National Grid UK Electricity Transmission plc

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NATIONAL SAFETY INSTRUCTION
and
Guidance

NSI 2
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

KEY CHANGES

Section	Amendments
Purpose and Scope	Removal of reference to G3 Procedure for Railway Connections.
Dangers & 5.1 Guidance	Words added to reflect danger from floating sections of busbar
5.2 Guidance	Clarification of wording for OHL circulating currents.
7.2 Guidance	Wording modified to reflect new Model Risk Assessment
7.5 & 7.5 Guidance	Additional wording to clarify when Drain Earths to be used for breaking/making connections.
7.6 & 7.6 Guidance	Wording amended to clarify management of OHL circulating currents
Appendix A	Addition to wording in A.1 to clarify number of earths to be applied.
Appendix C	Old Appendix C becomes Appendix D. New Appendix C - Guidance on the scope of NSI 2 when working on Cable Sealing Ends

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 C.

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)**
- **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** or conductors (e.g. 'floating' sections of busbar)

NSI 2
4.1 to 4.7

4 General Requirements for Primary Earths

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.

4.2 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 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 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 phases except where work is carried out on phase segregated **HV Equipment**.

4.5 Before a **Safety Document** is issued on an overhead line circuit, **Primary Earth(s)** are to be initially connected to the overhead line at all ends.

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 Earths

4.1 **Earthing Device(s)** used as a **Primary Earth** and associated portable application devices 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 earths 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**.

If the number of portable **Earthing Device(s)** applied needs to increase in line with current substation arrangements whilst quoted on **Safety Document(s)** then the following process shall apply:

a) The **Working Party** is withdrawn from the work area and the **Competent Person** signs the Transfer Record Section of the **Safety Document**.

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

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

d) A Switching instruction is given by **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**.

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.

Guidance
NSI 2
4.1 Cont. to 4.2

Figure 4.1A - Holtom Type Copper Conductor

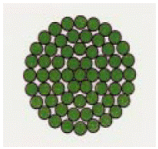


Figure 4.1B – Aluminium Alloy Stranded Conductor

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 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.

Guidance
NSI 2
4.2 Cont. to 4.3

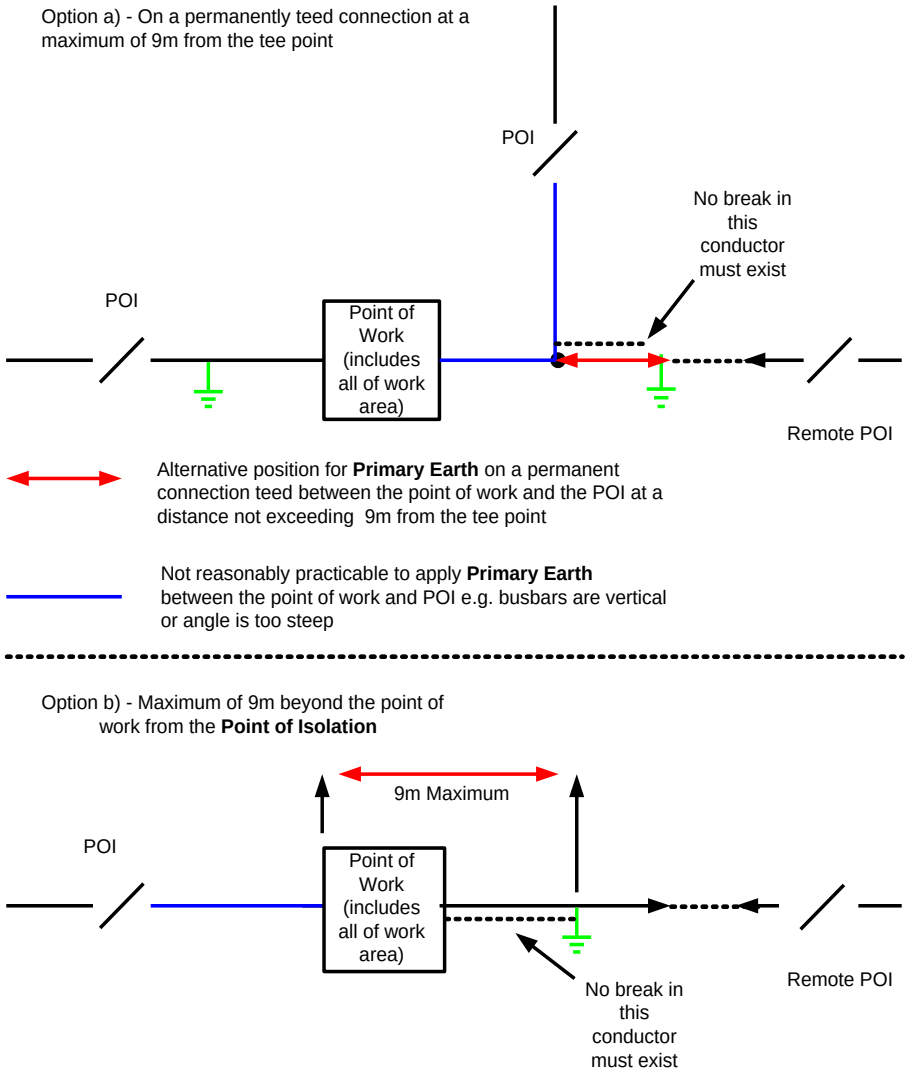
Where reasonably practicable local operation (e.g. at the CB or disconnector local control cubicle) to provide an earth, shall be avoided.

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)**.

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.

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 earths that have been compromised.

Guidance
NSI 2
4.4 to 4.7

4.4 When earthing against a single phase VT **Primary Earth(s)** shall be applied to all 3 phases.

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

4.5 For the management of circulating currents as described within Management Procedure - NSI 4 "Work on or Near High Voltage Overhead Lines" a **Primary Earth** shall be initially applied line side of any **Point(s) of Isolation** in a substation and not separated from the overhead line by any temporary or permanent disconnection including **Equipment** in the open position. When this is not reasonably practicable the **Senior Authorised Person** shall discuss and agree alternative earth arrangements with the overhead line **Senior Authorised Person**.

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 Earths

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 his **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 Earths

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**.

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 an OHL 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 himself, or:-

(a) For substation earths, by securing the earths 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**.

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

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 C. 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 Earths

6.1 Portable **Earthing Device(s)** and their associated application devices 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 devices shall be immediately withdrawn from service.

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 Earths

6.1 Portable **Earthing Device(s)** and their associated type registered application devices shall be maintained. Maintenance shall be carried out in accordance with Management of Maintenance Policy NSPM203 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 earths 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.

6.2 Portable **Earthing Device(s)** and their associated application / removal devices 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 Devices

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**.

7.5 Before a break is made in an electrical conductor or a connection is made across a break, the **SAP** 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 may be sought from an overhead line **Senior Authorised Person**.

Guidance
NSI 2
7.2

7 Application / Removal of Earthing Devices

7.2 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 Earths" 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

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.

The control measures shall include, where appropriate:-

- Switching out adjacent **Live Equipment**
- Ensuring that electrical protective devices 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 devices
- Use Mobile Elevated Work Platform (MEWP) for application / remove of **Earthing Device** at height

Guidance
NSI 2
7.2 Cont. to 7.3

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 "SITE 007 – Application and Removal of Portable Primary Earths", which is made site specific by the **Senior Authorised Person**.

The risk assessment shall be retained in an A4 folder titled "Portable Earthing Devices 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.

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.

When an increase of number of portable **Earthing Devices** is required for existing portable **Primary Earths** 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**.

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NSI 2
7.4 to 7.6

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**.

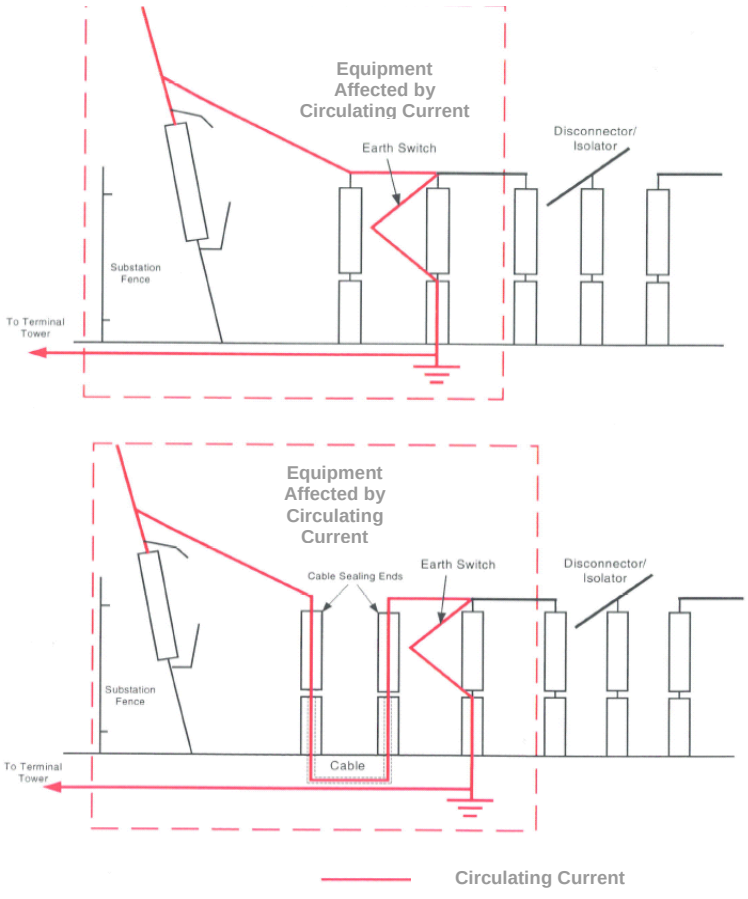
7.5 Where **Danger** is excluded due to existing earthing arrangements, reduced drain earthing may be utilised, for example, where **Primary Earth(s)** is in close proximity to the break.

7.6 High circulating currents may appear on substation line end **Equipment**. The **Senior Authorised Person** may 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.

Typical Configurations of Circulating Current in Substations



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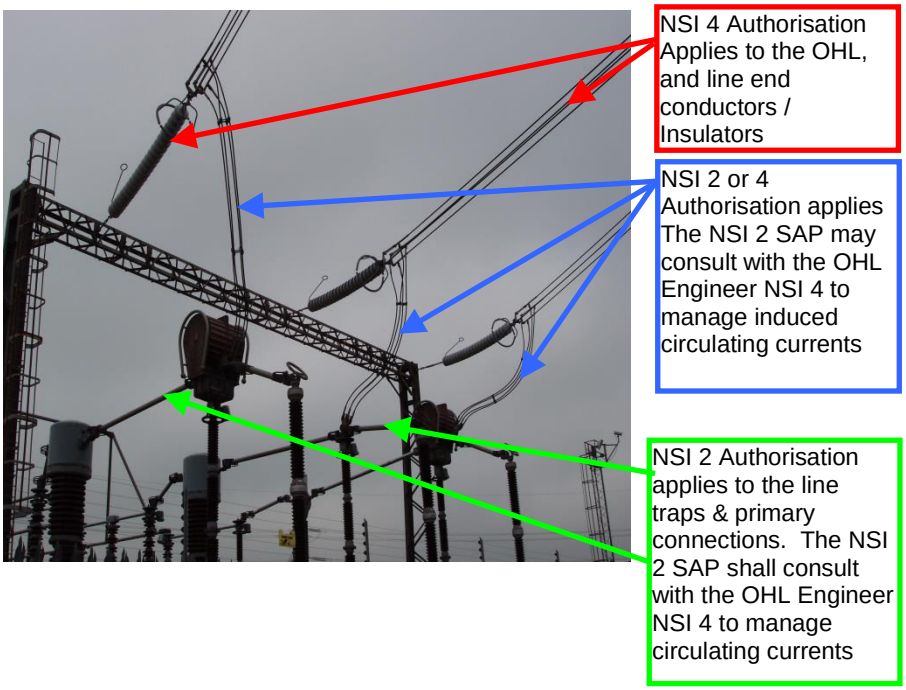
7.6 Cont.

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

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 Metalclad Switchgear and Earthing is required, reference shall be made to Management Procedure NSI 3 - High Voltage Metalclad Switchgear with Spouts.

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)** identified by the additional nomenclature suffix R are Restricted to a specific operating sequence which 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) **Operate as Required**

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.

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 *Operate As Required* instructions **shall** not be issued for a Restricted **Earthing Device(s)** if:-

i) a remote end **Earthing Device(s)** is quoted as **Equipment** or as a **Drain Earth(s)** on a **Safety Document** or if a remote end **Earthing Device(s)** is already under an *Operate As Required* instruction (where the remote end **Earthing Device(s)** position cannot be confirmed until either is cancelled) or

ii) both the remote end **Earthing Device(s)** are otherwise closed

unless a suitable **Primary Earth(s)** exists on the line side of the Restricted **Earthing Device(s).** Any deviation from this shall be with agreement of the OHL **Senior Authorised Person**.

NSI 2
8.1 to 8.5

8 Special Cases of the Application of Primary Earths

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

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 NSI 2 Section 4.3 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 transformers.

Guidance
NSI 2
8.1 to 8.3

8 Special Cases of the Application of Primary Earths

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

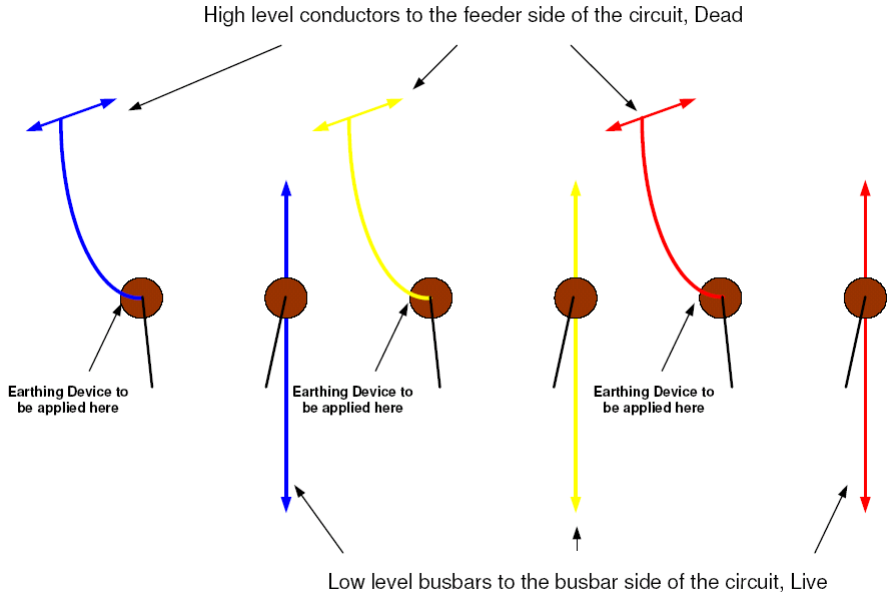


Figure 8.1B – Schematic View of Busbar Arrangement

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 earths 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 / Earthing Auxiliary Transformer then the **Primary Earth(s)** shall where reasonably practicable be applied to the **HV** conductors adjacent the Auxiliary / Earthing Auxiliary Transformer.

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).

NSI 2
9.1 to 9.2

9 Earthing Against Points of Isolation from the LV Side of Voltage Transformers

9.1 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.

9.2 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.

Guidance
NSI 2
9.1a

9 Earthing Against Points of Isolation from the LV Side of Voltage Transformers

9.1a Where an **HV** Capacitor is in series between the voltage transformer and the **Primary Earth**, the electrical properties of the capacitor will result in the Capacitor being a solid connection between the voltage transformer and **Primary Earth**.

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

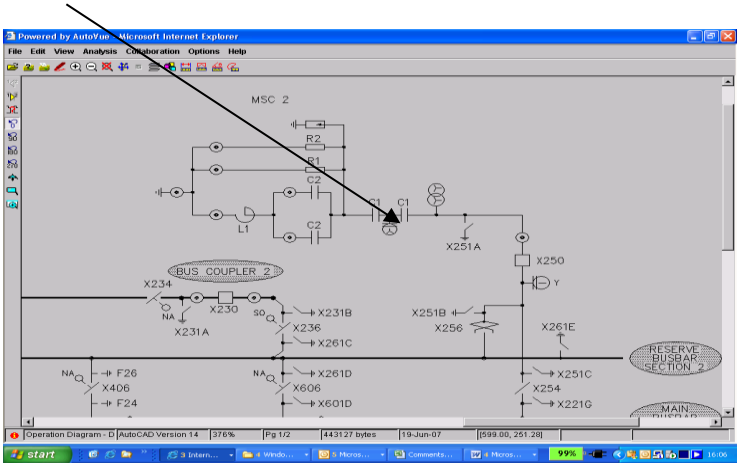
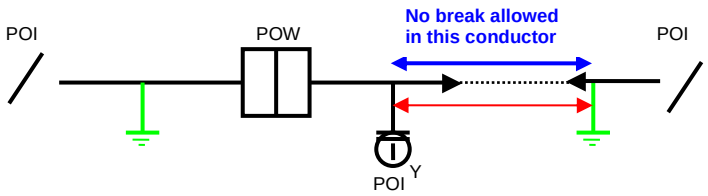


Figure 9.1 – HV Capacitor in Series between CVT and **Primary Earth**

Guidance
NSI 2
9.1b to 9.1c

Figure 9.1(b)



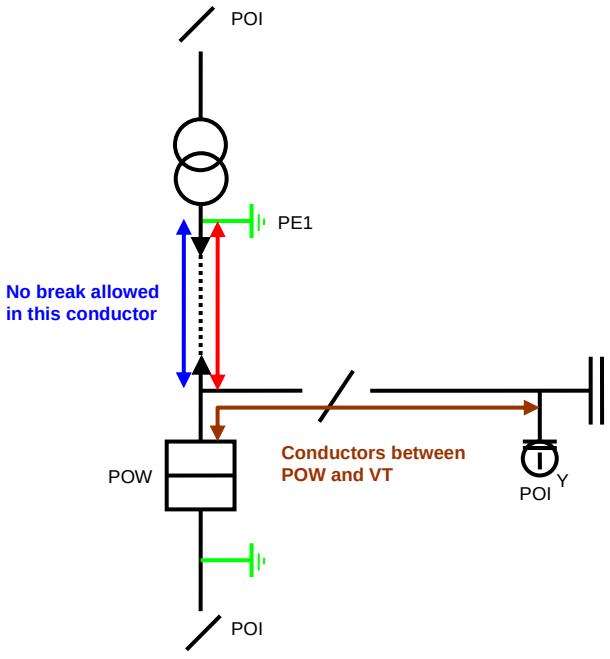
To protect from inadvertent energisation of the voltage transformer the **Primary Earth** has to remain solidly connected to the **HV** side of the voltage transformer, throughout the course of the work. This is irrespective of the distance between the voltage transformer and the **Primary Earth**, as 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.

Figure 9.1(c)



Guidance
NSI 2
9.1c Cont. to 9.2

In this example the capacitor voltage transformer on the capacitor bank does not have a **Primary Earth** solidly connected to the voltage transformer, as in example 9.1(b).

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

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

9.2(b) Where two **Points of Isolation** are utilised on a voltage transformer any **Points of Isolation** that are under the control of CPS2 shall be held for the CPS1 by the issue of a RISSP.

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 Devices(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 Devices (A.10) is now a live document which is updated as necessary.

A10. The Table A.10 – can be accessed via the National Grid Infonet in the SAP briefcase or at http://www2.nationalgrid.com/UK/Safety/NSI/

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

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

Note: 50mm Duplex earths can only be applied under a suitable Safety Document

Appendix B - Example of Application of Earthing Devices 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 earths 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

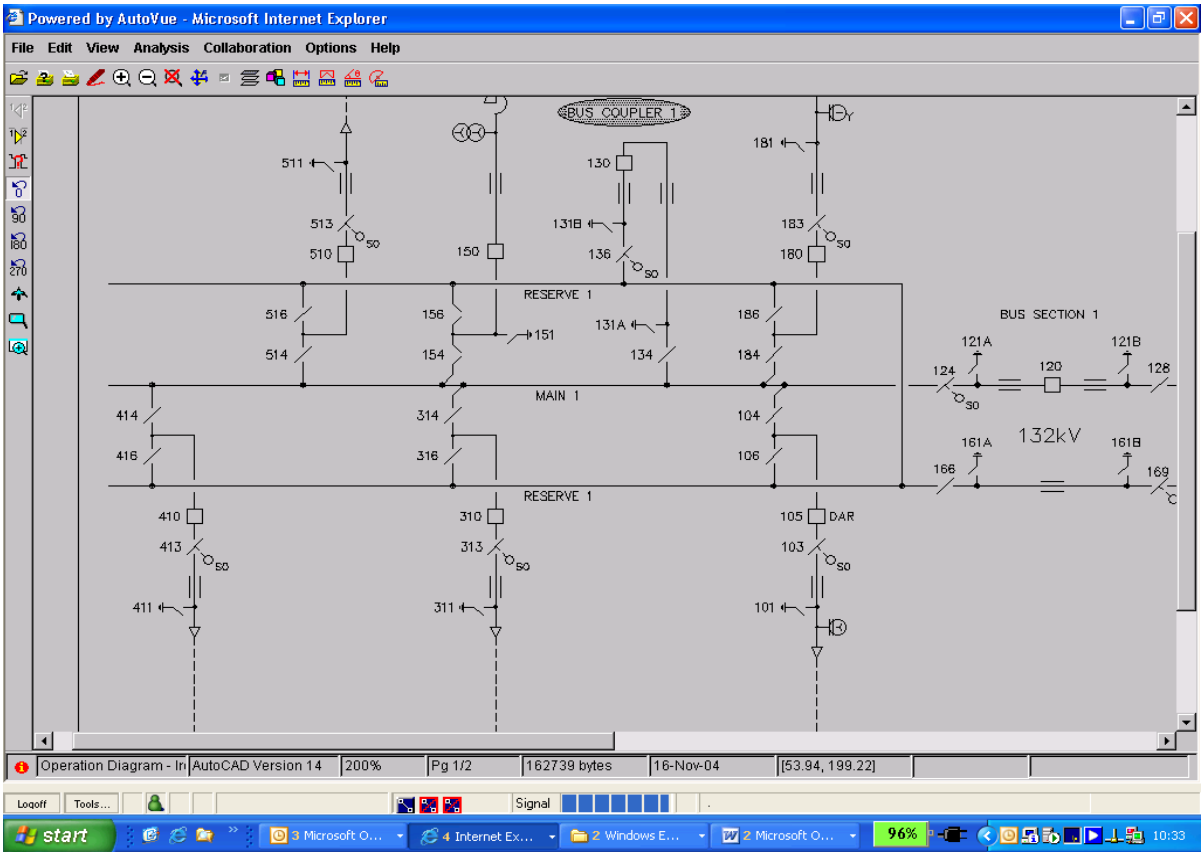


Figure B1 – Hall Type 132 kV Substation

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 resigtered **Earthing Device(s)** and their associated application devices 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

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.

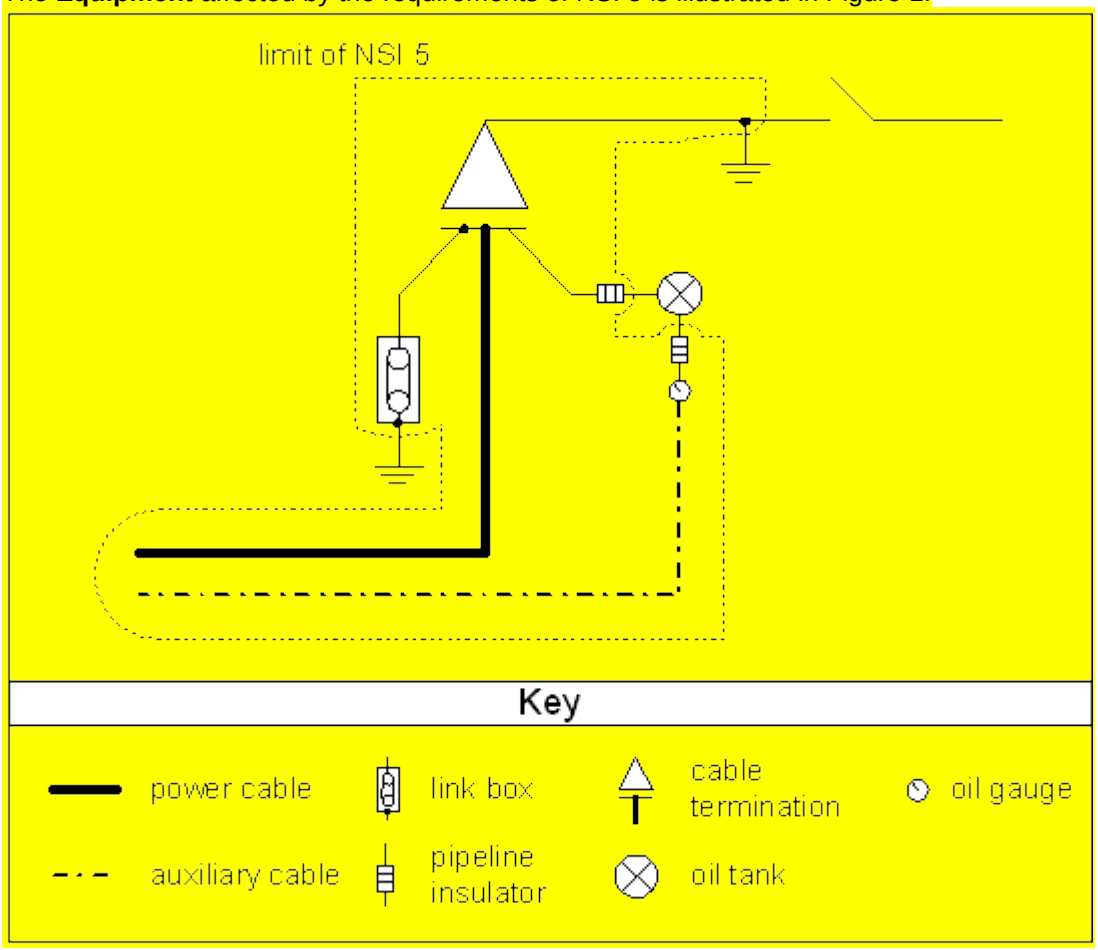


Figure 1 Scope of NSI 5.

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 earths 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 - 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.