

## ESR Supporting Procedure 3

### Earthing of HV Equipment

#### SHEQ/HS/TCSESR/SP/003-2.0

##### DOCUMENT AUTHORISATION SHEET

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## Appendices

### Appendix 1 – Substation Fault Levels

## 1 DEFINITIONS

Terms printed in bold type are as defined in the **TCS** Electrical Safety Rules.

OA	Carry out duties as prescribed by the Operational <i>Authorisation</i> level notwithstanding the individuals <i>Authorisation</i> level as <b>CP, AP, SAP or Control Person</b>
CP	Carry out duties of a <b>Competent Person</b> as defined in the TCS ESRs and the receipt of oral instructions
AP	Carry out duties of an <b>Authorised Person</b> , appointed to specified Operational <i>Authorities</i> . These duties <i>shall</i> be carried out under the instructions of a <b>Control Engineer</b>
SAP	Carry out duties of a <b>Senior Authorised Person</b> for <b>HV Equipment</b> , and is appointed to specified Operational <i>Authorisations</i>
<b>Control Person</b>	Carry out duties of a <b>Control Person</b> for <b>HV Equipment</b>
<i>Authorisation</i>	Formal appointment of an individual who has demonstrated an understanding and acceptance of the responsibilities set out in the <b>TCS</b> Safety Rules Supporting Procedures and associated procedures

Non Company	An individual who is not employed by TCS or affiliated companies and is appointed to specified Operational Authorities and Safety Rules Supporting Procedures to carry out their duties
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## 2 INTRODUCTION

This **Approved** procedure applies the principles established by the **TCS** Electrical Safety Rules to give guidance on the application and positioning of **Earthing Devices** to achieve **Safety from the System**, for personnel working on **HV Equipment**, against the effects of inadvertent energisation and **Equipment** that may become **Charged**.

The protection afforded by earthing is dependent upon the combination of;

- a) The effectiveness of the connection of **Primary Earths** and their capability to carry the fault current until the electrical protective devices operate;
- b) The reliability and speed of operation of electrical protective devices in service called upon to operate in such circumstances;
- c) The **System** voltage, voltage gradient to the point of earthing and the **System** fault level at the point of work.

## 3 DANGERS

The main **Danger** to individuals as a result of applying **Earthing Devices** to **HV Equipment** are as follows:-

- a) Electric shock
- b) Burns
- c) Damage/effects on eyes
- d) other bodily injury

These **Dangers** arise from:-

The inadvertent infringement of **Safety Distances**

The inadvertent earthing of **Live HV Equipment** by the loss of control or difficulty in the handling of portable earthing equipment.

The incorrect sequence or method of application or removal of **Earthing Devices**

Incorrect identification of **Earthing Device(s)**

The application of Earthing Device(s) to Live HV Equipment

Badly connected or insecure **Earthing Devices**

Inadequate Earthing of **Equipment**

The application of **Earthing Device(s)** to an inadequate or defective earth system

The arc drawn by the application or removal of an **Earthing Device**

**Charged Equipment** and the voltage difference across a break in electrical conductors

Incorrect management of circulating currents

## 4 PRIMARY EARTHS

### 4.1 General Requirements

**Primary Earths** shall be of adequate strength and capability to provide an efficient connection between earth and the **HV Equipment**. **Primary Earths** and the associated **Equipment** they are connected to shall be capable of safely discharging any resultant fault current due to any inadvertent energisation.

A fixed **Earthing Device** shall where reasonably practicable, be used to make the first and break the last earth connection. Where this is not reasonably practicable the **Senior Authorised Person** shall carry out a risk assessment to determine the safest way to apply / remove portable **Earthing Devices** to / from the **HV Equipment**.<sup>1</sup>

**Primary Earths** shall be positioned within the zone established by the **Points of Isolation**. They shall, where reasonably practicable, be positioned between the point of work and all **Points of Isolation**. This should include, where applicable, the **Points of Isolation** from common neutral earthing equipment.

Where it is not reasonably practicable to apply **Primary Earths** between the point of work and the **Points of Isolation** they may be placed in an alternative position so as to have a similar electrical effect. Such a position could be one of the following:-

- a) On a permanent connection teed between the point of work and the **Point of Isolation** at a distance not exceeding 9m from the tee point, or
- b) At a permanent connection point not more than 9m beyond the point of work from the **Point of Isolation**, or
- c) As detailed in an **Approved** procedure

For SF6 Gas Insulated Switchgear the distance of 9m quoted above can be extended to 30m where no other point of **Earthing** is practicable and it is deemed safe to do so.

**Primary Earths** shall be applied to all phases except where work is carried out on phase segregated **HV Equipment**.

Examples of phase segregated HV Equipment are 400kV metal enclosed SF6 Gas Insulated Switchgear and generator terminal connections where conductors are within individual single phase Earthed metal enclosures.

The **Senior Authorised Person** shall ensure that no work will be undertaken that may prevent a **Primary Earth** from being effective.

When portable **Earthing Devices** are to be used as **Primary Earths**, a label, sign or notice shall be attached to identify them as **Primary Earths**.

**Primary Earth(s)** subjected to short circuit fault current shall be inspected for damage prior to reuse. In the case of portable **Primary Earth(s)** the **Senior Authorised Person** shall immediately arrange disposal of the portable **Primary Earth(s)**.

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<sup>1</sup> This may include limiting the amount of **Equipment Earthed** by the application of portable **Earthing Devices** and closing a circuit breaker (preferred) or disconnector, within the zone of isolation, to connect the remaining **Equipment** to earth. The circuit breaker (or disconnector) must then be **Locked** closed to maintain the earthing connection, and the **Safety Key Locked** in the **Key Safe**.

## 5 PORTABLE EARTHS

### 5.1 Inspection

Portable **Earthing Devices** and their associated application devices *shall* be inspected and maintained on an annual basis and labelled after inspection. The inspection will include for example, checking for physical damage to the earth end connection and the line end clamp, checking to make sure there are no breaks in the flexible earth thus exposing any wires, doctoring and confirming all connections are tight.

**Earthing Devices** *shall* be examined immediately before and after for defects. Defective portable **Earthing Devices** and application devices *shall* be immediately withdrawn from service and labelled as 'Defective'.

### 5.2 Application

Portable **Earthing Devices** *shall* be applied and removed using a suitable **Approved** application device. This device is an Operating pole for the application and removal of portable Earthing Device(s), they shall not be greater than 6.1 metres in length (2 long poles and 1 short pole).

In any cell or cubicle, all exposed conductors *shall* be **Isolated** and **Points of Isolation** established before any portable **Earthing Devices** are applied.

It is essential that low resistance connections be established with the portable **Earthing Device**, to ensure any voltage differences present are limited to within safe levels. Prior to the application of the earth end clamp, the portion of the earth tape to which the earth clamp is to be applied *shall* be inspected and cleaned to remove paint etc.

When the line end clamp is being applied to the busbar appropriately sized earthing clamps *shall* always be used to ensure an adequate connection is made. When fitting the line end clamp it should be partially rotated in both directions during tightening process to encourage a low resistance connection between the clamp and the busbar.

At certain **Location(s)** it is necessary to apply multiple portable **Earthing Device(s)** per phase, at each point of earthing, to cater for the maximum fault level of the **HV Equipment**. These **Location(s)** and the number of earths required are specified in Appendix 1. During the *switching* instruction preamble the number of portable **Earthing Device(s)** required per phase *shall* be confirmed between both the **Control Person** and the **Senior Authorised Person**.

Portable **Earthing Device(s)** used as a **Primary Earth** *shall* be connected to busbars (which may be solid or stranded conductors) or points specifically designed for portable **Earthing Device** connections.

Portable **Earthing Device(s)** used as a **Primary Earth** *shall* not be connected to arcing horns, corona rings, etc.

When portable **Earthing Device(s)** are to be used as **Primary Earth(s)**, a label *shall* be attached in a position that is visible. The sign is designed to distinguish them from **Drain Earth(s)** and states: “No unauthorised interference”; see Figure 5.2. When **Primary Earth(s)** are removed/replaced under a **Sanction for Work**, this is classed as authorised interference.

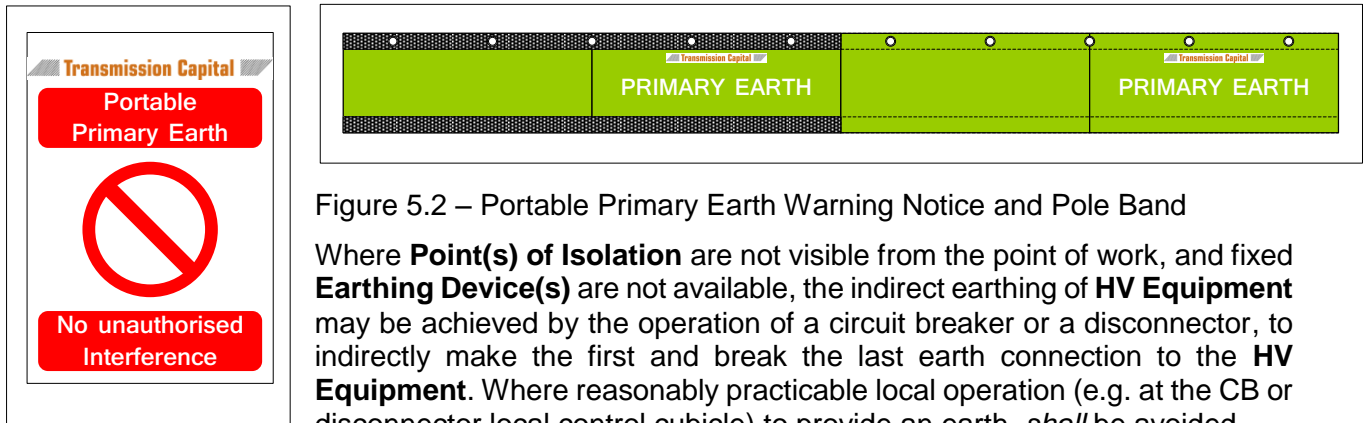


Figure 5.2 – Portable Primary Earth Warning Notice and Pole Band

Where **Point(s) of Isolation** are not visible from the point of work, and fixed **Earthing Device(s)** are not available, the indirect earthing of **HV Equipment** may be achieved by the operation of a circuit breaker or a disconnector, to indirectly make the first and break the last earth connection to the **HV Equipment**. Where reasonably practicable local operation (e.g. at the CB or disconnector local control cubicle) to provide an earth, *shall* be avoided.

A circuit breaker *shall* where *reasonably practicable* be used in preference to a disconnector for indirect earthing. In this instance any disconnector between the **Earthing Device**, the circuit breaker and the planned point of work, *shall* be closed prior to the closure of the circuit breaker.

Line end disconnectors are not designed to make or break circulating currents created by overhead line circuits and *shall* not be closed / opened to indirectly make / break the first / last connection to earth which may interrupt circulating currents.

If a fixed **Earthing Device** has a technical limitation, stating it is not fully rated as a **Primary Earth**, it *shall* still be used to make the first and break the last earth connection, prior to the application or removal of portable **Primary Earth(s)**.

### 5.3 In-Service, and Post Use, Condition

Where portable **Primary Earth(s)** have been applied for more than 6 months they *shall* be replaced in agreement with the **Control Person**. They *shall* then be quarantined until maintained.

A **Senior Authorised Person** *shall* immediately arrange to withdraw from service and dispose of any Portable **Primary Earth(s)** subjected to short circuit fault current. **Earthing Devices** *shall* be examined immediately after use for any defects. Defective portable **Earthing Devices** and application devices *shall* be immediately withdrawn from service and labelled as ‘Defective’.

## 6 DRAIN EARTHS

### 6.1 Use and Control of Drain Earths

Where **Charged Equipment** may cause **Danger** a portable **Earthing Devices** designated as a **Drain Earth** *shall* be applied in accordance with the **Safety Document**.

The recipient of the **Safety Document** is responsible for the control and safe custody of **Drain Earths** and associated issued application device.

The **Competent Person**, or a **Person** under his **Personal Supervision** may apply and remove **Drain Earths** in accordance with directions on the **Safety Document**.

Portable **Drain Earth(s)** where reasonably practicable shall be applied to a main current carrying conductors. Where this is not reasonably practicable, **Drain Earth(s)** may be applied to arcing horns, corona rings etc,

## 6.2 Control and Application

For the application / removal of **Drain Earth(s)** the recipient *shall* undertake a personal risk assessment to control the risks associated with weather conditions, ground conditions and manual handling etc.

## 7 APPLICATION / REMOVAL OF EARTHING DEVICES

- a) Fully or partially interlocked fixed **Earthing Devices** *shall* be applied and removed by an **Authorised Person**, under the instructions of the appropriate **Control Person**.
- b) Non interlocked fixed **Earthing Devices** *shall* be applied and removed by a **Senior Authorised Person**, under the instructions of the appropriate **Control Person**.

Application or removal of portable **Earthing Devices** to be used as **Primary Earths** *shall* be carried out by:-

- The **Senior Authorised Person** who has received the instruction from a **Control Person**
- A **Competent Person** under the **Personal Supervision** of the **Senior Authorised Person**. The **Senior Authorised Person** will have received the instruction from a **Control Person**

Where additional personnel are required to assist in the application or removal of portable **Earthing Devices** their role is to provide physical assistance only. This activity *shall* be carried out under the **Personal Supervision** of the **Senior Authorised Person**.

Before **Earthing Devices** are connected to the earthing system it should be inspected to ensure it is intact.

When a portable **Earthing Device** is to be applied the following sequence *shall* be undertaken:-

- All earth end clamps *shall* be applied first
- All line end clamps can then be applied

For removal of a portable **Earthing Device** the following sequence *shall* be undertaken:-

- All line end clamps *shall* be removed first
- All earth end clamps can then be removed

If a Mobile Elevated Working Platform (MEWP) is used for high level application/removal of portable **Earthing Device(s)**, **Safety Distance** *shall* be maintained at all times.

At no time *shall* the line end clamp of a portable **Earthing Device** be allowed to remain connected when its earth continuity path has been compromised / detached except as defined in an issued **Sanction for Test**. An additional earth *shall* be applied in parallel before the faulty **Earthing Device** is removed.

An appropriately authorised **Competent Person** may remove and apply fixed or portable **Primary Earths** as defined in a **Sanction for Test**.

When **HV Equipment** has been disconnected from all primary and secondary supplies in preparation for temporary removal from the normal position the use of **Drain Earths** is not necessary, provided that it is not **Charged** and **Danger** is excluded.

When **Drain Earths** prevent access to the point of work, and **Danger** could arise from **Charged Equipment**, the **HV Equipment** *shall* be connected to earth by applying **Drain Earths** at the nearest convenient point. These **Drain Earths** may be removed in turn as the work is done. Each **Drain Earth** removed *shall* be replaced before the next one is removed.

**Earthing Devices** applied for the dissipation of trapped charge at Gas Insulated Switchgear (GIS)

substations may only be applied to **Isolated** sections, and does not require the establishment of **Points of Isolation** prior to their application or removal.

## 8 BREAK OR CONNECTION OF CONDUCTOR

Before a break is made in a conductor, or a connection is made across a break, **Danger** which could arise from voltage difference must be excluded. If **Danger** cannot be excluded then the conductors *shall* be earthed on both sides of, and in close proximity to, the point where a break or connection is made.

## 9 SPECIAL CASES OF THE APPLICATION OF PRIMARY EARTHS

### 9.1 Outdoor Type Substations

When working on outdoor busbars or their associated disconnecters/isolators, it is generally possible to apply **Primary Earths** between the point of work and **Points of Isolation** using two or more earthing positions.

### 9.2 Earthing Against Points of Isolation from the LV Side of Voltage Transformers

When earthing against **Point(s) of Isolation** from the **LV** side of a voltage transformer one of the following shall be applied:

- a) Apply a **Primary Earth** between the point of work and the voltage transformer.
- b) Ensure a **Primary Earth** remains solidly connected to the **HV** side of the voltage transformer, throughout the course of the work. This is irrespective of the distance between the voltage transformer and the **Primary Earth**.
- c) Ensure a **Primary Earth** remains solidly connected to a teed section of the conductors between the Point of Work and the voltage transformer, throughout the course of the work. This is irrespective of distance.

If the work involves the disconnection of a VT or a VT has been disconnected from the **Earthed HV System** at the VT only **Danger** shall be excluded from inadvertent energisation from the VT by the following:-

- a) **LV Point of Isolation** with **Drain Earth(s)** applied to the VT **HV** connection.
- b) Where it is not Reasonably Practicable to apply the above then two **Points of Isolation** in series should be established on the **LV** side of the VT.

### 9.3 In-feeds from Auxiliary and Earthing / Auxiliary Transformers

a) **Primary Earth(s)** shall where reasonably practicable be applied to the **HV** System between the point of work and the **LV Point(s) of Isolation** on Auxiliary or Earthing / Auxiliary Transformers.

b) Where it is not reasonably practicable to apply **Primary Earth(s)** to the **HV** System between the point of work and the **LV Point(s) of Isolation** on Auxiliary or Earthing / Auxiliary Transformers, then the requirement of Section 4.1 shall where practicable be applied.



c) Where this is not practicable, safety from the **LV System** shall be achieved by applying two **Point(s) of Isolation** in series on the **LV** side of the transformer.

#### 9.4 Disconnection of Transformers and Reactors

If the work involves any disconnection of a Transformer or Reactor from the earthed **HV System**, all three phases of at least one winding of the Transformer or Reactor *shall* remain **Earthed** to avoid the possibility of induced voltages.

The requirement for continued earthing will be assessed by the **Senior Authorised Person** on site, and if required may be achieved by the application of either additional **Primary Earths** or **Drain Earths**. (The **Senior Authorised Person** *shall* assess if the transformer or reactor windings need to remain **Earthed**.)

## 10 NOTES


## APPENDIX 1 – SUBSTATION FAULT LEVELS

Location	Fault Level (kA)
ORMONDE 132kV (ONSHORE)	31.5kA
ORMONDE 33kV (ONSHORE)	17kA
LINCS 400kV (ONSHORE)	44kA (to be confirmed with NGET at the time)
LINCS 132kV (ONSHORE)	11.4kA
LINCS 132kV (OFFSHORE)	6kA

## PRIMARY PORTABLE EARTHS TO BE APPLIED PER PHASE

ORMONDE 132kV (ONSHORE)	2 per phase
ORMONDE 33kV (ONSHORE)	1 per phase
LINCS 400kV (ONSHORE)	3 per phase
LINCS 132kV (ONSHORE)	1 per phase
LINCS 132kV (OFFSHORE)	1 per phase