Operation and Earthing of System Equipment

Summary:

This document supports the Power System Safety Rules and its requirements assembled under:

- Operate HV AIS Switchgear – Category 5.5;
- Operate HV GIS Switchgear – Category 5.6;
- Issue a Field Access Authority – Category 6.4; and
- Operate HV AIS Switchgear for work on or near Overhead Lines – Category 6.5.

It applies to the operation and earthing of High Voltage switchgear under the direction of the Controller.

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When referring to TransGrid's policies, frameworks, procedures or work instructions, please use the latest version published on the intranet.

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1. Overview

1.1. Purpose

This document provides instructions for operating, isolating and earthing High Voltage apparatus in accordance with the Power System Safety Rules – Categories 5.5, 5.6, 6.4, and 6.5.

1.2. Policy Base

Document no	Document
GD SR G1 100	Power System Safety Rules

1.3. Reference Documents

Document no	Document
GD SR G2 150	Operating Process for Access to High Voltage Apparatus
GD SR G2 190	Operating Process for Access to Gas Insulated Switchgear
GD SR G4 154	Portable Earthing of High Voltage Conductors
GD SR G4 155	High Voltage Operating Rods
GD SR G4 153	Proving High Voltage Equipment De-energised
GD SR G2 010	Use of High Voltage Preparation and Restoration Instructions

1.4. Scope

This document applies to the

1.5. Accountability

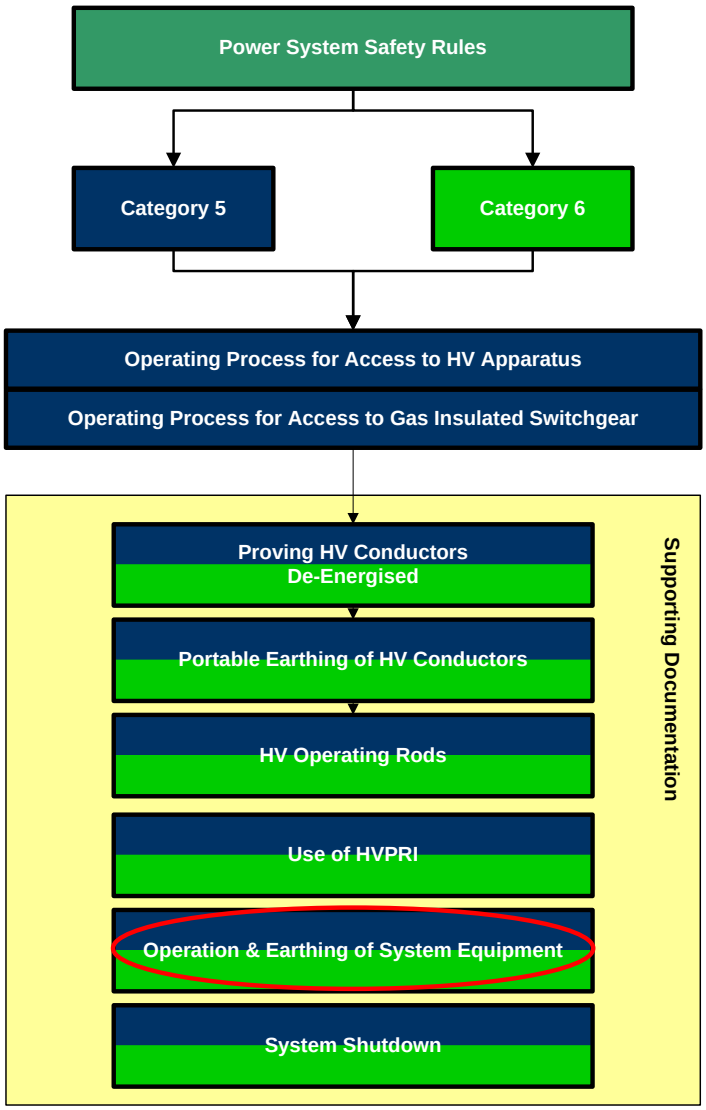
Responsible person	Responsibility
GM – System Operations	Maintenance and ownership of this standard
Mgr – Training	Implementation of training programs associated with this standard
Authorised persons	Comply with this standard

1.6. Implementation

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

1.7. Document Location

Block diagram showing location of document in relation to others.



2. Operating, isolating and earthing High Voltage apparatus

This document supports the Power System Safety Rules and its requirements assembled under:

- Operate HV AIS Switchgear – Category 5.5;
- Operate HV GIS Switchgear – Category 5.6;
- Issue a Field Access Authority – Category 6.4; and
- Operate HV AIS Switchgear for work on or near Overhead Lines – Category 6.5.

It applies to the operation and earthing of High Voltage switchgear under the direction of the Controller.

For some apparatus (e.g. GIS at Haymarket), there may be equipment specific procedures that must be followed when operating or earthing the apparatus. When such procedures exist, they take precedence over these general principles. Refer to 'Operating Process for Access to Gas Insulated Switchgear'.

2.1. 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.

2.1.1. 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:

2.1.1.1. 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) If available, warn all staff in the vicinity of the CB by sounding the alarm hooter.

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

(e) 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.

(f) 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.

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

2.1.1.2. 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.

Note: 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.

Note: Synchronising is normally auto except in power stations.

d) If available, warn all staff in the vicinity of the CB by sounding the alarm hooter.

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

f) 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.

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

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

i) Auto reclose/auto standby is made auto;

j) Automatic control of capacitors or reactors (e.g. by time switch, voltage etc) is made auto;

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

l) 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.

2.1.2. General limitations - Circuit breakers

2.1.2.1. Current rating

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

2.1.2.2. 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/System Operations subject to advice from Manager/Asset Performance (refer OMs 651 & 684). 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.

2.1.2.3. 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

Note: 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.

Some recognised limitations are set out in the following table:

Manufacturer	System Voltage kV	Operating Mechanism	Limitations - Trip Ops/Hour
Merlin Gerin	500	Hydraulic	12
Alstom	500	Hydraulic	8
Merlin Gerin	132	Air	4 (where resistors are fitted)
Sprecher & Schuh	66	Spring	4 (note 1)

Note 1: To avoid overheating the breaking resistors during on-load trip checks these CBs should not be tripped at intervals of less than 15 minutes.

- **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.

Manufacturer	System Voltage KV	Operating Mechanism	Interrupter Medium
ABB	330	Spring	SF6
GEC/ Alstom	330	Spring	SF6
Siemens	330	Hydraulic	SF6
M&G	330	Hydraulic	SF6
ABB	132	Spring	SF6
ASEA	132	Spring	Small oil volume
Brown Boveri	132	Double Pressure	SF6
GEC/ Alstom	132	Spring	SF6
M&G	132	Hydraulic	SF6
Oerlikon	132	Hydraulic	Small oil volume
ABB	66	Spring	SF6
Schneider	33	Spring	SF6

2.1.2.4. 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.

2.2. High Voltage Capacitors And Reactors

2.2.1. 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 and the star point(s) are generally not connected to earth.

2.2.1.1. 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.

2.2.1.2. 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; and,
- earthing is not to commence for at least ten minutes after de-energising to ensure safe conditions. This is because equipment for proving de-energised will not indicate the presence of any residual HV DC charge.

2.2.1.3. Earthing capacitors

After having been proved de-energised, the capacitor must be earthed as set out below. 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 the earth's and apply the same procedure to each section if the star points are not connected. Earthing steps shall be included in the PRI and any difference between the site conditions and the PRI steps shall be referred to the Controller for rectification before proceeding.

1. The capacitor bank should be earthed by operation of an earthing switch where an earthing switch is provided;
2. When applying portable earths, the cables and exposed metallic parts of the earth's should be kept well clear of the operator's body;
3. 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;
4. Whilst there is work on capacitors or associated circuits, the equipment should be continuously earthed. However, if the work requires removal of the earthing, this must not be done until at least ten minutes after the initial application. The earthing should be restored as soon as practicable and retained until the work has been completed; and
5. Where work requires the disconnection of individual cans, it is the responsibility of the work team to short circuit the terminals of these cans before disconnection.

2.2.2. 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.

2.2.3. 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.

2.2.3.1. 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.

2.2.3.2. Time switch control

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

2.2.3.3. 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.

2.2.3.4. 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.

2.3. Disconnectors and Similar Equipment

2.3.1. Operating requirements for disconnectors

The sequences to be followed when opening and closing disconnectors are set out in 'Operating Process for Access to High Voltage Apparatus'**.** This section summarises suitable procedures to comply with this procedure and the Rules.

2.3.1.1. Preparation and Restoration Instructions

HV PRIs shall be written so that the following requirements are met:

- Where remote operation of a disconnector is provided, this facility shall be used.
- Except for bypass switches, generally disconnectors and similar switches shall be operated only after associated circuit breakers have been opened and checked OPEN. Where there are individual CB poles or separate phase indications, check all phases OPEN.
- If there is no associated circuit breaker, the disconnector shall not be opened or closed except when breaking parallel unless a specific operating instruction permits its use in these circumstances.

2.3.1.2. 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 non-auto as protection initiation will be prevented by the circuit breaker open status.*

2.3.1.3. Visual checking of disconnector contact position

Unless special alternative approved procedures apply, after closing a disconnector by remote control, visual checks shall be made by the person carrying out the switching to ensure that contacts are secured by contact pressure or drive tension and arms are fully home on all three phases.

2.3.1.4. Ready To Operate Lamps and interlocks

'Ready to Operate' lamps are provided as an aid to safe operating. An unexpected indication warns the operator that an abnormal situation may exist.

2.3.2. Remote operation of disconnectors

The normal field switching practice is to operate a disconnector by remote operation from a substation control panel or HMI. Problems that arise with the operation need to be referred to the Controller.

If the remote operation fails, it could be that the facility is faulty 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.)

2.3.3. Local operation of disconnectors

In certain cases disconnectors are not provided with facilities for remote operation. Local operation is also permissible in cases where remote operation is unserviceable.

2.3.3.1. Manual Operation

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, followed by a visual check that the switch is, respectively, fully open or closed on all three phases. 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.

For best ergonomic advantage during manual operation:

- Operating handles that have a horizontal sweep motion should be pushed through their travel, not pulled;
- An open stance is suitable when operating vertical swing motion handles, which often require significant force by the operator to ensure full travel, particularly where a counterweight is fitted on the disconnector arm.

2.3.4. 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.

2.3.5. 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.

2.3.6. Locking of disconnectors and similar equipment

Where practicable, disconnectors or isolation devices shall be locked when used to provide visible breaks or to provide earthing continuity. Locking shall be with an operating padlock and shall be included as a step in the HVPRI.

In addition, when motor operated disconnectors or isolation devices can be operated from local or remote control points, each device shall be isolated from its operating supply source and Do Not Operate Tags 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 the local requirements.*** To achieve these requirements:

- the motor fuses and contactor lock-up link withdrawn;
- the control shall be placed in hand operating position;
- the door of the cabinet locked and Danger Tagged; and
- the drive shaft shall be locked and Danger Tagged.

NOTE: *Specific requirements will vary because of different disconnector designs, but the same outcomes must be achieved.*

If a disconnector must remain open to avoid a condition that is particularly dangerous and likely to cause a risk to system security or damage to system apparatus, then the switch must be locked open. If such a condition is long term and not part of a PRI, the status shall be shown on the relevant operating diagram.

2.3.7. General limitations – 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.

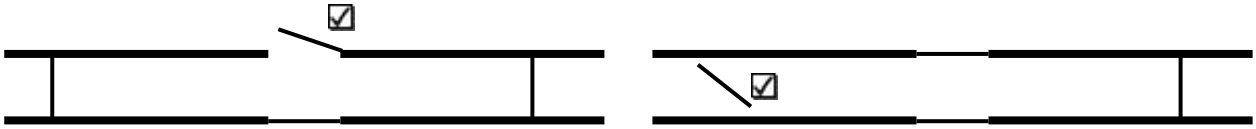
Because of the limited capabilities, a disconnector ***shall not be used to break load*** or significant charging current unless it has been identified as being suitable for the purpose. The specific conditions under which the equipment can be used for off loading or de-energising is be set out in substation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

2.3.7.1. Breaking parallel

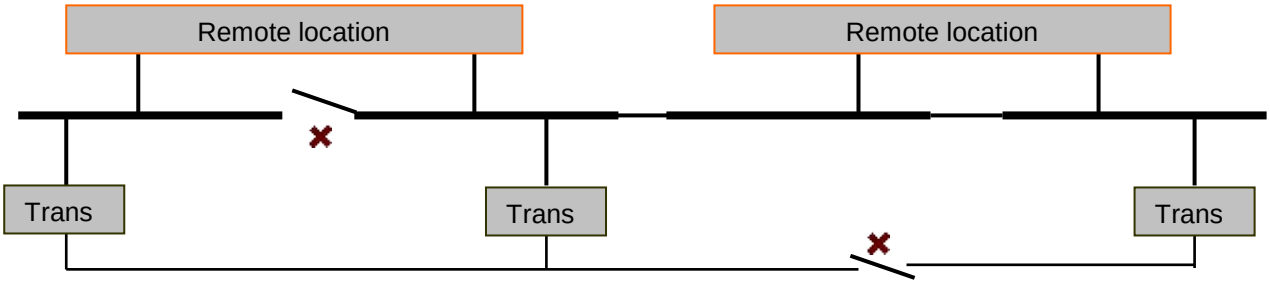
Breaking parallel means opening off one path of two or more parallel connections. Such operations shall be carried out using circuit breakers or load-breaking circuit switches whenever possible. However, a disconnector may be used to break parallel in those cases where the parallel path is effectively 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.



2.4. Earthing

This section sets out procedures for the earthing of high voltage conductors to comply with the Power System Safety Rules.

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.

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.

2.4.1. Operating requirements for earthing switches

The sequences to be followed when opening and closing earthing switches are set out in 'Operating Process for Access to High Voltage Apparatus'. This section summarises suitable procedures to comply with this procedure and the Rules.

The person carrying out the operation shall stand on the operator mat provided and not watch the contacts while the switch is operated because there may be a high intensity flash.

The manual opening or closing operation of an earthing switch shall be carried out in one complete and continuous movement, followed by a visual check that the switch is, respectively, fully open or closed on all three phases. The switch shall then be secured against movement caused by wind, vibration or magnetic forces etc., by inserting the holding bolt in the operating handle.

For best ergonomic advantage during manual operation:

- Operating handles that have a horizontal sweep motion should be pushed through their travel, not pulled;
- An open stance should be applied to operating handles that have a vertical swing motion, as where a counterweight is fitted on the disconnector arm, these often require significant force by the operator to ensure full travel.

2.4.2. Operating requirements for portable earths

Guidelines for operation, use, maintenance and storage of portable earthing equipment is set out in 'Portable Earthing of High Voltage Conductors'. This section summarises suitable procedures to comply with this procedure and the Rules.

2.4.2.1. Connection points for portable earths

Connection at the earth end point shall be performed prior to any connection to a conductor. Earth leads shall not to be lengthened by a clamp to clamp connection but may be joined using hardware as described in 'Portable Earthing of High Voltage Conductors'. Earthing equipment clamps are to be tightened so that they will not become dislodged during work. In addition:

- Earthing stubs shall be used for all earth end connections within Switchyards.
- For steel tower earthing, the tower itself is used as the earth point. CATU MT-847 surface penetrating clamps shall be used on painted or galvanised surfaces.
- Pole earthing involves the use of both the pole earth and an independent temporary earth electrode (earth stake).

2.4.2.2. Sets of three portable earths

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.

2.4.2.3. 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 High Voltage Equipment De-energised'.

Unless special alternative approved procedures apply, conductors must be proved de-energised at the intended point of application of the earthing equipment, immediately before the application of the portable earths, even though the conductors may have been proved de-energised previously at the same or other locations. Earthing shall be carried out immediately after proving the point de-energised and at that exact point.

If, for any reason, it is necessary for the authorised person to leave the point before earthing has been completed, on return, ***the point must be proved de-energised again before completing the earthing.***

2.4.3. Earthing of HV conductors in substations

2.4.3.1. Work on or near an earthing switch

Where there is a danger that the electrical contacts of an earthing switch could be accidentally disturbed during the course of work the earthing switch cannot be used as an earth for the work and an alternative earth shall be provided.

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.

2.4.3.2. Work on a wave trap

A wave trap (also referred to as a line trap) has sufficiently large impedance to make earthing ineffective through the equipment. Thus, 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. If it is impractical to apply earthing within the station on the line side of the line trap, then field earths shall be placed on the transmission line conductors at the first structure out from the station.

2.4.3.3. Work on a series reactor

A series reactor has sufficiently large impedance to make earthing ineffective through the equipment. Thus, earthing shall be applied on the side of the reactor where work is to be carried out and on both sides if work is on the reactor itself.

2.4.4. Earthing of HV transmission lines or cables

Before work is carried out on a transmission line or cable, earthing shall be applied at each location from which the HV conductors of a transmission line or cable could be connected to a source of electrical supply.

In cases where the operating of another organisation's equipment could energise TransGrid equipment, assurance that the other organisation's equipment has been isolated and earthed is to be obtained from that organisation's Controller. Where the organisation does not have a Controller on continuous duty, a written clearance shall be obtained from the organisation by use of a High Voltage Equipment Outage form (Refer OM 953).

2.4.4.1. Dissipation of charge on a cable

To avoid damage to equipment it is essential that high voltage cables are not discharged through earthing devices. Particularly in relation to 132 kV and 330 kV cable circuits, 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. Before earthing a cable circuit, reference should be made to the appropriate Operating Manual for special requirements applicable to the cable circuit in question.

2.4.4.2. 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.

2.4.4.3. Transmission line earthing

The line shall first be isolated and earthed at all points of supply before field earths are applied; refer to Rules 6.4, 6.5 and 'Portable Earthing of High Voltage Conductors'.

2.5. Fault Earth Switches

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

2.5.1. 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.

2.5.2. 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.

2.5.3. Fault earth switch under Access Authority conditions

2.5.3.1. Excluding fault earth switch from working area

Provided safe working conditions can be provided, fault earth switches should be kept out of the designated work area (DWA) whenever work is not required on the fault earth switch itself.

2.5.3.2. Fault earth switch is in working area, but operation not required during work

i) A fault earth switch must be discharged (closed) whenever it is included inside a DWA. The fault earth switch cabinet door shall then be closed and a Do Not Operate Tag applied to its handle.

ii) Closing of a fault earth switch to give safe working conditions and the subsequent opening (resetting) shall both be recorded as steps in an HVPRI.

2.5.3.3. Fault earth switch is in working area, operational checks required

When work on a fault earth switch is to be carried out under Access Authority conditions including operational checks then:

i) the fault earth switch shall be discharged and its cabinet door closed;

ii) the associated DC trip (closing) coil isolating link shall be opened. This link is normally located on the fault earth switch panel in the relay room;

iii) Warning Tags shall be applied to the trip link and the cabinet door handle;

iv) Records of the operation of the fault earth switch and the closing coil isolating link shall be included as steps on the HVPRI.

3. Attachments

Nil

4. Definitions

Nil

5. Change history

Revision no	Approved by	Amendment
1	GM/System Operations 8/8/2008	• Updated to reflect changes in Safety Rules nomenclature.
2	Neil Smith, GM/System Operations 3/9/2013	• Updated to reflect Power System Safety Rules v5.1 • References updated • All sections revised • Deleted duplications contained in other documents
3	Neil Smith, GM/System Operations 7/11/2014	• Capacitor unit discharge time revised to 10 minutes (IEC60871-1)

6. Monitoring and Review

The General Manager/Systems Operations 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.