1. SCOPE

This technical specification describes SPEN's requirements for earthing and bonding systems at primary substations. This Technical specification is applicable to the following installations:

i) 33 kV/11 kV and 33 kV/11/6.6 kV primary substations.
ii) 33 kV switching stations at sites other than those at Grid Supply Points and transmission substations.
iii) 11 kV and 6.6 kV HV customer substations at SPEN primary substations
iv) 33 kV HV customer substations at sites other than those at Grid Supply Points and transmission substations.

It is intended for application to new build or existing substations where significant work is carried out on site (e.g. switchgear replacement or transformer change) and is not retrospective.

This specification allows SPEN to demonstrate compliance with relevant national and international standards, as well as statutory legislation and licence conditions. This document has been issued to align with latest releases of the ESQCR, BS EN 50522, ENA TS 41-24 and ENA EREC S34.

This document replaces EART-02-002.

2. ISSUE RECORD

This is a Reference document. The current version is held on the EN Document Library.

It is your responsibility to ensure you work to the current version.

Issue Date	Issue No.	Author	Amendment Details
5th Mar 2020	1	Kevin Butter	This document replaces EART-02-002. This document is significantly different to EART-02-002 to reflect changes to ESQCR, BSEN Standards and ENA Technical Specifications

3. ISSUE AUTHORITY

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4. REVIEW

This is a Reference document which has a 5 year retention period after which a reminder will be issued to review and extend retention or archive.

5. DISTRIBUTION

This document is not part of a Manual maintained by Document Control and does not have a maintained distribution list.

6. CONTENTS

7. REFERENCE AND RELATED DOCUMENTS

This specification makes reference to, or implies reference to, the following documents. This document is intended to amplify and/or clarify the requirements of those documents where alternative arrangements are permitted by those documents and/or where further information is required.

It is important that users of all standards, specifications and other listed documents ensure that they are applying the most recent editions together with any amendments. For dated references, only the edition cited applies. For undated references, the edition of the referenced document (including any amendments) valid at the date of issue of this specification applies.

ESQCR	Electricity Safety, Quality and Continuity Regulations
BS EN 50522	Earthing of power installations exceeding 1 kV a.c.
BSEN 62305-1.	Protection against lightning
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
ENATS 41-24	Guidelines for the design, installation, testing and maintenance of main earthing systems in substations.
ENA EREC S34	A guide for assessing the rise of earth potential at electrical installations
ENA EREC S36	Identification and recording of 'hot' sites - joint procedure for Electricity Industry and Communications Network Providers.
ENA ER C55/4	Insulated sheath power cable systems
EART-03-002	Technical Specification for Earthing 132kV S/S and above

8. DEFINITIONS

Backup Protection	Protection set to operate following failure or slow operation of primary protection. (See *Normal Protection* also).
Bonding Conductor	A protective conductor providing equipotential bonding.
Earth	The conductive mass of earth whose electric potential at any point is conventionally taken as zero.
Earth Electrode	A bare conductor or group of bare conductors buried directly in the *Earth* to provide a direct electrical connection with the general mass of *Earth*. This includes earth rods driven into the ground, bare stranded conductors, bare earth tape and mesh.
Earth Electrode Resistance	The resistance of an *Earth Electrode* with respect to *Earth*.
Earth Fault	A fault causing current to flow in one or more earth-return paths. Typically, a single-phase to *Earth Fault*, but this term may also be used to describe two-phase and three-phase faults involving *Earth.*
Earth Fault Current (I_F)	The worst-case steady state RMS current to earth, resulting from a single-phase to *Earth f*ault. Not to be confused with *Ground Return Current* (I_{GR})
Earth Fault Current (Design)	Fault current used to calculate *Earthing Conductor* size based on maximum permissible system fault current design limit.
Earth Potential Rise (EPR))	The difference in potential which may exist between a point on the ground and a remote *Earth*. Formerly known as RoEP (rise of earth potential).
Earthing Conductor	A protective conductor connecting a main earth terminal of an installation to an *Earth Electrode* or to other means of earthing.
Earthing System	The complete interconnected assembly of *Earthing Conductors* and *Earth Electrodes* (including cables with uninsulated sheaths).
Global Earthing System (GES)	An *Earthing System* of sufficiently dense interconnection such that all items are bonded together and rise in voltage together under fault conditions. No true earth reference exists and therefore safety voltages are limited.
Ground Return Current (I_{GR})	The proportion of *Earth Fault Current* returning through soil via the general mass of *Earth*.
Hot / Cold Site	A *Hot Site* is defined as one which exceeds ITU limits for *EPR*. Typically, these thresholds are 650 V (for reliable fault clearance time <= 0.2 seconds), or 430 V otherwise.
High EPR	*High Earth Potential Rise* resulting from an *Earth Fault*. An *EPR* greater than twice the permissible *Touch Potential* limit.
Low EPR	*Low Earth Potential Rise* resulting from an *Earth Fault*. An EPR less than twice the permissible *Touch Potential*
Normal Protection	Clearance of a fault under normal (usual) circumstances. The normal clearance time will include relay operating time and mechanical circuit breaker delays for all foreseeable faults and may be calculated for design purposes.
Network Contribution	The electrode effect of the wide area HV (and LV) interconnected network. Large networks provide multiple parallel electrodes which can provide a relatively low impedance path to *Earth.*

Portable Earths	An earthing device made up of flexible leads
Primary Substation	An installation on the SPEN Distribution System where the highest operating voltage is 33kV. This includes 33/11kV substations, 33/11/6.6kV substations, 33kV switching stations and 33kV connected customer substations.
Supplementary Electrode	An electrode that improves the performance of an *Earthing System*, and may increase resilience, but is not critical to the safety of the system.
Step Potential (U_S)	Voltage between two points on the ground surface that are 1 m distant from each other, which is considered to be the stride length of a person
Stress Voltage	Voltage difference between two segregated *Earthing Systems*, which may appear across insulators/bushings etc. or cable insulation.
Touch Potential (U_T)	Voltage between conductive parts when touched simultaneously.
Transfer Potential	Potential transferred by means of a conductor between an area with a significant *EPR* and an area with little or no *EPR* and results in a potential difference between the conductor and earth in both locations
Transmission Substation	An installation on the SPEN Transmission System operating at 400 kV, 275 kV or 132 kV.

9. INTRODUCTION

9.1 General

The *Earthing System* is safety critical and helps ensure that during *Earth Fault* conditions, the following criteria is met:

i. Electric shock hazards are kept within acceptable safe limits
ii. Potential differences across equipment installation is kept below their specified withstand levels to avoid damage or fire.

A well-designed *Earthing System* includes a buried *Earth Electrode* to provide a low resistance connection to earth and minimise potential gradients in the soil. *Bonding Conductors* are provided to connect all metallic items of plant to the *Earth Electrode* system and to maintain all metalwork at around the same voltage during fault conditions, minimising potential differences. The *Earthing Conductor*s must dissipate fault current within their thermal capacity and without excessive heating of the surrounding soil.

In assessing the safety of an earthing design, it is necessary to consider the risks to operators and equipment inside the substation and those caused by potentials transferred to areas outside of the substation, either directly on metallic conductors or via conductive coupling through the soil.

9.2 System earthing

The neutrals of 33 kV, 11 kV and 6.6 kV distribution systems shall be earthed at a single point. Neutral earth resistance is applied on the 33 kV system and direct (solid) connection to earth on the 11 kV and 6.6 kV systems. Where solid neutral earthing is applied *Earth Fault Currents* are relatively high as they are limited only by circuit impedances.

10. DESIGN DATA

10.1 Soil resistivity

A site specific assessment of soil resistivity shall be made including measurements using Wenner soundings (see section 18.3). A sufficient number of soundings shall be taken as close to the site as practicable to allow average characteristics to be determined (a minimum of three locations is recommended). Each sounding shall include readings over a range of Wenner spacings up to approximately 50m where practicable to allow the resistivity-depth profile to be determined.

Measurement data shall be analysed using suitable computer software and a soil model derived that includes sufficient layers to reasonably represent site conditions (normally 2 to 5 layers).

Care shall be taken to avoid taking soil resistivity measurements above or near to buried underground metallic services as these can adversely affect the results. In urban locations or areas of high congestion of buried services, it may be necessary to take the measurements further away from the site of interest and determine average conditions over a larger area.

It is good practice to test the soil model against other available sources of information such as borehole records, resistivity mapping or measurements taken in nearby locations. Deriving a representative soil model is key to the success of the design and it is important that this task is awarded sufficient time, effort and competence.

10.2 *Fault Current*

10.2.1 *Fault Current* used for conductor sizing

BS EN 50522 requires that "The *Earthing System*, its components and bonding conductors shall be capable of distributing and discharging the fault current without exceeding thermal and mechanical design limits based on backup protection operating time". For selecting *Earthing Conductor* sizes (thermal capacity) the maximum *Earth Fault Current (Design)* level of 17.5 kA shall be used for the 33kV system.

10.2.2 *Fault Current* used to calculate *EPR*

The *Earth Fault Current* used to calculate the *EPR* level for *Touch Pot*entials and *Step Potentials* is the maximum symmetrical *Earth Fault Current* that the installation will experience under fault conditions. This is the prospective single-phase or three-phase fault current that has been calculated for faults at the node point applicable to the location of the secondary substation. Consideration shall be given to future network alterations and alternative running arrangements.

Calculations of *EPR* shall be undertaken for every operating voltage present at the site based on the relevant *Earth Fault Currents* stated in Table 1

Operating Voltage	*Earth Fault Current* (I_F)
33 kV	RMS Break current calculated at fault point
11 kV	RMS Break current calculated at fault point or a maximum of 13.1kA
6.6 kV	RMS Break current calculated at fault point or a maximum of 13.1kA

Table 1 - Earth Fault Currents for EPR Calculations

For calculation of *EPR,* the distribution of the *Earth Fault Current* (I_F) shall be assessed and only the component returning to source via the *Earth Electrode,* I_{GR} shall be used to calculate the *EPR*. For example, current returning to source via earthed underground cable screens will not contribute to *EPR* at the faulted substation and may be discounted.

11 kV or 6.6 kV *Earth Fault*s inside a primary substation normally result in a low *EPR* because current flows back via the substation *Earthing System* to the transformer neutrals located at the same site. However, the maximum fault current at the primary substation may be used to provide a worst-case upper value of *EPR*.

A more realistic calculation of *EPR* at these voltage levels requires consideration of fault conditions on the network beyond the primary substation. Worst case *Ground Return Current*s are normally found on underground cable networks beyond a section of overhead line. This can result in relatively high faults currents, due to the low fault impedance provided by the underground cable network, and the overhead line section forcing all of the fault current to return to source via the substation *Earth Electrode*.

10.2.3 *Earth Fault Current* used to calculate

When considering *Touch* and *Step Potentials,* consideration shall be given to future network alterations and alternative running arrangements. A margin should generally be added to allow for future changes without detailed assessment (e.g. typical 20 % increase, unless more accurate information is available).

10.3 *Earth Fault* clearance times

For selecting *Earthing Conductor* sizes (thermal capacity) a fault duration of 3 s shall be assumed based upon *Backup Protection* operation.

For *EPR* calculation, correct operation of primary protection may be assumed. Unless otherwise justified the values in Table 2 shall be used.

Operating voltage	*Earth Fault* clearance times
33 kV	0.3 s
11 kV	1.0 s
6.6 kV	1.0 s

Table 2 - Earth Fault Clearance Times for EPR Calculations

10.4 Other site specific features to be considered

The following information is also required during the design process:

i) Equipment layout drawing.
ii) The available area for *Earth Electrode* installation, including any cable trenches that may be available.
iii) The types of incoming and outgoing circuits to allow fault current distribution calculations to be made, (e.g. whether overhead lines have an aerial earth wire and the material and cross-sectional area of earthed screens on underground cables).
iv) Details of any structural components, (e.g. reinforcing bars in concrete foundations that may be used as part of the earthing design).
v) Ground levelling / backfill details that may influence the installation of the *Earthing System* or the soil resistivity model.

11. DESIGN REQUIREMENTS

The requirements for *Earthing System* design at primary substations are as follows.

11.1 *Touch Potential*

The earthing design shall maintain *Touch Potentials* within the limits provided in Table 3 based upon the *Earth Fault* clearance times specified in Table 2. This shall be demonstrated by calculation using suitable computer simulation tools.

Operating voltage	*Touch Potential* limits
33 kV	1179 V
11 kV	233 V
6.6 kV	233 V

Table 3 - Touch Potential limits

11.2 *Step Potential*

Normally *Step Potentials* will not foreseeably exceed acceptable limits and do not need to be considered if the design meets *Touch Potential* limits. *Step Potentials* shall only be considered where there is likelihood of people being bare footed combined with *Earth Fault* clearance times in excess of 1 s.

11.3 *Transfer Potential*

The design shall prevent voltages being transferred beyond the extent of the primary substation that may result in *Touch Potential* limits being exceeded unless suitable management / mitigation measures are employed. *Transfer Potentials* may be directly via metallic conductors or via conductive coupling through the soil.

Where the *EPR* exceeds *Touch Potential* limits, *Transfer Potentials* along metallic conductors (such as 11 kV cable sheaths or pilot wire armouring) are controlled by insulation of the conductors and similar *Earthing System* design (e.g. potential grading) at the remote end sites as at the primary substation. Transfer potential on telecommunications circuits is covered in section 14.2.

Transfer Potential onto nearby LV *Earthing Systems* via conductive coupling in the soil shall be considered. The worst-case scenario would be an LV *Earth Electrode* connected to a 'zero Volt' remote earth system that enters an area around the primary substation where the ground elevates to a potential exceeding *Touch Potential* limits. It is reasonable to assume that 50 % of the local soil potential will be transferred on to the LV *Earthing System*.

It is therefore only necessary to consider areas around the substation where the ground potentials may exceed twice the *Touch Potential* limit as stated in Table 4. These installations are defined as *High EPR* sites.

Operating voltage	***Transfer Potential* limits**
33 kV	2358 V
11 kV	430 V*
6.6 kV	430 V*

Table 4 - Transfer Potential Limits for *Touch Potentials* at *High EPR* Sites

*Note that although twice the *Touch Potential* limit of 233 V for 1 s clearance equates to 466 V, a lower value of 430 V has been used for consistency with the telecommunication *Transfer Potential* limit.

If the *EPR* is below the values stated in Table 4, then transfer potentials onto any surrounding LV *Earthing Systems* are deemed to be within safe limits.

If the *EPR* exceeds the values in Table 4, then the ground surface potential contours shall be calculated and plotted onto a geographical plan of the area. If there are any parts of the LV *Earthing System* enclosed within the applicable contours, then mitigation may be required. Before mitigation is implemented it is recommended that a detailed study is carried out to model the HV and LV *Earthing Systems* so that the actual *Transfer Potential* can be determined.

At a site with a HV metered supply the *EPR* calculated for the combined SPEN and Customer *Earthing Systems* may be relied upon to satisfy this requirement.

11.4 *Transfer Potential* (Telecommunications – Hot Sites S.36)

Where reasonably practicable and economic the *EPR* shall be designed to be below 430 V so that it may be classified as a '*Cold Site*'.

At *Primary Substations* where the *EPR* exceeds 430V, the site shall be classified as a '*Hot Site'*. Special measures are required to mitigate the effects of *Transfer Potentials* onto telecommunication circuits that enter the site. The mitigation required at *Hot Sites* is described in Section 14.2.

Where the *EPR* exceeds 1150 V, special measures are required to mitigate the effects of *Transfer Potential* onto telecommunication circuits that exist within the 1150 V surface potential contour. This may include telecommunication equipment in third-party property or dwellings.

At a site with a HV metered supply the *EPR* calculated for the combined SPEN and Customer *Earthing Systems* may be relied upon to satisfy these requirements.

11.5 *Earthing Conductor* thermal ratings

The Earthing Conductors stated in Table 5 shall be used at primary substations to meet the Earth *Fault Current (Design)* level of 17.5 kA.

Conductor	Spur / single connections	Duplicate connections and electrode
Copper Tape	40 x 4 mm	25 x 4 mm
Aluminium Tape	50 x 5 mm	50 x 3 mm

Table 5 - Approved *Earthing Conductor* Sizes – 17.5 kA /3 s rating

The above conductor sizes are suitable for use with brazed / welded or bolted joints. Only copper conductors may be used below ground.

Solid tape is preferred but, if used, stranded conductors shall have an equivalent cross-sectional area to the conductors in Table 5.

11.6 *Earth Electrode* surface current density requirements

A minimum *Earth Electrode* surface area is required to allow current to dissipate into the soil without overheating which can increase the resistance of the Earth Electrode-soil contact area due to drying. The total surface area of the buried *Earth Electrode* should be considered and the *Ground Return Current* (I_{GR}).

As a guide, Table 6 provides the minimum length required for different copper electrodes over a range of soil resistivity values.

Conductor	Required *Electrode* length for different soil resistivity values			
	50 Ωm	100 Ωm	300 Ωm	500 Ωm
40 x 4 mm copper tape	19 m / kA	26 m / kA	45 m / kA	58 m / kA
25 x 4 mm copper tape	28 m / kA	40 m / kA	69 m / kA	88 m / kA
70 mm^2 stranded copper conductor	55 m / kA	77 m / kA	134 m / kA	172 m / kA

Table 6 - Earth Electrode required to meet surface current density requirements

11.7 Consideration of livestock

UK legislation (ESQCR regulations) includes a duty of care to prevent harm to livestock, horses, etc. International standards do not provide earthing related safety limits for animals, but the available information suggests that for faults clearing in 1 s, a maximum *Step Potential* gradient of 25 V/m will reduce the risk of a fatal electric shock.

If a new primary substation the *Earthing System* is planned to be installed an area that is frequented by livestock (farms, stables, etc.), a *Step Potential* assessment shall be made. If the risk is considered unacceptable then reasonable mitigation measures shall be considered, (e.g. installing the Earth Electrode in a different location away from the livestock, insulating electrode as it passes across a cattle gate, or installing a wooden stock-proof fence to prevent cattle entering areas of excessive *Step Potentials*.

12. EARTHING DESIGN PROCEDURE

12.1 Overview

Using the design data described in section 10 the following procedure shall be used to assess the design and ensure it meets the design requirements set out in section 11. Figure 1 described the general design procedure that shall be employed.

12.2 Earth impedance calculation

12.2.1 Substation *Earth Electrode Resistance*

The proposed substation *Earth Electrode Resistance* shall be calculated using suitable computer simulation software including a representative soil resistivity model. Where extended horizontal *Earth Electrodes* are used (>50 m) the software must include conductor longitudinal impedance.

12.2.2 Parallel earth impedance contributions

The earth impedance contribution from parallel earthing components may be included where they can safely be expected to carry fault current and where they are reliable. This includes the following components:

(a) *Earth Electrode* effect from PILC / PILCSWA cables with metallic sheaths / armour in direct contact with the soil.
(b) Contribution from 11 kV distribution substation *Earthing Systems* and LV *Earthing Systems* connected back to the primary substation via the screens of HV cables with an insulating outer covering.
(c) The chain impedance provided by a steel tower line with an aerial earth wire.
(d) Large structural piles that are have sufficient cross-sectional area to carry fault current whilst meeting thermal ratings.

The earth impedance contribution provided by the above may be calculated (by computer simulation or other suitable method, e.g. formulae from ENA EREC S.34) or measured if already existing.

12.3 *Ground Return Current* calculation

The *Ground Return Current* (I_{GR}) shall be calculated from the *Earth Fault Current* (I_F) by subtracting current flowing back to source via metallic paths which do not flow through the *Earth Electrode* and thus does not contribute to *EPR*.

For underground cables with an earthed sheath connected to earth at each end, I_{GR} can be calculated from knowledge of the substation *Earth Resistances* at either end, the geometry of the cable phase and sheath conductors and the cable length. Calculations can be made using suitable computer software or from formulae / tables available in ENA EREC S.34.

Similar calculations can be made for overhead lines with an aerial earth wire fitted.

12.4 *Earth Potential Rise (EPR)* calculation

This is calculated by multiplying the *Ground Return Current* by the *Earth Electrode Resistance*.

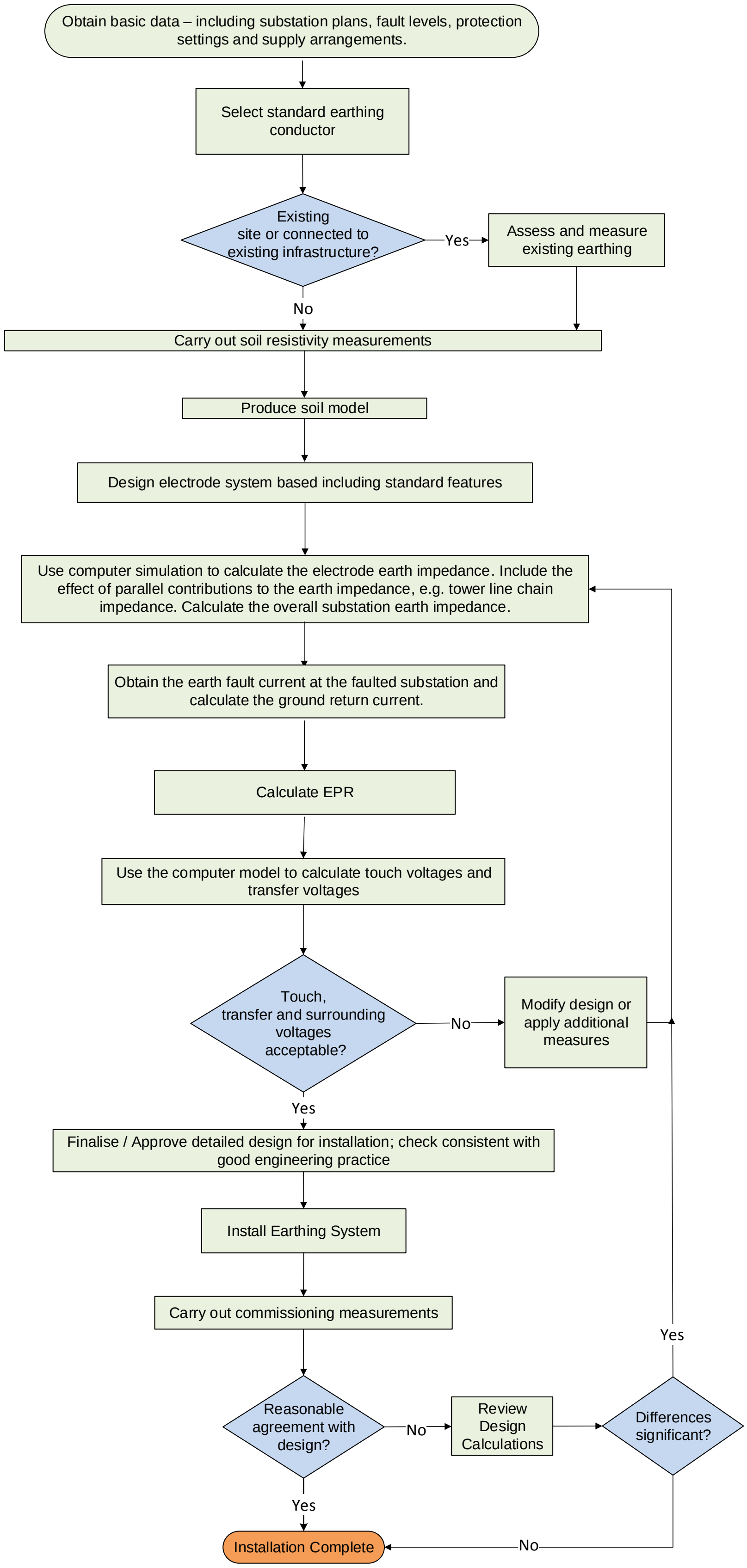

Figure 1– Earthing design procedure flowchart

12.5 Safety voltage calculations

Touch Potentials shall be calculated across the entire substation area and at 1 m beyond any earthed metalwork. Calculations shall be made using suitable computer simulations using a representative soil resistivity model.

12.6 *Transfer Potential* calculations (Hot zones)

Where the *EPR* exceeds the limits stated in Table 4, computer simulation shall be used to produce a plot showing the applicable surface potential contours, i.e. 2358 V (33 kV faults) and 430 V, 1150 V (11 kV and 6.6 kV faults). The contour plots shall be presented on a scalable geographical drawing such as an OS map to allow the impact on third-party property or equipment to be identified.

12.7 Mitigation methods

Before any mitigation is installed, the design calculations shall be reassessed, and any overly conservative assumptions refined.

The most effective way to reduce an excessive *EPR* is to lower the *Earth Electrode Resistance*. This may be achieved by installing deep vertical earth rods, extended horizontal *Earth Electrodes* or by achieving interconnection with an existing earthing network.

Where the *Earth Electrode Resistance*, (and hence the *EPR*), has been reduced as far as practicable, excessive *Touch Potentials* may be controlled by installing additional horizontal *Earth Electrodes* installed within the substation perimeter *Earthing System* to increase mesh density and provide more equipotential surface voltages.

Transfer Potentials can be mitigated by reducing the *EPR* or by relocation of the primary substation *Earthing System* to areas away from the affected *Earthing System*.

From the above methods, the most effective option will depend on the site specifics and the local soil resistivity conditions and shall be optimised via a detailed simulation study.

12.8 Major works at existing substations

Where there is a switchgear and / or transformer replacement / extension works at a substation the *Earthing System* shall comply with this document for that site. This will often necessitate an earthing condition assessment (including site measurements) to ascertain the present values of earth impedance, *EPR*, *Touch Potentials*, etc., so that upgrade works can be designed as part of the project.

13. STANDARD EARTHING DESIGN

The starting point for a primary substation earthing design will be to develop a basic layout based upon standard features. Once the basic layout has been produced, the design assessment procedure described in section 12 may then be followed and the basic layout augmented as required to meet the design requirements.

The standard features of an earthing design include:

i) A horizontal perimeter *Earthing Electrode* around all exposed earthed metalwork offset by up to 1 m.
ii) Vertical earth rod electrodes connected to the perimeter horizontal *Earthing Electrode* to reduce the *Earth Resistance* as necessary.
iii) Internal horizontal *Earth Electrodes* inside the substation to provide potential grading and facilitate plant connections.
iv) Duplicate earth connections to main plant items.

v) *Earthing Conductors* used on substation fencing.
vi) High frequency earth rods at surge arrester locations.
vii) Horizontal *Earthing Electrode* installed beneath operator handle stance positions.
viii) Rebar to be connected to the *Earth Electrode* where provision has been made in the foundation.

The standard features of the earthing design are illustrated in Figure 2.

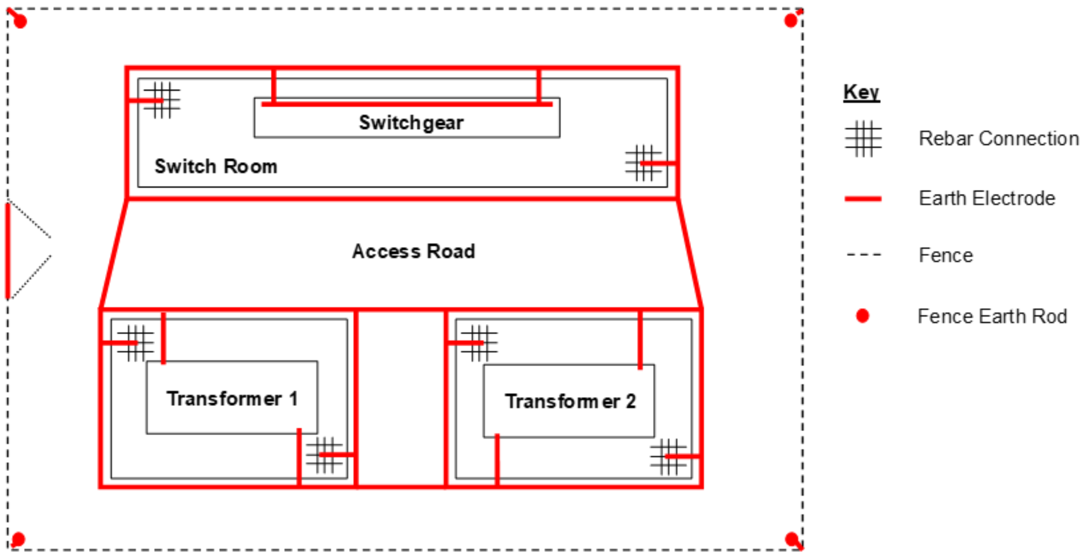

Figure 2 – Standard earthing design features

14. DESIGN ASPECTS

14.1 Transformers

14.1.1 Neutral Connections

The transformer neutral earth connection at a primary substation is a critical power system conductor as it is the return path for current for *Earth Fault*s on the associated 11 kV or 6.6 kV system. A fully rated *Earthing Conductor* shall be installed between the transformer neutral connection and the main substation *Earth Electrode* system. The connection shall not be via the transformer tank or any other steelwork.

14.1.2 Other Connections

The main transformer tank shall be connected to earth via two independent connections on diagonally opposite corners.

Where cable box terminations are used the HV cable sheaths shall be effectively connected to earth terminals provided within the cable box.

14.2 *Transfer Potential* and *Hot Site* Requirements

14.2.1 S.36 Reporting Requirements

For *Hot Sites,* a record shall be kept of the *EPR* and the hot zone presented on a geographical plan of scale not less than 1:2500 including the extent of the hot zone along PILC / PILCSWA cables. This information shall be provided to a telecommunication company if requested.

14.2.2 Telecommunication line isolation

Line isolation equipment shall be installed on any metallic telecommunication circuits at a *Hot Site*. The insulation withstand of this equipment shall be a minimum of 20% more than the *EPR*.

14.2.3 Third-party impact assessment

Where the *EPR* exceeds 430 V, an assessment shall be made of the *Transfer Potentials* onto any LV *Earthing Systems* enclosed within the 430 V surface potential contour. The assessment may be made using computer simulation or measurements.

Where the *EPR* exceeds 1150 V, an assessment shall be made of the *Transfer Potentials* onto telecommunication equipment located within the 1150 V surface potential contour. The assessment may be made using computer simulation or measurements.

14.3 Fence earthing

The earthing of fences can introduce complexity to an earthing design, especially where an existing substation is being modified or extended. Care shall be taken when designing the fence earthing because it can often be legitimately accessed by the public.

14.3.1 Options

Three fence earthing methods can be employed:

(a) Independently earthed fence;
(b) Fence connected to the substation *Earthing System*.
(c) A hybrid of (a) and (b) separated by ‘floating’ sections.

14.3.2 Independently earthed fences

An independently earthed fence is the preferred option for the perimeter fence because by applying this practice, only a fraction of the substation *EPR* appears on the fence and hence lower *Touch Potentials* are accessible to the public.

The main features of the arrangement are:

(a) A 2 m separation between the fence and any metalwork connected to the substation *Earthing System*. This is to avoid a hand-to-hand *Touch Potential* hazard between the different *Earthing Systems*.
(b) Generally, a 2 m separation between the fence (and its *Earth Electrodes*) and the substation *Earth Electrode*. This separation can be reduced if *Touch Potentials* on the fence are firstly confirmed to be within limits by calculation. Bare *Earth Electrodes* passing under the fence shall be installed in insulated ducts for 2 m either side of the fence.
(c) The fence shall be fitted with earth rod electrodes (2.4 m long) at each corner, change of direction and 1 m either side of overhead line crossings. For longer sections of fence a rod shall be installed every 50 m.

If this fence arrangement is used, care shall be taken to avoid inadvertent connection between the fence and the substation *Earthing System*, (e.g. by the supply cable armour to a fence mounted floodlight or CCTV camera, an automated gate opening mechanism, etc.).

The 2 m separation shall be maintained, and any new plant installed at the site in future must not be located within the 2 m zone unless the fence earthing arrangement is revised.

14.3.3 Fences connected to the substation *Earthing System* (Bonded system)

This is the preferred option for internal substation fences as it is normally difficult to achieve 2 m separation from substation equipment. It can be used for external fences where it is not practical to maintain a 2 m separation from the substation equipment. Since the fence is connected to the substation *Earthing System,* the full *EPR* will be transferred onto the fence during fault conditions.

The *Touch Potential* that may be experienced up to 1 m outside of the fence and must be calculated using computer simulation. If the *Touch Potential* on the fence exceeds allowable limits, the *EPR* must be reduced or the substation *Earth Electrode* system extended to 1 m outside the fence. Additional measures are required to prevent theft of electrodes installed outside of the substation security fence, such as anchoring with concrete.

The fence shall be connected to the substation *Earthing System* as a minimum at every corner.

14.3.4 Gates and gateposts

Regardless of the fence earthing arrangement, an earth bond shall be installed between each pair of fence gateposts and a flexible earth connection between each gatepost and gate.

14.3.5 Insulated fence sections

Where an independently earthed fence abuts a bonded fence, they shall be separated by 2 m to prevent a person simultaneously touching the different sections. This shall be achieved by mounting a 2 m fence section on suitable stand-off insulators to create a 'floating' section.

14.3.6 Third-party fences

The connection of third-party metallic fences to the substation fence shall only be permitted when authorised by SPEN who shall assess the risks depending on the substation *EPR* and fence earthing arrangement. If there is a risk of dangerous *Transfer Potentials,* then an insulated fence section shall be installed between the SPEN and third-party fence as per section14.3.5.

14.3.7 Plastic/powder coated fences

The fence earthing design shall not rely on plastic or powder coating to provide insulation from *EPR*. These fences shall be treated as if they are bare metal. Where connections to *Earthing Conductors* are made, the plastic/powder coating shall be removed to ensure an effective electrical contact. Individual fence panels may require bridging connections to be installed if there is poor electrical continuity (tested) between them.

14.3.8 Environmental fences (steel frame and wood panels)

Environmental fences that have a continuous metal frame upon which wooden panels are mounted shall be treated as metallic fences.

Wooden panels supported by individual (discrete) steel supports do not require earthing if the steel posts are 2 m apart or greater. Earthing of gates shall be as in accordance with 14.3.4.

14.3.9 Temporary fences

Where a temporary metallic fence is installed, appropriate measures shall be taken to limit *Touch* and *Transfer* Potentials to safe levels. An internal fence within the immediate area of the substation *Earthing System* shall be connected to the substation *Earthing System* at 50 m intervals, at changes of direction and where power lines cross overhead. Where a temporary metallic fence is connected to the substation *Earthing System* and it abuts an independently earthed fence then they shall be electrically separated in accordance with ENATS 41-24.

14.4 Metallic substation buildings

The structural framework and cladding of metallic substation buildings shall be effectively connected to the substation *Earthing System*. The main structure shall be connected as a minimum at each corner and at 20 m intervals in larger buildings. If the metal cladding is bolted directly to the structural frame, then additional earth bonding will not be required. Otherwise, equipotential bonding of each cladding panel will be required.

Prefabricated metal enclosures shall be connected to the main *Earthing System* at a minimum of two locations, preferable on diagonally opposite corners. This guidance also applies to a metal clad transformer noise enclosure.

A perimeter buried *Earth Electrode* shall be installed around the outside of the building or prefabricated metal enclosure offset from it by 1 m.

A typical arrangement is shown in Figure 3. .

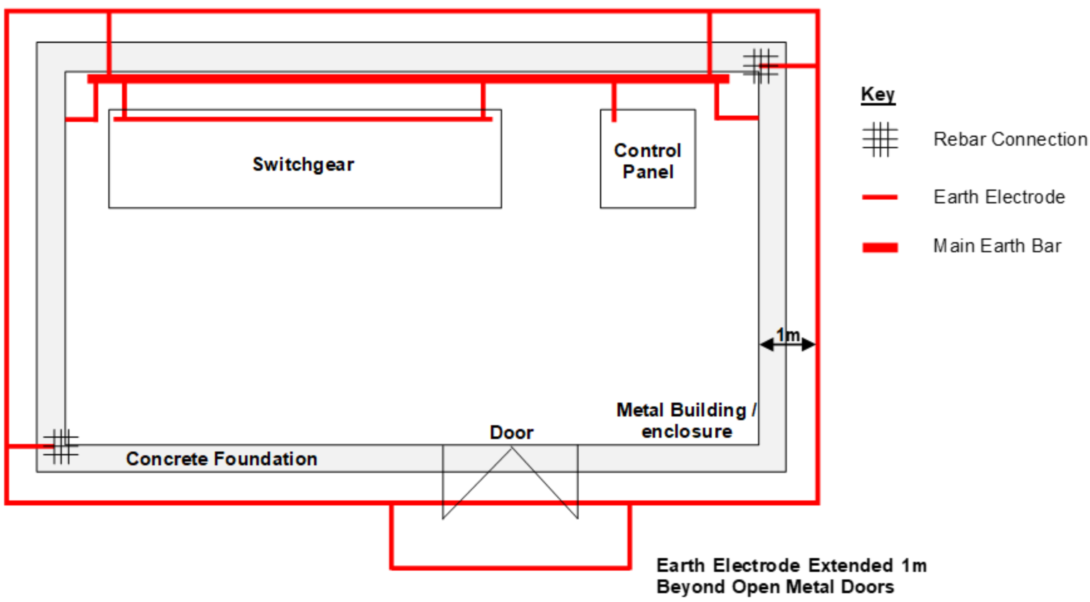

Figure 3 - Typical metal substation building earth connections

14.5 Surge arresters

In addition to a fully rated earth connection, surge arresters shall also have a dedicated HF (high frequency) *Earthing Conductor*. This shall be between the base of the surge arrester and a HF earth rod (nominally 4.8 m long) installed as close as possible to the bottom of the support structure. The HF *Earthing Conductor* shall be as short and straight as possible and avoid sharp bends.

14.6 Cable sheath/screens earthing

Generally, 33 kV, 11 kV and 6.6 kV underground cable feeder cable sheaths / screens shall be earthed at both ends and provide a parallel path for *Earth Fault Current*, diverting it away from the *Earth Electrode* system and hence not contributing to the *EPR*.

To avoid high circulating currents, the screens of short cable sections, (e.g. 33 kV, 11 kV and 6.6 kV interplant cables between the transformer and switchgear), are connected to earth only at one end only. For guidance on cable sheath/screen earthing, refer to document ENA ER C55/4 Insulated sheath power cable systems.

14.7 Overhead line terminations

Where a steel tower line fitted with an aerial earth wire terminates at a primary substation, the terminal tower shall be connected to the substation *Earthing System* via two independent connections at diagonally opposite legs. The aerial earth wire shall be effectively connected to the steelwork at the tower top.

Stays associated with an overhead line wooden termination poles located inside a primary substation shall be connected to its *Earthing System*. Stays shall not be located within 2 m of an independently earthed substation fence.

14.8 Operator switch handles

At all operator switch handle locations, the arrangement illustrated in Figure 4 and described below shall be applied:

i) An *Earthing Conductor* shall be provided directly from the high-level switch steelwork to the buried *Earth Electrode* i.e. not via the switch handle.

ii) A separate earth connection shall be provided from the buried *Earth Electrode* to the switch handle.

iii) The buried *Earth Electrode* shall be installed directly beneath the location where the operator would be expected to stand to operate the switch.

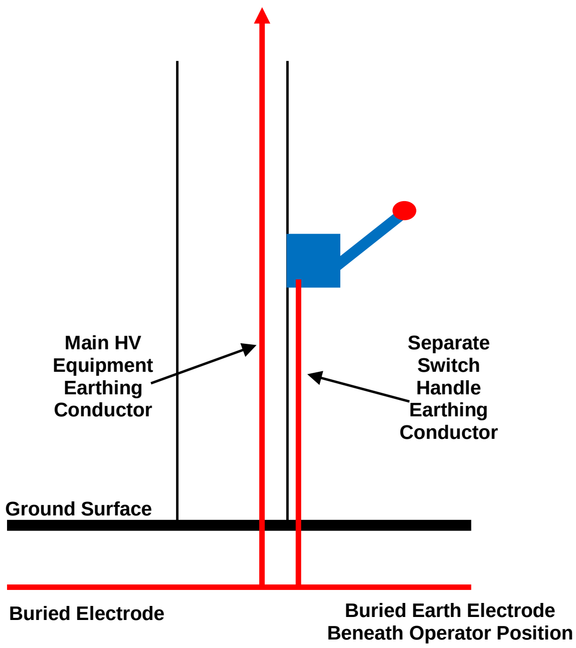

Figure 4 – Typical operator switch handle earthing arrangement

14.9 Portable earth connection points

In primary substation compounds with outdoor open busbars or terminals, a sufficient number of 'D' loops shall be included in the design in suitable locations to allow Portable *Earths* to be applied where required for operational safety.

14.10 Customer HV supplies

The following guidance applies to an installation that includes SPEN and Customer HV plant.

14.10.1 SPEN and customer equipment in same compound within one *Earthing System*

In some cases, SPEN may occupy a very small part of a larger customer owned installation (e.g. an incoming circuit breaker that is part of a large windfarm substation). It may be impractical to design a stand-alone *Earthing System* for the SPEN equipment to meet the requirements of this document in isolation. It is therefore acceptable that an *Earthing System* is designed for the whole site, as a single entity, providing safety for both the SPEN and customer equipment. The *Earthing System* may be installed, owned and maintained by the customer. SPEN must therefore receive sufficient documentation from the customer to confirm that its design and ongoing maintenance meets the requirements of this document. If the Customer's *Earthing System* is modified or removed in future the *Earthing System* of the SPEN substation shall be reviewed.

A *Cold / Low EPR* site status is preferable, but a *Hot* / *High EPR* site can be managed in a manner to be agreed by both parties.

14.10.2 SPEN and customer equipment in different compounds with separate *Earthing Systems*

This arrangement covers the situation where SPEN equipment is located in a compound that is distinct from the customer's equipment or occupies a large part of a joint site where SPEN owns and is responsible for its part of the *Earthing System*. SPEN is not responsible for substations beyond its ownership but has a duty of care to ensure that the customer's system will not become hazardous to SPEN staff under fault conditions. The SPEN and customer *Earthing Systems* are often physically close to each other and the effect of one on the other cannot be overlooked. Interconnection of the two *Earthing Systems* is the preferred option unless the alternative can be justified (i.e. is has been demonstrated as the safest option).

The SPEN and Customer HV *Earthing Systems* shall be designed to meet the fundamental requirements for an *Earthing System* and shall satisfy the requirements of ENA TS 41-24. These requirements shall be met independently of each other. The *Earthing Systems*, their components and bonding conductors shall be capable of distributing and discharging the fault current without exceeding thermal and mechanical design limits based on backup protection operating time. If this is satisfied, then the two *Earthing Systems* shall be connected together via two designated connections that are duly labelled. Note that, if the combined *Earthing System* results in a *High EPR* then the associated precautions shall be applied to both the SPEN and Customer sites. (e.g. segregation of LV Earth/Neutral *Earthing System* at the customer substation, precautions to control *Transfer Potentials* onto other metallic services, etc.).

If uneconomic to achieve an SPEN *Cold Site* in isolation, the earth impedance contribution from the Customer installation may be relied upon to meet transfer potential requirements. There shall be two fully rated *Earthing Conductor*s connecting the SPEN and customer *Earthing Systems*. These shall terminate onto a main earth bar and be clearly labelled at each end.

14.11 LV auxiliary supplies

When a LV auxiliary supply from the local network is provided to a primary substation, the design shall prevent dangerous voltages being transferred onto the LV *Earthing System* during a HV fault.

At *Low EPR* sites (EPR < 2 x *Touch Potential* Limit), the LV neutral-earth shall be connected to the primary substation *Earthing System*.

At *High EPR* sites (EPR > 2 x *Touch Potential* Limit), the Primary Substation LV power supply to be derived from dedicated substation on-site and shall not be connected to the external LV Network.

14.12 Other substation services

At *High EPR* sites, transfer voltages onto other services shall be assessed and mitigated as required.

Water supplies to a primary substation shall be via plastic pipes where practical. If metallic pipes are used, then a 2 m long plastic insert shall be installed beyond the relevant voltage contour from Table 4. The section of pipe nearest the substation shall be connected to the substation *Earthing System*.

Transfer Potentials along the armours of any non-power cables (pilots, telecommunication, control, etc.) shall be assessed. If there is a risk at the remote end, an *Earthing System* shall be installed to a similar level of protection as at the primary or the *Transfer Potential* must be prevented by breaking the armour continuity and applying suitable insulation. The continuity break may be most safely located in the ground away from each of the terminal sites to reduce the risk of an operator inadvertently bridging the gap.

14.13 Reactive compensation compounds

These may be found at a primary substation (e.g. at wind farm substations) and may include air-cored reactors which can generate high magnetic fields. These can couple to closed loops of *Earthing Conductor* producing high circulating currents that produce heat and associated loses.

To avoid these circulating currents, no closed loop shall be installed within the reactor design calculated magnetic field contour. A spur earth connection shall be made to the reactor. Care shall also be taken to prevent magnetic fields creating circulating current in rebar and fences in reactor compounds.

15. INSTALLATION REQUIREMENTS

An *Earthing System* installation must adequately carry fault current without failure and survive over the lifetime of the substation without being compromised by corrosion.

In general, buried parts of the *Earthing System* shall be copper and above ground earthing shall be copper, aluminium or via a suitable structure. Approved joints and corrosion protection shall be applied. Further guidance is given in this section.

15.1 Bonding (main and supplementary)

All substation equipment that may be subject to HV *Earth Fault Current* shall be provided with a main earth connection (fully rated, single or duplicate) as per Table 5.

Other metallic substation equipment (e.g. control panel enclosures, ladders, steel steps, etc), shall be provided with a supplementary earth connection. This shall have sufficient mechanical strength for the application and a minimum cross-sectional area of $35mm^2$ copper (or equivalent).

Very small (extraneous) metallic items (e.g. single wall brackets, window frames, etc.), do not require an earth connection.

15.2 Use of equipment structures

When an equipment support structure is used as part of the earth connection it must be able to carry the fault current without failure. Consideration shall be given to the total cross-sectional areas of the metal support and the types of joints used. Single section or welded section supports are preferred but bolted section supports can also be used if there is good contact area between the different bolted sections. Where there is insufficient contact area between bolted sections, a copper bridging conductor may be required.

The base of the structure shall be connected to the *Earth Electrode* system via a copper connection using a suitable joint depending on the structure material (see section 15.3). Additional copper connections may also be required between the structure and the high-level equipment,

The use of the structure as an *Earthing Conductor* is not permitted on line earth switches, surge arresters or fault throwers. On these items of equipment, a continuous *Earthing Conductor* (copper or aluminium) shall be provided from the high-level equipment to the *Earth Electrode* system.

15.3 Joints

Joints in *Earthing Conductor*s shall maintain the required level of thermal capacity and have a reasonable level of corrosion resistance. The approved methods are stated in Table 7.

Joint Type	Jointing Method
Tape to tape	Brazing, welding or exothermic weld
Circular (stranded) conductor to circular conductor	Approved compression tool or exothermic weld
Copper to steel rebar connection	Exothermic weld or mechanical clamp with moisture ingress protection, e.g. bitumastic tape wrapping.
Horizontal conductor to vertical rod	Exothermic weld
Copper to Aluminium	Double bolted connection in the vertical plane a minimum of 150mm above ground level. Suitable transition washers to be used. Moisture ingress protection must be applied, e.g. bitumastic tape wrapping, heat shrink, etc.
Copper to galvanised steel structure	Double bolted connection in the vertical plane. Copper to be tinned where in contact with the galvanised steel. Suitable transition washers to be used. Moisture ingress protection must be applied, e.g. painting with bitumastic paint.

Table 7 - Approved Jointing Methods

15.4 Earth Electrodes

All buried *Earth Electrodes* shall be made of copper or copper-clad steel for earth rods. Horizontal *Earth Electrodes* shall be installed at a minimum of 0.6 m below finished ground level for security and shall be positioned below the frost line. Deeper burial depth is permitted but the effect on *Touch Potentials* in the substation shall be assessed.

Where installed along underground cable routes, the copper *Earth Electrode* shall be installed a minimum of 150 mm away from the cables, ideally directly underneath the cables for added security. The *Earth Electrode* shall not be installed in sand which can present a high contact resistance.

Bare copper *Earth Electrodes* shall be surrounded by 150 mm of soil, free of stones. The soil shall have a pH of between 6 and 10 and shall not contain any contaminants that are corrosive to copper. Where the native soil does not comply with these requirements imported soil shall be used.

15.5 Use of structural steelwork

The above-ground structural steel frame of a primary substation building shall be connected to the *Earthing System*. In case of a continuous bolted frame structure, a connection at each corner is required as a minimum and at every 20 m in larger buildings.

The horizontal reinforcing bars (rebar) in large concrete foundations such as switchgear buildings and transformer plinths, shall be connected to the *Earthing System* by a minimum of two connections, ideally on diagonally opposite corners. The intention of these bonding connections is to raise the voltage on the rebar (and hence concrete surface) during fault conditions to help provide *Touch Potential* control. It is not intended that significant amounts of fault current flow through the rebar as this may cause heating and possible disruption to the integrity of the concrete.

The design shall include a perimeter copper *Earth Electrode* system with fully rated HV plant connections to carry the majority of the fault current and the rebar forms a *Supplementary Electrode*. For this reason, it is not necessary to ensure robust joints between each horizontal rebar. The high density of rebar in a typical mesh is considered to be sufficient for the purpose of potential grading even if loosely connected with twisted wire.

Where multiple layers of rebar are used in a deep foundation it is sufficient to bond the upper layer which will have the greatest effect in controlling *Touch Potentials* at the surface. In multi-floor substation buildings, the rebar in each floor shall be connected.

15.6 Theft prevention measures

Reasonable measures shall be employed to prevent or deter the theft of *Earthing Conductor*s. The level of security required will vary depending on the perceived risk factors (e.g. remoteness of the site, past history, general security measures such as electric fencing, etc.). The methods include:

i) The amount of exposed, visible, *Earthing Conductor* shall be kept to a minimum by design.
ii) Earth tape conductors shall be stamped with "Property of .SP Energy Networks"
iii) Aluminium conductors may be used above ground instead of copper.
iv) Where practicable, *Earthing Conductor*s shall be pinned to the floor or concrete structures every 200 mm.
v) Steel capping sections may be fixed around *Earthing Conductor*s.
vi) Where buried horizontal *Earth Electrode* is installed outside of the substation fence, it shall be anchored via lumps of concrete (approximately 500mm wide) poured over the *Earth Electrode* at 10 m intervals to make it more difficult to pull out of the ground.

16. COMMISSIONING

This section sets out the requirements for the actions required during commissioning of an *Earthing System* at a new substation or following a significant upgrade to an existing substation.

16.1 Inspection and testing requirements

The following activities shall be carried out during the commissioning of a new *Earthing System* and satisfactory outcomes are required before the installation is accepted.

i) A visual inspection of the above-ground *Earthing Conductors* shall be carried out with reference to the design drawing. Any defects or omissions shall be investigated and rectified where necessary.
ii) During construction, the earthing installer shall measure the resistance of each joint and record the reading. Any high resistance joints (in comparison to others) shall be remade. Records of this testing shall be available for inspection at the commissioning stage.
iii) At a new substation the earth resistance of the substation *Earthing System* shall be measured in isolation (i.e. prior to connection of any cable sheaths). The measurement shall be

repeated following connection of the HV cable sheaths. Both values shall be recorded and compared to the design calculations. Any significant differences shall be investigated, and the design calculations updated / revised as necessary.

iv) For a substation extension it is only necessary to measure the earth resistance with the HV cable sheaths connected. The value shall be recorded and compared to design calculations and / or the value measured prior to the extension. Any significant differences shall be investigated, and the design calculations updated / revised as necessary.

v) At a new substation a sample of *Touch Potential* measurements shall be taken in the areas where they are expected to be the highest, as shown in the design report. Where practicable, a series of surface potential measurements shall also be taken away from each corner of the substation to determine the extent of the 430 V contour. Any significant differences to the values calculated during the design shall be investigated and the calculations updated if required.

16.2 Records

Records of the commissioning tests shall be kept in the site safety manual. Electronic copies of the test sheets, together with any updated earthing design reports or drawings, shall be saved to the SPEN Earthing Database, held in SharePoint

17. SPECIAL SITUATIONS

17.1 Primary substation co-located with a Transmission substation

If a primary substation is co-located with a *Transmission Substation* the *Earthing System* shall be designed to meet the requirements of document EART-03-002.

It should be noted that *Earth Fault Current* from the transmission network may flow through the primary substation *Earthing System* on its way to the 11 kV cable network which may provide one of the lowest impedance paths. Larger *Earthing Conductor*s may be required at the primary substation to cater for this condition.

17.2 Sites Involving pipelines

If a primary substation is to be built within 50 m of a pipeline, a specialist study is required to assess the risks. Where present, a pipeline cathodic protection system can remove copper from the substation *Earthing System* and degrade its performance over time.

17.3 Lightning protection systems

Lightning protection design is covered in BS EN 62305. An SPEN or customer lightning protection system on or near to a secondary substation shall be connected to the substation HV *Earthing System* providing that:

- The lightning protection system has an independent earth resistance of 10 Ω or lower (before connection to the SPEN *Earthing System*).
- The substation is a *Low EPR* site.

If the above statements are not satisfied, guidance shall be sought from an earthing specialist. Connecting a lightning system to a High EPR earth might export a dangerous potential around the building under HV fault conditions and this must be assessed.

18. MEASUREMENTS

This section provides an overview of the measurement techniques required at design, commissioning or during maintenance of a primary substation. More detail on the testing methodology may be found in ENA TS 41-24.

18.1 Safety

The earthing related measurements described in this section are potentially hazardous. They must be carried out by competent staff using safe procedures following a thorough assessment of the risks. The risk assessment shall include, but not be limited to, consideration of the following aspects and the necessary control measures implemented as necessary, e.g. personal protective equipment, special procedures or other operational controls.

i) Potential differences that may occur during *Earth Fault* conditions between the substation *Earthing System* and test leads connected to remote test probes. The likelihood of an *Earth Fault* occurring shall be part of this assessment (e.g. not allowing testing to proceed during lightning conditions or planned switching operations).
ii) Potential differences that may occur between different *Earthing System*s or different parts of the same *Earthing System*. In particular, approved safe methods must be used when disconnecting *Earth Electrode*s for testing and making or breaking any connections to *Earthing Conductor*s which have not been proven to be effectively connected to earth.
iii) Potential differences occurring as a result of induced voltage across test leads which are in parallel with a high-voltage overhead line or underground cable.
iv) Environmental hazards of working in a live substation or a construction site as governed by SPEN Safety Rules or the CDM regulations as applicable.
v) Injury due to striking a buried service when inserting test spikes into the ground.
vi) Injury when running out test leads for large distances in surrounding land.

18.2 Instrumentation and equipment

All test instruments must have a current calibration certificate, have been regularly serviced and be in good working order with a charged battery.

18.3 Soil resistivity measurements

Site specific soil resistivity measurements are required during the design of each primary substation. The Wenner Method shall be used. A minimum of three soundings shall be taken, in different locations near to the substation. For primary substations it is recommended that each sounding includes measurements using a minimum of 10 different Wenner spacings up to 50m where practicable.

18.4 Earth resistance measurements using the fall-of-potential method

The fall-of-potential method shall be used to measure the substation earth resistance where practicable on commissioning of a new substation. The measurement will include all earthing components connected at the time of the test. The term ‘earth resistance’ normally refers to measurements taken using a standard switched-dc earth tester. A true earth impedance may be obtained if AC test equipment is used. The use of both AC and DC instruments is considered to be acceptable for primary substations. Recommended distances for the test current and potential electrodes are provided in Table 8.

Electrode Under Test	Distance C	Distance P	Interpretation of Electrode Earth Resistance
Substation *Earth Electrode* in isolation (smaller than 50 m x 50 m)	200 m	20 m to 80 m in 20 m steps.	61.8% Rule will be reasonably accurate.
Substation *Earth Electrode* after HV cable sheaths connected.	400 m	40 m to 320 m in 40 m steps.	61.8% Rule may return a value that is higher than the true value. Interpretation by an earthing specialist, using simulation software may be required.

Table 8 - Recommended fall-of-potential C and P distances

18.5 Comparative method of measuring *Earth Resistance*

This method is useful to measure the earth resistance of a relatively small *Earth Electrode* with reference to a larger interconnected *Earthing System*, for example a HF earth rod at a primary substation.

18.6 Earth Connection Resistance Measurements (Equipment Bonding Tests)

This technique shall be used to measure the resistance between a plant item and the main substation *Earth Electrode* to check bonding adequacy. This is useful during commissioning of a new substation to confirm that each item of plant is effectively connected to the *Earth Electrode* system. It is also useful as an on-going maintenance check and for operational procedures, e.g. post-theft surveys.

For measurements between points that are no more than 10 m apart the measured resistance shall not exceed 20 mΩ. Resistances higher than this must be investigated as it may indicate a bad joint or a disconnected Earth*ing Conductor*.

18.7 Earthing conductor joint resistance measurements

This test shall be used to measure the resistance across an *Earthing Conductor* joint to check its electrical integrity. This is normally performed for every joint created at a new substation prior to backfilling.

The measured resistance shall not significantly exceed that of an equivalent length of conductor without a joint. Joints which exceed this by more than 50% must be remade.

18.8 Earth potential measurements

Touch, Step and Transfer Potentials (e.g. Hot zones) shall be measured for comparison with calculated values.

19. EARTHING DESIGN DOCUMENTATION

The following documentation shall be produced and retained for each new primary substation and existing primary following major works:

i) An earthing layout drawing.
ii) An earthing design report including as a minimum:
   i. The results of site specific soil resistivity measurements and the derived soil model.
   ii. Calculated earth resistance.
   iii. Calculated ground return *Earth Fault Current*.
   iv. Calculated *EPR*.
   v. Calculated *Touch Potentials* and evidence that they meet the limits.
   vi. Calculated *Transfer Potentials* and determination whether the site is *Low EPR/ High EPR* and *Hot / Cold*, including a plot of the applicable contours (430V, etc.) superimposed onto an OS Map background.

iii) Commissioning inspection / testing report.

The above documentation must be retained on the SPEN Earthing Database. Similar documentation must be provided by third parties for primary substations that will be adopted by SPEN or joint sites including SPEN equipment.

20. ASSESSMENT OF THIRD-PARTY DESIGNS

Where a third-party (e.g. ICP or Customer) designs a primary substation that will be adopted by SPEN (fully or in part), the requirements of this standard shall be met. The design shall be assessed by an earthing specialist before it is accepted.

This clause also applies to a HV metered supply where SPEN has a limited presence within a larger substation site.

An IDNO constructing a primary substation within the SPEN operational area will be governed by the Distribution Code and will therefore be required to design an *Earthing System* to the applicable ENA standards. SPEN reserve the right to inspect the IDNO design documentation prior to energisation of the 33 kV supply.

21. EARTH POTENTIAL RISE DATABASE

The SPEN EPR Database is located in SharePoint

The database contains a summary of key earthing related data together with supporting documentation. It is intended to provide a central record of safety critical data and shall be updated as soon as possible when new or updated data is generated.