NSP/007/031 - Guidance on Substation Design: Multicore and Multipair Cables

1. Purpose

The purpose of this document is to provide technical guidance to all parties involved in the design and application of multicore and multipair cable installations in Northern Powergrid substations.

This document supersedes the following documents, all copies of which should be destroyed.

Reference	Date	Version	Title
NSP/007/031	May 2019	1.0	Guidance on Substation Design: Multicore and Multipair Cables

2. Scope

This document applies to secondary cables in distribution substations used for protection and control purposes and LV power distribution. It includes specific requirements for SCADA communication and pilot cables to remote substations. It also sets out the requirement for installation contractors to provide block cable diagrams, cable schedules and core sheets and gives guidance on methods of installation.

2.1. Table of Contents

3. Design Guidance on the Application of Secondary Cables

3.1. Use of Multicore Cables in Protection & Control Applications

Note that the detail in this Section (3.1.x) does not relate to multicore cables used for 400V and 230V power distribution or to multipair cables - these are dealt with in later Sections.

3.1.1. General Design Rules

All multicore cables for protection and control purposes shall conform to the current issue of NPS/002/018. All cables run in trenches or on cable tray/rack must be of the Steel-Wire-Armoured (SWA) type, and must use black coloured insulated outer sheath.

For all general light current applications (e.g. CTs and VTs, protection and control, local alarms, interlocking, etc) where technically permissible, ENATS 09-06 compliant cable shall be used, i.e. PVC insulated cables with cores of Cross-Sectional-Area (CSA) of 2.5mm^2 with white coloured core insulation and black core numbering. The core construction shall be of 7/0.67mm (7 strands of 0.67mm diameter).

In most applications, a core CSA of 2.5mm^2 is sufficient, but it is recognised that in some applications on larger sites, DC volt drop or CT burden issues may give rise to the need for multicore cables with larger Cross-Sectional-Area (CSA). In such (non-power-distribution) applications, PVC or XLPE insulated cable is acceptable, but where the inner cores of such cable are not white (i.e. 4c phase coloured cable), the inner cores shall be sleeved white and black cable core-number markers applied. This situation arises due to the fact that multicore cable with CSA greater than of 2.5mm^2 is not readily available with white insulated cores, but functionally the cores should be white (i.e. general light current/protection applications including CT and VT circuits).

The multicore cabling design shall be as simple as possible, and should aim to minimise route length and to rationalise the overall number of cables required.

For new-build substations, preliminary attention needs to be given to the secondary cabling design (in conjunction with the Civil designers) to ensure that the substations trench and duct design adequately accommodates the optimal cabling design.

A good example of this occurs at outdoor sites, where the multicore cables carrying the busbar protection CTs should run between bays rather than from each individual bay to the busbar protection relay panels (see section 3.1.8). This reduces the burden on the busbar protection CTs and reduces the extent to which secondary fault current flows in the cross-site multicores.

Apart from busbar protection, where practicable, multicore cables should be run direct between plant/switchgear and its associated Control/Relay panel. For example, the multicores from any given 33kV switchgear panel should be run direct to its respective 33kV relay panel, e.g. for a suite of panels there should be no ‘cross cabling’ of say CB 504 to relay panel 507 etc.

3.1.2. Number of Cores / Core Markers

The standard number of cores in all multicore cables shall be as follows:

2c, 4c, 7c, 12c, 19c or 27c.

Wire number markers (ferrules) shall be fitted to all cores, and apart from instances of double-ferruling (which should be minimised) all cores shall be ferruled the same at each end. These markers shall be black text on white background and shall comply with ENATS 50-19, and should read outwards from the point of termination.

Acceptable ferrule types include interlocking ‘Z’ type individual characters or pre-printed labels in suitable clear plastic sliding label carriers. Northern Powergrid reserves the right to reject ferrules which are deemed to be non-legible, subject to fading or otherwise not fit for purpose.

The active cores shall be terminated starting with the highest core number, such that the lower core numbers are allocated to the unused cores (e.g. core 1 will end up as 'U1').

3.1.3. Core Sizes / Paralleling of Cores

Where any cable greater than 2.5mm^2 is used in light current applications, the Contractor shall submit Voltage Drop / Burden calculations to Northern Powergrid, verifying the requirement for cable CSA being greater than 2.5mm^2.

As necessary, core sizes shall be specified as follows:

2.5mm^2, 4mm^2, 6mm^2, 10mm^2, 16mm^2 or 25mm^2.

Although the practice of paralleling cores (to achieve an effective overall CSA) is not precluded, this is deemed non-standard and should be approved by Northern Powergrid during the design phase of any given project.

3.1.4. Spare Cores

All new multicore cables with more than 7 cores shall be specified with at least 20% spare capacity (after rounding up) for future use. E.g. a 19 core cable must have at least 4 spare cores after completion of all As-built drawings.

All spare cores will be labelled with 'U' numbers (in line with ENATS 50-19)as defined by the Contractors core-sheets.

3.1.5. Segregation of Signal Types

CT and VT circuits may be run together in the same cable, but neither CT nor VT signals shall be combined with protection DC circuits.

It is acceptable for multiple CTs and VTs associated with the same circuit to be run in the same cable (e.g. Main and Back-Up CTs and VTs from 33kV feeder CB to the associated relay panel).

Where practicable, Metering CT and VT circuits shall use dedicated cables.

Multicore cables carrying DC protection functions may also accommodate cores for non-protection associated AC and DC functions (e.g. local alarms, 110V AC indications, interlocking etc), but these cables must not contain circuits intended for power distribution (e.g. heater supplies, LVAC supplies etc), pilot circuits or other communications type functions.

It is acceptable for 110V AC and 110V DC functions associated with Voltage Control to be combined in one composite cable where required, e.g. between a Primary Transformer Tapchanger and its associated AVC relay panel.

It is acceptable for multicore cables to carry DC signals of differing voltage levels (e.g. 110V DC and 24V DC), but multicore cables shall not be run directly to the substation RTU for SCADA signal purposes (see Section 3.3).

3.1.6. 110V DC Supplies

Refer to NPG drawing:

Y028S1167 Typical Cabling Distribution of 110V DC Supplies to Switchgear and Relay Panels in Supply Point and Primary Substations

3.1.6.1. Trip / Close Supplies

As shown on Y028S1167, the 110V DC Trip and Close supplies to HV switchboards shall be arranged radially, with one radial feed from the 110V battery per Section of switchgear. The associated cables from the 110V battery shall terminate in the respective transformer switchgear panels; bus-wiring within the switchboard will be distributed to the supplies per Section (e.g. 1J1, 1J2 for Section 1, and 2J1, 2J2 for Section 2).

The transformer HV switchgear panel will be equipped with a 16A Protection/Control fuse and link, from where the K1 and K2 associated with the Transformer HV protection supplies will be cabled to the respective transformer protection relay panel.

In EHV applications, the 110V DC Trip and Close Supplies shall be arranged in a ring, but again using a single (32A) fused way on the 110V battery distribution board. The associated cables from the 110V battery shall terminate in the respective transformer protection relay panels; bus-wiring within the relay panel suite will be distributed the supplies per Section (e.g. 1J11, 1J12 for Section 1, and 2J11, 2J12 for Section 2).

3.1.6.2. Switchgear Actuation / Spring Charge Motor Supplies

It should be noted that the 110V DC Closing supplies for HV switchboards (where necessary) should form a radial (bus-wired) arrangement, using the HV Bus-Section/Bus-Coupler panel as a point of interface for the associated cabling from the 110V battery.

For EHV switchgear, the 110V DC Closing/Spring Charge Motor supplies shall form a ring arrangement, with suitable isolation facilities at each device.

For 66kV and 132kV outdoor bays, it is acceptable that the ring isolation facilities are provided within the bay MK rather than at each individual device in the bay.

3.1.6.3. Common 110V DC Supplies / Common Alarms

At conventional Supply Point and Primary type substations, the Bus-Section/Bus-Coupler relay panel is often used to provide a marshalling point for common facilities such as Alarm/Indication 110V DC supplies as shown in drawing Y028S1167.

The Bus-Section/Bus-Coupler/Bus-Coupler panel may also provide Common Alarm facilities, and so will have multicore cabling to it direct from common equipment such as Battery Alarm Modules etc.

3.1.7. Cabling to Outdoor Switchgear

3.1.7.1. Use of Bay Marshalling Kiosks (MKs)

At 132kV sites, bay MKs will normally be provided. These kiosks shall be used to provide a marshalling point for all multicore cabling between the plant in any given bay (CB, disconnectors, earth switches, instrument transformers etc) and the associated Control/Protection panels in the Control building. All associated signals from each device, including CTs, VT, Trip and close, alarms, Status indications etc shall be run via the bay MK.

Cabling associated with site supplies, e.g. heater rings (110V AC), CB closing/spring charge circuits (110V DC), LVAC supplies etc shall be routed via each bay MK, where appropriate isolation facilities shall be provided.

Where bay MK’s are employed at 66kV sites, the principles described above (for 132kV sites) should be observed.

Where bay MK’s are not employed, it is preferable to use the circuit breaker mechanism box as a marshalling point for all multicore cabling from the other devices in the bay, thereby rationalising the cabling running across site to the Control Room.

3.1.7.2. Cabling of Switchgear Status Indications

Plant status indications can be run in composite multicore cables (e.g. those containing DC protection/control, alarms etc) and should be provided from each device in the bay to the bay MK or CB (as above). Separate multicore cabling will then run from the common outdoor kiosk to the associated bay 66kV or 132kV Control/Protection panel.

Supervised Status Repeat relays will be provided in the Control/Protection panel, providing contacts wired to provide local and remote (SCADA) status indications.

Cabling to the RTU will be via multipair cable as detailed in Section 3.3.1.

3.1.8. Busbar Protection Circuits

For metal-clad switchgear, the CT circuits for high impedance type busbar protection shall be paralleled together, (phase-by-phase) at the switchgear itself. For outdoor switchgear, the CT circuits shall be either paralleled at the switchgear or at the associated bay marshalling kiosk if the latter exists. Associated CT disconnect and short links shall be fitted at each CT location (e.g. CB or adjacent bay marshalling kiosk if latter exists).

At outdoor sites, where both Discriminating and Check Zones are provided, the CTs shall be connected in a closed ring formation. The ring should be designed to minimise the CT cabling, based on physical site layout.

The resultant CT connections per Zone (Red, Yellow, Blue and Neutral) shall be cabled directly from the ring to the associated busbar protection relay panel and not via any intermediate relay panels.

Busbar protection DC trip connections should be direct between the individual circuit in question and the busbar protection equipment. These must not be routed via any other circuit panel. This also applies to circulating current protection for single section EHV busbars.

3.1.9. Cable Glanding/SWA Earthing

All multicore cables shall be terminated by means of brass compression glands type using E1W type glands for both indoor and outdoor applications, providing IP66 ingress protection to BS 6121.

All cable armours on all multicore cables shall be earthed at both ends and in all cases earthing tags (banjo rings) shall be provided on the internal part of the cable gland (i.e. inside the enclosure). All tags shall be bonded to the associated earth bar/stud using 2.5mm^2 green/yellow wire, using blue ring crimps and nut-and–bolt type screw connections.

This earth bonding shall be provided in a ring arrangement, such that the disconnection of any one earthing conductor does not leave any cables un-earthed.

3.2. Use of Multicore Cables for 400V and 230V Power Distribution

3.2.1. General Design Rules

All multicore cables for LVAC power distribution purposes shall conform to the current issue of NPS/002/018.

All multicore cables used for 400V/230V AC power distribution shall be dedicated to this function, e.g. must not contain cores providing any functionality other than power distribution.

These may be of greater cross section than 2.5mm^2 as required for both current carrying capacity and acceptable voltage drop at the final loads.

All single phase and three-phase cables shall have the appropriate phase coloured core insulation (brown, black, grey, blue) and may be PVC/PVC/SWA/PVC type to BS6346 or

XLPE/PVC/SWA/PVC type to BS5467.

3.2.2. Number of Cores / Core Markers

Multicore cables used for 400/230V AC power distribution shall be 2c, 3c or 4c.

Wire number markers (ferrules) should be applied to the coloured cable core insulation of those cables associated with Protection and Control applications such as transformer cooler motor supplies, battery chargers, bund pumps etc.

However, core ferrules shall not be fitted in the case of main power distribution applications such as auxiliary transformer to LVAC board connections, domestic heating and lighting, small power etc.

3.2.3. Core Sizes / Paralleling of Cores

Where any cable greater than 2.5mm^2 is used, the Contractor shall submit Voltage Drop / Burden calculations to Northern Powergrid for comment.

As necessary, core sizes shall be specified as follows:

2.5mm^2, 4mm^2, 6mm^2, 10mm^2, 16mm^2 or 25mm^2, 35mm^2 or 50mm^2.

All new multicore cables for power distribution should be designed correctly, catering for any reasonable future loading; hence the paralleling of cores in power distribution applications is not acceptable.

3.2.4. Cable Glanding/SWA Earthing

All LVAC power distribution cables shall be terminated by means of brass compression glands type using E1W type glands for both indoor and outdoor applications, providing IP66 ingress protection to BS 6121.

The gland size fitted shall be that specified by the cable manufacturer and is dependent upon core CSA and number of cores. Earthing tags shall again be provided and all SWA bonding will be completed as specified in 3.1.9.

3.3. Use of Multipair (Light Current Control) Cable for SCADA Purposes

For clarity, here the term ‘Multipair’ cable is synonymous with the wider industry applied terminology ‘Light Current Control’ cable. Note that the detail in this Section (3.3.x) does not apply to Pilot cables (e.g. those that run between substations) nor does it apply to the use of screened cables, fibre optic, or other special cables; these are covered in later Sections.

3.3.1. General Design Rules

All multipair cables for SCADA purposes shall conform to the current issue of NPS/002/018 and shall be compliant with the latest version of ENATS 09-06 and shall be PVC/PVC/SWA/PVC type without individual or collective screens.

All multipair cables used for SCADA shall be dedicated to this function, e.g. must not contain cores providing any functionality other than SCADA, and it is therefore considered that all multipair cables will terminate at the substation RTU.

Although multipair cables may be run from any device to the RTU (e.g. from switchgear panel, control/protection panels, batteries, intruder alarms etc, in general it is not preferable to run multipair cables direct to/from the substation RTU to outdoor plant items (transformers, switchgear etc).

Multipair cable is therefore preferably contained within the Control building, rationalising the overall cabling design and guarding against cross-site ‘pick-up’ on the paired cabling.

All pairs shall be terminated at each end using flip-link type isolation terminals. Allocation of pairs shall follow the pair-colour ordering defined in ENAT 09-06, and in the application to hard-wired SCADA I/O, one pair shall be allocated per Control, Alarm or Indication signal.

3.3.2. Number of Pairs / Pair Markers

Number of cable pairs shall be 2pr, 5pr, 10pr or 20pr.

Pair markers (ferrules) shall not be applied at the pair termination.

Also, crimps shall not be fitted to the paired cable cores; these shall be terminated as bare-wire connections.

3.3.3. Pair Sizes / Allocation of Pairs

Conductor size shall be 1/0.8mm (0.5mm^2).

Paired cable terminations must be made in the same pair colour order at each end shall be in congruence ENATS 09-6. This must also marry with the associated Telecontrol Schedules and core sheets.

3.3.4. Cable Glanding/SWA Earthing

All Telecontrol multipair cabling shall be glanded at both ends using E1W type three part compression glands (with nylon inserts as applicable), and in compliance with:

Y028S38158	Standard Arrangement for RTU Cable Glanding / Earthing (at Supply Point and Primary Substations)

In essence, for all multipair cables carrying SCADA I/O, the cable armouring shall be insulated from earth at the plant (non-RTU) end and earthed at RTU end only. This shall be achieved by use of a nylon insert inside the glands at the non-RTU end. This also applies to screened cables carrying serial data to/from the RTU. This arrangement ensures that any earth fault current flowing in the armouring of the SCADA multipair cables will flow back through a common earth link at the RTU, thereby keeping the RTU and its associated cabling as one homogeneous unit. The glanding of all multi-pair cables and associated SWA earthing at the RTU end should comply with the arrangement detailed in Section 3.1.9 and must be completed in such a manner that future testing/proving of the armours insulation from earth can be achieved.

Note that the SWA of the screened cable carrying the analogue Telecoms signal to the remote outstation (and the multicore cable used to provide 24V DC power from the battery to the RTU) will be bonded to earth at the non-RTU end, and insulated from earth at the RTU end using glands with nylon inserts.

3.4. Use of Screened Cables, Fibre Optic and other Special Cables

Apart from fibre-optic type cables, in most applications where copper cables are used for data transmission, analogue measurement/signalling, serial current loops etc, the cable shall be fitted with an overall collective screen which should be of the foil/braid type. This screen shall run the entire length of the conductor and earthed at the source (e.g. relay/data processing) end only.

Where such copper cables are directly connected between relays (for inter-relay communication) such as CAN-bus signalling between AVC relays, the screen and SWA should be earthed at one end only.

3.4.1. Serial Comms Cable (RS485)

All cables carrying serial data shall be furnished with an overall collective screen in compliance with BS5308 Part 2 Type 2. If associated extension cables are run within relay panels (e.g. bus-wired) then these can be to BS5308 Part 2 Type 1 (e.g. no SWA required).

Conductors CSA shall be 0.5mm^2 consisting of 16/0.2mm and shall be single pair.

For type 2 cables, termination/glanding/bonding of the cable SWA shall be insulated from earth at the plant end and earthed at RTU end only.

The most common application of serial coms associated with Protection and Control equipment is that associated with protection relay connections to SCADA, where a number of RS485 (DNP.3) loops are cabled from relay panels to the RTU. The cabling design principles in this regard are established (per substation type) on the following standard drawing:

Y028S38100	DNP3 Architecture – Yorkshire Showing Loop Distributions and hardwired I/O at Supply Point and Primary Substations

Y028S38101 DNP.3 Architecture – Northeast Showing Loop Distributions and hardwired I/O at Supply Point and Primary Substations

A set of three flip links will be provided in each relay panel, providing facility for termination of the pairs and screen, as shown on standard drawing:

Y028S38159 Standard DNP3 Loop (RS485 Serial Bus) Connections at Supply Point and Primary Substations

Note that the cable shield/screen must run the full length of each RS485 cable and is bonded to earth at the RTU end only. This ensures effective shielding of the inner pairs and avoids circulating currents flowing in the cable screen.

3.4.2. Cabling to Digital WTI Units

The cross-site cabling provided between a transformers marshalling kiosk and remote Transformer (HV) relay panel for measurement functions associated with Winding Temperature Instruments (WTI's) must comply with BS3508 Part 2 Type 2.

For these cables, (WTI and Cooler Exerciser/Monitor functions) the DC resistance of a single run must be <40 Ohms at 20°C.

In each case, the cores shall be ferruled in line with the associated drawings and core-sheets.

The screen of these cables should be terminated at the WTI end only. The SWA should also be earthed at the relay panel end and insulated from earth (via an insulating gland) at the probe end.

The specific cable type and termination requirement normally specified per associated function is detailed below:

3.4.2.1. PT100 Thermo-probe Cabling

Used for PT100 for resistance temperature measurement of transformer top oil to the WTI:

- One triple conductor group (min CSA 1.5mm2),
- two conductors for probe resistance,
- 3rd conductor for cable resistance feedback.

3.4.2.2. Cooler Monitor Cabling

Used to provide AC voltage measurement to the WTI analogue inputs and is derived from small measurement CTs on the cooler motor supply circuits:

- One quad conductor group (min CSA 0.5mm^2),
- Two conductors for voltage signals;
- One conductor for cooler indication on WTI when fans and pump activated together from marshalling kiosk;
- 1 common conductor.

3.4.2.3. Cooler Exerciser Cabling (Applicable At Supply Point Sites Only)

Where an inhibit input is provided to the WTI from a remote device (such as the DOC relay on the Transformer LV relay panel – at Supply Point sites only) then an additional screened cable is required, as follows:

- One pair conductor group (min CSA 0.5mm^2),
- 1 conductor for 'cooler exerciser inhibit' input to WTI,

- 1 common conductor.

3.4.3. Tapchanger Tap Position Indication (TPI) Cabling

The cross site cable carrying the TPI signal from the Tapchanger drive mechanism to the remote Automatic Voltage Control (AVC) relay should be specified in line with the type of AVC relay being used, and the method by which the TPI signal is transmitted. The two methods used by NPG are either Resistor Chain or via a 4-20mA TPI transducer located in the Tapchanger drive mechanism or associated Tx MK.

Where AVC relays are being replaced in-situ on existing sites, and depending upon the specific AVC relay and TPI method used, it may be deemed acceptable that existing cross-site multi-core cables are suitable to carry the TPI signal.

However, for new-build sites, and as recommended by AVC relay manufacturer (or following direction from NPG), a dedicated screened cable may be required. In such instances this cable shall be complaint BS3508 Part 2 Type 2, and have a minimum CSA of 1.5mm2. The number of cores shall be specified depending upon the TPI method being used, and shall afford spare capacity in case of a change of method in the future.

The screen of these cables should be terminated to earth at the AVC relay end only. The SWA should also be earthed at the relay panel end and insulated from earth (via an insulating gland) at the drive-mechanism or Tx MK end.

3.4.4. Disturbance Recorder Interposing CT (IPCT) Circuits

Where Disturbance Recorder IPCT output circuits cannot be bus-wired, BS 5308 Part 2 Type 2 cables may be used to carry the output from IPCT boards to the associated Disturbance Recorder panel. Such cables shall have a minimum CSA of 1.5mm^2

The screen of these cables should be terminated to earth at the relay panel end only.

3.4.5. Fibre-Optic Patch Leads

All fibre optic cable installations must comply with:

NSP/002/001 Guidance document for the Installation of Fibre Optic Underground Cables

The above document generally refers to inter-substation fibre-optic (pilot) cables, but contains relevant information with respect to fibre-optic termination, and path lead installation and termination within the substation. The key issues are summarised here:

3.4.5.1. Fibre-Optic Patch Lead Type

Fibre optic pilot extension cables (patch leads) provided between the pilot termination patch panel/wallbox and associated protection/comms equipment shall be:

- Duplex SM type, 9/125µm fibre (to OS1 or OS2 as required by the given application)
- Yellow jacket,
- Supplied with factory fitted duplex ‘LC’ connectors for the patch panel/wallbox end.
- The protection/comms equipment end need may be duplex LC, ST or SC type depending upon application. Protection relays generally use ST type connections, but this may differ across relay types and manufacturers.

Where patch leads are required for short-haul Multi-Mode (MM) applications (with the substation), such as between a protection/intertripping equipment and a radio multiplexer device, then the following patch leads shall be supplied:

- Duplex MM type, 50/125µm (to OM3 or OM4 as required by the given application)

- Aqua jacket
- Supplied with factory fitted duplex 'LC' connectors for the patch panel/wallbox end
- The protection/comms equipment end need may be duplex LC, ST or SC type depending upon the given device/application. Protection relays generally use ST type connections, but this may differ across relay types and manufacturers

3.4.5.2. Fibre-Optic Patch Lead Installation and Termination

All patch leads will be carried in dedicated ruggedized/corrugated black flexible conduit (e.g. 'Kopex') with 25mm diameter through their route with one pair of fibres per conduit. These conduits will be secured to the wall of cable trenches and vertical cable trays. All flexible conduit runs in trenches below ground level shall have metallic protection to protect against vermin damage. For runs entirely on ladder rack or tray plate, plastic flexible conduit is acceptable.

Where wall-mounted patch boxes are used, additional glanding space may be required, and this should be achieved by the fitment of a section of steel trunking beneath the patching side of the box.

In all cases, suitable stuffing glands will be used for all associated conduits. As practicable, arrangements shall be made to ensure that patch lead is protected along the entire length of the route within the panel, shrouding the fibres along their route as far as possible.

The substation install contractor shall measure the route length between devices (e.g. wall-box and protection relay) and procure suitably long patch leads but without significant excess length. This avoids the need for additional management devices to cater for excess fibre length. It is not acceptable for excess patch lead to be left coiled up in the associated panel.

Care shall be taken with the routing of the flexible conduit to maintain the minimum bending radius of the fibres.

Trench covers (checker plate) shall be modified to accommodate the conduit and the conduit route shall not present a tripping hazard.

3.4.6. Ethernet Patch Leads

Internal panel cables shall be standard Cat5e UTP patch leads with RJ-45 connectors, either wired straight or crossed dependent upon application requirements

Inter Panel cables shall be Cat5e (LSOH, SWA, LSOH Sheathed with 24AWG conductors).

3.5. Pilot Cables (to/from Remote Substations) and Copper Pilot Extension Cables

3.5.1. Copper Type

As detailed in NPS/002/018, all new copper pilot cables running between substations shall be 7pr, 19pr or 37pr and shall the gel-filled type and insulated to either 5kV or 15kV depending upon the required application. These cables will be Polythene insulated (POLY/POLY/SWA/PVC) type, without collective screen, using twisted pair cores with conductor size 1/0.8mm (0.5mm^2).

These cables shall be compliant with:

NPS/002/018 Technical Specification for Pilot, Control and Telephone Cables

All copper pilot cables will be terminated in dedicated wallboxes, with all of the pairs landed on suitable termination blocks (e.g. no cores will be tied back). All un-used pairs will be earthed at the pilot wallbox.

Yorkshire practice is to use separate pilot cables/boxes for Protection and Telecoms services, whereas in the Northeast region, combined Protection/Telecoms pilot cables/boxes are accepted. In the latter case the terminal blocks should be grouped according to the use of the pairs (e.g. Protection Pilots or Telecoms Circuits).

Pilot extension cables (run to the associated protection relays panels or Telecoms cubicles) will be specified with the required number of cores/pairs for the given application, and shall be specified to have the same insulation level as the pilot cable itself, although it is not a requirement for the short extension cables (which are within the substation grounds) to be gel-filled.

All cores/pairs of the pilot extension cable will be terminated at the pilot box where any unused cores/pairs will be earthed. Unused cores/pairs at the Protection/Telecoms panel end can be terminated or tied-back but shall not be earthed at this end.

3.5.2. Fibre Optic Type

All new fibre optic pilots running between substations will be 12pr (24core) type, and will be Single-Mode (SM) type, tested at 1310nm and 1550nm.

All cores of fibre pilot cables will be terminated at the patch panel/wallbox and tested by the fibre-optic cable provider, e.g. no fibre cores will be left loose or ties back.

Of the 12c cable, six pairs will be grouped together for Telecoms purposes and six for Protection purposes.

These cables shall comply with:

NPS/002/024 Technical Specification for Fibre Optic Cables and Fibre Wrap

Fibre-optic pilot extension leads and their installation shall comply with Sections 3.4.3.

3.6. Cable Numbering System

3.6.1. Cables within Substations

All secondary cables, including multicore, multipair, LVAC, fibre-optic conduits and pilot extension cables installed within the confines of the substation shall be numbered in compliance with the structure defined below. Cable numbers shall take the form:

? / £ / $ (Note that the '/' does not appear in the actual cable number)

Where:

? = Circuit number (e.g. 301) or Transformer (e.g. T1).

Non-circuit-specific cables will use 'G' (e.g. General).

11kV Arc-Suppression Coil equipment's shall be numbered 390.

20kV Arc-Suppression Coil equipment's shall be numbered 490.

£ = Function (e.g. Protection, Metering, SCADA) - see list below.

$ = Incremental Number - e.g. 301P1, 301P2, GK1, GK2, T1A1, T1A2 etc.

The functionality (given by the '£' digit) is defined as follows:

A 400/230V AC Power Distribution (exclusively)

F Fibre Pilot Extension / Patch Lead (any purpose)

K SCADA Communication (exclusively)

M Metering (exclusively)

P Protection & Control (including all types of CTs, VTs, Voltage Control etc and may contain cores for non-Protection purposes)

S AC or DC Supplies (less than 150V)

X Hardwired SCADA/ Telecontrol (exclusively)

Y Copper Pilot Extension (Protection or Telecoms purpose)

The term 'exclusively' means that all cores of any given cable are dedicated to the named function.

3.6.2. Inter-substation Pilot Cables

The numbering of inter-substation pilot cables is outside of the scope of this document. Such cables are recorded on Northern Powergrid's Graphical Information System (GIS) and are numbered accordingly with that system.

3.7. Block Cable Diagrams (BCD), Cable Schedules(s) and Core Sheets

3.7.1. Drawing Content and NPG Review

A BCD, associated cable schedule(s), core termination sheets and SCADA Telecontrol Schedules shall be produced by the Install Contractor and submitted to Northern Powergrid for comment prior to any cable being ordered.

These drawings must provide full details of all multicore, multipair, power cables and special cables as detailed in the earlier sections of this document.

Where the project is limited to the minor modification of an existing substation, then it is acceptable the existing site BCD and cable schedules will be updated, rather than the production of new drawings. However, if the project involves say the addition of a new bay or replacement Transformer, then it is expected that new drawings (detailing the interface of new and old equipment) will be produced.

Where new drawings are produced, it is preferable for all new cables (including multicore, multipair, LVAC, fibre-optic conduits and pilot extension cables installed) to be captured on one BCD. The plant on the BCD will accurately reflect the layout of the substation, and cables will be shown with the associated cable number at each end. The cable numbering system (as detailed in Section 3.6.1) will be added to the BCD.

As a minimum, cable schedules must show cable termination to/from destinations, cable size, cable construction (e.g. PVC/PVC/SWA/PVC), core size, actual route length, and full details of core ferrules. The cable numbering system (as detailed in Section 3.6.1) will be added to the BCD.

The Install designer is responsible for the production of cable core termination sheets. Each cable will have a core sheet, identifying the cable number, to/from destination, core number, terminal number and associated core ferrule at each end. Apart from instances of double-ferruling (which should be minimised), each core will be ferruled the same at each end.

All spare cores will be detailed, and terminations will be as specified in Section 3.1.4

3.7.2. Drawing Format / Example Drawings

All cabling drawings shall be black and white and shall be submitted at As-Installed stage in Microstation (.dgn) or AutoCAD (.dwg) format as detailed in NSP/007/019.Core sheets may be produced in Microsoft Excel (.xls) or Word (.doc) formats.

The following drawings provide an example of each of these drawings for a typical new build Primary substation:

Y028S7301 Multicore/Multipair Cable Block Cabling Diagram for a Typical 33/11kV Cable Fed Primary Substation

Y028S7302 Multicore/Multipair Cable Schedule for a Typical 33/11kV Cable Fed Primary Substation

The format of the cable core sheets is to be determined by the Install contractor. Since all cable core information must be included on associated wiring diagrams and cabling drawings, core sheets do not need to be allocated drawing numbers or returned as final records, but clean printed copies should be available (for retention on site) upon request.

3.8. Methods of Installation / Cable Markers

3.8.1. General Guidance for Cable Installation / Installation Methods

All cables shall be installed (pulled-in and terminated) in line with the recommendations of the specific cable manufacturer (as applicable). This includes ambient temperatures at the time of installation.

The maximum specified bending radius of all cables must be observed along the full cable installation. This applies to all cables, including those laid in trenches, ducts, on tray-work or overhead ladder racking.

Cables shall be installed in a neat and orderly arrangement and suitably tied down when laid on racking etc. Where reasonably practicable all cables should be supported end to end with suitable containment. Separate cables shall be used for each circuit, and these shall be segregated as far as reasonably possible.

Additional cable supports shall be provided as necessary in any cable run to ensure cables are cleated every metre.

Where secondary cabling access to equipment is top-entry, then the overhead cable management system should be of the ladder type, with cables dropping down through the apertures in the racking. Tray work is not acceptable in this application.

Tray work, ladder rack and any other cable management infrastructure should be installed to accommodate a minimum of 50% future cabling. All cables shall be neatly and securely affixed to the tray/rack using suitably sized cable ties, and cables shall be grouped logically according to size, function and route.

It is not a requirement for cables to be installed on tray work in cable trenches; the only exception to this is that of fibre-optic conduits, which must be affixed by suitable brackets to the inner walls of cable trenches.

All secondary cables need to be glanded using gland plates at the enclosure into which they are terminating; it is not acceptable for cables to be glanded on bespoke bracket-mounted steel plates beneath (or above) switchgear, relay panels or other equipment for the purpose of glanding associated cables. Earthing tags shall always be fitted and earthed inside the enclosure.

Each cable tray installation is to be bonded to the site earth grid at one point, and continuity earth bond connections shall be made across all joints between successive sections of cable tray and accessories. Tray-work positioned at a lower level shall minimise any hazard or obstruction to the movement of persons especially in a basement or tunnel

Cables shall be ducted under roadways, minimum duct size 100mm internal diameter. Where ducts enter an oil retaining bund they shall extend to the height of the bund wall and be of a material resistant to oil and flame or be encased in concrete.

Where the Contractor installs cables in ducts the duct ends are to be suitably sealed to prevent ingress of gas, moisture and vermin etc. The seal shall be removable to facilitate the removal / insertion of cables. All cables included in the ducts shall be located in such an arrangement to facilitate a good seal. On completion of cable installation any empty ducts shall be similarly sealed by the Contractor.

Cables shall only be installed by suitably trained operatives. Winch pulling may only be carried out with a suitable dynamometer to ensure that the maximum recommended pulling tensions are not exceeded. The cable shall be connected to the winch via a swivel.

Under no circumstances shall mechanical excavators, tractors etc. be used to assist in pulling in cable(s).

Cables which have been cut must be capped immediately to prevent the ingress of moisture and/or contamination. If the cable is to be terminated immediately after cutting the cap may be dispensed with.

All cables shall have the inner sheath removed to within 50mm of the cable gland. Cable cores will be untwisted and straightened before being loomed together – the twisted pairs of multi-pair cables shall be retained in their respective pairs. The completed loom shall be neatly presented at the termination position with suitable provision for re-termination.

A proprietary cable stripping tool shall be used for stripping and terminating cables. The use of knives for this purpose is expressly prohibited by the Company.

3.8.2. Cable Labels / Markers

There are no specific standards with which cable markers must comply, but in all cases NPG reserves the right to reject labels that are not fit for purpose. A general guide to the required type and application is given here.

In general, cable markers shall be PVC type and use black (capitalised) text and numerals on yellow background. Text height shall not be less than 7mm in height. These shall be affixed to the cable using the label manufacturer provided cable ties, which should not be susceptible to becoming brittle in outdoor sunlight over time. Self-adhesive or paper printed labels (which are susceptible to fading in sunlight), are not acceptable.

All secondary cables shall be fitted with a cable marker at each end, clearly identifying the cable number. The cable marker must be the same at each end (in both form and content) and must align with the approved cabling drawings and wiring diagrams.

Cable numbers must read outwards from the cable gland.

Cable markers shall be fitted in a suitably observable location, without the need to lift trench covers or open devices with operational locks. Where practicable, cable markers shall be fitted on both the outer cable sleeve (outside the enclosure) and inner cable sleeve (inside the enclosure) and in both cases as close to the cable gland as possible.

Applying adhesive labels or writing the cable number on gland plates adjacent to cables (to identify the cable) should be avoided in all situations.

4. References

Technical documents referenced within this specification refer to the latest versions of the relevant International Standards, British Standard (BS) Specifications and all relevant Energy Networks Association Technical Specifications (ENATS) current at the time of supply.

4.1. External Documentation

The following BS and ENATS documents are relevant to this guidance note:

Reference	Title
BS 5308	Control and Instrumentation cables. Specification for PVC insulated Cables
BS 5467	Thermosetting Insulated, Armoured Cables of Rated Voltage of 600/1000V and 900/3000V for fixed installations.
BS 6121-1:2005	Mechanical cable glands. Armour glands. Requirements and test methods
BS 7655-0:2006	Specification for insulating and sheathing materials for cables
BS 7671 (Latest Version)	Requirements for Electrical Installations. IET Wiring Regulations
BS EN 60529:1992	Degrees of protection provided by enclosures (IP code)
ENATS 09-06 (Latest Version)	Auxiliary Multicore and Multipair Cables
ENATS 50-18 (Latest Version)	Application of Ancillary Electrical Equipment.
ENATS 50-19 (Latest Version)	Standard Numbering for Small Wiring

4.2. Internal Documentation

All of the relevant BS and ENATS for all multicore, multipair and pilot cables approved for use in Northern Powergrid substations are given in:

Reference	Title
NPS/002/018	Technical Specification for Pilot, Control and Telephone Cables
NSP/002/001	Guidance document for the installation of Fibre Optic Underground Cables
NPS/002/024	Technical Specification for Fibre Optic Cables, Wrap, OPGW and ADSS
NSP/007/019	Guidance on Substation Design: EHV Substation Drawing Policy
NSP/007/028	Guidance On Substation Design: Drawing Submission Requirement
Y028S7301	Multicore/Mulitpair Cable Block Cabling Diagram for a Typical 33/11kV Cable Fed Primary Substation
Y028S7302	Multicore/Mulitpair Cable Schedule for a Typical 33/11kV Cable Fed Primary Substation
Y028S1167	Typical Cabling Distribution of 110V DC Supplies to Switchgear and Relay Panels in Supply Point and Primary Substations
Y028S38100	DNP.3 Architecture – Yorkshire Showing Loop Distributions and hardwired I/O at Supply Point and Primary Substations
Y028S38101	DNP.3 Architecture – Northeast Showing Loop Distributions and hardwired I/O at Supply Point and Primary Substations
Y028S38158	Standard Arrangement for RTU Cable Glanding / Earthing (at Supply Point and Primary Substations)
Y028S38159	Standard DNP.3 Loop (RS485 Serial Bus) Connections at Supply Point and Primary Substations

4.3. Amendments from Previous Version

Reference	Title
4.1 External Documentation	BS 5308 - Control and Instrumentation cables. Specification for PVC insulated Cables

4.1 External Documentation	BS 5467 - Thermosetting Insulated, Armoured Cables of Rated Voltage of 600/1000V and 900/3000V for fixed installations.

5. Definitions

Reference	Title
None	

6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Liz Beat	Governance Administrator	15/05/2024

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period.

Standard CDS review of 3 years?	Non Standard Review Period & Reason		
Yes	Period: n/a	Reason: n/a	
Should this document be displayed on the Northern Powergrid external website?			Yes
			Date
David Johnson	Specification & Design Engineer		16/05/2024

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Michael Crowe	Protection Manager	16/05/2024
David Marshall	Technical Services Engineer	22/05/2024

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
David Sillito	Head of Major Projects	24/05/2024