

INSTALLATION REQUIREMENTS FOR POWER AND AUXILIARY CABLE

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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 the installation of power cables, their accessories and associated auxiliary cables.

PART 1 – PROCEDURAL

1 GENERAL REQUIREMENTS

All work shall comply with the New Roads and Street Works Act 1991, associated Codes of Practice and Water Resources Act.

All work shall be subject to the Construction (Design and Management) Regulations 2007 (CDM).

Note: Refer to UKBP/TP137 for details on implementation of CDM.

1.1 Induced Voltages

Note: Power and auxiliary cables which are isolated from the system can have voltages or currents induced in them from adjacent live HV cables or may have transferred rise or earth potentials.

Where the possibility of dangerous voltages or currents exists, working arrangements as described in NSI 5 shall be adopted. All such arrangements shall be subject to National Grid approval.

1.2 Fire Precautions

Special measures may be required to prevent or minimise the outbreak or spread of fire, when designing and constructing cable tunnels, cable bridges, cable basements and substations.

Note: Refer to TS 3.1.3 and TS 3.5.12 for further information.

1.3 Cable Reference Numbers

Each length of power and auxiliary cable shall be allocated a distinctive and separate manufacturers reference number. This number shall be used on all appropriate test sheets and other documentation.

1.4 Cable Route

National Grid shall be responsible for determining the cable route unless otherwise stated in the National Grid Enquiry Document.

National Grid shall agree the position and excavation of trial holes along the proposed cable route(s) and in particular to fix joint bay and auxiliary equipment positions.

Where specified by National Grid special precautions shall be taken when working in the vicinity of trees as set out in BS 5837.

1.5 Depth of Cover

The minimum depth below the surface of the ground to the top of the protective covers over the power cable shall be:

- a) AC System Voltage up to 132 kV: To be agreed with National Grid.
- b) AC System Voltages 132 kV and above and HVDC Systems.
 - (i) In roads 750 mm
 - (ii) Across good agricultural land 900 mm
 - (iii) Across open countryside 750 mm
 - (iv) Footpaths or grass verges 600 mm
 - (v) Across substation sites (unless surface trough) 600 mm
 - (vi) Under railways 1400 mm
 - (vii) Alongside and within 2 metres of a railway or tramway 1250 mm
 - (viii) Special Constructions (Bridges etc) To be agreed with National Grid.

1.6 Circuit Separation

For directly buried cable circuits, to enable a cable circuit to be repaired while other cable circuits remain energised, either there shall be a minimum separation of 450 mm between each circuit or some other form of physical separation shall be provided.

Obstructions

No diversions of utility services or alterations to buildings shall be undertaken without the prior written agreement of National Grid.

1.7 Cable Backfill

The cable backfill material shall meet the requirements given Appendix B.

Prior to backfilling, National Grid shall be given the opportunity to inspect the installation of cable and accessories.

Where there is a risk of backfill movement, due to the action of water or soil subsidence, any necessary precautions shall require the agreement of National Grid, examples of such precautions include:

- a) A stabilised backfill such as cement-bound sand.
- b) A trench lining such as TERAM or equivalent material.
- c) Piling a concrete raft.

A minimum backfill thickness of 75 mm shall be provided above, below, and alongside the cables, extending the full width of the trench and up to the protective cover.

Power rammers shall not be used for compacting backfill.

1.8 Cable Protection Covers

All laid direct buried power cables and where possible all power cables installed in ducts shall be protected from external damage by cable protection covers. Cable protection covers may either be manufactured from reinforced concrete or from a polymeric material. Reinforced concrete cable protection covers shall comply with BS 2484. Polymeric cable protection covers shall comply with the requirements of Appendix A of this document.

Where a stabilised backfill is used, the complete width of the backfilled area shall be covered by cable protection covers.

The width of the cable protection covers shall be such that there is a minimum 50 mm overlap on each side of the cable or outside cable of a group of cables. If more than one cover is to be used across the width of the cables the joint between covers shall lie above the space between the cables and not over the cables.

1.9 Identification Tapes

Identification warning tapes shall be laid 100 mm above the cable protective covers. The tapes shall be a minimum of 2.5 mm thick.

1.10 Ducts

All duct installations shall meet the mechanical requirements of the cable system.

Duct installations shall comply with the following:

- a) The internal bore and radius of any bends shall not be less than that specified by the cable manufacturer.
- b) Non magnetic materials shall be used for single core AC cable installations.
- c) Duct joints, cable seals and duct mouth seals shall be designed to prevent the ingress of moisture, other materials and vermin.
- d) Ducts shall have a smooth internal face and comply with current British standards where applicable.

For plastic ducts, the duct shall be marked “ELECTRIC CABLE DUCT” and “MFR” as specified below:

- a) “MFR” shall be replaced by manufacturer’s reference;
- b) minimum print size of 6mm for ducts of 50mm outside diameter and less;
- c) minimum print size of 8mm for ducts of more than 50mm outside diameter;
- d) the marking shall be repeated three times per metre;
- e) the marking shall be on two print lines, 180° apart.

During installation the ducts shall be brushed clean.

During installation a draw line, or pulling wire, shall be installed. This draw line shall be made of a corrosion proof material and may be expected to last up to 40 years.

When the cable is not drawn in immediately the ends of the duct shall be sealed.

All ducts crossing roads shall have a full concrete bed and surround, made with concrete of minimum strength grade C20/25.

To facilitate the drawing in of the cable duct shall be cleaned and, where necessary, the cable lubricated.

Where cables leave ducts to enter a cable trench a permanent support shall be provided subject to agreement from National Grid.

Where the cable system design requires the ducts to be filled a bentonite-sand-cement mixture shall be used. An alternative material may be used to fill the ducts subject to agreement from National Grid.

For long duct runs where it may be necessary in the future to locate sheath faults, the installer shall demonstrate that a technique exists that would enable the location of a sheath fault to within a reasonable short length.

1.11 Troughs for Cables

Cast-in-situ concrete troughs shall be subject to agreement from National Grid.

Where troughs are to be unfilled the power cables shall be restrained to prevent movement.

1.12 Supports, Racks, Cleats and Trays

All proposals for the supporting and fixing of cables are subject to agreement from National Grid.

Cleats and/or cable straps for single core AC cables shall be non-magnetic and be suitably spaced to withstand forces and prevent damage to the cable during normal and short circuit conditions.

1.13 Joint Bays

Note: Requirements for joint bays in tunnels are specified in TS 3.5.12.

Cable joint bays shall be provided with a cast-in-situ concrete raft, made from strength class C20/25 concrete, not less than 150 mm thick and with sufficient reinforcement to satisfy the cable system design requirements.

To facilitate pumping, the raft shall be provided with adequate sump facilities.

The cable shall be suitably supported from the joint to the cable trench to prevent possible strains at the joint entry due to cable settlement.

For oil-filled cable systems, joint bay liners shall be installed. For oil-filled cable systems, access conduit shall be installed. See TGN 100 for details of both these design requirements.

1.14 Cable Termination Support Structures

The thermo-mechanical design of the cable termination support structures shall satisfy the cable system design requirements.

1.15 Oil Tanks for Oil-Filled Cable Systems

The position of oil tanks shall be subject to agreement from National Grid. To minimise risk of damage to oil feed pipes, oil tanks shall normally be as close as practicable to the connection with the cable system.

Pressure tanks shall be bunded, where practicable, to minimise the risk of contamination of the surrounding area.

1.16 Multicore Cable

A remake loop not less than 1 metre in length shall be provided at the end of each multicore cable and each joint position.

The National Grid Enquiry Document shall state whether insulated glands are required and the type of termination required for each auxiliary multi-pair and multicore cable in accordance with one of the four methods below:

- a) Cable made off into cable gland only.
- b) Cable made off into the cable gland and cores tested.
- c) Cable made off into the cable gland, cores tested, identified and temporarily tagged.
- d) Cable made off into the cable gland cores tested, identified, laced out (as required) and finally connected to the terminals as required.

1.17 Bonding and Earthing

All metal pipes or conduit shall be bonded to the main earthing system.

Cable sheath bonding and earthing requirements for insulated sheath cable systems are specified in TS 3.5.4.

1.18 Marker Posts and Plates

Marker posts or plates are required where cables run across or along a railway, across agricultural land, change direction and at joint positions. National Grid may require marker posts at other locations to be agreed.

The position of all marker posts and plates shall be agreed with National Grid.

Where cables run under a railway, a marker plate with the Railway Crossing Marker Plate Label illustrated in Figure 3, bolted on top shall be provided either side of the crossing.

Where cables are laid on or under a bridge or cross over a railway line the Bridge Cable Route Marker Plate illustrated in Figure 4 shall be bolted to the bridge parapets or abutments as appropriate.

Labels indicating the circuit designation shall be installed at the ends of each route and also where specified by National Grid.

1.18.1 Plastic M4 Field Boundary Marker Posts

The plastic M4 marker posts, shown in Figure 12 shall be used wherever possible, instead of the concrete marker posts. The plastic marker post shall be manufactured from recycled high density polyethylene, coloured white with ultra-violet stabilisation added. This post shall weigh approximately 2.4Kg.

The post shall be 1m high, with 500 mm below ground,

The post can be secured in urban areas by installing a horizontal bar through a hole in the base, then backfilling. The post shall also be designed so that if cement is used to secure the post, the cement shall have good adhesion around the post base.

1.18.2 Concrete Marker Posts.

If plastic marker posts are considered unsuitable in certain cases then marker posts constructed from reinforced concrete can be used. The dimensions of the marker post are shown in Figure 1. The appropriate lettering shall be cast-in as indicated.

Where additional information needs to be displayed on a concrete marker post a supplementary plate shall be bolted to the marker. This shall be constructed from a sheet material such as aluminium coated with plastic film. The lettering height shall be a minimum of 5 mm and black on a white background.

1.19 Materials

The materials used shall be suitable for a design life of 40 years and meet the appropriate British Standards.

All ungalvanised iron or steelwork shall be provided with an oil and weather resistant coating to prevent any corrosion. The colour of the protective coating shall be agreed with National Grid.

All drilling of holes during iron or steelwork fabrication shall be carried out prior to galvanising.

1.20 Labelling

1.20.1 Labelling Terminations and Joints

For AC cable systems, the phase colours (red, yellow and blue) shall be permanently marked in a prominent position on cable boxes, tail ends and single-core cables, at all connecting points and at any other specified positions.

For AC and HVDC cable systems, each joint shall be permanently clearly labelled detailing the following:

Feeder Identification

Joint Number

Joint Phase colour (AC single core cables)

1.20.2 Plastic M4 Marker Posts

Pastic M4 marker posts shall have a notice on them to inform 3rd parties as to the nature of the hazard and who to contact prior to commencing works. The face plate should be constructed from 1 mm thick polycarbonate and attached to the plastic M4 marker posts in the recessed section using low density polyethylene push button fittings as shown in Figure 13. An example face plate is shown in Figure 14. The notice should be printed on a UV resilient, yellow background with black lettering.

1.20.3 “High Voltage Electricity Cables” Label for M4 Posts

A 300mm x 48mm “High Voltage Electricity Cables” Label, shown in Figure 15, shall be placed in the second recess below the face plate. It should be printed on self adhesive yellow vinyl with black lettering.

1.21 Route Records

1.21.1 General

The route records shall be provided as follows:

- a) All route records shall be created electronically in Computer Aided Design (CAD) format and in compliance with all requirements stated in TP 135 entitled ‘Management of Drawings (Electricity Assets)’
- b) Following completion of work and verification of drawing accuracy, all electronic master records shall be provided to National Grid together with supporting documentation in accordance with the timescales stated in TP135 for submission of final drawing records. The requisite sets of printed drawings shall be supplied in accordance with the contract.

1.21.2 Contents of Route Records

Example route records are shown in Figures 5, 6 and 7 and shall include records of the exact position of every joint, cable box, earth electrode and all connections, cable depth, arrangement of the cables and the position of every obstruction revealed during the course of excavations. The format/layout of these drawings shall be in accordance with TP135. The position of optical fibres, splices and any permanently fixed associated equipment shall be included. The length of the optical fibre(s) between the start of contact with the cable system and the end of the optical fibre(s) shall be clearly marked on the route records.

The exact position of each item shall include:

- a) The surface co-ordinates, relative to a specified Ordnance Survey datum and accurate to better than ± 1 m.
- b) The elevation to the top or the centre, clearly specified, of the item, relative to a specified Ordnance Survey datum and accurate to better than ± 0.1 m.

Figure 7 shows route cross sections and shall be included for every 5 m along the route and shall provide the depth from the ground surface to the top of the cable and the arrangement of the cables including their spacing. The position and details of any optical fibres for

temperature monitoring shall be included. All other relevant dimensions and details shall also be included.

The route records shall include a list of drawings applicable to the works.

The route records shall also include the following information:

- a) Straight line diagram as shown in Figure 8.
- b) Schematic diagram of bonding connections as shown in Figure 9.
- c) For oil-filled cables, the oil pressure settings and final profile as shown in Figure 10.
- d) Technical description of the cable and a fully dimensioned drawing of the cable cross section Figure 11.
- e) The operating and maintenance manual for the system.

1.21.3 Printed Copies

The printed copies shall each be bound in hard cover with the following clearly printed on the front:

- a) National Grid
- b) The Cable Route
- c) Contract Number
- d) Contractors Name and Address

All completed route records shall be made on a dimensionally stable approved material which shall be suitable for alterations without the use of chemicals.

Where practicable completed route records shall be made on material from recycled or renewable sources.

1.22 Earthing Requirement

1.22.1 General

The design of the earthing system shall satisfy the following requirements:

- a) To ensure mechanical strength and corrosion resistance.
- b) To withstand the maximum potential fault current.
- c) To avoid damage to property and equipment.
- d) To ensure personal safety by limiting earth potentials within the limits specified in Section 2.1.1.

1.22.2 System Design

Earth electrodes shall be designed to operate satisfactorily during faults, taking into account the area of the electrodes in contact with earth, the soil resistivity and earth electrode current magnitude and duration, in accordance with BS7430. The fault duration times to be used for rating the electrodes are 1 second for 275kV and 400kV and 3 seconds for all other voltages.

Cable joint bay earth electrode systems shall achieve an earth resistance not greater than 10 Ω. The earth resistance shall be measured as specified in BS 7430.

1.22.3 Installation

Where earthing conductors cross over or are laid parallel and touching either power or multicore cables, they shall be insulated at the point of contact to ensure that any potential rise of the earth conductor cannot damage the cable sheath.

Earthing conductors in air filled troughs shall be positioned so that any passage of fault current through them shall not damage any multicore or power cables.

Copper earthing conductors likely to come into contact with galvanised steel shall be tinned to prevent electrolytic action.

1.22.4 Conductors

For mechanical and electrical reasons the minimum cross section for copper earthing conductors shall not be less than 100 mm².

Aluminium conductors may only be used 250 mm or more above ground level.

Buried horizontal earth conductors should be installed at depth of not less than 500 mm below ground level so as to provide adequate protection against mechanical damage.

1.22.5 Joints and Connections

Connections between dissimilar materials shall be subject to agreement from National Grid.

Earthing conductor joints shall not have an impedance greater than the equivalent length of conductor which shall be demonstrated to the satisfaction of National Grid.

Exposed bolted earth connections shall be prevented from becoming loose by providing a double bolted connection.

To protect against corrosion, a heavy duty bituminous paint or equivalent shall be applied to all joints below ground level. Brazed joints shall be inspected prior to the application of the anti-corrosion coating.

1.22.6 Insulated Sheath Systems

At substations and cable sealing end compounds cable sheaths and/or SVL star points shall be bonded to the substation or compound earthing system.

At joint bays cable sheaths and/or SVL star points shall be bonded to an earth electrode system. A separate earth electrode system shall be provided for each circuit.

Note: Where alternative sheath bonding designs are used appropriate earthing methods shall be adopted.

The earth resistance of each electrode system shall be measured prior to any backfilling in the vicinity of the electrodes.

1.22.7 Pillars

Where the pillar is located within the area of an earth mat the latter and pillar carcass shall be bonded together.

Where the pillar is not located within the area of an earth mat, an equipotential area shall be provided extending for 1000 mm from each of the four sides of the pillar unless such sides are not accessible. The pillar carcass shall be bonded at two separate points to the equipotential conductors, and no other earth connection shall be provided.

Where metallic street furniture is located within the pillar's equipotential area, then consideration shall be given to the potentials to which this equipment may be subjected.

Where metal work inside an oil equipment pillar needs to be electrically isolated from the pillar carcass it shall be bonded together and connected to a common earth bar which is electrically insulated from the carcass. A normally open disconnecting link shall be provided to enable the common earth bar to be connected to the pillar carcass earthing system when work is to be carried out inside the pillar.

1.22.8 Oil Feed Pipes

For AC Systems, to prevent a closed loop being created to earth via the oil feed tanks, where oil feed pipes are to be fixed to the cable sealing end structures, then the pipework shall be insulated at the point of connection to withstand the voltages specified in TS 3.5.4.

1.22.9 Buried Structures

Link boxes and oil feed tanks to be sited below ground shall be connected to the SVL star point earth connection or sheath solid earth bond connection as appropriate.

2 PERFORMANCE REQUIREMENTS

2.1 Cable Earthing Systems

2.1.1 Potential Limits

The earthing system shall ensure that the potential body current shall not exceed the values detailed in IEC 60479 Figure 5 curve C1 corresponding to a 5% probability of ventricular fibrillation. HVDC systems shall adhere to the conservative AC guidance. In designing a safe system the following parameters shall be adopted:

a) Resistance of the Body and Footwear

Body resistance = 1 kΩ

Resistance per shoe = 4 kΩ

Based upon these parameters the appropriate step and touch resistances are as follows:

Current Path	Resistance (kΩ)
Touch Potential	3
Body – Footwear in parallel	
Step Potential Footwear – Body – Footwear	9

Table 1 – Step and Touch Resistances

b) Surface Resistance

Type of Surface	Surface Resistance per Shoe (kΩ)
Loose Chippings	2
Other Surfaces	Nil

Table 2 – Surface Resistances

In most cases the duration of fault currents on The National Grid System will be 200 ms or less and in these circumstances the following potential limits shall apply.

Type of Earth Potential	Maximum Limit on a Surface of Loose Chippings (V)	Maximum Limit on a Surface without Loose Chippings (V)
Transfer Potential	650	650
Step Potential	4500	3200
Touch Potential	1400	1050

Table 3 – Maximum Potential Limits

2.1.2 Bonding Connections

The connection resistance per mm shall not be greater than the resistance of conductor being joined to it. Where different conductors are being joined, the connection resistance shall not exceed the resistance of the conductor with the greatest resistance.

3 TYPE TEST REQUIREMENTS

Type test requirements are given in the appendixes of this document.

4 SAMPLE TEST REQUIREMENTS

Sample test requirements are given in the appendixes of this document.

5 SITE TEST REQUIREMENTS

Site test and inspection requirements are specified in SCT 36.

6 FORMS AND RECORDS

Forms are in Appendix D of this document.

PART 2 - DEFINITIONS AND DOCUMENT HISTORY

7 DEFINITIONS

The terms used in this document are defined in TS 2.5.

8 AMENDMENTS RECORD

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
1	November 1993	New document	Clive Ferguson Substations & Cables	Mike Humphries General Manager, Technology and Science Division
2			Clive Ferguson Substations & Cables	Mike Humphries General Manager, Technology and Science Division
3	October 1994	Changes to 3.4, 3.17, 3.22.2, 3.22.5, 3.22.7. New clauses 3.14 and 3.9	Clive Ferguson Substations & Cables	Mike Humphries General Manager, Technology and Science Division
4	July 1999	Changes made to take account of style, type registration, site testing reports moved to NGTS 2.5, change of IEC numbers, precautions for backfill handling added, route record requirements modified	Clive Ferguson Substations & Cables	John Scott General Manager, Engineering and Technology
5	September 2002	Requirements revised. Reference to NGTS 3.1.3 added (TP 10/11 removed)	Linda Desmond	Mike Dean Asset Strategy Manager
6	April 2011	Reformatted to new TS document format Various minor editorial changes References updated Section 1.1 on induce voltages reworded Section 1.5 modified to apply to HVDC systems. Section 1.6 on minimum circuit separation added Section 1.9 changed to allow polymeric cable protection covers and scope changed to buried and ducted cables only Section 1.10, the requirement for the identification tape to be a minimum of 2.5 mm added. Section 1.11, requirement for cement around ducts limited to road crossings only and requirement to be able to locate sheath faults added. Also removed requirement that ducts only to be installed by agreement. Also added duct marking requirements. Non-magnetic requirement made AC specific. Section 1.13 Non-magnetic requirement made AC specific. Section 1.14, the requirement for oil sensors removed and the access conduits made obligatory. Section 1.16, bunds only required for above ground tanks. Section 1.21, modified to be AC specific for phase colour. Section 1.24.7, link pillar earth mat requirement changed to agree with SCT 36. Section 1.24.7, removal of the requirement for an interlock on the insulating screen on a link pillar. Additionally removed duplicate requirements already in TS 3.5.4. Section 1.24.8, modified to be AC specific Section 2.1.1 modified to include HVDC. Appendix A added to give requirements for polymeric cable protection covers Appendix B on backfill added to collect together backfill requirements. Figure E1 to E3, removed company name from marker posts and plates	Francis Waite Asset Policy, Asset Management	David Wright Electricity Network Investment Manager, Asset Management