

Good Practice Guide

Requirements for the Siting, Installation and Operation of Battery Energy Storage Sites (BESS) in the Vicinity of Buried Pipelines

UKOPA/GPG/047 Ed 1

March 2026

GUIDANCE ISSUED BY UKOPA:

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

Comments, questions, and enquiries about this publication should be directed to:

UK Onshore Pipeline Operators' Association

Ripley Road
Ambergate
Derbyshire
DE56 2FZ

E-mail: secretary@ukopa.co.uk

Website: www.ukopa.co.uk

Disclaimer

This document is protected by copyright and may not be reproduced in whole or in part, by any means without the prior approval in writing of UKOPA. The information contained in this document is provided as guidance only and while every reasonable care has been taken to ensure the accuracy of its contents, UKOPA cannot accept any responsibility for any action taken, or not taken, on the basis of this information. UKOPA shall not be liable to any person for any loss or damage which may arise from the use of any of the information contained in any of its publications. The document must be read in its entirety and is subject to any assumptions and qualifications expressed therein. UKOPA documents may contain detailed technical data which is intended for analysis only by persons possessing requisite expertise in its subject matter.

Copyright @2026, UKOPA. All rights reserved

Revision and change control history

Planned revision: 2031

Edition	Date	No. of pages	Summary of changes
1.0	March 2026	34	1 st issued for use

CONTENTS

1	Introduction.....	1
1.1	UKOPA Best Practice Guide & Document Purpose.....	1
1.1.1	Document Intention	1
1.1.2	Initial Communications	1
1.1.3	Pipelines Safety Regulations.....	2
1.1.4	Pipeline Mitigations	2
1.2	Battery Energy Storage Systems (BESS).....	3
1.3	Application.....	4
2	UKOPA and the UK Pipeline Network	5
3	Communications Process.....	7
4	BESS Design Stage Considerations	8
4.1	Initial Design Submission	8
4.2	Stray Current Interference from BESS Sites.....	9
4.2.1	DC Interference	10
4.2.2	AC Interference	11
4.2.3	Effects of Stray Current on CP Systems	11
4.3	Electrical Design Risk Assessment	12
4.3.1	Lightning Risk.....	13
4.3.2	Fire Risk	14
4.4	Construction Design Considerations.....	14
4.4.1	Easement and Wayleave Requirements	15
4.4.2	Impact Protection and Temporary Road / Vehicle Crossing Design	15
4.4.3	Other Assets Associated with the Pipeline	16
4.4.4	Management of Change Procedures	16
4.5	Design Stage - Overview of Required Recommendations	17
5	BESS Site Construction Requirements.....	19
5.1	Legal Requirements	19
5.2	Notifications and Consents	20
5.3	Feasibility	20
5.4	Following Planning Consent.....	20
5.5	Prior to BESS Site Construction.....	20
5.6	Prior to the Commencement of Physical Work	21
6	Construction Requirements.....	22
6.1	Required Restrictions.....	22
6.2	Pipeline Operator Supervision	22
6.3	Safe Working Practices.....	22
6.4	Pipeline Infringements.....	23

7	BESS Energisation and Operation Requirements	24
7.1	Pipeline Monitoring and Surveys.....	24
7.2	Ongoing Communications.....	24
7.3	Changes in Operational Scenario	25
7.4	Construction Activity Recommendations Overview.....	26
8	Actions to Take In the Event of an Emergency	27
Appendix A	Applicable Standards and Papers.....	28
Appendix B	Typical Pipeline Information	29
Appendix C	Typical BESS Information	30
Appendix D	Commonly Used Terms and Definitions	31

1 INTRODUCTION

1.1 UKOPA Best Practice Guide & Document Purpose

This document has been produced by UKOPA and is the first edition (Edition 1) UKOPA/GP/047, issued in March 2026. The purpose of the document is to ensure that Battery Energy Storage Systems (BESS), which are to be constructed and subsequently operated within the vicinity of buried pipelines, are designed, sited, constructed, commissioned, operated, decommissioned, and demolished in the safest possible way.

1.1.1 Document Intention

The intention of this document is not to restrict BESS site development and operations, but to provide the developers and operators with an insight into the requirements of pipeline operators, to ensure integrity and safe operations of their assets, and to support the processes required to ensure BESS operations (as a whole) consider such interactions and provide guidance on how to achieve such aspects. The document has therefore been structured to provide BESS developers and operators with guidance and support which shall consider the overall process, from design to operation of BESS sites, with emphasis given to the following aspects:

- Providing a recommended communications protocol with pipeline operators.
 - Providing information relating to appropriate forums / working groups etc. for the ongoing management of such interactions pertaining to the life cycle of both assets.
- Providing recommendations and guidelines pertaining to safe operations of pipelines.
- Providing information relating to required mitigations systems for managing interactions associated with construction and operation of BESS sites and buried pipelines within the vicinity.
- Providing BESS operators with information relating to aspects of pipeline operations which may affect BESS operations.

1.1.2 Initial Communications

Any proposed BESS site developments within 1000m of a buried pipeline should be reviewed, to ensure elements such as pipeline access roads, cathodic protection (CP) system groundbeds (and associated furniture) and AC/DC mitigation measures have been considered.

Once knowledge of existing buried pipelines is clarified, it is of paramount importance that a communications process is established, between the BESS promoter and the associated pipeline(s) operator(s). This is a critical requirement for all proposed interactions; by sharing information at the earliest stage and managing required mitigations, it is possible to reduce costs and delays associated with development, construction and ongoing operations of such sites.

Pipeline operators when notified of the proposed construction of a BESS site, within the vicinity of a pipeline, should ensure that the relevant department is informed as soon as reasonably possible so that the risks to a pipeline can be assessed in line with the recommendations contained within this document, statutory legislation, and the company's stated procedures. Early communications may also identify any risks to which the BESS assets/operations may be subjected due to the presence of local pipeline infrastructure.

Cooperation at this 'early' stage, may present opportunity to mitigate risks (both to pipeline and BESS operation) through modification of initial design and reduce overall costs.

A proficient communication protocol should be implemented and agreed by all stake holders at the earliest possible stage of BESS site design process.

1.1.3 Pipelines Safety Regulations

In Great Britain, the control of risks arising from third party damage to pipelines is addressed by Regulations 15 and 16 of the Pipelines Safety Regulations 1996 (PSR)^[1]. PSR Regulation 15 states: *'No person shall cause such damage to a pipeline as may give rise to a danger to persons'*. Northern Ireland adopted the Pipelines Safety Regulations (Northern Ireland) 1997^[2]; Regulations 15 and 16 are the same as those adopted in the PSR(1996) in Great Britain.

Actions that may be necessary to comply with PSR Regulation 15 include:

- Checks carried out during the planning of a job to establish whether any pipelines or ancillary equipment are in the vicinity of the BESS installation.
- If a pipeline is present, contacting the pipeline operator and obtaining plans.
- Carrying out site surveys.
- Utilising appropriate safe digging techniques in consultation with the pipeline operator.
- Reassessing the risks if the scope of the work changes.
- Stopping work if there are any unexpected findings on site.

PSR Regulation 16 places complementary duties on pipeline operators and states the following: *'For the purpose of ensuring that no damage is caused to a pipeline, the operator shall take such steps to inform persons of its existence and whereabouts as are reasonable'*.

A range of measures can be utilised to secure compliance with PSR Regulation 16.

This GPG sets out to help BESS site developers and pipeline operators by describing the practical steps that they need to take to meet their legal duties and effectively minimise the risks to buried pipelines.

It is therefore suggested that consideration to the above aspects would provide BESS developers and operators with several key efficiencies and drivers (throughout the BESS development process), to increase project efficiencies and reduce subsequent delays.

1.1.4 Pipeline Mitigations

Promoters of new BESS site developments should also be aware that, it is highly likely that pipeline operators will incur additional costs because of the installation of BESS sites within the vicinity of existing pipelines throughout the operational lifetime of the BESS systems and that these costs are likely to be passed on to the promoter of the new works. The costs can include some of the following aspects:

- Above ground surveys pre and post construction of BESS sites to ascertain the current pipeline operational scenario / status.
- Pipeline depth of cover and location surveys.
- Supervision of any key interactions, excavations to the pipeline or work within a pipeline wayleave.
- Review and possible modifications to the pipeline CP systems.
- Requirement for additional CP system monitoring and stray current interference interaction testing pre and post energisation of BESS sites.
- Requirement for the installation of new mitigation measures.
- Management of change procedure implementation costs, legal fees and fees for external consultants that may provide specialist advice.

Note - Clarification relating to costs incurred for ongoing monitoring and maintenance of mitigation and monitoring systems should be discussed and agreed by the BESS developer and pipeline operator on a case-by-case basis. Such costs may include purchase of strategic spares to allow for replacement of consumables (such as ER Probes or remote monitoring equipment) or failure of equipment through time and routine monitoring,

If a CP system grounded is located within or near a BESS site then the grounded location may need to be relocated which could take time and involve considerable expense to the developer, as a new power source may need to be installed, a new grounded site selected and land purchased etc.

Activities required may vary between projects and the pipeline operator and therefore should be assessed on a case-by-case basis at the earliest possible stage of the development process.

Typical information that BESS developers / operators should request from the pipeline operator is detailed in Appendix C, whilst information that the pipeline operator should request from the BESS developer is detailed in Appendix D.

1.2 Battery Energy Storage Systems (BESS)

BESS technology is a means of storing excess energy from the localised electrical grid or associated renewable sources, for use during peak demand. BESS are relatively compact in design and can be installed in a short time frame. Locations can be sourced close to existing power generation systems or strategically across the intended grid route within areas close to the required customer load. Within the UK, BESS site capacity is typically categorised by the voltage levels attributed to the associated power grid connections, these are generally presented as shown in Table 1.

Application	Output Levels	Use
LV Applications	< 1 kV	Local / Residential / Commercial
MV Applications	1 – 69 kV	Commercial / Industrial
HV Applications	69 – 230 kV	Large Scale Grid Storage
EHV Applications	>230 kV	Large Scale Grid Storage / Multiple sites / Multi Giga watt

Table 1 – UK BESS Site Output Classifications

Most large-scale BESS projects within the UK are connected to the national electricity transmission system, above 132 kV (110 kV in Northern Ireland), and used for critical functions such as renewable energy integration and connection, power grid stability, energy trading, peak shaving and demand management. Potential risk to a pipeline from interference increases with proximity and in proportion to the BESS power rating.

With the current ‘global’ increase in electrical dependence, there has been a significant rise in the development and operation of electrical infrastructure to support the increase in demand inherent within the UK. Development and operation of offshore/onshore wind farms and solar/photovoltaic (PV) and BESS sites have seen an almost unprecedented rise, with a focus to transition to renewable energy sources. Such developments, however, do present significant, inherent threats to existing infrastructure such as buried high pressure gas and liquid pipelines, which still provide a significant, critical proportion of global (and UK) energy. In addition to the energy generation sites, there are also associated infrastructure which also increase the footprint of the electrical facilities and present further threat to existing infrastructure.

When considering BESS sites, there are numerous threats from high voltage AC and DC buried and overhead cables with localised sub-stations and associated electrical earthing systems, presenting significant additional threats to buried pipeline assets, which are being encroached upon from numerous directions. Factors associated with fault conditions and regular changes in electrical demand, together with routing of high voltage cables, complex earthing systems and an increase in lightning threat, make such installations a serious challenge when considering the integrity of neighbouring existing

infrastructure. In addition to integrity threats associated with electrical interferences, aspects relative to battery types such as excess heat generation and chemical usage in large scale battery systems also need to be fully understood with emphasis on how such aspects may affect the localised environment in which pipelines may be routed.

The guidance contained in this document is intended to help mitigate risks to buried pipelines from BESS constructions and operation. In addition, this document serves to provide pipeline operators with guidance relating to any state changes in operational scenarios that may have the potential to disrupt BESS operations. By adopting a joint approach to managing risks from such interactions, at the earliest possible stage, and incorporating appropriate mitigations, it is perceived that associated installation costs may be reduced, and interruption of ongoing management and operations of BESS sites may be limited or negated.

Appropriate communication between the BESS site developer/designer and pipeline operator is critical throughout the project to ensure that the interactions between BESS sites and pipelines are managed appropriately thus minimising associated risks and costs. The document has been produced to support both the BESS site developer and the pipeline operator in this communication process throughout the life cycle of both assets. To ensure that the requirements of the document are appropriately applied, it is important that the pipeline operator is contacted by the BESS site developer at the earliest possible stage in the project. This should be at the conceptual design and internal planning stages of any new development.

1.3 Application

The guidance has been developed to minimise the impact of the construction and operation of BESS sites on buried pipelines transporting hazardous materials as defined in Section 2. The requirements within the document cover the siting, design, construction, operation, subsequent decommissioning, and demolition of BESS sites.

The guidance is considered to represent industry good practice. It is based on technical work sponsored by UKOPA and is in line with regulatory requirements and pipeline industry standards. The document has been produced to ensure consistency across the pipeline industry for the mutual benefit of all parties.

Terminology within this document:

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

Information on standards referenced in this document is given in Appendix A, whilst details of commonly used definitions is provided in Appendix B.

2 UKOPA AND THE UK PIPELINE NETWORK

The network of pipelines operated by the UKOPA member companies, is over 27,000 km in length. The safety record for this pipeline network is considered excellent, which is a consequence of pipelines being designed, operated, and maintained to well-developed industry standards, comprehensive risk management and hazard avoidance, the application of a robust legal framework and recognised industry collaborations with appetite to share operational data and experiences.

The pipeline network operated by UKOPA members varies significantly in terms of pressure, materials, coatings, product, diameters, flows etc., therefore understanding the parameters and materials associated with a buried pipeline is critical. Typically, the high-pressure cross-country transmission pipeline networks are of steel construction and buried at depths of 1 m (however this depth may vary and contact with the pipeline operator shall be made to confirm the actual depth) and most of this network is in rural areas away from centres of population. Whereas local distribution utility pipelines are of polyethylene construction and buried at shallower depths of 0.45 m (and typically above). The precise depth of a pipeline would need to be confirmed by trial excavations to positively locate the pipeline, and any excavations would need to be carried out in accordance with the pipeline operators safe working procedures. The actual depth of the pipeline should be used in any calculations or modelling carried out.

The continued safe operation of this network is of paramount importance and requires input from various parties, including promoters of new construction projects and infrastructure which have the potential to jeopardise the integrity of buried pipelines, including BESS sites. Therefore, it is critical to all involved that sufficient safeguards are taken during development, construction and operation of BESS sites to ensure ongoing safe operations. It is well document within industry, that pipelines are subjected to failure, often through casual effects from interferences from neighbouring high voltage electrical infrastructure, such failures, although rare within UK operations, have the capacity to present loss of containment and subsequent environmental hazards and or loss of life.

In addition, both major and minor damage to pipelines can lead to significant production implications, which may lend rise to the loss of gas supplies to homes and industry or disruption of critical fuel supplies and significant environmental contamination.

It is considered that a BESS site could affect a buried pipeline operated by a UKOPA member company in one or more of the following ways:

Construction Activities

- Damage to the pipeline caused during the construction of the BESS site via:
 - Site preparation work including the excavation of soils associated with site levelling
 - Excavations to positively locate the pipeline.
 - The building of construction compounds, the construction and use of access roads, cable trenching, HDD cable installation, lifting operations, fencing/piling activities, landscaping and tree planting, etc.
- Reduction or increase in pipeline depth of cover owing to construction activities associated with a new development.
- Damage caused by drainage of the site including the excavation of drainage ditches.
- Damage caused by piling or the construction of foundations/security fencing and earthing, etc.
- Damage caused by heavy construction traffic crossing over or close to the pipeline.
- Damage caused by installation and operation of electrical, earthing and lightning mitigation systems.

Operational Activities

- DC stray current electrical interferences from HV battery systems and invertors etc. see 4.2.1 DC Interference.
- Interaction with earthing systems.
- Increase in the AC stray current interference risk to the pipeline, which may result in AC corrosion on the pipeline.
 - Enhanced touch and step potential risks from the electrical supply interaction with buried pipelines.
- Increase in the lightning risk on buried pipelines and associated apparatus.
- Increase risk of fire and potential effects of temperature changes to localised soils.
- Chemical impacts associated with industrial battery units and potential effects on local soils/environment.
- Restricting access to the pipeline (including wayleave/deeds of servitude) both during normal operation of the pipeline or in the event of a pipeline emergency.
- Impacts on the operation of the BESS site arising from a pipeline emergency.

Communications between the pipeline operator and the BESS site developer/operator, and taking suitable precautions as outlined in this document, can therefore ensure the above threats to pipeline integrity are managed and avoided.

3 COMMUNICATIONS PROCESS

The following is the recommended communication process between pipeline operators and the BESS proposer



4 BESS DESIGN STAGE CONSIDERATIONS

This section focusses on the initial design requirements associated with the proposed siting of BESS sites and the considerations that shall be given to pipeline operators with existing assets located within 1000 m of the proposed BESS site. The section considers the following elements:

Section	Aspect	Relevance
4.1	Initial Design Submission	Identifies initial interactions and promotes a suitable communication process
4.2	Stray Current Interference	Identifies potential threats relating to AC / DC corrosion and safety aspects attributed to BESS operations
4.2.1	DC Interference Currents	Provides insight into potential threats from DC stray current
4.2.2	AC Interference Currents	Provides insight into potential threats from AC stray current
4.2.3	Effects of Stray Current Interference	Provides insight into potential threats of stray current on pipelines and associated CP systems
4.3	Electrical Design Risk Assessment	Identifies requirements to assess risks associated with BESS operations at the final design stage
4.3.1	Lightning Risk	Provides insight into potential threats from lightning strikes
4.3.2	Fire Risk	Provides insight into potential threats from fire and excessive heat from BESS assets
4.4	Construction Design Considerations	Identifies potential threats relating to general construction activities stipulated within the design
4.4.1	Easement and Wayleave Requirements	Provides information relating to easement rights and future access rights relating to affected pipelines
4.4.2	Impact Protection and Temporary Crossing / loading Points	Provides recommendations for direct access, lifting operations and vibration assessments requirements for construction activities across / near to existing pipelines
4.4.2	Impact Protection and Traffic Crossings	Identifies requirements relating to vehicle loading and crossing of pipeline easements
4.4.3	Other Pipeline Assets	Provides insight into associated pipeline infrastructure that could be affected by BESS site construction
4.4.4	Management of Change	Provides insight into processes and management of change pertaining to BESS design and pipeline operations
4.5	Overview of Recommendations	Table identifying all aspects associated with BESS site design and associated recommendations

Table 2 – Design Stage Summary Overview

4.1 Initial Design Submission

At the earliest possible stage, preferably prior to applying for planning permission (Section 5.1.2), if there is believed to be a buried pipeline (or associated pipeline infrastructure) in the vicinity of a proposed BESS site development area (i.e. within 1000 m of the site boundaries), the pipeline operator should be contacted to confirm the exact location of the pipeline route. It is important that the pipeline operator is contacted by the BESS site developer at the earliest possible stage in the project to ensure that all the requirements of this document are fully understood and are actioned in a timely manner. Owing to the complexity of BESS sites from an electrical interference perspective, all electrical infrastructure should be clearly defined with intended separation distances from buried pipelines.

Note – There are several options/support functions for understating the locations of buried pipelines within the UK, including; online portal - LSBUD, direct contact with pipeline operators, local authorities/councils, the Health and Safety Executive (HSE) and the Oil and Gas Authority. HSE Guidance note HS(G) 47[3] provides guidance on “avoiding danger from underground services,” and is available as a free download from the HSE website. Such contact routes are either free or very low cost and may result in substantial savings by addressing any possible issues early in the design stage, rather than having to rectify issues once construction under way.

Most buried pipelines have legal negotiated rights of access to a strip of land typically between 6m to 25m wide centred on the pipeline. This access strip is known as an easement or wayleave (See Section 4.4.1, Easement and Wayleave Requirements). The proposed BESS site must be sited such that this access strip is always preserved to ensure the pipeline operator has access for maintenance or in the event of a pipeline emergency. If security fencing is to be installed, which may affect access to the buried pipeline, then the pipeline operator should be contacted to ensure that appropriate arrangements can be put in place to enable the operator to access the pipeline for essential maintenance or in the event of an emergency.

Understanding the pipeline operating parameters, materials, products and burial depth etc. are of paramount performance, and should be fully transparent. Any lack of detailed information should not be assumed, and pipeline operators shall endeavour to provide the most recent data relating to the pipeline scenario, depth and precise routes.

Where possible, pipelines should be clearly highlighted in the associated design documents with plans implemented to fence off (the pipeline) during the construction phase and ensure no unauthorised crossing of the pipeline is permitted – this will be advised by the pipeline operator. Where pipeline crossings are required, these shall be made at suitably designated locations, as agreed with the pipeline operator. Should it be the case that the pipeline traverses the proposed development, the pipeline route should be suitably marked with route marker posts, with emphasis on where the pipeline leaves and enters the development and at any change in direction.

The BESS site should be sited such that there is no electrical interference with the pipeline’s cathodic protection system and that any electrical interference is within safe limits. Section 4.2 (Stray Current Interference from BESS Sites) provides further guidance on siting requirements to avoid electrical interference.

The siting of the BESS site should also take account of hazards to the pipeline that may occur during the construction phase, including access for construction vehicles, lifting operations and any elements of construction that may present a vibration issue (pilling activities / HDD cable routing etc.). Further details regarding the precautions that should be taken during the construction activities are detailed in Sections 4.4 (Construction Design Considerations), Section 5 (BESS Site Pre-Construction Requirements) and Section 6 (Construction Requirements).

Note - Formal planning permission from the Local Authority does not take account of the hazards that BESS sites may pose for buried pipelines. Obtaining planning permission should not therefore be seen as confirmation that legal duties under the Pipelines Safety Regulations and Construction Design Management Regulations 2015 (CDM)^[4] have been met.

4.2 Stray Current Interference from BESS Sites

When considering stray current interferences on buried pipelines, BESS sites can present numerous, short and long-term, AC and DC stray currents which have the capacity to cause mechanical damage

and a threat to ‘electrically instructed’¹ personnel and the ‘general public’. Stray currents that are not controlled or mitigated, can present accelerated localised corrosion rates in pipeline material, which can lead to failure or rupture. In terms of liquid medium carrying pipelines, this may present a significant environmental impact, whereas gas carrying pipelines can result in catastrophic failure and loss of life. Additionally, stray currents can present an increased safety risk to humans/animals via differential voltage gradients within the ground, referred to as step and touch potentials. Step potentials are generated when persons traverse a location subject to differential potential gradients in the ground and touch potentials occur via direct contact with electrically continuous metallic pipeline connections.

When considering the HV electrical components that make up BESS sites, there are several aspects to consider, including, but not limited to:

- DC Current leakage
- AC Interference from HV infrastructure, cables and earthing systems (for primary assets and fencing)
- Interference with pipeline infrastructure and cathodic protection (CP) systems
- Increased lightning risks

4.2.1 DC Interference

There are a several issues to consider in relation to DC interference from BESS sites including, but not limited to:

- Long-term effect of DC leakage from battery storage.
- Short term DC current leakage during fault conditions associated with high frequency AC / DC invertors and transformer systems.
- Possible interaction between pipeline protection systems and BESS earthing systems which may lead to premature failure / reduced lifespan.
- Possible interference between pipelines and security fences and their associated earthing and lightning protection systems.

Promoters of new BESS developments should undertake an assessment of the likely risk of DC stray current interference on buried metallic utilities and advise the pipeline owner accordingly. Details of the short-term DC fault currents and the disconnection times of protective devices should be advised to the pipeline operator together with information on the anticipated fault frequency. The BESS operator should also advise the magnitude of any long-term DC current leakage and if the DC current leakage magnitude will be affected by seasonal variation or changes in environmental aspects. DC to AC conversion should be considered in any assessment.

DC Interference from existing pipeline systems, such as cathodic protection systems, may have an adverse effect on the longevity of earthing systems on BESS sites if interaction is not adequately managed from an early stage. Such interference may be avoided or mitigated by careful selection of locations of, and materials for, earthing systems. Addressing the likelihood of such issues at the design stage is more cost efficient than dealing with similar issues through later mitigation.

The use of modelling for ascertaining the levels and magnitude of DC leakage current from BESS systems, is understood to be challenging and may not present accurate results. Owing to the complex nature of the systems involved, non-linear leakage paths and time-based degradation issues, with the requirement to understand various parameters associated with the localised vicinity, it is recommended

¹ ‘Electrically informed’ persons and ‘general public’ referred in 4.2 are defined in IEC 60050-195-04-01^[5].

that an empirical testing approach, via long term remote monitoring or corrosion monitoring (via ER probes) is carried out.

Note - Liaison between BESS developer and the pipeline operator is required to assess the risk of DC current leakage. Specialized audits/review at regular intervals may be necessary including ongoing measurement and monitoring. The BESS operator may have to consider the cost of increased infrastructure inspections, insulation testing and retrofit monitoring devices against the potential cost and damage from DC stray current corrosion.

4.2.2 AC Interference

There are several potential AC interference threats to consider with BESS site operations, these include:

Induced AC Interference from high voltage/high frequency invertors and transformers – Separation distances should be considered to ensure HV/HF invertors and transformers remain as far as practically possible from existing buried pipelines (at least 50 m as per BS EN 50443:2011 separation for buried cables), in addition mathematical modelling should be carried out to ascertain potential induced voltage levels on buried pipelines within the vicinity, along with touch potentials on identified pipeline apparatus. Also the operational frequencies associated with HV/HF invertors and transformers should be fully understood and fed into subsequent interference modelling with buried pipelines.

Electrical earthing systems associated with BESS sites – Review of earthing system types and locations should be carried out, to ensure maximum separation from buried pipelines (at least 50m from the outside the pipeline easement) and associated systems, and robust design. Ground conditions should be reviewed and understood to identify locations of low resistance paths from which stray current may pass. Earth potential gradient modelling under fault conditions should be conducted to determine suitable separation distances between pipeline and earthing locations. Where applicable, pipelines may need to be equipped with electrical resistance probes for ongoing corrosion monitoring.

Induced and conductive coupling from HV AC overhead cables – Where AC overhead cables >132 kV (110 kV in Northern Ireland) are to be installed, maximum separation from pipelines should be implemented and any parallelisms avoided (*refer to UKOPA GPG 027*)^[6].

Induced and conductive coupling from HV AC buried cables - All electrical cables should be kept out of the pipeline easement (apart from pre-agreed pipeline crossing points) and any parallelism avoided or maintained at the maximum practicable distance from the pipeline (> 50 m). Any 'agreed' cable crossings should be kept right angles to the pipeline route and at a minimum depth of separation of 0.6 m for cables operating below 66 kV and 1.0 m above 66 kV and installed in suitably designed ducting / conduits. Cable jointing bays shall not be permitted within the pipeline easement.

4.2.3 Effects of Stray Current on CP Systems

To assess any impacts of the BESS site operation, on the pipeline and the pipelines CP system, the pipeline operator may wish to undertake pre and post energisation monitoring to ascertain the levels of any induced AC / DC voltages on the pipeline during steady state operations. This may be carried out at existing above ground pipeline test posts (TPs), however should distances be deemed 'too great', there shall be a requirement to install specific monitoring equipment at locations considered as high-risk from interference currents.

It should be noted that the potential for AC or DC interference should be considered throughout the lifetime of the pipeline and BESS site interactions, due to systems ageing and degradation of cable insulations, etc. Depending upon the perceived risks of the above and / or the result of initial monitoring surveys, the pipeline operator should install long term monitoring systems and modify existing CP monitoring facilities to detect any issue that may compromise the pipeline or associated CP system.

Where coupons are installed in CP test facilities, they should be AC coupons of 1cm² surface area, and these should be installed in any new and existing CP test facilities on the pipeline within 1000m of the BESS installation.

Should circumstance arise, the pipeline operator may also require installation of permanent corrosion monitoring at key locations, via installation new, or modified, CP test facilities, such as:

- Additional pipeline connections
- Monitoring electrodes
- Monitoring Coupons
- Remote access electrical resistance probes
- Other remote monitoring systems.

In addition, base line CP performance and coating condition assessments may be required to feed into the overall risk evaluation pertaining to the pipeline in question. It should be noted that any voltages or currents calculated as induced by means of modelling will be imposed upon the existing pipeline conditions by addition to values determined during fingerprint monitoring. Any modelled values should be confirmed by post commissioning and long-term routine monitoring. It is only by considering the totality of interference values imposed upon the pipeline that required mitigations may be identified.

Note: - UKOPA/GPG/031^[14] provides guidance on protection against stray current from direct current systems. UKOPA/GPG/027^[6] provides guidance on protection against stray current from AC systems.

The capital and incidental costs of any monitoring systems and any remediation works that are deemed necessary would be recharged to the BESS site developer. Should subsequent issues arise relating to changes in operational scenarios associated with BESS sites resulting in changes with pipeline interactions, additional consequential costs may be incurred.

4.3 Electrical Design Risk Assessment

Risk Assessment Overview - For the pipeline operators to fully understand the threat of stray current interference on existing buried pipelines, a comprehensive electrical risk assessment should be carried out upon completion of the initial BESS design stage. This should consider the potential for stray current interference from all associated electrical infrastructure attributed to the BESS site in question. Considerations should be given to understanding all aspects of AC/DC outputs and expected load implications such as high-capacity inrush currents and voltage surges associated with start-up and state changes in HV invertors and switching equipment. Separation distances, from buried pipelines, of all associated HV cabling and electrical infrastructure should be reviewed in line with guidance within BS EN 50443^[9].

In addition, effects from lightning and fire/excessive heat should be considered within the risk assessment.

Mathematical Modelling - A risk assessment showing the impacts of the effects of a rise of earth potential (touch and step potentials and possibility of the transfer voltage on a pipeline exceeding safe limits for personnel), under fault conditions from local connections to the distribution network operator (DNO). DNO connections should be submitted to the pipeline operator for consideration at the completion of the design phase and prior to the commencement of any construction works. For HV and EHV applications, mathematical modelling of induced AC voltages (steady state and fault conditions), should be carried out and provided to the pipeline operator for review against the applicable standards. This should include assessment of touch potentials on exposed pipeline apparatus such as test post terminals.

Note - BS EN 50443^[9] provides guidance on the permissible touch potential limits on pipelines during fault conditions. However, as this guidance only applies to electrically instructed personnel, it is considered that the permissible touch potential limits on cross country pipelines should be those detailed in BS EN 50122-1^[10]. The latter values should be utilised by BESS developers to determine safe transfer voltages on pipelines rather than the values given in BS EN 50443^[9]. HV earthing software, operated by electrically competent people, such as CDEGS, can allow for modelling of a pipeline and auxiliary equipment and confirmation of any issues. BS EN ISO 18086^[11] provides guidance on protection criteria in the presence of AC interference.

Electric Cabling & Earthing Systems - Cable and earthing diagrams should be provided to the pipeline operator for consideration at the completion of the design phase and prior to the commencement of any construction works. These should show the proposed location of all earthing and electrical cables (both buried and above ground) and the cable current carrying capacity and voltage ratings.

All electrical cables should be kept out of the pipeline easement (apart from pre-agreed pipeline crossing points). Both buried and above ground AC electrical cables should be routed to avoid the cables running parallel to the pipeline; sub-stations should not be placed adjacent to pipelines and kept at the maximum possible distance from the pipeline. It is essential that bare earth cables should not cross the pipeline easement under any circumstances, even if installed in ducts.

Where a buried electrical cable or other services are required to cross the pipeline route, then the pipeline operator should specify the minimum clearance distance above or below the pipeline.

Seasonal Variation - Levels of stray current interference affecting pipelines, are subject to seasonal variation. Wetter periods during winter months may see lower ground electrode resistance values and subsequent higher leakage currents, whilst during dryer summer months stored energy within BESS sites will most likely be higher.

Changes to Design - Any changes to the design after the initial agreement between the BESS developer and the pipeline operator will require the pipeline operator's informed, written consent.

The development of this risk assessment, and the initial design package review, shall enable the pipeline operator to understand the risk and develop and implement appropriate field testing / surveys, fingerprint & corrosion monitoring and or installation of required mitigations systems associated with the integrity of the pipeline being affected.

4.3.1 Lightning Risk

There are several aspects relating to the construction, design and operational parameters of BESS sites (high-capacity DC circuits, relative height of exposed metallic structures etc.) that present an increased risk of lightning strikes which could induce transient voltages onto nearby buried pipelines. Lightning surge currents are of a variable, unknown fault current magnitude and duration and could pass from any lightning protection or electrical earth system to the pipeline.

The pipeline operator may request the BESS site developer to undertake a lightning assessment, as detailed in BS EN 62305-2^[12] and BS EN 62305-3^[13] to fully understand the risk of lightning effects. It is understood that the standard focusses largely on the risks to human life and loss of directly connected public services, therefore understanding the actual threat of mechanical damage to an adjacent pipeline, from a nearby lightning strike, may not be included in the outputs. This said, the BESS developer should undertake a lightning risk assessment to understand what the probability of a lightning strike and consequences would be, not only to the BESS site but also the surrounding area, with emphasis given to providing calculated outputs for the likelihood of loss of human life, electric shock

(step and touch) and fire. If the risk assessment is performed correctly then the factors relating to the pipeline can be included.

4.3.2 Fire Risk

Operational BESS sites present an increased risk of fire which may have potential to impact buried pipelines within the vicinity. Aspects such as thermal runaway in battery cells, overvoltage in electrical infrastructure, cooling system failures and aspects associated with the chemical composition of storage cells and the complexities of managing such fires, all require consideration.

The threat of localised fires / excess heat in the vicinity of buried pipelines, can present multiple threats including, but not limited to:

- Temperature changes in localised soils which may affect the corrosion status of the local environment
- Damage to the pipeline and/or coating
- Increased risk of arc strike from HV overhead cables (subsequent increased stray current threat) due to changes in the ionization levels from smoke and hot gasses.

The BESS developers should therefore undertake a fire risk assessment to understand what effects of fire may have on the local environment and implement any required mitigations. This should include how any emergency pertaining to fire is managed and controlled.

4.4 Construction Design Considerations

As well as observing the siting requirements in Section 5.1 the construction of the proposed BESS site should be planned such that:

- There is sufficient access for all construction equipment and vehicles avoiding the need to cross over the pipeline.
- There is sufficient separation between the proposed construction activities and the pipeline including any planned lifting operations. Any work within the pipeline easement should be subject to agreement and a permit to work issued by the pipeline operator.
- No piling operations to take place within 15m of the pipeline without written approval from the pipeline operator (vibration monitoring or assessments may be required depending on the scenario).
- Advance notice shall be given to the pipeline operator for any planned infringements within the pipeline easement, to enable the operator to have site representation for witnessing any such activities.

Lifting of equipment over the pipeline route (i.e., the pipeline easement width) shall be avoided. The pipeline operator should review and comment on the lifting plans for all planned lifts in the vicinity of the buried pipeline. The pipeline operator may also request to be present whilst these lifts are taking place, see Section 6, Construction Requirements.

If the crossing of vehicles and heavy machinery over the pipeline cannot be avoided during construction of the BESS site, then the pipeline operator should agree the specific measures required to protect the pipeline. The pipeline operator should confirm that these measures are in place prior to the commencement of the proposed construction work.

Note – Any crossing of the pipeline shall only be permitted at designated crossing locations.

4.4.1 Easement and Wayleave Requirements

Most buried pipelines have easements, also known as a deed of grant or wayleaves. These are legal entitlements to rights of access agreed by the pipeline operator with the landowner which allow the pipeline operator to have access to install and maintain the pipeline within a specified strip of land.

Easement and wayleave strips vary in width depending on the diameter and pressure of the pipeline but are typically a strip between 6m and 25m in width centred on the pipeline. The majority of easement and wayleave agreements also allow the pipeline operator the right to restrict any permanent construction within the agreed easement strip.

The relevant pipeline operator should provide details of the extent of the easement strip in the vicinity of the proposed BESS site development.

A Deed of Indemnity may be required for any cables or concrete slabs that cross the pipeline. A Deed of Indemnity may also be required for the construction of temporary or permanent vehicle crossings over the easement.

4.4.2 Impact Protection and Temporary Road / Vehicle Crossing Design

Some UKOPA pipeline members have their own standards that cover the design of impact protection and installation of temporary structures across pipelines.

The design of the impact protection should ensure that that loads on the pipeline system will not exceed safe limits and will not cause deformation of the pipeline for the axle loads imposed. The use of vehicle crossings will be restricted to the loadings notified in the design and these shall not be exceeded throughout the lifetime of the BESS site.

The loads imposed on pipelines by vehicular movements should not cause deformation of a pipeline system and should be within safe limits.

The pipeline operator will need to approve any impact protection design calculations.

Prior to the installation of impact protection or temporary road crossings, a pipeline coating evaluation survey, such as CIPS, DCVG, or other inspection required by the pipeline operator, shall be required across the location in question. The pipeline operator shall be given the opportunity to repair any issues revealed by such surveys prior to construction of any impact protection or crossing point.

4.4.3 Other Assets Associated with the Pipeline

The planned construction works should also recognise any potential impacts on other infrastructure associated with the pipeline. This may include:

- Buried cables associated with the pipeline's CP systems, including
 - bond connections to other pipelines,
 - TR power supply cables (above or below ground),
 - Pipeline connection from TR,
 - Groundbed connections from the TR,
 - Test post cabling.
- Cathodic protection system groundbeds associated with the pipeline's CP systems.
- Above ground pipeline marker posts and above ground CP system test posts.
- Pipeline anchor points, if for example the pipeline is constructed in land that is susceptible to flooding.
- Buried pipeline valves, fittings, and sleeves.
- Any AC interference mitigation system earths.

The pipeline operator should provide appropriate advice on the precautions that need to be taken to prevent these systems being damaged.

There may also be buried land drainage in the vicinity of the pipeline, installed by the pipeline operator to protect the pipeline and its associated installations from flooding, or by the landowner to protect their land from the effects of flooding. It is important that both the landowner and the pipeline operator are contacted so that they can advise of the potential impacts of the proposed construction works on any buried drainage assets.

Should there be any CP groundbeds located within the vicinity of a new BESS site, these may have potential to cause DC stray current interference on buried / grounded metallic structures, electrical earthing systems and telemetry systems, and subsequently cause failure / damage or accelerated corrosion. It may therefore be necessary to relocate a groundbed, or to choose different materials for earthing systems, to avoid long term damage to being sustained to BESS systems / infrastructure.

The costs of any such relocations deemed necessary would be recharged to the BESS site developer. It should also be noted that changes to locations of groundbeds may take significant time, beyond the control of the pipeline operator.

4.4.4 Management of Change Procedures

Most UKOPA pipeline members have their own management of change (MoC) procedures that should be followed for modifications to pipeline / CP systems or work on those systems. Should the case be that any such activities are to be undertaken, relating to upgrading or significant changes to the operational scenario of a pipeline in the vicinity of a BESS site, the pipeline operator shall communicate with the BESS site operator at the earliest possible opportunity.

In addition, should any changes arise to the BESS design, cell chemistry or electrical outputs, these should be communicated to the pipeline operator at the earliest possible opportunity.

Personnel undertaking any design reviews should have the necessary levels of design competency.

4.5 Design Stage - Overview of Required Recommendations

Applicable Section		Recommendations	Relevance	Responsible Party
Section	Stage			
4.1	Initial Design	Initial Communication - Initial communication with Pipeline Operator to assess initial risks associated with the development	Communication to state the intentions of the BESS development to the Pipeline Operator	BESS Developer
		Communication Process - Set up and agreed communications process	Enables all parties to discuss relevant details pertaining to proposed interactions	Joint
		Design Review - Review of Initial BESS Design	Review of proposed design to ascertain initial threats which require consideration and define separation distances	Pipeline Operator
		Information Sharing - Sharing all pertinent information / details	Sharing of all pertinent information relating to the pipeline operational scenario and the proposed BESS development including funding requirements / cost implications for fingerprint monitoring, mitigation, validation and ongoing monitoring.	Joint
		Above Ground Surveys - Carrying out any required CIPS / DCVG surveys	To ascertain the status of the pipeline CP performance and coating condition local to the planned works	Pipeline Operator
4.2.1	Stray Current Interference from BESS Sites	DC Interference Modelling - Undertake Assessment of DC interference threats via empirical testing	Assessing short- and long-term effects of DC interference threats to pipelines within the vicinity	BESS Developer
4.2.2		AC Interference Modelling - Undertake Assessment of DC interference threats via mathematical modelling	Assessing short- and long-term effects of AC interference threats to pipelines within the vicinity	BESS Developer
4.2.2		Separation Distances – Stipulates recommended separation distances for electrical infrastructure	Provides recommended distances to be achieved between HV electrical infrastructure and buried pipelines to minimise interference effects	BESS Developer
4.2.3		Fingerprint Monitoring - Pre and Post energisation monitoring of steady state AC and DC potentials and currents	Assesses the actual levels of AC and DC interference affecting the pipeline before and after energisation of the BESS site	Joint

Applicable Section		Recommendations	Relevance	Responsible Party
Section	Stage			
4.2.3		Corrosion Monitoring - Where necessary, installation of additional corrosion monitoring facilities	To monitor the ongoing corrosion status pertaining to the pipeline location at locations considered high risk from interference	Joint
4.3	Electrical Design Risk Assessment	Electrical Risk Assessment - Undertake a comprehensive electrical risk assessment	To provide insight into potential interactions between HV BESS systems and pipelines within the vicinity	BESS Developer
4.3.1		Lightning Risk Assessment - Undertake a comprehensive lightning risk assessment	To ensure all control measures and mitigation steps are in place to mitigate / reduce the threat of lightning affecting pipelines within the vicinity	BESS Developer
4.3.2		Fire Risk Assessment - Undertake a comprehensive fire risk assessment	To ensure all control measures and mitigation steps are in place to mitigate / reduce the threat of fire / excess heat affecting pipelines within the vicinity	BESS Developer
4.4	Construction Design Considerations	Vehicle Loading Assessment - Where required, assessment to be carried out for vehicle loading and crossing points	Review to ascertain the maximum permissible loads which a buried pipeline can withstand	BESS Developer
4.4.2		Vibration Assessment - Where required, assessment to be carried out for vehicle loading and crossing points	Review to ascertain the effects of any vibration from piling or drilling activities and how they could affect pipelines within the vicinity	BESS Developer
4.4.3		Review of Existing Pipeline Assets - Review of all associated pipeline furniture and CP infrastructure	To ensure all pipeline assets are at reasonable distances from any potential third-party issues, and to ensure any local ICCP groundbeds will not interact with BESS operations	Pipeline Operator

Table 3 – Design Stage Recommendations

5 BESS SITE CONSTRUCTION REQUIREMENTS

This section focusses on the construction requirements associated with proposed BESS sites and the considerations that shall be given to pipeline operators with existing assets which are at risk of interaction / encroachment from proposed construction activities. This section considers the following elements:

Section	Aspect	Relevance
5.1	Legal Requirements	Identifies the legal requirements for managing the development and interactions with existing buried pipelines
5.2	Notifications and Consent	Identifies the required notification periods for each key stage of the development and subsequent interactions.
5.3	Feasibility Stage	Identifies the required communications and proposed intentions prior to any detailed design being submitted.
5.4	Planning Consent	Identifies the information which should be provided to the pipeline operator pertaining to the final design and any information required by the BESS developer to facilitate any required assessments.
5.5	Prior to Construction	Identifies the required and time scales for installation of any required mitigation / protection systems
5.6	Prior to Commencement of Physical Works	Identifies the key interactions and timescales associated with proposed construction and

Table 4 – Pre-Construction Summary Overview

5.1 Legal Requirements

Under the Construction (Design and Management) Regulations 2015 (CDM)^[4] the Principal Designer is required to plan, manage, and coordinate the planning and design work to ensure that the installation can be built, maintained and operated safely. The principal designer is also required to produce and maintain a health and safety file, which must include information related to the management of health and safety risks during any future maintenance, repair, construction work or demolition work. For work in the vicinity of a pipeline, the health and safety file and design safety risk register must also recognise the potential hazards associated with the pipeline, how these will be mitigated and the residual risk that will remain.

In addition to CDM, there are also several Regulations that are relevant to construction work in the vicinity of buried pipelines. These include Regulation 15 of the PSR^{[1][2]}. As detailed in Section 1, Regulation 15 specifies that ‘no person shall cause such damage to a pipeline as may give rise to danger to persons’. To meet this legal requirement, it is important that the requirements in the following sections of this document are followed.

5.2 Notifications and Consents

It is important that the pipeline operator receives a minimum of 4 weeks' notice of any planned work within the vicinity of the pipeline. This will allow the pipeline operator to provide the BESS site developer with early advice which will help with the planning of the proposed work and understand any constraints on the design, including details of any specific pipeline issues that need to be addressed. The pipeline operator should expect to be contacted at the following stages of the project:

- Feasibility Stage
- Acceptance of Planning Consent
- Prior to Construction Activities
- Prior to and During Construction Works
- Prior to commissioning

5.3 Feasibility

At the earliest possible stage in the project, the pipeline operator should be contacted in writing with details of the proposed BESS site development. This should include details, if known, of the proposed location of the major items of equipment, their foundations, lightning and earthing systems that might impact upon the buried pipeline. Details of the planned project timescales should also be provided at this stage.

This information will allow the Pipeline Operator to make an initial assessment of the risks presented to the pipeline and its' associated systems. The Pipeline Operator should respond with the data necessary to enable a formal risk assessment of likely pipeline interaction(s) and begin the process of identifying required actions and mitigations to support the safe installation and operation of the proposed BESS site.

The pipeline operator should be advised when formal planning permission is applied for to facilitate appropriate input into the planning process.

5.4 Following Planning Consent

Once planning consent has been given, the pipeline operator should be provided with details regarding the proposed location of the major items of equipment. This should include site plans providing the details of supporting foundations and other infrastructure such as the location of buried and / or overhead cables and any other ancillary equipment such as invertors, transformers, DC / AC converters and earthing systems. Any changes to the proposed project timescales should also be provided at this time. In addition, any pipeline specific information which may feed into any mathematical modelling, vibrations assessments or crossing / vehicle loading assessments, should be provided to the BESS operator.

5.5 Prior to BESS Site Construction

Once the construction programme is known, the pipeline operator should advise on any pipeline protection measures required. The pipeline operator should review construction arrangements and method statements at this stage including lifting plans and site access arrangements. Formal confirmation should be provided to the pipeline operator that any required pipeline protection measures have been put in place before the commencement of any construction work.

Depending on how close the proposed work is to the pipeline route, the pipeline operator may wish to supervise any work that was close to, or over, the pipeline. It is important that these arrangements are agreed with the pipeline operator at this stage.

The pipeline operator should be consulted during the design phase of the BESS site to ensure any issues that may impact on the integrity of the pipeline system can be identified prior to construction e.g. location of distribution network operator (DNO) equipment, cable and track/road crossing details and locations.

Location of any offices, stores, fencing, temporary electrical supplies and parking within the vicinity of the pipeline needs to be considered and agreed.

The pipeline operator will then need review records (including in-line inspection, maintenance, etc.) to take account of any fittings or features on the pipeline within the vicinity of the proposed works.

5.6 Prior to the Commencement of Physical Work

Prior to the commencement of the proposed construction work, the pipeline operator should review and comment on the method statements for the planned construction activities that might affect the pipeline. These method statements should include details of any pipeline protection requirements and any other constraints on working arrangements specified by the pipeline operator.

Prior to the works commencing, the pipeline operator should review:

- Details of any locations where the pipeline will be crossed with vehicles (specific vehicle types with ground loadings), plant and equipment, the operator may require additional pipeline protection measures at these locations.
- Details of any significant lifting operations to be carried out in the vicinity of the pipeline easement.
- Details of any utilities that will be crossing the pipeline, including the location of electrical cables and the associated voltages.
- Details of any drainage and fencing systems to be installed.
- Location of any other pipeline systems in the vicinity of the BESS site.
- The locations of all battery storage cells and associated electrical infrastructure.

The pipeline operator should be given a minimum of 4 weeks' notice prior to the commencement of work on site. The route of the pipeline should be marked out by the pipeline operator or the pipeline operator's representative prior to the commencement of any work on site, where possible, the pipeline should be separated from construction works via physical placement of fencing at the extremes of the easement.

Note: *Pipelines are not always laid in straight lines so the location of the marker posts should never be used to infer the location of the buried pipeline.*

All required pre construction field testing / surveys and monitoring should be carried out in advance of construction activities. The results of which should be shared between all parties, reviewed by the relevant personnel, and any actions discussed and agreed in writing.

6 CONSTRUCTION REQUIREMENTS

This section focusses on the construction requirements associated with proposed BESS sites and the considerations that shall be given to pipeline operators with existing assets which are at risk of interaction / encroachment during construction activities. This section considers the following elements:

Section	Aspect	Relevance
6.1	Required Restrictions	Identifies any required restrictions relating to actual construction processes / methods
6.2	Pipeline Supervision	Identifies any interventions into the pipeline or pipeline easement which should be witnessed / supervised by the pipeline operator
6.3	Safe Working Practices	Provides BESS developer with all required safe working practices pertaining to construction activities within the vicinity of a buried pipeline
6.4	Pipeline Infringements	Provides details of any potential third-party interference / infringements during construction activities
7.1	Overview of Recommendations – All Construction Related Activities	Table identifying all aspects associated with BESS site design and associated recommendations

Table 5 - Construction Summary Overview

6.1 Required Restrictions

The pipeline operator should provide the BESS site developer or their nominated agent with details of all restrictions that should be observed during the construction of the process. This shall include requirements regarding the use of excavating machinery, power tools and piling in the vicinity of the pipeline and any restrictions with respect to the storage of materials and equipment, including storage compounds, and the parking of vehicles. Additional consideration should be given to the storage of any equipment containing lithium-ion or harmful chemical substances.

6.2 Pipeline Operator Supervision

Prior to any construction activities taking place, the pipeline operator shall provide locating and physical demarcation of the pipeline route (and depth) and easement boundaries.

Where necessary, supervised trial excavations in accordance with the pipeline operator's standard procedures and permitry may be required to ascertain actual pipeline depth of cover.

The pipeline operator will also provide details of the specific activities that require supervision. This should include any activities taking place within the pipeline easement, any crossing of burial cables / cable ducting, or any requirement to install pipeline protection systems / fencing close to the pipeline.

Under no circumstances should any of these activities be undertaken without the pipeline operator or their nominated representative being present.

6.3 Safe Working Practices

Details of the pipeline operators' safe working practices/procedures shall be provided to the BESS developer/operator and appropriate, agreed, training is given to all construction personnel on the nature of the hazard namely a high-pressure pipeline system.

The pipeline operator shall confirm that any specified pipeline protection measures, including protection under vehicle access routes and fencing off vehicle access routes and / or roadways, are in place.

No work should commence until the BESS site developer has received a formal written confirmation from the pipeline operator that all the necessary controls are in place and that the work can proceed.

6.4 Pipeline Infringements

Any damage to the pipeline, including even minor damage to the pipeline's coating, can have a long-term effect on the pipeline's integrity. **It is therefore very important that any damage or suspected infringements to the pipeline that occur during construction work, no matter how slight, shall be reported immediately to the pipeline operator.**

All personnel working on site should be made aware of the potential hazards associated with the pipeline and the actions they should follow in case of an emergency, **see Section 8, Actions to Take In the Event of an Emergency.**

If at any time during the new construction the pipeline operator is required to carry out emergency works on the pipeline, the work on the new BESS site construction should cease until the work has been completed. This work will be carried out in the shortest possible time. The pipeline operator will not be responsible for any delay or associated costs to BESS site program of works; however any requirements shall be communicated at the earliest opportunity.

7 BESS ENERGISATION AND OPERATION REQUIREMENTS

Section	Aspect	Relevance
7.1	Monitoring and Surveys	Identifies any requirements to carry out additional post energisation monitoring or survey works
7.2	Ongoing Communications	Identifies relevant personnel contacts and ongoing communication requirements between BESS and Pipeline Operators
7.3	Changes in Operational Scenario	Identifies requirements to communicate any changes in the operational scenarios pertaining to the BESS site and the Pipeline
7.1	Overview of Recommendations – All Construction Related Activities	Table identifying all aspects associated with BESS site design and associated recommendations

Table 6 – Energisation and Operation Summary Overview

7.1 Pipeline Monitoring and Surveys

The pipeline operator may wish to undertake ongoing monitoring or install long term monitoring systems to detect any interaction relating to the operation of BESS sites, which may compromise the pipeline integrity, CP system or other associated components.

Any required post energisation monitoring or data logging shall be carried out to consider the following operational scenarios:

- During initial commissioning of the BESS site.
- Upon confirmation from the BESS operator that the site in question is fully energised and operating as expected and at the expected demand.
- During charging and discharge cycles at the earliest opportunities (Placement of ER probes may be required to conduct this testing).

The pipeline operator will require unobstructed access to the pipeline easement, to carry out any essential maintenance or above ground surveys / inspections at periodic intervals throughout the BESS lifespan, to assess the pipeline condition. Notifications of intended works shall be provided in advance to the BESS operator where possible.

7.2 Ongoing Communications

It is important that the pipeline operator is notified of any ongoing or future operational activities that have the potential to impact the pipeline. The pipeline operator shall provide the BESS site operator with the necessary contact details and shall provide guidance on the activities to be notified of and the required pre notification period. This would normally include any underground works within 50 m of the pipeline. Typically, the pipeline operator will require at least 4 weeks' notice prior to any work being undertaken that may impact the pipeline.

Contact details for all relevant parties associated with any interactions between the pipeline and the BESS site shall be shared via an open forum, this shall include the relevant pipeline integrity engineer (or their representative) and the BESS development manager and subsequent operations and maintenance manager (for operational BESS sites).

In addition, results of any associated monitoring or inspection data relating to any interactions between pipeline and BESS sites should be shared to all concerned and the relevance of the findings should be explained in via an open forum or designated interactions working group.

7.3 Changes in Operational Scenario

Any changes to the operation of the BESS site in terms of installation of additional assets or increases / state changes associated with electrical outputs / modifications in design or chemistry relating to battery cells etc. shall be communicated in advance and discussed with the pipeline operator.

The Developer should liaise with the pipeline operator and confirm that there will be no enduring detrimental effect from the new BESS development on buried pipelines and confirm that the BESS site and associated electrical infrastructure has the required electrical insulation resistances. Reports pertaining to periodic resistance and insulation testing should be issued to the pipeline operator for review. In addition, results of ongoing pipeline monitoring and inspections should be issued to the BESS operator and relevance of the captured data explained.

Ground fault protection devices should provide an alarm in the event of fault conditions. If there has been DC leakage current observed from the BESS site, the pipeline operator should be notified immediately. Details relating to any such events, including specific dates / times and current leakage magnitude etc. should be provided at the earliest opportunity.

Prior to BESS site operation, the operator should liaise with the pipeline operator to ensure all the relevant contact details for use in the event of an emergency have been provided and the key actions that should be taken have been specified.

It is important that any restrictions or requirements specified by the pipeline operator continue to be observed during the lifetime of the BESS site. If in any doubt, contact the pipeline operator.

There may be some non-routine operations associated with the pipeline that could have an impact on the operation of the BESS site. These may include operations that will require the BESS operations to temporarily cease / shut down. Should this be anticipated, then the pipeline operator will discuss any restrictions on the operation of the site with the BESS operator in advance of the proposed works.

The BESS operator shall ensure that no plant or equipment that may cause damage to the pipeline or crosses the pipeline easement and will indemnify the pipeline operator against any costs arising.

7.4 Construction Activity Recommendations Overview

Applicable Section		Recommendations	Relevance	Responsible Party
Section	Stage			
5.1	Legal Requirements	Health and Safety File - Development of a health and safety file to assess and mitigate all associated threats / risks associated with the pipeline	Ensure all threats and risks are documented and managed and to provide continuous update should BESS operations change over time	BESS Developer
5.2	Notifications and Consents	Notifications of Construction - Notification period to be given to the pipeline operator in advance of construction works commencing	Ensures the pipeline operator has ample time to communicate any required constraints pipeline specific operations to the BESS developer	BESS Developer
5.2.1	Feasibility	Locations of Major Infrastructure - Upon completion of final design, details of the final locations for major electrical and earthing equipment to be provided to the pipeline operator	Enables the pipeline operator to fully understand any design factors which could affect the pipeline which have not been considered during the initial design stage	BESS Developer
5.2.3	Prior to BESS Construction	Construction Programme - To be provided to the pipeline operator in advance of any construction works	Enables the pipeline operator to understand the construction processes and schedule, with emphasis given to dates associated with key interactions	Joint
6	Construction Requirements	Supervision of Interactions - Pipeline operator to provide details of personnel to undertake witnessing / supervision of key interactions and pipeline safety measures which are to be implemented	Enables all key interactions and safety measures to be supervised by the pipeline operator including allocation of cost.	Pipeline Operator
7	BESS Energisation	Ongoing Monitoring - Where required, pipeline operator to undertake any ongoing monitoring or installation of specific monitoring equipment	Enables ongoing changes in corrosion / third party inference issues to be monitored throughout the life of the interactions.	Joint
7	BESS Energisation	Ongoing Communications - Communication process and relevant key personnel to be defined to communicate any future changes in the BESS / Pipeline operational scenarios	Identify key personnel and maintain ongoing communications between all parties	Joint
8	Emergency Actions	Emergency Response - Identification of key personnel and contact details should any future emergency arise	Enables a suitable process to be established in the event of an emergency and defines roles and responsibilities	Joint

Table 7 Construction Activity Recommendations

8 ACTIONS TO TAKE IN THE EVENT OF AN EMERGENCY

What to do in an emergency:

If, because of BESS activities, ground is uncovered within the pipeline easement or any contact with a HP pipeline is noted, this potentially is a serious incident and should be treated as an emergency. The following actions should be realised:

- 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 that 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.

In addition, should there be any emergency actions (significant damage, rupture or leak leading to loss of product) pertaining to the pipeline, the following actions should be realised by the pipeline operator:

- Alarm to be raised, emergency services to be contacted and the BESS site emergency contact to be notified of the incident immediately.
 - Details of required emergency actions for the BESS site and operations to be shared at this point (product details / required actions and hazard zones for personal safety and equipment shutdowns to be communicated).
- Any required pipeline pressure reductions / isolations to be put in place.
- Relevant authorities to be notified (Electricity providers / local regulatory bodies etc.)
- Electrical isolations to be implemented.
- Pipeline emergency response team to attend site and assess situation.
 - Ongoing discussions / communications to be made with BESS operators regarding the situation and any timescales relating to impacts on operations etc.

APPENDIX A APPLICABLE STANDARDS AND PAPERS

UKOPA have provide a table of applicable standards and reference documents associated with all aspects considered within this Good Practice Guide. It should however be noted that, some pipeline operators will be reliant on operator specific standards which are not included below.

Reference	Document	Title
[1]	Regulation UK	Pipelines Safety Regulations (1996)
[2]	Regulation (Northern Ireland)	Pipelines Safety Regulations (1997)
[3]	HS(G)47	Avoiding danger from underground services
[4]	Regulation	Construction Design Management Regulations 2015 (CDM)
[5]	IEC 60050-195-04-01:2020	International Electrotechnical Vocabulary (IEV) - Part 195: Earthing and protection against electric shock
[6]	UKOPA GPG 027:2019	AC Corrosion Guidelines
[7]	BS EN 50162:2004	Protection against stray current from direct current systems
[8]	BS EN ISO 21857:2021	Petroleum, petrochemical and natural gas industries. Prevention of corrosion on pipeline systems influenced by stray currents
[9]	BS EN 50443:2011	Effects of electromagnetic interference on pipelines caused by high voltage AC electric traction systems and/or high voltage AC power supply systems
[10]	BS EN 50122-1:2022	Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Protective provisions against electric shock
[11]	BS EN ISO 18086:2020	Corrosion of metals and alloys – Determination of AC corrosion – Protection criteria
[12]	BS EN 62305-2:2024	Protection against lightning – Risk Management
[13]	BS EN 62305-3:2024	Protection against lightning – Physical damage to structures and life hazard
	BS EN 15280:2013	Evaluation of AC Corrosion likelihood of buried pipelines - Application to cathodically protected pipelines
[14]	UKOPA/GPG/031:2020	Good practice guide for DC Interference

Table 8 – Standards and Papers

APPENDIX B TYPICAL PIPELINE INFORMATION

The following is a typical example of pipeline information for consideration in BESS development.

Item	Question	Pipeline Operator Response
1.0	Pipeline design details, building proximity distance (BPS) and operating pressure?	
2.0	Product being transported	
3.0	Pipeline diameter and wall thickness within vicinity of BESS development	
4.0	Pipeline coating system	
5.0	Pipeline CP system details: is it an ICCP or sacrificial anode?	
6.0	CP test post locations and attributes within vicinity of BESS development	
7.0	Details of last CIP survey	
8.0	Has a DCVG survey ever been completed of the pipeline within the vicinity of the BESS development?	
9.0	Latest CP system survey report and results	
10.0	CP T/R and groundbed details and locations	
11.0	IJ and IF locations	
12.0	If pipeline is bonded into other pipelines or structures	
13.0	Details of pipeline operator and owner under PSR	
14.0	Presence and location of valve sites and any above ground apparatus such as offtakes near BESS development	
15.0	Pipeline operator's contact personnel	
16.0	Pipeline operator safe working procedures	
17.0	Pipeline operator emergency procedures	
18.0	Pipeline route and depth of cover details	
19.0	Date when last Inline Inspection conducted and if any external or internal metal loss features are present in the vicinity of the proposed solar far	
20.0	Pipeline wayleave details and if any rights of access agreements	
21.0	Pipeline operator Management of Change Procedures	
22.0	Location of emergency valves	
23.0	Is the pipeline known to have the possibility of defective girth welds?	
24.0	Ancillary equipment location (pipeline earth anchors / AC mitigation etc.)	
25.0	Details of any known pipeline AC interference issues	
26.0	Details of any known pipeline DC interference issues	

APPENDIX C TYPICAL BESS INFORMATION

The following is a typical example of BESS information for consideration regarding pipeline integrity risks.

Item	Question	Pipeline Operator Response
1.0	Provide details of location and layout of BESS development in the vicinity of the pipeline/pipelines	
2.0	Detailed electrical specification for BESS development, power output, DC output voltage and current, AC voltage from DC/AC converter	
3.0	Proposed cable crossing details with information on cables and construction arrangement	
4.0	Details of plant and equipment that will cross pipeline and arrangements for fencing off pipeline route prior to construction – vehicle loading assessment	
5.0	Details of any temporary or permanent construction road crossings with design calculations	
6.0	If any lightning risk assessment study has been conducted for the BESS development	
7.0	Details of ground potential rise studies, AC cable routes, AC operating current, fault current and AC supply disconnection time	
8.0	DNO equipment locations and planned connection route(s) to / from BESS development	
9.0	The transfer voltage on pipeline during phase to earth fault and disconnection time for protective devices	
10.0	Details of BESS operator and owner	
11.0	BESS operators contact personnel	
12.0	BESS operator safe working procedures	
13.0	Details of any ground fault leak detection and alarms installed	
14.0	Has the developer been provided with the operators Safe working in vicinity of HP pipelines document?	
15.0	Details of insurances and indemnities in place to protect pipeline operator	
16.0	Details of site drainage and any changes to drainage systems	
17.0	Future access arrangements for pipeline operator personnel	
18.0	Program for work and construction activities	
19.0	Arrangements to notify pipeline operator immediately prior to energization of PV farm	

APPENDIX D COMMONLY USED TERMS AND DEFINITIONS

The definitions applying to this GPG are given below:

AC Coupon: A circular 1 cm² surface area representative metal sample used to quantify the extent of corrosion, current discharge off the pipeline both AC and DC or the effectiveness of applied cathodic protection.

AC Corrosion: The presence of AC voltage and current on cathodically protected systems that may lead to AC corrosion. This may arise from poorly selected or poorly adjusted transformer-rectifiers or from external sources such as overhead lines, buried cables or by means of 3rd party systems that are subject to external interference.

AC discharge device: a device blocking DC current but allowing the flow of AC current; used in the connection between a cathodically protected pipeline and an earthing electrode.

AC interference: The presence of AC voltage and current on cathodically protected systems that may lead to AC corrosion. This may arise from poorly selected or poorly adjusted transformer-rectifiers (see AC ripple) or from external sources such as overhead lines, buried cables or by means of 3rd party systems that are subject to external interference.

AC Mitigation: Measures taken to either reduce the imposed AC current and voltage, or to safely discharge the imposed AC current and voltage to earth. The structure should be connected to a linear earth (preferably zinc) through a DC decoupler (to prevent loss of CP current) avoiding a galvanic couple between the structure and the zinc ribbon. The zinc ribbon will be consumed over time, at a rate dependant on the discharge current.

Alternating current voltage gradient (ACVG): An above ground surveying system that is used for the location and sizing of coating defects on buried pipelines. During ACFG surveys an alternating current is injected onto a pipeline. The current loss at coating defects is used to provide a qualitative assessment of defect size.

Anode: Electrically – the positive electrode of an electrochemical cell, which emits current in the form of ionic discharge and corrodes and produces electrons. In the cathodic protection context, a device used to transmit protective current through an electrolyte to the metal to be protected (the cathode).

BESS: Battery Energy Storage System – a technology that uses rechargeable batteries to store electrical energy when demand is low for later usage when demand is higher. Helps to stabilise loading on power grids by filling gaps in supply when renewable supply is low.

Bond: A piece of metal, usually in the form of rectangular strip, circular solid wire, or stranded conductor, usually of copper, connecting two points on the same or on different structures to prevent any appreciable change in the potential of one point in respect of the other.

Cathodic Protection: Commonly referred to as CP – system comprising either galvanic anodes or impressed current anodes that provide protective current to a buried metallic structure, such as a pipeline, to minimise the corrosion to an acceptable rate.

Capacitive coupling: - the transfer of alternating electrical signals or energy from one segment of a circuit to the other using a capacitor.

Cathode: Electrically – the negative electrode of a cell. In the cathodic protection context, it is the term given to the structure to be protected and where the cathodic reaction occurs, which in soil is reduction of dissolved oxygen in water.

Continuity bond: A bond designed and installed specifically to ensure the electrical continuity of a structure. This may be permanent or temporary, in the latter case it is used to connect two sections of a structure, which would otherwise be disconnected during modification or repair.

Copper/copper sulphate reference electrode: A reference electrode consisting of copper in a saturated copper sulphate solution.

Coupon: A representative metal sample of known bare surface area used to quantify the extent of corrosion or the effectiveness of applied cathodic protection or AC interference.

Corrosion rate: the rate of corrosion (metal dissolution). Corrosion rate is expressed as weight loss per unit of metal area and unit of time ($\text{g}/\text{m}^2/\text{year}$) or as loss of metal thickness per unit of time ($\mu\text{m}/\text{year}$ = $0,001 \text{ mm}/\text{year}$). Weight loss can be recalculated into loss of metal thickness. The rate of localised corrosion is usually expressed as depth penetration per unit of time ($\mu\text{m}/\text{year}$).

Current density (on metal surface): current per unit metal surface area, usually expressed as A/m^2

DC decoupling device: A protective device that will conduct DC current when pre-determined threshold DC voltage levels are exceeded but will allow AC current to flow at all AC voltages.

DC interference: stray current from a DC source that may adversely affect the correct operation of a cathodic protection system, leading to the risk of, or actual, accelerated corrosion of the protected structure – normally a pipeline.

Depolarisation: The change in the potential of the cathode due to cessation of current flow and is a time dependent process.

Direct current voltage gradient (DCVG): An above ground surveying system that is used for the location and sizing of coating defects on buried pipelines. During DCVG surveys, the cathodic protection current is pulsed. A sensitive milli-voltmeter and two copper-copper sulphate reference electrodes, placed about one metre apart by the surveyor, are typically used for surveying purposes. Thus, the potential gradient associated with coating defects can be identified and assessed to provide a qualitative assessment of defect size.

Drain point: The location of the negative cable connection to the protected structure through which the protective current returns to its source.

Earthing resistance: the electrical resistance between a metal surface (e.g. the steel surface in a coating holiday on a buried pipe, or an earthing electrode or an AC power line pole foundation) a remote earth.

Earth Potential Rise (EPR): the increased potential of an AC tower earthing point and the surrounding soil due to earth currents, especially the high fault current at a phase-to-earth fault in an AC power line tower. The potential rise may also be caused by a lightning strike to the tower, and which may result in a phase-to-earth fault. The EPR is a function of the AC tower earthing and the soil resistivity.

ER Probe: Electrical resistance (ER) probes are a specialised coupon that allows an accurate measure of corrosion rates from a measured increase in electrical resistance over time for a steel element in the probe face. The increase in electrical resistance is proportional to the accumulated corrosion in the exposure period. ER Probes have a finite lifespan and should be carefully selected to ensure that the film-thickness and geometry of the probe is appropriate to the conditions of the planned deployment. They can be used for periodic assessments, i.e. install new probes once every 5 years to capture data over 3 months to prove effective CP coverage or AC mitigation. They cannot be used for routine monitoring. ER Probes are only useful while the remaining film thickness is greater than half that originally specified. When the film thickness remaining reaches half of the original thickness the ER Probe should be removed and should be replaced if continued monitoring is required.

Free corrosion potential (natural potential): The potential of a corroding surface in an electrolyte relative to a reference electrode.

Groundbed: A system of buried or submerged electrodes connected to the positive terminal of an independent source of direct current, to lead to earth the current used for the cathodic protection of a buried or immersed metallic structure.

Ground potential rise (GPR): The maximum electrical potential that a substation grounding grid may attain relative to a distant grounding point assumed to be at the potential of remote earth. This voltage, GPR, is equal to the maximum grid current times the grid resistance.

NOTE—Under normal conditions, the grounded electrical equipment operates at near zero ground potential. That is, the potential of a grounded neutral conductor is nearly identical to the potential of remote earth. During a ground fault the portion of fault current that is conducted by a substation grounding grid into the earth causes the rise of the grid potential with respect to remote earth.

Holiday: A hole, break, or other discontinuity in the coating on a pipeline, which causes the pipe surface to be exposed.

IR error: This is the error contained within the pipeline potential recorded at ground level remote from the actual pipe surface. This error is caused by the flow of cathodic protection currents and the resistance of the soil and coating.

Impressed current: The current supplied by a rectifier or other direct-current source, (specifically excluding a galvanic anode), to a protected structure to attain the necessary cathodic protection.

Inductive coupling the coupling between two electric circuits through inductances linked by a common changing magnetic field.

Insulated flange: A flanged joint between adjacent lengths of pipe in which the nuts and bolts are electrically insulated from one or both flanges using insulating sleeves and the jointing gasket is non-conducting, so that there is an electrical discontinuity in the pipeline at that point.

Isolation joint: A manufactured joint or coupling between two lengths of pipe, inserted to provide electrical discontinuity between them.

Instant 'OFF' potential: The structure to electrolyte potential that is obtained immediately after the disconnection of the structure under CP from the CP current source. This is sometimes referred to as the polarised potential and is the true pipe to soil potential excluding any voltage created by current flowing through the soil and pipeline coating.

Interaction test: A test to determine the severity of corrosion interaction between two buried or immersed structures.

Interference: phenomenon resulting from conductive, capacitive, inductive coupling between systems, and which can cause malfunction, dangerous voltages, damage, etc.

Interference voltage: voltage caused on the interfered system by the conductive, inductive, and capacitive coupling with the nearby interfering system between a given point and the earth or across an insulating joint.

Natural potential: See free corrosion potential.

Permanent reference electrode: A permanently buried or immersed reference electrode designed for long life and installed close to the structure to enable the structure potential to be measured.

Polarisation: An effect of electrolysis, which occurs, on either the anode or the cathode of a cell when gas or chemical products form on the electrode. The polarisation effect is to increase the circuit resistance of the cell thus reducing the current for a given voltage.

Polarised potential: The potential between a reference electrode and the pipeline, which exists immediately after an interruption of the CP current, (i.e. instant off potential).

Reference electrode: A device used to compare potentials at various locations by providing a standard for potential measurement. Electrodes may be made of zinc, copper in a saturated copper sulphate solution or silver and silver chloride in a chloride ion solution of known concentration.

Sacrificial anode: An anode that relies on a natural potential difference as a source of power. The 'driving voltage' can be found from the electrochemical series.

Stray current: Incidental current picked up by a structure from adjoining foreign sources.

Soil resistivity: specific resistance of a soil to carry electric current. Soil resistivity is expressed in Ω m (earlier in Ω cm). The lower the soil resistivity, the easier it is for electric current to flow through the soil. Fine-grained soils with water holding capacity (clay, silt, peat etc.) usually have low resistivity, whilst coarse grained and water draining soils (sand, gravel, till etc.) usually have a high resistivity. The water and salt content of the soil have a large influence on the resistivity. A high water and a high salt content results in a lower resistivity. Road de-icing salt, which is drained through the soil, lowers the soil resistivity.

Spread resistance: ohmic resistance through a coating defect to earth or from the exposed metallic surface of a coupon to earth.

Note: This is the resistance which controls the DC or AC current through a coating defect or an exposed metallic surface of a coupon for a given DC or AC voltage.

Sulphate-reducing bacteria (SRB): These act as depolarisation agents in the soil around the structure and are harmful to the cathodic protection effect. They achieve this by reducing sulphate ions to sulphide and consuming the hydrogen of the polarisation film. They occur in anaerobic soil conditions and can result in relatively high rates of corrosion.

Telluric effect: A natural phenomenon caused by solar activity deforming the earth's magnetic field causing low frequency current to flow in the general mass of earth. Telluric currents can result in stray current interference on long pipelines.

Touch potential: The potential difference between the ground potential rise (GPR) and the surface potential at the point where a person is standing while at the same time having a hand in contact with a grounded structure.