

Facilities, Residential and Commercial Services

High Voltage Switching and Earthing Guidance

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1. Introduction

The University owns and operates a large, complex high voltage electricity distribution system which, from time to time, requires switching to be carried out to allow work to be carried out safely. This document details the procedures which must be adopted to ensure that any switching is carried out in a controlled and consistent manner whilst limiting risk to all persons involved.

2. Scope

This document applies to all staff and contractors carrying out Switching in accordance with the current HV Safety Rules (Standard Operating Procedure (SOP)) on the University High Voltage System.

3. Definitions

The definitions for words used in this document are to be found in Section 3 of the Electrical Safety Rules for High Voltage Systems (SOP).

4. General Requirements

4.1 All operations shall be undertaken in accordance with the current University of Liverpool Electrical Safety Rules for High Voltage Systems.

4.2 The operation of any switchgear shall always take into account its capability/operational classification and any applicable operational restrictions.

4.3 Staff authorised for HV Switching shall ensure that they have available any applicable operational restrictions.

4.4 Equipment on which switching is to be carried out must be readily identifiable or have fixed to it a means of identification which will remain effective throughout the course of the switching operations. This means of identification shall include the substation number & building name.

4.5 When equipment which is in service, is showing signs of distress, it must not be operated. The Designated Person shall be informed as soon as reasonably practicable and any automatic feature should be rendered in-operative. All persons must be kept clear of such equipment and switching should be effected as soon as possible such that the equipment concerned will be removed from service without being subject to further operations.

4.7 Before operating switchgear, the operator should ensure familiarity with the function of the selectors and interlocking facilities which are designed to limit the extent of switching operations and prevent the removal of access covers and inadvertent opening of shutters. The operator should plan the sequence of operations prior to taking any action. It should not be assumed that interlocks are infallible or comprehensive since there are variations in the levels of protection provided.

4.8 Before returning to service any equipment on which work or testing has been carried out, the person responsible for restoring the equipment to service must confirm with the relevant Authorised Person, the operational state of the equipment.

4.9 No high voltage oil circuit breaker shall be isolated within a period of ten minutes after it has operated under fault conditions. This precaution is necessary to allow sufficient time for any internal gases generated within the switchgear to escape to the atmosphere.

5. First aid and personal protective equipment

5.1 All persons who carry out high voltage switching shall:

- Have received basic first aid training within the last 3 years
- Have available an approved first aid kit
- Wear and make use of the appropriate PPE.

5.2 All persons whilst engaged in high voltage switching when entering a substation shall wear as a minimum: -

- A flame retardant coverall to arc retardant overall with a minimum Arc retardant coverall with minimum rating 10.5CAL/CM².
- Safety footwear.

5.3 When operating switchgear at locations where danger may arise from adjacent activity e.g. construction sites, head protection shall be worn and a comprehensive risk assessment to take into account both the inherent and general dangers.

5.4 Operators should carry out a risk assessment on the need to wear eye protection when operating switchgear.

6. Dependant manual and independent manual switchgear.

6.1 Any person required to operate dependant manual switchgear shall have received training for this category of switchgear.

6.2 The introduction of independent manual closing mechanisms does not mean that dependent manual equipment is no longer suitable. Dependent manual equipment is suitable when:

- The unit is operated within its rated making capacity
- The operator carries out the operation without hesitation and as rapidly as possible (thus ensuring the contacts close quickly and are fully closed. Particularly over the latter portion of the closing operation. In addition, should a lever/handle be closed onto a system fault, the force needed is significantly greater than when closed onto normal system load current. In some cases it may be physically impossible to close (or open) the device under fault conditions which may result in failure. It is important that the following guidance is deployed when operating Dependent Manually Operated (DMO) Switchgear.

- All operation and maintenance of DMO switchgear should be restricted to those personnel trained in the operation of the switchgear concerned.

- They should be aware of the dangers of operating the equipment incorrectly, the construction of the switchgear and the manufacturer's maintenance requirements.
- It is essential that the actions listed to allow the continued use of DMO switchgear be treated as a short term measure only.
A phased replacement programme should be prepared and implemented for all DMO switchgear manufactured prior to 1960.).

6.3 An operator should approach the hand closing of all switchgear with the determination that he will fully close it in a decisive manner. All closing operations should be carried out with the same determination irrespective of switchgear type, or, whether or not a fault is suspected on that part of the system being energised. Once commenced, the operation must be carried through to completion. When DMO switchgear is to be closed, the preferred method of operation is as follows (in order to achieve this preferred method of operation it may be necessary to change system running conditions and adjust the electrical protection accordingly):

- Make the system dead upstream using a suitably rated independent operated switch or circuit breaker;
- Check, where practicable, the system beyond the DMO switchgear to ensure that it is fault free.
- If the system is healthy, close the DMO switchgear to ON; and

Energise the system from the remote point, ensuring that no personnel are in the vicinity of the DMO switchgear.

6.4 Similarly, an operator should approach the hand opening of all switchgear with the determination that he will fully open it in a decisive manner. All opening operations should be carried out with the same determination irrespective of switchgear type. Once commenced, the operation must be carried through to completion.

7. Reverse operation delay facilities

7.1 During certain operations such as fault switching, a switch may be closed causing fault current to flow. This action does not in itself put the operator at risk, provided the fault current is allowed to continue until interrupted by the appropriate 'up-stream' fault breaking/ protective device.

7.2 Where during 'fault sectionalising' the fault position happens to be close to the operator, or, the operation was inadvertent, the natural reaction is to reverse the process which caused the fault current to flow. This action can have very serious consequences where the device being operated does not have a fault breaking capability.

7.3 The consequences of rapid reverse operation can be avoided by the use of a delay feature (3 second delay handle), which ensures that the operator has sufficient time to contemplate his actions and for protection to trip the controlling circuit breaker to clear the fault before he can reverse the initial operation.

7.4 No switch, capable of operation with a reverse operation delay handle, shall be operated whilst live by any other means.

8. Preparation for switching

8.1 Before switching instructions are issued by an Authorised Person, they must be recorded giving the name of the location (including voltage, if appropriate) at which the switching is to be carried out, the identification and nomenclature of the equipment involved and details of the intended operation.

8.2 The Authorised Person who is to issue the switching instruction must take account of all the likely consequences of the proposed operations.

8.3 The normal sequence of instructions shall be such that all the switching causing the equipment to be isolated from all points of supply is confirmed as having been completed before the Authorised Person issues any earthing instructions.

9. Switching

9.1 The operator should carry the switching schedule with them to the point at which the switching is to be carried out.

9.2 The operator must ensure that his full concentration is maintained during switching operations and that positive efforts are taken to minimise distraction during these operations.

9.3 Telephone communications whilst switching are not permitted unless directly associated with the operations being undertaken.

9.4 When carrying out switching instructions, the Authorised Person should observe the following requirements: -

9.5.1 Be deliberate, neither rushing nor causing undue delay and taking nothing for granted.

9.5.2 Have with him the written instruction, consulting it and checking that he is about to operate the correct equipment. He should also confirm that:

- The equipment does not show any signs of distress
- The equipment is 'fit for service' i.e. adequate gas pressure or sufficient oil.
- The equipment is clearly identified, and as expected
- The equipment is in the expected operational position.
- Any interlocks or selectors are in the correct position for the intended operation.
- The operational category of the equipment is appropriate.

Where circuit identification labels are not as expected and do not match the switching instruction another Authorised Person shall be consulted prior to the removal of any locks. Switching shall only continue when correct identification is assured. The operator shall then fit an approved temporary label and arrange for the correct permanent label to be fitted.

9.5.3 The operator shall then STOP and CHECK the proposed action as follows:

- Am I operating the correct equipment/circuit?
- What is the operation?
- What am I physically doing to the electrical circuit when I operate the equipment?

9.5.4 After carrying out each operation, he shall record the operation and time, and check by all means readily available that the intended operation has been satisfactorily completed.

9.6 All switching will be carried out on the principle of the removal of the minimum number of locks necessary to permit only one operation at a time. Locks should only be removed immediately prior to operation and be replaced immediately afterwards.

10. Procedures following switching

10.1 The Authorised Person shall record the operations carried out and the time of completion without undue delay. Any instructions that were not carried out must be notified on the Switching Schedule and the reason recorded.

10.2 All hand written entries should be written legibly and indelibly and the records, with copies of switching schedules which will form part of the log, retained in accordance with the approved procedure.

11. Emergency and agreed routine switching

11.1 Emergency switching is that switching carried out without reference to any other party to prevent danger to persons. Upon completion of the emergency switching a Safety Fault Log (SAFL) document should be completed. The Switching and Fault Log recording the actions taken to prevent danger.

11.2 Agreed routine switching is that regular switching agreed in advance.

11.3 When equipment opens under fault conditions, the relevant Authorised Person should cancel any audible alarms and immediately record the time of the operation (if known) and details of any available relay indications.

11.4 When deciding to re-energise a circuit which has opened under fault conditions, the Authorised Person shall confirm which relay flags require resetting before attempting to operate any equipment. Scottish Power control centre should also be consulted prior to energising a faulty HV circuit to establish if their protection relays have been initiated particularly in respect of A&B flags.

(Scottish Power have current transformers located within the 7.5MVA 33/11kV Distribution Transformer Neutral Earth Cabinet which are wired out to A&B Alarm relays in the Transformer Protection Panel at the Brownlow Hill Campus Crown Place HV Main Switch room.

Both relays indicate the presence of earth fault current being derived on the 11000Volt Distribution System. The A Flag will operate if primary current of more than 15Amps is present for a period longer than 8seconds. It typically suggests an open circuit fault condition and is more common on overhead line systems where a jumper has burnt off.

The B Flag will operate if more than 300Amps has occurred during fault conditions instantaneously. This is more applicable to your network and will indicate that a High Voltage Earth Fault has occurred somewhere on your distribution system.

Whenever a fault is investigated the Authorised Person shall verify that Scottish Power has any A&B Alarms to establish if a fault has occurred in the first instance or if the loss of supply has been caused by other means.)

12. Isolation

12.1 Isolation is defined in Section 3 of the Safety Rules and is the disconnection and separation of equipment from every source of energy in such a way that this disconnection and separation is secure. Where the equipment is an integral part of a source of energy, e.g. batteries, capacitors, springs etc. other approved procedures must be followed.

12.2 The variation in equipment on the network make it difficult to provide precise instructions for each type of equipment, therefore Authorised Persons must be trained to be aware of the detailed actions required of them to achieve safety from the system.

12.3 Isolation must be by either:

12.3.1 Maintaining an isolating device in the isolating position. The isolating position must be maintained by immobilising and locking the isolating device in the isolated position and affixing a Caution Notice to it or, maintained and secured by such other method which must be in accordance with an approved procedure.

12.3.2 An adequate physical separation or sufficient gap which must be in accordance with, and maintained by, the method set out in an approved procedure. If it is part of that procedure, a Caution Notice must be placed at the point of separation.

12.4 The application of safety locks and caution notices is part of the isolation procedure and shall remain in position throughout the course of the work. In particular on switchgear, safety locks shall, where practicable, be applied in such a way that it is not necessary to remove the safety lock to perform any subsequent earthing operations or for removal of an earth e.g. under a Sanction-for-Test.

12.5 On 'single handled' switches, the safety lock should be applied to the interlock/selector mechanism when the selector is in the "OFF – EARTH" position.

12.6 Withdrawable equipment

Withdrawable equipment, i.e. isolatable circuit breakers or isolatable switches shall be opened to "OFF" and withdrawn/ isolated. Voltage transformers must, where reasonably practicable, be de-energised and withdrawn/ isolated or the secondary fuses removed. All points of access to the system such as spout shutters and cubicle doors shall be locked off with safety locks and Caution/Danger Notices shall be attached as appropriate. A withdrawable circuit breaker in the open position alone is not acceptable as a Point of Isolation

12.7 Non-Withdrawable Equipment

Fixed, non-withdrawable circuit breakers shall be opened to "OFF" and the closing mechanism made electrically and mechanically inoperative. In addition, links or other Isolating devices must be locked in the open position using safety locks.

Other non-withdrawable switchgear e.g. metalclad switches, switch-fuses, fused-switches and isolators, or, outdoor type switch disconnectors and isolators shall be opened to "OFF" and their mechanisms locked in the open position using safety locks.

Caution/ Danger Notices shall be attached as appropriate.

13 Replacement of HRC fuses in switchgear

13.1 High voltage switch fuses and fused-switches are designed to allow fuses to be changed with the switchgear live. The fuse switch design either lifts the fuse tray out of the oil for fuses to be changed, or provides isolation by the operation of blades. The fuses are then earthed.

13.2 The activity of removal and replacement of such fuses has been risk assessed and can normally be carried out unaccompanied with the switchgear live.

13.3 The operator need only be accompanied by a second person where it could contribute significantly to safety, or prevention of injury due to practical difficulties on site, e.g. where switchgear requires sheeting because of the weather.

13.4 Fuses must not be changed with the switchgear live where there is considered to be a risk of failure of the switchgear because of condition, or by virtue of an operational restriction.

13.5 It is essential to ensure that the fuses are correctly positioned with the striker pin facing the trip bar. Failure to install fuses in the correct manner will prevent the switch operating correctly should a fault occur on the equipment protected by the fuses.

13.6 Fuses which may have carried fault current, but which have not operated the striker pin, must be replaced. Therefore where fuse replacement is required after fuse operation, all three fuses must be replaced with new ones. The removed fuses must not be retained as 'spares' under any circumstances.

13.7 During the replacement of fuses, care must be taken to avoid objects and debris falling into the switchgear. Adequate and effective sheeting is required during inclement weather conditions to prevent rain, snow or wind-borne debris entering the switchgear. Care must also be taken to avoid contamination of the fuses with fibres. Only approved 'fibre free' wipes are to be used for drying/cleaning fuses.

13.8 Where any other work is required on switchgear which involves dismantling and repositioning clamps etc. e.g. maintenance, or changing fuse sizes, this should be carried out with the switchgear dead and under a safety document.

14. Energising after installation or maintenance

14.1 Prior to energisation, the substation containing the newly installed or recently maintained equipment shall be vacated of all personnel.

14.2 Where reasonably practicable and following completion of all maintenance/ commissioning inspections and testing, recently maintained or newly installed equipment shall be: -

- Energised from a remote source, preferably using an automatic circuit breaker/ fault-making switch, or
- Energised from the equipment at which the high voltage test was carried out,

15. Locks and locking

15.1 A safety lock shall be used to secure a point of isolation where locking facilities are provided. Safety locks shall be used in conjunction with a Caution Notice.

15.2 Safety locks shall be applied in such a manner that local energisation of the circuit is prevented yet it is still possible to apply and remove Earths, and where necessary, undertake testing. The correct positioning of a safety lock is particularly important with single handled switchgear, as the safety lock is the main means of protecting persons working on the system. Once applied, it must be left in place until all safety documents have been cleared and cancelled.

15.3 A safety lock should only be removed using the original key. Where the original key has been lost or there is an urgent operational reason for the lock to be removed then it shall only be carried out in accordance with Section 4.6 of the Safety Rules.

16. Earthing

16.1 Earthing of high voltage equipment is carried out as part of the safety precautions to protect people working on or testing such equipment against a failure of a Point of Isolation the effects of inadvertent energisation, impressed voltages and inadvertent back feeds. With particular with reference to the low voltage interconnectors between main switch rooms incorporated in the University Electrical System.

16.2 The main dangers to personnel in applying earths to high voltage equipment are electric shock, burns or falls, arising from:

- The application of earths to live high voltage equipment.
- Badly connected or insecure earthing devices.
- The incorrect sequence or method of application or removal of portable earthing leads.

16.3 The application/ removal of a circuit main earth is classed as a switching operation and shall be carried out and documented accordingly

16.4 Currently, there are several methods of earthing high voltage equipment, including:

- Designated manufacturer's earthing switches
- Switchgear incorporating integral earthing
- Circuit breakers utilising transfer earthing
- Circuit breakers with switchgear manufacturer's earthing attachments
- Independent metal clad approved and tested, earthing devices for circuit breakers
- Portable earthing leads

16.5 Portable earthing leads

16.5.1 Only portable earthing leads of an approved type shall be used.

16.5.2 Portable earthing leads shall be regularly inspected to ensure their integrity in accordance with an approved procedure.

16.5.3 Where reasonably practicable, a circuit breaker or earthing switch shall be used to apply the initial earth.

16.5.4 The application of a portable earthing leads shall be carried out in the sequence detailed in Section 4.24 of the Safety Rules. Prior to checking that a circuit is not live using an approved voltage tester, the testing device itself should be tested immediately before offering up to the conductors, and again immediately the testing is complete. The portable earthing lead should be applied immediately following the testing. However, where there is a delay, the conductors shall be re-tested.

16.6 Use of Additional Earths

16.6.1 Section 3.16 of the Safety Rules defines Additional Earths. The Safety Rules allocate the responsibility for application, removal and management of the Additional Earths to the Competent Person in receipt of the Safety Document.

16.6.2 The Authorised Person issuing the Safety Document may specify where Additional Earths are to be applied within the Other Precautions section of the safety document. The Competent Person shall comply with these instructions.

16.7 Loss of connection with earth

16.7.1 If for any reason, the connection with earth becomes disconnected or the connection is faulty, a voltage may appear across the point of disconnection.

16.7.2 If such a disconnection does occur, no attempt shall be made to recover the connection or to come into contact with the disconnected/ faulty earth connection.

16.7.3 All work shall stop until the earth connection has been replaced as follows;

- i. A second portable earth shall be connected at the same point in parallel with the disconnected earth. Only when this has been done, can the faulty connection be remade using approved equipment.
- ii. In the case of the loss of a circuit main earth, this procedure shall be carried out under the Personal Supervision of the Authorised Person. This procedure may also be used where a previously applied portable earthing lead is found to be missing. However, under these circumstances the Authorised Person shall satisfy himself that other portable earthing leads which have been applied are intact and have not been tampered with, before allowing work to recommence.

17.0 Other FRCS Electrical Information.

<i>Design and Installation Guidance:</i>		
Project Electrical Briefing Document	V5.0	31 ST January 2019
Standard Specification for Electrical Installation Work	V3.1	11 th January 2019
High Voltage Underground Cables	V2.0	31 ST January 2019
High Voltage Switching & Earthing	V2.0	31 ST January 2019
<i>Standard Operation Procedures:</i>		
Low Voltage Safety Rules	V1.0	11 TH December 2017
Management of the Access to Low Voltage Switch rooms	V2.0	22 ND January 2017
High Voltage Safety Rules	V2.0	29 th November 2018