National Grid UK Electricity Transmission plc

NATIONAL SAFETY INSTRUCTION 27
and
Guidance

WORK ON OR NEAR TO HIGH VOLTAGE DIRECT CURRENT (HVDC) EQUIPMENT

DOCUMENT HISTORY

Issue	Date	Summary of Changes / Reason	Author(s)	Approved By (Title)
1	Dec 2015	New NSI & Guidance Document.	HVDC Working Group	Matt Staley ETAM Operations North Manager
2	Nov 2018	User Group Feedback and refining initial version	Nathan Farrell-Jones (NSI27 User Group comprising of ET Operations NW & SE, SMPA, TNCC)	Matt Staley Head of Operations ET Operations
3	Feb 2021	Rewritten to align with Company Structure, Current Ways of Working and Reformatted	Electricity Transmission Operations Safety Rules Team	Head of ET Operations Matt Staley

KEY CHANGES

Section	Amendments
Definitions	Amended to represent current terminology only
6.3	Reference to a G3 Procedure within this document removed
6.4	Removed reference to removal of cables from the National Grid Safety Rules.
Appendix D	Proposed 'G3 Example' removed and converted into a Live G3 procedure New Appendix created – Earthing Devices (Operational / Testing Configuration usage)
Appendix E	Proposed 'SFW Example' removed – G3 updated to allow existing SFWWP/02 to be utilised
Appendix F	Updated Authorisation Matrix for Personnel now becomes Appendix E

Work on or near to High Voltage Direct Current (HVDC) Equipment

CONTENTS

1 Purpose and Scope

To apply the principles established by the Safety Rules and provide guidance to protect **Personnel** from **Danger** arising due to working on or near a **HV***DC* **Equipment***.*

National Grid **Personnel** when working or testing within the scope of this document will be authorised specifically in accordance to this NSI document.

The layout of these guidance notes reflects that of legislative codes of practice, where the rule (or mandatory obligation) is identified by a green panel on the left-hand side. The guidance follows after the rule and is identified by a blue panel.

Within National Grid the guidance notes hold equivalent status of an **Approved** Code of Practice (ACOP) in law. If not followed, you will be required to demonstrate that your Safe System of Work is of an equal or higher standard.

This document covers the following:

- **Safety Distance(s)** for Approach to **HV**DC **Equipment**
- Access to **Equipment** within a **HV**DC *Converter Station*
- Work or testing on **HV**DC **Equipment** within a *Converter Station*
- Work or testing on **HV**DC Cables, including submarine cables
- Work or testing on Auxiliary **Equipment** which is specific to a *Converter Station*
- Specific Switching Instructions for work on a ***HV****DC* ***System***

This NSI addresses further specific hazards found within a *Converter Station* and its associated **Equipment**. This does not negate any compliance with any other obligation or directive within the existing Safety Rules or National Safety Instructions unless explicitally stated.

This NSI provides generic as well as site specific information. Authorisation to this NSI is relevent to all location(s) referenced within this document but **Personnel** shall have supplementary site specific knowledge and training relevant to the task they are undertaking.

2 Definitions

Terms printed in bold type are as defined in the Safety Rules.

Title	**Definition**
Bipole	Two *Pole*s connected such that they operate together as one energy transfer unit. Normally consists of two *Pole*s having opposing direct voltages with respect to earth.
Bypass Switch	Switching Device connected across the DC terminals of a *Pole* which may be used during the switch on / off procedure and allows operational re-configuration during a *Pole* outage.
Converter Station	Part of a ***HV**DC **System*** which consists of one or more *Converter Unit*s installed in a single **Location** together with buildings, reactors, filters, reactive power supply, control, monitoring, protective, measuring and auxiliary **Equipment**.
Converter Unit	Operative unit comprising *Valves*, converter transformer(s), control and protection **Equipment,** switching devices and auxiliaries used for conversion.
DC Current Measuring Device	DC Current is typically measured using a Resistive Current Shunt (RCS). This **Equipment** uses laser light technology to read the voltage across a known resistance (shunt) in the **HV**DC circuit.
DC Hall / Area	Room in which **HV**DC **Equipment** associated with the *Converter Station* is located.
DC Voltage Divider	Devices used to measure the voltage of a **HV**DC circuit. They may include capacitors, resistors and / or laser light technology.
Heating, Ventilation and Air Conditioning (H-VAC)	**Equipment** used to control the air temperature within a building (e.g. *Valve Hall* or *DC Hall / Area*) and can also create a pressure differential within that building with respect to atmospheric pressure. (N.B. Positive Pressure may be used to limit dust ingress to an area)
***HV**DC System*	**Equipment** which transfers energy in the form of high-voltage direct current (**HV**DC) between two or more alternating current buses.
Neutral Bus	A conductor connecting the DC neutral terminals of two *Poles.*
Pole	Part of a ***HV**DC **System*** consisting of both AC and DC **Equipment** at the **HV**DC *Converter Station(s)* and the interconnecting transmission medium, if applicable.
Valve	Device used for conversion which is connected between an AC terminal and a DC terminal.
Valve Cooling Equipment	Equipment by which heat is transferred from the **HV**DC *Valve*s to atmosphere to maintain them within their operating temperature limits. (N.B.This usually comprises a closed loop liquid cooling system)
Valve Hall	Restricted room or enclosure in which the *Valve*s are located.

3 Dangers

The main dangers when working on **HV**DC **Equipment** and their associated components are electric shock, burns and / or other injuries arising from:

- Inadvertently infringing **Safety Distance**.
- The mistaking of **Equipment** on which it is unsafe to work, from that which it is safe to work.
- Inadequate precautions, or security of those precautions, to manage hazards rising from **Impressed Voltage Conditions**.
- Inadequate precautions, or security of those precautions, to suppress or safely discharge stored mechanical energy.
- Contact with electrical test supplies at dangerous voltages / energy levels.
- Contact with an unearthed **System**.
- Inadequate precautions against laser light sources e.g. fibre optic light signals.
- Inadvertent access to **Equipment** such as air cored reactors, that are **Live** and generating high magnetic fields.
- Contact with **Equipment** which may be operating at harmful temperatures.
- Specific **Dangers** arising from work on *H-VAC* to be considered:
    - Positive or negative differential air pressure across access doors and hatches
    - Rotating Parts
    - Noise
    - Heater Elements
    - Enclosed Spaces
    - Sources of **Low Voltage** Electrical Energy

NSI 27
4.1 to 4.4

4 Approach to Exposed HVDC Conductors and Insulators

4.1 Individuals shall not allow any part of their body or objects to approach within the specified **Safety Distance(s)**, to exposed **HV**DC **Equipment** as detailed in Section 4.2; the only exceptions to this are where:

- Application of Safety Rule R2.2 or R2.3
- Application of Section 4.3 or 4.4

4.2 **Safety Distance(s)**

Location	High Voltage Equipment		*Neutral Bus*
Flintshire Bridge nominal operation voltage of 600kV DC	**Equipment on the *Valve* side of (and including) the Smoothing Reactor**	**Equipment on the line side of (but excluding) the Smoothing Reactor**	
	5.1m	4.4m	0.8m
Sellindge nominal operation voltage of 280kV DC	2.4m		0.8m

A distance of 300mm shall also be maintained from that part of the insulators supporting exposed unearthed **High Voltage** conductors which are outside the appropriate **Safety Distance**.

4.3 Application of **Safety Distance** to **HV**DC Bypass Circuits

Some **HV**DC Bypass Circuits comprise **Equipment** of different rated voltages which are connected together.

Those conductors which directly connect *Neutral Bus* switchgear to **HV**DC switchgear shall be treated as *Neutral Bus* conductors. The appropriate **Safety Distance** shall still be maintained in full from the **HV**DC **Equipment**, including any corona rings.

4.4 Application and removal of **Earthing Device(s)** for Operational Purposes

Earthing Device(s) specified in 'Appendix D' can be used for Operational Configuration or for testing and may be applied / removed under the instruction of a **CP(O)1**.

There is no requirement for **Point(s) of Isolation** to be established prior to application or removal of such **Earthing Device(s)** when used in this context.

Guidance
NSI 27
4.2 to 4.3

4 Approach to Exposed HVDC Conductors and Insulators

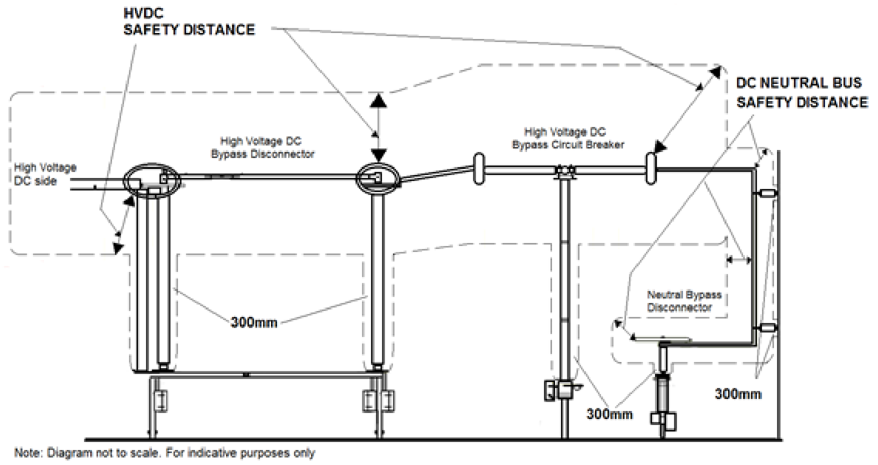
4.2 All **HV**DC Conductors shall be considered to be operating at their nominal voltage regardless of DC Operating Configuration.

Personnel who are not authorised to this document but are required to work at a *Converter Station* shall receive instruction and information regarding relevant **HV**DC **Safety Distance(s)** via site induction. Where appropriate this shall also be recorded in a written Risk Assessment prepared for the work.

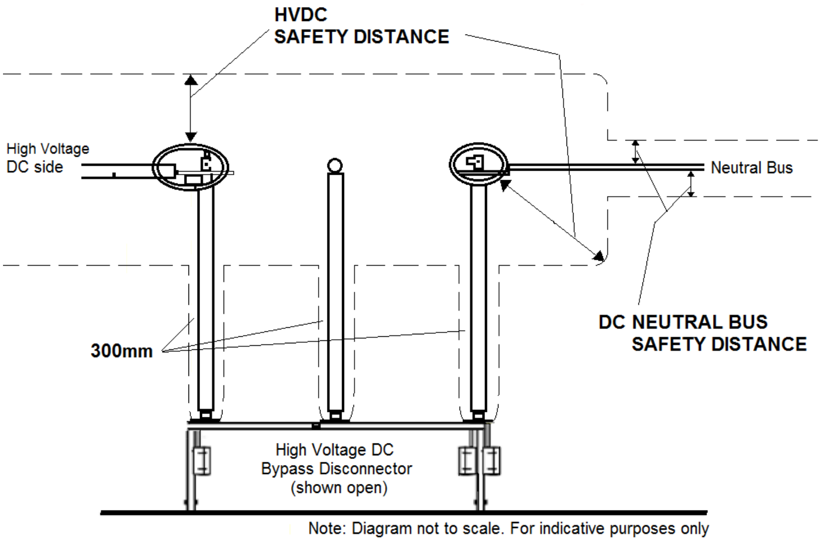
4.3 Application of **Safety Distance** to **HV**DC Bypass Circuits

The following drawings indicate the application of **Safety Distance(s)** for different **Equipment** layouts.

<u>Where the **HV**DC bypass circuit includes a *Bypass Switch*</u>



<u>Where the **HV**DC Bypass Circuit includes only a Bypass Disconnector</u>



NSI 27
5.1 to 5.2

5 Specific Requirements for Working in HVDC *Converter Stations*

5.1 When work is to be carried out on or near to **HV**DC **Equipment**, a Safe System of Work shall be established in accordance with the National Grid Safety Rules and associated National Safety Instructions.

5.2 Access shall not be permitted to a Valve Hall until the Pole has had **Point(s) of Isolation** and Earthing established, and the **Safety Document** Issued.

Guidance
NSI 27
5.1

5 Specific Requirements for Working in HVDC *Converter Stations*

5.1 **HV**DC **Equipment**

- The *Neutral Bus* may contain earthing capacitors. The capacitors shall be considered as part of **HV Equipment** and **Earthed** / discharged in accordance with NSI 11.
- *DC Voltage Dividers* are not considered as a **HV** infeed. It is not necessary to establish secondary **Point(s) of Isolation** on this **Equipment** for work on the **High Voltage** side.
- *DC Current Measuring Devices* can exhibit unique hazards. The Operational and Safety implications shall be understood before work is carried out on this **Equipment** by reference to the Manufacturers manuals or other relevant documentation.

<u>Work on Laser Systems</u>

- When working on or near to Class 4 laser systems a Safe System of Work shall be established. Consideration shall be given to the risk of inadvertent exposure to laser hazards. Reference shall be made to the manufacturer’s recommendations and any relevant Management Procedure.
- In order to implement safety precautions it may be necessary to enter a cubicle containing a live laser system. Note that although usually safe by design, it is not always possible to guarantee that a hazard would not exist when a cubicle door is opened (e.g. damaged fibre within) and the use of appropriate laser safety goggles shall be considered as a precaution.

<u>Auxiliary Equipment</u>

- *Valve* cooling is achieved by:
  (i) Closed loop liquid cooling systems comprising pipework and associated Valves, pumps, heat exchangers and control systems.
  (ii) Air management systems (*H-VAC*) and their control system. The *H-VAC* system may also be used to regulate the temperature in other buildings (e.g. *DC Hall / Area*) and may also be capable of heating.
- When working on the *Valve Cooling **Equipment***; **Isolation**, **Draining**, **Venting** and **Purging** may be required to achieve a Safe System of Work.

Guidance NSI 27 5.2	*5.2 Valve Hall*s • Access to a *Valve Hall* is prevented by interlocks whilst the *Pole* is in operation. Where **Earthing Device(s)** are located inside the *Valve Hall*, correct engagement of the **Earthing Device** shall be confirmed where reasonably practicable. Where such **Earthing Device(s)** fails to operate or cannot be confirmed as fully closed an alternative means of Earthing either external and / or internal to the *Valve Hall* will be required, this will be determined by a **Senior Authorised Person**. The **Senior Authorised Person** shall consider any residual hazards which remain within the *Valve Hall* (for example **Charged Equipment** which could be infringed) and implement suitable controls to prevent **Danger.** • Where external Earthing is applied which does not initiate the *Valve Hall* door interlock, it will be necessary to defeat interlocks to allow access to the *Valve Hall*. Where access is to be gained by defeating interlocks, this should be identified in the RAMS along with any further controls necessary to be implemented in the absence of the internal **Earthing Device(s)**. • Before work is undertaken in the *Valve Hall*, the Valve-Side windings of the relevant Converter Transformer(s) are required to be Short-Circuited and **Earthed**. This may require the application of a **Drain Earth** to neutral star-point connections if not fitted with a Fixed **Earthing Device**. • Before work is undertaken on any Thyristor Rack, it should be discharged and **Earthed** in line with a local procedure and / or Manufacturer's instruction. The minimum approach for **Drain Earth(s)** is to earth all racks below and one rack above the point of work. • Snubber Capacitors shall be discharged using a Discharge Stick connected to the **Earthed** Thyristor Rack. Additional General Safety Hazards Specific to **HV**DC **Equipment** • There are other hazards and unique methods or work within a *Valve Hall* that are not normally found in conventional Substations. Reference shall be made to the Operation and Maintenance Manuals to identify all hazards at a particular **Location** and then appropriate Safe Systems of Work shall be developed. Authorisation to this NSI does not in itself imply competence to work on **HV**DC **Equipment**. All **Personnel** involved in the work shall be familiar with the requirements of the operation and maintenance manuals and have received **Equipment** specific training.

NSI 27
6.1 to 6.3

6 HVDC Cables

6.1 When working on **HV**DC cables and / or associated terminations, precautions shall be taken to protect **Personnel** against **Impressed Voltage Conditions**. This shall include consideration of energy retained in the cable due to effects of dielectric polarisation.

6.2 When work or testing is to be carried out on or near to **HV**DC land cables, then a Safe System of Work shall be established in accordance with the National Grid Safety Rules and associated National Safety Instructions. Specific methods for working on **HV**DC land cables shall be in accordance with NSI 5.

6.3 When work or testing is to be carried out on or near to **HV**DC submarine cables, a **Senior Authorised Person** (NSI 27 & NSI 5) shall assess the means of achieving **Safety from the System**.

Where the work involves contact with the **HV**DC cables, intrusive work, or there is a significant risk that inadvertent contact could be made then work shall only proceed under an appropriate **Safety Document** and the utilisation of a G3 Procedure.

Where the work is non-intrusive then the methodology within this guidance section shall be used.

Guidance
NSI 27
6.1 to 6.2

6 HVDC Cables

6.1 **HV**DC cables are subject to **Impressed Voltage Conditions** and Safe Systems of Work shall be developed accordingly. In addition, particular attention shall be given to the effects of dielectric polarisation which is only prevalent in **HV**DC cables.

Dielectric polarisation is known to re-charge **HV**DC cables (even if they have previously been briefly discharged or **Earthed**) to up to 15% of their previous operating voltage if they become free of Earth before the cable has de-polarised.

It is important that **Earthing Device(s)** are only applied to **HV**DC cables which are confirmed as discharged or already **Earthed**. If the cable has been left free of Earth and it is not possible to establish its voltage (for example if measurement devices have been isolated from the cable), an assessment must be made as to whether sufficient time has elapsed for the cable to have de-polarised prior to application of an **Earthing Device**.

Reference shall be made to manufacturers recommendations, manuals and site-specific operational experience to determine the time necessary for polarisation energy to decay once the cable is **Earthed** (or conversely left free of Earth), after which time the cable can be considered to be de-polarised. A means of force-discharging the cable may also be available, for example the use of an adequately rated *Bypass Switch*.

6.2 Work on or near to **HV**DC land cables shall be in accordance with NSI 5. The **Safety Document** shall be issued by a **Senior Authorised Person** holding NSI 5 and NSI 27 (or counter-signed by a combination of both). The boundary between land and marine is normally the shoreline. In some circumstances an assessment must be made as to the working environment and which method of work to adopt (i.e. land or marine). Where the cables can be positively identified via GPS records with reference to the installation records there is no requirement to spike the **HV**DC Land cables.

Guidance
NSI 27
6.3

6.3 Work on or near to **HV**DC marine cables requires assessment by a **Senior Authorised Person**.

National Grid Electricity Transmission Safety Rules are in place for onshore **HV Equipment**. They were not primarily written to suit the marine environment and dependant on work location or nature, may prove to be impractical, even prohibitive to adopt.

A National Grid **Senior Authorised Person** shall review the Contractor's Safe System of Work and assess whether the cable is required to be made **Dead** or can remain in service.

Intrusive Work

When the work requires the cable to be made **Dead**, work shall only be allowed to proceed under a **Safety Document** and the associated G3 Procedure. Where the work requires a **Permit for Work** or **Sanction for Work**, this shall be issued by a **Senior Authorised Person** holding both NSI 5 and NSI 27 (or co-signed by both).

An example of this type of work would be a cable fault repair.

Non-intrusive Work

Where non-intrusive work is required near to the **HV**DC Cable(s), work can be allowed under RAMS or a **Limited Access Certificate**.

Examples of non-intrusive work are:

- Remotely operated vehicle taking images of the cable.
- Towing a submerged sensor near the sea bed to detect the level of burial cover above the cables.
- Reburial works involving the use of a Mass Flow Excavator, placement of rock or concrete mattress.
- Cable crossing.

Advice may be sought from the contractor and independent marine survey / installation consultants in order to assess the risk of damage or inadvertent contact with the cable. A decision will then be made by the **Senior Authorised Person** as to whether the work is considered intrusive or non-intrusive.

The **Senior Authorised Person** shall;

- make an assessment as to the risk of such apparatus making contact with the cable (including inadvertent contact),
- provide written confirmation to the specialist contractor when work may commence and whether or not a Safety Document is to be issued,
- be kept aware of progress of the work and be informed in writing when work is complete.

General Guidance and Information to SAPs

Typically, those involved in offshore cable repair work will be multi-national specialists. It is imperative that clear communication is established, especially between the vessel and land-based personnel.

During a cable repair operation there may be 50+ mariners onboard a vessel. Around 12 of these may be on the cable deck at any time.

Personnel working offshore are trained in offshore survival techniques (BOSIET qualification). They are also subjected to an offshore medical and drugs / alcohol checks.

Appendix A - HVDC Clearances

Defining Electrical Clearances and Safety Distance(s) for HVDC Equipment.

The clearance in air required to provide adequate insulation for **HV**DC **Equipment** in *Converter Station*s is usually governed by the level of switching impulse voltage to which the **Equipment** might be exposed.

*Converter Station*s tend to be of a bespoke design in order to achieve an optimum solution for a given application and a number of design related factors influence the switching impulse voltage. Consequently, the switching impulse voltage and hence the electrical clearance is not directly related to the DC operating voltage.

The level of switching impulse is determined by the manufacturer in the insulation coordination studies which are performed at the design stage of a **HV**DC scheme. The value is rounded up to the nearest standard switching impulse level and the necessary air clearance determined from values given in the International Standards. Electrical clearances are determined by International Standards, with the addition of a safety margin, these **Safety Distances** for *Converter Station*s are given in section 4.2.

Note: As the **Safety Distance** is not directly related to **HV**DC operating voltage, it is necessary to specify **Safety Distances** by site.

Changes to System configuration or Equipment and its effect

During the life of a **HV**DC **System**, a major change to the **Equipment**, such as a *Valve* replacement, may be necessary. In such circumstances, a new insulation coordination study will be required as it may be found that the standard switching impulse withstand level has changed. Where any work is planned that requires a new insulation coordination study, it will be necessary to confirm whether the existing **Safety Distances** remain applicable and where necessary, to derive new **Safety Distances**.

Appendix B - Specific Switching Instructions

Flintshire Bridge Converter Station

The Western **HV**DC Link is a 2250MW *Bipole System*. Flintshire Bridge (Southern *Converter Station*) is National Grid owned and operated, and Hunterston (Northern *Converter Station*) is Scottish Power Transmission owned and operated.

The control system features a high degree of automation, including Operational and Safety switching sequences.

Use of Automated Switching Sequences

Prior to the issue of any 'automated switching instruction', the **Control Person** (NSI 27) and **Authorised Person** (NSI 27) shall familiarise themselves with the status of **Equipment** at the *Converter Station* and where appropriate, the remote end. They shall agree with reference to site specific documentation, exactly which **Equipment** is both desired and expected to operate when the automatic sequence is executed. This **Equipment** shall be listed individually on the switching instruction, along with reference to the execution of the desired automatic sequence.

Automated Operational Switching Instructions

Automated switching sequences may be used to operate **Equipment** for the purposes of Operational reconfiguration. Reference to site specific documentation may be necessary to determine which sequence is required.

The switching instruction shall take the form;

On Pole 1 Station; Execute Connect Command.*

**Substitute 'Connect' for desired Switching Sequence*

The **AP** shall ensure that the switching sequence was successful (with reference to the site control system) before reporting back the switching instruction.

Automated Safety Switching Instructions

Automated switching sequences may be used to operate **Earthing Device(s)** for the purposes of Safety switching, provided that adequate safeguarding of those **Earthing Device(s)** is achieved during the same switching instruction. Some Earth Switches may be within the *Valve Hall* and inaccessible during switching. This method presumes that Earth Switches will be operated by telecommand from the site SCP, and subsequently checked and locked accordingly.

The switching instruction shall take the form;

On Pole 1; execute Pole Earthed command.
Check closed and apply lock to Earth Switches x,y. Confirm closed only Earth Switch z.

When removing those **Earthing Device(s)**, the switching instruction shall take the form;

On Pole 1, render operative Earth Switches x,y,z.
Execute stopped command.
Check open Earth Switches x,y,z.

Note: The correct sequence shall be discussed and agreed by all parties. There are two sets of sequence controls for Pole Sequences and Station Sequences respectively. There are Earthing sequences in both Pole and Station Control.

If either party is unable to agree what **Equipment** is expected to operate when automated sequences are commanded, switching must be carried out manually using the method described in NSI 1. This Appendix serves only to facilitate the use of automated switching sequences. Manual switching may still be carried out where preferred.

Where a switching sequence fails to complete, the cause shall be evaluated and the switching instruction cancelled. Manual switching may then be required to complete the instruction / sequence.

Sellindge Bridge Converter Station

Switching Sequences

As the Sellindge *Converter Station* was built in the 1980's the philosophy for interlocking and therefore *Valve Hall* access was derived from the then agreed standard design criteria, therefore compatible with NSI 1 & 2. The standard isolation and earthing required to gain access to all areas is detailed in site specific procedures.

There are two aspects of this overall philosophy that should be noted.

1. At the time of construction it was normal for Safety Document recipients to view the earth switches from their point of work. Consequently, the current on-site procedure for a Safe System of Work is to establish the **HV** isolation and earthing for a *Valve Hall* then issue an **Earthing Schedule** to apply the Converter Transformer valve hall side earth switches and *Valve Hall* side **HV**DC through wall bushing earth switch. These *Valve Hall* side earths ensure the mechanical interlocks are satisfied and therefore allow the doors into this **HV** Compartment to be unlocked.

2. The 2012 *Valve* Replacement Project allowed partial updates to the **HV**DC Switchgear controls. These allow only the **HV**DC switchgear associated with the *Pole*s to be automatically configured in *Pole* or *Bipole* modes.

3. There are no interlocks between the Sellindge and Les Mandarins *Converter Station*s. All isolation and earthing for a *Bipole*, *Pole* or Cable circuit must therefore be completed in agreement with the French and UK *Converter Station* Operators. The basis of these co-ordination requirements are set out in the agreement within the operational document known as "The Pink Version". (RISSP Process)

Note: Refer to onsite Operational Procedures for detailed site specific diagrams, configurations and switching sequences.

Appendix C – Marine Fault Location Techniques

The Procedure for identifying the cable may include, but is not limited to using:

- Time Domain Reflectometry (TDR).
- Signal / Tone Generator cable locator.
- The cable route GPS markers marked on charts.
- Identification of *Poles.*

Time Domain Reflectometers (Echo-Meters)

This kind of equipment is used for pre-localisation of faults with precision of a few percent of the cable length and is carried out from an onshore cable termination.

In most cases this is enough to determine the method of repair and the relevant vessel and equipment. It may be necessary to conduct TDR tests from both ends of the cable system to improve accuracy. It may also be desirable to carry out TDR tests from the vessel.

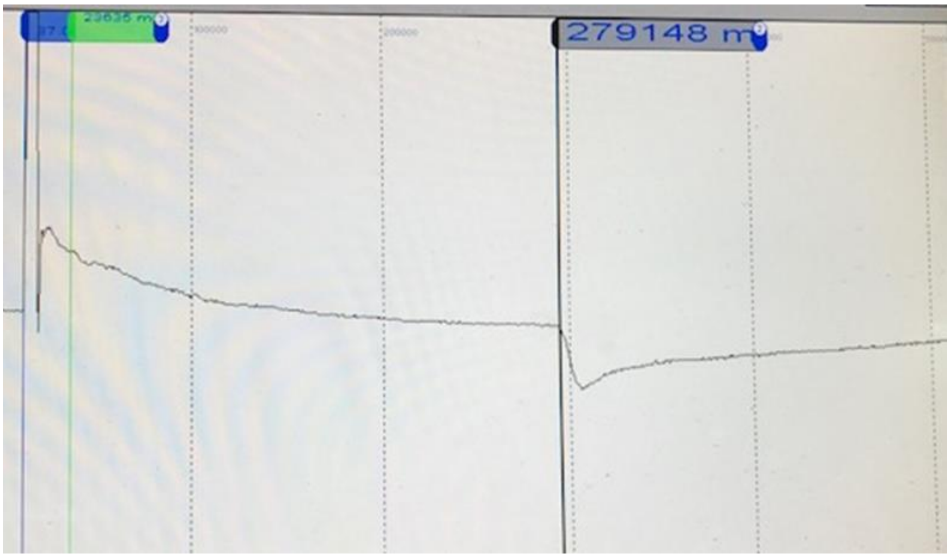


Figure 1: Example TDR trace from a defective cable

Alternative techniques such as Murray Loop and Varley Loop can be used; to more accurately pinpoint problem areas but require a healthy parallel cable.

Signal / Tone Generation Cable Locator

To locate submarine cables on the sea bed and to measure the burial depth; a method used is to inject a signal of suitable amplitude and frequency into the cable.

A suitable device [for example a Remote Operated Vehicle (ROV) in deep waters] will be moved close to the sea bed. The probes installed on it will detect the magnetic field created by the injected signal. Then a signal conditioner will analyse the detected field and will evaluate the position of the cable and its burial depth. A typical signal generator may have an output of 20A, 250V and 10-20Hz. The tone may need to be injected from both ends of the cable to locate the suspected area of fault.

Figure 2: A Typical ROV being launched

Global Positioning System (GPS) and Markers

For offshore operations, it may be appropriate to refer to satellite based positioning systems such as GPS, it is now accurate to within a few metres. The GPS markers attached to the cable are used to identify its location. This can be used in conjunction with the signal / tone generator to establish a positive identification of an offshore cable.

An Example of *Pole* Identification

For the Sellindge Cross Channel Link and Western Link the outer most layer of the marine cable is covered with a black polypropylene sheath. Woven into the sheath for the *Pole* 1 cable is a single yellow stripe and two yellow stripes in the sheath for *Pole* 2 (as depicted in Fig 3).

Note: Spare cable usually has completely black sheath and dependant on the cable repair i.e. length inserted, one *Pole* or two *Pole* cable repair, the inserted sections are to be marked during the repair process as appropriate or recorded otherwise.

Methodologies for fault locations will be evaluated depending on circumstances, in order to find the best solution to be adopted. All viable solutions may be considered.

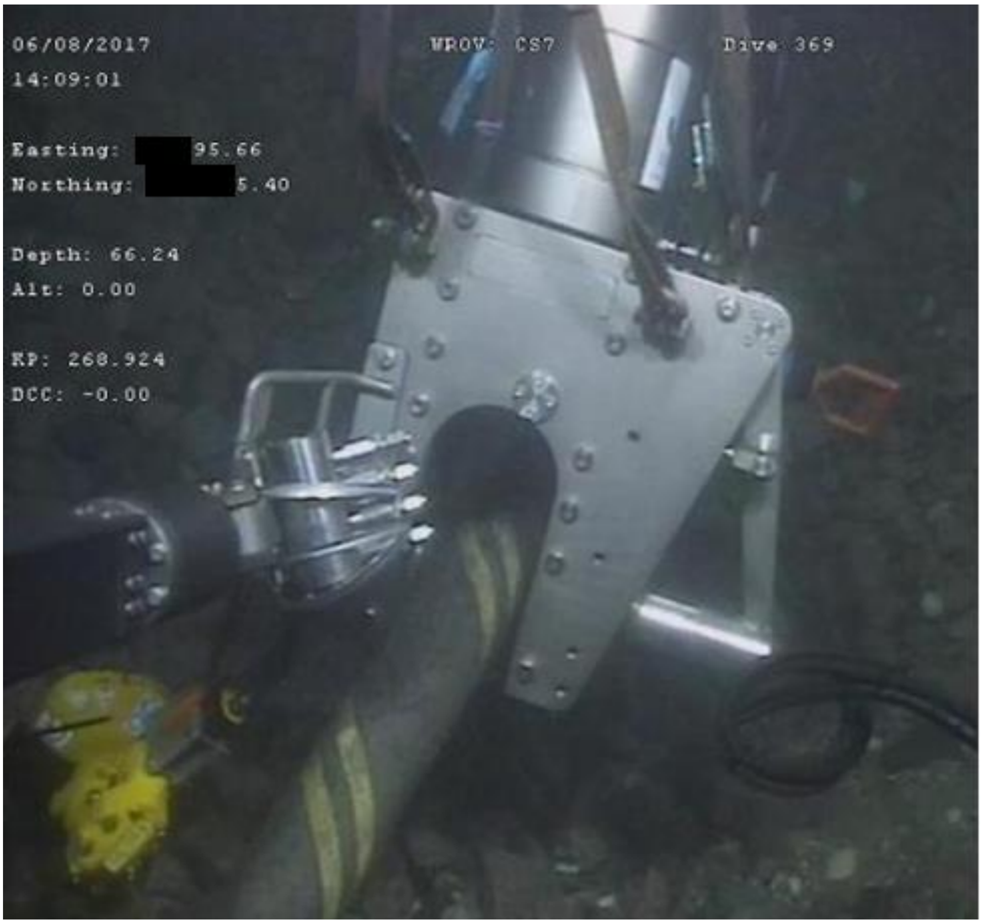


Figure 3: Pole Identification (example depicts a cable cutting operation)

<u>Additional Information</u>

<u>Western Link</u>

Submarine cable installation comprises bundled (paired) installation in shallow waters and segregated installation in deeper water. The routing, method of installation and location of segregated cables are defined on the cable records.

<u>Sellindge Cross Channel Link</u>

Submarine cables are laid in pairs for the whole of the submarine cable crossing. The routes are clearly defined on drawings and in addition are one kilometre apart, thus allowing positive location. Safety precautions at the *Converter Station*s in France and UK will isolate and earth a pair of cables for the whole route between *converter station*s.

Appendix D – Earthing Devices (Operational / Testing Configuration Usage)

Converter Station	Earthing Device(s) which may be operated under the instruction of CP(O)1
Flintshire Bridge 400kV	***Pole* 1** D101B2 (for OCT and OLT from FLIB) D101A1 (for OLT from HUCS) X111A (for OLT from HUCS, required as part of “AC side **Earthed**” to satisfy D101A1 interlocks) ***Pole* 2** D201B1 (for OCT and OLT from FLIB) D201A1 (for OLT from HUCS) X211A (for OLT from HUCS, required as part of “AC side **Earthed**” to satisfy D201A1 interlocks)

Appendix E - Authorisation Matrix for Personnel

Contractor **Personnel**	**Person**	**Competent Person**	**Authorised Person**	**Senior Authorised Person**	**Control Person Operations**	**Control Person Safety**
N/A	N/A	N/A	Section 1-4 Appendix B	All Sections	All Sections	All Sections

Contractors Personnel

Note: Contractors are not authorised to this NSI; instruction and information regarding site specific **HV**DC Safety Clearences should be communicated at site induction and contained within the NG **Safety from the System** RAMS as a minimum.

Contractors by law have a duty to provide a Safe System of Work for their employees.

National Grid have a duty in law to employ competent Contractors to undertake work on **HV**DC **Equipment** and provide them with National Grid's Safe System of Work to enable them to develop their own Safe Systems of Work.

National Grid Supply Chain Management processes ensure competent Contractors are selected.

Once a competent Contractor is selected, National Grid has a duty to ensure the contractor understands **Danger(s)** associated with undertaking work within a **HV**DC compound, permit systems, demarcation and safe access and egress, including movement of objects and vehicles etc. This is accomplished by contractors employees being authorised to National Grid Safety Rules, NSI 6 and NSI 8, via NSI 30 'Appointment of Persons' for work onshore.

The Contractor selected shall be an expert, as deemed by a contracted service providers agreement, in the area of working on **HV**DC **Equipment** and therefore there is no requirement for authorisation under NSI 27.

Before a **Safety Document** is issued the NSI 27 **Senior Authorised Person** shall establish **Safety from the System**. The Contractors Risk Assessment and Method Statement shall be reviewed by the **Senior Authorised Person** to ensure the **Danger(s)** identified in NSI 27 are suitably controlled.