Operating Process for Access to High Voltage Apparatus

CONTROLLED DOCUMENT

Summary

This procedure supports the Power System Safety Rules and its requirements assembled under the Operation of High Voltage Switchgear - Categories 5, 6 and 7.

It applies to the Operation of High Voltage Air Insulated Switchgear and Gas Insulated Switchgear for the purpose of issuing an Access Authority and subsequent Restoration.

This document also provides general guidance and background information related to the operation of various types of high voltage apparatus and guidance material related to use of a High Voltage Preparation and Restoration Instruction

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1.1. Purpose

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Access for Work on High Voltage Overhead Lines

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Safe Work Practices on LV/MECH Apparatus

OM973 – HV Preparation and Restoration Instructions

1.3. Scope

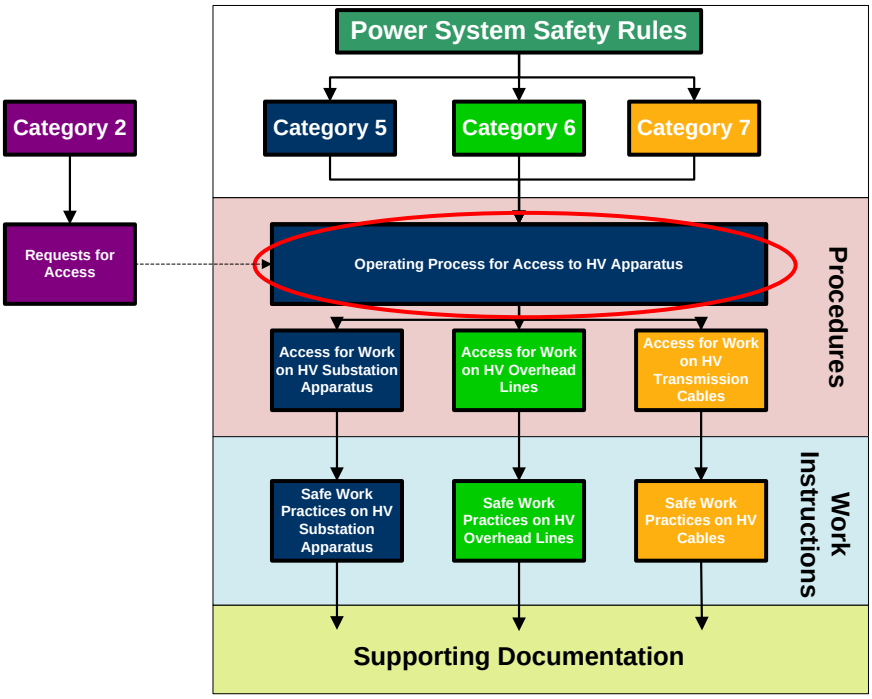
This procedure applies to the operation of high voltage switchgear for the purpose of issuing an Access Authority and subsequent restoration. This document also provides general guidance and background information related to the operation of various types of high voltage apparatus.

1.4. Accountability

Responsible person	Responsibility
Head of HSE	Maintenance and ownership of this procedure
Training Manager	Implementation of training programs associated this procedure
Authorised persons	Comply with this procedure

1.5. Document Location

Block diagram showing relationship to other PSSR documents:



2. Operating Requirements

2.1. Introduction

The operation of high voltage switchgear is required to ensure that safe conditions are established prior to the issuing of an Access Authority on high voltage apparatus including overhead lines and cables.

The sections within this procedure cover:

- The general operating process
- The generic sequence required to safely prepare high voltage apparatus ready for the issue of an Access Authority and the generic restoration sequence required after cancellation of an Access Authority
- Requirements for making Gas Insulated Switchgear safe for work
- General operating requirements for logging, tagging and locking of high voltage switchgear.

This procedure should be read in conjunction with procedures for access to high voltage apparatus which cover the issue and cancellation of Access Authorities:

- Access for Work on High Voltage Substation Apparatus;
- Access for Work on High Voltage Overhead Lines; and
- Access for Work on High Voltage Transmission Cables.

To access these procedures, refer to the Wire PSSR Page or Power System Safety Rules @ Transgrid

2.2. Requirements to make high voltage apparatus safe to work on or near

High voltage apparatus is made ready for work by use of a High Voltage Preparation and Restoration Instruction (HVPRI). The HVPRI is used to ensure safe working conditions are in place before any Access Authorities are issued and work commences. The HVPRI will include specific instructions for:

- Isolation of the high voltage apparatus including locking open of points of isolation and affixing tags where relevant. These points of isolation shall include low voltage sources, which can cause the conductors to become live at high voltage.
- Verifying that the high voltage conductors have been de-energised;
- Earthing of the high voltage conductors and,
- Taking Local Safety Precautions.
  Note: Local Safety Precautions for isolation of hazardous low voltage and mechanical apparatus are detailed in a Low Voltage or Mechanical Preparation and Restoration Instruction (LVMPRI).

2.3. Use of High Voltage Preparation and Restoration Instructions

2.3.1. Overview

When planning and performing a High Voltage Preparation & Restoration Instruction (HVPRI) the safety of persons in the electrical station, including the authorised person performing the switching, is of the utmost importance, as is the prevention of damage to high voltage equipment and maintaining reliability of supply.

HVPRIs shall be prepared in accordance with OM 973 and shall only be prepared and checked by persons authorised Category 2.3.

HVPRIs shall only be carried out by persons authorised:

- Operate LV/MECH Apparatus – Category 4.3;
- Operate HV Air insulated switchgear – Categories 5.5, 6.5; and
- Operate HV Gas insulated switchgear – Category 5.6.

When an Access Authority is to be issued in accordance with an approved Request for Access (RFA), the required HVPRI shall be carried out by an appropriately authorised person.

A written, checked HVPRI issued to the Authorised Person assigned to carry out the switching shall be followed.

2.3.2. Communication between an Authorised Person and Controller

Oral communications regarding a HVPRI must be precise and accurate, otherwise errors and inaccuracies might develop in the transmission and receipt of operating messages and lead to incorrect switching. Where clear transmission of instructions is prevented by poor quality communication channels, alternative methods shall be pursued by the controller and the authorised person until a method is found that allows clear communication.

Where a step of a HVPRI requires advice to be given or accepted, the Controller and the Authorised Person shall quote the step number and clearly state the specific action that is to be undertaken or that has been completed.

The Controller shall approve or request only one group of switching steps to be carried out at one time by the authorised person.

If the Controller loses contact with the Authorised Person at any time (e.g. there is no ring back within a reasonable period after the estimated time for a series of switching steps), then an attempt shall be made to contact the Authorised Person. If the call is not answered, emergency action shall be initiated to verify that the authorised person has not been injured.

An example of correct communication protocols is provided in Appendix A.

2.3.3. Preparation for Use of a HVPRI

2.3.3.1. Field copies delivered by electronic transmission

Field copies of HVPRIs are sent to the locations where they are to be used by using the local printer, facsimile transmission (FAX) or may be used where a printer is not available.

2.3.3.2. Checking of field copy of HVPRI before use

The authorised person carrying out the switching shall:

a. Check completeness and correct collation of the HVPRI just before use, ensuring that all pages are present and in the correct order;
b. Check that the HVPRI to be used matches the task to be performed;
c. Review the HVPRI ensuring the steps make sense for the work to be performed and can be safely performed by the switcher; and
d. When issue of an Access Authority is involved, that the copy of the Request for Access (RFA) held by the working party exactly matches the RFA attached to the HVPRI and referred to in it. If there is a discrepancy in this regard, or if it is considered that there is a discrepancy between the safety conditions for the working party required by the Power System Safety Rules and those provided by the HVPRI, the matter shall be referred to the controller for resolution.

Any issues or discrepancies detected or suspected must be resolved before the switching commences.

2.3.3.3. Amendments to a checked HVPRI

Minor changes to a HVPRI are permitted based on consultation between the switcher and the Controller.

The field switcher may only amend the field copy of the HVPRI after approval has been given by The Controller. All deleted steps on the HVPRI must be crossed out with pen, made completely illegible and marked as deleted. The amendments section at the bottom of the page must be completed, and a written note provided to record the details of why the amendment was made, for future referencing.

Example of an amended HVPRI:

Transgrid

TRANSGRID - H.V PREPARATION AND RESTORATION INSTRUCTION 112402 Version 2
Page 001 of 006
To: Authorised Person/ Operating Diagrams NO.2 CAPACITOR
CB 3722A & CTs

Rearrange Earthing

KC37 [redacted]
Deleted

KC38 No.1 Capacitor Earth Switch.. 5710 -REMOVE DO NOT OPERATE TAG(S) & UNLOCK
-APPLY WARNING TAG(S)

KC39 No.1 Capacitor Star Point -REMOVE DO NOT OPERATE TAG(S) FROM APPLIED EARTHS
-APPLY WARNING TAG(S)

KC40 ADVISE CONTROLLER WHEN THE PREVIOUS STEP IS COMPLETED
...HRS

*Step KC37 deleted due to faulty earth switch which was not required for work to proceed.

Checked by Network Operations on the 11/11/2021 2:34:00 PM
Amendment sent by: D Jeffs Received by: D Moore Time: 08:32

2.3.3.4. Preamble Discussion

To confirm that the correct HVPRI is being used, the authorised person shall identify all three of the following features with the Controller prior to commencing switching:

- Its unique number
- The equipment specified in the heading
- The number of pages in the switching.

Before commencing a switching operation, the Controller shall spend a few moments discussing with the Authorised Person the objectives of the switching, plus other significant operational factors. This might include:

- Whether any customer load might be left radial by the outage
- Any similar work that may be planned for the same day
- Whether the equipment being switched has already been off-loaded from its remote end (so no current flow would be expected)
- Significant prevailing weather conditions
- Any other information that may be of assistance to the authorised person in discharging their duties.

This preamble shall be kept brief, but shall be sufficient to ensure that all parties involved with the switching have a “big picture” overview. If the Authorised Person is still unclear, further information shall be requested before commencing switching.

2.3.4. Execution of the HVPRI Steps

2.3.4.1. General Requirements:

(a) The Authorised Person and the Controller shall ensure they have access to the HVPRI at all times.

(b) The steps must be executed in order, unless agreed between the Authorised Person and the Controller.

(c) If any errors are found in the course of the switching, these shall be immediately reported to the Network Control Manager by either the Controller or Authorised Person and amended as required.

(d) If any of the HVPRI steps are not or cannot be completed in the anticipated manner, the Authorised Person and the Controller shall discuss this before deciding whether to proceed. Steps shall not be repeated without this discussion taking place.

(e) Before commencing each agreed group of steps, the Authorised Person shall discuss with the Controller the probable duration. By doing this,

- The Controller will be able to assess whether the switching is proceeding according to plan
- The Controller will not disturb the Authorised Person unnecessarily by requesting the status of progress
- If the Authorised Person is overdue, the Controller will know when it is an appropriate time to raise the alarm

In the event that the Authorised Person considers that they cannot perform the HVPRI or groups of steps in the HVPRI in the estimated time they shall advise the Controller.

(f) All HVPRI steps shall be carried out carefully and without undue haste. All staff involved in the switching process need to be aware of potential and actual distractions and interruptions and adopt strategies to avoid these affecting their switching performance.

(g) If at any stage either party (Authorised Person or Controller) is not happy to proceed, then switching shall be suspended until the problem is resolved. This could be for safety, operational or personal factors all of which are acceptable reasons for suspending the switching and preferable to incurring a switching error.

(h) Initiating and blocking steps are required to have the time noted on the HVPRI.

Steps shall be crossed off by drawing a non-obliterating line through the whole step and only after all the required actions are completed. In the case of a multi-action step the individual action parts may be crossed off as each is completed ahead of crossing off the whole step.

2.3.4.2. Actions to be Taken by Authorised Person (8 Step Method)

At each step of the HVPRI the Authorised Person shall apply a disciplined approach to ensuring the HVPRI step is completed correctly. The following 8-step method is suitable:

1. Read the HVPRI step
2. Take the HVPRI to the point of operation
3. Check the equipment description against the HVPRI
4. Prepare to perform the required actions
5. Check again the equipment description and required actions against the HVPRI
6. Perform the required actions
7. Check device has operated and all actions completed correctly
8. Cross off the step in the HVPRI

On completion of the last step of the HVPRI, the Authorised Person will advise the Controller accordingly and place the completed HVPRI in the on-site file, where it is to be retained for 12 months.

2.3.4.3. Changing Switchers

Where a second Authorised Person is to take over switching, the first Authorised Person shall complete the HVPRI to the next suitable blocking step so that the second Authorised Person has a clear and logical starting point. Before continuing, the Authorised Person taking over switching shall review the actions taken in previous steps and ensure that they are familiar with all relevant conditions existing at the time of taking over switching.

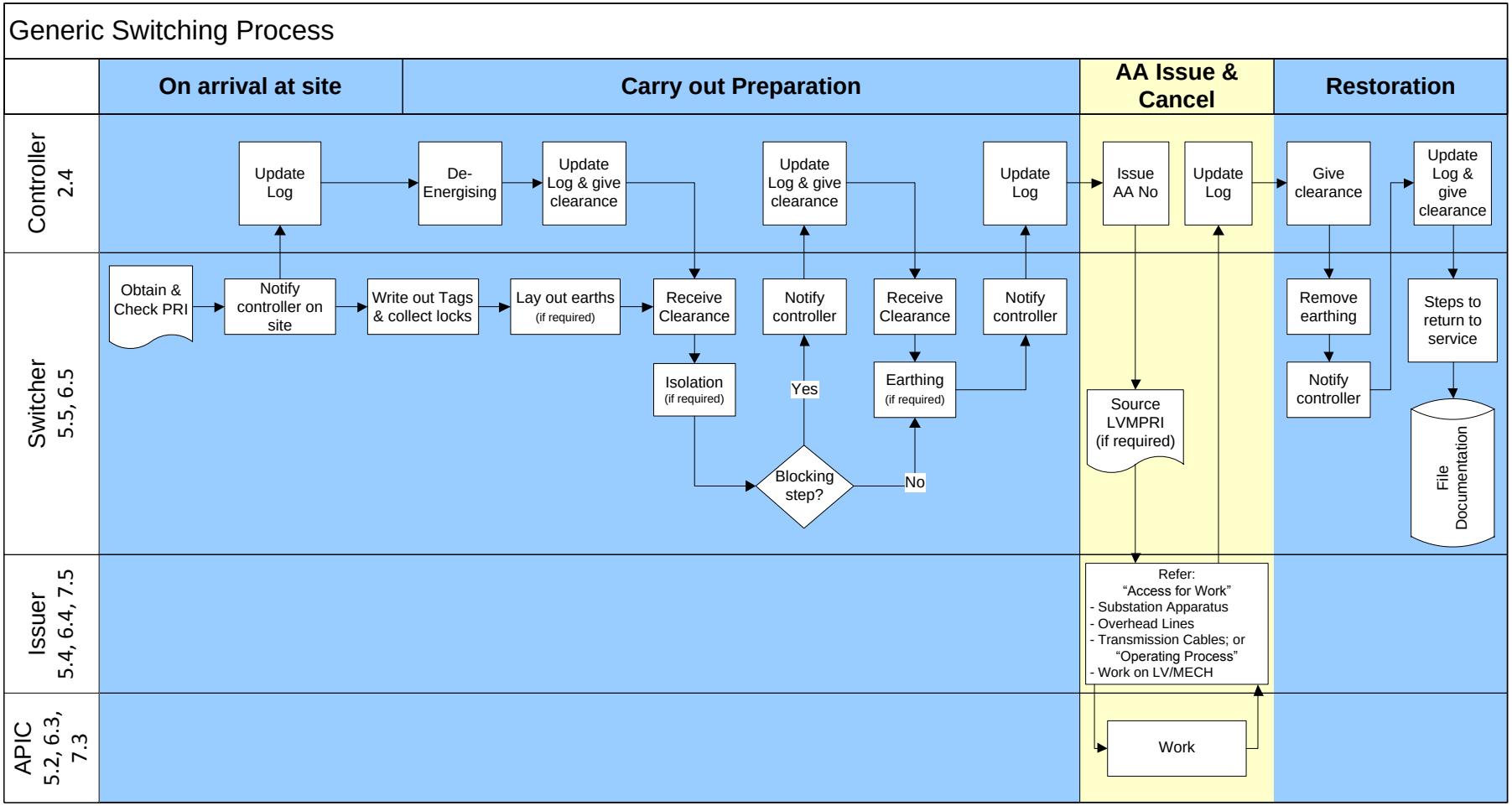
2.4. Switching Focus

Switching is a safety critical activity. For the Authorised Person, those around them and the work group who are relying on the isolations and earthing being performed.

Persons authorised PSSR Category 5.5, 5.6 or 6.5 carrying out HV switching duties must ensure they are completely focused on the switching tasks they are required to perform. They must ensure they adhere to the following requirements:

- Always perform the IMSAFER check prior to commencing switching. Use this time to focus on the switching and eliminate other distractions and tasks from their mind.
- Always wear the pink “Switching in Progress” vest when completing switching steps.
- Only perform the switching activity. Never perform another task at the same time.
- Review the switching before you commence to ensure you understand the steps you are to perform and ensure they make sense in relation to the work to be performed. Prepare yourself with the equipment (tools, tags, etc.) you will need to complete the switching.
- Always use the 8 step method to complete every step. Every step in the switching is important.
- Ensure you use correct communication protocols with the System Operator. Speak clearly and purposefully and read back instructions.
- If you do become distracted, stop, take the time to reassess where you were up to and what you were doing, prior to recommencing the switching activity, never rush back into the switching task.
- If you are on site when switching is occurring do not interrupt, distract or ask questions of the switcher.

3. Generic Switching Process



NOTE: This process is a generic sequence, some sites and types of access have specific requirements.

3.1. On arrival to site

The switcher shall perform the steps listed below when arriving at site:

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 5.6, 6.5	Complete IMSAFER Self Check	Consider whether you are affected by Illness, Medication, Stress, Alcohol, Fatigue, Emotion or Rushing. If you are you should not proceed until you are in a fit state or someone else who is in a fit state should be required to perform the switching task.	
2	5.5, 6.5	Collect PRI from printer and ensure collation is correct	Not required when using switching tablet	This document section 2.3.3.2
3	5.5, 6.5	Check RFA matches PRI		
4	5.5, 6.5	Check PRI against work requested	Reference HVOD to confirm correct equipment, earthing etc.	
5	5.5, 6.5	Switcher to notify Controller that they are onsite	Or notify using switching tablet	
6	5.5, 6.5	Write out required Tags (Do Not Operate or Warning Tags)	PRI number & date	
7	5.5, 6.5	Collect required number of O1 locks	Suitable locks may also be left at equipment	
8	4.3, 5.5	If required, source LVMPRI for equipment to be worked on & write tags to suit required Isolations	Step performed if enough time prior to switching commencing	Access for Work on HV Substation Apparatus
9	5.5, 6.5	Lay out any required portable earths and connect to approved Earthing points at ground level	Step performed if enough time prior to switching commencing	

3.2. Preparation

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Receive Clearance from Controller to carry out PRI	CB's normally de-energised by Controller steps	This document section 2.3.3.4
2	5.5, 6.5	Follow steps of PRI	Carry out PRI to blocking step stated by Controller	

Depending on the type of equipment, operating sequences will vary. The following sections describe generic sequences for different types of equipment.

3.2.1. De-energising or Offload - Operation of Circuit Breaker

Step	Safety Rules Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Go to Control Panel of CB or CB symbol on HMI that matches name on PRI.		This document section 8.1
2	5.5, 6.5	Check associated current or power indication	Panel meters, Power meter or HMI	
3	5.5, 6.5	If required place auto re-close switch to 'NON-AUTO'		
4	5.5, 6.5	Open requested CB.	Via Control Discrepancy Switch (CDS) or HMI	
5	5.5, 6.5	After CB has been opened, check associated current or power indication is nil.	Panel meters, Power meter or HMI	
6	5.5, 6.5	Cross out step in the PRI requesting the CB to be opened.	Use a non-obliterating line	This document section 2.3.4.1
7	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise controller and receive clearance to proceed.	

3.2.2. De-energising or Offload – Confirm Operation of Circuit Breaker

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	If required place auto re-close feature to 'NON-AUTO'		This document section 8.1
2	5.5, 6.5	Proceed into Switchyard		
3	5.5, 6.5	Check CB indicators are showing open.		
4	5.5, 6.5	Cross out step in the PRI requesting the CB to be confirmed open.	Use a non-obliterating line	This document section 2.3.4.1
5	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.2.3. Isolation - Operation of Motorised Disconnector

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Go to control panel of Disconnector or Disconnector symbol on HMI that matches name on PRI	Note: the HMI will often have an abbreviated name due to space. The full name and number may only be able to be read on the bay screen if at all unsure use other means to confirm correct switch prior to operating.	This document Section 8.3
2	5.5, 6.5	Check Disconnector name and number on control panel or HMI and check against PRI again.		
3	5.5, 6.5	OPEN requested Disconnector via CDS switch or HMI.	Problems that arise with the operation need to be referred to the Controller. Local operation may be permitted where remote operation is unserviceable	
4	5.5, 6.5	Check indication on CDS or HMI	Confirm disconnector indication is showing open.	
5	5.5, 6.5	Cross out step in the PRI requesting the disconnector to be opened	Use a non-obliterating line	
6	5.5, 6.5	Proceed into Switchyard to listed Disconnector		

7	5.5, 6.5	Check all phases of disconnector are OPEN	Visual checks shall be made to ensure that arms are fully open on all three phases	
8	5.5, 6.5	Place Local / Remote Switch to “OFF” or “Local”		
9	5.5, 6.5	Isolate motor supplies and apply tags per PRI step	Using one of the following methods: • Electrical interlock “OFF” as part of mechanical isolation • Removal of Fuses / Links; or • Switch “OFF” Thermal Over Load or Motor Supply MCB Refer to the Standard Operating Instruction for the correct locking and tagging approach.	
10	5.5, 6.5	Lock OPEN and apply tags specified by the PRI.	Mechanically locked to prevent manual operation, where practicable	
11	5.5, 6.5	Cross out step in the PRI requesting the disconnector to be checked open, locked and tags applied.	Use a non-obliterating line	This document section 2.3.4.1
12	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.2.4. Isolation - Operation of Manual Disconnector

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Proceed into Switchyard		This document Section 8.3
2	5.5, 6.5	Check CB indicators are showing OPEN.	On all poles - if provided and that the CB is in a satisfactory condition	
3	5.5, 6.5	Proceed to listed Disconnector		
4	5.5, 6.5	OPEN Disconnector	The person carrying out the operation shall stand on the operator mat provided and not watch the contacts while the disconnector is operated	

			The manual opening or closing operation of a disconnector (or similar switch) shall be carried out in one complete and continuous movement,	
5	5.5, 6.5	Check all phases of disconnector are OPEN	Visual checks shall be made to ensure that arms are fully open on all three phases	
6	5.5, 6.5	Lock OPEN and apply tags specified by the PRI		
7	5.5, 6.5	Cross out step in the PRI requesting the disconnector to be checked open, locked and tags applied.	Use a non-obliterating line	This document section 2.3.4.1
8	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.2.5. Isolation – Voltage Transformer

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Identify correct VT Marshalling Box per PRI	Switcher needs to ensure that where multiple secondary isolation boxes are present isolations are performed in both locations. This information is contained in the Switching Information Manual for the site and site signage also highlights this issue.	
2	5.5, 6.5	Identify correct secondary isolation links	Note, some Voltage transformers have multiple secondary windings and both windings need to be isolated.	
3	5.5, 6.5	ISOLATE as required by PRI	Appropriate tools and PPE for work on or near live LV exposed conductors. When SAD of 250mm from live exposed LV conductors not being operated cannot be maintained: LV gloves shall be worn; or Work shall be performed in accordance with an approved SWMS	Safe Work Practices on LV/MECH Apparatus

4	5.5, 6.5	Apply tags as requested by PRI		
5	5.5, 6.5	Cross out step in the PRI requesting isolation of the voltage transformer secondary's		
6	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.2.6. Isolation – 415V Transformer connections

For work on a power transformer, it is necessary to isolate from each point of supply typically requiring primary, secondary and tertiary isolations. In most Transgrid transformer arrangements it is unusual to have isolation points in the 11kV circuit so typically these isolations are taken at the 415V switchgear.

How the 415V isolation is described on the HVOD will determine how the HVPRI step is written. Where a nominated isolation point is available, the naming of that isolation point will be used. Where no isolation points are named a generic description will be used and the switcher will need to use an isolation point suitable for the description of work and description of apparatus on the RFA.

Use of a 415V isolation device with a visible break is preferable as it provides a ready source for the work party to verify the isolation during the warnings and demonstrations process. When the isolation is not provided by a device with a visible break, it must be by a device designed to provide isolation for the voltage and the effectiveness of the isolation must be supported by a testing and earthing procedure. In this case the proving de-energised and the earthing applied after isolation will be used as the testing and earthing procedure.

Isolation at the 415V is to be performed after the isolation of both the primary and secondaries. This will in general provide certainty that the circuit is de-energised prior to operating the 415V isolating device. This is advantageous to safety as generally 415V isolations require the operator to be present locally at the switchgear. Where remote operation points are available they should always be used in preference to local operation.

Isolation sequences to be followed for 415V isolations are similar to those described in sections 3.2.3 to 3.2.5.

3.2.7. Earthing - Preparation

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Collect Operating Rods & Proving De-energised device.		Proving High Voltage Conductors De-Energised High Voltage Operating Rods
2	5.5, 6.5	Inspect all equipment to be used for correct assembly and condition before use.	HV operating rod, proving de-energised tester and earthing equipment	High Voltage Operating Rods Portable Earthing Of High Voltage Conductors Proving High Voltage Conductors De-Energised

The following sections describe the generic earthing sequence required for different types of apparatus.

3.2.8. Earthing - Earth Switch Manual

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Proceed to earth switch identified on PRI.		
2	5.5, 6.5	Set proving dead device to correct voltage and prove against a known supply of the same voltage that is being earthed.	Safe approach distances are to be maintained from all high voltage conductors whilst proving a high voltage conductor de-energised.	Proving High Voltage Conductors De-Energised
3	5.5, 6.5	Check conductors that are to be earthed are de-energised and re-test against a known supply of the same voltage that is being earthed.		Proving High Voltage Conductors De-Energised
4	5.5, 6.5	Place proving dead device back onto conductors that are to be earthed adjacent to phase nearest earth switch		Proving High Voltage Conductors De-Energised
5	5.5, 6.5	Unlock earth switch and CLOSE	The person carrying out the operation shall stand on the operator mat provided and not watch the contacts while the disconnector is operated. The manual opening or closing operation of an earth switch shall be carried out in one complete and continuous movement	
6	5.5, 6.5	Check that all phases are closed correctly	Visual checks shall be made to ensure that contacts are secured by contact pressure or drive tension and arms are fully home on all three phases	
7	5.5, 6.5	Lock CLOSED (if required) and apply tags specified by the PRI	If earths form part of testing, locking is not required and a “Warning” tag to be applied.	
8	5.5, 6.5	Cross out step in the PRI requesting the earth switch to be closed.	Use a non-obliterating line	This document section 2.3.4.1

9	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.2.9. Earthing - Earth Switch Motorised

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Proceed to earth switch identified on PRI.		
2	5.5, 6.5	Set proving dead device to correct voltage and prove against a known supply of the same voltage that is being earthed.	Maintain safe approach distance from all high voltage conductors	Proving High Voltage Conductors De-Energised
3	5.5, 6.5	Check conductors that are to be earthed are de-energised and re-test against a known supply of the same voltage that is being earthed.		Proving High Voltage Conductors De-Energised
4	5.5, 6.5	Place proving dead device back onto conductors that are to be earthed adjacent to phase nearest earth switch		Proving High Voltage Conductors De-Energised
5	5.5, 6.5	Unlock earth switch and CLOSE	The person carrying out the operation shall stand on the operator mat provided and not watch the contacts while the disconnector is operated	
6	5.5, 6.5	Check that all phases are closed correctly	Visual checks shall be made to ensure that contacts are secured by contact pressure or drive tension and arms are fully home on all three phases	
7	5.5, 6.5	Place Local Remote Switch to “OFF” or “Local”		
8	5.5, 6.5	Isolate motor supplies and apply tags per PRI step	Using one of the following methods: • Electrical interlock “OFF” as part of mechanical isolation	

			• Removal of Fuses / Links; or • Switch “OFF” Thermal Over Load or Motor Supply MCB Refer to the Standard Operating Instruction for the correct locking and tagging approach.	
9	5.5, 6.5	Lock CLOSED (if required) and apply tags specified by the PRI	Mechanically locked to prevent manual operation, where practicable	
10	5.5, 6.5	Cross out step in the PRI requesting the earth switch to be closed.	Use a non-obliterating line	This document section 2.3.4.1
11	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.2.10. Earthing - Portable Earths

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Collect portable earths and lay in position as per the PRI, connecting the earths to approved earthing points.	Confirm earth stub is securely mounted on the structure and ensure that the earthing equipment is in a serviceable condition	Portable Earthing of High Voltage Conductors
2	5.5, 6.5	Check location of conductors to be earthed against the PRI	Refer to this document section 8 for additional requirements for different HV apparatus types	
3	5.5, 6.5	Set proving dead device to correct voltage and prove against a known supply of the same voltage of the conductors to be earthed.	Maintain safe approach distance from all high voltage conductors	Proving High Voltage Conductors De-Energised
4	5.5, 6.5	Check conductors that are to be earthed are de-energised and re-test against a known supply of the same voltage of the conductors to be earthed.		Proving High Voltage Conductors De-Energised
5	5.5, 6.5	Place proving dead device back onto a phase of the circuit previously proved de-energised.		Proving High Voltage

				Conductors De-Energised
6	5.5, 6.5	Apply the earth clamp on phase to be earthed.		
7	5.5, 6.5	Repeat Steps (5) & (6) above for each phase to be earthed. Apply tags specified by the PRI to each earth lead.		
8	5.5, 6.5	Remove tester from conductor		
9	5.5, 6.5	Cross out step in the PRI requesting the earths to be applied	Use a non-obliterating line	This document section 2.3.4.1
10	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.2.11. Earthing for inadvertent re-energisation from the tertiary connections.

As described in 3.2.6 for work on transformers, isolation is typically required on the 415V connections to prevent back energisation of the transformer from the tertiary winding side. In case of inadvertent restoration of that isolation earths must be applied between the work party and the point of isolation on the 415V side.

HVPRI procedures preference the application of earths for this situation on the 11kV conductors wherever possible. There are two circumstances where the application of the earths at 11kV is not possible:

1. Where there is no ability to access the 11kV conductors
2. Where the work requires breaking connections at the 11kV terminals of the auxiliary transformer making an earth applied at 11kV ineffective if the 415V isolation was inadvertently restored.

In these situations earths will be required on the 415V terminals. Earthing at the 415V terminals must be suitable for the rating in the event of inadvertent re-energisation. Requirements for earthing of this type are described in the procedure “Portable earthing of High Voltage Conductors”.

This earthing shall only be applied after proving de-energised in accordance with the procedure “Proving HV Conductors de-energised”.

3.2.12. Earthing – Voltage Transformer Secondaries

Step	PSSR Authorisation	Task	Comments	Reference

				Document
1	5.5, 6.5	Identify correct VT Marshaling Box per PRI		
2	5.5, 6.5	Identify correct secondary isolation links		
3	5.5, 6.5	Prove de-energised at secondary isolation links	Using approved two-pole voltage & continuity tester	Proving High Voltage Conductors De-Energised
4	5.5, 6.5	Earth as required by PRI	When SAD of 250mm from live exposed LV conductors not being operated cannot be maintained: • LV gloves shall be worn; or • Work shall be performed in accordance with an approved SWMS	Safe Work Practices on LV/MECH Apparatus
5	5.5, 6.5	Apply tags as required by PRI		
6	5.5, 6.5	Cross out step in the PRI requesting earthing of voltage transformer secondaries.	Use a non-obliterating line. If a blocking step, advise Controller and receive clearance to proceed.	This document section 2.3.4.1

3.2.13. Shorting and Earthing Busbar Protection CT Contributions

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 5.6	Identify correct BBP Kiosk as per PRI		
2	5.5, 5.6	Identify correct CT BBP isolation links		
3	5.5, 5.6	Insert 4 way short into CT side of isolation links or attach 4 way short to shorting terminals with tool on CT side of isolation links NOTE: Short should be applied to Neutral first then the three phases	Use 4 way Phoenix style push in shorts or 4 way lugged building wire shorts – dependent on CT link style When SAD of 250mm from live exposed LV conductors not being operated cannot be maintained: • LV gloves shall be worn; or • Work shall be performed in accordance with an approved SWMS	Safe Work Practices on LV/MECH Apparatus
4	5.5, 5.6	Open Red, White and Blue phases of the shorted CT contribution leaving the link of the earthed leg (usually the neutral) closed to provide an earth through to CT cores	The links must be opened quickly following the application of the short, the protection is disabled for the time the short is applied and the links are not open. If you are not sure which phase is earthed seek advice prior to proceeding. When SAD of 250mm from live exposed LV conductors not being operated cannot be maintained: • LV gloves shall be worn; or • Work shall be performed in accordance with an approved SWMS	Safe Work Practices on LV/MECH Apparatus
5	5.5, 5.6	Apply tags as/if required by PRI		
6	5.5, 5.6	Cross out step in the PRI requesting shorting and earthing of CT BBP links	Use a non-obliterating line.	This document section 2.3.4.1
7	5.5, 5.6	Proceed to next step on PRI	If a blocking step, advise Controller and receive clearance to proceed.	

3.3. Access Authority Issue and Cancellation

Apparatus	PSSR Authorisation	Task	Comments	Reference Document
Substation HV Apparatus	5.4	Issue HV Access Authority Cancel HV Access Authority	Access for Work on High Voltage Substation Apparatus	Access for Work on High Voltage Substation Apparatus
Overhead Lines	6.4	Issue Field Access Authority Cancel Field Access Authority	Access for Work on High Voltage Overhead Lines	Access for Work on High Voltage Overhead Lines
Transmission Cables	7.5	Issue Cable Access Authority Cancel Cable Access Authority	Access for Work on High Voltage Transmission Cables	Access for Work on High Voltage Transmission Cables

3.4. Restoration

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 5.6, 6.5	Complete IMSAFER Self Check	Consider whether you are affected by Illness, Medication, Stress, Alcohol, Fatigue, Emotion or Rushing. If you are you should not proceed until you are in a fit state or someone else who is in a fit state should be required to perform the switching task.	
2	5.5, 6.5	Receive clearance from Controller to carry out PRI	Carry out PRI to blocking step stated by Controller	This document section 2.3.3.4
3	5.5, 6.5	Follow steps of PRI	Cross out steps as completed with a non-obliterating line	

3.4.1. Removal of Earthing - Earth Switch

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Identify correct earth switch per PRI		
2	5.5, 6.5	Remove Tags, unlock and OPEN earth switch.	**If motorised earth switch:** • Restore motor supplies; and • Place local / remote switch to local	
3	5.5, 6.5	Check that all three (3) phases have opened correctly	Visual checks shall be made to ensure that arms are fully open on all three phases	
4	5.5, 6.5	Lock OPEN the earth switch	**If motorised earth switch:** • Place local / remote switch to OFF	
5	5.5, 6.5	Cross out step in the PRI requesting the earth switch opened.	Use non – obliterating line	
6	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.4.2. Removal of Earthing - Portable Earths

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Check correct location of portable earths to be removed per the PRI		
2	5.5, 6.5	Remove tags		
3	5.5, 6.5	Remove earths	Return to correct storage location at completion of PRI	Portable Earthing of High Voltage Conductors
4	5.5, 6.5	Cross out step in the PRI requesting the earths to be removed	ONLY after all three phases are removed	
5	5.5, 6.5	Proceed to next step on PRI	If a blocking step, advise Controller and receive	

			clearance to proceed.	

3.4.3. Removal of Earthing – VT Secondaries

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Identify correct VT Marshalling Box per PRI		
2	5.5, 6.5	Identify correct secondary isolation links		
3	5.5, 6.5	Remove Tags		
4	5.5, 6.5	Remove earth(s)	Appropriate tools and PPE for work on or near live LV exposed conductors. When SAD of 250mm from live exposed LV conductors not being operated cannot be maintained: • LV gloves shall be worn; or • Work shall be performed in accordance with an approved SWMS	Safe Work Practices on LV/MECH Apparatus
5	5.5, 6.5	Cross out step in the PRI requesting removal of earthing from the voltage transformer secondaries.	Use a non-obliterating line	This document section 2.3.4.1
6	5.5, 6.5	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.4.4. Removal of Earthing and Shorting of BBP CT contributions

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 5.6	Identify correct BBP Kiosk as per PRI		
2	5.5, 5.6	Identify correct CT BBP isolation links		
3	5.5, 5.6	Remove tags (if PRI required them)		
4	5.5, 5.6	Close Red White and Blue phase links, confirm	When SAD of 250mm from live exposed LV conductors not being operated cannot be	Safe Work Practices on

		Neutral link is still closed	maintained: • LV gloves shall be worn; or • Work shall be performed in accordance with an approved SWMS	LV/MECH Apparatus
5	5.5, 5.6	Remove 4 way short from CT contribution links	When SAD of 250mm from live exposed LV conductors not being operated cannot be maintained: • LV gloves shall be worn; or • Work shall be performed in accordance with an approved SWMS	Safe Work Practices on LV/MECH Apparatus
6	5.5, 5.6	Cross out step in the PRI requesting removal of earthing and short from the BBP CT Contributions.	Use a non-obliterating line	This document section 2.3.4.1
7	5.5, 5.6	Proceed to next step on PRI.	If a blocking step, advise Controller and receive clearance to proceed.	

3.4.5. Return to Service

Step	PSSR Authorisation	Task	Comments	Reference Document
1	5.5, 6.5	Receive clearance from Controller to carry out PRI	Carry out PRI to blocking step stated by Controller	
2	5.5, 6.5	Check associated CB is OPEN		
3	5.5, 6.5	Identify correct VT Marshalling Box per PRI		
4	5.5, 6.5	Identify correct secondary isolation links		
5	5.5, 6.5	RESTORE as required by PRI	Appropriate tools and PPE for work on or near live LV exposed conductors. When SAD of 250mm from live exposed LV conductors not being operated cannot be maintained: • LV gloves shall be worn; or	Safe Work Practices on LV/MECH Apparatus

			• Work shall be performed in accordance with an approved SWMS	
6	5.5, 6.5	Cross out step in the PRI requesting restoration of the VT secondaries		
7	5.5, 6.5	Proceed to next step on PRI.		
8	5.5, 6.5	Proceed to the listed disconnector		
9	5.5, 6.5	Remove Tags		
10	5.5, 6.5	Unlock disconnector	**If motorised disconnector:** • Restore motor supplies; and • Place local / remote switch to REMOTE	
11	5.5, 6.5	CLOSE Disconnector/s as per the PRI	If motorised disconnector CLOSE requested Disconnector remotely	
12	5.5, 6.5	At the apparatus visually confirm Disconnector/s CLOSED	Visual checks shall be made to ensure that contacts are secured by contact pressure or drive tension and arms are fully home on all three phases If manual disconnector, the disconnector shall then be secured against movement caused by wind, vibration or magnetic forces etc., by inserting the holding bolt in the operating handle	
13	5.5, 6.5	Cross out step in the PRI requesting the disconnector to be closed		
14	5.5, 6.5	Proceed to next step on PRI.		
15	5.5, 6.5	If required by PRI place auto re-close switch on 'AUTO'		
16	5.5, 6.5	Advise Controller when blocking step has been reached and that equipment is ready for service	CB's normally energised by Controller steps	

17	5.5, 6.5	File ‘used PRI’ and associated documentation	In designated filing cabinet.	

4. Operating Gas Insulated Switchgear (GIS)

4.1. Power System Safety Rules Requirements

The Power System Safety Rules require that:

Making GIS Safe for Work

- For normal switching operations, GIS shall be operated remotely using the substation Human machine Interface (HMI) or other remote control facility; and
- Manual operation of GIS for switching purposes shall not be considered when equipment is energised, as this will bypass all interlocking.

Normally GIS switchgear must be operated remotely. **Operation from the local control cubicle is not considered to be remote operation** therefore if remote operation is not possible then addition precautions are required as detailed in Section 4.4.

In addition to these requirements, all workers shall vacate the GIS hall during switching operations.

4.2. General Requirements

4.2.1. Electrical and Mechanical Safety features

Extensive interlocking is provided at GIS substations and on GIS switchgear to inhibit the closing of an earth onto live High Voltage conductors. Safety may also be provided by three-position switches that are mechanically designed to prevent any individual phase from being in more than one state at any one time, i.e. a phase that switches to earth cannot physically also be in the closed position at the same time.

Characteristics of equipment specific to individual sites are provided in the Switching Information Manuals and Standard Operating Instructions for GIS Sites.

4.2.2. Defeating of Interlocks during Operational Switching

Where the nature of the work requires the defeating of interlocks during operational switching Rules 5.6.8 and 5.6.9 of the Power System Safety Rules apply.

4.2.3. Defeating of Interlocks during work under an Access Authority

Following the issue of an Access Authority, defeat of interlocking on equipment under the work party's control as part of the Access Authority is permitted. Defeating of interlocking shall be performed by a person familiar with the operation of the equipment and the interlocks. In normal circumstances this would be a person authorised category 5.6. Interlocks defeated during the currency of the Access Authority must be restored prior to the cancellation of the Access Authority.

4.2.4. Preparation of Switching Instructions

The High Voltage Preparation and Restoration Instruction will not be written in a manner that prescribes remote or local operation for each step. This will assist the work where remote operation is unexpectedly unavailable. It will be the responsibility of the authorised person performing the switching to comply with the requirements of section 4.3 and 4.4 of this procedure.

Example GIS switching sequences that are written in this style are provided in Appendix C.

4.2.5. Order of Switching Operations

All switching shall be carried out in accordance with all the normal rules and conventions except:

- Earths may be applied prior to isolating VT secondary circuits and will be the normal practice;
- Visual checking of individual switchgear status using the mechanical indication is not required.

Locking and tagging of apparatus shall be undertaken when convenient, rather than immediately after completing each individual operation. This is to allow the switcher to complete a number of remote operations before returning to the switchgear.

Note: For certain types of switchgear it is necessary to lock the isolators before closing the earths.

4.3. Making GIS Equipment Safe for Work using Remote Operation

Where Remote operation of GIS switchgear is available the requirements of this section apply.

An example GIS switching sequence that complies with this procedure is provided in Appendix C.

4.3.1. Isolation

Isolation will be in accordance with Rule 5.6.2(a) of the Safety Rules. The switchgear position on the HMI satisfies the requirements of this rule.

4.3.2. Earthing

The application of HV Access Authority earths shall be in accordance with Rule 5.6.3 of the Power System Safety Rules. An approved earthing method shall be used that ensures:

- Earthing switches shall only be closed onto High Voltage conductors that are identified as de-energised from all sources by voltage and/or disconnector indication.
- Earthing switches may be applied to High Voltage conductors that are identified as de-energised if the earth is already in place and is being extended to other conductors by the closure of a circuit breaker.

4.3.3. Securing the Isolation and Earthing

This is to be done on the switchgear level by locking / tagging effective points of isolation in their open positions and locking / tagging effective earthing switches in their closed positions

4.4. Making GIS Equipment Safe to Work where Local operation is required

When there is no capability to operate the GIS equipment remotely or the remote capability is not functioning then Rule 5.6.6 of the Power System Safety Rules applies. The additional safety precautions applicable in such circumstances are as follows:

4.4.1. Isolation

The indication of the switchgear position must be established **visually**, either directly or by using appropriate cameras. The gas pressure must also be confirmed as satisfactory.

4.4.2. Earthing

There are no additional requirements when earthing locally.

5. Site log and incidents

5.1. Operating functions that are not steps in a PRI

Operating functions that are not steps in a PRI shall be fully recorded in the site log. Examples of relevant functions are:

- Operational switching of circuit breakers without the use of a PRI;
- Switching of HV equipment during an emergency without the use of a PRI – Commonly referred to as Log Entry Switching;
- Local operation of an Auto Reclose/ Auto Close/ Time Switch Control that is not a step in a PRI;
- Messages to and from the Controller relating to significant occurrences, unusual conditions and observations at the station (including circuit breaker operations not included in a HVPRI); and
- Any other matter affecting the safe and efficient operation of the substation.
- Note: Such functions must be communicated to the Controller and must only be carried out by an appropriately Authorised Person.

5.2. Recording of Site Incidents

When responding to a system incident e.g. equipment trip, then a Site Incident Record Sheet shall be completed, this includes sections for all protection details etc. Once completed, this form is to be forwarded to the Controller; there is no need to duplicate this information in the switching log book.

6. Tags and Labels

Tags and labels are used to indicate temporary abnormal conditions of apparatus. Printed tags and labels are physically attached to equipment whereas electronic tags associated with supervisory systems (SCADA and HMI etc.) are graphic symbols shown adjacent to a device on the display. The following tags and labels are in use:

- Do Not Operate Tag (DNOT)
- Warning Tag (WT)
- Unusual Condition Label (UCL)
- Control Inhibited Tag (CIT)

6.1. Do Not Operate Tags and Warning Tags

Use of DNOTs and WTs is controlled because they are part of the process to set up safe working conditions on or near high voltage, low voltage and mechanical apparatus in the charge of the Controller. Application and removal of DNOTs and WTs in this circumstance shall only be carried out by a person authorised PSSR Category 4.3, 5.5, 5.6 or 6.5.

- **Do Not Operate Tag** - PROHIBITS personnel from operating any device switch, control, valve, link etc., to which it is attached.
- **Warning Tag** allows LIMITED OPERATION of the device or control to which it is attached, to the extent indicated on the tag.

6.1.1. Obsolete Do Not Operate Tags or Warning Tags

If a DNOT or WT is found attached to apparatus which is required to be operated, and it is likely that the tag is obsolete the matter shall be investigated by the Controller, who shall establish from records of Access Authorities whether the tag is no longer applicable and can be removed.

6.2. Control Inhibit Tags

Where supervisory control is provided, an electronic Control Inhibit Tag (CIT) shall be used in lieu of a paper tag as part of the safe working conditions established when work is required on or near HV apparatus or for security of the system. A CIT shall be used primarily for visual indication and not for work party safety for which isolations which can be proven are to be used.

7. Locking Of High Voltage Switchgear

O1 Series – 'Operator' key locks are provided for locking of switchgear and other operating purposes and the associated keys are only issued to person's authorised PSSR Category 5.5, 5.6 and 6.5.

When locking HV switchgear the following points are to be observed:

(a) HV switches required open for isolation purposes must be locked open unless an approved alternative procedure is available;

(b) Locks should not be applied to HV switches in substations that are open or closed for system operating requirement only;

(c) No in-service HV disconnector in a substation is to be locked closed, unless:

- Environmental factors could cause maloperation; or
- When directed by the Controller;

(d) Earthing switches must be locked in either the open or closed position except when provision is made for a switch to be operated in association with a Testing Access Authority, or when an approved alternative procedure that does not require locking exists for the specific equipment;

(e) Where a HVPRI requires HV switches to be locked, where practicable, the disconnector or earthing switch shall be mechanically locked to prevent manual operation;

(f) When special individual locks are provided for each switch (e.g. on SF6 switchgear), corresponding individual keys will normally be kept in a dedicated key cabinet located in the control room; and

(g) Where a motor operated disconnector or earthing switches can be operated from local or remote control points, each device shall be isolated from its operating supply source and tags as per the HVPRI shall be attached at the point of isolation. This requirement is normally not included as a detailed step in the HVPRI and it is the responsibility of the person carrying out the HVPRI to ensure familiarity with different apparatus types. Standard Operating Instructions are available to guide authorised persons on the correct way to isolate and tag motorised disconnectors and earthing switches.

8. General Operating Principles

8.1. Circuit Breakers

Whenever possible, load break switching operations shall be carried out using circuit breakers or load-breaking circuit switches. Some circuit breakers have multiple interrupter units per pole, in which case they are usually provided with grading capacitors to ensure uniform voltage distribution. Also, some types of circuit breakers are fitted with breaking resistors that are connected in parallel with the main contacts for dampening transient recovery voltages. Circuit breakers, in general, may be operated according to system requirements without risk of failure, but nameplate ratings and specific local limitations must be observed.

8.1.1. Operating requirements for circuit breakers

- HV circuit breakers may only be operated as a step in a PRI or with the specific approval of the Controller, except in an emergency. Operations for maintenance checks, testing and commissioning may also take place in accordance with procedures relevant to the work.
- Where a circuit breaker is considered to be defective it should be de-energised by the operation of another circuit breaker to reduce the risk of damage to equipment, danger to personnel and effects on system security.
- Should there be any apparent abnormality within the substation or other reason that suggests that the CB should not be operated, refer to the Controller for advice before proceeding.
- In the case of automatically switched capacitors or reactors (e.g. those controlled by time switches, voltage level etc.) Select control to non-auto before operating the CB.
- Check what instruments are available on the control panel as operating aids, consider their expected behaviour and check that the behaviour occurs during operation.
- Circuit breakers shall preferably be operated remotely, from the Network Operations' control room. Otherwise the circuit breaker shall be operated from the CB control panel in the substation control room/relay room, as follows:

Opening a circuit breaker

(a) Check whether the circuit is carrying load. If so, check that an alternative parallel supply is available to pick up that load. If this can't be checked locally, receive assurance from the Controller that an alternative supply is available. This principle applies to auxiliary supplies as well as external load. If the ammeter reading is near zero, press the fine scale button (where provided) and watch for pointer movement.

(b) In the case of generating units, gradually reduce the load to zero before switching to avoid frequency or voltage surges, damage to plant and to reduce the breaking duty of the CB.

(c) First select the CB to be opened, and then check that the correct CB has been selected before proceeding to open the CB.

(d) Immediately after opening the CB, check the ammeters to ensure that the expected load drop off or pick-up has occurred on alternative circuits and that no overload has arisen. Check that voltage conditions are satisfactory and that auxiliary supplies are still effective.

(e) Check that the local (at the circuit breaker) indicator on the CB shows 'open' (on all poles - if provided) and that the CB is in a satisfactory condition.

(f) For those CBs where the close operation is performed mechanically by a spring, check that the spring has recharged.

Closing a circuit breaker

(a) Check local conditions: The CB control switch, in the local cabinet, must be selected to remote. LV/mechanical isolations must have been restored. All associated protection devices must be auto and there should be no relays showing an operation. Any abnormality (relays operated or flags down) should be reported to the Controller and then be reset when requested. There should be no alarms associated with the CB.

(b) If required by the HVPRI, check that the line auto-reclose facility, if provided, is in the non-auto condition. Auto reclose is not normally made non-auto where there is duplicate memory protection installed.

(c) If required by the HVPRI, synchronising facilities must be used to check synchronism and matching phase angle and voltage levels across the CB before closing it. Synchronising is normally auto except in power stations.

(d) Select the CB to be closed, and then check that the correct CB has been selected before proceeding to close the CB.

(e) During the close operation, observe the behaviour of ammeter, voltmeter and control room lighting. Should the circuit breaker trip on an attempted closure, these indications are valuable aids in diagnosing whether there has been a HV fault, or some malfunction of protection, or non-latching of the CB.

(f) After the CB has been closed ensure, unless instructed otherwise by the Controller, that:

(g) CB control is restored to the normal remote/supervisory condition;

(h) Auto reclose is normally made auto and Auto closing is normally non-auto, any discrepancies are to be referred to the Controller;

(i) Automatic control of capacitors or reactors (e.g. by time switch, voltage etc.) is normally made auto, any discrepancies are to be referred to the Controller;

(j) Check that the local CB indicator is showing 'closed' (on all poles - if provided) and that the CB is in a satisfactory condition;

(k) For those CBs where the close operation is performed mechanically by a spring, check that the spring has been recharged after closing of the CB and all alarms associated with the CB are reset.

8.1.2. General limitations - Circuit breakers

8.1.2.1. Current rating

Loadings must not exceed the published ratings except when a higher loading is approved for special purposes. Circuit ratings are set out in 300 series OMs, which take into account the current carrying capacity of the circuit breaker.

Rupturing duty

Generally, circuit breaker operation above rated rupturing capacity is not permitted. However, in specific cases the rated rupturing capacity may be temporarily exceeded with the approval of the Manager/Network Operations. An example would be that if the only alternative would be interruption to supply, then under abnormal conditions normal rupturing capability might be exceeded for the short period during supply re-arrangement.

Circuit breaker maximum duty cycles

Circuit breakers may have a limit to the number of operations within a given time, as follows:

Circuit breakers with breaking resistors

Some circuit breakers (particularly 500kV and some lower voltage small oil volume circuit breakers) are fitted with breaking resistors to dampen transient recovery voltages (TRV). These resistors are connected in parallel with the main interrupters and following the opening of the main contacts auxiliary interrupters open the breaking resistor circuits. Tripping operations cause heating of the resistors and to avoid the risk of damage due to thermal build-up, the number of successive trips must be limited. In general, circuit breaker specifications allow for an operating sequence of **TRIP - CLOSE - TRIP - 3 MINUTE TIME DELAY - CLOSE – TRIP.** A trip followed by auto-reclose and trip must be counted as two trip operations.

In addition, limitations apply to certain makes of circuit breakers with respect to breaking: load current, fault current, line (or cable) charging current and capacitor charging current. No limitation applies to the frequency of switching transformer magnetising current.

Circuit breakers without breaking resistors

SF6 and pressurised head, small oil volume circuit breakers do not require breaking resistors. Although these circuit breakers have no resistor thermal limitations, the general **TRIP - CLOSE - TRIP - 3 MINUTE TIME DELAY - CLOSE - TRIP** operating sequence still applies.

Other operating limitations

Hydraulically operated CBs must not be operated if the hydraulic pressure is below the limits prescribed for the particular CB.

In the case of SF6 gas interrupters there is a possibility of the SF6 gas leaking from the interrupter units at a rate of approximately 1% per year, relative to gas quantity. As the gas acts as a damper, these circuit breakers must not be operated if the poles do not contain SF6 gas.

- Double Pressure CBs: The operation of double pressure SF6 CBs depends on the SF6 pressure differential between the high and low pressure gas chambers and they must not be operated if this differential pressure drops below the limits prescribed for the CB.
- Single Pressure CBs: Single pressure SF6 CBs must generally have a nominal pressure in the interrupter, below which it is recommended that the CB not be operated. Gas pressure monitoring (gas density relay) will initiate an alarm if the SF6 gas pressure drops to a point where lockout is imminent. Lockout circuitry is provided to prevent the CB from being operated if the SF6 pressure is too low for safe operation.

8.2. High Voltage Capacitors and Reactors

8.2.1. High Voltage Power Capacitors

Shunt connected HV power capacitors are used for voltage control. Most such capacitors comprise banks of multiple cans mounted on racks and connected in double star. The mounting racks are generally not connected to earth. Star point earthing depends on the bank arrangement.

Capacitor circuit breaker operation

A circuit breaker shall be used at all times to switch high voltage power capacitors into or out of service. To minimise surges and/or damage when switching the capacitors the designated capacitor circuit breaker should be used, as it will have been designed for capacitor switching duty, with point on wave facility when appropriate.

Capacitor residual charge

HV DC charge might be left on a capacitor and its framework after removing supply. Because of this, a period of at least ten 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. Specifically, a capacitor is not to be re-energised until at least ten minutes after being de-energised. This will avoid voltage-doubling effects from switching onto residual HV DC charge, which could cause protection fuses to rupture and possibly damage the capacitor.

8.2.2. HV Capacitor Earthing

The capacitor bank should be earthed by operation of an earthing switch on the primary supply conductors where an earthing switch is provided. Capacitor banks have internal discharge circuits to dissipate any residual charge after they are de-energised. Reduction of the capacitor voltage to a safe level for earthing requires time for the discharge circuit to operate. As proving de-energised equipment will not indicate the presence of any residual HV DC charge, earthing is not to commence for at least the time specified on the Capacitor bank nameplate, where this information is not available the switcher is to wait ten minutes after de-energising to allow the residual charge to dissipate and ensure safe conditions for earthing. After having been proven de-energised the star points of the capacitor as well as the supply conductors on each phase must be earthed to effectively short and earth each phase of the capacitor bank. Where the capacitor bank comprises two parallel sections, each with its own star point, the authorised person shall visibly check the connection between the star points for continuity before applying earthing and apply the same procedure to each section if the star points are not connected.

8.2.3. High Voltage Power Reactors

Shunt connected HV power reactors are also used for voltage control. Although not subject to the same residual charge problems as capacitors, a circuit breaker shall be used at all times to switch high voltage power reactors into or out of service to minimise surges and/or damage.

8.2.4. Operating requirements for control schemes

All control devices shall be selected to the non-auto position before any circuit breaker operation to avoid hunting effects should the control scheme initiate an operation during a manual switching sequence.

Any auto-switching scheme shall be selected to the non-auto position before resetting capacitor or reactor protection MTM relays after fault tripping. This is to prevent an uncontrolled operation of the capacitor or reactor circuit breaker when the protection MTM relays are reset. When the protection MTM relay operates, contacts in the automatic control circuit are broken in order to prevent the scheme reclosing the circuit breaker onto faulted equipment and when the MTM is reset the automatic control circuit is remade and conditions on the network could cause operation of the auto-switching scheme.

Automatic Control of Capacitors And Reactors

HV shunt power capacitors and reactors often have automatic controls that will switch the units in and out of service to assist with system voltage control (refer to Operating Manuals). Where there are automatic controls, the circuit breaker discrepancy (CDS) switch on the control panel will commonly be left with the knob pointing to the “OPEN” status position to prevent a ‘Circuit Breaker Tripped’ alarm being activated every time the automatic control initiates an ‘Open’ command. Such operation causes the lamp to be on over an extended period to indicate a discrepancy and they can burn out. Lamp integrity on these devices should be checked to ensure the indication is reliable and there is no confusion between a blown lamp and a dark lamp condition.

Time switch control

Used on smaller installations where remote supervisory control equipment is not provided.

Var control

Also used on smaller installations where remote supervisory control equipment is not provided or where a local HMI is programmed for local voltage control, but in some cases the equipment might be part of a distributed voltage control scheme in conjunction with static var compensators.

System disturbance control

Capacitor banks at 220 kV and above substations (generally 80 Mvar and above) will typically switch into service when the voltage falls below 92% of nominal and will switch out of service if the voltage rises to 111% of nominal.

Reactors at 220 kV and above substations (generally 50 Mvar and above) will typically switch into service when the voltage rises to 109% of nominal and will switch out of service if the voltage falls below 94% of nominal. Switching is time delayed and settings vary depending on location.

8.3. Disconnectors and Similar Equipment

The interruption capability of a disconnector is usually not defined as it is generally not a basic function of the design. An IEC standard defines one specific current switching role, which is “Bus-transfer current switching”. The voltage across the contacts also plays an important part in re-establishing the arc current at each current zero. According to IEC, a disconnector is generally able to interrupt up to 80% of the current rating provided the bus transfer voltage does not exceed 100V. However, this is reduced to only 10V in 132kV GIS. The inclusion of transformers, feeders or long bus sections in the interruption circuit creates a reasonable probability that voltages across the contacts will be significant enough to cause problems.

Due to limited capabilities, a disconnector ***shall not be used to break load*** or significant charging current unless it has been identified as being suitable for the purpose. The specific conditions under which the equipment can be used for off loading or de-energising is set out in OMs.

Except for bypass switches, generally disconnectors and similar switches shall be operated only after associated circuit breakers have been opened and checked OPEN. If there is no associated circuit breaker, or the circuit breaker is inoperable the disconnector shall not be opened or closed except when ‘Breaking parallel’ unless a specific operating instruction permits its use in these circumstances. Where remote operation of a disconnector is provided, this facility shall be used.

Avoiding automatic operation of associated circuit breakers

Where inadvertent automatic closure of a circuit breaker could cause current to flow through an associated disconnector, the automatic closure of that CB should be made non-auto before operating the disconnectors. Check auto-close, auto-changeover and auto-standby arrangements.

Note: Transmission line auto reclose is not required to be made no-auto as protection initiation will be prevented by the circuit breaker open status.

Visual checking of disconnector contact position

Unless special alternative approved procedures apply, after operating a disconnector, visual checks shall be made by the authorised person to ensure that contacts fully OPEN or CLOSED on all three phases.

8.3.1. Operation of disconnectors

The normal field switching practice is to operate a disconnector by remote operation from a substation control panel or HMI. If the remote operation fails, it could be that the facility is unserviceable or that the conditions required for operation have not been met. (e.g. the associated circuit breaker is open and interlocking arrangements exist between the disconnector and the circuit breaker.) Problems that arise with the operation shall be referred to the Controller.

In certain cases disconnectors are not provided with facilities for remote operation. Local operation is also permissible in cases where remote operation is unserviceable. 'Ready to Operate' lamps may be provided as an aid to safe operating, an unexpected indication warns that an abnormal situation may exist.

8.3.2. By-pass switches

By-pass switches may be opened or closed only after the associated circuit breaker and its isolating disconnectors have been checked closed.

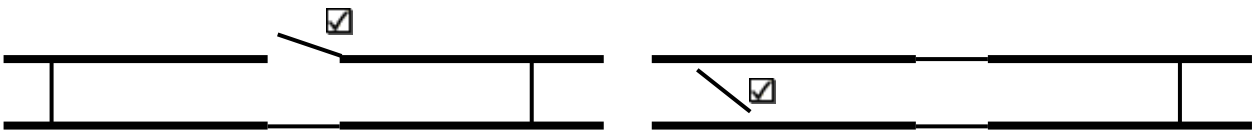
8.3.3. Bus selector disconnectors

A bus selector disconnector associated with a double selection may be opened or closed with its associated circuit breaker closed, provided the conditions in 'Breaking parallel' are met, and protection is designed to allow the transfer of supply between the busbars involved.

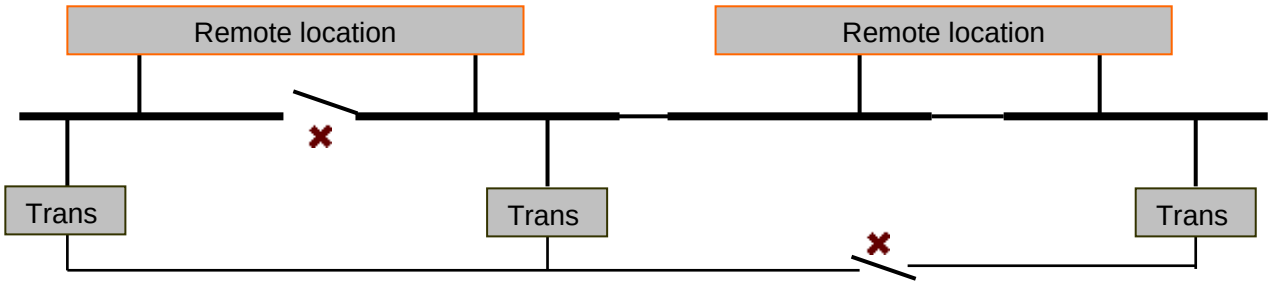
Breaking parallel

Breaking parallel means opening off one path of two or more parallel connections. Such operations shall be carried out using circuit breakers or load-breaking circuit switches whenever possible. However, a disconnector may be used to break parallel in those cases where the parallel path is effectively a short-circuit such as via busbars, bus section breakers and bus couplers ***within a switchyard***. That is, the parallel path must be of low impedance through short lengths of conductor so as to ensure there will be virtually no voltage difference across the disconnector when it is opened. Examples:

Permissible: Double bus with circuit breaker or disconnectors: One disconnector may be opened if other paths remain closed.



Not Permissible: Single bus with circuit breaker or disconnectors: One disconnector may not be opened as parallel paths through lines and transformers are of high impedance.



8.4. Earthing

Except in an emergency, earthing shall only be carried out as a step in a High Voltage Preparation and Restoration Instruction (HVPRI) or with the approval of the Controller. Unless special alternative approved procedures apply, earthing shall be carried out before work starts, immediately after the conductors have been isolated and proved de-energised.

Work on or near an earthing switch

If portable earths are to be applied to allow work on an earthing switch, the earthing switch should still be closed before application of the portable earths.

Work on a wave trap or series reactor

This apparatus has sufficiently large impedance to make earthing ineffective through the equipment. Earthing shall be applied on the side of the wave trap where work is to be carried out and on both sides if work is on the wave trap itself.

Dissipation of charge on a cable

Sufficient time must be allowed between the de-energising of the cable and the application of the earths to permit any trapped charge on the cable to be dissipated. Discharge time will vary from negligible, where cables are connected to magnetic VTs (on all phases) or power transformers at the time of de-energising, up to several hours when there is no connected equipment or where there are only CVTs.

Transmission line earthed for work in a substation

In cases where work takes place just inside the perimeter of the switchyard, field earths may need to be applied on a transmission line to provide earthing for the work. The line shall first be earthed at all points of supply as for normal field work before field earths are applied, typically at the first structure outside an electrical station.

8.4.1. Proving de-energised

Only approved devices shall be used to prove de-energised. Guidelines for operation, use, maintenance and storage of proving de-energised equipment is set out in ‘Proving HV Conductors De-energised’.

8.4.2. Portable earths

Guidelines for operation, use, maintenance and storage of portable earthing equipment is set out in 'Portable Earthing of HV Conductors'. Portable earths shall be applied and removed in sets of three. Allowable exceptions are the earthing of neutrals or star points or DC and where apparatus is connected to one phase only of a three phase supply. Portable earths shall be placed so that they will not interfere with the work and so that they will not be accidentally disturbed by the work.

8.5. Fault Earth Switches

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

8.5.1. Operating requirements for fault earth switches

Fault earth switches in service are OPEN. However, they must be capable of being actuated by protection and automatically closed, therefore whilst set and ready to operate on in service equipment, no part of a fault earth switch is to be locked.

8.5.2. Post fault checks

Before re-energising any circuit on which a fault earth switch is installed (possibly at a remote substation) it is important to establish that each fault earth switch is open. A visual inspection at site is usually required due to the lack of remote indications of fault earth switch condition. FESs are not designed for frequent operation, and can be damaged during the resetting process if the winding handle is overwound.

9. Change history

Revision no	Approved by	Amendment
0	Lionel Smyth, EGM/Network Services & Operations	• Replaces documents 'Operating Requirements – General' GD SR G2 005; and • 'Operating Requirements – Local Safety Precautions' GD SR G2 007.
1	Neil Smith, GM/System Operations	• Attachment 1 – deleted • References updated
2	Neil Smith, GM/System Operations	• Section numbering corrected
3	K McCall, Manager Health, Safety & Environment	• Revised accountability for this procedure • Added section- • Identification of persons carrying out HVPRI • HV Capacitor earthing • Deleted sections – • Logging requirements when carrying out a PRI

		• Attachment of labels and tags
4	M Gatt EGM Field Services	• All significant new additions and alterations from Revision 3 have been highlighted in this version by a vertical sidebar. Editorial changes have not been highlighted. • The following has also been altered: • Added section – “General operating principles” • Supersedes ‘Operation and Earthing of System Equipment’
5	Ken McCall, Manager/Health, Safety and Environment	• All significant new additions and alterations from Revision 4 have been highlighted in this version by a vertical sidebar. Editorial changes have not been highlighted. • The following has also been altered: • Section 3.2.5.3 - methods for isolation of VT secondaries aligned with other similar sections of the document.
6	Jeremy Roberts, Acting EM, Works Delivery	• Procedure updated to new template. • Requirements of the procedure “Use of High Voltage Preparation and Restoration Instructions” incorporated into this procedure and that procedure has been retired. • Requirements of the procedure ‘Operating Process for Access to Gas Insulated Switchgear’ have been incorporated into this procedure and that procedure has been retired. Appendices from that procedure have been added to this procedure. • Switching Focus section updated • Requirements for isolating and earthing busbar protection contributions added. • Section 2.3.4.1 removed provision to not cross off blocking step Now all blocking steps must be crossed off. • Isolation and Earthing of 415V transformer supplies added to explain how these steps are to be performed and the principles regarding them. • Additional detail of Capacitor bank earthing requirements added. • References to Standard Operating Instructions and Switching Information Manuals added.
7	Krista-Lee Fogarty, Head of HSE	• Section 2.3.3.3 Amendments to a checked HVPRI updated to included additional detail for requirements when deleting steps on a HVPRI and an example of an amended HVPRI included • Updated to new Transgrid template

10. Implementation

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

11. Monitoring and Review

The Head of 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:

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

12. Attachments

Appendix A – Typical Verbal Exchange between the controller and an Authorised Person

Appendix B – Site Specific GIS Information (Haymarket, Beaconsfield, Rookwood Rd and Holroyd)

Appendix C – Example Switching Sequences

Appendix A Typical Verbal Exchange between the controller and an Authorised Person

A typical verbal exchange between a Controller and an Authorised Person who is required to carry out a group of switching steps shall be similar in form to the following:

FROM	MESSAGE
Controller:	(Name), Controller/South speaking, on HVPRI No. 1234 for 132kV No. 2 Bus Coupler. The switching instruction shall contain six pages., Be aware that this outage will leave some customer feeders radial. Weather is expected to be fine throughout this outage. It is important that this outage is restored before 1600 hrs this afternoon due to high forecast peak demands. I am giving you clearance to carry out steps No. SE22 to No. SE31 to isolate the 132kV No. 2 bus coupler. The time for step No SE22 is 1015 hours.
Auth. person:	I confirm that I have HVPRI 1234 relating to no.2 bus coupler, which has six pages. I understand that I have clearance to proceed with HVPRI No. 1234, steps SE22 to SE31 to isolate the 132kV No. 2 Bus Coupler, at 1015 hours
Controller:	That is correct, please contact me again at step No. SE31.
Auth. person:	I expect the switching will take about half an hour to complete. Will contact you at step no. SE31
Auth. person:	Identify self and location), the 132kV No. 2 Bus Coupler is isolated only and I am advising you that I am down to step No. SE31 on HVPRI No. 1234.
Controller:	(Identify self and location) I understand that the 132kV No. 2 Bus Coupler is isolated only at (location) and that you are down to step No. SE31 on HVPRI No. 1234. The time is now 1040 hours.
Auth. person:	That is correct, 1040 hours for step No. SE31

Appendix B Site Specific GIS Switching Information

B.1 Haymarket 132kV GIS

The 132kV GIS at Haymarket is totally enclosed, three phase encapsulated SF_6 insulated with the following features:

- All High Voltage switching operations can be carried out from the substation control room as well as from the local control panels on the equipment floor. It is only necessary to go to the equipment floor for switching purposes to carry out low voltage/mechanical isolations to render equipment inoperable, to apply locks and to apply tags.
- The disconnector/earthing switches are three position switches. They are essentially a rotating switch that has the states closed / open / earthed, but they are polarised in that only one side of the switch can be earthed. The mechanical design of the switch prevents any phase being in the closed and earthed position simultaneously.
- A self-checking system is provided on the three-position switches to monitor drive motor current; if the current is outside the normal operating range, the system renders the switch inoperable and alarms the unhealthy condition. This is designed to detect mechanical problems such as failure of the drive shaft between phases that could result in (say) 2 phases being in the earthed position and 1 phase being in the closed position.
- Fault-making high speed earthing switches on all cables (line side of line disconnector only) and on all transformers (transformer side of transformer disconnector only).
- Non fault-making earthing switches in all 3-position switches and on all 132kV bus sections.
- The electrical interlock system consists of hardwiring between auxiliary contacts at the GIS and is separate from the substation control system. A mal-operation of the substation control system will not affect the GIS interlocking system.

  The interlocking is functional for both local and remote electrical operation. **Manual operation of the devices over-rides all interlocking**. Manual operation facilities are intended and designed for maintenance purposes only, after isolation and earthing has been completed. Manual operation facilities are neither intended nor designed to be used for High Voltage switching purposes.

  - The electrical interlock system incorporates the following design philosophy:
  - Earthing switch operation is inhibited unless all of the associated disconnectors are open
  - Earthing switch operation is inhibited when the equipment to be earthed is energised. For cables and bus sections three phase VT secondary voltages are used for this check.
  - Disconnector operation is inhibited when the disconnector is under load, unless there are two other local parallel circuits closed.
  - Disconnector operation is inhibited from applying an earth to an unearthed section of switchgear.
  - Circuit breaker close operation is inhibited when associated disconnectors are in transit.
  - The position of the equipment is determined by the use of auxiliary contacts connected to the operating shaft.

- Mechanical status indication is available on the front panel of all device operating mechanisms. Due to the physical arrangement of the GIS this will not be visible on all circuit breakers.
- Viewing of contact position is provided on all disconnectors and earthing switches via windows fitted to the GIS chambers using fixed or portable cameras depending on accessibility of the window. The camera view can be difficult to interpret and the ongoing reliability of the cameras and optical fibre cabling has not been warranted by the manufacturer.

- Proving de-energised facilities have been provided adjacent to all earthing switches using capacitive coupling to detect High Voltage. Due to the extremely limited accessibility of some of these points, coaxial cables have been used to provide access to them for operating purposes. The ongoing reliability of the fixed coaxial cables provided for proving de-energised equipment has not been warranted by the manufacturer.
- Explosion venting has been designed such that the GIS may be operated safely from the local control panel.

B.2 Haymarket 330kV GIS

Totally enclosed Gas Insulated Switchgear (GIS) is used at Haymarket 330/132kV Substation for 330kV transformer bays and the 330kV cable 42 to Sydney South substation.

The 330kV GIS at Haymarket is totally enclosed, single phase encapsulated SF_6 insulated with the following features:

- All High Voltage switching operations can be carried out from the substation control room as well as from the local control panels on the equipment floor. It is only necessary to go to the equipment floor for switching purposes to carry out low voltage/mechanical isolations to render equipment inoperable, to apply locks and to apply tags.
- Disconnectors and non-fault making earthing switches have a single motorised operating mechanism per three-phase set.
- High-speed fault making earthing switches have a single motorised operating mechanism per phase and may be operated individually.
- A self-checking system is provided on each disconnector and earthing switch drive, to monitor drive motor current; if the current is outside the normal operating range, the system renders the switch inoperable and alarms the unhealthy condition. This is designed to detect mechanical problems such as failure of the drive shaft between phases that could result in (say) 2 phases being in the open position and 1 phase being in the closed position.
- Fault-making high-speed earthing switches are directly connected to 42 cable and each transformer. All other earthing switches are not fault-making.
- The electrical interlocking system consists of hardwiring between auxiliary contacts at the GIS and is separate from the substation control system. A mal-operation of the substation control system will not affect the GIS interlocking system.

  The General De-Interlocking key switch at the local control panel overrides all interlocking for switchgear in that bay. Interlocking functions shall be active for all High Voltage switching purposes.

  The electrical interlocking system is functional for both local and remote electrical operation. **Manual operation of the devices overrides all interlocking**. Manual operation facilities are intended and designed for maintenance purposes only, after isolation and earthing has been completed. Manual operation facilities are neither intended nor designed to be used for High Voltage switching purposes.

  The electrical interlocking system incorporates the following design philosophy:

  - Earthing switch operation is inhibited unless all of the associated disconnectors are open, including on the 132kV side of the transformer for transformer earthing switches.
  - Disconnector operation is inhibited when the associated circuit breaker is closed.
  - Disconnector operation is inhibited from extending an earth to an unearthed section of switchgear.
  - Circuit breaker close operation is inhibited when associated disconnectors are in transit.

- The position of the equipment is determined by the use of auxiliary contacts driven by the operating shaft.

- Mechanical status indication is available at each phase of all equipment and is readily visible.
- Viewing of contact position is provided on all disconnectors and earthing switches via windows fitted to the GIS chambers using portable cameras. Viewing of the contacts using the naked eye is not recommended due to the proximity to some windows of moving, external linkages of the operating mechanism.
- There is no provision for proving de-energised on the 330kV GIS.
- The local control panels are located several metres from the switchgear.
- Explosion venting has been designed such that the GIS may be operated safely from the local control panel.

B.3 Beaconsfield South and Beaconsfield North 132kV GIS

The 132kV GIS at Beaconsfield South and Beaconsfield North substations is totally enclosed, three phase encapsulated SF_6 insulated with the following features:

- All High Voltage switching operations can be carried out from the substation control room as well as from the local control panels on the equipment floor. It is only necessary to go to the equipment floor for switching purposes to carry out low voltage/mechanical isolations to render equipment inoperable, to apply locks and to apply tags.
- The disconnector/earthing switches are three position switches. They consist of a single plunger that can only move lengthwise – one direction moving it towards the earthing position, the other direction moving it towards the isolator closed position. The mechanical design of the switch prevents any phase being in the closed and earthed position simultaneously.
- A mal-operation on the three-position switches is indicated on the control system by being in the Intermediate position. The interlocking system ensures that further operation of this equipment is not possible if it is in the intermediate position. This status indicator is available on the substation control system.
- Fault-making high speed earthing switches are on:
- all cables (line side of line disconnector only)
- all transformers (transformer side of transformer disconnector only).
- All bus section connections (bus side of isolators only)
- Non fault-making earthing switches in all 3-position switches and on all 132kV bus sections.
- The electrical interlock system consists of hardwiring between auxiliary contacts at the GIS and is separate from the substation control system. A mal-operation of the substation control system will not affect the GIS interlocking system.

  The position of the equipment is determined by the use of auxiliary contacts connected to the operating shaft.

  The interlocking is functional for both local and remote electrical operation. **Manual operation of the devices over-rides all interlocking**, blocking operation of all equipment that is dependent on its state. Manual operation facilities are intended and designed for maintenance purposes only after isolation and earthing has been completed. Manual operation facilities are neither intended nor designed to be used for High Voltage switching purposes.

The electrical interlock system incorporates the following design philosophy:

(a) For Line/Cable bays:

- Earthing switch operation is inhibited unless all of the associated disconnectors are open
- Line Earthing switch operation is inhibited when the equipment to be earthed is energised. Three phase VT secondary voltages are used for this check.
- Bus earthing switch operation is inhibited unless all sources of supply are isolated
- Circuit breaker close operation is inhibited when associated disconnectors are in transit or in an intermediate state
- Cable bay Isolators are inhibited from operation unless all bay Earth Switches are open

(b) For Bus Couplers and bus section connectors :

- Earthing switch operation is inhibited unless all of the associated disconnectors are open
- Circuit breaker close operation is inhibited when associated disconnectors are in transit or in an intermediate state.
- Cable bay Isolators are inhibited from operation unless both coupler Earth Switches are open.
  - > Mechanical status indication is available on the Local Control Cubicle. The status of all HV equipment that can be operated and the HV equipment on which its operation depends (according to the interlocks) is available from the Substation Control System.
  - > Viewing of contact position is provided on all disconnectors and earthing switches via windows fitted to the GIS chambers using portable cameras and light sources.
  - > Specific Proving de-energised facilities have not been provided. The only indicators are:
    - ○ Visual indication via the windows;
    - ○ Electrical indication at the substation level (No Volts/No Current); and
    - ○ Use of VT Secondaries and/or HVDS system where fitted.
  - > Explosion venting has been designed such that the GIS may be operated safely from the local control panel.

B.4 Holroyd 330kV GIS

Totally enclosed Gas Insulated Switchgear (GIS) is used at Holroyd 330/132kV Substation for 330kV transformer bays, the 330kV lines 1C and 1F to Sydney West substation and the 330kV Cables 43 and 44 to Rookwood Rd.

- The 330kV GIS at Holroyd is totally enclosed, single phase encapsulated SF_6 insulated with the following features:
- All High Voltage switching operations can be carried out from the substation control room as well as from the local control panels on the equipment floor. It is only necessary to go to the equipment floor for switching purposes to carry out low voltage/mechanical isolations to render equipment inoperable, to apply locks and to apply tags.
- Disconnectors and non-fault making earthing switches have a single motorised operating mechanism per three-phase set.
- High speed fault making earthing switches have a single motorised operating mechanism per three phase set.
- A self-checking system is provided on each disconnector and earthing switch drive, to monitor drive motor current; if the current is outside the normal operating range, the system renders the switch

inoperable and alarms the unhealthy condition. This is designed to detect mechanical problems such as failure of the drive shaft between phases that could result in (say) 2 phases being in the open position and 1 phase being in the closed position.

- Fault-making high-speed earthing switches are directly connected to:
  - No.1 and No.2 330/132kV transformers (ESw 5410, 5420)
  - 1F and 1C 330kV lines (ESw 1C0, 1F0)
  - 43 and 44 330kV cables (ESw 430, 440)
  - No.1 Capacitor (ESw 5710)
  - 5X1 Spare Bay (ESw 5X10)
  - Bus Sections – Earthing Switches 5110, 5120, 5130, 5140.

  All other earthing switches are not fault-making.

- The electrical interlocking system consists of hardwiring between auxiliary contacts at the GIS and is separate from the substation control system. A mal-operation of the substation control system will not affect the GIS interlocking system.

  The General De-Interlocking key switch at the local control panel overrides all interlocking for switchgear in that bay. Interlocking functions shall be active for all High Voltage switching purposes. The electrical interlocking system is functional for both local and remote electrical operation. Manual operation of the devices overrides all interlocking. Manual operation facilities are intended and designed for maintenance purposes only, after isolation and earthing has been completed. Manual operation facilities are neither intended nor designed to be used for High Voltage switching purposes. The electrical interlocking system incorporates the following design philosophy:

  - Earthing switch operation is inhibited unless all of the associated GIS disconnectors are open. This does not include the 132kV side of the transformer for transformer earthing switches.
  - Disconnector operation is inhibited when the associated circuit breaker is closed.
  - Circuit breaker close operation is inhibited when associated disconnectors are in transit.
  - The position of the equipment is determined by the use of auxiliary contacts driven by the operating shaft.

- Mechanical status indication is available on a single phase only per three phase set and is readily visible.
- Viewing of contact position is provided on all disconnectors and earthing switches via windows fitted to the GIS chambers where accessible. Viewing of the contacts using the naked eye is not recommended due to the proximity to some windows of moving, external linkages of the operating mechanism.
- There is no provision for proving de-energised on the 330kV GIS.
- The local control panels are located a few metres from the switchgear.
- Explosion venting has been designed such that the GIS may be operated safely from the local control panel.
- Local locking and tagging of a disconnector is required after opening of a disconnector and prior to closing an adjacent earthing switch.

B.5 Rookwood Rd 330kV GIS

Totally enclosed Gas Insulated Switchgear (GIS) is used at Rookwood Rd 330/132kV Substation for 330kV transformer bays, the 330kV cables 43 and 44 to Holroyd substation, and No. 4 Reactor Bay.

The 330kV GIS at Rookwood Rd is totally enclosed, single phase encapsulated SF_6 insulated with the following features:

- All High Voltage switching operations can be carried out from the substation control room as well as from the local control panels on the equipment floor. It is only necessary to go to the equipment floor for switching purposes to carry out low voltage/mechanical isolations to render equipment inoperable, to apply locks and to apply tags.
- Disconnectors and non-fault making earthing switches have a single motorised operating mechanism per three-phase set.
- High speed fault making earthing switches have a single motorised operating mechanism per three phase set.
- A self-checking system is provided on each disconnector and earthing switch drive, to monitor drive motor current; if the current is outside the normal operating range, the system renders the switch inoperable and alarms the unhealthy condition. This is designed to detect mechanical problems such as failure of the drive shaft between phases that could result in (say) 2 phases being in the open position and 1 phase being in the closed position.
- Fault-making high-speed earthing switches are directly connected to:

  - No.1, No.2 and No.3 330/132kV transformers (ESw 5410, 5420, 5430)
  - 43 and 44 330kV cables (ESw 430, 440)
  - No.4 Reactor (ESw 5940/1)
  - Bus Sections – Earthing Switches 5110, 5110/1, 5130, 5130/1.

  All other earthing switches are not fault-making.

- The electrical interlocking system consists of hardwiring between auxiliary contacts at the GIS and is separate from the substation control system. A mal-operation of the substation control system will not affect the GIS interlocking system.

  The General De-Interlocking key switch at the local control panel overrides all interlocking for switchgear in that bay. Interlocking functions shall be active for all High Voltage switching purposes. The electrical interlocking system is functional for both local and remote electrical operation**. Manual operation of the devices overrides all interlocking**. Manual operation facilities are intended and designed for maintenance purposes only, after isolation and earthing has been completed. Manual operation facilities are neither intended nor designed to be used for High Voltage switching purposes. The electrical interlocking system incorporates the following design philosophy:

  - Earthing switch operation is inhibited unless all of the associated GIS disconnectors are open. This does not include the 132kV side of the transformer for transformer earthing switches.
  - Disconnector operation is inhibited when the associated circuit breaker is closed.
  - Circuit breaker close operation is inhibited when associated disconnectors are in transit.
  - The position of the equipment is determined by the use of auxiliary contacts driven by the operating shaft.

- Mechanical status indication is available on a single phase only per three phase set and is readily visible.
- Viewing of contact position is provided on all disconnectors and earthing switches via windows fitted to the GIS chambers where accessible. Viewing of the contacts using the naked eye is not recommended due to the proximity to some windows of moving, external linkages of the operating mechanism.
- There is no provision for proving de-energised on the 330kV GIS.
- The local control panels are located a few metres from the switchgear.
- Explosion venting has been designed such that the GIS may be operated safely from the local control panel.

- Local locking and tagging of a disconnector is required after opening of a disconnector and prior to closing an adjacent earthing switch.

B.6 Rookwood Rd 132kV GIS

The 132kV GIS at Rookwood Rd substation is totally enclosed, three phase encapsulated SF_6 insulated with the following features:

- All High Voltage switching operations can be carried out from the substation control room as well as from the local control panels on the equipment floor. It is only necessary to go to the equipment floor for switching purposes to carry out low voltage/mechanical isolations to render equipment inoperable, to apply locks and to apply tags.
- The disconnector/earthing switches are three position switches. They consist of a single plunger that can only move lengthwise – one direction moving it towards the earthing position, the other direction moving it towards the isolator closed position. The mechanical design of the switch prevents any phase being in the closed and earthed position simultaneously.
- A mal-operation on the three-position switches is indicated on the control system by being in the Intermediate position. The interlocking system ensures that further operation of this equipment is not possible if it is in the intermediate position. This status indicator is available on the substation control system.
- Fault-making high speed earthing switches are on:
  - all lines, cables and reactor bays (line side of line disconnector only)
  - all transformers (transformer side of transformer disconnector only).
  - All bus section connections (ESw 4110, 4110/2, 4120, 4120/2, 4130, 4130/2). They are not 3 position switches.
- All other Earthing Switches are not fault-making earthing switches.
- The electrical interlock system consists of hardwiring between auxiliary contacts at the GIS and is separate from the substation control system. A mal-operation of the substation control system will not affect the GIS interlocking system.

  The position of the equipment is determined by the use of auxiliary contacts connected to the operating shaft.

  The interlocking is functional for both local and remote electrical operation. Manual operation of the devices over-rides all interlocking, blocking operation of all equipment that is dependent on its state. Manual operation facilities are intended and designed for maintenance purposes only after isolation and earthing has been completed. Manual operation facilities are neither intended nor designed to be used for High Voltage switching purposes.

  The Interlocking system prevents the simultaneous operation of apparatus, and will block the operation of other HV equipment if the status of any monitored HV equipment is in an intermediate position.

  The electrical interlock system incorporates the following design philosophy:

(a) For Transformer bays:

- Transformer Earthing switch operation is inhibited when the transformer is not isolated on the 132kV and 330kV side.

(b) For Line bays:

- Earthing switch operation is inhibited unless all of the adjacent disconnectors are open
- Bus earthing switch operation is inhibited unless all sources of supply are isolated
- Circuit breaker close operation is inhibited when associated disconnectors are in transit or in an intermediate state

(c) For Bus Couplers:

- Earthing switch operation is inhibited unless all of the associated disconnectors are open
- Circuit breaker close operation is inhibited when associated disconnectors are in transit or in an intermediate state.
- Line bay Isolators are inhibited from operation unless both coupler Earth Switches are open.

- Mechanical status indication is available on all CB's, Disconnectors and earthing switches. The status of all HV equipment that can be operated and the HV equipment on which its operation depends (according to the interlocks) is available from the Substation Control System.
- Viewing of contact position is provided on all disconnectors and earthing switches via windows fitted to the GIS chambers using portable cameras and light sources.
- Specific Proving de-energised facilities have not been provided. The only indicators are:

  - Visual indication via the windows;
  - Electrical indication at the substation level (No Volts/No Current); and
  - Use of VT Secondaries and/or HVDS system where fitted.

- Explosion venting has been designed such that the GIS may be operated safely from the local control panel.

Appendix C Example Switching Sequences

C.1 Haymarket 132kV GIS - Feeder Bay Equipment Only (9SC feeder)

Refer to Haymarket HVOD diagram HYM 809067.

The following switching sequence is an example that applies the principles for isolation and earthing when using remote or local operation of switchgear. Manual operation is prohibited.

It is assumed that the feeder and both bus sections will remain energised during an outage of the bay equipment.

Note that there are no integral earthing and short-circuiting equipment with adequate fault making capacity within the area to be isolated so the requirements of Sections 4.3.2 and 4.4.2 apply.

All local and remote operations are common except those specifically stated as “Local Operation” or “Remote Operation”.

Switching to Isolate and Earth

Operative step	Operating function	Secondary action and explanation
	OFF-LOAD 9SC	
Open CB 9SC2		Use CB status indication
	ISOLATE AND EARTH	
Open Disc 9SC5		**Local Operation** : Ensure visible break exists **Remote Operation** : Use disconnector status indication to check change of status
Open Disc 9SC6		**Local Operation** : Ensure visible break exists **Remote Operation** : Use disconnector status indication to check change of status
Open Disc 9SC1		**Local Operation** : Ensure visible break exists **Remote Operation** : Use disconnector status indication to check change of status
	Check open CB 9SC2	Use CB status indication
Close E/S 9SC0/2	(Note 1)	Use earthing switch status indication to check change of status
Close CB 9SC2	(Note 2)	Use CB status indication to check change of status
Close E/S 9SC0/A3	(Note 3)	Use earthing switch status indication to check change of status
Close E/S 9SC0/B3	(Note 3)	Use earthing switch status indication to check change of status
	Normal condition on completion of PRI	
All three isolation points are now considered confirmed and earths have been applied		

Notes:

(a) Earthing switch 9SC0/2 may be closed because the HV conductors are indicated as de- energised from the:

- busbars by bus disconnector indication (or visible break if operating locally), and
- cable by cable disconnector indication (or visible break if operating locally).

Following closure of this earthing switch, earths are considered to have been applied to the conductors between the line disconnector and the circuit breaker. If the line disconnector had not opened successfully the interlocking would have prevented the earths from being applied. The mechanical design of the 3-position switch prevents any one phase from being in the closed and earthed positions simultaneously.

(b) Closing circuit breaker 9SC2 extends the earths from E/S 9SC0/2 up to the isolation points at 9SC5 and 9SC6. This confirms that bus disconnectors 9SC5 and 9SC6 are open on the conductors that 9SC0/2 has earthed. The isolation points 9SC5 and 9SC6 are now considered confirmed.

(c) Either earthing switch 9SC0/A3 or 9SC0/B3 may be closed because the open conditions of 9SC6 and 9SC5 have already been confirmed (de-energised from the busbars) and Disc 9SC1 is indicated as open (de-energised from the cable).

Secure the Isolation and Earthing This is to be done on the switchgear level by securing the three position switches 9SC1, 9SC5 and 96C6 in their open positions and securing earthing switches 9SC0/2, 9SC0/A3 and 9SC0/B3 in their closed positions

Access to three position switches 9SC1, 9SC5 and 9SC6 is not provided in the above switching sequence and therefore the manual operation of the switches is not available and the locks provided on the manual operation points shall remain intact with appropriate tags applied. Electrical operation of all 3-position switches shall be disabled in the local control cubicle by the opening of links and application of tags.

Prepare the Area for Access Authority Issue

If earths are required to be removed to enable testing of the above equipment, high voltage access to the 3-position switch will need to be requested or (and more likely) the external earth connections to the GIS may be removed. These shall only be removed under testing high voltage access conditions.

C.2 Haymarket 132kV GIS - Feeder Only (9SC feeder)

Refer to Haymarket HVOD diagram HYM 809067.

The following switching sequence is an example that applies the principles for isolation and earthing when using remote or local operation of switchgear.

This switching sequence assumes that the feeder will be offloaded by Transgrid, isolated at the remote end by AusGrid, then isolated and earthed by Transgrid and finally earthed by AusGrid.

Note: All checks of isolation shall be performed using ALL three phases.

All local and remote operations are common except those specifically stated as “Local Operation” or “Remote Operation”

Switching to Isolate and Earth

Operative step	Operating function	Secondary action and explanation
	OFF-LOAD 9SC	
Open CB 9SC2		Use CB status and current indications to ensure off-load
Request AusGrid to Isolate 9SC feeder within their system	AusGrid are required to isolate the transmission line from all sources of supply within their system using a procedure acceptable to Transgrid.	
Receive clearance from AusGrid that 9SC feeder is isolated within their system		
	ISOLATE AND EARTH	
Open Disc 9SC1	(Note 1)	**Local Operation** : Ensure visible break exists **Remote Operation** : Use disconnector status indication to check change of status
	Check feeder de-energised	Use feeder voltage indication
Open CB 9SC2	(Note 2)	Use CB status indication to check change of status
Close E/S 9SC0	(Note 3)	Use earthing switch status indication to check change of status

NOTES:

(a) The effectiveness of the 9SC1 point of isolation is confirmed by:

- The switch position indication (or visible break if operating locally),

(b) Circuit breaker 9SC2 may be left in either the open or closed position as far as this procedure is concerned.

(c) Earthing switch 9SC0 is an integral earthing and short-circuiting device with adequate fault making capacity. Earthing switch 9SC0 may be closed because the HV conductors are indicated as de-energised from the:

- Busbars by disconnector indication or visible break; and
- Transmission line by the isolation clearance from AusGrid

Secure the Isolation and Earthing This is to be done on the switchgear level by securing the three position switch 9SC1 in the open position, securing earthing switch 9SC0 in the closed position and isolating the feeder CVT.

Access to three position switch 9SC1 is not provided in the above switching sequence and therefore the manual operation of the switch is not available and the locks provided at the manual operation point shall remain intact with appropriate tags applied. Electrical operation of the 3-position switch and earthing switch shall be disabled in the local control cubicle by the opening of links and application of tags.

Advise AusGrid that the transmission line is isolated and earthed.

This switching sequence only provides access to the transmission line, if access is required to the Transgrid bay equipment further isolation and earthing steps will be required.

C.3 Haymarket 330kV GIS - Bay Equipment Only (CB 5412A)

Refer to Haymarket HVOD diagram HYM 809067.

The following switching sequence is an example that applies the principles for isolation and earthing when using remote or local operation of switchgear. All checks of isolation shall be performed using ALL three phases.

This example assumes that the No.1 and No.3 transformers will remain energised during an outage of the bay equipment.

All local and remote operations are common except those specifically stated as “Local Operation” or “Remote Operation”

Switching to Isolate and Earth

Operative step	Operating function	Secondary action and explanation
	OFF-LOAD CB5412A BAY	
Open CB 5412A		Use CB status + current indications to ensure off-load
	ISOLATE AND EARTH	
Open Disc 5417	(Note 1)	**Local Operation** : Ensure visible break exists **Remote Operation** : Use disconnector status indication to check change of status
Open Disc 5437		**Local Operation** : Ensure visible break exists **Remote Operation** : Use disconnector status indication to check change of status
Close E/S 5410/A2	(Note 2)	Use earthing switch status indication to check change to closed status
Close E/S 5410/A3		Use earthing switch status indication to check change to closed status

NOTES:

(a) The effectiveness of the 5417 and 5437 points of isolation are confirmed by:

- The switch position indication (or visible break if operating locally),

(b) Earthing switches 5410/A2 and 5410/A3 are integral earthing and short-circuiting devices with adequate fault making capacity. Earthing switch 5410/A2 may be closed because the HV conductors are indicated as de-energised from:

- No.3 Tx by disconnector indication or visible break, and
- No.1 Tx by disconnector indication or visible break.

Secure the Isolation and Earthing This is to be done on the switchgear level by securing the disconnectors 5417 and 5437 in their open positions and securing earthing switches 5410/A2 and 5410/A3 in their closed positions.