Victorian Electrolysis Committee

Guideline for Electrical Hazards on Metallic Pipelines

Focus Group: owners and operators of metallic pipelines and high voltage infrastructure

This guideline is not intended to replace or substitute AS/NZS 4853: Electrical hazards on metallic pipelines (AS/NZS 4853), it is only to provide a brief overview and create industry awareness. A reference in this document to AS/NZS 4853 is a reference to the current edition of the standard.

Who we are

The Victoria Electrolysis Committee (**VEC**) was established under the Electricity Safety Act 1998 to establish and maintain standards for systems for cathodic protection and for the mitigation of stray current corrosion, provide advice to Energy Safe Victoria on any matter related to electrolysis and the regulations relating to cathodic protection and to the mitigation of stray current corrosion and encourage the development of new methods and technology to increase the efficiency of systems for the mitigation of stray current corrosion.

Although the VEC is an advisory body on matters relating to stray current corrosion, LFI and EPR issues are usually addressed by corrosion specialists, as the disciplines are similar in nature. The mitigation of Electrical Hazards and the mitigation of stray currents also need to be considered together as they will impact on each other

Introduction

This guideline has been created to improve industry awareness, promote an understanding of electrical hazards on metallic pipelines and assist in exchange of necessary information between relevant industry bodies/representative. The guideline has been produced by the Electrical Hazards on Pipelines (**EHoP**) working group established by the Victorian Electrolysis Committee (**VEC**).

The close proximity of high voltage (**HV**) power networks to metallic pipelines can result in hazardous voltages on a pipeline necessitating the application of risk management strategies and action. Electrical traction systems and lightning activity can also be a source of electrical hazards on metallic pipelines.

The guideline predominately refers to electrical hazards that occur in two forms; Low Frequency Induction (**LFI**) and Earth Potential Rise (**EPR**). These hazards have the potential to cause harm to people, damage pipelines and damage ancillary equipment. LFI is a form of electromagnetic interference that occurs when HV transmission lines are in parallel with metallic pipelines. EPR is the voltage gradient induced in the ground during an earth fault condition.

AS/NZS 4853 provides guidance on minimum requirements for managing safety, provides a risk management based methodology and assists with the assessment and requirements for the control and mitigation of electrical hazards on metallic pipelines.

There are three levels of assessment:

Level 1 – Conservative compliance

Level 2 – Calculated voltage limit compliance

Level 3 – Risk based (personal safety) compliance

The sources and consequences of electrical hazards may change throughout the operating life of a pipeline, and therefore pipelines at risk of electrical hazards shall have their risk management plan reviewed every 5 years as a minimum in accordance with clause 7.3 of AS/NZS 4853

Assessment and management of electrical hazards

Pipelines owners are required to consider LFI and EPR issues as recommended by AS/NZS 4853.

For pipelines designed and operated to the AS 2885 series, licensed pipeline owners are required to conduct an LFI/EPR study (which should form part of the safety management plan):

- as part of the pipeline design; and
- the applicable hazard management plan shall be reviewed when circumstances that could change the electrical hazards are identified, or at a maximum period of 5 years, unless a different period for review is approved.

Considerations in assessment and management of electrical hazards:

- Elimination – When a new pipeline or an alteration to an existing pipeline is proposed, it is recommended that the proposed route is reviewed for a Level 1 assessment. If there is likelihood of interaction consider alternative paths and locations for the pipeline and ancillary equipment.

  If new HV network or an alteration is proposed, a review of adjacent existing pipelines needs to be considered and communicated to the pipelines owners. An alternative route may need to be considered.

  Note: Exposure to risk must also be considered during the design and construction phase.

- Design and physical controls – If there is no other reasonable option and the pipeline is located within proximity of HV networks, a full risk assessment must be carried out as per AS/NZ 4853. Design and risk controls must be applied as required to comply with AS/NZ 4853.

  Controls may include: earthing, earthing mats, restricting access and limiting exposure times

- Procedural controls – Ensure anyone exposed to electrical risk is fully aware of possible danger
- Development of: Safe Work Method Statements (**SWMS**), Safe Operating Procedures (**SOP**), Site Risk Assessment (**SRA**), Personal Protective Equipment (**PPE**).
- Assessment and mitigation of electrical hazards on pipelines is a specialised field combining corrosion protection expertise and electrical and earthing expertise. Assessments should be performed by suitably qualified and experienced persons.
- Information needed for typical LFI/EPR studies, carried out in accordance with AS/NZS 4853, will vary from study to study. In many cases information may be requested in stages in accordance with the assessment levels. If a pipeline passes the Level 1 assessment, other detailed information may not be required.

  When an EPR assessment is required (such as at a powerline crossing or earthing electrode relocation), much of the data relating to LFI assessment may not be required.

  Appendix 1 provides a detailed procedure for gathering information for an LFI analysis.

  To assist both the requestor and recipient of information needed for an LFI analysis, checklists for a:

  - Level 1 assessment is provided in **Appendix 2;** and
  - a Level 2 & 3 is provided in **Appendix 3.**

- Power industry owners should endeavour to provide relevant information required for assessment in a timely manner. A fee for information may be applicable.

Note: Any addition or alteration to the electrical infrastructure that may affect the LFI/EPR or change an assessment of the LFI/EPR should be communicated to the affected structure owner.

Note: Commissioning and maintenance of pipeline earthing systems including performance testing shall be carried out in accord with AS/NZS 4853.

Request for information

Table 1. Indicative timeframes and likelihood of costs for the information required for the three assessment levels in AS/NZS 4853, (based on information provided by power industry)

Level Assessment	Assessment Information	Typical timeframe for assessment*	Indication of cost
Level 1	Request of data (e.g. GIS layers, files, drawings etc.)*	2 weeks from receipt of NDA or longer by negotiation	No cost
Level 2	Involving data and network review/assessment	4-6 weeks or longer by negotiation	Cost may be associated with the resource to review and assess the requested information if not readily available**.
Level 3	Involving data and network review/assessment & fault studies	4-6 weeks or longer by negotiation	Cost may be associated with resource to review and assess requested information, including completion of fault studies if not readily available**.
Data format: Any spatial format requested, preferably ESRI Shapefiles (other formats may incur a fee) Information to be provided to the utility making the request or an EHoP specialists acting on their behalf A sharing of data agreement may be required *Typical timeframes are estimates and subject to the information being requested. The actual timeframe should be determined and communicated with the applicant once each request has been evaluated. **Data may be readily available for the asset without the need to run dedicated new calculations.			

Contact Details for EHoP requests:

- CitiPower-Powercor: https://www.powercor.com.au/contact-us/general-enquiry/
  Title: Head of Network Asset Management

- AusNet Services: lmg@ausnetservices.com.au
  Title: Line Management Group

- United Energy: CICProjects@ue.com.au or HVCustomer.Projects@ue.com.au
  Title: General Manager Electricity Networks

- Jemena:
  https://contactus.jemena.com.au/enquiry/electricity?enquirytype=FeedbackAndGeneralEnquiry

Reference Documents

VEC - Terms of Reference for Sub-committee for Electrical Hazards on Pipelines (SCEHoP)

Current edition of Standards as below:

AS/NZS 4853: Electrical hazards on metallic pipelines

AS/NZS 2885.1 Pipelines-Gas and liquid petroleum Part 1: Design and construction

AS 2885.3 Pipelines-Gas and liquid petroleum Part 3: Operation and maintenance

AS 2832.1 Cathodic protection of metals Part 1: Pipes and cables

Review

It is recommended this guideline is reviewed annually to ensure the Electrical Hazards on Pipelines – Working Group – Terms of Reference are being appropriately addressed.

Next review: these guidelines will be reviewed and amended on an annual basis, or more frequently as required.

Review date	Issue date	Due for review date
1/04/2022	1/04/2022	1/04/2023
10/10/2024	10/10/2024	10/10/2025

Note: This guidance material has been prepared using the best information available to the VEC and should be used for general use only. Any information about legislative obligations or responsibilities included in this material is general in nature and should not be taken to constitute legal advice. You should always check the legislation referred to in this material and make your own judgement about what action you may need to take to ensure you have complied with the law. Accordingly, VEC cannot be held responsible and extends no warranties as to the suitability of the information for your specific circumstances; or actions taken by third parties as a result of information contained in this guideline

Appendix 1

Information Gathering for LFI/EPR analysis on Metallic Pipelines

Appendix 1 contains general notes on a typical information gathering process for carrying out an analysis of powerline LFI/EPR on metallic pipelines. The situations encountered between pipelines and powerlines can vary substantially from being simple to complex. These notes are intended to provide guidance on moderately complex situations. They are aimed principally at LFI, rather than simple individual locations where EPR may require consideration due to an individual powerline earthing situation or where a powerline crosses perpendicularly. However, both LFI and EPR need to be considered in accordance with AS/NZS 4853.

The information gathering process is best approached in stages, with the requirements of each subsequent stage being dependent on the outcomes from the previous one. The intent is to limit the scope of information required to carry out the analysis and to expand the scope of information progressively, rather that commencing the analysis by asking for broad information which may not actually be necessary to complete the analysis.

Stage one

The first stage is to assemble in some suitable format an overall map of the pipeline and powerline configuration in and adjacent to the study area. This may include:

- A map of the pipeline(s) being studied, showing locations of any offtakes, valve stations, reservoirs/tanks, pump/compressor stations, regulator stations, cathodic protection units, CP test points, insulated joints, and other such substantial pipeline infrastructure. It should be noted that in general only electrically continuous pipelines will be subject to significant LFI. The map should also include, as far as practicable, any other major electrically continuous pipelines in close proximity running parallel to the pipeline being analysed. For example, a large water pipeline running in the same road reserve or easement as a gas pipeline being analysed (or vica versa, or a pipeline owned by the same utility) may have a significant impact on the induced voltage levels. GIS formats are preferred where available with attribute fields against objects included.
- A map of the powerlines in and adjacent to the pipeline being analysed. This should show all high voltage powerlines and cables, together with major electrical infrastructure such as terminal stations and zone substations within (nominally) 5 km minimum of the pipeline. Where there are different feeders in the study area, each feeder should be separately identified and its source and termination points clearly shown or stated. Operating voltages should also be shown. GIS formats are preferred where available with attribute fields against objects included.

These maps or route drawings should provide sufficient information to allow distances between powerlines / cables and pipelines to be determined, together with the lengths of the various sections of interaction. This information should preferably be provided in a suitable agreed format. Google Earth is a freely available common format which also provides detailed aerial views and street views that can be used to assist with obtaining supplementary information. However, the format(s) to be used needs to be agreed by the various parties involved – the pipeline company, the powerline company and the company carrying out the LFI/EPR analysis.

Once the overall map of the pipeline(s) and powerlines has been assembled it is then relatively straightforward to identify the sections of pipelines where significant LFI/EPR is likely to occur. This process may simply use the Level 1 analysis as per AS/NZS 4853, or, possibly better, follow a similar approach, but input the pipeline & powerline data as known to be more relevant for the specific situation, together with specific known risk scenarios for the relevant activities on the pipeline. The tables in AS/NZS 4853 Level 1 can be adjusted to take into consideration this more relevant data. In any event, the outcome from this stage of the information gathering process is to identify those locations where further information is required. It should err on the conservative side and include all locations of possible significant risk that require further consideration.

The first stage of the information gathering process as described above is intended to allow the Level 1 conservative assessment and to identify those locations where more detailed data is required.

Stage two

The second step is to obtain some more detailed powerline data in the zones of interest, such as:

- Physical details of the various powerlines. Dimensioned sketches of the support structures showing the height and horizontal separation of each conductor and shield wire(s) if present. The type of support structure, such as steel tower, concrete pole or wooden pole should be stated, and whether they are earthed. Where HV and LV circuits are on shared poles, the LV circuits should also be shown, as they may produce significant LFI reduction. Type of shield wire(s) or their electrical parameters is also required.
- For underground cables, details of cable dimensions, whether multicore or in separate phase conduits, screening details including the a.c. resistance of the screen (Ω/km) and the geometric mean radius **(GMR)**.
- Phase-to earth (ground) current (single phase) at specified locations.
- Primary fault clearing time at these locations.
- Number of phase-to-ground faults per year (nominal) at these locations. Overall data for a specific feeder or powerline system, where this is more readily available, can be used to make quite reasonable estimates of the fault frequency as affecting a particular powerline LFI section or individual earthing.
- For steady state LFI calculations (if required) - steady state load current information at specific locations. Note: Where possible, such as on existing pipelines, measurements of AC pipe-to-soil potential taken over a nominal 24 hour recording period will generally provide much more reliable information.

Section 4 of AS/NZS: 4853 provides a reasonably extensive list of data that is commonly needed.

Some further pipeline and other general information will also be required for input into the LFI/EPR analysis, such as:

- Physical details of the pipeline further to those mentioned earlier, such as material of construction, jointing mechanism, diameter, wall thickness, depth of burial to centreline
- Details of the pipeline coating, including, if determined to be necessary, information that allows pipeline coating resistance to be calculated or estimated. Pipeline coating resistance can be calculated using data pipeline CP recordings, showing the attenuation of on/off switching of CP units along the pipeline. This should always be considered for (usually) older pipelines with deteriorated coatings, where coating resistance may have fallen sufficiently to have a substantial impact in reducing induced voltage levels.
- Similar information as above for any relevant pipelines running parallel in very close proximity which may reduce LFI effects on the pipeline being analysed.
- Details of the pipeline facilities as mentioned earlier, such as CP units and groundbeds, sacrificial anodes, surge protection equipment, earthing beds and facility earthing, pits, valve stations, pump stations, etc.
- Details of any interconnections or bonding to other pipelines.
- Soil resistivity data.
- Depending on the nature of the assessment required, soil resistivity may be required only at a single location (such as for an individual EPR calculation with no significant LFI parallelism) or at many representative points along a pipeline route. AS/NZS 4853 provides very useful information on soil resistivity measurement.

- In many instances, soil resistivity has a substantial influence on the analysis. Measurements should be carried out, using equipment fully suited to the task, by personnel highly experienced with taking and interpreting data at wide pin spacings. To enable deep layer soil resistivity modelling as needed for LFI analysis, pin spacings of at least 32 metres should be used as mentioned in AS/NZS 4853, if such data is not already available.
- Note that it is not always possible to gain physical access to sufficiently long areas of soil in heavily built-up urban areas in which case the largest pin spacing practicable should be used. 100 metre coils of suitable light gauge cable are readily available, which easily facilitate pin spacings out to 50 metres where space allows for long runs of cable. These should be taken whenever practicable.
- AS/NZS 4853 and AS 2832.1 provide guidelines on procedures and requirements for obtaining reliable soil resistivity data. Soil resistivity layer analysis and modelling should also be considered for EPR calculations when near-surface and deeper layer resistivity are significantly different.

Stage three

The next step, having carried out the analysis to determine voltages induced on the pipeline and potential rise in the soil, is to further assess their significance in relation to the safety of personnel and to the integrity of the pipeline and its associated facilities.

For the safety of personnel, the ARGON software, as developed by Ausgrid and adopted by Energy Networks Australia, is an approved method within AS/NZS 4853 as a means of analysis, although other methods may be applicable.

AS/NZS 4853 describes a variety of default scenarios, it is extremely important to note that it also states that the pipeline owner shall review and expand the scenarios to reflect realistic scenarios for each asset. Refer to local acts and regulations for general duty and safety obligations. Similarly, the default fault clearing times and fault durations should be subject to review and the relevant actual values used in the safety analysis.

Stage four

Once the safety analysis has been carried out, the final step is to determine the most appropriate and practicable means of making the pipeline safe for the personnel who work on it and to maintain the integrity of connected equipment and hardware.

Appendix 2

Information for the conservative first pass (Level 1) assessment of powerline LFI/EPR on metallic pipelines

The following should be considered as an overview of the information needed to complete a Level 1 assessment of powerline LFI/EPR on metallic pipelines and may be useful as a basis for developing a data request form / checklist for the assessment.

The situations encountered between pipelines[1] and powerlines can vary substantially from being quite simple to being quite complex. Accordingly, the following general information is not exhaustive and should be considered and applied having regard to the specific circumstances of the assessment.

The following information is intended to facilitate a first level of analysis of the interactions between a pipeline and the powerlines that may affect it. In a typical metropolitan situation there will be several individual powerlines (often referred to as feeders) which may cause sufficient LFI to require further analysis to determine if mitigation is needed.

The first level of analysis may use the default parameters/scenarios and corresponding tables that have been used in the First Pass Assessment (Level 1) in AS/NZS 4853 or may be based on typical parameters as have been determined based on general knowledge or experience on similar infrastructure in a given area.

As a general comment, it should be noted that the default parameters/scenarios can often not be particularly applicable, and it is recommended that you always review the AS/NZS 4853 table, having regard to the parameters and scenarios applicable to the assessment being undertaken.

Once this first level of analysis has been completed, it will reveal the details of which feeders require further consideration and of the additional data needed for them. In many situations, although several feeders may have some influence on all or parts of a pipeline, only a small number of these will have dominant influence and require this additional data to be obtained.

Table 2 is an example of a list which could be used to collate information about the pipeline(s). Note, other formats may also be considered.

[1] Pipelines as referred to in this document are electrically continuous metallic pipelines. Non-metallic pipelines, or pipelines that are not electrically continuous, are not generally relevant.

Table 2. Information relating to the pipeline subject to powerline influences

Item	Checkbox	Estimate time/cost
Map of the pipeline(s) being studied. Maps to be provided in suitable format as agreed between pipeline utility and LFI analyst. Google Earth is freely available (kmz, kml, shp, etc. files) and can also usually provide very useful aerial and street level views. However other formats may be more appropriate for the given analyst and may be requested and agreed.		
Map of pipeline to be marked with features and appurtenances, such as: • Offtakes - identified as being electrically connected or isolated. If electrically isolated, details of any surge devices connected to protect the isolation must be provided. • Reservoirs/tanks, pump/compressor stations, regulator stations, pits. • Air valves, drain valves, syphons, line valves. • In-line insulated joints and details of any surge protection, bonding connections and traction drainage connections. • Cathodic protection units, galvanic anodes, test points. • Details of pipe size, typical depth of burial, coating type and age. • Where known, other electrically continuous metallic pipelines running parallel in close proximity.		

Table 3 is an example of a list which could be used to collate information about the powerline(s). Note, other formats may also be considered.

Table 3. Information relating to the powerlines/electrical infrastructure

Item	Checkbox	Estimate Time/cost
Map of all HV distribution & transmission powerlines / feeders within at least 5 km of the pipeline; (a 10 km or wider zone may be preferred.) Each individual feeder should be clearly identified (e.g. by feeder ID such as ABC123). Where a feeder, or section of it, is a cable this should also be shown. *Note: Multiple powerline details out to these distances may be impractical in a heavy urban environment where large numbers of distribution power lines operate in every street.* The map should provide sufficient detail to allow location relative to the pipeline to be determined, such as including roads and other infrastructure. Maps to be provided in suitable format as agreed between powerline utility and LFI analyst. Google Earth is freely available (kmz, kml, shp, etc. files) and can also usually provide very useful aerial and street level views. However other formats may be more appropriate for the given analyst and may be requested and agreed.		
The map provided should include the power sources (terminal stations, zone substations etc.) for each feeder. Where these are not included on the map, these details should be separately provided so that the normal power/current flow along each feeder can be determined. Where the map data does not include identification of the operating voltage, this should be separately provided for each feeder. Where there are cables, the cable screen earthing configuration should be provided – both ends crossbonded or otherwise. Any powerlines with shield wires / overhead earth wires should be identified accordingly.		

It is important to distinguish between transmission (≥ 66kV) and distribution (< 66 kV) powerlines since these are subject to different acceptance criteria in the Level 1 assessment in AS/NZS 4853.

Once this information has been provided, an overall map of the pipeline(s) and powerlines can be assembled. It is then relatively straightforward to identify the sections of pipelines where significant LFI is likely to occur. This process may simply use the Level 1 analysis as per AS/NZS 4853, or, possibly better, follow a similar approach, but input the pipeline and powerline data already known to be typical for the area, together with specific known risk scenarios for the relevant activities on the pipeline. The tables in AS/NZS 4853 for Level 1 can be adjusted to take into consideration this more relevant data. In any event, the outcome from this stage of the information gathering process is to identify those locations where further information is required. It should err on the conservative side and include all locations of possible significant risk that require further consideration.

The urgency for this information will vary substantially. It is suggested that 2 weeks could be a typical time for a response.

Appendix 3

Information for the Level 2 and Level 3 assessments of powerline LFI/EPR on metallic pipelines in relation to safety aspects (excluding AC corrosion).

Note:

Steady-state load current data has not been included in this information request template. For existing pipeline/powerline LFI studies it is suggested that recordings of AC pipe-to-soil voltage taken along the pipeline will provide much more reliable data. However, for new pipeline or powerline installations steady-state load data can be analysed to provide an indicative value of likely induced voltage levels.

AS/NZS 4853 provides some guidelines based around soil resistivity and induced voltage levels which can be used to assess AC corrosion risk. In recent years has been an increased awareness towards criteria based on AC and DC current density levels. On existing pipeline/powerline systems these current density criteria can be employed in conjunction with the recordings of AC voltage level data, which may be used to determine whether an AC corrosion problem is likely to exist.

As with Appendix 2 in this guideline, the following information is intended to provide a high level overview of the information needed to complete a Level 2 or 3 assessment of powerline LFI/EPR on metallic pipelines in relation to safety aspects, and may be useful as a basis for developing a data request form / checklist for the assessment.

The input data requirements prescribed in AS/NZS 4853 include:

For the powerline - phase-to-ground faults

- Fault frequency (number of faults per year). Usually provided as faults/y/km and can be used to calculate faults/y based on the relevant length of the powerline.
- Fault duration or fault clearance time.

For the operations being performed on the pipeline:

- Contact frequency (number of contacts per year for the particular operation being performed).
- Contact duration (duration of contact each time the operation is being performed).

At the location where an operation is being performed:

- Type of contact – touch or step potential (usually only touch potential needs consideration.)
- Type of footwear being worn – barefoot, standard or electrical.
- Environment conditions – wet or dry.
- Surface layer soil resistivity.
- Surface layer type (if installed) – none, crushed rock, asphalt, concrete slab.

Process for calculation of LFI and/or EPR

Stage one analysis

The next step in the process is to study the mapping data that has been assembled in the previous stage to determine those locations where analysis is required. AS/NZS 4853 provides some guidance on this where it refers to a “Level 1” or first pass assessment.

When viewing the tables in AS/NZS 4853, the notes and assumptions that have been made must be carefully considered. It is not uncommon to find that some of the assumptions are not particularly applicable in some locations. It can often be found that more relevant data is available based on experience in similar situations elsewhere. The tables given in Section 5 of AS/NZS 4853 for New Zealand may be of use when carrying out this assessment using the alternative data.

Stage two analysis.

At this stage of the process it has been established where LFI or EPR problems may exist which require more detailed analysis.

The next step is to obtain the necessary powerline / power system data required for this analysis. Often not all information is required upfront. The information required for the assessment will evolve throughout the assessment. To avoid a waste of resources, as the assessment progresses, this form may be resubmitted, with different boxes ticked, requesting additional information only at the time it is required. In this case the timeframe for response starts over for each resubmission of the form.

Table 4 is an example of a list which could be used to collate information about the powerline(s); other formats may also be considered.

Table 4. Information about the powerline(s) and electrical infrastructure that may be required for the Level 2 and Level 3 assessments.

Item	Req'd	Prov'd	Estimate Time/cost
A. For powerline / feeder ID number ABC123			
Operating voltage			
Nominal length			
CMEN or non-CMEN earthing			
Type of construction (wooden pole, concrete, steel etc.)			
Dimensioned drawing showing typical height & separation of conductors and overhead earth / shield wires.			
Geometric Mean Radius (GMR) and DC resistance per unit length of overhead earth / shield wires (if any)/screens (for underground cables with neutral screens).			
Shielding factor			
For cable sections, cable screen earthing arrangement (e.g. one end or both ends bonded.)			
Phase-to earth fault current and primary fault clearing time at the following locations: (As found from the mapping data to be at the end of exposure sections.)			
Location 1 (e.g. Fitzroy Rd at Victoria St)			
Location 2			
Location 3, Location 4, etc.			
Number of faults per annum. For entire length of feeder. (To enable estimate of the number affecting a section for LFI calculation.)			

Number of faults per annum. Estimate for specific single location. (To enable estimate of the number at a single point. Typically needed for EPR calculation). Note: Analysis of many situations has indicated that 1 fault every 10 years may be a reasonable & somewhat conservative value to use in non-CMEN situations – for further discussion.			
For calculation of EPR at specific individual locations on the pipeline: Dimensioned drawing/plan of location and earthing electrode arrangement, or provide EPR if known			
B. For powerline feeder ID number DEF456			
Repeat of table for A.			
C. For powerline feeder ID number GHI789 D. For powerline feeder ------,….etc.			
Repeat of table for A. Repeat of table for A.------,…etc.			
For calculation of EPR only at a single specific location. (Such as at a new pole transformer or kiosk substation installation.)			
Dimensioned drawing/plan of location showing pipeline and ancillaries together with the earthing electrode configuration			
Phase-to earth fault current and primary fault clearing time at the location:			
CMEN or non-CMEN earthing			
Number of faults per annum on the earthing at the specific location. Note: Analysis of many situations has indicated that 1 fault every 10 years may be a reasonable & somewhat conservative value to use in non-CMEN situations – for further discussion. EPR in CMEN areas tend to be so low as to not pose a safety problem, with a fault frequency of 10 per annum.			