PR-NET-OSM-064

MANAGEMENT OF FAULTS ON HIGH VOLTAGE UNDERGROUND CABLES

OPERATIONAL SAFETY MANUAL - SECTION 8.3

Scottish & Southern Electricity Networks

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CONTENTS

1 Introduction

1.1 This document defines the requirements and responsibilities for management of faults on the **SSEN-D High Voltage System**. **High Voltage** underground cables are those cables operating at a voltage above 1000V AC and 1500V DC within **SSEN-D**.

1.2 The purpose of this Approved procedure is to ensure a safe, effective and customer focussed response to **High Voltage** faults and restoration of affected supplies, thereby limiting risk to all persons involved and minimising customer minutes lost.

2 Scope

2.1 This document relates to the operational requirements and procedures required for the management of faults on **High Voltage** underground cables under the **Operational Safety Rules (OSR).** It covers the process required up to and including the point at which the fault location has been confirmed.

2.2 It applies to all persons employed by or working on behalf of **SSEN-D** who are responding to **High Voltage** underground cable faults.

2.3 This **Approved** procedure is provided to help ensure that, following appropriate risk assessment, the management of and response to faults on **High Voltage** underground cables is undertaken safely, using **Approved** techniques and procedures, with the correct equipment and PPE, and is in compliance with **OSR** and all relevant legislation.

2.4 This **Approved** procedure also covers the requirements when responding to reports of third-party damage to **High Voltage** underground cables.

2.5 The procedures for dealing with faults on **High Voltage** underground cables which may be affected by induced voltages due to their proximity to other **High Voltage** cables or overhead lines, are also covered.

2.6 Additionally, this **Approved** Procedure covers any response to faults on **High Voltage** underground cables forming part of a third-party owned **System**, if that work is undertaken by persons on behalf of **SSEN-D**.

2.7 This scope does not apply to:

- excavation of **High Voltage** underground cable faults
- the repair of faulted **High Voltage** underground cables
- **High Voltage** underground cable testing requirements
- the restoration of repaired **High Voltage** underground cables to service
- submarine cables

3 References

The documents detailed in Table 3.1 - Scottish and Southern Electricity Networks Documents, should be used in conjunction with this document.

Table 3.1 - Scottish and Southern Electricity Networks Documents

Reference	Title
PR-NET-OSM-006	SSEN Distribution Operational Safety Rules – Operational Safety Manual – Section 1.1

Reference	Title
PR-NET-OSM-028	Switching Terminology and Approved Abbreviations - Operational Safety Manual - Section 4.4
PR-NET-OSM-008	System Control Procedures - Operational Safety Manual – Section 2.1
PR-NET-OSM-014	Response to System Faults - Operational Safety Manual – Section 2.4
PR-NET-OSM-020	Manual Reclosing of Circuits Post Trip, Sequence Operation and Lockout - Operational Safety Manual – Section 2.10
PR-NET-OSM-026	High Voltage Switching and Earthing - Operational Safety Manual – Section 4.2
PR-NET-OSM-043	Access to Substations and Switching Sites - Operational Safety Manual – Section 6.1
PR-NET-OSM-062	Access and Work on High Voltage Underground Cables - Operational Safety Manual – Section 8.1
PR-NET-OSM-065	Testing of High Voltage Apparatus - Operational Safety Manual – Section 9.1
WI-NET-OSM-002	Personal Protective Equipment and Workwear for Live Environments
PR-NET-EPR-012	Switching to Restore Supplies on HV Networks
WI-NET-CAB-401	Dealing with Damaged LV and HV Cables up to and including 33kV
N/A	SSEN SHE Handbook (Held in Safety, Health and Wellbeing SharePoint Site)

4 Definitions

4.1 The words printed in bold text within this document are either headings or definitions. Definitions used within this **Approved** Procedure are defined within the list presented immediately below, or within section 2 of the **OSR**.

4.2 **Automation**

Device(s) connected or installed on the **System** that can be operated remotely or, if necessary, automatically without manual intervention. **Automation** may refer to a number of devices connected in an **Automation** scheme and includes auto-reclosing devices.

4.3 **Cable Sheath**

Cable sheath, serving, armour, joint sleeve, plumb or joint seal.

4.4 **Operational Safety Rules (OSR)**

The **SSEN-D** Distribution set of rules, as read with related documents and procedures, that provide generic safe systems of work on the **System** therefore ensuring the health and safety of all who are liable to be affected by any **Danger** that might arise from the **System**.

5 General Responsibilities

5.1 All work and operational activities must be carried out in compliance with **SSEN-D** Safety, Health and Environmental Policy and procedures, including **SSEN-D OSR**.

5.2 Persons who are required to operate and undertake work on the **System** or part thereof, **Shall** have a thorough understanding of the work and ensure that on site risks are suitably assessed and that appropriate control measures are put in place before, during and after all activities.

5.3 The procedures and instructions in this **Approved** procedure must only be carried out by suitably trained and authorised Persons.

5.4 Persons must ensure that at all times during the work (or associated testing) **General Safety** arrangements are maintained and that other work areas are not adversely affected by the activities for which they are responsible.

5.5 Other specific responsibilities in this **Approved** procedure must be followed.

6 Authorisation

6.1 All personnel involved in operations and work on **High Voltage** underground cable faults **Shall** hold the requisite authorisations for the operations and work to be undertaken.

6.2 Competence and authorisation certificates **Shall** be retained personally and be made available upon request.

7 Personal Protective Equipment

7.1 When carrying out operations or work associated with faults on **High Voltage** underground cables, Approved PPE **Shall** be worn, depending upon the operations and work being undertaken. This **Shall** include; helmet, AR (Class 2) overalls or trousers and top (which **Shall** be buttoned up to neck with sleeves fully rolled down) and safety footwear.

7.2 As a minimum, PPE **Shall** meet the requirements of WI-NET-OSM-002.

8 Dangers from High Voltage Cable Faults

The main **Dangers** to personnel involved in operations and work associated with faults on **High Voltage** underground cables are electric shock, burns or falls arising from the same hazards listed in PR-NET-OSM-062 Access and Work on High Voltage Underground Cables - Operational Safety Manual – Section 8.1, plus the following additional hazards:

- Disturbing or making contact with a faulty **High Voltage** underground cable which has not tripped at source
- Being in the vicinity of an exposed faulted cable when the **Control Engineer** is attempting a reclose operation
- Carrying out operations involving the making or breaking of fault current beyond the capability of the switchgear being operated

9 General Requirements for Work or Operations Associated with High Voltage Cable Faults

9.1 Serious injuries can result from the explosive effects and associated fire or flames from a **High Voltage** cable fault. Cable damage may already be present or may be caused during excavation by penetration with a sharp object or crushing. It is important that all work in the vicinity of any cables at all voltages is carried out such as to reduce the risk of injury to the minimum.

9.2 The safety and welfare of all personnel involved with the management of and response to faults on **High Voltage** cables must always take priority over any perceived pressure to restore supplies. There will always be a sense of urgency to reduce customer minutes lost and restore supplies, but this should never take priority over the safety of personnel and the wider public.

9.3 Any work or operations associated with **High Voltage** cable faults **Shall** only be carried out in accordance with **Approved** procedures.

9.4 Regular communication and updates with the **Control Engineer** are an important factor in the safe management of **High Voltage** underground cable faults.

9.5 Work **Shall** not commence on any **High Voltage** underground cable fault unless the person in charge of the work is in receipt of the correct **Safety Document** and has been personally instructed at the point of work by the **Senior Authorised Person** issuing the **Safety Document**.

9.6 All **High Voltage** underground cables **Shall** be treated as **Live** unless confirmed as **Dead** using **Approved** procedures by an **Authorised Person**.

9.7 More information on the response to **System** faults can be found in PR-NET-OSM-014 Response to System Faults - Operational Safety Manual – Section 2.4.

10 High Voltage Cable Circuit Identification

10.1 The requirements for the identification of **High Voltage** cable circuits are as stated in PR-NET-OSM-062 Access and Work on **High Voltage** Underground Cables - Operational Safety Manual – Section 8.1.

10.2 Generally, a **High Voltage** underground cable fault will be associated with a circuit breaker trip and a large number of customers off supply, so the circuit identification is obvious.

10.3 Occasionally, specifically with a third-party damage, a **High Voltage** underground cable may be damaged but not sufficiently to cause a protection trip. In such cases, the provisions for identification set out in **Approved** Procedure PR-NET-OSM-062 Access and Work on **High Voltage** Underground Cables - Operational Safety Manual – Section 8.1, and the documents referred to therein **Shall** be followed.

11 Fault Passage Indicators

11.1 It is unusual for **High Voltage** underground cable faults not to have some element of **Earth** fault current and therefore, where fitted, information gathered from Fault Passage Indicators (FPIs) can help in the location of **High Voltage** underground cable faults and significantly reduce the time taken to isolate the faulted zone.

11.2 The location of FPIs should be made available on network records, so that they may be quickly accessed and any FPI operations then reported back to the **Control Engineer**.

11.3 There are several types of FPI in use and all may be used for positive indication. However, only three-phase FPIs or circuit-breaker based protection relays (including pole-mounted circuit-breakers), which register the passage of both **Earth** and phase fault current, should be used for negative indication. Caution should be exercised when interpreting any FPIs that have not flagged.

11.4 Any information gleaned from FPIs **Shall** be reported back to the **Control Engineer** so that it can be used to inform the chosen sequence of operations to restore supplies to healthy sections of the affected circuit and isolate the faulted section.

12 Application of Automatic Reclosing

12.1 Faults on underground cables are almost certainly permanent in nature and automatically reclosing onto underground cable faults imposes unnecessary stress on the network and causes more damage at the point of fault and can endanger persons nearby to the fault location, especially with regards to third-party damage.

12.2 For this reason, any **High Voltage** circuit consisting of 100% underground cable throughout its length should have auto-reclosing facilities disabled or inhibited on the source circuit breaker (if such facilities are fitted at all).

12.3 **High Voltage** circuits which include sections of overhead line will generally have auto-reclosing facilities fitted and enabled depending upon the ratio of overhead to underground section lengths and other aspects of the make-up of the circuit.

13 High Voltage Underground Cable Fault Sectionalising

13.1 More detailed information regarding the sectionalising process for **High Voltage** underground cable faults can be found in PR-NET-OSM-008 System Control Procedures - Operational Safety Manual – Section 2.1, and PR-NET-EPR-012.

13.2 Where **Automation** exists, network reconfiguration and reclosures **Shall** be carried out automatically or remotely by the **Control Engineer** prior to staff arriving on site wherever practicable.

13.3 In deciding the **Switching** sequence for the sectionalisation of a **High Voltage** cable fault, which has resulted in loss of supplies to customers, the prime consideration **Shall** be safety after that it **Shall** be to prioritise the resilience of the Network and restoration of customers supplies.

13.4 During the switched restoration of supplies, the procedures in this section **Shall** be applied to safeguard staff, third parties and the components of the network. The approach to be taken and the procedures which apply vary according to the circuit configuration and the type of controlling switchgear.

13.5 Some restoration of supplies may take place automatically if any **Automation** exists on the circuit affected.

13.6 In cases where there are sections of overhead line involved and customers are off supply after auto-reclosing has locked out, the **Control Engineer** may attempt one or more further manual reclosures, as long as there have been no reports of dangerous situations (see PR-NET-OSM-020 Manual Reclosing of Circuits Post Trip, Sequence Operation and Lockout - Operational Safety Manual – Section 2.10).

13.7 Where a circuit is fitted with downstream protection and the circuit is running normally, protection grading of all the devices should be presumed as correct unless otherwise indicated on the **System** diagram. Restoration **Shall** be attempted as soon as practicable to restore customers from an alternative source, provided that no notification of a potentially dangerous situation has been received.

13.8 When reclosing onto underground cable circuits, the most significant risk is injury to third parties who have inadvertently damaged **High Voltage** cables. For this reason, cable sections should not normally be re-energised without a reasonable time delay during the hours 06:00-22:00, unless the following criteria have been met:

- Positive indication from site exists to suggest that any suspected cable damage is outside the section to be re-energised, or
- Reliable FPI indication suggests that the section to be re-energised is not faulty, or
- A period of 20 minutes from the time of the initial tripping has elapsed and no notification of a potentially dangerous situation is received at relevant report centres, or
- The reclosure attempt is made within 3 minutes of the initial tripping via **Automation**, or

- Protection grading indicates that any suspected cable damage is outside the section to be re-energised, or
- Where **Automation** has operated on a circuit and the faulty section has been proven, then restoration of the supplies outside the faulted section **Shall** be attempted as soon as practicable, provided that no notification of a potentially dangerous situation is received

13.9 Outside the above hours, sectionalising and reclosure may be attempted after 5 minutes, provided that no notification of a potentially dangerous situation is received at relevant Customer Contact Centres or directly to an NMC.

13.10 Before attempting any restoration of supplies from any back feed with a downstream tripping circuit breaker, due consideration must be taken of the circuit capacities and wherever possible the fault **Shall** have been proven first.

13.11 Before reclosing onto suspected faulty sections of network, temporary fault **Switching** protection settings may be applied under instruction from the **Control Engineer**. These settings **Shall** be reset to normal once sectionalising is complete. Temporary settings may also be applied remotely by the **Control Engineer** where such remote operation facilities exist.

13.12 On every occasion that a wholly underground circuit trips and is re-energised without any cause being found, the connected substations, **Switching** stations and cable compounds should be visited as soon as practicable in daylight to check that the busbars, cable boxes and exposed cables show no sign of distress.

13.13 Field staff despatched in response to faults, **Shall** not enter substations, without specific instruction from the **Control Engineer**, to assess the condition of the **Plant** and **Apparatus**. This also includes visual indications such as checking operation of switchgear or FPIs. **Should** the assessment indicate a **Danger** to public safety and / or the integrity of the **Plant**, **Apparatus**, this **Shall** be immediately reported to the **Control Engineer**.

13.14 Field staff **Shall** follow the precautions given in PR-NET-OSM- 026 High Voltage Switching and Earthing - Operational Safety Manual – Section 4.2 when entering substations and carrying out **Switching**

13.15 Before carrying out remote operations to re-energise the circuit or instructing field staff to carry out operations to re-energise the circuit, the **Control Engineer Shall** ensure that all field staff known to be operating on the circuit, with the exception of the staff carrying out the instructed operation, are positively excluded from all substations on that circuit.

13.16 In the case of a Grid and Primary substations, it is preferable to be outside the switch-room, in a separate room or a minimum distance of 15m maintained from the equipment to be energised.

13.17 In the absence of reliable or positive indication of the fault location, the first stage of sectionalisation should normally be to split the affected circuit at the mid-point (based on customer numbers).

13.18 To reduce the risk of interruption of supply to additional consumers, a reclose **Shall** be attempted from the same source as the original trip (the only exception being when prevented by existing operational restrictions).

13.19 Further sectionalising at quarter points, following the same procedure, should be considered, depending upon the results of initial sectionalising and reiterated as appropriate until the individual faulted section has been narrowed down.

13.20 The **Control Engineer Shall** take note and due consideration of the number of operations each item of switchgear has been subjected to during fault **Switching**. It is important that post fault maintenance limitations of switchgear are adhered to. Oil filled circuit-breakers in

particular have a limited fault **Switching** capability before they require post fault maintenance.

13.21 Regardless of the post fault maintenance levels, on each occasion after clearing fault current, the circuit-breaker should be inspected externally for signs of distress (e.g. indications of excess tank pressure, evidence of emission of oil, etc) before any further **Switching**. However, where:

- no personnel are available on site to check the condition of the circuit-breaker
- control of the circuit-breaker is by Telecontrol; and
- it will speed the restoration of supplies

the need for such inspection may be waived. Following such action, inspection **Shall** take place at the first convenient opportunity.

13.22 It is the responsibility of the **Control Engineer** to ensure switchgear is operated within its rating as far as is reasonably practicable. Switchgear which may be overstressed **Shall** be recorded on the **System** diagram.

14 Location of High Voltage Underground Cable Faults

14.1 Once the faulted section of circuit has been ascertained through the sectionalising process, it **Shall** be **Isolated** and **Earthed** following normal operating procedures.

14.2 If the actual fault location is not known, i.e. it is not a reported third-party cable damage and the fault is still buried, then standard fault location techniques using the **SSEN-D** or contractor's **High Voltage** test equipment **Shall** be used to identify the precise fault location. Further guidance on cable fault location can be found in PR-NET-OSM-065 Testing of **High Voltage Apparatus** - Operational Safety Manual – Section 9.1.

14.3 Once a reliable fault location has been established, the fault position **Shall** be excavated following the guidance given in PR-NET-OSM-062 Access and Work on **High Voltag**e Underground Cables - Operational Safety Manual – Section 8.1.

14.4 When the fault has been exposed and confirmed, the cable **Shall** be identified and proved **Dead** by an **Approved** procedure per PR-NET-OSM-062 Access and Work on **High Voltage** Underground Cables - Operational Safety Manual – Section 8.1, before repairs are undertaken.

15 High Voltage Underground Cables in the Vicinity of or Connected to Overhead Lines

The same procedures and precautions as stated in PR-NET-OSM-062 Access and Work on **High Voltage** Underground Cables - Operational Safety Manual – Section 8.1 are also relevant when carrying out work on faulted **High Voltage** underground cables in the vicinity of or connected to overhead lines.

16 Induced Voltages on High Voltage Underground Cables

The same procedures and precautions as stated in PR-NET-OSM-062 Access and Work on **High Voltage** Underground Cables - Operational Safety Manual – Section 8.1 are also relevant when carrying out work on faulted **High Voltage** underground cables likely to be subject to induced voltages.

17 Response to Reports of Third-Party Cable Damage

17.1 All contractors and other utilities or agencies carrying out excavations in the vicinity of buried Apparatus are encouraged to report all suspected third-party damage to **SSEN-D** underground cables.

17.2 There may be instances where a cable has been struck and damaged, but the source circuit-breaker has not tripped. This is a very dangerous situation, as the exposed cable could fail catastrophically at any time, endangering any person nearby.

17.3 It is thus vitally important that all third-party damages are attended as soon as possible by suitably **Authorised SSEN-D** staff to assess the situation on site, ensure the safety of on-site staff and to confirm the cable damage.

17.4 No assumption **Shall** be made that any **High Voltage** cable with exposed **Conductors**, whether from damage or otherwise, is **Dead**.

17.5 **SSEN-D** staff should also check for signs of damage to any other cables or to plant belonging to other utilities or contractors that might give rise to **Danger**.

17.6 WI-NET-CAB-401, gives more detail on the procedures to be followed in the event of a no trip fault.

17.7 Only once this initial assessment is complete should **SSEN-D** staff begin arranging for the relevant circuit to be identified, then switched out (if it has not already tripped) for formal identification (and spiking if necessary) to prove the cable **Dead** before it is then repaired and put back into service.

17.8 If only the **Cable Sheath** is damaged and it can be confirmed that the **Conductors** and their insulation are not damaged, then the procedures laid out in Appendix A **Shall** be followed.

18 Faults on Fluid Filled Cables

18.1 Faults on **High Voltage** underground fluid filled cables will normally involve a loss of fluid pressure and in some instances falling or low-pressure alarms will be received by the **Control Engineer** well in advance of an actual cable electrical fault.

18.2 The location of fluid filled cable leaks is a specialist process involving repeated excavation and freezing of the cable at strategic distances along the route and monitoring the pressure on both sides of each freeze to aid in sectionalising the leaky section down to a small area along the route.

18.3 Tracer chemicals can then be added to the cable fluid, so that sensitive detectors can be used along the leaky section which has been established through the freezing process, to then establish the actual location of the leak.

18.4 If a fluid filled cable has an actual electrical fault which causes a trip of the source circuit breaker, then the same fault location techniques as for other **High Voltage** underground cable faults can be used to identify the position of the fault.

19 Revision History

No	Overview of Amendments	Previous Document	Revision	Authorisation
01	New document created	TBC	1.00	Richard Gough
02				

Appendix A High Voltage Underground Cable Sheath Faults

1. The following procedure applies when work is only required to take place on the **Cable Sheath** of **High Voltage** cables without access to the **Conductors** or the insulation covering them.

2. If removal of the **Cable Sheath** is required, then operations **Shall** be carried out as for when work on the **Conductors** is required and the normal procedures for identification and spiking **Shall** apply.

3. Minor repairs to **Cable Sheaths**, including re-plumbing of joints, maintenance of barrier joints and similar work may all be carried out under this procedure.

4. If the **Cable Sheath** repair is required as a result of third-party contact, the work **Shall** only proceed after a careful examination of the cable and a risk assessment by a **Senior Authorised Person**.

5. The following procedure **Shall** be followed for **Cable Sheath** repairs:

   - Identification **Shall** take place as per PR-NET-OSM-062 Access and Work on **High Voltage** Underground Cables - Operational Safety Manual – Section 8.1, except that the cable will not be spiked. The **Sanction-for-Test** will be endorsed "only tests for cable identification purposes are to be carried out".
   - All cables present at the point of work **Shall** be exposed and each cable and joint identified from records by the **Senior Authorised Person** in charge of the work.
   - The **Senior Authorised Person Shall** confirm the identity of the cable to be worked on at the point of work by injected signal tone as per PR-NET-OSM-062 Access and Work on **High Voltage** Underground Cables - Operational Safety Manual – Section 8.1.
   - The cable to be worked on **Shall** be marked with coloured tape by the **Senior Authorised Person**, or other **Person** acting under their **Personal Supervision**, on each side of the point of work.
   - The **Senior Authorised Person Shall** issue a **Permit-to-Work** and give **Personal Supervision** to the commencement of the work. The **Permit-to-Work Shall** state "there **Shall** be no interference with the screen or insulation of the cable cores".
   - All work **Shall** be carried out in accordance with the **OSR**.