# ELECTRICAL

## SECTION E4 - CABLE INSTALLATION & TESTING

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GENERAL REQUIREMENTS

1. ACCESS TO WORK SITE

Before climbing a pole (to install, test or maintain a cable termination), the pole must be assessed for climbing safety, as described in ENERGEX's safety standards.

Before the commencement of work in an enclosed underground cable pit, trench or basement (depth greater than 1500 mm), Service Providers must comply with ENERGEX safety standard entry (and working) requirements for enclosed underground cable pits (confined spaces).

2. SITE PREPARATION

The Jointer must ensure that adequate precautions are taken so the joint can be completed without being contaminated by foreign matter or moisture.

The cable ends shall be adequately supported during the installation of the joint, and supports shall remain in place until the joint bay is backfilled.

3. CABLE IDENTIFICATION

The ENERGEX Nominated Officer shall be responsible for arranging identification of existing commissioned HV cables to be cut or spiked, using the recognised ENERGEX procedures.

4. UNDERGROUND CABLES ON POLES

Underground cables shall be positioned on poles so that the danger of vehicle impact is minimised. LV UG cables shall not be installed on poles with 33 or 110kV earth downleads.

5. MOISTURE CONTAMINATION

XLPE cable should be examined for signs of moisture on conductors or discolouring of copper screen wires. Wet XLPE often exhibits "leprous" spots on the outer surface of the XLPE insulant.

When 11 kV XLPE Underground Cables exhibit any of the following conditions:
- water is found in the cable sheath, around the conductors or in the cable fillers
- there is discolouration of the copper screen wires or conductors
- Instances where the cable has failed and the cause of failure is unknown.

Where feasible the following actions shall take place:
- notify the Project Manager
- cut off a 400 mm section of the affected cable
- seal both ends with heat shrink caps
- complete the 11 kV XLPE Report and attach to the 400 mm cable section
- forward cable sample to ENERGEX's Engineering Standards Group.
6. **PRE-JOINTING OR PRE-TERMINATING**

Prior to constructing joints or terminations, an assessment shall be performed to determine the integrity of the cable(s) to be jointed or terminated. This assessment shall include:-

- Visual inspection of the seal fitted onto the cable end;
- Visual inspection of the cable core(s) for moisture, dirt or any other foreign material;
- Visual inspections of the outer serving of the cable;
- A cable insulation test;
- A phasing test before joining conductors.

Any anomalies must be reported to the Project Manager who shall advise ENERGEX. Where moisture or foreign material is found in cables, ENERGEX must be immediately informed.

7. **CONSTRUCTION STANDARD**

Joints and terminations shall be constructed; as specified in the ENERGEX approved proprietary Jointing Instruction. The Jointing Instruction shall be supplied in the manufacturer’s kit with all the required materials.

Additional construction details will be made available on ENERGEX drawings when required.

However, the following basic principles shall be applied:

- Conductors shall be cut with a hacksaw or power driven saw to prevent deformation of stranded conductors when fitting to ferrules/lugs.
- Cable sheaths shall be abraded and heat treated prior to applying mastics and heatshrink to ensure a good seal.
- Cable shall be cleaned and degreased prior to application of mastics.
- Heatshrink shall be correctly positioned and evenly shrunk.
- PVC tape shall not be placed around MV heatshrink terminations as this prevents surface currents flowing and causes tracking and discharge on the termination.
- Ensure all stainless steel bolts are coated with anti-seize grease to avoid binding of the thread.
- Ensure all bolted connections are made to torque setting as per Section E1 or the manufacturer’s instructions. All surfaces shall be coated in a suitable compound/grease.
- Suitable compounds or grease are a stable, have a high-drop-point to provide continuing environmental protection to the contact interfaces. Approved greases are:
  - s/c14835 Karl Pfisterer P1 (100ml tube)
  - s/c16256 Dulmison Alvan R3 (225g tube)
  - s/c16390 Kopr Kote (500g can)
  - s/c03843 Shell Alvania EPLF2 (450g cartridge)
- Aluminium, as soon as it is exposed to air, forms an invisible oxide film which has high electrical resistance. It is essential that this film be removed before a joint is made and precautions be taken to prevent the oxide re-forming either before or during the life of the joint.
- For aluminium lugs and phase bars, a coating of jointing compound is then applied and the joint faces abraded with emery cloth or a wire brush, so that the oxide film is removed from under the compound and is prevented from re-forming.
- Removal of the semi-conductive insulation screen shall be in the approved method as per E4 1.3.
• Completed resin filled joints shall be allowed to cool down and set completely before applying mechanical load to the joint. This is in the order of 2 hours (LV) or 3 hours (HV).
• All direct buried joints shall be backfilled with a minimum 100mm cover of soft bedding sand around the joint.

8. **AIR CLEARANCES IN 11KV CABLE BOX**
   The following is minimum air clearance required in an 11kV air insulated cable box to maintain 95kV BIL:
   • Phase – ground - 160mm
   • Phase – phase - 185mm

   If these clearances cannot be maintained, then connectors will need to be covered in accordance with E6 3.18, or the box filled with bitumen or Guroflex.

   Guroflex (SC20345) can be used as a replacement for bitumen in cable boxes where heatshrink terminations can be used. Minimum clearances between live terminals for Guroflex filled cable box are:
   • Phase – ground - 32mm
   • Phase – phase - 45mm

   Refer Technical Instruction TSD0133 for use of Guroflex.

9. **EARTHING OF 11KV CABLE SCREENS**
   For all 11kV three core and triplex cables, screenwires and lead sheaths shall be earthed at each end. Single core cables in zone substations may have the screen wires earthed at one end only to increase current ratings.

   Screen wires shall be bunched together as per the installation instruction to form an earth lead, and covered with re-jacketing tubing. Where the screen wires are required to be extended to reach the earth bar (eg when passing through CTS for Safeplus AFLR switchgear), an appropriately sized inline mechanical connector is acceptable.

   Screenwire sizes for current cables are as follows:

<table>
<thead>
<tr>
<th>Cable Size</th>
<th>Screen wire size per core (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11kV 35 Al 3c</td>
<td>6</td>
</tr>
<tr>
<td>11kV 240 Al triplex URD</td>
<td>20</td>
</tr>
<tr>
<td>11kV 95 Al triplex</td>
<td>20</td>
</tr>
<tr>
<td>11kV 400 Al triplex</td>
<td>40</td>
</tr>
</tbody>
</table>

   Deadbreak elbows shall have drainwires off the outer surface of the elbow connected to earth.

10. **CURRENT TRANSFORMERS AROUND 11KV CABLES**
    When LV current transformers for metering and/or protection are placed around 11kV cables, they shall be positioned such that they are over the screened portion of the cable. Positioning them above the screen off position may cause discharge between termination and current transformer.

    Screenwires from the termination shall pass back through the current transformer to cancel out any circulating current flowing in the screenwires, so that the phase current only is measured. Drain wires from dead break elbows do not have to pass back through the current transformer.
12. **REMOVAL OF WATER SWELLABLE TAPES**

Some polymeric cables incorporate water swellable tapes as a precautionary measure against radial ingress of moisture into the cores. Water swellable tapes incorporate water swellable powder, which is not classified as a toxic substance. However, safety precautions and good hygiene are essential for minimising the risks of exposure.

12.1 **Method of Removal from Cables and Disposal**

Remove the water swellable tapes as follows:
- Wear a dust mask and rubber gloves.
- Carefully remove the tape, cut it where required, and place it in a plastic bag.
- Seal off the bag and dispose of it as ordinary waste.

Note: Rough handling of the tape may lead to emission of water swellable dust.

12.2 **Health Risks**

Water swellable tape is a moderate irritant to skin, eyes and mucous membranes. Employees who have a history of skin disease or allergy should seek medical advice before direct contact or dust exposure during slitting or rough handling.

12.3 **Special First Aid Procedures**
- **Eye:** Flush eyes with plenty of water and seek medical attention if irritation persists.
- **Skin:** Wash with mild soap and water, remove contaminated clothing and launder before reuse.
- **Inhalation:** Remove person to fresh air and seek medical attention.

For earth fault indicators, please consult Technical Instruction TSD00140 for positioning of indicators on cables.

### Figure 10.1 – Correct and Incorrect CT Position

![Correct and Incorrect CT Position](image)

### 11. JOINTING TOOLS

The following tools are the minimum required for cable preparation for 11kV cables:
- Insulation scoring tool (0.4mm depth)
- 6mm rat tail file
- Long nose pliers
- Cable sheath stripper
- Cable insulation stripping tool to expose conductor
- Assorted dies/presses for crimping
- Torque wrench
13. REMOVAL OF GRAPHITE
Graphite has been classified as having low toxicity, and a non-carcinogenic substance. However, normal industrial safety precautions such as wearing leather gloves, safety glasses and safety boots should be observed.

First aid procedures are:
- Swallowed: Keep individual calm, do not induce vomiting, seek medical attention.
- Eye: Flush eyes with water for 15 minutes, seek medical attention if irritation persists.
- Skin: Wash with soap and water, remove contaminated clothing and launder before reuse.
- Inhaled: If affected, remove individual to fresh air, seek medical attention if breathing difficulties occur.

14. GREASING OF LOW VOLTAGE CONNECTIONS
Low voltage connections require greasing with an approved oxide inhibiting conductive grease, include:

- Neutral/Active connections
- Neutral/Active links
- Connections exposed to moisture
- Connections in underground service pits

Grease shall be applied generously to all conducting surfaces.

15. COMPLETION OF JOINTS AND TERMINATIONS
Where work is carried out on previously commissioned mains and/or system apparatus, the Jointer shall surrender the access permit to the URD Testing Operator or to ENERGEX (Control), as directed, after completing the work.

16. FAULT DETECTION
Fault detection and repair (by the service provider) shall be required in the event of a cable failing a test during commissioning.
SERVICE PIT SYSTEM CONSTRUCTION

1. SERVICE CABLE

Service cable installed in underground residential reticulated areas with pit system, shall be 16 mm², stranded copper conductor, 4 core, XLPE insulated, PVC sheathed to AS/NZS 4026.

The service cable ends, depending on the construction co-ordination of the electrical reticulation, may need to be sealed with a heat shrink or roll-on end cap.

The end caps shall prevent the ingress of moisture or other foreign material until such time as the insulation piercing connectors are fitted.

2. FITTING INSULATION PIERCING CONNECTORS (IPC)

Insulation piercing connectors shall only be fitted to service cable after the completion of Stage 1 of the electrical testing.

An insulating piercing connector shall be fitted to the nominated phase and neutral core of the service cable.

For the purpose of new underground residential development construction, insulation piercing connectors shall not be connected to cables that are energised.

3. PREPARATION OF SERVICE CABLE TAILS

When a phase (core of the service cable) is not required for connection to street light column or other non-residential services at a service pit, the core of the cable shall be encapsulated with a heatshrink cap. The encapsulation shall prevent the ingress of moisture and other foreign material.

The service cable tails shall be loosely coiled together and placed into the service pit with the terminated ends close to the top of the service pit.

Phase selection for services shall be in accordance with the works plan.

ENERGEX staff only shall perform the connection of residential consumers' mains to the service cable tail IPC's in the service pits.

4. TERMINATION OF LOW VOLTAGE CIRCUITS

The permanent end of a low voltage distribution circuit, such as found at the end of a cul-de-sac shall be terminated within the last low voltage service tee joint of the circuit.

A combination stop end/service tee joint shall be constructed at the end of such a circuit.
## LV Cable Rating & Fuse Sizes

<table>
<thead>
<tr>
<th>Conductor Size &amp; Type</th>
<th>Description</th>
<th>Single Circuit Summer Continuous Rating (A)</th>
<th>Max Fuse Size (A)</th>
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</thead>
<tbody>
<tr>
<td>4 sq mm. Cu 2-core</td>
<td>PVC/NS/PVC</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>16 sq mm. Cu 4 Core</td>
<td>XLPE/PVC</td>
<td>110</td>
<td>80</td>
</tr>
<tr>
<td>25 sq mm Cu 2-core</td>
<td>PVC/NS/PVC</td>
<td>150</td>
<td>120</td>
</tr>
<tr>
<td>25 sq mm Cu 3.5-core</td>
<td>PVC/NS/PVC</td>
<td>125</td>
<td>100</td>
</tr>
<tr>
<td>70 sq mm Cu 4-core</td>
<td>PLYSW/PVC</td>
<td>220</td>
<td>160</td>
</tr>
<tr>
<td>120 sq mm Al 3.5 core</td>
<td>XLPE/NS/PVC</td>
<td>265</td>
<td>200</td>
</tr>
<tr>
<td>185 sq mm Al 4 core</td>
<td>XLPE/PVC</td>
<td>340</td>
<td>250</td>
</tr>
<tr>
<td>185 sq mm Cu 4 core</td>
<td>XLPE/PVC/HD PE</td>
<td>405</td>
<td>315</td>
</tr>
<tr>
<td>240 sq mm Al 4-core</td>
<td>XLPE/PVC</td>
<td>380</td>
<td>315</td>
</tr>
<tr>
<td>300 sq mm Al 4-core</td>
<td>PLYPVC</td>
<td>395</td>
<td>315</td>
</tr>
<tr>
<td>300 sq mm Cu 4 core</td>
<td>XLPE/PVC</td>
<td>555</td>
<td>400</td>
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## DIE SIZES TO SUIT UTILUX 38A COMPRESSION TOOL

<table>
<thead>
<tr>
<th>CROSS SECTION (sq.mm)</th>
<th>LUG TYPE</th>
<th>LUG STOCK CODE</th>
<th>DIE ACROSS FLATS (MM)</th>
<th>UTILUX DIE</th>
<th>DIE STOCK CODE</th>
<th>NO. OF CRIMPS</th>
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<tbody>
<tr>
<td>35 AI Stranded</td>
<td>BI-METAL STALK</td>
<td>14463-15895</td>
<td>9.0</td>
<td>38-90 Al</td>
<td>13936</td>
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<tr>
<td>95 AI Stranded</td>
<td>PALM LUG</td>
<td>14877-16089</td>
<td>17.3</td>
<td>38-173 Al</td>
<td>11084</td>
<td>2</td>
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<tr>
<td>120 AI Stranded</td>
<td>PALM LUG</td>
<td>12788</td>
<td>17.3</td>
<td>38-173 Al</td>
<td>11084</td>
<td>2</td>
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<tr>
<td>240 AI Stranded</td>
<td>PALM LUG</td>
<td>05934-16090</td>
<td>28.4</td>
<td>38-284 Al</td>
<td>2143</td>
<td>2</td>
</tr>
<tr>
<td>240 AI Stranded 90 deg</td>
<td>PALM LUG</td>
<td>15507</td>
<td>28.4</td>
<td>38-284 Al</td>
<td>2143</td>
<td>2</td>
</tr>
<tr>
<td>120 AI Solid 120 deg</td>
<td>PALM LUG</td>
<td>5931</td>
<td>-</td>
<td>NEST 12 INDENT 16</td>
<td>2151</td>
<td>3</td>
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<tr>
<td>120 AI Solid 90 deg</td>
<td>PALM LUG</td>
<td>15861</td>
<td>-</td>
<td>NEST 14 INDENT 16</td>
<td>2150</td>
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<tr>
<td>240 AI Solid 120 deg</td>
<td>PALM LUG</td>
<td>11975</td>
<td>-</td>
<td>NEST 12 INDENT 19</td>
<td>2151</td>
<td>3</td>
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<tr>
<td>240 AI Solid 90 deg</td>
<td>PALM LUG</td>
<td>15507</td>
<td>28.4</td>
<td>38-284 Al</td>
<td>2143</td>
<td>2</td>
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<tr>
<td>16 Cu Stranded</td>
<td>SHT BARREL</td>
<td>15125</td>
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<td>38-63 Cu</td>
<td>17449</td>
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<td>10886-10379</td>
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<td>38-77 Cu</td>
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<td>50 Cu Stranded</td>
<td>SHT BARREL</td>
<td>6259</td>
<td>10.4</td>
<td>38-104 Cu</td>
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<td>70 Cu Stranded</td>
<td>SHT BARREL</td>
<td>6260</td>
<td>11.5</td>
<td>38-115 Cu</td>
<td>2144</td>
<td>1</td>
</tr>
<tr>
<td>95 Cu Stranded</td>
<td>SHT BARREL</td>
<td>6264-10380</td>
<td>14.2</td>
<td>38-142 Cu</td>
<td>2145</td>
<td>1</td>
</tr>
<tr>
<td>120 Cu Stranded</td>
<td>SHT BARREL</td>
<td>6265</td>
<td>16.5</td>
<td>38-165 Cu</td>
<td>2150</td>
<td>1</td>
</tr>
<tr>
<td>185 Cu Stranded</td>
<td>SHT BARREL</td>
<td>6266-13969</td>
<td>20</td>
<td>38-200 Cu</td>
<td>2147</td>
<td>1</td>
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<tr>
<td>240 Cu Stranded</td>
<td>SHT BARREL</td>
<td>11976-13970</td>
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<td>38-231 Cu</td>
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<tr>
<td>300 Cu Stranded</td>
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<td>6269</td>
<td>26</td>
<td>38-260 Cu</td>
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### SHEAR BOLT CONNECTORS FOR CIRCULAR STRANDED CONDUCTORS

<table>
<thead>
<tr>
<th>CROSS SECTION (sq.mm)</th>
<th>FERRULE STOCK CODE (PACK OF 3)</th>
<th>LUG STOCK CODE (PACK OF 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 - 95</td>
<td>23932</td>
<td>22847</td>
</tr>
<tr>
<td>95 - 240</td>
<td>18109</td>
<td>23929</td>
</tr>
<tr>
<td>185 - 600</td>
<td>23942</td>
<td>23926</td>
</tr>
</tbody>
</table>

(see manufacturer's instructions for solid & sector shaped)
REMOVING SCREEN FROM XLPE CABLES

1. Apply a nylon cable tie to the cable adjacent to the required insulation screen off point. Make allowance for the size of the file to be used in step 4 (see Figure 1).

2. Use a 0.4mm fixed depth blade (SC23890) or set a depth knife to approximately 60% of thickness at its thinnest point (see Figure 1).

3. With the depth knife score the screen into longitudinal strips 20-25mm wide down to the nylon tie (see Figure 1).

4. Using the cable tie as a guide, file a groove around the screen with a round file, to a depth where the underlying white XLPE insulation is just showing (see Figure 2).

NOTE: It will be necessary to move the “buckle” of the cable tie around the cable to allow a neat, even groove to be achieved.

5. Using pliers, pull the scored strips away from the XLPE insulation (see Figure 3).

NOTE: If the strips of screen material break due to the bond between the screen and XLPE insulation being too great, the screen should be heated lightly with a gas flame.

6. Remove the cable tie.

NOTE

Alternative tools for screen removal, including those manufactured by Alroc or Speed Systems, shall be approved by the Underground OAC committee before use.
1. **ELECTRICAL TESTING**

1.1 **URD & C&I Estate Commissioning Tests**

Pre-commissioning electrical testing of the works shall be carried out by the Service Provider/Operator and coordinated by the Consulting Engineer/ENERGEX Supervising Officer.

ENERGEX shall be notified of the testing dates and will advise the Consulting Engineer if it desires to witness the tests. If required, ENERGEX will carry out the HV testing at the Developer's cost.

**NOTE:** Personnel testing HV cables must have appropriate authorisation from ENERGEX. Approved instrumentation and test methods are to be used. Any queries shall be directed to ENERGEX's Condition Monitoring Senior Officer.

All instruments used in testing are to be properly maintained and calibrated every six months by a recognised laboratory. All records of instrument testing and calibration shall be kept for two years.

Instruments are to bear identification at all times nominating the due date for re-calibration.

1.2 **Energex Network – Tests after Augmentation / Repair to Network**

Low voltage tests in accordance with this section are required after augmentation or repair to the Energex low voltage network. Work Practice 1202 – Low Voltage Connections specifies additional polarity or neutral integrity tests to be performed when reconnecting transformers, service lines, consumer mains, low voltage mains and street lights.

Augmentation or repair of 11kV and 33kV cables where work is performed on the core of the cable (not screenwires or sheath) shall also be tested in accordance with this section. Refer to the flowchart on Page 6 of this section to determine test level required for 11kV cables.

1.3 **LV Cable Tests (Pit System)**

Note LV cable tests will need to be undertaken in two stages.

Stage 1 will require continuity and insulation test to be undertaken after the installation of all joints on the LV circuits but before the installation of the IPC connectors.

The stage 1 tests will prove the integrity of the main LV circuits. Stage 2 will require continuity, insulation resistance and phasing tests at all service pits and streetlights.

**Stage 1**

a) **Visual Check**

The labels at all padmount transformers link pillars and three way loop pillars shall be inspected to determine their accuracy and that all the cable ends are correctly designated.
b) **LV Cable Continuity**

The continuity test shall be carried out on each circuit from the ends of each branch or open point to the circuit origin. At circuit ends the caps installed on the service cables will need to be removed to access the conductors. The approved method is as follows:

**Step 1** Connect the phase conductors to the neutral of the cable circuit to be tested at the circuit origin, normally the padmount transformer.

**Step 2** At the remote end of the circuit check for continuity between each phase and neutral and between any two phases using the continuity range of the insulation test instrument. The difference in readings between each phase should be less than 10%.

**Step 3** If readings differ by 10% or more, physically check each bolted connection on the circuit from the remote end to the circuit origin.

If the readings still differ by 10% or more, sectionise the circuit if possible at sectionising pillars.

Bridge phase conductors to the neutral at the sectionising pillars and test for continuity from all service pits to locate the faulty connection or section of mains.

The instrument used for this measurement shall have a resolution to the second decimal place, in a 1 to 5 ohm range.

c) **Insulation Resistance Test**

Ensure that the phases and neutral of the cable circuit to be tested are isolated from each other. Isolate the phase and neutral at all street light panels and all MEN connections from the circuit. Apply a 2.5 kV DC voltage for 1 minute and complete the standard test report.

The minimum insulation resistance should be 100 MΩ.

This measurement should be taken with an instrument, which has a resolution of 10 MΩ on a 0 to 500 MΩ range.

The cable should be temporarily bonded to earth on the completion of testing to ensure that it is permanently discharged.

d) **LV Phasing Test**

Check to ensure that correct phasing is maintained and that the neutral is identified at all link pillars, service pillars and sectionising link pillars. At service pits remove end caps if installed and check correct phasing and identify the neutral.

**Stage 2**

*After installation of IPCs and heatshrink caps on unused phases.*

(a) **Insulation Resistance Test with IPCs**

Ensure that the phases and neutral of the cable circuit to be tested are isolated from each other. Isolate the phase and neutral at all street light panels and all MEN connections from the circuit. Apply a 2.5 kV DC voltage for 1 minute and complete the standard test report.

The minimum insulation resistance should be 5 MΩ.

The cable should be temporarily bonded to earth on the completion of testing to ensure that it is permanently discharged.
(b) **Polarity**

The connection of public lighting is the responsibility of the service provider, but prior to connection, an ENERGEX accredited person must successfully complete a service polarity test at all streetlight panels.

When LV mains need to be energised for testing, the service provider or the consulting engineer is to contact the ENERGEX Officer who will arrange for the cable(s) to be energised, in accordance with SWP 31, "Commissioning and Operation of the Distribution Network".
1.4 **LV Cable Tests (Pillar System)**

(a) **Visual Check**

The workmanship of the installation shall be inspected by both the service provider and the consultant to ensure that it meets ENERGEX's requirements.

The labels at all padmount transformers and link pillars shall be checked by both the service provider and the consultant to determine they are in the correct position and all the cable ends are correctly designated.

(b) **LV Cable Continuity**

The continuity test shall be carried out on each circuit from the ends of each branch or open point including all cross road service pillars to the circuit origin. An approved method would be as follows:

**Step 1.** Connect the phase conductors to the neutral of the cable circuit to be tested at the circuit origin, normally the padmount transformer.

**Step 2.** At the remote end of the circuit check for continuity between each phase and neutral and between any two phases using the continuity range of the insulation test instrument. The difference in readings between each phase should be less than 10%.

**Step 3.** If readings differ by 10% or more, physically check each bolted connection on the circuit from the remote end to the circuit origin.

The instrument used for this measurement shall have a resolution to the second decimal place, in a 1 to 5 ohm range.

(c) **Insulation Resistance Test - 4 core Cables and Neutral Screen Cables**

The insulation resistance test for neutral screened cable shall be performed after the sheath test.

Ensure that the phases and neutral of the cable circuit to be tested are isolated from each other and apply a DC test voltage for 1 minute (or until charging current stabilises). The result of these tests shall be recorded by the Testing Officer using a standard test report.

The minimum insulation resistance should be as follows:

<table>
<thead>
<tr>
<th></th>
<th>New (Automatic)</th>
<th>Existing (Conditional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Voltage</td>
<td>2.5kV</td>
<td>500V</td>
</tr>
<tr>
<td>Minimum Reading</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>(Megohms)</td>
<td></td>
<td>0.1</td>
</tr>
</tbody>
</table>
Existing circuits with a reading between 0.1 to 10 Megohms may be returned to service, but the local Asset Manager to be advised of the condition for future replacement. Cables with values less than 0.1 Megohms shall not be returned to service.

This measurement should be taken with an instrument which has a resolution of 1 Megohms on a 0 to 500 Megohm range.

The cable should be temporarily bonded to earth on the completion of testing to ensure that it is permanently discharged.

(e) **LV Phasing and Polarity**

Check to ensure that correct phasing is maintained and that the neutral is identified at all link and service pillars, at cable joints and on the fuse panel/neutral link.

The connection of public lighting is the responsibility of the service provider, but prior to connection, a service polarity test must be successfully completed by an ENERGEX accredited person.

When LV mains need to be energised for testing, the service provider or the consultant is to contact the Contract Officer to arrange this, in accordance with SWP 31, "Commissioning and Operation of the Distribution Network".

**Sequence of LV Cable Tests**

The sequence of tests (a) to (e) is the recommended sequence of testing where the cables are installed in conduits.
**Selection Criteria for 11 kV Level 1 and Level 2 Tests**

**ALL 11 kV CABLES**

- Is the type of cable known for the entire section of cable under test? (See Note 1 for exemptions)
  - Yes
  - No

- Has cable been out of service > 12 months?
  - Yes
  - No

- Has the cable been subject to a reclose attempts to sectionallise the fault or during cable fault location ‘Thump’? See Note (3) for guidance
  - Yes
  - No

- Is the cable suspected of having water ingress?
  - Yes
  - No

- Is the cable the first leg from a zone substation?
  - Yes
  - No

**Level 2 test as per test requirements (A)**

**Notes:**

(A) The Level 2 test requirements are laid out in WP1072 - Distribution Cable Testing. Staff to have AHVT2 – Level 2 HV Cable Testing accreditation.

(B) The Level 1 test requirements are laid out in WP1072 - Distribution Cable Testing. Staff to have AHVT1 – Level 1 HV Cable Testing accreditation.

- Are readings below minimum insulation resistance values?
  - Yes
  - No

**The Service Provider/Operator or Scoping Officer shall request a Level 1 test as per test requirements (B)**

**Test Requirements:**

(A) The Level 2 test requirements are laid out in WP1072 - Distribution Cable Testing. Staff to have AHVT2 – Level 2 HV Cable Testing accreditation.

(B) The Level 1 test requirements are laid out in WP1072 - Distribution Cable Testing. Staff to have AHVT1 – Level 1 HV Cable Testing accreditation.

**Notes:**

1. A cable fed directly from a set of EDOs or HV fuses to a single ground transformer are exempt from a Level 2 test, and require testing to Level 1 only (provided Level 1 readings above minimum insulation resistance values).

2. After testing, the cable shall only be re-energised by a fault make switch (eg air break switch, ring main unit isolator) or closing in a set of EDOs – refer WP 1131 Ferroresonance Load box.

3. Contact Network Operations to obtain details on Reclose activity.

---

**UNDERGROUND DISTRIBUTION CONSTRUCTION MANUAL**

**ELECTRICAL CABLE INSTALLATION & TESTING TESTING**

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1.5 **HV Cable Tests**

Only an operator who is authorised by ENERGEX shall perform HV cable tests. The test results shall be recorded on the standard test report.

**LEVEL 1 TESTS**

- Labelling checks.
- Terminal phasing verification.
- Insulation Resistance test.

**LEVEL 2 TESTS**

LEVEL 2 TESTS are required when working on the conductor core, or when significant movement in the crutch of 3 core paper cables occurs. Not required if unbolting and re-bolting previously fitted lugs/terminations.

- All LEVEL 1 tests.
- High Voltage DC pressure test for PLY cables.
- High Voltage VLF tests for XLPE or mixed XLPE/PLY cables.

**Cable Test Procedures – as per Works Practice 1072 “Distribution Cable Testing”**

**Table 1 – Insulation Resistance Requirements**

<table>
<thead>
<tr>
<th></th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A φ TO EARTH</td>
<td>&gt; 1000 MΩ</td>
</tr>
<tr>
<td>B φ TO EARTH</td>
<td>&gt; 1000 MΩ</td>
</tr>
<tr>
<td>C φ TO EARTH</td>
<td>&gt; 1000 MΩ</td>
</tr>
<tr>
<td>A φ TO B φ</td>
<td>&gt; 1000 MΩ</td>
</tr>
<tr>
<td>B φ TO C φ</td>
<td>&gt; 1000 MΩ</td>
</tr>
<tr>
<td>C φ TO A φ</td>
<td>&gt; 1000 MΩ</td>
</tr>
<tr>
<td>SCREEN TO EARTH (at 2500 V)</td>
<td>&gt; 40 MΩ</td>
</tr>
</tbody>
</table>

**NOTE:** If an XLPE cable to be tested is to have a Tee-joint installed, the Screen to Earth insulation resistance of all sections shall be taken prior to the commencement of jointing. This is necessary since some XLPE tee-joints have the screen wires in direct contact with earth. This also tests that the existing cable has not developed a low insulation resistance from screen to earth.

**LEVEL 2 TESTS**

Level 2 tests are to be conducted as per Tables 2, 3 and 4, dependant on cable construction.
### Table 2 - DC Test Voltages for Level 2 tests on PLY cables

<table>
<thead>
<tr>
<th></th>
<th>New Cables (100% test voltage)</th>
<th>Old Cables (75% test voltage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11kV</td>
<td>25 kV (core to sheath)</td>
<td>19 kV (core to sheath)</td>
</tr>
<tr>
<td></td>
<td>34 kV (core to core)</td>
<td>26 kV (core to core)</td>
</tr>
<tr>
<td>33kV</td>
<td>75 kV (core to sheath)</td>
<td>56 kV (core to sheath)</td>
</tr>
<tr>
<td>33kV HSL</td>
<td></td>
<td>45 kV (core to sheath)</td>
</tr>
</tbody>
</table>

**NOTE:** Should the cable have all "screened type" joints installed then only the "all cores to sheath and earth test" is required.

### Table 3 – VLF Testing of 11kV XLPE or Mixed XLPE/PLY Cables

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Voltage</th>
<th>Duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance (New)</td>
<td>2U₀ (13 kV)</td>
<td>15</td>
</tr>
<tr>
<td>Maintenance (Old)</td>
<td>1.6U₀ (10 kV)</td>
<td>15</td>
</tr>
</tbody>
</table>

Testing configurations required are:
- A - BC & E,
- B - AC & E,
- C - AB & E.

### Table 4 – VLF Testing of 33 kV XLPE or XLPE/Paper Cables

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Test Voltage (Core-screen)</th>
<th>Duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance (New)</td>
<td>2U₀ (38 kV)</td>
<td>30</td>
</tr>
<tr>
<td>Maintenance (Old)</td>
<td>1.6U₀ (30 kV)</td>
<td>30</td>
</tr>
</tbody>
</table>

Testing configurations required are:
- A B C to E.
NOTES

1. Removal of test probes should be carried out in the following sequence:
   
i. The RMU must have its isolator for the cable under test in the earth position.
   
ii. Insulating gloves and protective clothing shall be worn whilst removing test plugs.

2. On completion of testing, the circuit should be restored to the “as found” condition.

3. A tested cable not energised within 48 hours shall be re-tested.

4. The test permit, access permit, test authority or construction authority shall be signed off and marked as either a pass or fail.

5. To apply test voltage to cables terminated with dead break elbow connectors, use test bushing (SC22536) to clear voltage input from (earthed) outer casing. The insulated test rod provides 310mm clearance.

Figure 1 – Test Adaptor for Elbow Termination
1. PHASING

1.1 Introduction

This standard covers the phasing system presently in use throughout the Energex power system, as it applies in particular to underground distribution equipment. This phasing system is a consequence of a number of different approaches that were taken by previous entities prior to the formation of SEQEB (subsequently renamed Energex) in 1977.

Unless otherwise noted, the objective for all low voltage phasing is to be configured such that the phasing to the LV network is ABC-084 as per Figure 1. This should indicate as anti-clockwise (or BAC) phase rotation as shown in Figure 2.

![Figure 1 - Standard Phase Rotation - LV](image1)

![Figure 2 - Phase Rotation Meter](image2)

Note that non-standard phasing may exist at some C & I substations, especially those that have no tie back to the LV network, and at these sites phasing shall be restored with the same phase rotation to what was present before de-energising to make sure three phase motors run in the correct direction. Refer WP9800 - Low Voltage Network - Confirming System Normal for additional information.

1.2 Metro & Regional Phasing

Phasing requirements are specific to the area the work is occurring, due to historical differences between BCC and SEAQ phasing practice. Where the terms "Metro" and "Regional" are used, the definitions are as follows:

**Metro**

- 11kV feeders that emanate from zone substations in the Brisbane City Council (BCC) area. Refer Substation Design Standards Section 1.5 for further details if unsure. Phasing at these substations on 11kV circuit breaker cable box:
  - A - U, B - V, C - W

**Regional**

- All other areas. Phasing at these substations on 11kV circuit breaker cable box:
  - A - U, B - V, C - W

1.3 Relay Operated Substations (SS)

When making connections in relay operated substations (designated SSXXX), phase connections shall be in accordance with the phasing and polarity diagram for the substation.
Where there is no phasing and polarity diagram for the site (e.g., at some regional relay operated C & I substations), then the phasing shall be in accordance with that for a ground transformer (SG) site below.

### 1.1 Ground Transformer Substations (SG)

The following connections shall be made at a ground transformer (SG) site irrespective of whether the transformer is oil filled or dry type:

<table>
<thead>
<tr>
<th></th>
<th>Metro</th>
<th>Regional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A - C cross at the HV cable box of the distribution transformer, n-b-c-a at LV cable box</td>
<td>No cross on HV or LV cable box at distribution transformer</td>
</tr>
</tbody>
</table>

#### Metro Area

```plaintext
A
B
C
RMU
Transformer
Outside LV Network

Metro Area

A
B
C
U
V
W
n
u
v
w
n
a
b
c
```

#### Regional Area

```plaintext
A
B
C
U
V
W
n
u
v
w
n
a
b
c
```

#### Padmount Transformer Substations (SC)

1.5 Padmount Transformer Substations (SC)

<table>
<thead>
<tr>
<th></th>
<th>Metro</th>
<th>Regional</th>
<th>Metro Area</th>
<th>Regional Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B - C cross at the RMU incoming circuit cable box, no cross on LV cable box</td>
<td>No cross on HV or LV cable boxes.</td>
<td>Metro Area</td>
<td>Regional Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A - U</td>
<td>A - U</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B - V</td>
<td>B - V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C - W</td>
<td>C - W</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RMU</td>
<td>RMU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Transformer</td>
<td>Transformer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Outside LV Network</td>
<td>Outside LV Network</td>
</tr>
</tbody>
</table>

**Cable Connections:**
- A - C cross at the HV cable box of the distribution transformer, n-b-c-a at LV cable box
- No cross on HV or LV cable box at distribution transformer

**Regional Phasing:**
- B - C cross at the RMU incoming circuit cable box, no cross on LV cable box
- No cross on HV or LV cable boxes.
1.6 Notes

- Padmount transformer - any cross to correct the phasing shall be done at RMU isolator not on the fuse switch cables.
- Ground transformer - any cross to correct the phasing shall be done at the GT HV cable box.
- Existing older installations that are being upgraded may have phase connections to older phasing standards. If installing new transformers or HV switchgear at these sites phasing shall be upgraded to the current phasing standard whilst ensuring correct phase rotation and phasing out on the LV.
- Phase rotation being correct does not necessarily mean it will phase out, but phasing out means the same phase rotation will be on both sides of the open point.

Notes

1.6