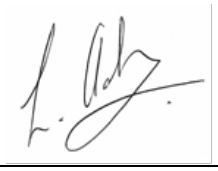
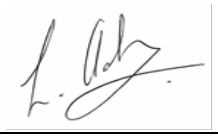
National Grid UK Electricity Transmission plc

NATIONAL SAFETY INSTRUCTION 2
and
Guidance

EARTHING HIGH VOLTAGE EQUIPMENT

DOCUMENT HISTORY

Issue	Date	Summary of Changes / Reason	Author(s)	Approved By (Title)
1	01/08/08	New Guidance Document to follow 3rd edition Electricity Safety Rules layout. Safety notes and safety bulletins SEB 130, 146, 18/2006, 02/2006, 22/2005, 27/2003 incorporated.	NSI Working Group	MDE Manager Les Adams 
2	14/11/08	Appendix A amended	Gary Thornton	MDE Manager Les Adams 
3	29/03/10	Re-issue of document as part of annual review. Modified or inserted text identified by yellow highlighting. Safety Bulletins SB 201, SB 233 embedded into guidance.	Safety Rules Assurance Team	MDE Manager Les Adams 
4	04/04/2011	Annual review: document amended as detailed below and minor text changes as highlighted in yellow.	NSI Review Group	MDE Manager Les Adams 
5	02/04/2012	Annual review; document amended as detailed below and minor text changes as highlighted in yellow.	NSI Review Group	MDE Manager Les Adams 
6	12/03/2013	Appendix A reviewed and updated.	Mark Poucher Electricity Operations Safety Manager	MDE Manager Michael Dean
7	11/03/2013	Appendix A reviewed and updated.	Mark Poucher Electricity Operations Safety Manager	MDE Manager Michael Dean
8	April 2014	Renamed as “National Safety Instruction and Guidance” which now incorporates and replaces NSI 2 Issue 8 and NSI 2 Guidance Issue 7.	NSI Review Group	ETAM Operations North Manager Mike Dean
9	April 2016	Annual review: document amended as detailed below and minor text changes as highlighted in yellow.	NSI Review Group	ETAM Operations North Manager Matt Staley
10	Jan 2021	Update to application / removal of first / last earth(s) & the earthing requirements on / near to Line End Equipment.	Electricity Transmission Safety Rules Team	Matt Staley Head of Operations ET Operations
11	Feb 2022	Full review includes NSI Boundary information changes & application of Substation Applied DrESS. Reorganisational role changes.	Electricity Transmission Safety Rules Team	Matt Staley Director of Asset Operations
12	Jan 2023	Clarity added following Penwortham Circulating Current Safety Bulletin	Safety Rules Team	Matt Staley Director of Asset Operations

Issue	Date	Summary of Changes / Reason	Author(s)	Approved By (Title)
13	July 2025	Review and updates	Safety Rules Team	Kate Grant Director of Asset Operations

KEY CHANGES	
Section	**Amendments**
4.4 Rule	Information added regarding phase segregated **Equipment** by designs, **Earthing** requirements.
5.1 Guidance	Words added to explain the portable **Drain Earth** requirement at Line Ends for the management of circulating current.
5.2 Guidance	Portable **Drain Earth(s)** applied or removed outside of a demarcated work area must be carried out under the **Personal Supervision** of a **Senior Authorised Person.**
6.1 Guidance	Clarity provided on the process for the replacement of out of date portable **Earthing Device(s)**.
7.4 Rule	Clarity regarding who can apply / remove **Portable Primary Earths** under a **Sanction for Work**.
7.11 Guidance	Guidance updated to clarify when a restricted earthing device can be operated under an OAR switching instruction.
8.5 Rule	Minor grammatical corrections and the introduction of requirements for working on **Earthing** or Earthing & Auxiliary Transformers with regards to Intrusive and Non-intrusive working.
8.5b Guidance	Clarity provided for the application of **Earthing Device(s)** against infeeds from Auxiliary / Earthing & Auxiliary Transformers for both non-intrusive and intrusive work.
8.5c Guidance	Clarity that one **LV Point of Isolation** only is required for Neutral Earthing Resistor isolation.
9.8 Rule & Guidance	Table and information added regarding the number of Substation Applied DrESS Earths required to form a **Primary Earth**
10.1 Rule	Example 10.1d added for earthing through an auto transformer against **Point(s) of Isolation** from the **LV** side of a Voltage Transformer.
10.2 Guidance	Reference to further information on the dismantling of CVT's added.
Appendix D	Minor text addition.

EARTHING HIGH VOLTAGE EQUIPMENT

CONTENTS

1 Purpose and Scope

To apply the principles established by the Safety Rules and provide guidance on National Safety Instruction 2, on the use of **Earthing Device(s)** to achieve **Safety from the System** for **Personnel** working on or near to **High Voltage Equipment** in substations.

Earthing is carried out as part of the application of safety precautions. It protects **Personnel** against the effects of inadvertent energisation and **Equipment** that may be **Charged**.

The management of earthing **High Voltage Equipment** on overhead lines and substation terminal **Equipment** is covered by the Management Procedure – NSI 4 "Work on or Near High Voltage Overhead Lines".

National Grid **Personnel** when applying principles established by the Safety Rules on the use of **Earthing Device(s)** to achieve **Safety from the System** shall be appointed to this NSI. For Contractor appointment see Appendix E.

The layout of this guidance note reflects that of legislative codes of practice, where the rule (or mandatory obligation) is identified by a green panel on the left-hand side. The guidance follows after the rule and is identified by a blue panel.

Within National Grid, guidance notes hold equivalent status of an Approved Code of Practice (ACOP) in law. If not followed, you will be required to demonstrate that your safe system of work is of an equal or higher standard.

2 Definitions

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

3 Dangers

The **System Danger(s)** to **Personnel** applying or removing **Earthing Device(s)** to **HV Equipment** are electrocution, burns and effects on eyes arising from:-

- Inadvertent infringement of **Safety Distance**
- The application of **Earthing Device(s)** to **Live HV Equipment**
- Badly connected or insecure **Earthing Device(s)**
- The incorrect sequence or method of application or removal of **Earthing Device(s)**
- Incorrect management of **Impressed Voltage Conditions**
- **Charged Equipment** and the voltage difference across a break in electrical conductors
- Incorrect management of circulating currents
- The electrical arc drawn by the application or removal of an **Earthing Device**
- The application of **Earthing Device(s)** to an inadequate or defective earth system
- Incorrect identification of **Earthing Device(s)**
- Inadequate permanent Earthing of **Equipment /** conductors (e.g. 'floating' sections of busbar)

NSI 2
4.1 to 4.5

4 General Requirements for Primary Earth(s)

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

If the number of portable **Earthing Device(s)** applied needs to increase in line with current substation arrangements whilst quoted on already consented **Safety Document(s)** then the process within Appendix A13 shall apply.

4.2 A fixed **Earthing Device**, shall where reasonably practicable be used to make the first and break the last earth connection. This may include the use of indirect earthing of **HV Equipment** via the operation of a suitably rated circuit breaker or a disconnector to indirectly make the first and break the last earth connection to the **HV Equipment**. Where this is not reasonably practicable the **Senior Authorised Person** shall carry out a written risk assessment to determine the safest way to apply / remove portable **Earthing Device(s)** to / from the **HV Equipment**.

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

Where it is not reasonably practicable to apply **Primary Earth(s)** between the point of work and the **Point(s) 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 SF_6, or any equivalent Type Registered Gas Insulated Switchgear (GIS), the distance of 9m quoted above can be extended to 30m provided the full intent of this section is met.

4.4 **Primary Earth(s)** shall be applied to all 3 phases, including when the description makes reference to **Equipment** not present on all phases.

Where a phase is not present by design, such as at a connection to a 2 phase transformer, a **Primary Earth** shall be applied to the phase conductors present as per the Operational Diagram. Such an earth shall only be quoted to cover an infeed from a **Point of Isolation** on those same phases.

Where phase segregation exists by **Equipment** design, a **Primary Earth** can be applied to the phase being worked upon only.

4.5 For work on the Line End of circuits; **Point(s) of Isolation** and **Primary Earth(s)** shall be established at all points of infeed.

Where the **Primary Earth** does not fulfil the requirements to manage the circulating current and voltage at the Line End, an alternative earth path shall be established, this can be achieved via the application of a Substation or Tower Drain Earth Shorting Scheme (DrESS).

A **Safety Document** can be **Consented** to and issued for the application and / or removal of a Substation Applied DrESS, Tower DrESS or an effective earthing scheme.

NSI 2
4.5 Cont. to 4.7

Alternatively, an NSI2 **Senior Authorised Person** staff may receive a suitable switching instruction from a **Control Person (Safety)** to apply or remove a **Primary Earth** to / from the OHL circuit Downdroppers / Downleads, as indicated in Fig 7.6A. subject to a Risk Assessment being undertaken.

The circuit shall where practicable be solidly bonded to Earth via a **Primary Earth**, up to the point of application. This may require **HV Equipment** being **Locked** in the closed position to establish / maintain the earth path. The **Senior Authorised Person** shall carry out a Risk Assessment to ensure the **Dangers** associated with establishing circulating current when applying or removing **Earthing Device(s)** are managed. Risk may be reduced or mitigated by the correct sequence of earthing.

The Substation **Senior Authorised Person** and OHL **Senior Authorised Person** shall consult, agree and record any Safety Precautions that need to be established and maintained throughout the course of the work.

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

4.7 When portable **Earthing Device(s)** are to be used as **Primary Earth(s)** a label shall be attached to identify them as **Primary Earth(s)**.

Guidance
NSI 2
4.1

4 General Requirements for Primary Earth(s)

4.1 **Earthing Device(s)** used as a **Primary Earth** and associated portable application device(s) shall be Type Registered.

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 earth(s) required are specified in Appendix A. During the switching instruction preamble, the number of portable **Earthing Device(s)** required per phase shall be confirmed between both the **Control Person (Safety)** and the **Senior Authorised Person**.

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

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

Portable **Earthing Device(s)** used as a **Primary Earth(s)** may be applied to solid stranded aluminium conductors or internally supported (This can be verified by local knowledge or reference to engineering drawings), tinned, copper, Holtom type conductors.

Figure 4.1A - Holtom Type Copper Conductor

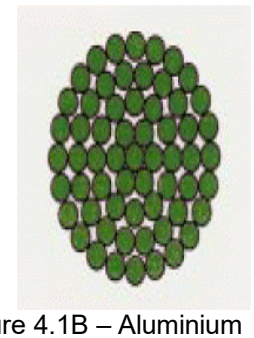


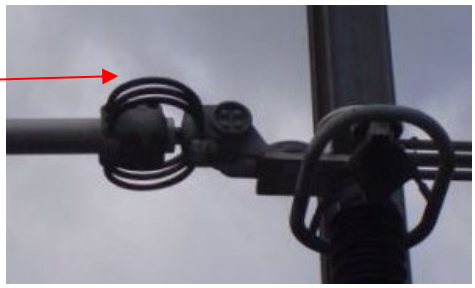
Figure 4.1B – Aluminium Alloy Stranded Conductor

Guidance
NSI 2
4.1 Cont. to 4.2

When applying portable **Primary Earth(s)** to braid / shunts the following shall be confirmed by the **Senior Authorised Person** prior to application:-

- Braid / Shunt shall have a round profile, refer to Figure 4.1C
- Ensure the line end clamp is the correct size for the cross sectional area of the conductor
- Only one portable **Primary Earth** to be applied to each braid / shunt
- If a short circuit fault was to occur the busbar connector will require replacement

Figure 4.1C
Braid Example



For work involving line end **Equipment** it is also recognised that a potential hazard may exist under certain **System** configurations from high circulating currents. In line with Management Procedure – NSI 4 “Work on or Near High Voltage Overhead Lines” a Substation Applied Drain Earthing Shorting Scheme (DrESS) to the overhead line entry point may need to be applied.

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

4.2 An example of where it is not reasonably practicable to apply a fixed **Earthing Device** is a mesh bus section where there are no fixed **Earthing Device(s)** by design. As **Point(s) of Isolation** are visible from the point of work, the correct circuit can be identified. **Danger** from **Charged** conductors is minimal due to the short length of busbar. There is therefore a reduced risk and it is acceptable to apply portable **Earthing Device(s)**, refer to Guidance Section 7.2 for information on written risk assessments.

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 a circuit breaker shall 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.

Where reasonably practicable local operation (e.g. at the CB or disconnector local control cubicle) to provide an earth, shall be avoided.

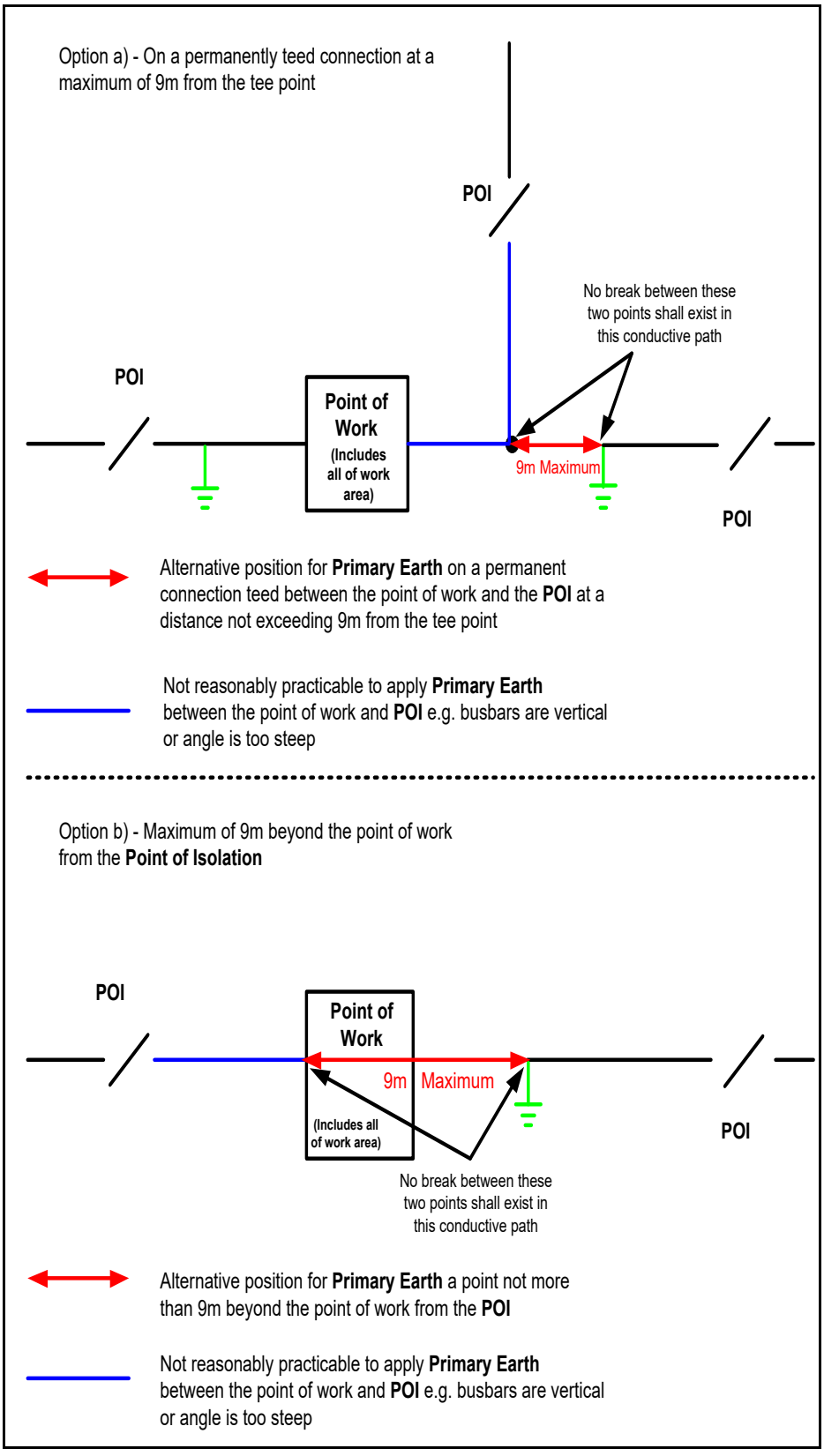
Line end disconnectors are not designed to make or break circulating currents created by overhead line circuits and shall not be closed / opened to indirectly make / break the first / last connection to earth which may interrupt circulating currents.

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)**.

Guidance
NSI 2
4.3

4.3 **Primary Earth(s)** should be close to and visible from the point of work. If not, the **Senior Authorised Person** shall consider the application of additional **Earthing Device(s)** at the point of work.

Schematic diagram for Option (a) and (b)



Guidance
NSI 2
4.3 Cont. to 4.7

Primary Earth(s) shall, where reasonably practicable, be positioned outside the demarcated work area. If not reasonably practicable then a safe system of work shall be established to ensure that the integrity of the **Primary Earth(s)** are not affected by the work.

If the **Primary Earth(s)** are compromised stop work, withdraw the Working Party and inform an **Senior Authorised Person** immediately. If an **Senior Authorised Person** cannot be contacted, the PIC shall contact the TNCC and inform them of the location and description of the earth(s) that have been compromised.

4.4 When earthing is described in terms such as adjacent a VT that is not on all 3 phases, **Primary Earth(s)** shall still be applied to all the phases.

Where a two-phase transformer is connected to the **System**, there will be a point at which the unused phase ceases. Any earthing applied where there is only 2 phases will cover any infeed that can cross those phases. It will not be suitable for the missing phase. This includes use of the 9m / 30m rule, and solid bonding to a VT.

Examples of phase segregated **HV Equipment** are 400 kV metal enclosed SF_6, or any equivalent Type Registered Gas Insulated Switchgear and generator terminal connections, where conductors are in individual single phase **Earthed** metal enclosures.

4.5 To fulfil the requirements to manage the induced current and voltage, consultation between the Substation **Senior Authorised Person** and the OHL **Senior Authorised Person** shall take place.

To manage the circulating current and voltage, a Substation or Tower DrESS can be applied. This shall be documented by the Substation **Senior Authorised Person** in the RAMS; or via further consultation with an OHL **Senior Authorised Person**, **Control Person (Safety)** and / or Engineering and Asset Management to develop an effective scheme, documented via the TGN 313 Form F1.

4.7 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”. When **Primary Earth(s)** are removed / replaced under a **Sanction for Work**, this is classed as authorised interference.

Figure 4.7 – Example of Portable Primary Earth Label

NSI 2
5.1 to 5.2

5 General Requirements for Drain Earth(s)

5.1 Where **Charged Equipment** may cause **Danger**, **Drain Earth(s)** shall be applied in accordance with an **Earthing Schedule** that will be issued along with the **Safety Document**.

5.2 The recipient of the **Safety Document** is responsible for the control and safe custody of **Drain Earth(s)** and associated application device issued with an **Earthing Schedule**.

The **Competent Person**, or a **Person** under their **Personal Supervision** may apply and remove **Drain Earth(s)** in accordance with an **Earthing Schedule** under a **Safety Document**.

Guidance
NSI 2
5.1 to 5.2

5 General Requirements for Drain Earth(s)

5.1 **Earthing Device(s)** to be used as **Drain Earth(s)** shall be Type Registered. Consideration shall also be made of **Equipment** disconnected from earth resulting in a floating section which may in itself become **Charged**.

Portable **Drain Earth(s)** applied at a Line End to manage circulating currents will be via Appendix A10; combined with Table A11 where applicable to manage the sub-conductor requirements. A minimum of two 150mm^2 Portable **Earthing Device(s)** per phase are required to manage the circulating current level.

The **Senior Authorised Person** shall also consider the potential to create circulating currents when applying **Earthing Device(s)**. Where reasonably practicable, elimination of large earth loops should be made, when an **Earthing Schedule** is produced.

When planning any disconnection / connection of conductors, especially in an AIS 400kV double busbar substation, the **Senior Authorised Person** shall ascertain the adjacent circuit loadings and bay centre distances. Actions to be taken are determined by the table and advice in Appendix D.

5.2 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., this excludes **HV Equipment** which is electrically connected to the overhead line due to high circulating currents unless the circulating currents have been removed by the application of a TGN 313 Earthing Scheme.

To ensure **Drain Earth(s)**, when not in use, are kept in safe custody, the **Safety Document** recipient shall keep them in a locked vehicle, box, cupboard or room etc. which can only be unlocked by themself,
or for substation earth(s), by securing the earth(s) together by a lockable strap e.g. earth strap

For the application / removal of **Drain Earth(s)** the recipient of the **Earthing schedule** shall undertake a personal risk assessment to control the risks associated with weather conditions, ground conditions and manual handling etc. Where a Contractor is authorised to apply **Drain Earth(s)** they shall produce the risk assessment which shall be reviewed as acceptable by the **Senior Authorised Person** for safety from the system issues, e.g. detached **Drain Earth**.

Portable **Drain Earth(s)** applied / removed outside of a demarcated work area shall be undertaken under the **Personal Supervision** of a **Senior Authorised Person** and the requirement recorded on the **Earthing Schedule. Competent Person** retains control of the **Safety Document**.

For the application and removal of **Drain Earth(s)**, refer to Section 7.3.

Guidance
NSI 2
5.2 cont

In order to hold a **Safety Document** where the **Earthing Schedule** is issued to a Contractor, the Contractor shall be authorised in accordance with Appendix E. The recipient of the **Safety Document** is responsible for the control and safe custody of **Drain Earth(s)**.

NSI 2
6.1 to 6.2

6 General Requirements for Portable Earth(s)

6.1 Portable **Earthing Device(s)** and their associated application device(s) shall be inspected and maintained.

Earthing Device(s) shall be examined immediately before and after use for defects. Defective Portable **Earthing Device(s)** and application device(s) shall be immediately withdrawn from service.

Portable **Earthing Device(s)** will only remain suitable as a **Primary Earth** or a **Drain Earth** for a period of 6 months after application.

6.2 Type Registered Portable **Earthing Device(s)** shall be applied and removed using a Type Registered application device.

In any cell or cubicle, all exposed conductors shall be **Isolated** and **Point(s) of Isolation** established before any portable **Earthing Device(s)** are applied.

Guidance
NSI 2
6.1

6 General Requirements for Portable Earth(s)

6.1 Portable **Earthing Device(s)** and their associated Type Registered application device(s) shall be maintained. Maintenance shall be carried out in accordance with the Maintenance Policy for all portable **Earthing Device(s)**.

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.

When portable **Earthing Device(s)** are to be applied, or issued under an **Earthing Schedule**, only those necessary for the immediate operations shall be removed from the store.

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., refer to Figure 6.1B, to encourage a low resistance connection between the clamp and the earth tape.

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. Refer to the Type Registration List for details of clamp sizes and the busbar sizes they are designed for. Figure 6.1A shows incorrect application.

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.

When applying or removing large head clamps, application device S2 Sockets, refer to Figure 6.1C are more suitable as they have a spigot retaining spring, for applying earth(s) in downward direction or at an angle, whilst allowing clamps free to rotate.

S1 Socket – has a slot, stopping the smaller clamps from rotating, but has no spigot retaining spring.

Guidance
NSI 2
6.1 Cont. to 6.2

Figure 6.1A

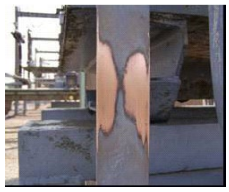


Figure 6.1B

Figure 6.1C "S2" clamp top

Portable **Earthing Device(s)** shall be returned to the storeroom as soon as practicable after use.

Due to imposed **Impressed Voltage Conditions** once applied and in addition to any weather factors, a 6 month limit is in place for portable **Earthing Devices(s)**. This is to assure that the portable **Earthing Device(s)** remain electrically and mechanically suitable to carry a fault or induced current.

The TNCC carry out regular audits to identify portable **Earthing Device(s)** that have reached or are approaching this limit and will inform the responsible Operations Manager(s) at the relevant **Location**. The Operations Manager(s) will then inform the relevant **Senior Authorised Person(s)** affected (Substations & OHLs). This allows for a controlled replacement of the portable **Earthing Device(s)** to take place where necessary.

The controlled replacement will consist of the following sequence:

a. The **Working Party(s)** are withdrawn from the work area(s) and the **Competent Person(s)** have signed the Surrender element of the Transfer Record Section(s) of the **Safety Document(s)**.

b. The **Safety Document(s)** are in the safe custody of the **Senior Authorised Person(s)**.

c. The **Control Person (Safety) 1** will then confirm with a logged statement that all affected **Safety Document(s)** are accounted for, and in safe custody.

d. A Switching instruction shall then be given by the **Control Person (Safety) 1** to the **Senior Authorised Person** to apply an equivalent value set of PPEs and remove the affected portable **Earthing Device(s).** *(where space precludes application before removal agree the instruction sequence with the* **Control Person Safety 1***)*.

e. Once the switching instruction is confirmed back to **Control Person (Safety) 1**, the **Safety Document(s)** can be taken out of safe custody by the **Senior Authorised Person(s)** and then reissued to the **Competent Person(s)**.

Where portable **Earthing Device(s)** have been replaced with a maintained and inspected set as part of precautions that can be varied on a **Safety Document**, the TNCC should be informed at an appropriate point in time to ensure that they can update the records on the Integrated Energy Management System (IEMS), for example at the cancellation of the **Safety Document**.

6.2 Portable **Earthing Device(s)** and their associated application / removal device(s) are identified in Type Registered List TRL 2.2 Part 4 – Substation Portable Earthing Equipment.

NSI 2
7.1 to 7.6

7 Application / Removal of Earthing Device(s)

7.1 (a) Fully or partially interlocked fixed **Earthing Device(s)** shall be applied and removed by an **Authorised Person**, under the instructions of the appropriate **Control Person.**

(b) Non interlocked fixed **Earthing Device(s)** shall be applied and removed by a **Senior Authorised Person**, under the instructions of the appropriate **Control Person.**

7.2 Application or removal of portable **Earthing Device(s)** to be used as **Primary Earth(s)** shall be carried out by:-

- The **Senior Authorised Person** who has received the instruction from a **Control Person (Safety)**
- 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 (Safety)**

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

7.3 Before **Earthing Device(s)** are connected to the earth system the earth system 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

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. An additional earth shall be applied in parallel before the faulty **Earthing Device** is removed.

7.4 An appropriately authorised **Competent Person** may remove and apply **Primary Earth(s)** as defined on a **Sanction for Work**. If the associated **Portable Primary Earth(s)** are outside of a work area, a **Senior Authorised Person** shall provide **Personal Supervision** for either removal or application by the **Competent Person** as part of the **Working Party**.

7.5 Before a break is made in an electrical conductor or a connection is made across a break, the **Senior Authorised Person** shall assess the means of excluding **Danger**, which could arise from voltage difference. Where **Danger** exists, **Earthing Device(s)** shall be applied on both sides of, and in close proximity to, the point where a break or connection is to be made.

7.6 **Equipment** connected to line end circuits are subject to circulating currents, before a break is made consultation shall be sought from an overhead line **Senior Authorised Person**.

NSI 2
7.7 to 7.11

7.7 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 Earth(s)** is not necessary, provided that it is not **Charged** and **Danger** is excluded.

7.8 When **Drain Earth(s)** 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 Earth(s)** at the nearest convenient point. **Drain Earth(s)** shall be applied in accordance with an **Earthing Schedule**. These **Drain Earth(s)** may be removed in turn as the work is done. Each earth removed shall be replaced before the next one is removed.

7.9 When working on Metal Enclosed Switchgear and Earthing is required, reference shall be made to Management Procedure NSI 3 - High Voltage Metal Enclosed Switchgear.

7.10 **Earthing Device(s)** applied for the dissipation of trapped charge at GIS substations may only be applied to **Isolated** sections and does not require the establishment of **Point(s) of Isolation** prior to their application or removal.

7.11 Fixed line end **Earthing Device(s)** at the Mid-Point of a complex circuit should be identified by the additional nomenclature suffix 'R' (or determined by a suitable Technical Limitation). These are restricted to a specific operating sequence to prevent them interrupting high levels of circulating current. This shall be co-ordinated and instructed by the **Control Person (Safety)**.

If any restricted **Earthing Device** is required:

I. as a **Drain Earth** on an **Earthing Schedule**
II. to be operated under a **Sanction for Work**
III. as **Equipment** to be maintained under a **Safety Document**
IV. under an 'Operate as Required' switching instruction

The **Control Person (Safety)** shall confirm the availability of the restricted **Earthing Device(s)** as a **Drain Earth(s)** and / or its suitability to be maintained before **Consent** to a **Safety Document**.

If an 'Operate As Required' instruction is requested for a restricted **Earthing Device(s)** by substation staff, the **Control Person (Safety)** shall review the overhead line circuit on which the restriction exists on the Integrated Energy Management System (IEMS).

Where a suffix 'R' **Earthing Device** has been installed, the route it is associated with is classified as a Complex Circuit and the circulating current flowing could be up to a maximum of 900A. See Appendix A12 for the earthing requirements.

Guidance
NSI 2
7.1 to 7.2

7 Application / Removal of Earthing Device(s)

7.1 The application or removal of any **Earthing Device**, including an 'Operate As Required' (OAR) switching instruction, requires the receiver of the instruction to be compliant with NSI 30 and all relevant Operational Authority Authorisations.

7.2 Application and removal of portable **Primary Earth(s)** is controlled by either switching instruction, or under a **Safety Document**.

A **Senior Authorised Person** shall receive the instruction for the application or removal of portable **Primary Earth(s)**. Switching Instructions for earthing shall be carried out in accordance with the requirements of Management Procedure - NSI 1 "Operational and Safety Switching".

Before applying portable **Primary Earth(s)** the **Senior Authorised Person** shall carry out a risk assessment and record the appropriate controls e.g. Model Risk Assessment for Application and Removal of Portable **Primary Earth(s)**" or the rear of the Switching Instruction Sheet. To achieve this, the **Senior Authorised Person** shall carry out a visual risk assessment at the point of earthing.

Senior Authorised Person shall consider the following as part of their risk assessment:-

- Condition of portable **Primary Earth(s)** inspected for damage and within inspection date
- Condition of earth tape at point of application
- **Point(s) of Isolation** confirmed
- Point at which **Earthing Device(s)** are to be applied
- Proximity of adjacent **Live HV Equipment**
- Proximity of lower level exposed conductors e.g. stress shields, corona rings, CT housing etc.
- Ground conditions at point of application
- Height at which portable **Earthing Device** has to be applied
- Prevailing weather conditions
- If using already applied Earthing Device(s), the time they have been applied for and whether a new set will need to be applied to comply with the 6 months rule.

Figure 7.2A - Example of proximity of lower level equipment - **Safety Distance** to be maintained when applying portable **Earthing Device(s)** will be from the bottom of the CT housing not the conductor as indicated by the red arrows.

Guidance
NSI 2
7.2 Cont. to 7.3

The control measures shall include, where appropriate:-

- Switching out adjacent **Live Equipment**
- Ensuring that electrical protective device(s) are in service on adjacent busbars and circuits
- Number of portable **Earthing Device(s)** required
- Deciding whether additional **Personnel** should be used to assist with the application or to help prevent loss of control
- Reference to dimensional drawings
- Use of Optical measuring device(s)
- Use Mobile Elevated Work Platform (MEWP) for application / remove of **Earthing Device** at height

If a MEWP is used for high level application / removal of portable **Earthing Device(s), Safety Distance** shall be maintained at all times. The controls for this shall be identified in the generic risk assessment, which is made site specific by the **Senior Authorised Person**.

The risk assessment shall be retained in an A4 folder titled “Portable Earthing Device(s) Risk Assessments” located within the substation switching office for a period of 6 months.

Contractors shall not apply, remove or assist in the application or removal of portable **Primary Earth(s)** to or from the **System** unless they are under the instructions specified with a **Sanction for Work Safety Document** and have the appropriate authorisations to do so.

Where reasonably practicable portable **Earthing Device(s)** with single earth leads shall be applied. The application of single earth leads will assist to reduce potential manual handling issues associated with the application of multiple earth leads. An example where it is not reasonably practicable is where some caged equipment have double earth leads specifically designed.

Earthing at Hall Type 132 kV Substations is controlled via an interlock system. An example is included in Appendix B for guidance.

Where portable **Primary Earth(s)** are applied or removed under a **Safety Document**, this shall be noted in the ‘Work to be Done’ area, and no switching instruction will be issued.

Where portable **Primary Earth** application or removal requires a **Safety Document** for proximity only, it is permitted to obtain such a document for the **Equipment** on which proximity will be infringed, and then obtain a switching instruction for the application / removal.

Example: High level National Grid busbars are to be earthed, requiring approach to the conductors in the bay of a 3rd party.

- A **Safety Document** would be obtained from the 3rd Party for proximity working only.
- The **Senior Authorised Person** shall confirm possession of the proximity **Safety Document** to the NG **Control Person (Safety),** who can then issue a switching instruction to apply portable **Primary Earth(s)** to the busbar.

7.3 Before **Earthing Device(s)** are connected to the earth system endeavours should be made to ensure the earth system is intact. This may consist of a visual inspection, communication with site representatives or viewing Technical Limitations.

Guidance
NSI 2
7.3 Cont. to 7.6

When an increase of number of portable **Earthing Device(s)** is required for existing portable **Primary Earth(s)** as detailed in Section 4.1 Guidance; the requirement to ensure all earth end clamps are applied first followed by all line end clamps will apply for the additional **Earthing Device(s)** only.

Operating pole, type ESI-P1 for the application and removal of portable **Earthing Device(s)** shall not be greater than 6.1 metres in length (2 long poles and 1 short pole).

Where multiple earth leads are connected in close proximity to each other at the earth end connection, and cannot be adequately separated, if one is required to be removed then both shall be removed prior to the re-application of the other.

When the continuity path of a portable **Earthing Device** has been compromised, an additional earth shall be applied in parallel. All work relying on the portable **Earthing Device** as a safety precaution or as a further precaution shall be halted, until the portable **Earthing Device** has been replaced. For **Primary Earth(s)** the **Control Person (Safety)** shall be immediately informed.

The risk assessment for the application of the additional portable **Earthing Device** shall ensure that no **Personnel** are exposed to **Danger**.

7.4 A **Competent Person** authorised to Management Procedure – NSI 9 “Testing High Voltage Equipment”, may remove and apply **Primary Earth(s)** as defined on a **Sanction for Work**.

7.5 Where **Danger** is excluded due to existing earthing arrangements, reduced drain earthing may be utilised, for example, where **Primary Earth(s)** is in close proximity to the break.

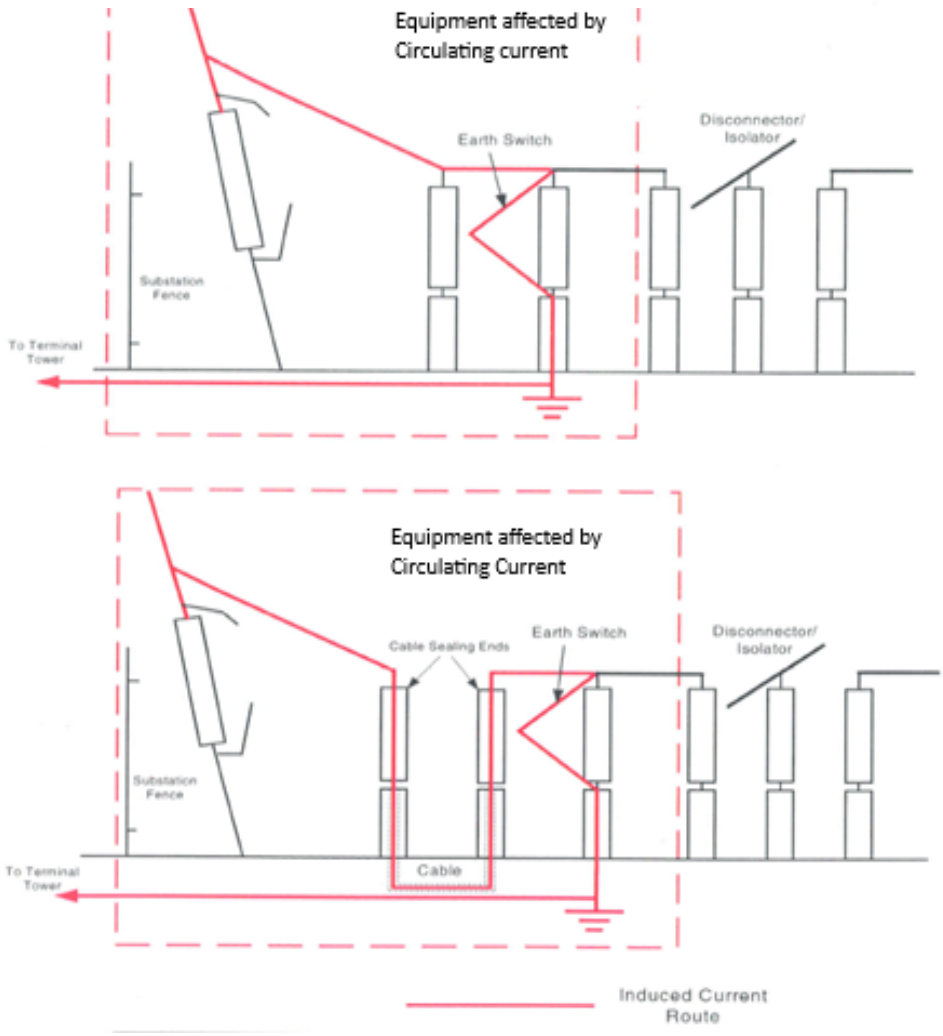
7.6 High circulating currents may appear on substation line end **Equipment**. The **Senior Authorised Person** shall consult with an overhead line **Senior Authorised Person** competent to Management Procedure - NSI 4 “Working on or Near High Voltage Overhead Lines”.

High circulating currents (900 A) can flow in the **Earthing Device(s)** applied by overhead lines to a Complex Circuit. Prior to work commencing the overhead line **Senior Authorised Person** may apply additional **Primary Earth(s)** to sectionalise the circuit or by the local application of a DrESS.

High circulating currents (450 A) can flow in the conductors of a simple circuit. The overhead lines **Senior Authorised Person** will guide and assist in the management of this current.

Guidance
NSI 2
7.6 Cont.

Typical Configurations of Circulating Current in Substations

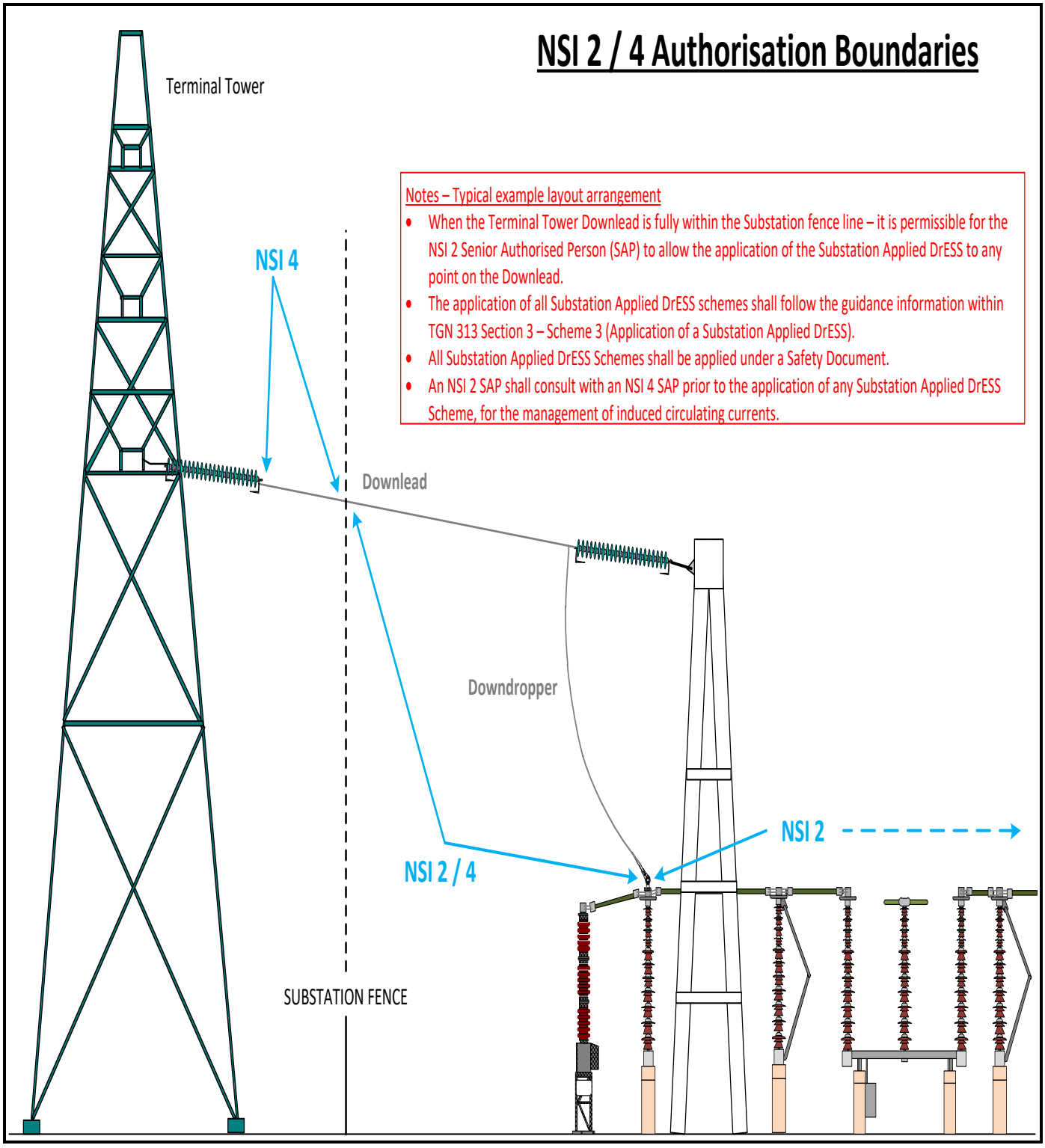


Guidance
NSI 2
7.6 Cont.

Figure 7.6A shows the overhead line and substation authorisation interface when earthing on line end **Equipment**.

Note: NSI 6 & 8 applies to all work inside the HV compound

Figure 7.6A – OHL / Substation Interface



Guidance
NSI 2
7.7 to 7.11

7.7 Management Procedure NSI 33 – "The Addition / Removal To / From The System" gives guidance on the process for temporarily removing **Equipment** from the **System** e.g. for workshop repair.

7.11 Where a fixed **Earthing Device** has been identified as at the Mid-Point of a complex circuit, it should be identified with a suffix 'R'; for example, X101AR.

A Technical Limitation can also identify a suffix 'R' fixed **Earthing Device**, but this should be temporary until such time as the numbering can be updated.

When carrying out safety switching activities, the sequencing to prevent a Mid-Point earth from interrupting established high levels of circulating current is 'not last one applied' and 'not first one removed'. To avoid the interruption of any circulating current, the methodology of 'first applied' and 'last removed' shall where practicable be utilised.

Where an alternative **Earthing Device** is utilised in place of a suffix 'R' device, e.g. X101B, then all the requirements and restrictions of being a Mid-Point earth still apply. The rating for a portable **Earthing Device** in such a position is covered in A12.

A suffix 'R' **Earthing Device** can be maintained / operated under a **Safety Document**, provided a suitable earth is quoted adjacent or on its line side.

An 'Operate As Required' (OAR) switching instruction can only be issued if at least one of the remote ends is not directly earthed (including earthing applied to OHL's).

This will be coordinated by the **Control Person (Safety)** at the TNCC.

NSI 2
8.1 to 8.5

8 Special Cases of the Application of Primary Earth(s)

8.1 Earthing at Tandem Isolators

When it is necessary to apply or remove portable **Primary Earth(s)** at Tandem Isolators and special earthing facilities are not provided, this shall where reasonably practicable be carried out with **Point(s) of Isolation** established at both sides of the Isolator. If this is not reasonably practicable the **Senior Authorised Person** shall carry out a written risk assessment and decide the appropriate control measures and safe method of applying the portable **Primary Earth(s)** to the **HV Equipment**.

8.2 Earthing Above **Live** Circuits shall not be carried out.

8.3 Indoor Type Substations

When applying **Earthing Device(s)** at Hall Type Indoor 132 kV Substations the **Senior Authorised Person** shall carry out a written risk assessment detailing the control measures required to prevent items falling out of the busbar trolley whilst traversing above **Live** circuits.

8.4 Transformers and Reactors

If the work involves any disconnection of the 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 Earth(s)** or **Drain Earth(s)**. (The **Senior Authorised Person** shall assess if the transformer or reactor windings need to remain **Earthed**.)

When a generator transformer is connected to a generator turning on barring gear, care shall be taken that the continuity of the earth path through the windings is maintained. If work on the tap changer or windings is undertaken, any point of disconnection shall first be bridged. This is to avoid an induced decaying **High Voltage** being produced across the disconnection due to the collapse of a magnetic field associated with any small circulating current in the transformer windings.

8.5 In-feeds from Auxiliary and Earthing / Auxiliary Transformers & Neutral Earthing Resistors

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 of Isolation** on Auxiliary or Earthing / Auxiliary Transformers, then the principles of NSI 2 Section 4.3 shall be applied.

c) Where the above is not reasonably practicable, safety from the **LV System** shall be achieved by applying two **Point(s) of Isolation** in series on the **LV** side of the transformers. This is known as Double Isolation.

Where work is on the (Earthing) Auxiliary Transformer itself, and it is not possible to place a **Primary Earth** between the **LV POI** and the Point of Work, a **Primary Earth** placed within 9m and visible from the Point of Work may be used for non-intrusive work. For work that is intrusive, Double Isolation shall be used.

Guidance
NSI 2
8.1 to 8.3

8 Special Cases of the Application of Primary Earth(s)

8.1 The design of Tandem isolators is such that it is possible when applying or removing portable **Earthing Device(s)**, with one side of the Tandem Isolator still **Live**, for loss of control to result in inadvertent earthing of **Live Equipment**.

Figure 8.1A – End Rotating Post Busbar Isolators Arranged in Tandem

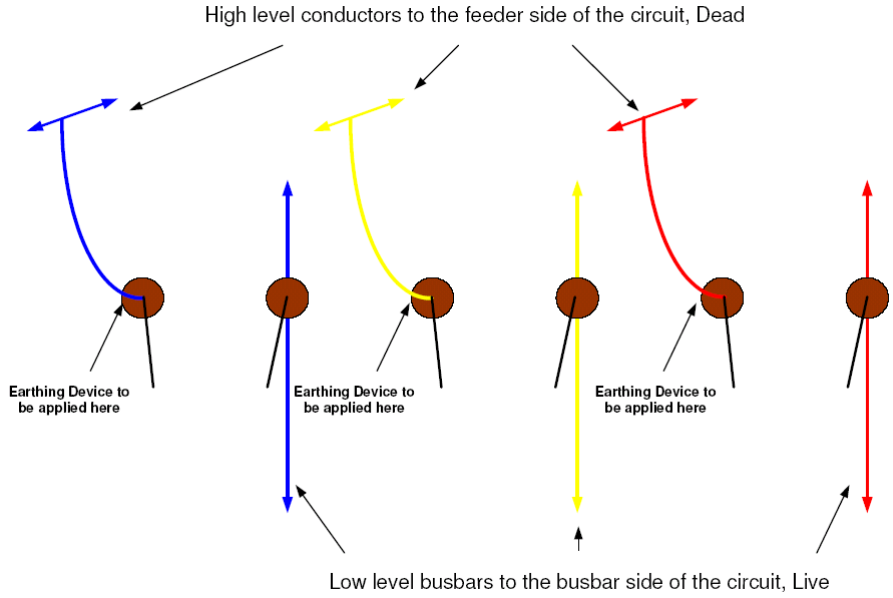


Figure 8.1B – Schematic View of Busbar Arrangement

8.3 The risk assessment shall take account of how all items of tools; objects etc. are to be secured within the trolley to prevent the potential for them to fall onto **Live** circuits whilst the trolley is traversing.

Guidance
NSI 2
8.4 to 8.5

8.4 The possibility of induced voltages appearing on a disconnected transformer terminal may be avoided by ensuring that all three phases of at least one winding of the transformer are short circuited and earthed, and all windings are earthed either at a terminal or the neutral. The short circuit and earth may be formed by the previously applied **Primary Earth(s)**.

If the neutral connection of an autotransformer which has three separate phase neutral connections is broken, then both the higher and lower voltage terminations of that winding will need to be earthed to maintain an effective short circuit.

For example, it is possible to change the 400kV bushings of a 400 / 132kV autotransformer provided earth(s) are maintained on the 132kV terminals, the Neutral and the Tertiary terminals (if connected to an Auxiliary Transformer).

8.5 b) Where the point of work is the Auxiliary or Earthing & Auxiliary Transformer, then where a **Primary Earth** is unable to be placed between the transformer and the **LV POI**:

i. for non-intrusive work, such as bushing oil samples / basic or major maintenance, one **LV POI** is required (usually under **CPS1 Control** – if not then a RISSP will be required) in addition to the **Primary Earth(s)** which shall where reasonably practicable be applied to the **HV** conductors within 9m and visible from the Auxiliary or Earthing & Auxiliary Transformer being worked on. The Double Isolation methodology could also be utilised at the **SAPs** discretion if **Primary Earth(s)** cannot be applied.

ii. for intrusive work, such as bushing replacement / internal access, busbar removal, since a transformer coil or any other winding coil is always considered to be greater than 9m (30m - GIS) due to its inherent impedance, then two **Point(s) of Isolation** in series on the **LV** side of the winding shall be used.

c) Where two **Point(s) of Isolation** are utilised on an Auxiliary / Earthing & Auxiliary Transformer any **Point(s) of Isolation** under the control of CPS2 shall be held for the CPS1 by the issue of a RISSP (Record of Inter System Safety Precautions).

With regards to Neutral Earthing Resistors that have no actual **Live LV** infeed – one **LV Point of Isolation** is deemed sufficient to demonstrate that a Safe System of Work is in place.

NSI 2
9.1 to 9.8

9 Special Cases of the Application of Drain Earth(s)

Application / Removal of a Substation Applied DrESS

9.1 **Point(s) of Isolation**, **Primary Earth(s)** shall be established to cover all infeeds; prior to a **Safety Document** being issued to apply or remove a Substation Applied DrESS.

For the application or removal of a Substation Applied DrESS, the circuit where practicable shall be solidly bonded to Earth via a **Primary Earth**, up to the point of application**.** This may require **HV Equipment** being locked in the closed position to establish and maintain the earth path. The Substation **Senior Authorised Person** and OHL **Senior Authorised Person** shall consult, agree and record any Safety Precautions that need to be established and maintained throughout the course of the work.

9.2 The methodology within TGN 313 – Section 3 - Schemes 3A or 3B shall be utilised when applying / removing a Substation Applied DrESS.

9.3 The Substation Applied DrESS shall be applied in accordance with an **Earthing Schedule** that will be issued along with the **Safety Document**.

The recipient of the **Safety Document** is responsible for the control and safe custody of the Substation Applied DrESS **Earthing Device(s)** and application device(s) issued with an **Earthing Schedule**.

A **Competent Person**, or a **Person** that is under their **Personal Supervision** may apply and remove the Substation Applied DrESS in accordance with an **Earthing Schedule** under a **Safety Document**.

The application and removal of a Substation Applied DrESS, can only be undertaken by National Grid **Personnel**, under no circumstances should any contractor be allowed to apply or remove a Substation Applied DrESS.

9.4 Substation Applied DrESS **Earthing Device(s)**, and the application device, shall be Type Registered, inspected, and maintained. They shall be examined immediately before and after use for defects. Defective **Earthing Device(s)** and application device(s) shall be immediately withdrawn from service.

9.5 For all following work, separate, dedicated **Safety Document(s)** shall be issued. Reference to the Substation Applied DrESS **Safety Document** shall be made on all subsequent **Safety Document(s)** quoting that DrESS.

9.6 Immediately prior to the clearing of **Safety Document(s)**, all issued Substation Applied DrESS **Earthing Device(s)** and associated application device(s) shall be accounted for.

9.7 Prior to cancelling the **Safety Document(s)**, the **Senior Authorised Person** shall ensure that, all the Substation Applied DrESS **Earthing Device(s)** and associated application device(s) has been accounted for.

9.8 The Substation Applied DrESS may be converted to a **Primary Earth**, where suitably rated, on cancellation of the **Safety Document**.
This process will be managed by the TNCC.
(Table 9.8, below guidance, confirms the number of Substation Applied DrESS Earths required to form a **Primary Earth**)

Guidance
NSI 2
9.1 to 9.5

9 Special Cases of the Application of Drain Earth(s)

9.1 The point a Substation Applied DrESS is being applied to must be connected to a **Primary Earth** at the time of application and removal. This can be achieved on the same document that makes a disconnection between the point of work and the **Primary Earth**, provided the sequencing of work ensures a connection between the point of application and a **Primary Earth** is in place at the time it is applied / removed.

Where the point at which a Substation Applied DrESS is required cannot be connected to a **Primary Earth** at the time of application (e.g. downed conductors), an alternative Safe System of Work will need to be established. Consultation should include the Substation **Senior Authorised Person**, **Control Person (Safety)**, OHL **Senior Authorised Person** and Asset Engineering to develop an effective earthing scheme.

9.3 For the application / removal of a Substation Applied DrESS the recipient of the **Earthing Schedule** shall undertake a personal risk assessment to control the risks associated with weather conditions, ground conditions and manual handling etc.

Note: Dedicated Type Registered Substation Applied DrESS Earthing Device(s) have a cross sectional area of 50mm^2 and are a maximum of 30m in length.

A Type Registered Earth pole of 1400 mm in length has been designed and Type Registered for use when applying / removing the Substation Applied DrESS. Calculations undertaken, confirm that the circulating current that creates an **Impressed Voltage** at the application / removal point will be no greater than 30kV.

The Type Registered 1400 mm Earth pole, as a minimum, can therefore be utilised but a greater length pole can be used. Which length pole is used should form part of the risk assessment considering accessibility, manual handling, working position, etc.

For further information on the sequence of the application and removal of **Drain Earth(s)** in general, refer to Section 7.3.

9.4 Dedicated Type Registered (Substation Applied DrESS only) Earthing Device(s) and their associated application devices shall be uniquely identified and stored in the Earth store.

Substation Applied DrESS **Earthing Device(s)** and their associated application devices shall be maintained. Maintenance shall be carried out in accordance with the Maintenance Policy for all portable **Earthing Device(s).**

Further information on the general requirements for portable earths can be found in Section 6.

9.5 The **Safety Document** issued for the application / removal of the Substation Applied DrESS is a stand-alone **Safety Document** for the application / removal of the Substation Applied DrESS only.

Control of a Substation Applied DrESS **Safety Document**

The **Safety Document** and associated **Earthing Schedule** after the application of the DrESS shall be **Locked** in a **Card Safe** / **Keysafe**.

The **Senior Authorised Person** issuing any subsequent **Safety Document(s)** shall issue a **Key** from the **Card Safe** / **Keysafe** holding

Guidance
NSI 2
9.5 Cont. to 9.8

the DrESS **Safety Document.** The **Key** issued shall be recorded on that subsequent **Safety Document(s)** in Section 5.

All subsequent **Safety Document(s)** shall also be endorsed in Section 2, under "Further Precautions", with the words "Substation DrESS is applied (location) under **Safety Document** (no.)"

When all subsequent **Safety Document(s)** are cancelled the Substation Applied DrESS **Safety Document** can be released from the **Card Safe** / **Keysafe** to remove the Substation Applied DrESS and then cancelled.

9.8 An appropriately uniquely named / rated Substation Applied DrESS can be declared to a **Control Person (Safety)** at the TNCC, as a **Primary Earth** on cancellation of a **Safety Document**; to allow for alternative earthing to be quoted on further **Safety Document(s)**.

Number of Substation Applied Dress Earths Required to form a Primary Earth

Table 9.8

No. of Substation PPE's applied per phase on line end equipment	Conductor Configuration	No. of (50mm^2) Drain Earth(s) per sub conductor	No. of (150mm^2) Drain Earth(s) per sub conductor
2	Single	6	2
	Twin	3	1
	Triple	2	1
	Quad	2	1
3	Single	8	3
	Twin	4	2
	Triple	3*	1
	Quad	2	1

Notes:

i) A Substation Applied DrESS is required to carry fault currents and manage circulating currents of up to 450A.

ii) The figures quoted in table 9.8 are per sub conductor.

iii) The ratings for the 150mm^2 and 50mm^2 Aluflex leads are as follows:

150mm^2 Short Circuit – 25kA for 1 second Continuous Current – 225A

Duplex Short Circuit – 8kA for 1 second Continuous Current – 150A

iv) The figures in table 5.2 above for the 50mm^2 Aluflex leads relate to the number of line end clamps applied per sub conductor. It is acceptable to use a duplex pair as two separate earths.

* When **Drain Earth(s)** are used on triple conductor the remaining 'extra' line end clamp can be applied to any of the three sub conductors.

NSI 2
10.1 to 10.3

10 Earthing Against Point(s) of Isolation from the LV Side of Voltage Transformers

10.1 When earthing against **Point(s) of Isolation** from the **LV** side of a Voltage Transformer (VT), the preferred method is for a **Primary Earth** to be applied and quoted either;

a) between the point of work and the VT.
or
b) solidly connected to the **HV** side of the VT, throughout the course of the work. This is irrespective of the distance between the voltage transformer and the **Primary Earth**.
or
c) solidly connected to a teed section of the conductors between the Point of Work and the VT, throughout the course of the work. This is also irrespective of distance.
or
d) solidly connected to the **HV** side of the VT, throughout the course of the work through an auto transformer. This is also irrespective of distance.

10.2 Where it is not reasonably practicable to utilise a **Primary Earth** as per 10.1, **Danger** shall be excluded from inadvertent energisation from the VT by either;

a) **Drain Earth(s)** applied to the VT **HV** connection.
or
b) two **Point(s) of Isolation** in series should be established on the **LV** side of the VT, to form Double Isolation as per AMBP101.

Note: Should any work on a Capacitor VT be required, especially if dismantling the Capacitor VT, whilst utilising Double Isolation; then caution should be taken to ensure all capacitive elements are discharged and shorted out prior to physical contact.

10.3 Where a VT features an integral **Earthing Device**, that connects it to an earth as part of the same action that disconnects itself from the **HV System**:

a) The isolating mechanism can be moved to the earthing position as part of the same instruction that establishes the **Isolation**.

b) The **Earthing Device** is considered a **Primary Earth** solely for the requirements of earthing the VT itself.

Guidance
NSI 2
10.1a to 10.1b

10 Earthing Against Point(s) of Isolation from the LV Side of Voltage Transformers

10.1a Where an **HV** capacitor is in series between the VT and the **Primary Earth**, the electrical properties of the capacitor will result in the capacitor being a solid connection between the VT and **Primary Earth**.

Capacitor C1 electrical properties act as a solid connection to earth switch X251A

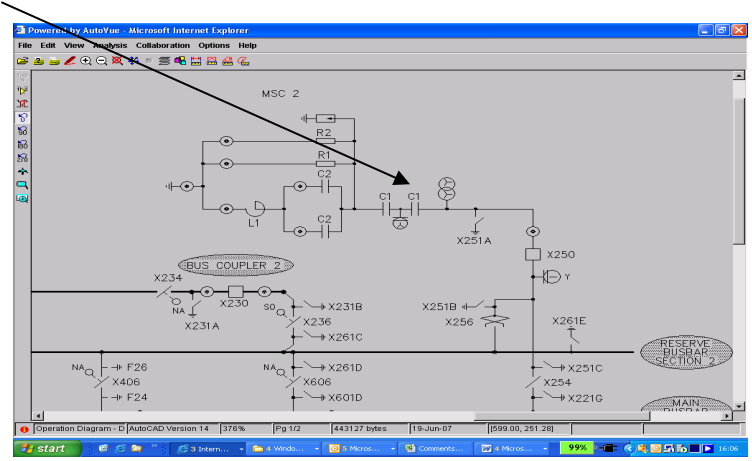


Figure 10.1a – HV Capacitor in Series between VT and **Primary Earth**

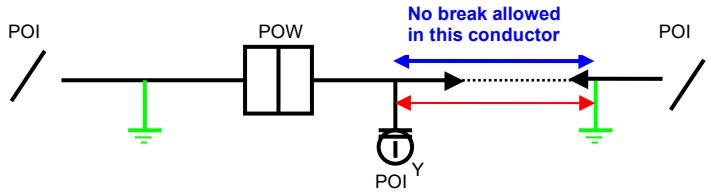


Figure 10.1b

To protect from inadvertent energisation of the VT the **Primary Earth** has to remain solidly connected to the **HV** side of the VT, throughout the course of the work. This is irrespective of the distance between the VT and the **Primary Earth**, as indicated by the Red arrowed line.

Solid connection means that the VT is connected directly to a **Primary Earth** i.e. no physical break between the two, for example by:-

- a disconnection.
- Disconnector / Isolator or Circuit Breaker in the open position.
- double wound transformer winding.

A solid connection is however acceptable provided through a disconnector or circuit breaker providing the **Equipment** is in the closed position and secured by a locking device i.e. **Locked** and the associated **Safety Key** secured in a **Key Safe** as a safety precaution.

Guidance
NSI 2
10.1c to 10.1d

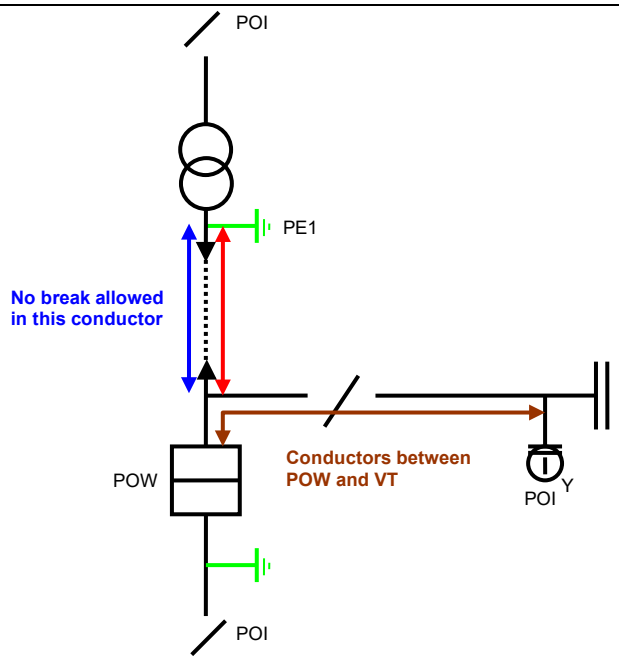


Figure 10.1c

In this example the capacitor VT on the capacitor bank does not have a **Primary Earth** solidly connected to the VT, as in example 10.1b.

The **Primary Earth** (PE1) is solidly connected to a teed section of the conductors between the point of work and the capacitor VT, as indicated by the red arrowed line. This is irrespective of distance and therefore is adequate earthing against the capacitor VT **Point of Isolation**.

The windings of a double wound transformer shall not be considered as a solid connection.

The tertiary connection of a transformer is double wound and hence shall not be considered as a solid connection between the **HV** or **LV** windings of the transformer.

The windings of an auto transformer are considered a solid connection.

10.2a To protect against in-feed from the VT itself, it is acceptable to apply **Drain Earth(s),** these may be applied to the VT arcing horns / corona rings.

10.2b Where two Point(s) of Isolation are utilised on a VT any Point(s) of Isolation that are under the control of CPS2 shall be held for the CPS1 by the issue of a RISSP.

For further information on the dismantling of CVT's - please consult TR(E) 526 - Study on the Charges Trapped in the Intermediate Flange of CVT.

Appendix A - Substation Multiple Primary Earth Requirements

A.1 The assessment of the number of portable **Earthing Device(s)** to form a **Primary Earth** at each substation owned or operated by National Grid has been based on the projected maximum and worst case fault level for each substation. Where **Earthing Device(s)** are to be applied to **Equipment** operating at a different voltage to that shown listed in Appendix A.10 e.g. 132kV Transformer Bushings in a 400kV Substation, the number of Earthing **Device(s)** applied shall be as shown for the operating voltage of the **Equipment**.

A.2 This assessment also included a consideration of the maximum theoretical inducted circulating current likely to be seen on circuit line ends at 400 kV and 275 kV substations against that of the continuous current rating of the portable **Earthing Device**. It should be noted that in some circumstances line end circulating currents may be present further in the substation and where this condition is applicable; then the line end earthing requirements shall be used. See Table A11 “Earthing Line End Sub-conductors” for details of number of portable **Earthing Device(s)** for circuit line end sub-conductors.

A.3 Normal running arrangement fault levels (or switchgear nameplate short circuit fault current ratings when no other information was available at the time of publication) have been used to calculate the required number of portable **Earthing Device(s)** to form a **Primary Earth** for substations at 132 kV and below which are not owned or operated by National Grid.

Where the number of portable **Earthing Device(s)** are calculated using switchgear nameplate short circuit fault current ratings, it may be possible to reduce the number required if the maximum fault level for the site in question can be established prior to their application. The **Senior Authorised Person** should seek advice on the expected fault levels from the owner or operator of the substation and apply the appropriate number of portable **Earthing Device(s)** to cater for new fault levels.

A.4 At sites not listed the number of portable **Earthing Device(s)** applied should be equal to or exceed the rating of the switchgear installed at the substation.

A.5 13 kV tertiary fed busbar systems, by exception default to 3 leads.
25 kV Rail Connection systems, by exception default to 1 lead.

A.6 The short circuit capability of a portable **Earthing Device** has been reviewed and reassigned for use within 400 kV and 275 kV substations where switchgear ratings are defined against a 1 second rating. The benefits from this are an increase in short circuit capability of the portable **Earthing Device** at these voltages. The new short circuit rating of a single lead and clamp system for use at 400 kV or 275 kV is 25 kA / 1 second.

A.7 The existing rating of 17.5 kA / 2 seconds for a portable **Earthing Device** still applies to 132 kV substations and below.

A.8 The numbers of portable **Earthing Device(s)** declared within the lists are based on portable **Earthing Device(s)** which have a single lead attached (150mm^2 flexible aluminium).

A.9 The Standard Number of Portable **Earthing Device(s)** (A.10) is now a live document which is updated as necessary.

A10. The Table (NSI 2 AppA.10) – can be accessed via the National Grid Infonet in the SHES Briefcase or via the ECM / Vault portal.

A.11 **Earthing Line End Sub-conductors**

Where it is necessary to apply portable **Earthing Device(s)** on subconductors, most commonly at line ends, each of those subconductors must have the same number of **Earthing Device(s)** applied, and the total number of **Earthing Device(s)** must equal or exceed the requirement listed in table A10.

No. of Substation Portable Earthing Device(s) applied per phase on line end equipment	**Overhead Line Sub conductor Configuration**	**No. of 150mm^2 Portable Earthing Device(s) per sub conductor**
2	Single	2
	Twin	1
	Triple	1
	Quad	1
3	Single	3
	Twin	2
	Triple	1
	Quad	1
4	Single	4
	Twin	2
	Triple	2
	Quad	1

Note: Earths with a different equivalent cross sectional area, such as 50mm Duplex earth(s), can only be applied under a suitable **Safety Document**, and not under a switching instruction.

A12 **Earthing Applied at the Mid-Point of a Complex Circuit**
[e.g. - adjacent to suffix 'R' **Earthing Device(s)**]

Earthing at a Line End is nominally managed by the Appendix A10; combined with Table A11 where applicable to manage the sub-conductor requirements. This is due to the circulating current being no greater than 450A and therefore a minimum of <u>two</u> 150mm^2 Portable **Earthing Device(s)** per phase are required to manage the circulating current level.

Where suffix 'R' Earthing Device(s) are installed the circulating current could be up to 900A and therefore <u>four</u> 150mm^2 Portable **Earthing Device(s)** per phase are required to manage the <u>increased</u> level of circulating current.

No. of Substation Portable Earthing Device(s) (150mm^2) applied per phase adjacent to suffix 'R' Earthing Device(s)	**4**

A13 **Changes to Appendix A10**

If calculations, undertaken by Engineering and Asset Management determine, that the number of portable **Earthing Device(s)** required - changes in the Appendix A10 table then the following process shall be followed.

1. Engineering and Asset Management to communicate all portable **Earthing Device(s)** changes to the Safety Rules Team and the TNCC Policy Team.

   Changes could occur due to a new **Location** being constructed, addition / removal of **Equipment** at an existing **Location;** or as part of the nominal, frequency derived, portable **Earthing Device(s)** calculations review.
   (TP 106 – Equipment Commissioning and Decommissioning; contains a process for any portable **Earthing Device(s)** requirement additions / changes at a new **Location /** existing **Location**).

2. Safety Rules Team and TNCC Policy Team to review and agree the content changes.

   Safety Rules Team to prepare the documentation changes - this shall include:

   a) Appendix A10 table update, that clearly indicates all the portable **Earthing Device(s)** changes to be made.
   b) Immediate Action Safety Bulletin issued, prior to the release of the updated Appendix A10 table to warn all parties of the impending changes. Safety Bulletin to contain agreed Appendix A10 change-over 'go-live' date.

      (date to be agreed by Safety Rules Team and TNCC Policy Team)

   (May take up to 7 days to complete)

3. TNCC Policy Team to communicate to all **Control Person (Safety)** staff the impending changes of portable **Earthing Device(s)** requirements at all **Locations**, as per Appendix A10.

   a) When the change-over date directly impacts a **Location(s)** with already issued **Safety Document(s)**, a plan shall be in place for any increase of portable **Earthing Device(s)** required.
   b) No action is required where the portable **Earthing Device(s)** have decreased at a **Location**, with already issued **Safety Document(s)**, the existing earthing arrangements shall stay in place until the **Safety Document(s)** they are quoted on are all cancelled.

4. Safety Rules Team to ensure the publication of Appendix A10 aligns with the change-over 'go-live' date stated within the Safety Bulletin, if this cannot be achieved then communications are sent out to confirm a revised 'go-live' date.

5. **Control Person (Safety)** to liaise with any **Location** that requires an increase in Portable **Earthing Device(s)** requirements, an appropriately Authorised **Senior Authorised Person** shall need to be at the **Location** to follow the process outlined below:

   The **Control Person (Safety)** shall confirm with the **Senior Authorised Person** that;

   a) The **Working Party** is withdrawn from the work area and the **Competent Person** has signed the Transfer Record Section of the **Safety Document**.

   b) The **Safety Document** is in the safe custody of the **Senior Authorised Person** and managed by the Status of Transfer Form.

   c) The **Control Person (Safety)** will then confirm with a logged statement that all affected **Safety Document(s)** are accounted for, and in safe custody.

   d) A Switching instruction shall then be given by the **Control Person (Safety)** to the **Senior Authorised Person** to apply portable **Earthing Device(s)** (amount per phase) to achieve the correct number.

   e) Once the switching instruction is confirmed back to **Control Person (Safety)**, the **Safety Document** can be taken out of safe custody by the **Senior Authorised Person** and reissued to the **Competent Person**.

Appendix B - Example of Application of Earthing Device(s) in Hall Type 132 kV Substations

B.1 This appendix is for the guidance for applying **Earthing Device(s)** to the busbar side of busbar isolators in 132 kV Hall Type substations with a full interlocking system of busbar isolators, busbar fixed earth(s) and bascule / trolley doors. Actual switching sequence may vary depending upon the interlocking design for the substaiton in question.

B.2 With reference to Figure B1, to apply the first fully rated **Earthing Device** to the appropriate section of busbar after **Point(s) of Isolation** have been established to the appropriate section of busbar. **Safety Distance** shall be maintained at all times for the application of the first fully rated **Earthing Device**:-

- To earth busbar adjacent to isolator 414
- 413, 416, 514,154,314, 184, 104, 136, 128 all **Point(s) of Isolation**
- Close and lock isolator 134
- Close the appropriate fixed **Earthing Device** i.e. earth switch 131B
- Close bus coupler circuit breaker 130
- Close the appropriate fixed **Earthing Device** i.e. earth switch 131A
- Open the bus coupler circuit breaker 130

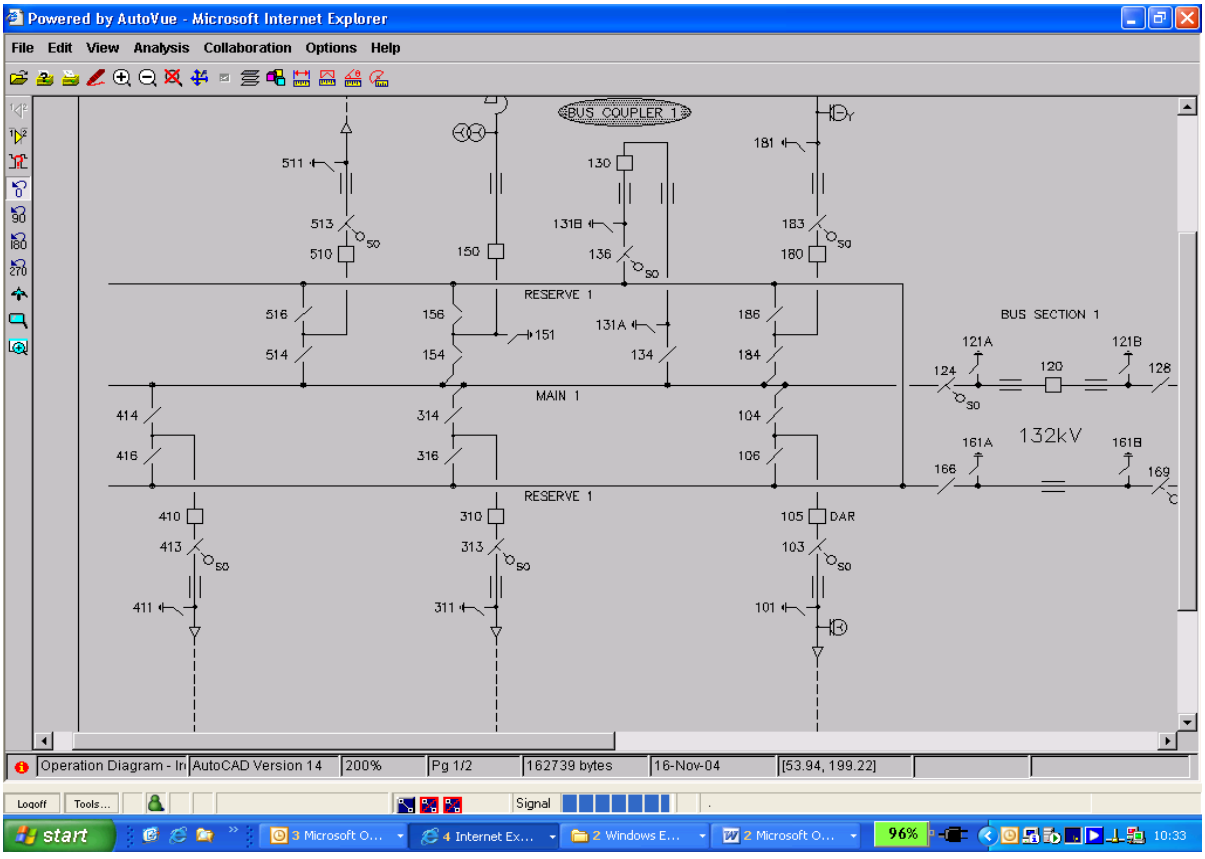


Figure B1 – Hall Type 132 kV Substation

B.3 Once the above sequence has been followed and the appropriate section of busbar has been **Earthed** via a fully rated **Earthing Device**, where it is not reasonably practicable to maintain **Safety Distance**, encroachment within the specified **Safety Distance** may now be allowed for the application / removal of Type Registered **Earthing Device(s)** and their associated application device(s) under rule R2.3b of the National Grid UK Electricity Transmission plc Safety Rules.

Appendix C - Guidance on the scope of NSI 2 when working on Cable Sealing Ends (CSE)

When cable is earthed at local CSE by the application of an **Earthing Device**, disconnections can be made from the cable primary conductor connection to the busbar side by NSI 2 authorised **Senior Authorised Person** / **Competent Person**. Consideration shall be given to circulating currents when the cable is part of line end equipment

The scope of NSI 5 includes not only the cable but also any **Equipment** electrically connected (not via an earth) to the cable as current may be circulating in or voltage may be transferred onto the connected **Equipment**.

The **Equipment** affected by the requirements of NSI 5 is illustrated in Figure 1.

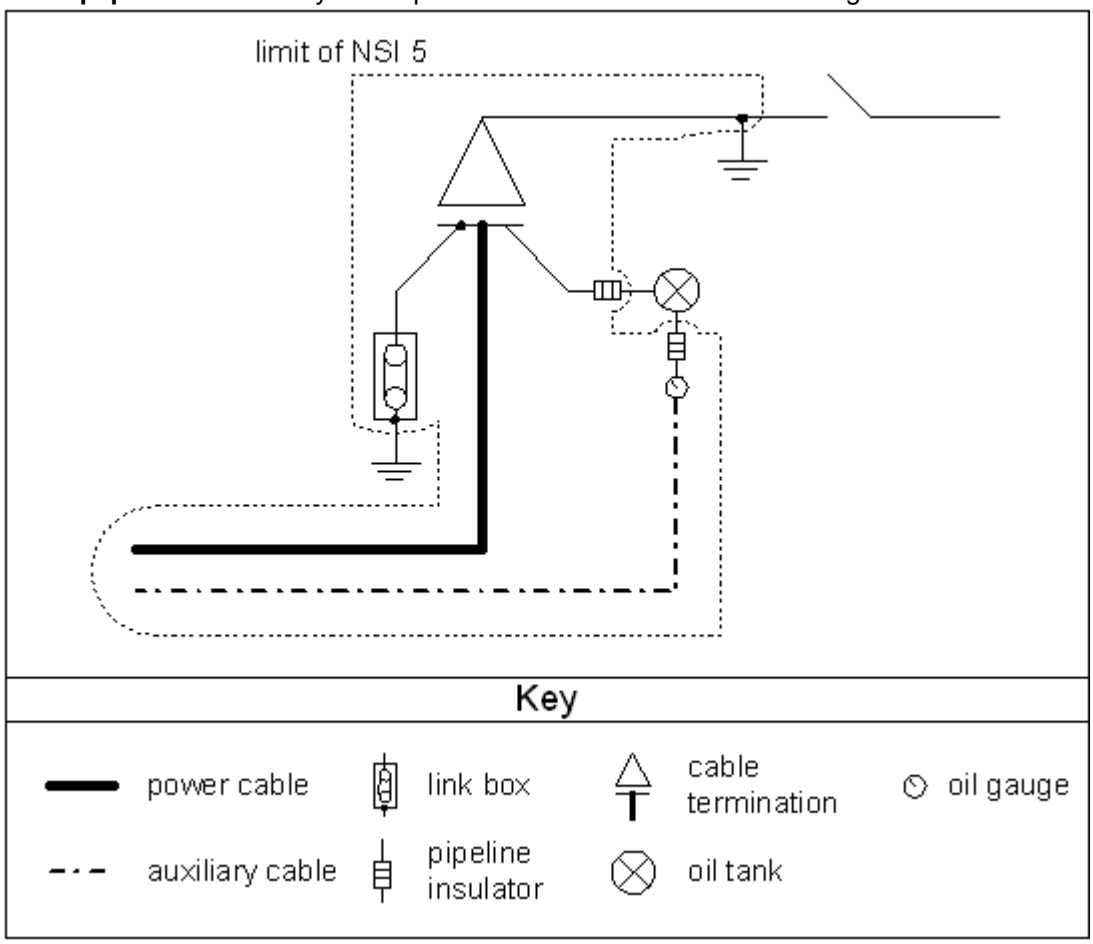


Figure 1 Scope of NSI 5.

Referring to Figure 1, a number of features are observed. Auxiliary cables are included within the scope of NSI 5 as induced voltages or transfer of earth potential rise affect auxiliary cables. Oil tanks are outside the scope of NSI 5 since pipeline insulators isolate the oil tanks.

Note: That while the earth(s) of cable systems are outside the scope of NSI 5, that currents circulating in cables can be returned via the earth and that the requirements of NSI 24 **Shall** to be met.

Appendix D - Creating Circulating Currents when applying Earthing Device(s)

The following process shall be followed by a **Senior Authorised Person** when preparing a **Safety Document** for work involving the separation / disconnection / reconnection of conductor joints.

The table below summarises the variation of calculated circulating current magnitude, as a function of loading condition and bay separation distances.

	Load (MVA)	150	200	250	500	750	1000	1250	1500	1750	2000
Bay-centre to Bay-centre (m)	Load (a) 400kV case	216.5	288.7	360.8	721.7	1082.5	1443.4	1804.2	2165.1	2525.9	2886.8
15	Calculated Circulating Current	17.41	23.22	29.02	58.05	87.07	116.1	145.12	174.15	203.17	232.19
21.6		10.67	14.22	17.78	35.56	53.33	71.11	88.89	106.67	124.45	142.22
25		6.07	8.09	10.11	20.23	30.34	40.45	50.56	60.68	70.79	80.9
30		4.42	5.89	7.36	14.73	22.09	29.45	36.81	44.18	51.54	58.9
35		3.43	4.57	5.72	11.43	17.15	22.87	28.59	34.3	40.02	45.74

For a Green level, no further action is required in addition to applying NSI 2.

For a Red level, further actions are required that need to be determined on advice from the Earthing Specialist within Engineering and Asset Management. At these energy levels, when breaking or making joints arcing may be experienced resulting in burns, or startlement resulting in additional hazards especially when working at height.

Immediately before any separation / disconnection / reconnection of conductors the **SAP** shall re-check the adjacent circuit loadings and confirm if the level of calculated circulating current is as planned. If not, STOP, re-reference the table and determine if Red or Green actions are required.

A hold point reflecting this check shall be included in the Risk Assessment for the work being undertaken.

Appendix E - Authorisation Matrix for Contractors Personnel

Contractors appointment under this NSI shall be limited to the following sections.

Contractor **Personnel**	**Person**	**Competent Person**	**Authorised Person**	**Senior Authorised Person**
Sections		5.2 6.1 6.2 7.3 7.4*		

* If the contractor is Competent to NSI 9 then in addition to the above sections they will also be limited to 7.4.