

## Safe Work Practices on High Voltage Substation Apparatus

### Summary:

This document supports the Power System Safety Rules and its requirements assembled under 'High Voltage Substation Apparatus Category 5.

The document describes safe work practices for the control of hazardous situations.

This standard applies to all persons working on HV Substation Apparatus.

Document reference no: GD SR G3 152	Revision no: 3	TRIM No: D2012/07707	Date: 22 March 2016
Business function: Operate the Network		Document type: Safety Rules Work Instruction	
Process owner: General Manager/Systems Operations			
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When referring to TransGrid's policies, frameworks, procedures or work instructions, please use the latest version published on the intranet.

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## 1. Overview

### 1.1. Purpose

This document supports the Power System Safety Rules and its requirements assembled under 'High Voltage Substation Apparatus Category 5. The document describes safe work practices for the control of hazardous situations.

### 1.2. Policy Base

Document No.	Document
<a href="#">GD SR G1 100</a>	Power System Safety Rules

### 1.3. Reference Documents

Document No.	Document
<a href="#">GD SR G3 162</a>	Safe Work Practices on HV Overhead Lines
<a href="#">GD SR G3 172</a>	Safe Work Practices on HV Cables

### 1.4. Scope

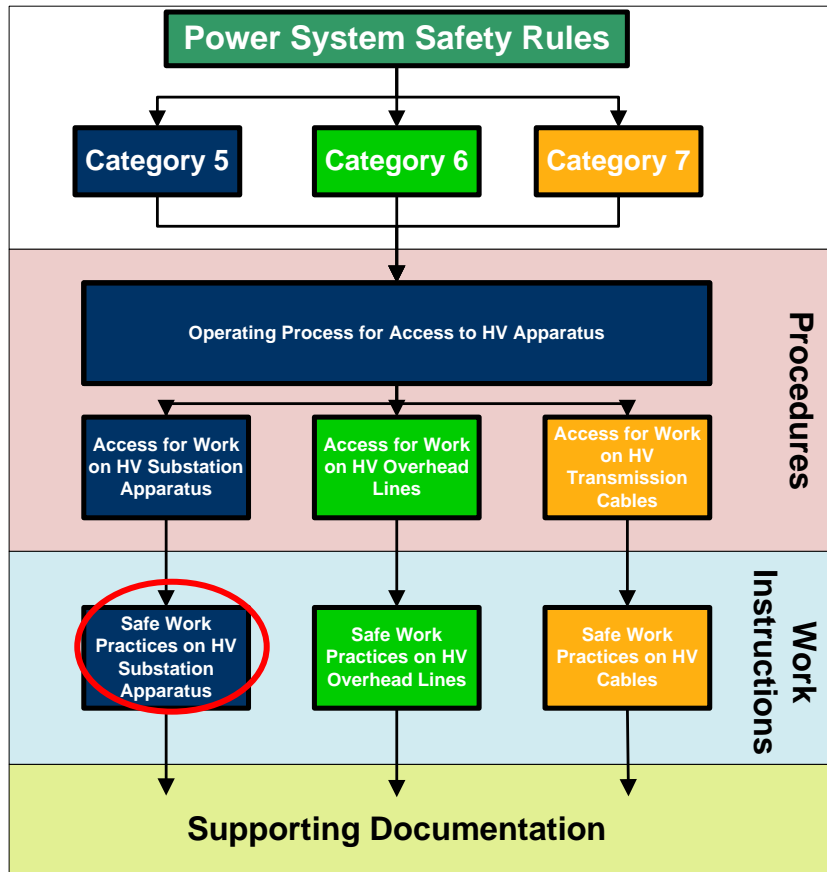
This standard applies to work practices on all High Voltage Substation Apparatus.

### 1.5. Accountability

Responsible person	Responsibility
GM – System Operations	Maintenance and ownership of this standard
Mgr – Training	Implementation of training programs associated with this standard
Authorised persons	Comply with this standard

## 1.6. Document Location

Block diagram showing location of document in relation to others.



## 2. Introduction

This standard was developed as a guide to assist in selecting the correct safe work practices to be used when performing work on HV substation apparatus. Work may only commence on HV substation apparatus when it has been made safe for work and an access authority has been issued.

The safe work practices contained within this document protect staff from the hazardous occurrences or effects that can develop on or around HV substation apparatus and associated equipment, including:

- Induced voltages;
- Transfer voltages; and
- Earthing Systems

This document sets out a range of hazardous situations, the controls (safeguards) to be implemented and describes the safe work practices which must be observed. The possible safe work practices are referenced for each situation.

This document should be read in conjunction with 'Portable Earthing of High Voltage Electrical Equipment'. This document indicates when various practices should be used and the Portable Earthing document indicates what hardware should be used when implementing the nominated practices.

It is the responsibility of all employees engaged in work on HV substation apparatus to follow all the safe work practices applicable to the work.

These safe work practices are to be used in conjunction with TransGrid's [OHS Risk Assessment](#). The process may identify that additional controls are required for particular tasks and situations.

### **3. HV Substation Apparatus Hazards**

This section details the possible hazards that can occur when working on, or installing HV Substation Apparatus and the following sections provide examples of working procedures recommended for use under such conditions.

The following table lists the risks encountered when working on or in the vicinity of HV Substation Apparatus and controls to be implemented.

### 3.1. HV Substation Apparatus Risks and Controls

Situation	Hazard	Control	Reference
Carrying long items of equipment, eg ladders or conduit	Near approach to HV conductors	Carry equipment below shoulder height if longer than 2 metres use two people	<a href="#">Near Approach</a>
Excavation	Buried Services	<a href="#">TransGrid Excavation permit</a> Services check Bridging of earth grid	<a href="#">Buried Services</a> <a href="#">Work on Earthing Systems</a>
Un-bonded cable sheaths.	High Voltages from Unusual Sources	Care is necessary when working on low voltage equipment and circuits to ensure that nothing occurs which can bring about such a condition.	<a href="#">HV Cables</a>
Removal, breaking or cutting of Earth or Neutral Connections	High Voltages from Unusual Sources	Connections between apparatus and the earthing system shall not be removed, broken or cut while the equipment is in service. HV Access authority required for such work.	<a href="#">High Voltages from Unusual Sources</a>
Work on isolated electrical apparatus that is located close to live electrical apparatus.	Induced Voltages	Additional Access Authority earths, bridges and bonds shall be applied where necessary to ensure equipotential conditions are maintained. For example: support structures, scaffolding or elevating work platforms used to provide access to high voltage apparatus may require bonding to the high voltage conductors being worked on.	<a href="#">Induced Voltages</a>
Stringing conductor on landing span to Substation	Transferred earth potential	Bridging leads applied using insulated methods. Set up equipotential work area and controls	<a href="#">Stringing conductor on landing span to Substation</a>
Overhead conductors/earth wires, metallic communication, control and protection circuits, cable sheaths and pulling ropes, fences, water, sewage and storm water service pipes all provide a means for "remote" earth potentials to be transferred	Switchyard Earth Grid Voltage Rise and Transferred Earth Potentials	Equipment that may be subject to transferred earth potentials shall be either: insulated, isolated, or otherwise rendered safe.	<a href="#">Switchyard Earth Grid Voltage Rise and Transferred Earth Potentials</a>

Situation	Hazard	Control	Reference
HV Power Capacitors may retain an electrical charge	Retained electrical charge hazardous to persons even after the apparatus has been isolated from the source of supply.	Equipment shall be fully discharged before approaching, or working on or near the apparatus, and after electrical testing has been performed.	<a href="#">HV Power Capacitors</a>
HV Transmission and Pilot Cables may retain an electrical charge	Retained electrical charge hazardous to persons even after the apparatus has been isolated from the source of supply.	Equipment shall be fully discharged before approaching, or working on or near the apparatus, and after electrical testing has been performed.	<a href="#">High Voltages from Unusual Sources</a>
Working near Fault Earth Switches (FES)	This apparatus contains a charged spring that operates a swinging arm.	Barrier FES out of the work area when work is not required on the fault earth switch. Discharge or Close the FES whenever it is included inside a work area.	<a href="#">Fault Earth Switches</a>
Work in HV Substations by ordinary persons	Near approach to HV conductors	Either supervised by person Authorised Category 5.2 or set up safe work area for Disconnected Apparatus	<a href="#">Near Approach</a> <a href="#">Disconnected Apparatus</a>



## 4. Safe Work Practices

Safe work practices are applicable to all HV Substation working situations and are to be used (as applicable) for all work.

It is essential when developing safe working procedures to carefully assess the possibility of hazardous situations occurring at the work site and where appropriate, give consideration to the following basic safe working practices and safeguards.

These safeguards (controls) are to be used in conjunction with TransGrid's [OHS Risk Assessment](#).

## 5. Work on HV Substation Apparatus - General

For all work associated with HV Substation Apparatus, in the charge of a controller, an RFA shall be submitted in accordance with section 2 of the Power System Safety Rules.

### 5.1. Work with HV Substation Apparatus Isolated and Earthed

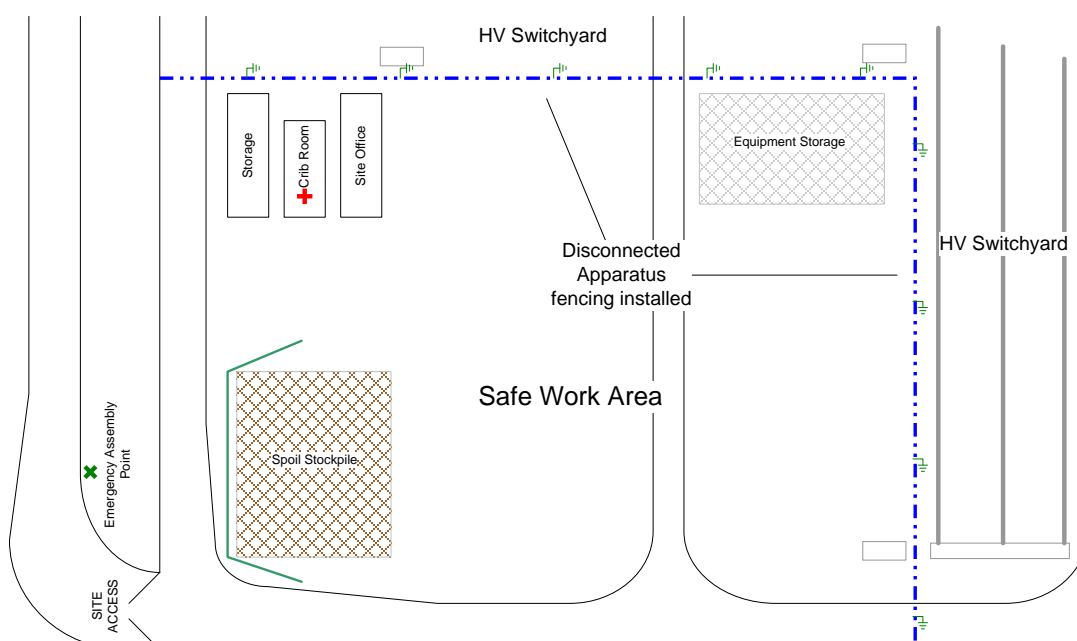
Work that requires the HV Apparatus be made safe for work shall have either a HV Access Authority or a HV Testing Access Authority issued in accordance with TransGrid's '[Power System Safety Rules](#)' and '[Access for Work on HV Substation Apparatus](#)'.

### 5.2. Work on HV Substation Apparatus as Disconnected Apparatus

If a long outage of HV Substation Apparatus is proposed it may be possible to disconnect it temporarily from the system to enable work without an Access Authority. In such a case, the Safety Rules requirements for Making Disconnected Apparatus Safe for Work Rule 5.5.3 must be complied with if work is to proceed without an Access Authority.

Once the safe work area is approved, employees and contractors not authorised under the Safety Rules may be escorted to the safe work area and can carry out work on the disconnected apparatus.

A typical Safe Work Area for disconnected apparatus is shown in the following diagram.



## 6. HV Power Capacitors

Shunt connected HV power capacitors are used for power factor correction. Most such capacitors comprise banks of multiple cans mounted on racks and connected in double star. The mounting racks and the star point(s) are generally not connected to earth.

### 6.1. Capacitor residual charge

This apparatus is able to retain an electrical charge of sufficient magnitude to be hazardous to persons even after the apparatus has been isolated from the source of supply. Such equipment shall always be fully discharged using a suitable means of earthing before approaching, or working on or near the apparatus, and before working on the apparatus after electrical testing has been performed.

HV DC charge might be left on a capacitor and its framework after removing supply. Because of this, a period of at least five minutes should elapse between the time a HV capacitor is switched out of service and the start of further operations, which will allow the residual charge to dissipate.

Earthing is not to commence for at least five minutes after de-energising to ensure safe conditions. The standard equipment used for proving de-energised will not indicate the presence of any residual HV DC charge.

When working on capacitors or associated circuits, all components are to be continuously earthed. If the work requires removal of the earthing, this must not be done until at least five minutes after the initial application. The earthing should be restored as soon as practicable and retained until the work has been completed.

Where work requires the disconnection of individual capacitor cans, the terminals of these cans must be short circuited before disconnection.

NOTE: Because of induction effects from overhead conductors and the like, HV DC voltages could also occur during installation work. The work party is to ensure adequate earthing of terminals and bank connections to reduce the likelihood of dangerous conditions.

## 7. Fault Earth Switches

Fault Earth Switches have been installed in some locations on the 132kV system to provide back up for primary protection schemes. They automatically apply a permanent, solid, single-phase earth connection to the 132kV conductors so that the distance protection at the remote end of the circuit will see the fault and trip the remote end circuit breaker.

Fault earth switches in service are OPEN. This apparatus contains a charged spring that operates a swinging arm and is capable of being actuated by protection and automatically closed. Whilst set and ready to operate on in service equipment, no part of a fault earth switch is to be locked.

### 7.1. Fault Earth Switches and Work Areas

Provided safe working conditions can be provided, fault earth switches shall be:

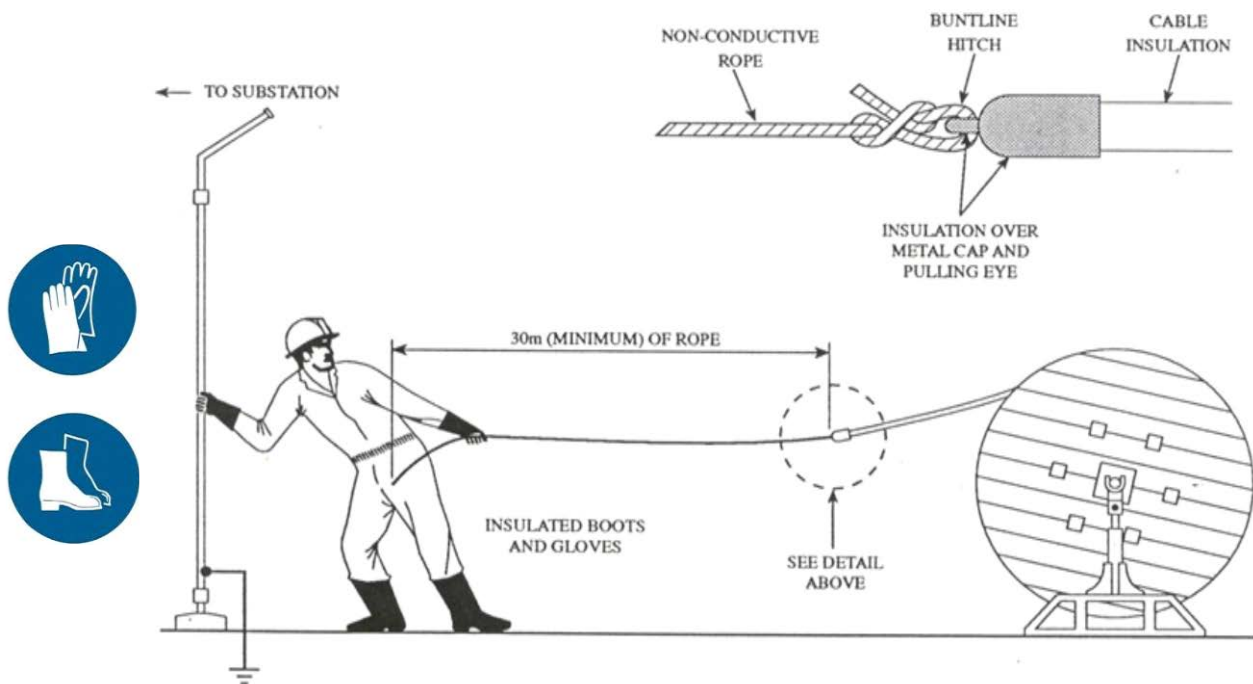
- a) Kept out of the designated work area when work is not required on the fault earth switch.
- b) Discharged (CLOSED) whenever they are included inside a designated work area. In addition, the fault earth switch cabinet door shall be closed and a Do Not Operate Tag applied to its handle.

## 8. Switchyard Earth Grid Voltage Rise and Transferred Earth Potentials

Substations and the circuits connecting them may be subject to dangerous rises in electrical potential due to faults either locally or elsewhere in the network.

Overhead conductors/earth wires, metallic communication, control and protection circuits, cable sheaths and pulling ropes, fences, water, sewage and storm water service pipes all provide a means for "remote" earth potentials to be transferred to or from the substation.

Insulated work methods are used to control hazards from earth grid voltage rise and transferred earth potentials, as shown below.



**Pulling Cable into Substation**

### 8.1. Stringing Conductor on Landing Span to HV Substations

Staff working on the stringing of conductors and overhead earthwires up to the landing span in the substation, i.e. between a HV overhead line and a structure in a HV substation can be subject to significant hazards from the rise in voltage of the substation earth grid under system fault conditions or system switching activities.

Earth grid voltage rise can be transferred to persons outside the switchyard and may occur at any time. Similarly, staff working within the switchyard can become connected to a remote earthing system which can lead to a hazardous voltage during a rise in the voltage of the substation earth grid.

#### 8.1.1. Standard Safeguards

- a) It is best practice for all work on the HV overhead lines to be completed before the landing span is erected. If this cannot be done it may be necessary to temporarily install a single disc insulator in the overhead earth wire at the first structure and to leave the conductor jumpers completely disconnected or tied back onto the landing spans.

These precautions will limit the extent of transfer voltage effects.

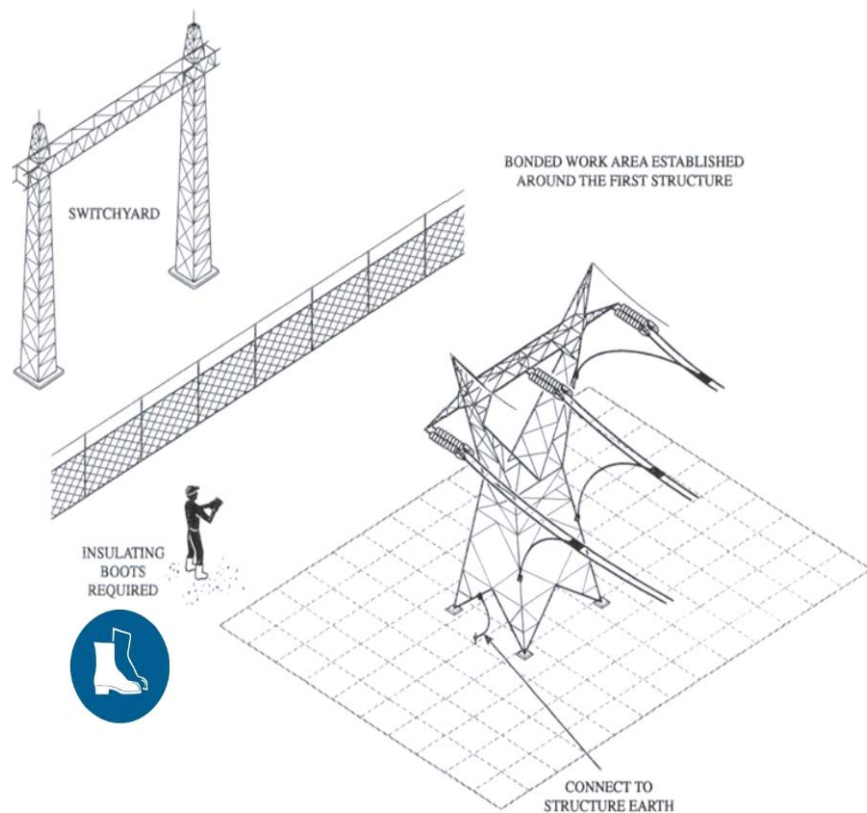
- a) The connection and disconnection of jumpers is to be carried out using the standard bridging process.
- b) All terminations to conductor or overhead earth wire made at ground level in the general vicinity of the landing spans are to be carried out under bonded work area conditions.
- c) The person in charge of the work is to ensure that the Controller is advised prior to the commencement and on completion of stringing operations involving landing spans.

### 8.1.2. Outline of Procedure for Stringing landing Spans

Access authority procedures must be implemented prior commencement of the work.

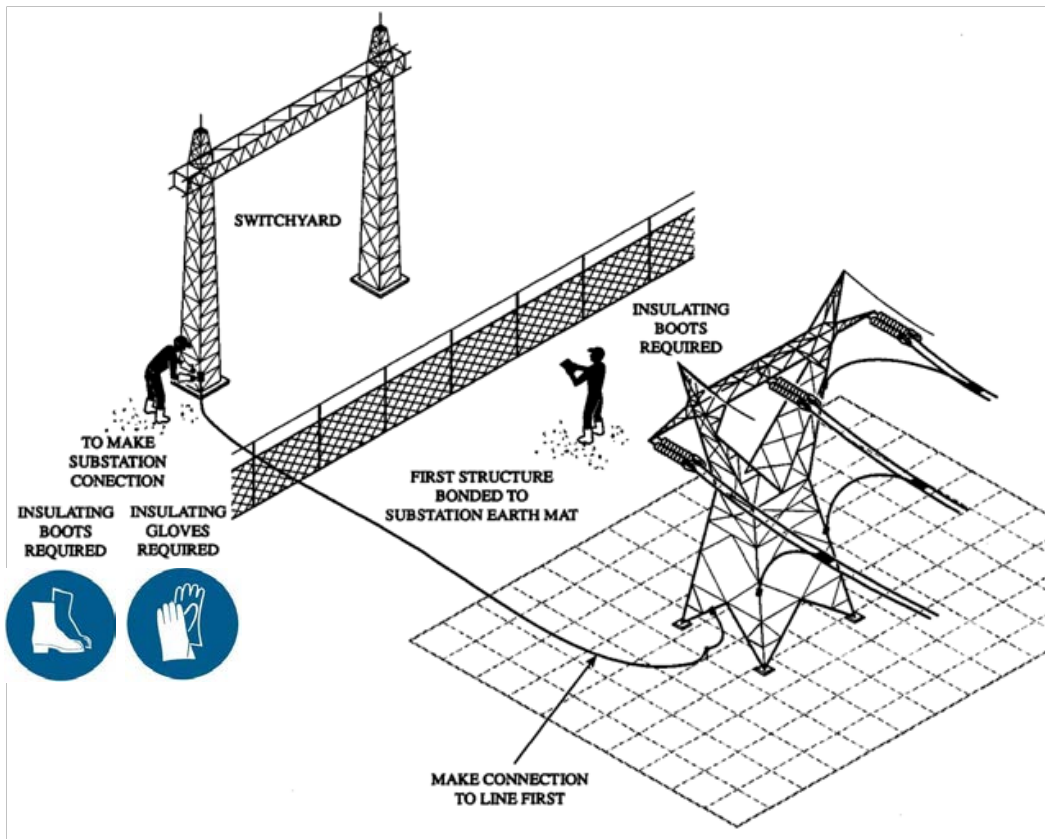
Procedures to be followed for stringing landing spans are:

- a) A bonded work area shall be established around the first structure and connected to the structure earth, as shown right. Insulating boots are to be worn by all persons working at ground level during the course of the work. (This will be a safeguard from possible step and touch voltage which could arise when the structure is connected to the switchyard earth grid).
- b) The first structure shall be bonded to the switchyard earth mat in the following way:
  - i. using a standard portable earthing lead, the lead shall be connected to the first structure outside the switchyard;



and then:

- ii. under insulated working conditions, the lead shall be run out towards and into the switchyard;
- iii. under insulated working conditions, persons shall connect the lead to the switchyard earth grid as shown in the following diagram.



- (c) Winches, brakes and other equipment associated with the stringing operation are to be connected to the switchyard earth mat directly or via the earthing of the first structure. The connection shall be carried out using the procedure outlined in (b) above.
- (d) Stringing of each conductor or overhead earthwire shall be carried out in such a way that neither the conductor nor the overhead earthwire makes contact with the switchyard earth grid whilst the conductor is being handled by persons outside the switchyard.

For additional information refer to "[Safe Work Practices on HV Overhead Lines](#)".

## 9. Buried Services

Any excavation or digging in a switchyard has the possible danger of contact with buried services and could include earth grid, gas, water, sewer, communication and HV or LV cables.

An [Excavation Permit](#) is required for any excavation in a switchyard and excavating plant shall be earthed per Section 9 whilst digging in a substation.

### 9.1. Excavation Permit

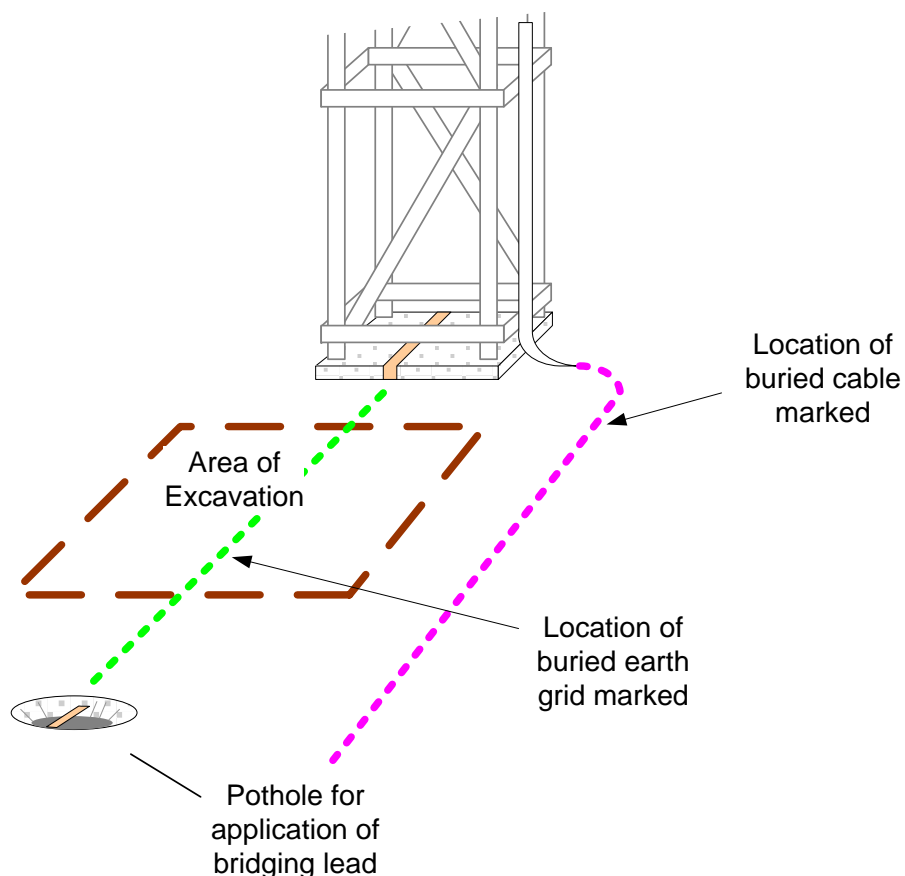
Refer TransGrid [Excavation Permit](#)

### 9.2. Earth Grid

Refer "[Earthing Systems](#)".

### 9.3. Services check

All known buried cables, earth grid and other services within 1m of the proposed excavation shall be highlighted on the drawings and marked on site prior to excavation as shown below.



## 10. High Voltage from Unusual Sources

There are some ways in which high voltage can occur on apparatus which normally carries low voltage and particular care is necessary to ensure that nothing occurs which can bring about such a condition. For example, dangerous voltages may exist on un-bonded cable sheaths.

### 10.1. HV Cables

This apparatus is able to retain an electrical charge of sufficient magnitude to be hazardous to persons even after the apparatus has been isolated from the source of supply. In addition, connections between the earthing system and high voltage cable sheaths are not to be disconnected except under a Cable Access Authority.

During system fault or system switching the potential of the substation earth grid may rise and be transferred via cable pulling equipment and/or cable conductors or metallic parts of the cable to working parties remote from the substation. Similarly, persons working in high voltage areas connected via pulling equipment and/or cable conductors or metallic parts to remote earth may be in danger.

Refer to [‘Safe Work Practices for Work on High Voltage Cables’](#) for further information.

### 10.2. Pilot Cables

During a system fault or system switching the potential of the substation earth grid may rise and be transferred via cable pulling equipment and/or cable conductors or metallic parts of the pilot cable to working parties remote from the substation. Similarly, persons working in high voltage areas connected via pulling equipment and/or cable conductors or metallic parts to remote earth may be in danger.

Refer to [‘Safe Work Practices for Work on High Voltage Cables’](#) for further information.

### 10.3. Earth or Neutral Connections

Refer [“Earthing Systems”](#).

## 11. Earthing Systems

If earthing systems are damaged, electrical performance may be affected and dangerous voltages may occur.

### 11.1. Removal of Earth or Neutral Connections

If an earth or neutral on high voltage apparatus which is in service is removed, cut or broken, a dangerous voltage may occur. Connections between apparatus and the earthing system shall not be removed whilst the apparatus is in service.

### 11.2. Work on Earthing Systems

Where work includes the connection, cutting, disconnection or potential to break or damage any part of an earthing system (the point of work), then prior to the work commencing a *bridging lead shall* be applied across the point of work. The *bridging lead shall* be applied by a person authorised category 5.5 in accordance with PSSR Section 5.5.5 ‘Bridging of Earthing Grids’.

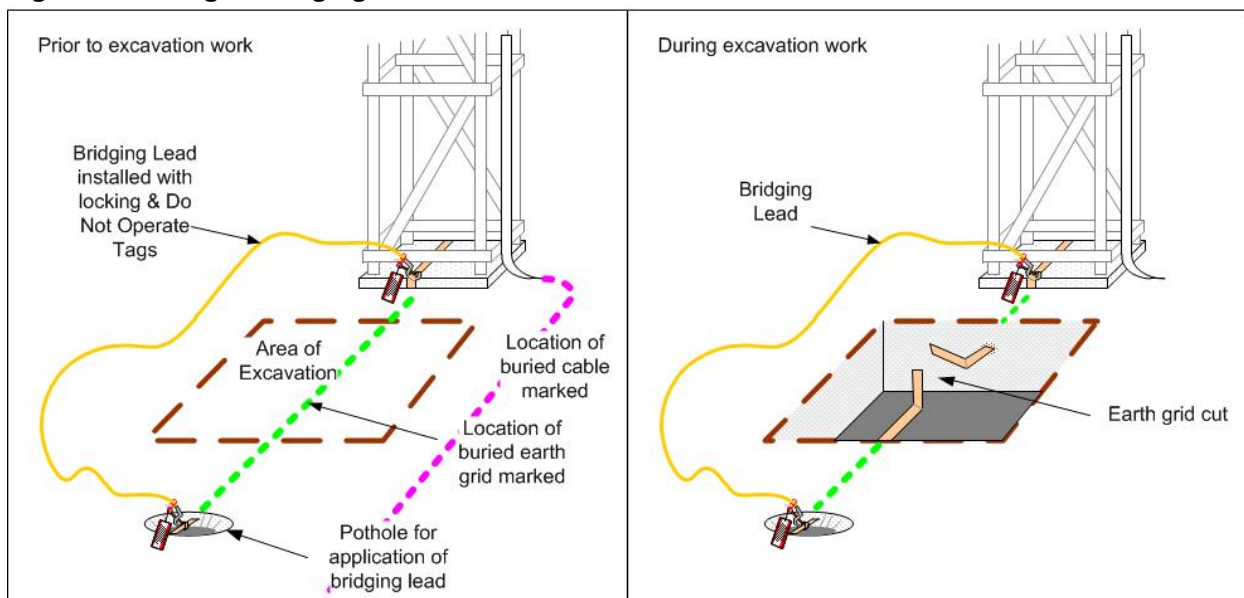
All persons *shall* comply with the requirements of *Do Not Operate Tags* attached to *bridging leads*. Any damage caused to the *substation* earth grid or connections which could adversely affect its electrical performance *shall* be repaired on the same day.

The bridging lead shall be applied using an approved insulating handle, as shown below, or another approved insulated working method.

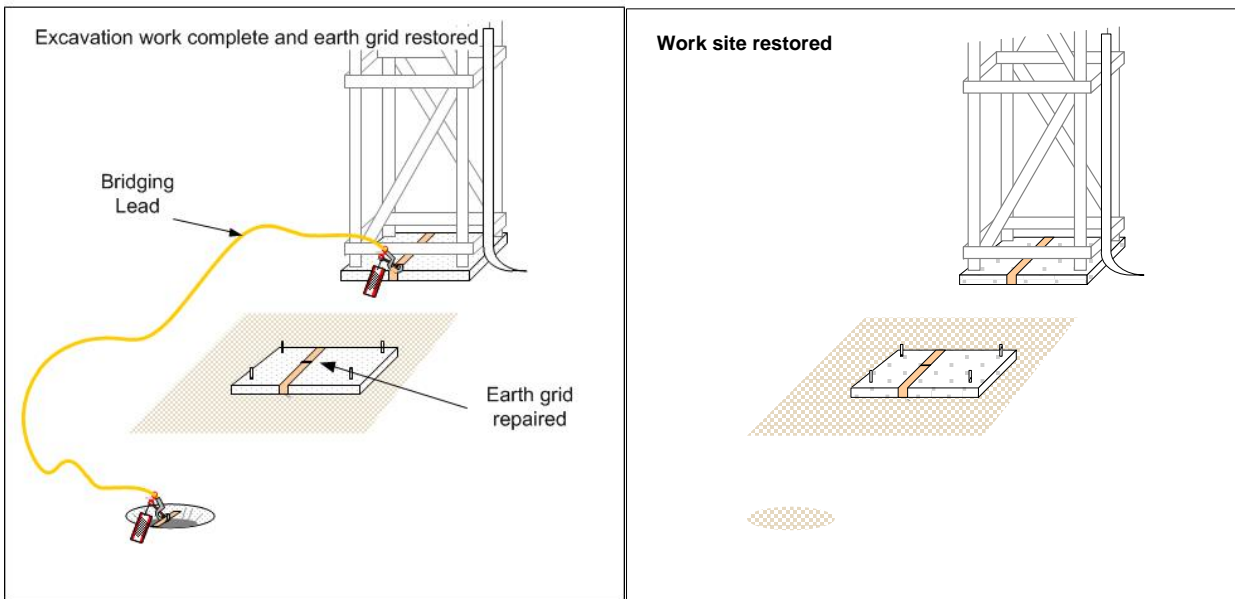


The following diagrams display the step by step method by which a bridging lead is applied where work includes the connection, cutting, disconnection or potential to break or damage any part of an earthing system during excavation work.

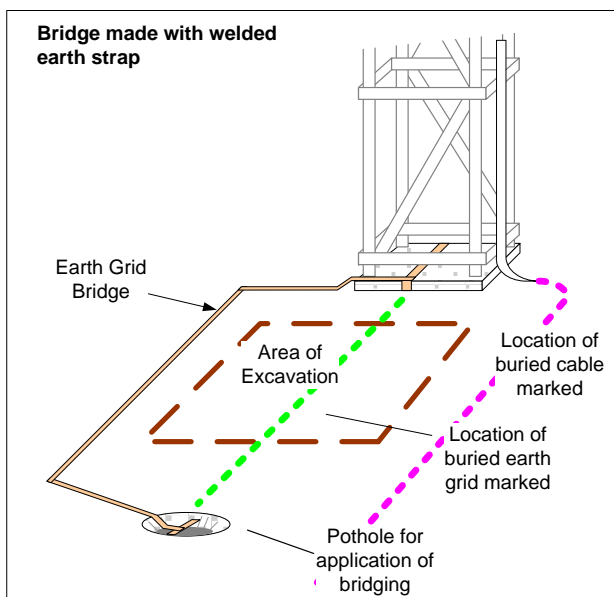
**Figure 1: Earth grid bridging method**







**Figure 2: Alternative method of bridging using earth strap welded in place**



## 12. Near Approach

Personnel and plant clearance distances shall be maintained as specified in 'Safe Approach Distances to exposed conductors' refer: [Power System Safety Rules Attachment B](#).

Warning signs (as shown right) shall be erected where there are live high voltage conductors adjacent to the work area from which persons and plant will need to keep clear.



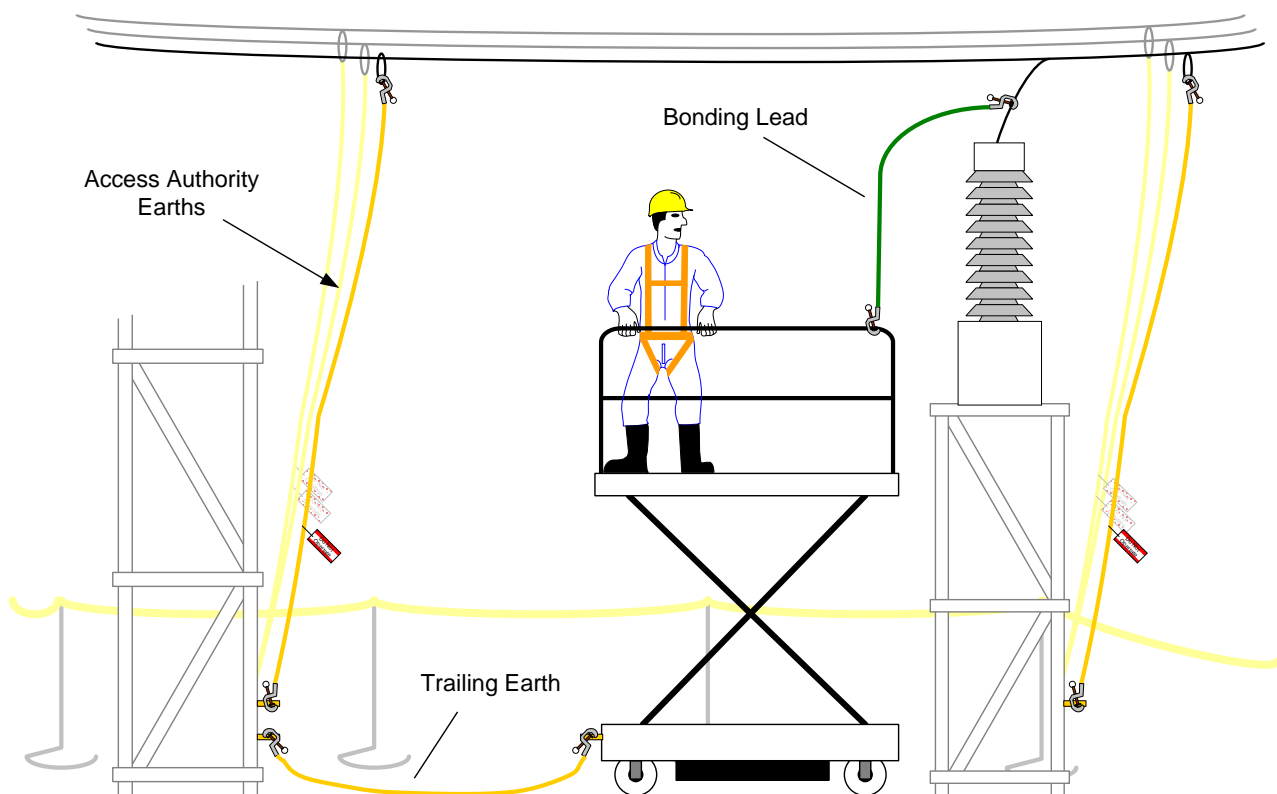
### 13. Induced Voltages

Induced voltages (induction) may be caused by adjacent in-service equipment, high voltage switching or electrical faults in adjacent equipment.

Refuelling of equipment and plant should always be carried out in an area where induction from in-service equipment is not present. Equipment and plant should be checked prior to use for fuel levels and refuelled only at their storage locations, well away from the risk of induced voltages from the switchyard.

There is also a risk of induced voltages when carrying out work on isolated electrical apparatus that is located close to live electrical apparatus.

The figure below illustrates an Elevated Work Platform (EWP) being used for work on HV substation apparatus made safe for work on an Access Authority. The figure shows a conductive platform, which is bonded to the conductor through the bonding lead attached to the boom or platform to create an equipotential work area.



## 14. Change history

Revision no	Approved by	Amendment
0	Lionel Smyth, EGM/Network Services & Operations	Revision 0 New Work Instruction
1	Lionel Smyth, EGM/Network Services & Operations	<ul style="list-style-type: none"> <li>• Section 'Mobile Plant' deleted.</li> <li>• Section 'Disconnected Apparatus' revised</li> <li>• Section 'Work on Earthing Systems' revised</li> <li>• Section 'Switchyard Earth Grid Voltage Rise and Transferred Earth Potentials' revised</li> </ul>
2	Neil Smith, GM / System Operations	<ul style="list-style-type: none"> <li>• Section 11.2 pictures revised for locking of clamps</li> </ul>
3	Ken McCall, Manager/HSE	<ul style="list-style-type: none"> <li>• This procedure has been reviewed and reissued with no changes</li> </ul>

## 15. Implementation

This procedure is to be implemented in conjunction with the implementation of TransGrid's Power System Safety Rules. It will be available as a resource, published on the Wire.

## 16. Monitoring and Review

The Manager/Health, Safety and Environment is responsible for the ongoing monitoring and review of the documents associated with the Power System Safety Rules. This can include but is not limited to:

- Requesting regular feedback on the effectiveness of procedures and work instructions. Appropriate feedback tools include focus groups and online assessments;
- Where a change has occurred in our processes; and
- Recommendations arising from incidents.

## 17. Attachments

Nil.