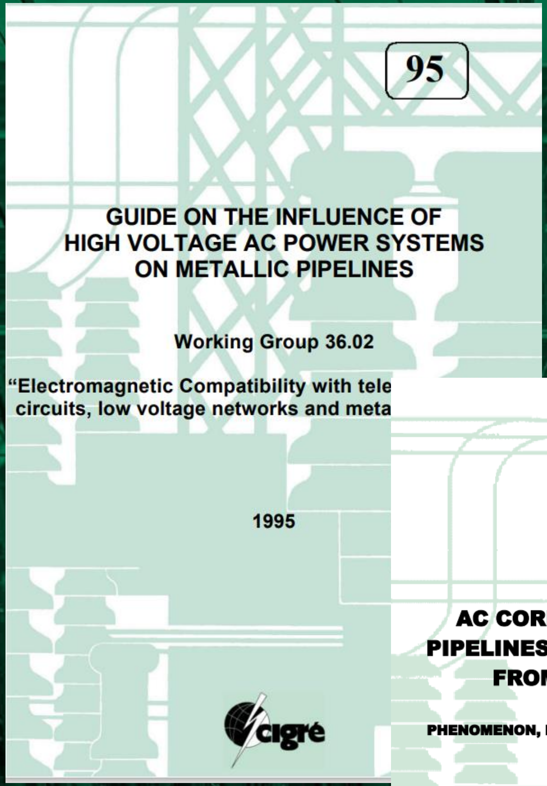
Summary

- No one owns all data/assets and resources in the shared corridor, hence partnering is essential to mitigate safety hazards on pipelines. Early partnering is key to minimising costs and improve safety.
- Education to both gas/electrical engineers is important to understand the subject.
- Strong need for technical guidance within the electrical industry, for example from Energy Networks Association (ENA).
- The energy industry is evolving quicker than it has for decades. Sources of generation are changing, and new connections are being made to the transmission network resulting in substantial different patterns in electricity circuits. Operators need to collaborate!.

Further Reading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GUIDE ON THE INFLUENCE OF
HIGH VOLTAGE AC POWER SYSTEMS
ON METALLIC PIPELINES

Working Group 36.02

“Electromagnetic Compatibility with tele
circuits, low voltage networks and meta

1995

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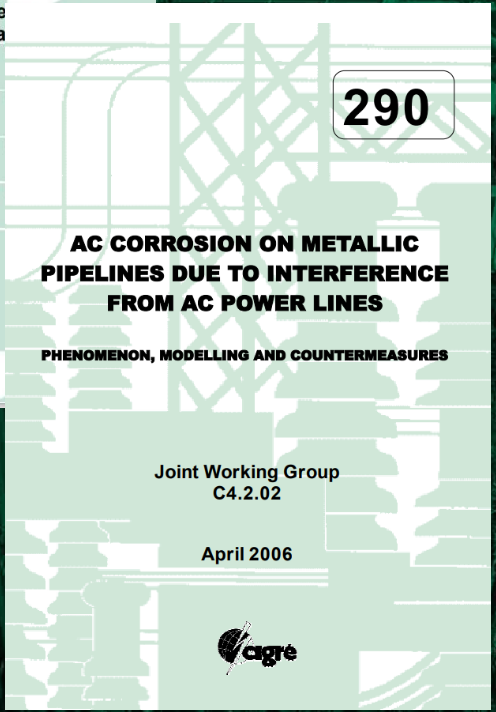
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AC CORROSION ON METALLIC
PIPELINES DUE TO INTERFERENCE
FROM AC POWER LINES

PHENOMENON, MODELLING AND COUNTERMEASURES

Joint Working Group
C4.2.02

April 2006

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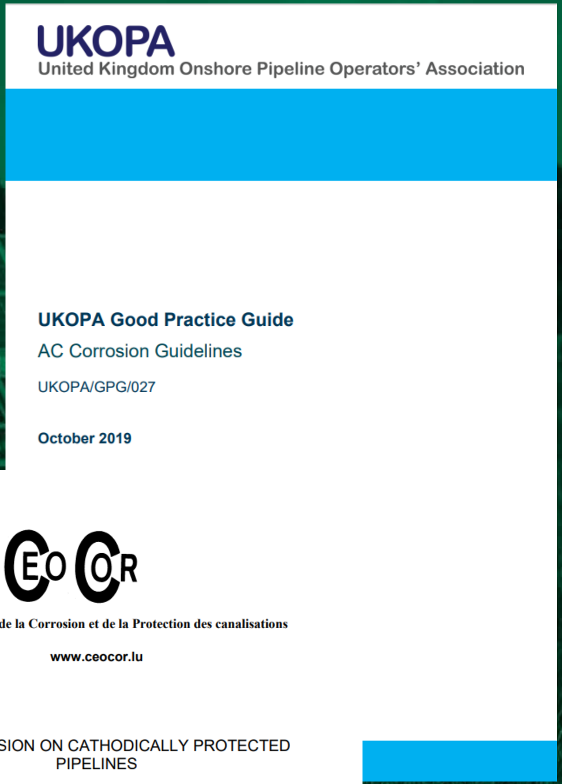
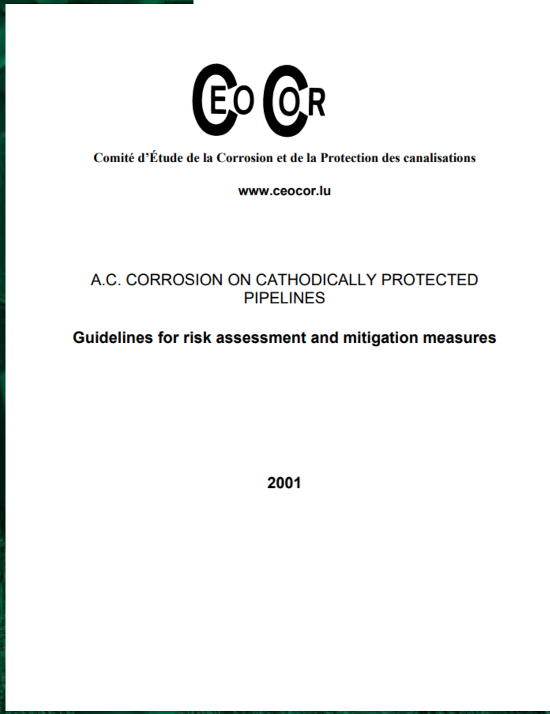

UKOPA
United Kingdom Onshore Pipeline Operators’ Association

UKOPA Good Practice Guide
AC Corrosion Guidelines
UKOPA/GPG/027

October 2019


CEOCOR

Comité d’Étude de la Corrosion et de la Protection des canalisations

www.ceocor.lu

A.C. CORROSION ON CATHODICALLY PROTECTED
PIPELINES

Guidelines for risk assessment and mitigation measures

2001

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