UKOPA

United Kingdom Onshore Pipeline Operators' Association

Good Practice Guide

Electrical Interaction on Pipelines: Collaboration between Developers and Operators

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The guidance in this document represents what is considered by UKOPA to represent current UK pipeline industry good practice within the defined scope of the document. All requirements should be considered guidance and should not be considered obligatory against the judgement of the Pipeline Owner/Operator. Where new and better techniques are developed and proved, they should be adopted without waiting for modifications to the guidance in this document

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EXECUTIVE SUMMARY

This United Kingdom Onshore Pipeline Operators' Association (UKOPA) good practice guide (GPG) has been developed by the UKOPA Corrosion Prevention Working Group (CPWG) in collaboration with electrical infrastructure operators, regulators, and other stakeholders (including local authority planners and project designers). This document outlines the potential electrical interactions between pipelines and electrical infrastructure, highlights key issues to consider and emphasises the need for coordinated efforts to mitigate associated impacts.

Operators of both metallic pipelines and electrical infrastructure have a statutory obligation to assess and mitigate stray current risks under the Pipelines Safety Regulations, the Electricity at Work Regulations, and the Electrical Safety, Quality and Continuity Regulations, as well as broader obligations under the Health and Safety at Work etc. Act. Their key responsibilities include assessing risks and carrying out regular monitoring and maintenance to ensure ongoing compliance.

The rapid expansion of renewable energy and electrification projects across the UK is creating a growing risk of electrical interference on buried high-pressure (Major Accident Hazard) steel pipelines. Such interference can accelerate corrosion, compromise the long-term integrity of critical pipeline infrastructure with potentially catastrophic consequences, and pose safety hazards such as electric shock to pipeline personnel and the public.

This guidance has been developed for promoters and operators of electricity networks (both transmission and distribution systems) and other electrical infrastructure. It also provides pipeline operators with guidance on the factors that should be considered to mitigate risks to pipeline integrity and to the safety of pipeline personnel and the public.

Mitigating these risks requires early engagement, transparent communication, and sustained collaboration between electrical and pipeline asset operators. This partnership must begin at the earliest stages of project planning and continue throughout the full asset lifecycle.

Effective risk management relies on robust Electrical Interference Assessments (EIAs), maintaining appropriate separation distances, and ensuring full compliance with UK legislation and established industry standards. In a densely populated nation where shared infrastructure corridors are unavoidable, a proactive, integrated, and collaborative approach is essential to manage these complex interactions, safeguard asset integrity, and protect people, property, and the environment.

This document is for guidance only and should not be considered mandatory. Users of this document should consult with the relevant duty holders (both electrical and pipeline asset operators) to ensure relevant Company procedures and adopted Standards are adhered to.

COLLABORATION PARTNERS

This document was developed in collaboration with the following organisations and companies

- Arcadis Consulting
- British Pipeline Agency Ltd (BPA)
- Cadent
- Department for Energy Security and Net Zero
- EDF Energy
- Energy Networks Association
- EP Language
- ESB Networks
- Exolum
- Gas Networks Ireland
- Health and Safety Executive
- IACS Corrosion Engineering Ltd
- Independent Consultants
- Ineos Energy
- INEOS Olefins & Polymers
- LSTC Group
- Mutual Energy
- National Gas
- National Grid Electricity
- Northern Gas Networks
- OFGEM
- Rosen
- Sabic
- Scottish and Southern Electricity Networks
- Scottish Power
- SGN
- Shell
- Technical Earthing Services
- UK Power Networks
- UKOPA
- Vattenfall
- VPI
- Wales & West Utilities
- Wood

1 INTRODUCTION

1.1 Background

The UK's commitment for Net Zero Emissions by 2050 is driving the rapid expansion in renewable energy infrastructure and electrification projects, leading to potential issues with electrical interference on buried high-pressure metallic pipelines.

Electrical interference on buried pipelines has long been managed on a case-by-case basis, often requiring costly retrospective solutions. However, with the growth of renewable energy, upgrades to electricity networks, battery storage and railway electric traction systems, the cumulative impact of interference is increasing. As knowledge of these effects improves, greater industry collaboration is needed to ensure a holistic approach to protecting the UK's energy infrastructure.

The Pipelines Safety Regulations 1996 - Regulation 15 states that "no person shall cause such damage to a pipeline as may give rise to a danger to persons".

The Electricity at Work Regulations 1989 - Regulation 4 states that "All systems shall at all times be of such construction as to prevent so far as is reasonably practical danger ".

Planning rules for nationally significant infrastructure projects differ from normal local authority planning applications, as a result early engagement between electricity system developers, transmission and distribution system operators, and pipeline operators is being missed.

1.2 Scope

This guidance document is applicable to the routing and installation of electrical infrastructure in close proximity to high-pressure metallic pipelines. These pipelines include but are not limited to:

- Natural gas high-pressure (HP) pipelines
- Petrochemical liquids and gas pipelines
- All other high-pressure pipelines (such as CO_2, H_2, ethylene, etc)

Note: This guidance is not intended for non-metallic pipes (polyethylene, PVC, etc) which are not affected by electrical interference. Concrete pipelines should be considered due to their metallic reinforcement.

For natural gas pipelines, the guidance is generally applicable to pipelines with operating pressures above 7 Barg. However, the principles of the document can be equally applied to metallic pipelines operating at lower pressures.

1.3 Application

The guidance in this document is applicable to all buried pipelines operated by the UKOPA member companies.

Within this document:

Shall: indicates a mandatory requirement.
Should: indicates good practice and is the preferred option.

1.4 Relevant legislation

- **Health and Safety at Work etc. Act 1974** (HSAWA) – imposes a duty on employers and operators to ensure the safety of their operations, including interactions between pipelines and electrical networks.

- **Electricity Act 1989** – governs the generation, transmission, distribution, and supply of electricity in the UK, including safety and operational aspects.

- **Gas Act 1986 and 1995 as amended** – governs the transportation and supply of gas through pipelines, ensuring coordination with other infrastructure.

- **Pipelines Safety Regulations 1996** (PSR) – governs the safe design, construction, and operation of pipelines, and requires the identification of credible risks to pipeline integrity, which should include lightning risk assessments.

- **Pressure Systems Safety Regulations 2000** (PSSR) – requires operators to maintain the integrity of pressure-containing assets to prevent failure, protect personnel, and ensure safe operation throughout their lifecycle.

- **The Gas Safety (Management) Regulations 1996** (GS[M]R) – requires gas transporters to ensure the safe conveyance of gas, maintaining system integrity to protect the public, property, and the environment.

- **The Electricity Safety, Quality and Continuity Regulations 2002** (ESQCR) – requires the safe design of electrical infrastructure to avoid danger from induced or fault currents and prevent interference with other utilities, such as pipelines.

- **The Electricity at Work Regulations 1989** (EAWR) – ensures electrical installations and equipment are maintained in a manner that prevents danger, including interactions with other infrastructure.

- **The Construction (Design and Management) Regulations 2015** – sets out the health and safety responsibilities of clients and duty holders for all new construction projects, ensuring risks are managed throughout design and delivery.

NOTE: Other statutes and regulations may apply in regions outside of Great Britain and the UK. Reference should be made to the equivalent legislation of the country concerned.

1.5 Relevant standards and codes of practice

There are numerous standards offering detailed technical guidance on electrical interference and cathodic protection criteria, aiding in project planning.

Standards used in the assessment and mitigation of electrical interference should be agreed between all parties prior to being applied.

- **BS EN ISO 15589-1** provides information for CP criteria to prevent corrosion and acceptable safe limits for stray current density.

- **BS EN ISO 18086** gives guidance for acceptable levels of AC interference.

- **BS EN ISO 21857** provides guidance on calculating induced voltage, assessing electrical interference risks and selection of protection or mitigation measures. In addition, it emphasises the need for collaboration between the interference source operator and the pipeline operator throughout design, construction, and operation.

- **PD CLC/TR 50427** gives guidance on the assessment of inadvertent ignition of flammable atmospheres by radio-frequency radiation.

- **BS EN 50122-1** sets standards for the design, installation, and maintenance of electrical bonding, earthing, and stray current monitoring systems for railway infrastructure to control and minimise stray current-induced corrosion on nearby metallic structures.

- **BS EN 50443** provides guidelines for assessing and mitigating electromagnetic interference effects on metallic pipelines caused by high-voltage AC (HVAC) power transmission and railway systems (>1 kV).

- **NACE SP0177** gives guidelines for design, construction, operation, and maintenance of metallic structures and corrosion control systems to mitigate effects from lightning and overhead AC power systems.

- **NACE SP0169** provides guidelines for controlling the external corrosion of buried metallic structures and pipe systems, including managing interference currents.

- **NACE SP21424** provides guidance for safety, risk assessment, mitigation and monitoring of AC corrosion on buried pipelines (complimentary to BS EN ISO 18086)

- **UKOPA/GPG/13** Requirements for the Siting and Installation of Wind Turbines Installations in the Vicinity of Buried Pipelines

- **UKOPA/GPG/014** Requirements for the Siting and Installation of Solar Photovoltaic (PV) Installations in the Vicinity of Buried Pipelines

- **UKOPA/GPG/027** provides guidelines for identifying, assessing, and mitigating AC corrosion risks on buried pipelines caused by electrical infrastructure

- **UKOPA/GPG/031** offers guidance on managing and mitigating DC stray current interference to protect buried pipelines from corrosion and safety risks.

- **UKOPA/TBN/005** gives guidance on how to minimise the safety risks on pipelines from AC interference from power lines and AC traction systems.

- **UKOPA/TBN/016** AC Corrosion – provides guidance on hazards, risk assessment and mitigation.

Note 1: This list is not exhaustive - pipeline and power operators are likely to have their own internal specifications and procedures which implement the requirements of the above.

Note 2: UKOPA Technical Briefing Notes (TBN) are only available to UKOPA Members.

2 OVERVIEW OF UK PIPELINES

The UK pipeline network operated by UKOPA members is over 27,000 km in length and includes gas transmission and distribution networks, oil companies, fuel distributors and emerging hydrogen and carbon capture and storage (CCS) operators.

The safety record of these pipelines is extremely good due to strict industry standards and a strong legal framework. However, electrical interference could pose risks to pipeline safety if not properly managed. Without sufficient safeguards during routing, construction, and operation, this could contribute to pipeline failures, leading to hazardous fluid leaks and potential thermal or environmental hazards.

A list of UKOPA Members is included in Appendix C, correct at the time of publication.

Note: not all pipeline operators are UKOPA members.

3 ELECTRICAL INTERFERENCE

3.1 Sources of interaction

Typical sources of electrical interaction include -

- High-voltage power lines (overhead and buried)
- Solar photovoltaic (PV) farms
- Wind farms
- Battery Energy Storage Systems (BESS)
- High-voltage direct-current (HVDC) interconnectors
- DC/AC converter stations
- Electrical traction systems
- New radio frequency transmission stations
- Distribution lines/networks
- Substations
- Above ground structures adjacent to pipelines presenting a lightning arc/surge risk

Note: This list is not exhaustive. Other sources of interaction may exist and could include plant and equipment associated with the sources above.

3.2 Interference mechanisms

Sources of interaction can cause voltages to build up in adjacent metallic pipelines due to:

- **Inductive coupling** – arises due to inductive coupling between long-running structures in parallel and is the main source of AC corrosion risk.
- **Capacitive coupling** – due to the location of pipework/pipelines near overhead power lines, or when pipelines and insulated power cables are in direct contact with each other.
- **Resistive coupling** – occurs when current discharges from a power line to earth, creating an earth potential rise (EPR). This can result in an increase in pipeline touch potential and accelerated AC corrosion. Lightning can also be a source of EPR.

3.3 Effects of interaction

Electrical interaction can affect a buried pipeline in the following ways:

- **Accelerated corrosion** – caused by the disturbance of the electrochemical balance at the pipeline surface, leading to localised pitting or high rates of general surface corrosion. The corrosion rates where AC and DC interference occur can be considerably more than the general corrosion rate for steel in soil, even if cathodic protection (CP) is applied to a pipeline system.

- **Safety hazards** - include electric shock risks to pipeline workers, particularly during maintenance, and the potential for spark-induced ignition in explosive atmospheres. Sparks may result from long-line AC currents caused by inductive coupling, or from voltage differences across isolation joints. There are also public safety risks if individuals come into contact with above-ground pipeline apparatus.

- **Disruption of cathodic protection (CP) systems** – CP is used to prevent pipeline corrosion; electrical interference can disrupt the effectiveness of a CP system. Ground beds associated with pipeline CP systems may be located remote from the pipeline and therefore not appear in general pipeline search enquiries or be considered in construction activities.

- **Structural integrity issues** – causing a reduction in pipeline lifespan, increased maintenance and repair costs, greater potential for leaks which may result in significant environmental damage and disruption of supply.

- **Damage to pipeline** – caused by new road or cable crossings or work within close proximity to a pipeline system, or by fires associated with new electrical developments.

- **Lightning risk** - new large scale metallic structures constructed in the vicinity of a pipeline can create an enhanced lightning strike risk.

- **Operational challenges** – interference with over-the-line pipeline inspection (CIPS, DCVG, ACVG, etc) and need for enhanced corrosion monitoring and maintenance programs.

Note: other construction activities related to new infrastructure — such as excavations, piling, blasting, and heavy vehicle movement — can also pose significant risks to pipeline integrity. These risks must be identified, assessed, and effectively mitigated as part of any project plan.

4 GOOD PRACTICE

4.1 Existing UKOPA guidance

This Good Practice Guide highlights the importance of effective communication and collaboration between electrical infrastructure developers and pipeline operators.

Further technical guidance on electrical interaction is available in the UKOPA publications listed in Section 1.5. UKOPA Good Practice Guides are freely available from the UKOPA website at https://ukopa.co.uk/document-category/good-practice-guides/.

4.2 Benefits of collaboration

Collaboration in the energy sector on electrical interference is essential to maintain reliability, safety, and efficiency for both pipelines and electrical infrastructure. Key reasons to collaborate on electrical interference include:

- **Improved safety** – for the integrity of the assets, safety of the general public and pipeline operator's personnel arising from risk of accelerated corrosion, leading to leaks or ruptures, environmental damage, equipment malfunctions (sensors/alarms/control valves), touch and step voltage hazards, and arcing risks in hazardous atmospheres.

- **Early risk reduction** – Early engagement on project plans (including cable and pipeline routes, substations, voltage uprating, or renewable energy locations) enables operators to identify affected assets, review asset integrity data, and assess whether modifications are needed.

- **Identify and secure land rights** – Mitigation works to the pipeline or electrical infrastructure may require changes to existing leases or new land rights, especially where works extend beyond current boundaries. These requirements should be identified early so that agreements can be negotiated and secured with landowners or third parties in good time, reducing legal and commercial risk.

- **Time and cost savings** – Addressing issues during the planning phase is more efficient than after design approval or construction, reducing the need for costly retroactive fixes.

- **Streamlined processes** – Including pipeline operators as stakeholders in electrical infrastructure planning encourages earlier collaboration and smoother project delivery.

- **Knowledge sharing** – Cross-industry cooperation enhances understanding of electrical interference, leading to better risk management, cost savings, and overall industry upskilling.

- **Effective and reliable studies through data sharing** – early sharing of comprehensive data on pipelines and electrical infrastructure will avoid errors, assumptions, costly over-design or harmful under-design (e.g. providing transmission powerline loading data and pipe-to-soil potential measurements for the same time period can be helpful in calibrating the actual coating properties of the pipeline, rather than relying on manufacturers values).

- **Reduces delays in energisation** – Establishing baseline surveys and identifying any required modifications to the pipeline's cathodic protection system are essential steps for developers to meet target energisation dates, as electrical infrastructure may not be permitted to energise until pipeline operators are satisfied.

4.3 Considerations to minimise interference

Given that the UK is densely populated with a mature and growing energy infrastructure network, it is inevitable that buried pipelines and electrical power systems end up sharing the same routes, which can lead to electrical interference. Key considerations that can help to minimise interference include:

a) **Separation distance** between power system and pipeline – to be as large as possible

b) **Avoiding parallelism** between power line and pipeline by achieving separation distances of

   i. 500 m for parallelisms > 3 km

   ii. 200 m for parallelisms < 3 km

c) **Areas of low soil resistivity** increase the risk of AC corrosion, especially in soils with high moisture content, small particle size, and high mineral content, as these factors enhance soil conductivity and facilitate the flow of AC currents to and from pipelines.

d) **Optimum crossing angle** – must be discussed with the pipeline operator. Where possible the crossing of a pipeline with an electricity cable should be at 90° (and definitely more than 60°).

e) **Formal Crossing Agreements** – When one infrastructure asset (e.g. a new pipeline, cable, or other utility) needs to cross, come into close proximity of, or otherwise interact with an existing pipeline or asset (especially high-pressure or hydrocarbon pipelines), operators should discuss the need for a formal crossing agreement that defines the responsibilities, technical requirements, liability, monitoring, insurance, and interaction protocol between the parties.

Further guidance can be found in BS EN ISO 18086, BS EN 50433, NACE SP21424 and UKOPA/GPG/027, UKOPA/GPG/031.

4.4 Planning

4.4.1 General

Changes in planning rules mean more developments are approved without standard land use considerations. Nationally Significant Infrastructure Projects (NSIPs) should engage pipeline operators early, preferably at the site selection/route optioneering phase and particularly during the pre-application consultation phase, in order to agree the relevant protective provisions as part of the application. Electricity network upgrades and railway electrification (which bypass planning permission) also require early coordination.

Projects that do not need to follow National Infrastructure planning rules and only require planning consultation at local authority levels (e.g. wind farms, solar farms and BESS), should be engaging with pipeline operators during the site selection/route optioneering phase and the statutory consultation phase. Where statutory consultation is not required, engagement should take place with pipeline operators during the site/route selection and optioneering phase.

Note: Planning legislation and rules vary between England, Scotland, Wales and Northern Ireland.

4.4.2 Third-party developers, designers and constructors

Third-party developers, designers and constructors must be conversant with the risks of electrical interference on buried assets, including pipeline networks that may not automatically be part of the statutory consultation process. To prevent construction delays, costly retrospective solutions, and legal issues, constructors should engage with Local Authority Planning teams and pipeline operators early in the planning stages of a project. This early coordination helps identify whether additional surveys, data collection (both before and after energisation), and mitigation measures need to be incorporated into the design.

Additionally to electrical interference issues, constructors should verify the specific requirements for construction activities near pipelines, particularly regarding safe excavation practices and work within the vicinity of pipelines, plus any additional indemnity insurance required by the pipeline operator.

Due to the complexity of interference, multiple specialists (such as earthing and electrical system designers, geotechnical surveyors, Cathodic Protection engineers, and maintenance teams) must be involved to ensure the right experience and competence is available for effective cooperation.

4.4.3 Relevant organisations

When planning infrastructure projects that could create an interaction issue, relevant UK organisations to consider contacting include, but not limited to:

- **Government and Regulatory Bodies**
    - Ofgem
    - HSE
    - DESNZ
- **Network Operators and Utilities**
    - National Energy System Operator (NESO)
    - System Operator for Northern Ireland (SONI)
    - National Grid Electricity Transmission
    - Scottish & Southern Electricity Networks (SSEN) Transmission
    - Northern Ireland Electricity Networks (NIE Networks)
    - SP Energy Networks (SPEN)
    - Distribution Network Operators (DNOs)
    - Independent Distribution Network Operators (IDNOs)
    - Pipeline operators (gas, oil, fuel, others)
    - Network Rail
    - Northern Ireland Railways
- **Public Consultations and Planning Applications**
    - Local Planning Authorities
    - National Infrastructure Planning (Planning Inspectorate)
- **Industry Association and Forums**
    - Energy Networks Association (ENA)
    - Future Energy Networks (FEN)
- **Geospatial Information Systems (GIS) and Data Services**
    - One-call services, such as Linesearch BeforeUdig (LSBUD) or NUAR
    - GIS platforms

4.5 Risk analysis

4.5.1 General

Operators of both metallic pipelines and electrical infrastructure have a statutory obligation to assess and mitigate stray current risks under the Pipelines Safety Regulations, the Electricity at Work Regulations, and the Electrical Safety, Quality and Continuity Regulations, as well as broader obligations under the Health and Safety at Work etc. Act. Their key responsibilities include assessing risks and carrying out regular monitoring and maintenance to ensure ongoing compliance.

Analysis and interpretation of data can be complicated and should consider that risks may change with time and operating conditions. The aim of the analysis is to ensure that the pipeline stays within the recommended criteria given in BS EN ISO 15589-1. Although the calculations to determine AC interference are provided in BS EN ISO 21857, finite element modelling (guidance also provided in the standard) is often carried out.

Analysis may need to be conducted for different criteria or for complex situations and can be expensive. Costs therefore need to be considered and agreed between the parties.

Note: UKOPA/GPG/027, Appendices C and D, list the typical information required of each party to assess or model the AC interference risk. Appendix C lists information that powerline operators would require from pipeline operators, whilst Appendix D lists the typical information that pipeline operators would require of each power line operator.

Developers/promoters should also be aware that construction of occupied buildings associated with an electrical infrastructure development near a Major Accident Hazard Pipeline (MAHP) can have legal implications under the Pipelines Safety Regulations 1996 and the Health and Safety at Work etc. Act 1974. Such development may alter the pipeline's risk profile and route classification, triggering the need for reassessment of safety measures and consultation with the Health and Safety Executive (HSE).

4.5.2 Electrical Interference Assessments

Electrical Interference Assessment (EIA) is an early-stage essential. It should be carried out by the operators / designers of the interfering system to provide the pipeline operator with a report on the risks posed to the pipeline. The nature of the EIA will vary depending on the type of interfering system.

Standards used in the assessment and mitigation of electrical interference must be agreed between all parties prior to being applied.

Initial assessments of pipe/soil potentials should be undertaken before construction starts to establish the existing base line values. Monitoring should be undertaken over a sufficient period to provide reliable data and should include at least one weekend day.

A preliminary EIA should be undertaken based on design assumptions to estimate interaction during normal operation and fault conditions to identify mitigation requirements.

Following completion of works the preliminary EIA should be reviewed applying the as-built conditions, enabling mitigation designs to be finalised.

The EIA, and any proposed mitigation, must take account of existing CP measures in place on the structures likely to be affected and how limitations may affect the mitigation options available. Consideration should be given to the risks of 'overprotection' where excess electrical current can accelerate corrosion, degrade coatings and cause serious integrity issues such as hydrogen embrittlement.

Acceptance criteria shall be determined by the pipeline operator but should be based on the recommendations of BS EN ISO 15589-1 and BS EN ISO 18086.

Persons undertaking EIAs, CP surveys, testing and designs should be able to demonstrate competence to the relevant levels set out in BS EN ISO 15257.

4.6 Developing collaboration between operators

Collaboration across the wider energy industry is key to ensuring asset integrity and reducing the risk of failures, supported by effective information sharing on infrastructure development and a clear, shared consultation process among all stakeholders. This could be achieved by:

- Internal processes for all stakeholders should be updated to take account of good practice to prevent electrical interference, the need for early engagement and collaborative approaches across the industry.
- A register is maintained of pipeline operators, electricity companies, electricity infrastructure developers to facilitate communication.
- Pipeline operators should be included as key stakeholders in projects, allowing them to participate in the consultation process. Communication should be continued throughout the project lifecycle to maintain collaboration (see Figure 4-1).
- Can data be shared to enable modelling and analysis to be conducted?
- Can changes be made to the design or route to minimise impacts?
- Once the design is finalised, are other mitigation methods required to reduce interference, and what are the timeframes and costs involved?
- Pipeline operators are expected to share asset location information when engaged early in major infrastructure projects to support safe and informed planning.
- Asset operators should enter into formal agreements for crossings or shared corridors to ensure adherence to commitments and protocols.
- Once new electrical infrastructure is commissioned there needs to be ongoing communication between electrical and pipeline operators.
- Changes to operating regimes and long term fault conditions should be communicated between electrical and pipeline operators.
- If an electrical development is sold, it is essential that contractual terms or other mechanisms are considered to ensure the new owners continue to uphold existing safety, operational and communication commitments.
- Regular cross-industry meetings are held to share planning horizons for future projects (outline routes, size, scale etc), companies involved, key contacts and timeframes.

- **Feasibility or Conceptual design stage**
- Contact the pipeline operator at the earliest opportunity to discuss project objectives, timescales and potential conflicts/interference issues.

- **Planning stage** (see section 4.4)
- All infrastructure projects should engage pipeline operators early, at the site/route selection stage, to consult, identify and agree protective measures.

- **Detailed design stage**
- Further consultation to discuss how the requirements outlined in this document are observed and the impacts upon the pipeline are minimised.
- share asset data to enable risk analysis /EIA to be carried out (sections 4.5).

- **Pre-construction stage**
- Ensure the pipeline operator has agreed to all of the working methods and pipeline protection measures.
- Inform the pipeline operator when construction is scheduled to start.

- **Construction stage**
- Observe all the operators requirements regarding the protection of the pipeline.
- Ensure the operator is present for those activites they have asked to observe.
- Report any accidental damage to the operator, no matter how minor.

- **Post Construciton / Commissioning**
- Notify the pipeline operator when the construction work has been completed.

- **Operation & Maintenance stage**
- Maintain open channels of communication for operational anomalies, significant fault conditions and future maintenance works in shared corridors

Figure.0_7.Typical.consultation.stages.between.operators.and.developers

5 OVERVIEW OF MITIGATION TECHNIQUES

Where interference cannot be 'designed out' of the project, then there are numerous mitigation methods that could be considered between the designers and pipeline operators.

Mitigation of electrical interference from AC/DC power sources and pipelines must be determined on a site-by-site basis, balancing effectiveness, safety, and cost in line with the As Low As Reasonably Practicable (ALARP) principle.

The introduction of a new source of interference changes the operating environment of the pipeline and requires the adequacy of the existing Cathodic Protection (CP) system to be reviewed. In addition to mitigation designs, new monitoring points may be needed to cover the zone of influence, and increased frequency of measurements may be needed.

Techniques may be appropriate at either the source of interference or at the receiving structure and may be achieved either through improved design or additional measures. Some common effective techniques include:-

- AC buried cable configuration (trefoil)
- Maximising separation distances
- Optimised crossing angle (ideally 90°)
- Avoidance of parallelisms
- Bonding and control devices (metallic bonds, unidirectional controls, DC decoupling)
- Augmentation of existing CP (while avoiding overprotection risks)
- AC phasing and increased cable transposition frequencies on buried and overhead cables
- Utilising underground cables instead of overhead powerlines in shared corridors
- Consideration of location joint bays for underground cables and earthing arrangements
- Use of circuit disconnection devices with improved disconnection times
- Balanced loads
- Good earthing designs
- Gradient control mats, zinc ribbon, or other grounding techniques

The final approach should be guided by field measurements, modelling, and risk assessment by competent individuals. Detailed guidance can be found in industry codes and specifications such as those listed in section 1.5.

6 EMERGENCY EVENT

Prior to construction works commencing near a pipeline, the energy asset owner or promoter must liaise with the pipeline operator to confirm emergency contact details and the key actions in the event of an incident.

This communication must also establish safe working distances in proximity to the pipeline and permissions for activities nearby, such as use of mechanical excavation equipment, piling, blasting or any activity that could cause vibration, soil settlement or interference with ground water along the pipeline route.

6.1 What to do in an emergency

If, as a result of construction activities, a pipeline is exposed or damaged in any way (including coating damage), this should be treated as an emergency situation. In this event, you must:

- Shut down all working machinery.
- Remove all sources of ignition.
- Remove everyone from the immediate area of the pipeline and move to a safer area.
- If the pipeline is leaking, dial 999 inform police and emergency services.
- Do not attempt to seal a leaking pipeline.
- If the leak is burning, do not attempt to extinguish the fire.
- Contact the pipeline operator's emergency telephone number. This can be obtained either from communications you will have had from the pipeline operator, or on the documentation provided by the pipeline operator prior to you commencing work.
- Follow the advice provided by the pipeline operator and then let them make the situation safe.

Note: should a pipeline fail, the hazards that result are product specific. It is important that the pipeline operator's advice for a specific pipeline is followed.

APPENDIX A REFERENCES

Documents referenced in this GPG.

BS EN 50443	-	Effects of electromagnetic interference on pipelines caused by high voltage a.c. electric traction systems and/or high voltage a.c. power supply systems
BS EN ISO 15257	-	Cathodic protection. Competence levels of cathodic protection persons. Basis for certification scheme.
BS EN ISO 15589-1	-	Oil and gas industries including lower carbon energy – Cathodic protection of pipeline systems – Part 1: On-land pipelines
BS EN ISO 18086	-	Corrosion of metals and alloys – Determination of AC corrosion – Protection criteria
BS EN ISO 21857	-	Petroleum, petrochemical and natural gas industries. Prevention of corrosion on pipeline systems influenced by stray currents
ENA/TS/41-24	-	Guidelines for the design, installation, testing and maintenance of main earthing systems in substations
NACE SP0169	-	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE SP0177	-	Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
NACE SP21424	-	Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring
UKOPA/GPG/13	-	Good Practice Guide - Requirements for the Siting and Installation of Wind Turbines Installations in the Vicinity of Buried Pipelines
UKOPA/GPG/14	-	Good Practice Guide - Requirements for the Siting and Installation of Solar Photovoltaic (PV) Installations in the Vicinity of Buried Pipelines
UKOPA/GPG/27	-	Good Practice Guide - AC Corrosion Guidelines
UKOPA/GPG/31	-	Good Practice Guide - DC Interference Guidelines
UKOPA/TBN/005	-	Technical Briefing Note – Electrical hazards on pipelines
UKOPA/TBN/016	-	Technical Briefing Note – AC Corrosion
UKOPA/TBN/017	-	Technical Briefing Note – DC Interference

APPENDIX B DEFINITIONS

AC	-	Alternating Current
ACVG	-	Alternating Current Voltage Gradient - a non-intrusive, above-ground method used to assess the condition of coatings on buried metallic pipelines/structures.
ALARP	-	As Low As Reasonably Practicable - a principle of risk management that requires risks to be reduced to the lowest possible level by implementing protective measures, unless the cost of doing so is grossly disproportionate to the benefit gained.
Barg	-	Bar gauge - unit of pressure relative to atmospheric pressure, as opposed to Bar absolute.
BESS	-	Battery Energy Storage Systems
CCS	-	Carbon Capture and Storage
CDM	-	The Construction (Design and Management) Regulations 2015
CIPS	-	Close Interval Potential Survey, a non-intrusive, above-ground method used to accurately evaluate the effectiveness of a pipeline's cathodic protection (CP) system.
CP	-	Cathodic Protection
DC	-	Direct Current
DCVG	-	Direct Current Voltage Gradient - a non-intrusive, above-ground method used to assess the condition of coatings on buried metallic pipelines/structures.
DESNZ	-	The Department for Energy Security and Net Zero
EAWR	-	The Electricity at Work Regulations 1989
EIA	-	Electrical Interference Assessment
ENA	-	Energy Networks Association
EPR	-	Earth potential rise - also known as ground potential rise
ESQCR	-	The Electricity Safety, Quality and Continuity Regulations 2002
FEN	-	Future Energy Networks
GIS	-	Geographical Information System
GPG	-	Good Practice Guide - documents published by UKOPA, free access
GS[M]R	-	The Gas Safety (Management) Regulations 1996
HSAWA	-	Health and Safety at Work etc. Act 1974
HSE	-	Health and Safety Executive
HVDC	-	High Voltage Direct Current
LSBUD	-	Linesearch BeforeUdig - free online enquiry service to locate utility apparatus in the UK.
NESO	-	National Energy System Operator
Net Zero	-	Current UK Government Strategy to reduce carbon emissions by 2050.
NIE	-	Northern Ireland Electricity Networks
NSIP	-	Nationally Significant Infrastructure Projects - large-scale developments in the UK concerning energy, transport, water, waste, and wastewater that bypass standard local planning rules to speed up the consenting process.

NUAR	-	National Underground Asset Register - UK government-led repository for buried utility apparatus.
Ofgem	-	The Office of Gas and Electricity Markets
PSR	-	Pipelines Safety Regulations 1996
PSSR	-	Pressure Systems Safety Regulations 2000
SONI	-	The independent Transmission System Operator for Northern Ireland.
SPEN	-	Scottish Power Energy Networks
SSEN	-	Scottish and Southern Electricity Networks
TBN	-	Technical Briefing Note - document published by UKOPA, available to UKOPA member companies.
UKOPA	-	United Kingdom Onshore Pipeline Operators' Association

APPENDIX C UKOPA MEMBER COMPANIES

List of UKOPA member companies at the time of publication.

- British Pipeline Agency Ltd (BPA)
- Cadent Gas Ltd
- CATS
- ESB
- ENI
- EP Langage Ltd
- ESSAR
- ESSO
- Exolum
- Gas Networks Ireland
- INEOS
- INEOS FPS
- InterGen
- Mainline Pipelines Ltd (Valero)
- Mutual Energy
- National Gas Transmission
- Northern Gas Networks
- Penspen
- Perenco
- Petroineos
- RRP
- SGN
- Shell
- Sabic
- Swiss Gas +G
- Tata Pipes
- Uniper
- VPI
- Wales & West Utilities