

UKOPA Good Practice Guide

Requirements for the Siting and Installation of Solar Photovoltaic (PV) Installations in the Vicinity of Buried Pipelines

UKOPA/GP/014 Edition 2

September 2023

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.

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Revision and change control history

Planned revision: January 2028


Edition	Date	No. of pages	Summary of changes
1	June 2017	14	Edition 1 issued for use
2	September 2023	27	Detail review and update of practices


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EXECUTIVE SUMMARY


An overview of the overall process described within this document is provided in the diagram below, however the individual sections of this document should be consulted for the detailed requirements at each stage of the planning, design, construction, and operation of a solar photovoltaic (PV) Installation, which is to be installed in the vicinity of a high-pressure pipeline.


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- **When planning a solar farm development**
 - Contact the pipeline operator at the earliest opportunity
 - See Section 4.2 and 4.3

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- **During the design phase**
 - Ensure the requirements detailed in this document are observed and the impacts upon the pipeline are minimised
 - See Sections 3.1, 3.2, 3.3, 3.4 and 3.5

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- **Prio to construction**
 - Ensure the pipeline operator has agreed to all of the working methods and pipeline protection measures
 - Inform the pipeline operator when construction is scheduled to start
 - See Sections 4.2 and 4.3

- 
- **During construction**
 - Observe all the operators' requirements regarding the protection of the pipeline
 - Ensure the operator is present for those activities they have asked to observe
 - Report any accidental damage to the operator, no matter how minor
 - See Section 5

- 
- **Post Construction**
 - Notify the pipeline operator when the construction work has been completed
 - See Section 6

- 
- **In the event of an emergency**
 - Contact the pipeline operator on the designated emergency number
 - Evacuate the immediate vicinity
 - See Section 8

1 INTRODUCTION

This document has been produced by UKOPA and is an update of Edition 1 of UKOPA/GP/014 issued in June 2017. Its purpose is to ensure PV farms are designed, sited, constructed, commissioned, operated, decommissioned, and demolished in the safest possible way. The intention of the document is to ensure that the most appropriate decisions are made throughout every stage of life cycle of the solar PV farm installation project.

Pipeline operators when notified of the proposed construction of a PV farm 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.

Any developments within 500m of a pipeline should be reviewed to ensure elements such as pipeline access roads, cathodic protection (CP) system groundbeds and AC mitigation measures have been considered. If a CP system groundbed is located within or in close proximity to a PV farm then the groundbed 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 groundbed site selected and land purchased.

This document has also been produced to provide guidance to Promoters of new PV farms on the issues that they need to consider in relation to the effect of PV farms on existing buried pipelines. It also provides advice to pipeline operators on the factors that need to be considered.

Appropriate communication between the PV farms developer and designer is critical throughout the project in order to ensure that the safety impacts on pipelines are minimised. The document has been produced to support both the PV farms developer and the pipeline operator in this communication process throughout the pipeline lifecycle. In order to ensure that the requirements of the document are appropriately applied, it is important that the pipeline operator is contacted by the PV farms developer at the earliest possible stage in the project. This would be preferably at the planning and conceptual design stage of any new development.

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'.

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 located in the vicinity of the PV installation.
- If a pipeline is present, making contact with 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 Good Practice Guide sets out to help PV farms developers by describing the practical steps that they need to take in order to both meet their legal duties and effectively minimise the risks to buried pipelines.

1.1 Background

The pipeline network operated by UKOPA members is buried typically at depths of 1m (however this depth may vary and contact with the pipeline operator shall be made to confirm the actual depth) and the majority of this Network is located in rural areas away from centres of population. 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.

This document provides guidance to ensure that the safety impacts of PV farms on buried pipelines are minimised throughout their lifecycle by ensuring that they are suitably designed, installed, sited, constructed, commissioned, operated, and decommissioned. PV farm hybrid designs (for example including DC battery storage) can present additional risks which will need to be considered separately by consultation with the pipeline operator.

The intention of the document is not to restrict PV farms development but to make PV farms promoters, installation contractors, designers, and operators aware of the pipeline operator's requirements. This should minimise any potential project delays by ensuring that all of the pipeline operator's requirements are known and understood by the PV farms developers and operators at the earliest possible stage in the project.

Promoters of new PV farms should also be aware of the fact that it is highly likely that pipeline operators will incur additional costs as a result of the installation of PV farms within the vicinity of existing pipelines and that these costs may be passed on to the Promoter of the new works.

The costs can include supervision of excavations to the pipeline or work within a pipeline wayleave, over the line surveys pre-construction of PV farms, pipeline depth of cover and location surveys, modifications to the pipeline CP system, additional material for CP system monitoring, stray current interaction testing pre and post energisation of the PV farm, Management of Change procedure implementation costs, legal fees and fees for external consultants that may provide specialist advice. Activities required may vary between projects and pipeline operator, hence early engagement is essential.

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

Typical information that the PV operators should request off the pipeline operator is detailed in Appendix C, whilst information that the pipeline operator should request off the PV developer is detailed in Appendix D.

1.2 Scope

The guidance in this document is applicable to siting and installation of PV farms in the vicinity of buried pipelines operated by the UKOPA member companies. These pipelines can be categorised as:

- Natural gas high-pressure (HP) pipelines
- Petrochemical liquids and gas pipelines

- Oil and refined liquid pipelines

For natural gas pipelines, the guidance is generally applicable to pipelines with maximum operating pressures above 7 bar, however the principles of the document can be equally applied to natural gas and other metallic pipelines operating at lower pressures.

1.3 Application

This guidance has been developed for the promoters and operators of PV farms but also to provide pipeline operators with guidance on the factors that should be considered to mitigate the pipeline integrity and safety risks to the pipeline, the pipeline operators' personnel, and the general public.

The guidance has been developed in order to minimise the impact of the construction and operation of PV farms 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 PV farms.

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 [2] [3] [4] [5]. The document has been produced in order to ensure consistency across the pipeline industry for the mutual benefit of all parties.

Within this document:

Shall: indicates a mandatory requirement.

Should: indicates good practice and is the preferred option.

2 OVERVIEW OF UK PIPELINES

The network of pipelines operated by the UKOPA member companies is over 27,000km in length. The safety record for these pipelines in the UK is extremely good. This is as a result of pipelines being designed, operated, and maintained to well-developed industry standards and the application of a robust legal framework.

The continued safe operation of this pipeline network could be adversely impacted by PV farms unless sufficient safeguards are taken during their siting, construction, and operation. A pipeline failure could result in a loss of containment of the hazardous fluid being transported by the pipeline, resulting in a thermal or environmental hazard.

A PV farm could affect a buried pipeline operated by a UKOPA member company in the following ways:

- Damage to the pipeline caused during the construction of the PV farm during 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 of access roads, cable trenching, fencing etc.
- Reduction or increase in pipeline depth of cover as a result of construction activities associated with a new PV installation.
- Damage caused by drainage of the site including the excavation of drainage ditches.
- Damage as a result of piling or the construction of foundations for the solar panels or security fencing.
- Damage caused by heavy construction traffic crossing over or close to the pipeline.
- Damage to the pipeline caused during the repair or maintenance of the PV farm.
- DC stray current electrical interference on the pipeline's CP system, see Section 3.2.
- Enhanced touch and step potential risks from the electrical supply and Distributed Network Operator (DNO) connections.
- Increase in the AC interference risk to the pipeline, which may result in AC corrosion on the pipeline.
- Increase in the lightning risk on buried pipelines from the construction of the PV farm.
- 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.

Communication between the pipeline operator and the PV farm developer, and taking suitable precautions as outlined in this document, can ensure the above issues are avoided.

Damage to a buried pipeline containing hazardous material is a safety and environmental concern and could have a major economic impact due to the loss of gas supplies to homes and industry or disruption of critical fuel supplies.

Minor damage to a pipeline may result in a requirement for the pipeline operating pressure to be reduced causing supply constraints.

3 DESIGN CONSIDERATIONS

3.1 Siting of Solar PV Installations

At the earliest possible stage, preferably prior to applying for planning permission (Section 4.2), if there is believed to be a buried pipeline in the vicinity of a proposed PV farm development area (i.e. within 500m), 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 PV farm developer at the earliest possible stage in the project in order to ensure that all of the requirements of this document are fully understood and are actioned in a timely manner.

The majority of buried pipelines have legal negotiated rights of access to a strip of land typically between 6 m to 25 m wide centred on the pipeline. This access strip is known as an easement or wayleave (See Section 3.2). The proposed PV farm must be sited such that this access strip is preserved at all times to ensure the pipeline operator has access for maintenance or as a result of a pipeline emergency. If security fencing is going to be installed, which might 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 maintenance or in the event of an emergency.

The pipeline should be fenced off to facilitate construction of the PV farm and ensure no unauthorised crossing of the pipeline – 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. The pipeline route should be suitably marked with route marker posts throughout the PV farm and where the pipeline leaves and enters the development.

The PV farm should also 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 3.3 provides further guidance on siting requirements to avoid electrical interference.

The siting of the PV farm should also take account of hazards to the pipeline that might occur during the construction of the PV farm including access for construction vehicles, lifting operations and the construction of the foundations for the solar panels. Further details regarding the precautions that should be taken during the construction activities are detailed in Sections 4.3 and Section 5.

Note that formal planning permission from the Local Authority does not take account of the hazards that the PV farm might 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) [6] (Section 4.1) have been met.

3.2 Stray Current Interference from Solar PV Installations

Solar farms can act as a source of short and long-term DC current leakage and should be located as far as possible from buried pipelines.

There are two issues to consider in relation to DC interference from solar farms; one is the effect from long-term DC leakage and the other is short term DC current leakage during fault conditions. Promoters of new solar farm systems 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 current and the disconnection times of protective devices should be advised to the pipeline operator together with information on the anticipated fault frequency. The PV operator should also advise the magnitude of any long-term DC current leakage and if the DC current leakage magnitude will have any seasonal variation. DC to AC conversion should be considered in any assessment.

Levels of stray current interference can show a seasonal variation. The winter months may see lower ground electrode resistance values and hence higher leakage currents and in the summer months the stored energy from the PV system will be higher.

Liaison between the PV operator and the pipeline owner is required to assess the risk. Specialized audits at regular intervals may be necessary including measurement and monitoring. The PV operator may have to consider the cost of increased infrastructure inspections and retrofit monitoring devices against the potential cost and damage from DC stray current corrosion.

3.3 Siting/Routing of Associated Electrical Infrastructure

3.3.1 Electrical design and risk assessment

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 any 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.

BS EN 50443 [7] 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 [8]. The latter values should be utilised by PV farm designers to determine safe transfer voltages on pipelines rather than the values given in BS EN 50443 [7].

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 in the vicinity of the pipeline.

All electrical cables should be kept out of the pipeline easement (apart from pre-agreed pipeline crossing points). Both buried and above ground alternating current (AC) electrical cables should be routed to avoid the cables running parallel to the pipeline; sub-stations should not be placed adjacent to pipelines.

Bare earth cables should not cross the pipeline wayleave 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.

Ideally power cables should only cross a pipeline at right angles and parallelism of power cables with pipelines should be avoided to minimise the risk of long term AC interference and AC corrosion.

Any changes to the design after the initial agreement between the PV farm developer and pipeline operator will require the pipeline operator's consent.

3.3.2 Impact upon pipeline cathodic protection system

In order to assess any impacts of the PV farm on the pipeline's CP system, the operator may wish to undertake pre-construction and post-construction monitoring. Potential impacts could be as a result of:

- The PV farm grounding rings or grounding networks shielding the pipeline from the CP system.

- AC interference from buried or above ground AC cables [9] [10] .
- Stray current direct current (DC) interference from the PV farm.
- Arcing of lightning protection or DNO earth system to the pipeline during fault conditions

The potential for AC or DC interference could increase under fault conditions or after a period of time if some degradation of the cabling insulation occurs.

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 in order to detect any impact which may compromise the CP system.

The pipeline CP system modifications could include the addition of new CP test facilities, monitoring electrodes/coupons and/or the installation of remote access ER probes.

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 1km of the PV installation.

The costs of any monitoring systems and any remediation works that are deemed necessary would be recharged to the PV farm developer.

BS EN ISO 21857 [11] gives specific guidance to pipeline and PV system operators on the risks of DC interference on pipelines from PV farms and the acceptable protection criteria.

BS EN ISO 21857 provides guidance to PV farm operators on the construction of PV power sources and the PV operator should comply with the guidance given to ensure that the levels of DC interference created by the PV system are within manageable limits. The effective insulation resistance should be measured before connecting the PV system to Ground Fault Protection Device (GFPD). These devices are designed to interrupt the flow of DC fault currents and also to alert about fault occurrences.

The PV developer should provide written confirmation to the pipeline operator that the PV system will not cause detrimental levels of interference to the pipeline system and will comply with guidance given in BS EN ISO 21857.

UKOPA/GPG/031 [12] gives general guidance on DC stray current interference on pipelines and should also be consulted.

3.3.3 [Lightning strike](#)

It is likely that a PV farm will result in an increased risk of a lightning strike that could impact the buried pipeline. Lightning surge currents are of a variable fault current magnitude and duration and could pass from any lightning protection or electrical the earth system to the pipeline.

Over voltages due to lightning may cause serious damage to the pipeline, the pipeline operator's CP system and could create safety risks to personnel working on a pipeline system. The operator may request the PV farm operator to undertake a lightning assessment as detailed in BS EN 62305-2 [13] and -3 [14]

It is good practice to undertake a lightning risk assessment to understand what the probability of a lightning strike and consequences would be not only to the PV farm but also the surrounding area.

If the risk assessment is performed correctly then the factors relating to the pipeline can be included.

PV farm earthing system should have been designed to already manage touch potentials that could occur from an earth fault. The earthing systems of PV farms tend to be ring electrodes buried around each PV array, so that a low resistance and equipotential plane is achieved during fault conditions.

Any earthing study needs to factor in the pipeline.

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.

3.4 Other Considerations

As well as observing the siting requirements in Section 4.1 the construction of the proposed PV farm 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 crane lifts. Any work within the pipeline easement should be subject to agreement and a permit to work issued by the pipeline operator.
- No piling operations take place within 15m of the pipeline without written approval from the pipeline operator.

Lifting of equipment over the pipeline route (i.e., the pipeline easement width) should 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.

If the crossing of vehicles and heavy machinery over the pipeline cannot be avoided during construction of the PV farm, 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.

Crossing of the pipeline will only be permitted at designated crossing locations.

3.5 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.

The requirement for any MoC should be identified at as early a stage as possible, as they can take time to complete.

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

Changes in developers design should be made available to pipeline operator.

3.6 Easement and Wayleave Requirements

The majority of 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 PV farm development.

A Deed of Indemnity may be required for any cables or concrete slabs that cross the pipeline.

3.7 Impact Protection and Temporary Road 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.

Guidance on applicable calculation methodologies is given in IGEM/TD/1 [3] and also in NEN 3560-1 [15].

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 DCVG survey will be required of the pipeline.

3.8 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,
- 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 PV farm construction works on any buried drainage assets.

If there are any CP groundbeds located within the vicinity of a new PV farm these may cause DC stray current interference on the PV farm foundations and result in accelerated corrosion on buried metallic components. It may even be necessary to relocate a groundbed to avoid long term damage to PV farm foundations and if groundbed relocation is required this may take time to facilitate and incur the PV developer in additional costs.

4 REQUIREMENTS PRE-CONSTRUCTION

4.1 Legal Requirements

Under the Construction (Design and Management) Regulations 2015 (CDM) [6] the Principal Designer is required to plan, manage, and coordinate the planning and design work to ensure that the installation can be built 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 a number of Regulations that are relevant to construction work in the vicinity of buried pipelines. These include Regulation 15 of the PSR [1]. 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*'. In order to meet this legal requirement, it is important that the requirements in the following sections of this document are followed.

4.2 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 PV farm 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 location specific pipeline issues that need to be taken into account. The pipeline operator should expect to be contacted at the following stages of the project:

4.2.1 [Feasibility](#)

At the earliest possible stage in the project, the pipeline operator should be contacted in writing with details of the proposed PV farm development. This should include details, if known, of the proposed location of the major items of equipment and their foundations that might impact upon the buried pipeline including the location of the solar panels. Details of the planned project timescales should also be provided at this stage. The pipeline operator should be advised when formal planning permission is applied for to facilitate appropriate input into the planning process.

4.2.2 [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 transformers, DC/AC converters and earthing. Any changes to the proposed project timescales should also be provided at this time.

4.2.3 [Prior to Solar PV Installation 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 PV farm to ensure that issues that may impact on the integrity of the pipeline system can be identified prior to construction e.g. location of DNO equipment, cable and track/road crossing details and locations.

Location of any offices or stores within the vicinity of the pipeline needs to be considered and agreed.

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

4.3 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, plant and equipment, the operator may require additional pipeline protection measures at these locations.
- 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.
- Location of any other pipeline systems in the vicinity of the PV farm.
- The locations of all PV panels and their footings.

The pipeline operator should be given a minimum of 28 days' 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.

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.

The pipeline operator should carry out a fingerprint survey of the CP system so that impact of the PV farm can be monitored.

5 CONSTRUCTION

The pipeline operator should provide the PV farm developer or their nominated agent with details of all of the restrictions that should be observed during the construction of the PV farm . This will 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.

The pipeline operator will also provide details of the specific activities that require supervision. **Under no circumstances should any of these activities be undertaken without the pipeline operator or their nominated representative being present.**

Details of the pipeline operators safe working procedures shall be provided to the PV developer and the PV installation contractor shall ensure appropriate 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 PV farm 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.

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 to the pipeline that occurs 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.

If at any time during the course of the new construction the pipeline operator is required to carry out emergency works on the pipeline, the work on the new PV farm 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 the PV farm .

6 POST CONSTRUCTION

The PV farm developer should inform the pipeline operator when construction work has been completed. The pipeline operator should undertake a post construction review. This may include:

- A CP survey to confirm that pipeline CP protection is not being adversely affected by the new installation.
- DCVG and CIP survey post construction to confirm absence of coating defects and no detrimental effect on the pipeline CP system.
- Checks to confirm that the ground cover in and around the pipeline has been reinstated to the correct depth.
- Confirmation that any of the above ground infrastructure such as CP test posts and pipeline marker posts have not been damaged by the construction and installation work.
- DC stray current interaction testing as required by the pipeline operator.
- Confirmation that pipeline marker posts have been installed.

The PV farm operator should confirm the precise time and date that the PV farm is energised so that the pipeline operator can check whether any stray current interference is present. The pipeline operator will need to confirm that the CP levels on the pipeline comply with the protection criteria given in BS EN 12954 [16]

The pipeline operator will require evidence to confirm that any drainage affected by the construction work has been successfully reinstated.

The pipeline operator will require a data record pack to be provided on completion of the works, which would include as built drawing, details of any earthing and lightning studies, inspection work on the pipeline, details of all crossings and design report and the final installed PV farm electrical system.

The pipeline operator will seek to recover from the PV farm developer costs associated with any remediation/rectification work that may be required to be undertaken by the pipeline operator subsequent to the completion of the PV farm.

7 ONGOING OPERATIONS

The pipeline operator may wish to undertake ongoing monitoring or put long term monitoring systems in place in order to detect any impact from the PV farm, which may compromise the pipeline CP system or the pipeline integrity.

It is important that the pipeline operator is notified of any ongoing or future operational activities that might impact upon the pipeline. The pipeline operator shall provide the PV farm 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 metres of the pipeline. Typically, the pipeline operator will require at least 28 days' notice prior to any work being undertaken that may impact upon the pipeline.

The pipeline operator should be provided with a contact address and contact telephone number for the PV farm operating company. The pipeline operator should be notified if these details change.

The pipeline operator will require unobstructed access to the pipeline wayleave to carry out over the line surveys at intervals in the future to assess the pipeline condition.

If there are any changes to the operation of the PV farm in terms of installation of additional assets.

The Developer should liaise with the pipeline operator and confirm that there will be no enduring detrimental effect from the new PV system on buried pipelines and confirm that the PV system has the required electrical insulation resistance.

Ground fault protection devices installed in the PV system should provide an alarm in the event of fault conditions. If there has been DC leakage current observed from the PV then the Developer should notify the pipeline operator.

It is important that any restrictions or requirements specified by the pipeline operator continue to be observed during the lifetime of the PV farm. 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 PV farm. These may include operations that will require the PV farm to be temporarily shut down. If this is anticipated, then the pipeline operator will discuss any restrictions on the operation of the PV farm with the PV farm operator in advance of the proposed works.

The PV farm operator shall ensure that no plant or equipment that may cause damage to the pipeline or crosses the pipeline wayleave and will indemnify the pipeline operator against any costs.

8 ACTIONS TO TAKE IN THE EVENT OF AN EMERGENCY

Prior to PV farm operation, the PV farm operator should liaise with the pipeline operator in order to ensure all of 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.

What to do in an emergency:

If, as a result of your activities, you uncover ground near or have any contact with a HP pipeline, be that with mechanical equipment or otherwise, this potentially is a serious incident and should be treated as an emergency situation. Please:

- 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.

9 REFERENCES

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APPENDIX A ABBREVIATIONS

Abbreviation	Meaning
3LPE	Three Layer Polyethylene
A	Amps
AC	Alternating Current
ACVG	Alternating current voltage gradient
AGI	Above Ground Installation
ALARP	As Low as Reasonably Practical
BS	British Standard
CALT	Cold Applied Laminate Tape
CCTV	Closed Circuit Television
CDM	Construction (Design and Management)
CIGRE	Conseil International des Grands Réseaux Électriques,
CIP	Close Interval Potential
CP	Cathodic Protection
CPR	Cardiopulmonary Resuscitation
CSA	Canadian Standards Association
DC	Direct Current
DCVG	Direct Current Voltage Gradient
DFT	Dry Film Thickness
DNO	Distributed Network Operator
EI	Energy Institute
ELV	Extra Low Voltage
EN	European Norm
ENA	Energy Networks Association
EPR	Earth Potential Rise
ER	Electrical Resistance
FRS	Fire and Rescue Service
GFPD	Ground Fault Protection Device
GPG	Good Practice Guide
GPR	Ground Potential Rise
GPS	Global Positioning System
GSM	Global System Mobile Communication
HAZCON	Hazards of Construction
HAZOP	Hazards of Operation
HP	High Pressure
HSE	Health and Safety Executive
HV	High Voltage
HVAC	High Voltage Alternating Current
ICCP	Impressed Current Cathodic Protection
IEC	International Electrotechnical Commission
IET	Institute of Engineering Technology

Abbreviation	Meaning
IGEM	Institute of Gas Engineers and Managers
I/F	Insulated Flange
I/J	Isolation Joint
ILI	Inline Inspection
IP	Intermediate Pressure
ISO	International Standards Organisation
kA	Kilo Amps
Kg	Kilogram
Km	Kilometre
kV	Kilo Volts
LEF	Longitudinal Electric Field
LFI	Low frequency Induction
LP	Low Pressure
m	Metre
MAOP	Maximum Allowable Operating Pressure
MCL	Multicomponent Liquid
MoC	Management of Change
MP	Medium Pressure
MPI	Magnetic Particle Inspection
MPPT	Maximum Power Point Tracking
mV	mV
NACE	National Association of Corrosion Engineers
NDT	Non-Destructive Testing
PCR	Polarisation Cell Replacement
PD	Published Document
PIG	Pipeline Internal Gauge
PSR	Pipelines Safety Regulations
PSSR	Pressure System Safety Regulations
PV	Photovoltaic
QRA	Quantified Risk Assessment
RDX	Road Crossing
rms	Root Mean Square
SOL	Safe Operating Limit
TBN	Technical Briefing Note
T/R	Transformer Rectifier
TS	Technical Standard
UV	Ultraviolet
V	Volts

APPENDIX B USEFUL INFORMATION DEFINITIONS

The definitions applying to this GPG are given below:

AC corrosion: corrosion caused by alternating current, which originates from an external current source.

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 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.

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 ACSVG 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).

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.

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 the course of 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 a.c. 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 (g/m²/ year) or as loss of metal thickness per unit of time (µm/year = 0,001 mm/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 (µm/year).

Current density (on metal surface): current per unit metal surface area, usually expressed as Am⁻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.

Depolarisation: The change in the potential of the cathode as a result of 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 a.c. 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.

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, in order 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 in order 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 of the flanges by the use of 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 in order 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 1 to entry: 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 phenomena 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 voltage: 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.

APPENDIX C INFORMATION EXAMPLE

Operators should be aware of prior to discussions with developers

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 PV farm	
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 PV farm	
7.0	Details of last CIP survey	
8.0	Has a DCVG survey ever been completed of the pipeline within the vicinity of the PV farm	
9.0	Latest CP system survey report	
10.0	CP T/R and groundbed details and locations	
11.0	If pipeline is bonded into other pipelines	
12.0	Details of pipeline operator and owner under PSR	
13.0	Pipeline operator's contact personnel	
14.0	Pipeline operator safe working procedures	
15.0	Pipeline operator emergency procedures	
16.0	Pipeline route and depth of cover details	
17.0	Are there any offtakes from pipeline system in PV farm development?	
18.0	Date when last Inline Inspection conducted and if any external or internal metal loss features are present in the vicinity of the proposed solar farm	
19.0	Pipeline wayleave details and if any rights of access agreements	
20.0	Pipeline operator Management of Change Procedures	
21.0	Location of emergency valves	
22.0	Is the pipeline known to have the possibility of defective girth welds	
23.0	Ancillary equipment location (pipeline earth anchors / AC mitigation etc.)	

APPENDIX D EXAMPLAR QUESTIONS

Questions from Pipeline Operator to PV Farm Developer

Item	Question	PV Operator Response
1.0	Provide details of location of PV farm in the vicinity of the pipeline/pipelines	
2.0	Detailed electrical specification for PV farm, 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 – ground 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 PV farm	
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	
9.0	The transfer voltage on pipeline during phase to earth fault and disconnection time for protective devices.	
10.0	Details of PV operator and owner	
11.0	PV operators contact personnel	
12.0	PV 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	

Item	Question	PV Operator Response
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	