

SHEATH BONDING AND EARTHING FOR INSULATED SHEATH POWER CABLE SYSTEMS

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PURPOSE AND SCOPE

This Specification forms part of a suite of documents that define National Grid requirements for new plant. The Level 2 Specifications for cable systems, TS 2.5, covers major requirements and there is a series of Level 3 Specifications covering various specific requirements.

This document is a Level 3 Specification giving the requirements for bonding and earthing of cable systems using cables specified in TS 3.5.1 and TS 3.5.2 (generally single core cables for a system voltage above 33 kV). This specification may also be used for specially bonded and earthed cable systems at voltages of 33 kV and below. Included within this specification are test requirements for bonding leads, earth continuity conductors and link housings. The technical requirements of sheath voltage limiters are covered in TS 3.5.3.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

1.1 Sheath Bonding and Earthing Arrangements

One of the following sheath bonding arrangements shall be adopted unless otherwise agreed.

1.1.1 Solidly Bonded

The cable sheaths shall be bonded together and earthed at each end of the circuit. At selected joint bay positions the sheaths may also be bonded together and where necessary earthed.

1.1.2 Single Point Bonded

The cable sheaths shall be bonded and earthed at only one point, this is normally at one end of the circuit. A circuit which contains joints may have its cable sheaths sectionalised to create a number of single point bonded systems or alternately a mixture of single and cross bonded systems (see clause 1.1.3).

The earth system at each end of the cable shall be connected by at least one earth continuity conductor running along the whole length of each single point bonded circuit. Earth continuity conductors shall be suitably positioned to minimise circulating currents in the earth continuity conductor during normal operation and minimise the zero sequence impedance of the cable circuit.

1.1.3 Cross Bonded

The sheaths shall be cross connected between phases at the sheath sectionalising positions to form major section(s).

Each single core cable shall be transposed at each sheath sectionalising position.

The cable sheath shall preferably be solidly bonded to a joint bay earth at each end of a major section, the requirements for joint bay earths are specified in TS 3.5.7. In any case the cable sheath shall be bonded to the earthing system provided at each termination. The functional performance requirements of specific substation and overhead line tower earthing systems may be obtained from National Grid on request.

1.1.4 Cable Systems That Are Not Three Phase Systems

While one of the bonding and earthing systems described above may still be used, the detail of the arrangement may need to be adjusted to meet specific project requirements. Typical project requirements additional to those described in the rest of this specification may include:

- Consideration of return current through the earth
- Need to manage the rise of earth potential

The project should review all project specific requirements and the requirements given in this specification to design a satisfactory bonding and earthing system.

1.2 Oversheath Testing

The sheath bonding and earthing shall facilitate oversheath voltage tests as specified in SCT 36 and subsequent maintenance oversheath voltage tests. The bonding and earthing shall be arranged so that the location of any oversheath faults can be located within a section of 3 km of single phase cable.

Note: The above requirement is normally achieved using sheath sectionalisation and sheath disconnection links at a maximum interval of 3 km.

Oversheath voltage tests as specified in SCT 36 and subsequent maintenance oversheath voltage tests shall not cause damage to any part of the cable system.

Where sheath voltage limiters are used, the bonding and earthing design shall allow the sheath voltage limiters to remain connected during the maintenance oversheath voltage testing. The maintenance oversheath test voltage shall be at least 4 kV.

Note: The test voltage is usually chosen in order to remove the need to take out the SVLs.

1.3 Links and Link Housings

Link housings are not required for links bridging sectionalising insulation on metalclad equipment as described in clause 1.7 or for areas of restricted access such as tunnels. All other links shall be housed in earthed lockable link housings. Where sheath voltage limiters are housed in a link housing, sheath voltage limiters and associated links shall be accommodated in a common housing. Link housings used shall meet the requirements of Appendix A.

The number of link positions should be minimised, as link housings are a potential hazard during internal cable fault conditions.

For underground link housings, the link housing shall be mounted horizontally and installed in a pit with access covers. The highest point (excluding lifting handles) of a pit-mounted link housing shall not be more than 500 mm below ground level.

Above ground link housings are preferred to underground link housings.

Where an above ground link housing is not located within an area of a substantial earth mat (e.g. outside a substation), the link housing carcass earth shall be separated from the earth connected to the cable sheaths. This shall be achieved using link housings with a separate carcass earth and detailed requirements for separate carcass earth link housing are given in Appendix A.

1.4 Bonding Leads and Earth Continuity Conductor

Joints in bonding leads are not acceptable in new installations, but may be used in subsequent modifications to the cable system.

Bonding leads and Earth Continuity Conductors used shall meet the requirements of Appendix B.

Where more than one bonding lead is brought into a link housing, the leads shall be marked so that in conjunction with drawings the various leads can be identified.

1.5 Maintenance to UK BP/SE/NSI 5

Note: Currents and voltages may still be present on components of cable systems when they are out of service. UK BP/SE/NSI/NSI 5 includes more information on the subject.

When considering Cable Systems maintenance, a written safe system of working must be provided as part of the Type Registration, including specifying any tools and equipment used along with their necessary test requirements. The maintenance shall include oversheath voltage testing, sheath voltage limiter testing and sheath voltage limiter replacement. To facilitate this, the cable sheath may need to be connected to earth for extended periods of time, and each section of sheath needs to be able to be earthed separately.

The general and performance requirements assigned to temporary bonding leads for use in link boxes and pillars to facilitate maintenance is detailed within Appendix C.

1.6 Metalwork at Joints and Terminations

The cable sheath shall be isolated as far as practical from other metalwork associated with terminations or joints to allow the metalwork to be permanently earthed.

Note: Typically outdoor terminations are on pedestal support type insulators, oil pipes use insulated couplings and metalclad terminations incorporate sectionalising insulation.

When the steady state voltage of metalwork at a termination exceeds 10 volts, exposed metalwork with the voltage and outside the safety distance shall be screened against accidental contact.

Note: For example, some of the base metalwork for outdoor sealing ends may require an insulating shroud while metalclad equipment may require alternative solutions.

1.7 Termination into Metalclad Equipment

The sectionalising insulation on terminations into metalclad equipment, where there is no transformer between the termination and the switchgear, shall be protected against induced transient voltages during switching operations.

Note: Suitable methods are sheath voltage limiters or short circuit links across the sectionalising insulation. Typically two or more connections shall be provided not more than 500 mm in length evenly spaced around the sheath sectionalising insulation. These links or sheath voltage limiters do not need to be enclosed by a link housing.

For any links or sheath voltage limiters across the sectionalising insulation, the arrangement shall be designed so that the link or sheath voltage limiter can be removed during maintenance without disturbing fixings of the accessory or GIS.

Note: in order to meet the requirements of clause 1.5, it may be necessary to use additional links housed in lockable link housings.

Note: if current transformers are fitted over the cables, it will not be possible to meet the requirements of clause 1.8 with earth straps and sheath voltage limiters across the sectionalising insulation are typically used. The cable sheaths can then be earthed using bonding leads and a link housing. The typical arrangement is shown in Figure 1.

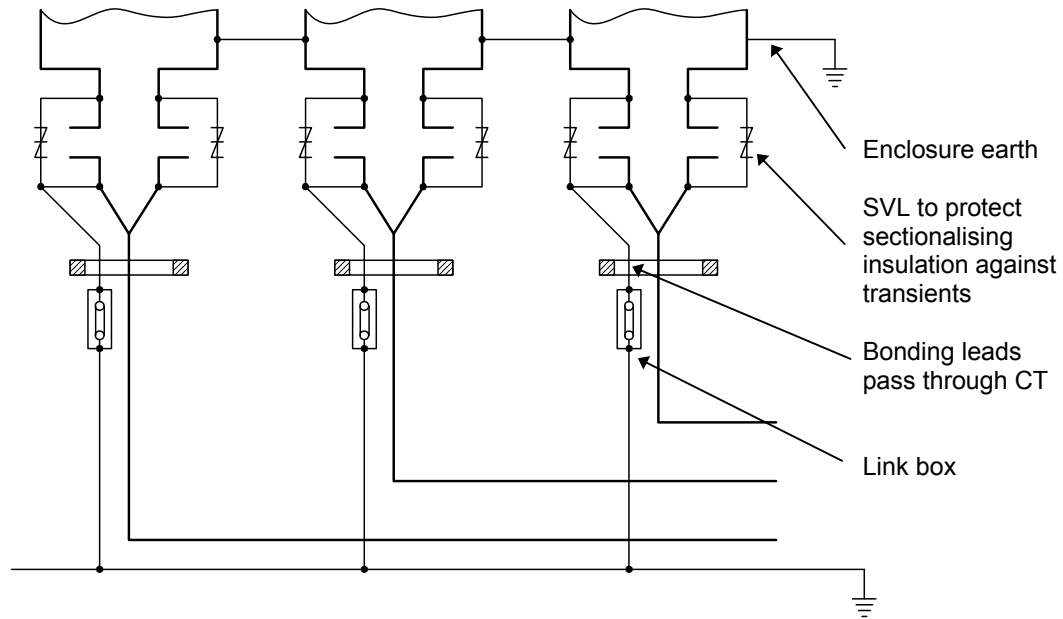


Figure 1 – Typical Arrangement at Metalclad Switchgear Termination with Current Transformers

By preference, unearthed cable sheaths should be avoided on terminations into metalclad equipment where there is no transformer between the termination and the switchgear.

1.8 Bonding Arrangement When Current Transformers are Installed

The bonding leads shall be arranged so that the current transformer shall measure the current in the power cable conductor and not the combined current of the power cable conductor and sheath.

1.9 Multiple Cable Circuits

Where a route comprises two or more circuits and/or two cables per phase each circuit and/or cable shall be designed for independent operation and have separate earthing and cross bonding arrangements.

For circuits comprising two cables per phase, the cables shall be laid so that the cables of the same phase are symmetrical about the centre point of the group (e.g. for cables in flat formation RYB, BYR).

2 PERFORMANCE REQUIREMENTS

2.1 Induced Transient Sheath Voltages

The bonding and earthing design will ensure that any induced transient sheath voltages will not exceed the rating of the cable oversheath, joint sheath sectionalising insulation, bonding leads, link housings or any other part of the cable system.

To ensure that induced transient sheath voltages do not exceed equipment ratings sheath voltage limiters may be used and requirements for sheath voltage limiters are specified in TS 3.5.3.

Note: Typically sheath voltage limiters are installed at:

- i. *joints at cross bonded positions and unearthed positions*
- ii. *unearthed terminations into metalclad equipment, where there is no transformer between the termination and the switchgear (see clause 1.7)*
- iii. *unearthed terminations of all other types of termination other than ii. above on systems operating at a voltage of 132 kV or above*
- iv. *earthed terminations into metalclad equipment, where there is no transformer between the termination and the switchgear and current transformers are installed around the cables (see clause 1.7)*

Assessment of induced transient sheath voltages shall include the length of bonding leads.

Note: Typically concentric bonding leads are used to minimise the impedance of the bonding lead and the length of leads is kept to a minimum (under 10 m).

2.2 Induced Power Frequency Sheath Voltages and Currents

Induced short circuit sheath voltages shall not exceed the rated sheath voltage limiter withstand voltages or that of any other part of the cable system during normal, emergency or through fault conditions.

It is recognised that induced short circuit sheath voltages during internal cable faults may exceed the rating of parts of the cable system, particularly the sheath voltage limiters. However any consequential failure shall be contained so that it does not pose a health or safety risk.

Induced sheath voltage calculations shall be carried out as described in CIGRE Technical Brochure 283.

2.3 Short Circuit Current Carrying Performance

Unless otherwise specified by National Grid, the cable system design shall be such as to ensure that there is a continuous metallic return path of adequate cross section for the short circuit current specified for the circuit.

Sheath voltages during single phase to earth short circuit conditions are greatly affected by the grounding resistance at the cable terminations. The cable installer shall be responsible for ensuring that the sheath voltage limiter rated voltages shall not be exceeded during the external single phase to earth short circuit conditions.

Except for connections to sheath voltage limiters at unearthed positions, the link connections and bonding leads shall be capable of carrying the maximum short circuit current specified for the circuit, without sustaining any permanent damage.

2.4 Sheath Voltage Limiters in Series

Where sheath voltage limiters are in series, unless the sheath voltage limiters are matched units, one of the sheath voltage limiters is likely to be subjected to a higher voltage than the other. Therefore where matched sheath voltage limiters are not used the matched design sheath voltage limiter rated voltage shall be increased by 20% to compensate for any such imbalance.