NP001.2
General Specification for Underground Electrical Reticulation

This document is extracted from Network Policy NP 001, Design and Construction of Network Assets.

Other documents in this series include:

- NP001.1 Design and Construction of Network Assets – General Requirements
- NP001.3 General Specification for Overhead Electrical Reticulation
- NP001.4 General Specification for Overhead Rural Residential Subdivisions
- NP001.5 General Specification for Overhead Commercial and Industrial Subdivisions
- NP001.6 General Specification for URD Subdivisions
- NP001.7 Reliability Criteria for Distribution Networks
- NP001.8 Handover Documentation
- NP001.9 Electricity Supply to Large Customers
- NP001.10 Documentation Requirements

Further Information: For additional information or advice regarding this document, please contact the Manager Network Engineering on 1800 245 092

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General Specification for Underground Electrical Reticulation

Power and Water's Standards Volume 2 sets out the standard arrangements for the installation of underground cables and equipment. From time to time Power and Water may vary these arrangements, either permanently or on a trial basis.

Where a developer wishes to vary any standard arrangements, a formal application, setting out full details of the proposed variations, shall be submitted to the Manager Network Engineering, PO Box 37471, Winnellie, NT, 0821.

This document summarises, and should be read in conjunction with, the Electricity Supply Association of Australia publication C(b)2 1989, "Guide to the Installation of Cables Underground".

1 Scope

This document sets out the basic requirements for the installation of high and low voltage underground cables and related equipment. It covers XLPE and MIND paper insulated cables. Generally "low voltage" refers to cables operated at a nominal voltage not exceeding 500 volts, while "high voltage" refers to 11 or 22 kV.

2 Safety

New underground cables that are separated from existing parts of the network by virtue of missing sections of cable are not treated as power lines in respect of Power and Water's *Electrical Safety Manual (Green Book)*.

However, it is a requirement that all construction work complies with the *Work Health (Occupational Health and Safety) Regulations*.

It should also be noted that the construction of underground power systems is classified as "electrical work" by the *Electrical Contractors and Workers Act*, and can only be carried out by licenced persons.

Where work is required to be carried out on cables or equipment that have been, or can be, energised, then strict compliance with the *Electrical Safety Manual* and the *Regulations* will be enforced by Power and Water.

3 Cable Types

Only cables supplied by approved manufacturers may be connected to Power and Water's network. Power and Water always reserves the right to inspect and test any cable purchased by a developer or contractor to ensure compliance with the relevant standards. In any event, the developer shall provide copies of the suppliers' offer to confirm manufacturer and manufacturing standard. Cables that are found to not comply with Power and Water standards will be rejected, including all cables from that particular batch or order.

Generally Power and Water does not use wire armouring, but may require this in certain circumstances, such as where a particularly long pull is required.

(a) Paper/Lead

Power and Water has both high and low voltage paper/lead cables in service. Where existing cables are to be jointed or terminated, the cable jointer will need to familiarise him/herself with the construction of the particular cable.

No new paper/lead cables are to be used. However, Power and Water may approve the replacement of a short section of existing cable like-for-like where it is not practicable to use XLPE cable. Paper/lead cable shall comply with the following:

- Mineral Insulated Non Draining (MIND) to AS/NZ 1026 and AS/NZ 4026.
- Lead alloy sheathed to AS/NZ 2893
- Belted
- Stranded sector-shaped aluminium conductors to AS/NZ 1125
- Nylon jacketed or double brass taped

(b) XLPE

Most low voltage and high voltage cables are XLPE insulated. Power and Water generally uses single-core cables for ease of installation, but 3 or 4-core cables may also be used.

Such cables are generally:

- Low voltage to AS/NZ 4026, 4961 and 5000 as appropriate
- High Voltage to AS/NZ 1429 and 4026
- Nylon jacketed and sheathed, (or "Termitex" or equivalent) except in fully ducted systems where the entry of termites is completely excluded by approved means
- In the case of high voltage, fitted with conductors impregnated with water-blocking compound
- In the case of high voltage, fitted with a water-blocking (HDPE) sheath

4 Protection of Cable

It is essential to ensure that during transport, storage and handling, cable sheaths and/or armouring are not damaged. In particular, any cable found to have damage to the nylon protective sheath or water blocking sheath will be rejected.
Cable ends shall be sealed against moisture at all times with an effective cap.

5 Types of Cable Installation

(a) Direct Buried

With this system, the cable is laid directly into a trench bedded in sand. A cable warning strip or mechanical protection is used to provide a measure of mechanical protection.

Direct burial has the advantage that heat is transferred more efficiently into the soil than in ducted systems, thus maximising current rating. It has the disadvantage that cables may only be replaced by excavating the route; this can be very expensive in an established area.

(b) Ducted

Ducting allows for replacement of faulty cables, and facilitates construction in cramped locations. Ducting is required by Power and Water in all cases where the cable route passes through private land, across roads or concrete footpaths; Power and Water may also require ducts in any area where it believes that future access may be restricted. In particular, in commercial areas where future paving is likely, all cables (including street light cables) shall be ducted.

Ducting has the disadvantage that the cable is derated in comparison to direct burial.

Power and Water may require the installation of spare ducts to allow for future cable installations.

(c) Shared Trenches

Trenches may be shared with telecommunications cables such as telephone and cable TV. Typical arrangements are set out in Drawing No. S2-2-6-2. Generally 450 mm separation is required between power and communications cables.

Note that where telecommunications cables are installed in the same trench as power cables, all power cables shall be installed in ducts.

Note the requirements for separation and mechanical protection between power and telephone cables. When a telephone line crosses a power cable, or a power cable passes underneath a Telstra pit, a 50 mm concrete slab is required between the two.

6 Excavation and Trenching

(a) Safety

The *Work Health (Occupational Health and Safety) Regulations* require (Clause 145(b)) that trenches be shored when a "..worker is required to work in an excavation or opening in the ground that is 1.5 metres or more in depth."

Compliance with this Clause can be achieved either by shoring "..of a standard that will prevent the collapse of the excavation or the movement of the earthwork" (Clause 145(3)) or by sloping the trench walls at a sufficient angle to provide stability. Shoring is also not necessary where the ground is stable (e.g., solid rock).

The ESAA publication C(b)2 describes typical arrangements for shoring.

The *Work Health Regulations* also require safe means of access/egress to the trench, and require that plant or excavated material be kept clear of the edge of the trench. Clause 61 of the *Regulations* discusses the identification of, and measures to be taken to combat dangers associated with, confined spaces, such as cable tunnels.

Power and Water requires that personnel who need to work in confined spaces attend an accredited course and be equipped with, and use when required, the necessary protective equipment. A current first aid certificate is required from an accredited training authority.

(b) Trench Alignment

This shall be in accordance with the S2-4-1 series of Drawings in Volume 2 of the Standards Manual. The typical trench alignment is 0.75m from the property boundary unless approved otherwise by Power and Water.

(c) Existing Services

When excavating in an area where there are existing services, it is a requirement that all existing services be accurately plotted, all relevant Authorities consulted, and appropriate permits issued. Always ring Dial Before You Dig on 1100 if there is any doubt about location of services. If excavating within 3m of any cable, Power and Water shall be notified on 1800 000 254 and a cable location requested.

Where unforeseen services or site conditions are found during excavation, proposed design changes shall be documented and approved by the Design Officer before proceeding.

When working within 1 metre of an existing high or low voltage cable, Power and Water is to be notified at least 7 days in advance. Power and Water will notify the contractor of the measures to be taken to limit the dangers associated with excavation close to live cables. Typically hand tools must be employed for excavation within 1 metre of a cable.

Attention is drawn to the Electricity Reform (Safety and Technical) Regulations, which imposes severe penalties upon persons who carry out work close to power infrastructure without the approval of Power and Water. Approval takes the form of an "Approval to Work in the Vicinity of Electrical Apparatus" or "AWV".

Power and Water also runs a training course at regular intervals covering the basics of excavating near existing services.

Care should be taken when working close to existing buildings or structures to ensure that foundations are not damaged by the work.

Where excavation work is likely to damage or require removal of any tree on Crown Land, the relevant authority should be approached and grant permission for the work prior to proceeding.

(d) Direct Laid Cable

The trench shall be completed with a smooth and level bottom, with no protruding rocks. Spoil should be deposited at least 600 mm from the trench to prevent material

from falling back into the trench. Spoil containing rocks larger than 50mm diameter shall be removed and not used as backfill. The quality of the spoil shall be approved by the Project Officer before it may be used as backfill.

The trench shall be partially filled with sand to ensure that, after cable laying, there is a minimum of 50 mm of sand between the cable and the bottom of the trench. All foreign material that could attract termites, such as scraps of timber or plastic, shall be removed.

The cable/s and earth conductor shall be laid out carefully to avoid damage. After placement of the cables, any rocks or similar hard material that may have fallen into the trench shall be removed.

The trench shall then be backfilled to the required depth with sand, compacted in layers not exceeding 150 mm.

Finally the trench is to be backfilled to surface layer with clean backfill material, laying marker tapes as required. The backfill material is to be free of boulders or rocks greater than 50 mm in diameter, and is to be compacted in layers not exceeding 150 mm to match the adjacent undisturbed material.

Generally, the installation shall comply with Drawing S2-2-6-1. Single core high voltage cables should preferably be laid in a close trefoil arrangement. Single core low voltage cables shall be separated slightly to assist cooling, and to limit damage to neighbouring cores when one core is faulted.

(e) Ducted Cabling

Trenching and backfilling for ducted systems shall be carried out in a similar manner to direct buried systems as described above.

Ducting shall generally be orange PVC heavy duty conduit to AS/NZ 2053, complying with the requirements of the Wiring Rules for Category A enclosures. Alternatively, heavy duty continuous HDPE orange conduit may be used with the approval of Power and Water.

In certain circumstances Power and Water may consider the use of other ducting systems where it is satisfied that a combination of depth, location and/or mechanical protection provides enclosure equivalent to Category A.

A ducted cable run shall be designed to ensure that permitted cable tension is not exceeded during construction. This may require the installation of additional sand pits to permit the use of "caterpillar" type cable pulling equipment.

Ducts entering concrete pits shall be cut flush with the pit wall and carefully rounded internally to prevent edges damaging the cable. Bell mouths must be used at the start of any pull to prevent damage to the cable sheath. Entering and exit holes in a pit must be exactly lined up (±10mm max).

Duct runs shall be as straight as practicable to minimise pulling tensions. Joints may be glued; however, there shall be no visible glue on the surface of the joint, as the softening of PVC by glue facilitates termite entry. Conduits shall be laid so that the "belled" end is at the leading end of each length in relation to the direction of pull.

Pits shall be installed at each change in direction of a high voltage cable run, unless otherwise approved by Power and Water. Ducts shall be positioned to maximise the bending radius as the cable/s enter and exit the pit. Under no circumstances shall the manufacturer's recommended minimum bending radius be exceeded (i.e., the cable shall not be bent to a radius smaller than recommended).

Where there is a change of height at, for example, road crossings, the change shall be gradual to minimise pulling tensions. Where a conduit diversion is required for any reason, a radius bend of at least 2.3m radius shall be employed.

Where spare ducts are installed, they shall be capped to prevent ingress of foreign material. Spare ducts that start and/or finish away from a pit, pillar or substation shall have locating devices installed at each end. These shall be the 3M radio marker type specified from time to time by Power and Water. (Power and Water may consider GPS bearings provided that these are accurate to 10cm). A synthetic draw wire shall be installed in all spare ducts; there shall be at least 2 m spare coiled just inside the cap.

Where spare conduits are installed across a road, the curb shall be marked with the letter "E" in accordance with Drawing S2-2-6-1. Note the requirement to run such a conduit at least 450mm past the curb and any other service or obstruction. Generally such conduits shall be run to within 1 metre of the street cable alignment.

Duct diameter is generally 150 mm for high voltage and 100 mm for low voltage cables.

7 Boring

Where required, thrust or directional boring may be used to avoid surface excavation.

In such cases, it is essential to adequately locate all existing cables and services, and obtain relevant permits, prior to commencement of work.

When using directional boring methods, it is usually necessary to utilise continuous conduit for pulling back into the hole. Orange HDPE is acceptable for this purpose.

When using 125 mm HDPE ducting, adequate means shall be provided for connections into 150 mm PVC duct.

With thrust boring, the casing shall be adequate in size to permit the appropriate duct (150 or 100 mm, or multiples) to be installed.

8 Trench Width and Cable Spacing

The trench width is dependent on the number and size of cables and/or conduits to be installed, and possibly on the type of excavating equipment to be employed.

High and low voltage cables and/or ducts shall be separated as much as practicable in the trench, preferably at least 150 mm apart. This may be reduced to 75 mm where cables/ducts cross.

Note that where telecommunications cables or other services are installed above power cables, the power cables shall be installed in a ducting system.

9 Barriers, Signs and Covers

Where any trench is left unattended, barriers or similar means shall be fitted to prevent inadvertent falls into the trench by members of the public.

In existing residential suburbs, trenches shall not be left open at night-time. This may require the complete covering of the trench, or the erection of a fence capable of prevention of access by children. Preferably, the job should be arranged so that the trench is backfilled each day after installation of cables or ducts.

Cover boards or plates shall be designed to take the maximum likely load, be maintained in good condition, and shall be large enough to overlap the trench adequately. If necessary, stakes or other means shall be employed to prevent movement of the covers.

In existing residential areas, barriers, covers, dumps of spoil, and other obstructions shall be lighted with hoarding lamps or similar.

Roadway excavations shall be carried out only with the approval of the Department of Infrastructure, Planning and Environment or local Council, as appropriate. Work within road reserves shall, in lieu of specific instructions from the local authority, be carried out in accordance with AS 1742, Manual of Uniform Traffic Control Devices. Warning signs shall be to AS 1743, Road Signs.

10 Cable Installation

(a) General

The pulling arrangement used shall subject the cable to minimum stresses. Pulling tensions shall be minimised by considering the location of bends and the relative heights at each end of a pull.

Adequate lubrication shall be employed in duct systems to minimise tension. Lubricant shall be non-corrosive, and contain no solvents likely to affect PVC. A record shall be maintained of lubricant usage.

(b) Induced or Transferred Voltages

When working on cables that are close to energised cables, particularly if they are running in parallel, precautions shall be taken to minimise the risk of injury to personnel. Similar precautions are required when working within 100 metres of a Zone Substation. Reference should be made to the ESAA publication "Guide for Working on Cables and Ancillary Equipment under Induced Voltage Conditions and Transferred Earth Potentials".

(c) Cable and Cable Drum Inspection

Before use, the cable drum/s shall be visually inspected for damage. The manufacturer's seal on the two cable ends shall be examined, the condition of the sheath inspected for damage and, in the case of paper/lead cables, inspected for oil leaks.

Cables showing damage to the lead sheath, brass tapes, nylon sheath or water-blocking sheath shall be rejected. Only minor damage to the outer sheath is acceptable.

If it is necessary to roll the cable drum, it shall be rolled only in the direction indicated by arrows on the drum.

Drum holding rods are to be tightened before use.

(d) Cable Drum Mounting

Drums should be mounted on a stand, cable trailer or jacks. Except in the case of a purpose-built braking trailer, the drum shall be mounted such that the cable is pulled from the top.

When pulling from drums larger than 2 m in diameter, the cable should be supported from the drum to ground level by a suitable ramp. The drum should be checked to ensure that it is level, and that it rotates freely and evenly.

During pulling, slack shall be prevented from accumulating by applying moderate braking to the drum.

The inner end of the cable shall be constantly observed where it protrudes through the side of the drum. It will have a tendency to protrude further as the cable is played out. It is advisable to free any restriction on movement, and to attach a retaining rope to prevent contact between the cable end and the equipment.

During pulling the cable shall be carefully examined for any sign of damage as it leaves the drum.

(e) Cable Pulling Equipment

Cables are either fitted with pulling eyes, or stocking grips are used. Pulling eyes are to be specified for longer runs of larger multi-core cable. In some cases, pulling eyes may be necessary on larger single core cables if the run is long or has numerous deviations.

Various types of pulling ropes may be used. However, only fibre or synthetic ropes may be used when pulling cables through duct systems. The rope diameter shall be such as to prevent significant damage to the duct at radius bends.

(f) Pulling Tension

In lieu of permissible tension data provided by the cable manufacturer, the following maximum tensions shall be used:

Single core unarmoured XLPE		**Three core unarmoured XLPE**	
400 mm^2 HV	7.0 kN	400 mm^2 11kV al	20 kN
240 mm^2 HV	5.3 kN	300 mm^2 11kV cu	21 kN
95 mm^2 HV	3.0 kN	500 mm^2 22kV al	22 kN
35 mm^2 HV	1.8 kN	240 mm^2 11kV al	12 kN
185 mm^2 LV	3.2 kN		
240 mm^2 LV	3.7 kN		

Cables fitted with pulling eyes may be pulled with tensions up to 50 N per square mm of conductor area for aluminium and 70 N per square mm for copper; however, the maximum pulling tension in any pull through 150mm PVC conduit shall not exceed 22kN without prior approval and supervision by Power and Water staff.

For runs exceeding 200 m, or involving more than one radius bend, a dynamometer shall be used to measure pulling tension. This shall be constantly monitored during each pull, and the maximum tension recorded. Power and Water may require the

contractor to provide records (see Appendix K) of pulling tensions for each pull during a project.

Swivels should be used to prevent build-up of torsion during a pull.

Rollers should be placed at intervals not exceeding 3m in trenches. Corner rollers shall be set up at changes in direction to prevent abrasion between the side of the trench and the cable. Rollers should be set up at the trench entry to prevent cable contact with ground.
Appendix A of C(b)2 provides a method for calculating pulling tensions.

When pulling single core cables, additional care is required to prevent twisting of the cores, which can add to stress at bends. The cores must be fed smoothly into the run from multiple drums so placed and handled that the cores do not cross prior to entry. The tension in each core shall be maintained as close as practicable to each other.

(g) Pulling Speed and Control

A cable pull requires planning, with personnel aware of the requirements to maintain a smooth, steady pull throughout the run.

Pulling speed should ensure that the drum/s rotates smoothly. Speed should not be so high that a sudden stop causes excessive overrun. Personnel must be positioned at every caterpillar site, and at bends, to ensure that the cable is running correctly on rollers, and **is not bunching**.

When laying in a trench, an observer with a 2-way radio should follow the nose of the cable to ensure that snags and cable damage do not occur, and to stop the process and make adjustments to roller positions (particularly at corners) as necessary.

(h) Bending Radii

The manufacturer's recommended minimum bending radii shall not be exceeded (i.e., not bent further than the minimum). In any event, on long runs with high pulling tensions, considerably larger bending radii (typically twice minimum) should be used to minimise the risk of cable **flattening**.

(i) Pulling Methods

Pulling shall be carried out in a workmanlike manner so as to minimise risk of cable damage.

The methods discussed in Sections 6.8 to 6.10 in C(b)2, including Figure 10, are recommended. If methods other than those depicted are proposed, prior approval of Power and Water must be obtained.

(j) Cable Location and Recording

Where the depth and alignment of a cable run is not within 100 mm of the standard depth and alignment shown in the relevant Standards drawing, the contractor shall record the offset and depth of each cable and include this information in the "As Constructed" drawing. Cable marker plates and/or marker posts shall be installed as required by the Standards Manual.

The exact location and type of each joint shall also be recorded and marked with a 3M radio marker. Alternatively, Power and Water may consider GPS locations as in

A6(e) above.

The contractor shall provide a report, attached to the "As Constructed" drawing, listing the following details in relation to each high voltage cable:

- size
- type
- voltage rating
- length of each run
- drum number
- cable manufacturer and country of origin
- year of purchase

(k) Direct Laying Method

This may be used in green field sites where there is ready vehicle access to the trench, and there are no obstructions.

Generally, the cable drum is mounted on a truck or trailer, and is payed out while the vehicle moves along the trench. In this case the cable must be carefully placed in the trench without sustaining abrasion damage, and without allowing rocks etc., to fall into the trench.

If it is proposed to use this method for high voltage cables, prior approval of Power and Water must be obtained, and sufficient notification given to permit witnessing of the laying out process.

(l) Cable Loops

Provision shall be made at every cable pole for a loop of cable at the pole foot. This is to enable cable termination replacement. The preferred method is to increase depth by an additional 0.5m for the metre or so immediately before the pole. The last 2 metres of trench shall be completely backfilled with sand. The cable shall have a metallic tag fitted 2.5m above ground with the loop details stamped on it.

(m) Qualifications of Persons Installing Conduits and Cables

Persons installing conduits shall demonstrate competency in conduit installation. Persons pulling in cables shall demonstrate suitable experience in cable installation; Power and Water may require an applicant to sit for an examination to determine the level of knowledge.

11 Substations and Switchgear

(a) General

After installing cables, ducts and earthing, the pit/s are to be filled with sand to within 50 mm of the slab surface level. The sand is to be compacted by mechanical means in layers not exceeding 150 mm.

After compaction, an approved moisture barrier such as 0.50 mm black nylon sheeting is to be carefully placed on the sand so as to completely cover the entire surface. The barrier is then to be covered with approximately 50 mm of 8:1 sand/cement mixture and finished to the surface level. Care shall be taken to ensure that this layer provides a complete and continuous barrier to termites.

An alternative to sand/cement is the material "Granite Guard" marketed by the CSIRO. This material is preferred in low voltage pits.

Where it is intended to run future services from a substation, ducts shall be installed initially running outside the foundation area. These shall be capped. The number and orientation shall be as directed by Power and Water.

(b) Fuses

Attention is drawn to the need to de-rate low and high voltage fuses in certain circumstances. Generally, low voltage fuses in Striple S/F units operate at ambient temperatures up to 65^0C, and must be derated by about 25%.

High voltage fuses in air-insulated switchgear such as Magnefix MD4 units are also derated because of the thermal insulation properties of the fuse chambers. Refer to Standards Bulletin S1-020 for details.

12 Jointing of Cables

(a) Jointing Pits

Jointing pits should be large enough to allow jointers to work freely, without undue restrictions to movement. Earth-sided pits shall have a concrete base at least 75mm thick. The sides should be covered with tarpaulins or similar to prevent soil from being dislodged while working in the pit.

Pits must be kept dry; if necessary a weatherproof canopy should be used. Pits shall be backfilled with clean sand after work is complete.

The exact location of each jointing pit shall be included in the "As Constructed" drawing and marked with a cable marker plate or post. In addition, except for pits with Gatic covers, they shall be marked with a 3M radio marker buried near the surface above the joint; alternatively, with Power and Water approval, GPS coordinates to 10cm accuracy can be provided.

When pulling in cables, an overlap of 1 metre is required at each pit for jointing.

(b) Jointing of High Voltage Cables

Jointing of high voltage cables shall only be carried out by personnel trained and accredited for a particular joint type. The contractor shall maintain a register of personnel, recording details of training and qualifications of all jointers employed by them. This register will be made available to Power and Water on request.

Prior to jointing, each cable section shall be meggared and the results recorded. The minimum voltage is 500 V for low voltage cables and 1000 V for high voltage cables.

Joints shall be carried out in a workmanlike manner in accordance with the manufacturer's recommendations and Power and Water's Standard Drawings – refer S2-2-2 series.

Underground joints shall be protected from termites by the use of "Termimesh" or similar applied continuously from the nylon jacket or double brass tapes each side of the joint.

Joints and terminations in paper-lead cables with HDPE sheaths shall be designed for elevated pressures – typically 100psi or 690kPa.

Through joints shall employ compression sleeves for conductor jointing.

Conductors shall be carefully cleaned of oil, compound, etc., prior to crimping.

No high voltage through joints are permissible in new installations except in exceptional circumstances and with the prior approval of Power and Water. No low voltage joints are permissible in new installations.

Joints shall be in an accessible location. Under no circumstances may joints be located under carriageways, driveways or the like where repair crews could be endangered by vehicles.

Jointing of high voltage cables is not permitted if it is raining. Furthermore, during the wet season the jointer shall employ methods to ensure that perspiration is prevented from contacting the insulation material. These measures may be audited by Power and Water.

Measures such as the covering of prepared cable with "cling wrap" shall be employed to reduce moisture contamination.

The contractor shall provide to Power and Water at least 2 working days' notice of intention to carry out any high voltage joint.

(c) Testing Paper Insulation

At every joint in a paper/lead cable, the insulation shall be tested for the presence of moisture. This is done by immersing samples of inner and outer paper from each core and section in oil heated to about 120^0C.

Paper sections should be held with tweezers to prevent perspiration contamination. Moisture is present if crackling is heard, and/or a yellowish froth appears on the surface of the oil. If moisture is detected the jointing must not proceed, and measures are to be taken to remove the contaminated section of cable.

(d) XLPE Insulation

At every joint in XLPE cable, each core shall be inspected for moisture. Immediately after removal of the cap and outer sheaths, the core insulation should be completely dry.

If moisture is observed, the joint is not to proceed, and measures are to be taken to remove the contaminated section of cable.

(e) Earthing of Cable Screens

As a general rule, cable screens of single core cables should only be earthed at one end. This is because current flow in the conductor will induce a voltage in the screen around it. Earthing both ends can result in a significant circulating current, which can derate the cable. Advice on particular projects should be directed to the Power and Water Project Officer.

Earthing is normally at the source end. At the load end of the cable, the three screens should be kept isolated from each other and adequately insulated. It should be borne in mind that a fault anywhere on the high voltage network will cause a voltage rise on the zone substation earthing system. A remote cable screen connected to the zone substation earth can transfer large voltages, resulting in a hazard to staff working in the vicinity of the cable termination.

Where it is important to earth the far end of a cable (e.g., at an overhead termination), and the cable run can be broken into three sections of similar length, transposition of earthing along the route will minimise problems. A more practical approach is to bond all three screens at regular intervals (cross bonding) to minimise voltages. Advice on this technique must be obtained from Power and Water before proceeding.

Generally, three core cables may be earthed at both ends, as the screens of each core are in continuous contact with each other.

13 Testing

High voltage cables and switchgear shall be electrically tested before commissioning. All readings shall be recorded on approved test sheets and provided to Power and Water. Testing shall be carried out as follows:

(a) High Voltage XLPE Cables

1. Earth continuity test
2. Check of phasing
3. 5 kV meggar test for each core, holding until reading is stable. Minimum test values are 2400 MΩ/km for 11kV and 4000 MΩ/km for 22kV cables.
4. hipot test at 2.7x rated voltage to ground for 15 - 30 minutes, using a low frequency AC tester, or
5. alternatively, soak the cable at rated voltage for 24 hours
6. 5 kV meggar test for each core, holding until reading is stable
7. Note that, for cables other than new cables, the hipot test should be at 2.0x rated voltage for not more than 15 minutes, using a low frequency AC tester

(b) Paper/Lead Cables

Generally the same as for XLPE cables, except that phase-phase tests are also carried out on 11kV belted cables at 20 kV for 15 minutes, in lieu of soaking.

(c) Low Voltage Cables

1. Earth continuity test (if not covered in the HV test)
2. Check of phasing and polarity
3. 1.0 kV meggar test each phase to neutral, holding until reading is stable

14 Ferroresonance

This is a phenomenon associated with the single phase switching of high voltage networks. While it occurs with overhead networks, it is most pronounced with underground networks because of the large capacitance associated with the use of screened cables.

Any circuit containing capacitance (cables) and inductance (transformers) can resonate. Ferroresonance occurs when the right combination of capacitance and inductance causes an initial resonant over-voltage. The over-voltage causes saturation of the iron core of the transformer, causing a change in the inductance. The change of inductance causes a change of state of the resonance, increasing the voltage, which in turn further changes the saturation of the core, etc. Over-voltages of 20+ kV to ground have been recorded on 11 kV cable systems, leading to flashover in switchgear, or cable puncture.

Refer to drawings S2-4-2-9 and 10 for data on the critical lengths of cable associated with different transformer sizes.

15 Cable Terminations in Holec Magnefix MD4 Series Switchgear

These units are designed for a maximum cable size of 240 mm^2. Larger cables are not to be used.

Each cable core shall be positioned so as to, as far as practicable, prevent contact between the core and the nylon spacing tube.

16 High Voltage Fuses

The derating of fuses mentioned in A11(b) also applies in Holec Magnefix switchgear. Heat dissipation is limited to about 25 watts. The fuse sizes listed in the S2-4-2 series for "Hazemeyer" RMUs shall be adhered to for Magnefix switchgear. (Holec was previously known as "Hazemeyer-Holec").

High voltage fuses normally contain several elements in parallel, contained in a quartz powder. Rough handling of fuses can cause fracture of an individual element or elements, leading to increased losses. This can result in catastrophic failure of the RMU.

Consequently, high voltage fuses must be handled with great care, preferably by carrying them in the field within foam-lined boxes. Power and Water may test the resistance of any fuse, and may reject all fuses used in a project if evidence of poor handling is found.

Generally other types of switchgear are more capable of dissipating heat from fuses, but the same problems can occur if fuses are mishandled.

17 Fault Indicators

These are to be fitted to all incoming and outgoing circuits in each substation and/or RMU. Care must be taken in their selection and installation to ensure that they operate correctly. If the installing contractor is not familiar with their installation, advice from Power and Water should be sought.

18 Maximum Demand Indicators

All package substations shall be fitted with an MDI. These shall utilise a single 0.2 class metering CT, securely mounted, and arranged to record the total low voltage output current of one phase. The MDI shall be mounted in a readily accessible location.

19 Construction Program

The contractor is required to submit an Electrical Installation Program as per Network Policy NP001.1 before commencement of construction. It shall be submitted to the Manager Distribution Development in Darwin (PO Box 37471 Winnellie 0821, Fax 89245121). For centres other than Darwin the Manager Distribution Development will determine the auditing process and notify Regional staff accordingly.

Cable Pulling Record

Name of Contractor: .....

Project: .....

Cable type: ..... Size: ..... No. Cores: .....

Drawing No./s .....

Pull 1: Date: ...../...../.....

Start Reference: ..... Finish Reference: .....

Direction of pull: ..... Max. tension: .....kN

Details of Dynamometer: .....

Winch Description: ..... Type of Rope: .....

Pull 2: Date: ...../...../.....

Start Reference: ..... Finish Reference: .....

Direction of pull: ..... Max. tension: .....kN

Details of Dynamometer: .....

Winch Description: ..... Type of Rope: .....

Pull 3: Date: ...../...../.....

Start Reference: ..... Finish Reference: .....

Direction of pull: ..... Max. tension: .....kN

Details of Dynamometer: .....

Winch Description: ..... Type of Rope: .....

Pull 4: Date: ...../...../.....

Start Reference: ..... Finish Reference: .....

Direction of pull: ..... Max. tension: .....kN

Details of Dynamometer: .....

Winch Description: ..... Type of Rope: .....