PR-NET-OSM-054

# DEPLETED SUBSTATION EARTHING SYSTEMS

## OPERATIONAL SAFETY MANUAL - SECTION 6.12

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# 1 Introduction

1.1 Any network operating without a **System Earth** connection creates a safety issue together with a major risk of **Plant** damage / fire, since an **Earth** fault on the associated network might not draw enough current to operate the protective device(s). It also contravenes the statutory requirements of the Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002 (as amended) regarding the requirement for **Systems** to be **Earthed**. This **Approved** procedure identifies the **Danger** and **Approved** procedures necessary to restore safe and satisfactory **Earthing**.

1.2 At Primary and Grid Substations, an **Earth** is normally provided on the 11/6.6 kV networks by connecting the star point of the primary transformer 11/6.6 kV winding(s) to **Earth**, either directly or via a resistor or reactor to limit **Earth** fault current.

1.3 The integrity of Substation **Earth** systems is of paramount importance. This **Approved** procedure is designed to give guidance on what is required when a Substation **Earthing** system has been depleted.

NOTE: Attention **Shall** also be given to possible degradation due to corrosion/ageing even though testing and routine maintenance is carried out to prevent this type of deterioration.

1.4 Significant **Dangers** can arise when **Earth** systems are depleted or totally removed. Such **Dangers**, to staff, contractors or members of the public, are due to electrical potential rises on **Plant** and **Apparatus** and by the consequences of mal or non-operation of protective systems under **Earth** fault conditions.

# 2 Scope

2.1 This **Approved** procedure provides guidance on the safe operation of the network including access and egress of Substations which have been affected by the removal or partial removal of the **System Earth**.

2.2 In addition, this **Approved** procedure identifies the significant hazards that could be encountered when entering Substations that have been affected by the removal or partial removal of the **System Earth**.

2.3 This **Approved** procedure outlines the actions to be taken upon entry into a Substation and actions necessary when problems are identified.

2.4 This **Approved** procedure applies to:

- Depleted **System Earths** (identification of, response to and reinstatement of)
- Ground mounted and pole mounted Substation and Switching stations
- Grid, Primary and Secondary Substations
- **Earthing** of **Plant** and **Apparatus** at Substation and Switching sites

2.5 It does not apply to:

- **Depleted Earthing** at other locations which are not Substations or Switching sites, e.g., **Earthing** of lattice tower structures.

2.6 It applies to all persons who are authorised or assessed by **SSEN-D** to enter Substations.


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# 3 References

The documents detailed in Table 3.1 - Scottish and Southern Electricity Networks Documents, should be used in conjunction with this document.

**Table 3.1 - Scottish and Southern Electricity Networks Documents**

| Reference | Title |
|---|---|
| PR-NET-OSM-006 | SSEN Distribution Operational Safety Rules – Operational Safety Manual – Section 1.1 |
| PR-NET-OSM-028 | Switching Terminology and Approved Abbreviations - Operational Safety Manual - Section 4.4 |
| PR-NET-OSM-043 | Access to Substations and Switching Sites - Operational Safety Manual – Section 6.1 |
| TG-NET-SST-004 | Bonding and Earthing design standards |
| PR-NET-OPS-024 | Loss of System Neutral Earthing of Primary Substations |
| WI-NET-OSM-002 | Personal Protective Equipment and Workwear for Live Environments |
| N/A | SSEN SHE Handbook (Held in Safety, Health and Wellbeing SharePoint Site) |

# 4 Definitions

4.1 The words printed in bold text within this document are either headings or definitions. Definitions used within this **Approved** Procedure are defined within the list presented immediately below, or within section 2 of the **Operational Safety Rules**.

4.2 **Depleted Earth**

An **Earthing** installation that is confirmed as being incomplete or has been damaged, stolen or has deteriorated due to age or site conditions.

4.3 **Operational Safety Rules (OSR)**

The **SSEN-D** Distribution set of rules, as read with related documents and procedures, that provide generic safe systems of work on the **System** therefore ensuring the health and safety of all who are liable to be affected by any **Danger** that might arise from the **System**.

4.4 **Suitably Experienced Person**

A Person who has the technical knowledge and experience to understand the **Dangers** involved with incomplete **Earthing Systems**.

# 5 General Responsibilities

5.1 Persons who are required to operate and undertake work on the **System**, **Shall** have a thorough understanding of the work and ensure on-site risks are suitably assessed and appropriate control measures put in place before, during and after all activities.

5.2 Persons **Shall** ensure that, at all times during the work (or associated testing), **General Safety** arrangements are maintained and that other work areas are not adversely affected by the activities for which they are responsible.

# 6 Authorisation

6.1 It **Shall** be the responsibility of the individual to ensure that any actions performed are within the bounds of their competency and authorisation level.



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6.2 Competence and authorisation certificates **Shall** be retained personally and be made available upon request.

# 7 Personal Protective Equipment

7.1 Persons who are required to work or carry out work in substations **Shall** wear suitably **Approved** Personal Protective Equipment (PPE). Furthermore, where warning labels or labels that identify a particular hazard exist, additional and appropriate PPE **Shall** be worn.

7.2 As a minimum, PPE **Shall** meet the requirements of WI-NET-OSM-002.

7.3 **Approved** insulated rubber gloves and insulated boots Shall be worn in addition to **Approved** PPE when accessing sites where **Depleted Earths** have been identified.

# 8 Dangers

8.1 The main **Dangers** to personnel in a Substation that has a **Depleted Earth** are electric shock and burns arising from electrical potential (voltages) on unearthed **Plant** and **Apparatus.** Remote locations might also be affected during fault conditions.

8.2 In addition, Substation access security might have been breached, presenting the above electrical **Dangers** to the public.

8.3 Non-electrical hazards might also be present and personal safety might also be at risk from intruders if they are still on site.

8.4 Damage to the Substation might create physical hazards, e.g. missing trench covers, floodlighting inoperative and insecure fences etc.

8.5 The normally **Earthed** metalwork of **High Voltage Plant** / **Apparatus**, which has lost its connection to **Earth**, might become **Live** up to **System** voltage during fault conditions. This includes metal-enclosed switchgear, fences, **Earth** tape and Substation ancillary fittings, e.g. conduits and light switches etc.

8.6 When the **System** neutral **Earth** has been disconnected, protection against **System Earth** faults might be lost. Buried **Earth** tapes which have been disconnected from the substation **Earth** might, under fault conditions, incur a step potential which presents a **Danger** to persons walking on the surface.

# 9 Identifying Depleted Earths

9.1 Guidance for initially identifying a site with **Depleted Earths** is covered in PR-NET-OSM-043 Access to Substations and Switching Sites - Operational Safety Manual Section 6.1.

9.2 Until the risk assessment has been completed, access to the Substation or **Switching** station, following identification of **Depleted Earths**, **Shall** be restricted to the **Senior Authorised Person**, or the person carrying out the risk assessment.

9.3 A distance not less than the **Safety Distance Shall** be maintained from any **Plant**, **Apparatus**, or equipment unless it has been assessed as having a satisfactory **Earth** connection, unless in accordance with **OSR** 4.1.1 and 5.1.2 or clause 9.4 of this **Approved** procedure.

9.4 Where the distance specified in clause 9.3 must be encroached to carry out an assessment to check if the substation **Earthing** is compromised, then this **Shall** be conducted under the **Personal Supervision** of the **Senior Authorised Person** and at no point **Shall** the


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unearthed equipment be touched, without first proving **Dead** with a suitably rated **Approved** voltage testing device.

9.5 Only **Approved** voltage testing devices are suitable for testing for the presence of **High Voltage.**

# 10 Response to Depleted Earthing

10.1 If any defect in the **System Earth** is discovered the following actions **Shall** be taken:

- Work **Shall** cease immediately and no work **Shall** start until the situation is assessed. This requirement includes suspending works on remote sites that might rely on the identified site's earthing arrangements
- The **Control Engineer Shall** be notified immediately, who **Shall** then inform the Control Centre Manager

10.2 The **Control Engineer Shall** arrange for a **Senior Authorised Person** to attend site and carry out a risk assessment without delay.

10.3 The **Senior Authorised Person Shall** immediately report to the **Control Engineer** on their arrival at site and, once assessed, give complete details on the state of the **Earth System**.

10.4 The **Control Engineer** and the **Senior Authorised Person Shall** then agree the most appropriate way to proceed. If the assessment indicates immediate **Danger**, then the equipment **Shall** be made **Dead**.

10.5 The **Senior Authorised Person Shall** ensure remedial measures are taken to ensure the safety of staff and the public.

10.6 If the **Senior Authorised Person** is not suitably trained and experienced to carry out the **Depleted Earth** risk assessment, then a **Suitably Experienced Person Shall** also attend.

10.7 A safe distance **Shall** be maintained around any **Plant**, **Apparatus**, or equipment unless it has been assessed as having a satisfactory **Earth**, in accordance with **OSR** 4.1.1 and 5.1.2 or clause 9.4 of this **Approved** procedure.

10.8 Access to Substation compounds and Switch rooms containing metal-enclosed switchgear **Shall** be restricted to **Suitably Experienced Persons** only or where necessary, persons under their **Personal Supervision**.

10.9 An **Approved** notice warning of the specific **Danger**, **Shall** be affixed to all entrances of the site. The Network Management System (NMS) **Shall** be updated with the appropriate remarks.

10.10 Subject to the assessment, it may be possible to permit the equipment with **Depleted Earths** to remain in service until the load is transferred or reduced to a level which can be fed from an alternative source. In such cases steps must be taken to control access during operation of the Substation with **Depleted Earths**.

# 11 Risk Assessment and Hierarchy

## 11.1 General

11.1.1 As soon as **SSEN-D** become aware of the loss of the **System** neutral **Earth** connection at a Substation due to theft or equipment failure, the priority **Shall** be to either:

- Disconnect supplies, or


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- urgently re-establish a **System Earth** by providing a temporary neutral **Earth** connection, or
- by backfeeding the **High Voltage** network from another Primary Substation and opening the local primary transformer 11/6.6 kV circuit breakers

11.1.2 A risk assessment to decide whether to make the network **Dead Shall** include:

- The speed with which a neutral to **Earth** connection can be re-established
- The probability of a concurrent fault occurring out on the network and the consequent risk to public safety and **Plant**
- The alternate risks to the public from having supplies disconnected
- The risks to the operator when re-establishing an **Earth** connection

11.1.3 At sites with more than one source transformer, if one of the transformer at the site still has its neutral **Earth** intact, then the **Low Voltage** transformer circuit breakers of the affected transformers **Shall** be opened as soon as possible, transferring the load on to the 'healthy' transformer(s), thus removing the risk.

## 11.2 Rural Networks under Storm Conditions

If all neutral **Earth** connections are missing, the network **Shall** only remain energised for a short time, as the risk of grounded **Conductors** on the network is comparatively high. In this situation, unless a temporary **Earth** connection can be established without undue delay, from the **Competent Person** confirming the loss of neutral **Earthing**, the network **Shall** be de-energised.

## 11.3 Urban Network, or Rural Network under Normal Weather Conditions

11.3.1 Where a report of a break-in or theft is received from a non-technical member of staff who indicates that the Substation **Earthing** might have been interfered with, then the priority is to get the nearest competent **Authorised Person(s)** to site as soon as possible to assess the situation. It is imperative that the **Authorised Person** takes at least one portable **Earth** with them, in case there is no portable **Earth** on site.

11.3.2 Once the **Authorised Person** has confirmed that there has been a total loss of neutral **Earthing** on the site, then assuming this is not during storm conditions, the first consideration should be to put at least two feeders in parallel from another Primary or Grid Substation via remote-control switching to re-establish a token neutral **Earth,** which should enable **Earth** fault protection to operate until the neutral **Earth** is repaired or replaced.

11.3.3 If it is not possible to put at least two feeders in parallel from another Primary or Grid Substation, then the network can only be allowed to remain energised for up to 30 minutes. This should allow enough time for a temporary neutral **Earth** connection to be established.

11.3.4 The level of risk will also be affected by the likelihood of a **System** fault occurring, which will be enhanced during adverse weather conditions. Levels of risk will also vary according to the extent of the **Depleted Earths**, the **Plant** and **Apparatus** affected, the running arrangements at the time, ground conditions (wet/dry/soil types), and a host of minor factors. The most significant areas are listed in below, this is not an exhaustive list.

## 11.4 High Risk

11.4.1 This is the highest level risk where there might be an immediate **Danger** present. This includes the **Plant** and **Apparatus** listed below.


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11.4.2 Primary VTs:

The loss of the **Earth** connection can result in phase voltage appearing on the **Earth** point of the VT. **Danger** is greatest where single phase VTs are present. Capacitor VTs have a high frequency terminal which **Shall** be connected to **Earth** as well as the normal VT **Earth** connection. A phase voltage will appear on the high frequency terminal if the **Earth** connection is missing.

11.4.3 Tower Line **Earths**:

If the **Earth** connection between the tower and the substation is missing, then a **High Voltage** might result on the tower steelwork under normal service conditions.

11.4.4 Transformer and **Earthing** Auxiliary Transformer Neutrals:

If the neutral connection between the transformer and the Substation **Earth** is missing, then a **High Voltage** might result between the missing connections under normal service and fault conditions. Loss of this connection might affect the operation of protection schemes.

11.4.5 Neutral **Earthing** Resistor / Reactor **Earth** Connection:

If the **Earth** connection between the neutral **Earthing** Resistor / Reactor and the Substation **Earth** is missing, then a **High Voltage** might appear between the missing connections under normal service and fault conditions. Loss of this connection might affect the operation of protection schemes.

11.4.6 **Apparatus** that might be associated with uncleared **Earth** faults:

This is where a **Danger** occurs only during a **System** fault. A **Depleted Earth** System may cause the protection scheme to fail to clear the fault. If this occurs then a **High Voltage** might result between the two items of **Apparatus** or as a step potential. This particularly affects the additional **Apparatus** listed below:

- Earth mat
- Cable sheaths
- Pilot cables
- Post insulators
- Surge arresters
- Fault throwers
- Switchgear
- Normally **Earthed** structures carrying **Live Conductors**

## 11.5 Medium Risk

This covers all the other ancillary equipment on site, which could include the following:

- Relay and control panels
- Marshalling kiosks
- Storage tanks
- Lighting columns
- Telecom equipment/ masts


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### 11.6 Running Substations in Parallel

11.6.1 If the decision by the **Control Engineer** and the **Senior Authorised Person** requires the Substation to be run in parallel with a remote site to import a neutral **Earth** connection from another site, then prior to any **Switching**, the remote site (the Primary or Grid Substation from where the imported neutral is sourced), **Shall** be inspected and the **Earthing** integrity and protection confirmed as satisfactory.

11.6.2 It must be remembered that running in parallel with another site does not ensure that all **Earth** faults will be cleared by protection. A protection assessment **Shall** be carried out to establish the level of risk as soon as reasonably practical. It is acceptable to employ the temporary use of a bespoke control system-based sequence scheme to assist with fault clearance.

11.6.3 Where **Earth** nest interconnectors at large substations are depleted or damaged, it is possible that an adjacent substation **Earth** system might be intact. e.g. where a 132/33 kV substation is on the same site as a 33/11/6.6 kV substation. Under these circumstances it is acceptable, where possible, to make temporary **Earth** connections between the sites.

11.6.4 The **Control Engineer** and **Senior Authorised Person Shall** agree on a sequence of regular patrols and inspections at any site used to maintain **Earth** connections, or any protection point that does not provide remote indication of operation to the Control Centre, to ensure that **Earth** integrity is maintained.

## 12 Specific Actions for Items of Plant

### 12.1 11/6.6 kV Transformer Windings

12.1.1 When the Primary Substation transformer winding neutral **Earth** has been disconnected at a Substation, the **System** supplied from the transformer must immediately have at least two feeders placed in parallel from another Primary or Grid Substation, or the network can only be allowed to remain energised for up to 30 minutes. This should allow enough time for a temporary neutral **Earth** connection to be established.

12.1.2 If it is suspected that the integrity of the 11/6.6 kV switchboard **Earth** has been compromised, it **Shall** not be energised from an alternative source until the **Earth** has been verified as satisfactory or temporary repairs have been affected.

### 12.2 33 kV or 66 kV Transformer Windings

12.2.1 When transformer neutral **Earth** connection has been disconnected at a Substation, the 11/6.6 kV **System** voltage will not be adversely affected, although 33 kV **System Earth** fault protection might be lost. It is therefore, essential to take action to either provide a temporary neutral **Earth** connection or immediately make **Dead** any 33 kV circuits that run external to the Substation perimeter or have customers' **Plant** or **Apparatus** connected directly to them.

12.2.2 Primary transformers and circuits which are confined within a Substation perimeter fence, may be left in service until the 11/6.6 kV load they supply has been transferred.

### 12.3 132 kV Transformer Windings

12.3.1 All 132 kV transformer winding star points are **Earthed**.


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12.3.2 When 132 kV transformer neutral **Earth** connection has been disconnected at a Substation, the 11/6.6kV **System** will not be adversely affected and the 132 kV **System Earth** fault protection might not be entirely lost in every case.

12.3.3 Where Feeder Main Protection is of the 'Unit Type' with 2-Way Intertripping, feeder **Earth** fault protection will still be satisfactory and these transformers may be kept in service until urgent repairs are carried out or alternative supplies are arranged.

12.3.4 Where 'Feeder Main Protection' is 'Distance' or 'High-Set Over-Current' with Fault Throwers, i.e. no intertripping, the feeder **Earth** fault protection will be lost for back-energised 132 kV **Earth** faults and these transformers **Shall** be made **Dead** as soon as the condition is positively identified, unless additional control system-based sequence scheme protection can be activated.

NOTE: Transformer **High Voltage** Restricted **Earth** Fault (REF) protection will be lost in all cases.

## 12.4 Metal-Enclosed Switchboards

12.4.1 When the **Earth** connection to metal-enclosed switchboards has been disconnected, the **Dangers** will be present whilst the switchgear remains **Live**.

12.4.2 The level of **Danger** will be influenced by site conditions including the type of cable connected to the switchgear.

12.4.3 Where cables have a significant proportion of steel wire or tape armour protection, it is likely that these will provide a low impedance path to **Earth**, and **Danger** will be minimal.

12.4.4 Where there are a significant proportion of XLPE insulated cables, these will not provide a local low impedance **Earth** and under fault conditions might transfer significant potential gradients to the switchgear. In these circumstances, steps **Shall** be taken to provide temporary **Earthing** or to make the switchboard (including Transformer/Feeder cable Box/CT Chambers) **Dead**.

## 12.5 HV Plant and Equipment in Substation Compounds

12.5.1 When the **Earth** connections to **Plant** or **Apparatus** in Substation compounds have been disconnected, the **Dangers** will be present whilst the equipment remains **Live**.

12.5.2 **Apparatus** situated on independent structures may remain **Live** pending urgent reconnection to **Earth** provided that access to the unearthed **Apparatus** / **Plant** within the **Safety Distance** is prevented by barriers or cones and chain with **Danger Notices** posted.

NOTE: Capacitor VT **Earth** connections present a significant **Danger** as they become charged to full phase voltage when the **Earth** is disconnected.

12.5.3 Equipment which is connected to other **Apparatus** including multicore cables etc, might transfer dangerous voltages to such other **Apparatus** under fault conditions and an assessment of the **Danger** must be made to decide if the **Apparatus Shall** be made **Dead** immediately.

## 12.6 Pole Mounted Circuit Breakers and Transformers

12.6.1 Where **Depleted Earths** are identified at Pole Mounted Circuit Breaker or Transformer installations, consideration **Shall** be given to installing PVC covered aluminium or BLX above ground:

- Up to 35mm2 copper, 50mm2 aluminium alloy **Shall** be used
- Above 35mm2 copper, 120mm2 aluminium alloy **Shall** be used


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12.6.2 Any of the following can give rise to voltages being present on control boxes and steelwork which are normally required to be **Earthed**.

- Leakage across insulators due to wet or polluted conditions
- Surge arresters fitted to the same pole
- A transformer supplying the **Low Voltage** to the control cabinet (**Low Voltage** neutral not **Earthed**)
- Voltage transformers providing measurements to the control cabinet
- **High Voltage** cable pole terminations

12.6.3 The work **Shall** be done with the circuit **Dead**, unless subject to a risk assessment. The risk assessment will use the work flow analysis of TG-NET-SST-004. It may also be necessary to use a **Live** Line team where the **Earth** is missing up the pole.

12.6.4 Ensure records of cables are available on site. Any cables must be traced before installing temporary or enhancing the existing earthing.

# 13 Principles of Earth Re-Connection

## 13.1 General

13.1.1 Unless specifically identified in this **Approved** procedure, the following principles of reinstating **Earthing** assets **Shall** be employed.

13.1.2 Work **Shall** be completed under the **Personal Supervision** of a **Senior Authorised Person** who **Shall** either be or have taken guidance from a **Suitably Experienced Person**.

13.1.3 Prior to any connection being made, the **Plant** and **Apparatus Shall** be tested with a suitably rated **Approved** voltage testing device. Locations indicating the presence of **High Voltage Shall** be made **Dead** prior to a connection being made.

13.1.4 Where practical, permanent connections **Shall** be made whilst there is a temporary connection in place.

## 13.2 Connecting Temporary Earths

13.2.1 The preferred method of establishing a temporary **Earth** connection **Shall** be by using a flexible **Earthing** lead to reconnect the substation **Earth** mat to the neutral **Earth** connection. This connection **Shall** be made using insulated rods in the same manner as applying a **Circuit Main Earth**, i.e. connect to an established **Earth** first.

13.2.2 Where a local neutral **Earthing** isolator is fitted, then this Shall be opened to allow for the temporary neutral **Earth** bond to be applied. Where there is no local earthing isolator then proceed as follows:

13.2.3 For multi-transformer sites:

1. Off-load one transformer by opening the transformer **Low Voltage** circuit-breaker.
2. Where there are common neutral-**Earthing** switches, open the **Earthing** switch to the off- loaded transformer.
3. In addition, where it is possible to de-energise the transformer remotely without delay and without affecting other customer supplies then this **Shall** be done, e.g. transformer feeders/non-teed circuits.
4. Make the temporary connection.


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13.2.4 For single transformer sites:

1. The interruption to supplies **Shall** be kept as short as possible.
2. Either open the transformer **Low Voltage** circuit-breaker, or where it is possible to de-energise the transformer remotely without delay and without affecting other customer supplies, then disconnect supply to the site.
3. Make the temporary connection.

NOTE: Although it is possible to test the **Earth** connection with a potential indicator before applying the connection, it is possible that a healthy network might still give a positive indication.

# 14 Grid and Primary System Temporary Replacement

14.1 The best remaining **Earth Shall** be identified by the **Senior Authorised Person** and agreed with the **Control Engineer**. This **Shall** typically be a metal-enclosed switchboard with outgoing cable sheaths connected to remote **Earth** systems.

14.2 The **Control Engineer Shall** be notified at the start and at the completion of the work.

14.3 All reconnections of **Plant** / **Apparatus** to the known **Earth Shall** be tested with a suitably rated **Approved** voltage testing device and this **Shall** be done under the **Personal Supervision** of the **Senior Authorised Person**.

14.4 Working from the best remaining **Earth**, each item of **Plant** / **Apparatus Shall** be reconnected to the **Earth** System. Reconnection of any **Earth Conductor** which might allow fault current to flow in the event that a known uncleared power **System** fault is present, **Shall** be done with the source **Isolated**.

14.5 Temporary **Conductors** for this application **Shall** be a minimum of 120mm2 Cu or equivalent. Where reasonably practicable the replacement **Earth Conductor Shall** have a cross sectional area equivalent to, or greater than, that of the original **Earth Conductor**.

14.6 On completion, the **Earth** resistance measurement **Shall** be taken for the Substation and the results recorded by the **Senior Authorised Person** in the Substation logbook. Bonding resistance checks **Shall** also be carried out across the site.

# 15 High Voltage Distribution System Temporary Replacement

15.1 In underground Distribution Substations, the **High Voltage** and **Low Voltage Earths** are generally combined unless it is a designated hot site, where they will be separate. On the overhead **System**, **High Voltage** and **Low Voltage Earths** are not usually combined.

15.2 **High Voltage** Steelwork **Earth:**

The **High Voltage** steelwork **Earth** is provided from a locally installed **Earth** mat. All exposed metalwork and **High Voltage** cable sheaths are bonded to this **Earth** mat. The **High Voltage** cable sheath also provides a contribution to the **Earth** mat from a remote location.

15.3 **Low Voltage Earth:**

At ground mounted hot sites and all pole mounted sites, the **Low Voltage Earth** is a separate electrode system to that of the **High Voltage** steelwork **Earth.** This **Earth** electrode is connected to the **Low Voltage** neutral of the local transformer.

15.4 The best remaining **Earth Shall** be identified by the suitably authorised **Senior Authorised Person**. This **Shall** typically be:


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- Existing substation **Earth**
- Metal-enclosed switchboard with outgoing cable sheaths connected to a remote Substation
- Incoming circuit cable sheaths directly connected to a remote Substation
- **Earth** from an inter-connected **Low Voltage System**
- If none of these are available, an **Earth** nest **Shall** be installed in a suitable location

15.5 The **Control Engineer Shall** be notified at the start and at the completion of the work.

15.6 All reconnections of **Plant** / **Apparatus** to the known **Earth Shall** be tested immediately prior to connection with a suitably rated **Approved** voltage testing device and **Shall** be done under the **Personal Supervision** of the **Senior Authorised Person**. Testing may require an initial test using an **Approved High Voltage** testing device followed where necessary by a further test using an **Approved Low Voltage** testing device.

15.7 Working from this best remaining **Earth,** each item of **Plant** / **Apparatus Shall** be reconnected to the **Earth** System. Reconnection of any **Earth Conductor** which might allow fault current to flow in the event that an uncleared power **System** fault is present, **Shall** be done with the source Isolated.

15.8 Temporary **Earth Conductors** for this application Shall be a minimum of 70mm2 Cu equivalent and where reasonably practicable, the replacement **Earth Conductor Shall** have a cross sectional area equivalent to, or greater than that of the original **Earth Conductor**.

15.9 The re-connection of these **Earths** may be done **Live** unless:

- All exposed phase **Conductors** cannot be shrouded when working on the Neutrals / **Earths**
- Excessive damage has been done to the **Plant** and **Apparatus** making it dangerous to work on or adjacent to it
- Voltage testing shows **System** voltages to be present on **Earths** that are to be worked on
- Voltages greater than 50 volts are present on the **Low Voltage** Neutral/ **Earths**
- Working **Live** would break existing **Operational Safety Rules** or Codes of Practice.

15.10 Use a suitably rated **Approved** voltage testing device to ensure no **System** voltages are present on transformer housings, **High Voltage** Switchgear, outgoing cable sheaths, transformer star points, **Low Voltage** cabinets, and **Low Voltage** neutrals. This may require an initial test using an **Approved High Voltage** testing device followed where necessary by a further test using an **Approved Low Voltage** testing device.

15.11 If the voltages detailed within clause 15.9 are present then isolation and **Earthing** must be carried out, in accordance with the **Operational Safety Rules** and the work carried out under a **Safety Document.**

15.12 At cold sites the steelwork and neutral **Earths** may be combined.

15.13 Hot Sites

If the site is a designated hot site, then two separate portable **Earths** are required, one for the steelwork **Earth** the other for **Low Voltage** Neutral **Earth**. A good indication of a hot site is that the link in the **Low Voltage** pillar will be removed between the Neutral and the steelwork **Earths**.

NOTE: To minimise the **Danger** of touch potentials, all exposed metalwork **Shall** be connected to a known **Earth** prior to accessing the **Apparatus**.


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The following steps **Shall** be followed in the order listed below:

1. Test the potential difference between the closest **Low Voltage Apparatus** metalwork and the portable **Earth**, using an **Approved** voltage testing device. If a voltage less than 50 volts is indicated then the metalwork can be connected to the portable **Earth**.
2. Test the potential difference between the transformer star point / neutral and the portable **Earth**, using an **Approved Low Voltage** testing device. If less than 50 volts the connection can be made.
3. Check that the **High Voltage** switchgear metalwork is not **Live** at **System** voltage using an **Approved** voltage testing device. If less than 50 volts the connection can be made.
4. Once the first connection has been made, subsequent testing and application of **Earth** bonding on the switchgear may be carried out until all parts of the switchgear housing are connected to **Earth**.

NOTE: Where **Plant** and **Apparatus** is coupled, i.e. a unit Substation, some steps might not be necessary.

5. Prior to reconnecting the outgoing **High Voltage** cable sheaths, checks **Shall** be carried out by use of an **Approved** voltage testing device, to ensure that the incoming **High Voltage** cable sheaths are not **Live** at **System** voltage. If the testing device does not indicate a voltage, then a connection can be made to the **High Voltage** switchgear as indicated below.
6. Confirm that on all outgoing **Low Voltage** cables, that the neutrals are also connected to the neutral **Earth** bar. If any outgoing neutrals are missing then the outgoing fuses must be removed immediately and the circuit is to be treated as it would for a suspect neutral fault condition.

15.14 Once all the **Plant** and **Apparatus** in the Substation has been connected to **Earth**, other damaged Earthing can be repaired.

# 16 Permanent Repair of Earth to Earth Connections

16.1 When the Substation **Earth** can be reconnected to an **Earth Conductor**, this **Shall** be done one item at a time ensuring that the temporary **Earth** remains connected to the **Plant** and **Apparatus** until the substation **Earth** is connected.

16.2 **Low Voltage** cable neutral **Earths** may now be reconnected to the **Low Voltage** pillar neutral. Testing **Shall** be done using an **Approved Low Voltage** testing device, e.g. voltmeter, before each connection is made. If voltages above 50 volts are measured, the cable **Shall** be **Isolated** before the connections are made.

16.3 Where sheaths are not connected to **Earth** at the point of work, there might be a potential rise on the sheath. Any exposed braid / gland at the point of work **Shall** be tested using an **Approved** voltage testing device and where possible, **Earthed** using the portable **Earths**. To work on **High Voltage** cable sheaths, isolation and **Earthing** must be carried out as required by the **Operational Safety Rules**.

16.4 On completion of the reconnection of all **Earths**, the **Senior Authorised Person Shall**:

1. Test the bonding between all **Plant** and structures in accordance with **SSEN-D Approved** procedure.
2. Confirm with the **Control Engineer** that the Substation **Earth** System is back to normal and request removal of the **Depleted Earth** notification from Network Management System.
3. Remove **Depleted Earth** signs from the Substation.


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# 17 Revision History

| No | Overview of Amendments | Previous Document | Revision | Authorisation |
|---|---|---|---|---|
| 01 | New document created | TBC | 1.00 | Richard Gough |
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