

 <b>Eskom</b>	<b>Standard</b>	<b>Technology</b>
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Title: **GENERAL INFORMATION AND REQUIREMENTS FOR LOW-VOLTAGE CABLE SYSTEMS**

Unique Identifier: **240-56030637**

Alternative Reference Number: **34-1176**

Area of Applicability: **Engineering**

Documentation Type: **Standard**

Revision: **2**

Total Pages: **42**

Next Review Date: **August 2026**

Disclosure Classification: **Controlled Disclosure**

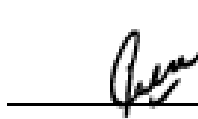
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## **Executive Summary**

This standard sets out the requirements for low-voltage underground distribution cable systems. The standard aims to establish and promote uniform designs for all such systems. Asset Design, Maintenance and Operations personnel and other related departments and parties must adhere to all the requirements and follow all the requirements as stipulated in this standard.

The standard covers all the commonly found components of a typical underground low voltage cable reticulation system such as Mini-substations feeding low voltage metering kiosks or meter panels, ground mounted transformers feeding meter panels with supplies up to 500 kVA, large power users and small power user meter panels, small power users meter kiosks, secured meter kiosks, low voltage feeder cables, service cables and customer cables. The standard covers all aspects related to the design, installation, and operation of these low voltage cable systems including the related considerations such as protection, earthing and metering.

## **1. Introduction**

This standard has been prepared to establish and promote uniform planning and design for low-voltage cable distribution or reticulation systems. The Planning and Asset Design departments should take cognizance of the constraints regarding system operation, system protection considerations and of the design application within the Eskom standards and South African National Standards. This document contains the requirements for installation of low voltage cable systems. The installation, construction and commissioning of low voltage cable systems shall be in accordance with standard requirements to avoid an unnecessary premature failures as this type of network construction and maintenance is generally expensive. The affected departments should take into consideration proposed future developments and adjacent supply areas.

## **2. Supporting clauses**

### **2.1 Scope**

This standard covers the general requirements for a low voltage underground cable distribution system throughout the project life cycle, i.e. concept release approval at planning, definition release approval at design, execution release approval at construction and final release approval at commissioning. These systems are normally fed from medium voltage/ low voltage mini-substations or ground-mounted transformers connected through cables and are used to supply consumers at low voltage. A low voltage cable system would typically consist of all or part of the following:

- a) Mini-substations feeding LV meter kiosks and meter panels;
- b) Ground-mounted transformers feeding meter panels with supplies up to 500 kVA;
- c) LPU and SPU meter panels;
- d) SPU meter kiosks;
- e) Secured meter kiosks; and
- f) LV feeder cables, service cables and customer cables.

This standard also covers the requirements for LV cable terminations onto overhead lines.

#### **2.1.1 Purpose**

The main purpose of this document is to establish and promote uniform designs for low-voltage cable distribution/ reticulation systems.

#### **2.1.2 Applicability**

This document shall apply throughout the Clusters of Eskom Distribution Division.

## **2.2 Normative/informative references**

### **2.2.1 Normative**

Parties using this document shall apply the most recent edition of the documents listed below:

- [1] 240-75661043, Distribution Standard: Part 8 – Services Section 3: Outdoor low-voltage services for small power users and larger power users.
- [2] 240-76628117, Distribution Standard – Part 17: Standard for energy meter kiosks: outdoor pole- or ground mounted, low-voltage, 200 kVA to 500 kVA for large electrical power users (LPU)
- [3] 240-75660815, Distribution Standard – Part 8: Common base and standard passive units for single-phase 230 V service connections.
- [4] 240-70500880, Distribution Standard – Part 12: Standard for the control and application of master locks and issue of master keys.

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- [5] 240-45683927, Compaction Testing of Cable Systems Installations
- [6] 240-61523882, Distribution Standard – Part 12: Low-voltage Operating Regulations.
- [7] 240-120804300, Distribution Standard – Part 12: Standard for the labelling of sub-stations and networks.
- [8] 240-7661951, Particular requirements for prepayment meters.
- [9] 240-76628293, Distribution Standard – Part 17: Specification for SPU outdoor meter panels.
- [10] 240-76628297, Distribution Standard – Part 17: Specification for 1 MVA LPU outdoor meter panels.
- [11] 34-926, Distribution Standard – Part 21: Procedure for the environmental assessment of reticulation and sub-transmission projects.
- [12] 240-126521379, Distribution Standard – Part 22: Specification for a ground-mounted, low-voltage kiosk.
- [13] 240-56063805, Distribution Standard – Part 22: Specification for LV power and control cable with rated voltage 600/1000 V.
- [14] 240-76625427, Distribution Standard – Part 17: Specification for SPU multi-way outdoor meter kiosks.
- [15] 240-86845625, Distribution Standard – Part 12: Identification and spiking of high voltage power cable.
- [16] 240-56030635, Distribution Standard – Part 22: General information and requirements for medium voltage cable systems.
- [17] 240-56063792, Distribution Standard: Part 8 – Services: Section 5: Public lighting.
- [18] 240-56062752, Distribution Standard – Part 22: Medium-voltage miniature substations for systems with rated voltages from 11 kV to 22 kV.
- [19] 240-56062542, Distribution Standard – Part 22: Cable jointing kits for power and control cable with rated voltage 600/1000V.
- [20] 240-45395762, Distribution Standard – Part 22: Specification for ground-mounted oil-immersed power transformers up to 1 MVA and 33 kV with MV and LV cable boxes.
- [21] 240-130615754, Distribution Standard – Part 2: Earthing Section 1\_ MV and LV reticulation earthing.
- [22] 240-56062542, Distribution Standard – Part 22: Cable jointing kits for power and control cable with rated voltage 600/1000V.
- [23] 240-45395762, Distribution Standard – Part 22: Specification for ground-mounted oil-immersed power transformers up to 1 MVA and 33 kV with MV and LV cable boxes.
- [24] 240-130615754, Distribution Standard – Part 2: Earthing Section 1 MV and LV reticulation earthing.
- [25] 240-70465489, Distribution Voltage Regulation and Apportionment Limits Zip File Standard.
- [26] 240-100176167, Excavations
- [27] 240-75561041, Public lighting standard
- [28] NRS 074-1, Low-voltage (600/1000 V) cable systems for underground electrical distribution – Part 1: Cables
- [29] NRS 074-2, Low-voltage (600/1000 V) cable systems for underground electrical distribution – Part 2: Cable accessories
- [30] SANS 1507, Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V).
- [31] SANS 10142-1, The wiring of LV premises – Part 1 Low-voltage installations.

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- [32] SANS 10198-1, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 1 Definitions and statutory requirements.
- [33] SANS 10198-2, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 2 choice of cable type and methods of installation.
- [34] SANS 10198-3, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 3 Earthing systems – General provisions.
- [35] SANS 10198-4, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 4 Current ratings.
- [36] SANS 10198-5, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 5 Determination of thermal and electrical resistivity of soil.
- [37] SANS 10198-6, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 6 Transportation and storage.
- [38] SANS 10198-7, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 7 Safety precautions.
- [39] SANS 10198-8, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 8 Cable laying and installation.
- [40] SANS 10198-9, The selection, handling and installation of electric power cables of rating not exceeding 33kV – Part 9 Jointing and termination of extruded solid dielectric-insulated cables up to 3,3 kV.
- [41] SANS 10198-13, The selection, handling and installation of electric power cables of rating not exceeding 33 kV – Part 13 Testing, commissioning and fault location.
- [42] SANS 10292: Earthing of low-voltage (LV) distribution systems.
- [43] SANS 61238-1, Compression and mechanical connectors for power cables with copper or aluminium conductors: Part 1 – Test methods and requirements.
- [44] VC 8075, Compulsory specification for the safety of electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V).
- [45] D-DT-0830, Earthing and bonding arrangement for LV underground cable network (kiosks).
- [46] D-DT-0831, LV outdoor cable termination to ABC line (unfused) .
- [47] D-DT-0832, LV outdoor cable termination to open wire line (unfused).
- [48] D-DT-0833, LV outdoor cable termination to transformer (unfused).
- [49] D-DT-0834, LV outdoor cable termination to ABC.
- [50] D-DT-0835, LV outdoor cable termination to open wire line (fused).
- [51] D-DT-0836, LV outdoor cable termination to transformer (fused).
- [52] D-DT-0854, MV and LV power cable electrical services detail.
- [53] D-DT-0855, Mini-substation earthing for MV systems without E.C.C. to source substation.
- [54] D-DT-0856, Standard power and control cable codes.
- [55] D-DT-0858, Example of as built medium voltage cable layout.
- [56] D-DT-0862, Transformer earthing for MV systems with E.C.C. to source substation.
- [57] D-DT-1000, Meter kiosk, 100 kVA – 500 kVA LPU.
- [58] D-DT-1023, Meter kiosk, 100 kVA – 500 kVA LPU (wall and ground-mounted).
- [59] D-DT-1016, Meter kiosk, 1 MVA LPU.
- [60] D-DT-1002, Meter kiosk, SPU three phase 25, 50 and 100 kVA.



- [61] D-DT-1015, Meter kiosk, SPU three phase – pre-payment.
- [62] D-DT-1004, Meter kiosk, SPU single phase.
- [63] D-DT-1011, Meter kiosk, SPU two-way single phase.
- [64] D-DT-1019, Meter kiosk, SPU four-way single phase.
- [65] D-DT-1020, Meter kiosk, SPU six-way single phase.
- [66] D-DT-1012, Meter kiosk, SPU two-way three phase.
- [67] D-DT-1018, Meter kiosk, SPU four-way three phase.
- [68] D-DT-1017, Standard passive unit for 1-phase 230 V service connections.
- [69] D-DT-1018, Meter Kiosk 4 Way Three Phase Manufacturing Details.
- [70] D-DT-1019, Meter Kiosk 4 Way Single Phase Manufacturing Details.
- [71] D-DT-1020, Meter Kiosk 6 Way Single Phase Manufacturing Details.
- [72] D-DT-1023, Meter Kiosk 100-500kVA 400V LPU Wall Mounted.
- [73] D-DT-1022, Meter Kiosk 15 Way Single Phase Manufacturing Details.
- [74] D-DT-1023, Meter Kiosk 100-500kVA 400V LPU Wall Mounted.
- [75] D-DT-1027, Meter Kiosk Secure 6 Way Single Phase Manufacturing Details.
- [76] D-DT-1028, Meter Kiosk Secure 8 Way Single Phase Manufacturing Details.
- [77] D-DT-1040, Meter Kiosk Secure 2 Way Three Phase Manufacturing Details.
- [78] D-DT-1041, Meter Kiosk Secure 4 Way Three Phase Manufacturing Details.
- [79] D-DT-2501, Torque Shear Lug.
- [80] D-DT-3102, Copper Crimp Lug.
- [81] D-DT-3034, LV MCCBs.
- [82] D-DT-3039, Clamps, IPC.
- [83] D-DT-3049, Plate, blank ALU pole MK 25x150mm.
- [84] D-DT-3057, Connector, pre-insulated pin – crimp.
- [85] D-DT-3058, Clamps, PG.
- [86] D-DT-3070, LV cable glands.
- [87] D-DT-3090, Coach screw.
- [88] D-DT 3102, Lug, crimping Cu.
- [89] D-DT-3110, Buckle - stainless steel strapping 12 mm.
- [90] D-DT-3116, Lugs, pre-insulated ABC crimp.
- [91] D-DT-3127, Pipe, HDPE / LDPE.
- [92] D-DT 3128, LV cable.
- [93] D-DT-3129, Staple, galvanised.
- [94] D-DT-3131, Stainless steel strapping 12 mm.
- [95] D-DT-3136, Conductor, overhead line.
- [96] D-DT-3138, LV cable tubing sets.
- [97] D-DT-3141, Conductor, LV ABC.
- [98] D-DT-3145, Meters, pre-payment.

- [99] D-DT-3147, LV cable outdoor termination kits.
- [100] D-DT-3148, LV cable ends.
- [101] D-DT-3166, Lugs, bi-metallic crimp.
- [102] D-DT-3170, Wire, barbed galvanised.
- [103] D-DT-3171, Passive base units.
- [104] D-DT-3181, LV fuses.
- [105] D-DT-3182, LV fuse-holders and brackets.
- [106] D-DT-3202, Sign, danger electrical symbol 150x150x0.6.
- [107] D-DT-3214, LV kiosk.
- [108] D-DT-3236, LV meter panels and kiosks.
- [109] D-DT-3229, LV cable gland reducers.
- [110] D-DT-3409, LV vertical fuse-holder (for NH2 fuses).
- [111] D-DT-8012, Cable route marker, concrete.
- [112] D-DT-8013, Cable warning tape.
- [113] D-DT 8014, LV cable joint kits, 2-4C 600/1000 V.
- [114] D-DT-8015, Cap, cable end seal.
- [115] D-DT-8016, Connectors, separable unscreened 11 kV.
- [116] D-DT-8017, Connectors, separable screened 22 kV.
- [117] D-DT-8018, Pipe, PVC cable.
- [118] D-DT-8019, Clamps, cable.
- [119] D-DT-8020, Ferrules, cable.
- [120] D-DT-8026, Cable, flexible 1-core Cu.
- [121] D-DT-8077, Sleeve, cable repair 60-120 1m LG.
- [122] D-DT-9420, Meters.

**2.2.2 Informative**

- [123] Occupation Health and Safety Act (OHS Act) No 85 of 1993 – Construction, Electrical Machinery and Explosives Regulations Explosives Act No 26 of 1956
- [124] Safety at roadworks in urban and rural areas – site manuals (issued by the Department of Transport)

**2.3 Definitions****2.3.1 General**

The definitions in accordance with NRS 000 and SANS 10198-1. The definitions of the terminology used in this standard are as follows:

Definition	Description
<b>Compacted Crown</b>	A layer of compacted soil above the natural ground level along the trench.
<b>Customer cable</b>	The customer's cable, used to connect the customer's plant to the supply at the metering point. The customer cable uses a separate neutral and earth conductor, so it may be three core armoured cable (for a single-phase customer) or four core armoured cable with a separate earth continuity conductor for a three-phase supply.
<b>Low Voltage</b>	A voltage of r.m.s. value not exceeding 1000 V.
<b>LV feeder cable</b>	The supplier's three-phase, LV cable used to distribute electricity from the miniature substations to the metering kiosks. LV Feeder cables use a combined neutral and earth system, so four core armoured cables are used. No Customers are supplied directly from a LV Feeder.
<b>LV service cable</b>	The supplier's LV cable, used to supply electricity from the metering kiosk to a customer's premises. The service cable uses a combined earth and neutral, so it may be a two-core armoured cable (for single-phase supplies) or a four-core armoured cable (for three-phase supplies).
<b>Meter panel</b>	It is the enclosure for mounting plate for meters, moulded case circuit breaker (MCCBs), plugs, and other accessories (but not for busbars)
<b>Metering Kiosk</b>	It is the enclosure used to provide a safe and convenient point at which to connect multiple customer cables to the bus bar and feeder cable via meters and circuit breakers
<b>Miniature substation (or mini-substation)</b>	A factory-assembled and tested free-standing unit that is suitable for use in an area accessible to the public, that comprises a transformer, an equipped medium-voltage compartment and an equipped low-voltage compartment and that is suitable for connection to underground cables (NRS 004).

**2.3.2 Disclosure classification**

**Controlled disclosure:** controlled disclosure to external parties (either enforced by law, or discretionary).

**2.4 Abbreviations**

The abbreviations in accordance with 34-261 and NRS 000. The following abbreviations were used in this to this standard:

Abbreviation	Description
<b>ABC</b>	Aerial bundled conductor.

Abbreviation	Description
ACSR	Aluminium Conductor Steel Reinforced.
Al	Aluminium
CAB	Cable
Cu	Copper
DT	Distribution Technology
HDPE	High Density Polyethylene.
IPC	Insulation Piercing Connector.
LPU	Large Power User.
LV	Low Voltage.
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker (Also Referred to as A Large Frame Circuit Breaker).
NRS	National Rationalised Standards
OU	Operating Unit
PEN	Protective Earth and Neutral
SANS	South African National Standards
SCOT	Steering Committee of Technology
SPU	Small power user

## **2.5 Roles and responsibilities**

The employer or his/her delegate and the governance committees such as project review forum and technical evaluation forum shall ensure that this standard is implemented and adhered to when planning, designing and installing low voltage cable systems.

## **2.6 Process for monitoring**

The relevant divisional project approval processes and technical governance structures shall apply such as Cluster technical change implementation forum.

## **2.7 Related/supporting documents**

Not applicable.

## **3. Requirements**

### **3.1 Statutory requirements**

- a) The requirements of the Occupational Health and Safety Act, Act 85 of 1993, (OHS Act) and all subsequent amendments and regulations shall be observed and adhered to except where exemption has been obtained from the Chief Factories Inspector. If any text or drawings in this standard are in conflict with the OHS Act and no exemption has been obtained, the OHS Act requirements shall take precedence over the standard.
- b) The requirements of SANS 10198-1 shall be observed and adhered to, except where exemption has been obtained from the relevant authority.

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### **3.2 Other Statutory Bodies**

- a) Other statutory bodies from which permission may have to be obtained installing LV cable systems are:
  - 1) National roads agency;
  - 2) Provincial and/or metropolitan roads agencies;
  - 3) Dept. of Water and Forestry;
  - 4) Dept. of Environmental Affairs and Tourism;
  - 5) local metropolitan / municipal town councils; and
  - 6) Any other statutory body that may be considered a stakeholder.
- b) Applications to the water, rail and local authorities shall be made in accordance with 240-75909267.

### **3.3 Servitude and Wayleave Agreements**

- a) LV feeder cables that traverse private property shall have wayleave agreements signed with the property owner.
- b) The special requirements of municipal wayleaves shall be considered.
- c) The local Asset Creation Department - Land Development Section shall be consulted for further details regarding wayleave agreements.
- d) In the event that Eskom's rights (servitudes / wayleaves) may be encroached upon and / or services / assets placed at risk, the customer service process shall be followed.

### **3.4 Environmental Considerations**

- a) The requirements of the National Environmental Management Act, 1998 (Act 107 of 1998) and Eskom's environmental directives, policies and procedures shall be observed and adhered to except where exemption has been obtained from the relevant authority.
- b) An environmental assessment and report shall be produced to minimise environmental contraventions.

### **3.5 Performance and Operability Requirements**

#### **3.5.1 General**

- a) Cable systems shall be planned and designed to ensure that the desired network performance is achievable. The operations and maintenance department shall be consulted to ensure optimisation of the network.
- b) Only products that have been evaluated and found to be compliant with the relevant Eskom standards shall be used.

#### **3.5.2 Plant Location**

- a) The location of plant e.g. mini-substations, ground mounted transformers, meter kiosks and meter panels kiosks shall be decided upon considering the following factors:
  - 1) Vehicular and pedestrian traffic;
  - 2) Environmental impact;
  - 3) Water run-off;
  - 4) Accessibility for ease of operation and maintenance; and
  - 5) Location of other underground services, for example telecommunication, water etc.

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### 3.5.3 System Configuration

- a) The majority of LV feeder cables are supplied from mini-substations (see 240-56062752) for underground distribution network.
- b) LV feeder cables can also be fed from pole mounted transformer.
- c) Where possible, the LV feeder cables shall be installed on one side of the roads.
- d) The LV feeder cables shall supply metering kiosks.
- e) The SPUs and LPUs shall be supplied from the metering kiosk using customer cable.
- f) Pre-payment SPUs shall be supplied using service cables fed from metering kiosks.
- g) Mini-substations shall be positioned as near as possible to the load centres to minimise technical ( $I^2R$ ) losses and to minimise volt drop issues.
- h) Ground-mounted transformers shall be positioned at the customer's property boundary and be treated as live chamber.

**Notes:** There is no provision for mounting protective devices in ground-mounted transformers, and therefore service cables do not have protection. For a short cable the risk of a fault is minimal and is accepted.

### 3.6 Protection Philosophy

- a) The general protection philosophy for LV cable systems shall be as follows:
  - 1) Overload as well as short circuit protection devices shall be provided;
  - 2) Short circuit protection of the transformer shall be provided by means of the MV breaker.
  - 3) Overload protection on the transformer shall be provided by means of a thermal relay initiating a trip on the MV breaker.
  - 4) LV feeder cables from mini-substations shall be protected with either MCCBs (see D-DT-3034) or "NH2" fuses (see D-DT-3409 and D-DT-3181).
  - 5) LV customer cables from meter kiosks or meter panels shall be protected using either MCBs or MCCBs (see D-DT-3034);
  - 6) The rupturing capacity of the protective device shall be based upon prospective three-phase fault levels; Consider Cascading of MCCB/MCBs where fault levels are too high. LV Fuses can also be used due to the fault current limiting characteristic of fuses.
  - 7) The operating characteristic shall be based upon the phase-to-neutral fault levels; and
  - 8) For further information on Eskom's LV protection philosophy, see 240-57649065.

### 3.7 Earthing Philosophy

- a) The general earthing philosophy for LV cable systems shall be in accordance with 240-130615754 and the following:
  - 1) The TN-C-S system earthing philosophy (see 240-130615754 and SANS 10292) shall be used for all LV underground cable networks;
  - 2) The combined protective earth and neutral conductor (PEN) shall be earthed at the source MV/LV transformer;
  - 3) The bonding and earthing at the mini-substation, and metering kiosks shall be in accordance with D-DT 0830;
  - 4) The earthing for mini-substations shall be in accordance with D-DT-0855;
  - 5) The earthing for ground-mounted transformers shall be in accordance with D-DT 0862;

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- 6) The cable armouring shall be bonded to the earth bar or earth terminal by mechanical glands via the gland plate;
  - 7) Continuity of the cable armouring shall be maintained at all cable joints by using a main earthing conductor (tinned copper braid) in accordance with 240-56062542. The main earthing conductor shall be connected to the armour wires at both sides of the joint using constant force springs.

All exposed conductive parts of a consumer's installation shall be connected via the consumer's separate protective earth conductor and consumer earth terminal to the supply earth terminal at the point of supply.

**Notes:**

- 1) High resistance faults on LV networks are discussed in 34-609.
- 2) A separate earthing conductor is therefore not required up to the customer's point of supply. The neutral conductor serves as a combined protective earth and neutral (PEN) conductor.
- 3) Application of lugs on the armour wires and connecting them to the earth bar or earth terminal may only be done in existing installations where there are no gland plates provided. In this case, all the armour wires are to be used.
- 4) The requirements for the MV and LV earth electrodes associated with mini-substations, pole mounted transformers and ground-mounted transformers are described in 240-56030635.
- 5) The supply earth terminal, in turn, is connected to the protective earth and neutral (PEN) conductor of the LV system.
- 6) Where split meter kiosks are installed, a service cable having a PEN conductor is used to supply the consumer. The service cable PEN is connected to the LV feeder cable PEN at the kiosk.

### **3.8 Metering Applications**

The metering application and requirements shall be in accordance with 240-75661043.

### **3.9 Low-Voltage Cables**

After the installation of LV cables at the minisubstation's LV compartment and kiosks, the plinths shall be backfilled and sealed (using a concrete screed). An approval shall be obtained from the design engineer prior to any deviations from the design package/ document.

#### **3.9.1 Cable Selection**

- a) Low-voltage cable (see D-DT 3128) shall comply with the requirements of 240-56063805 and shall have either copper or aluminium conductors.
- b) The LV cables to be terminated onto LV compartment of the minisub or onto the bus bar of the metering kiosk by means of indoor termination kit in accordance with D-DT 0830 relevant sheet.
- c) The LV feeder cable can be terminated using bi-metallic torque shear lugs and suitable insulating sleeves.
- d) If crimp lugs are used, then the following shall apply:
  - 1) For copper conductor LV feeder cable, terminate by using copper crimp lugs and suitable insulating sleeves.
  - 2) For aluminium conductor LV feeder cable, terminate by using torque shear lugs and the suitable insulating sleeves in accordance with relevant sheet of D-DT 0830.
- e) The LV cables to be terminated onto the overhead lines by means of outdoor termination kit in accordance with D-DT 0831, D-DT 0832, D-DT 0833, D-DT 0834 or D-DT 0835.
- f) Compulsory safety specification VC 8075 stipulates that all low-voltage cables in South Africa shall comply with the requirements of SANS 1507.



- g) The world market price of copper and aluminium dictates the type of conductor that is most cost effective at any time, however copper conductors have been preferred for the following reasons:
- 1) The core and outer diameters of a copper conductor cable are smaller for equivalent ampacity than an aluminium conductor cable – facilitating easier working when jointing and terminating;
  - 2) Due to the sizes required, torque shear lugs cannot be used in all applications. cold flow properties of aluminium can result in hot connections if not crimped properly; and
  - 3) Copper conductor cables do not require bi-metallic lugs when connecting to equipment fitted with brass stem bushings.
- h) Aluminium cables can be considered as a theft mitigation measure.
- i) Low voltage feeder cables shall be four-core, three-phase armoured cables.
- j) Service cables may be any one of the following:
- 1) Two-core armoured cable for single-phase supplies;
  - 2) Four core armoured cable for three-phase supplies; and
  - 3) Single core aluminium conductor armoured cable for LPU supplies > 500 kVA.
- k) Customer cables will typically be either two core armoured cable for single-phase supplies or four core armoured cable with an earth continuity conductor (ECC) for three-phase supplies.
- l) For the purpose of labelling of drawings and purchasing, a method of cable coding has been implemented by Eskom (see D-DT 0856).
- m) The cable cross-sectional area shall be chosen to suit the network load and volt drop requirements as well as the prospective fault level of the system. The symmetrical and earth fault levels of the cables are given in tables 1 to 4 below. These fault levels based on K values of 0,115 and 0,076 for Cu and Al conductors as supplied in SANS 10198-4 and SANS 10142. The formula used for calculating these values are:
- $$I_{sc} = \frac{KA}{\sqrt{t}} \text{ kA}$$
- n) The standard cable sizes and current ratings for copper and aluminium cables used within Eskom are given in table 5 and table 6 respectively:

**Table 1: Symmetrical fault levels for 600/1000 V extruded solid dielectric insulated armoured cables with copper conductors – initial conductor temperature 70 °C, final conductor temperature 160 °C**

Nominal conductor size, mm <sup>2</sup>	Fault duration, s						
	0.2	0.3	0.4	0.6	1	2	3
	Fault current, kA						
16	4.114365	3.359365	2.909295	2.37543	1.84	1.301076	1.062324
25	6.428695	5.249008	4.545774	3.711609	2.875	2.032932	1.659882
35	9.000174	7.348611	6.364084	5.196253	4.025	2.846105	2.323835
70	18.00035	3.779359	12.72817	10.39251	8.05	5.69221	4.64767
120	30.85774	25.19524	21.81972	17.81572	13.8	9.758074	7.967434
150	38.57217	31.49405	27.27464	22.26965	17.25	12.19759	9.959292
185	47.57235	38.84266	33.63873	27.46591	21.275	15.0437	12.28313
240	61.71548	50.39048	43.63943	35.63145	27.6	19.51615	15.93487



**Table 2: Symmetrical fault levels for 600/1000 V extruded solid dielectric insulated armoured cables with aluminium conductors – initial conductor temperature 70 °C, final conductor temperature 160 °C**

Nominal conductor size, mm <sup>2</sup>	Fault duration, s						
	0.2	0.3	0.4	0.6	1	2	3
	Fault current, kA						
35	5.947941	4.856473	4.205829	3.434045	2.66	1.880904	1.535752
70	11.89588	1.650629	8.411659	6.86809	5.32	3.761808	3.071503
120	20.39294	16.65077	14.41999	11.77387	9.12	6.448814	5.265434
150	25.49117	20.81346	18.02498	14.71734	11.4	8.061017	6.581793
185	31.43912	25.66993	22.23081	18.15138	14.06	9.941921	8.117545
240	40.78588	33.30153	28.83997	23.54774	18.24	12.89763	10.53087

**Table 3: Earth fault levels for 600/1000 V 2-core extruded solid dielectric insulated armoured cables with copper or aluminium conductors – steel wire temperature 60 °C to 160 °C**

Nominal conductor size, mm <sup>2</sup>	Fault duration, s						
	0,2	0,3	0,4	0,6	1,0	2,0	3,0
	Fault current, kA						
16	3,8	3,05	2,65	2,2	1,8	1,2	1,0
25	6,0	4,9	4,3	3,5	2,7	1,9	1,5
35	6,8	5,4	4,7	3,8	2,9	2,1	1,7
70	7,4	6,0	5,1	4,3	3,3	2,3	1,9
120	13,0	10,5	9,2	7,6	5,8	4,2	3,4
150	14,5	12,0	10,2	8,4	6,6	4,6	3,8
185	20,0	16,0	14,0	11,5	9,0	6,3	5,2
240	23,0	19,0	16,0	13,0	10,0	7,1	5,8

**Table 4: Earth fault levels for 600/1000 V 3-core extruded solid dielectric insulated armoured cables with copper or aluminium conductors – steel wire temperature 60 °C to 160 °C**

1	2	3	4	5	6	7	8
Nominal conductor size, mm <sup>2</sup>	Fault duration, s						
	0,2	0,3	0,4	0,6	1,0	2,0	3,0
	Fault current, kA						
25	6,6	5,4	4,7	3,8	3,0	2,1	1,7
35	7,4	6,0	5,2	4,3	3,3	2,3	1,9
70	11,5	9,4	8,2	6,6	5,2	3,7	3,0
120	13,5	11,0	9,6	7,8	6,0	4,3	3,5
150	19,0	15,6	13,5	11,0	8,5	6,0	4,8
185	21,5	17,5	15,0	12,4	9,7	6,9	5,6
240	24,0	19,5	17,0	14,0	10,7	7,6	6,2

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**Table 5: Earth fault levels for 600/1000 V 4-core extruded solid dielectric insulated armoured cables with copper or aluminium conductors – steel wire temperature 60 °C to 160 °C**

1	2	3	4	5	6	7	8
Nominal conductor size, mm <sup>2</sup>	Fault duration, s						
	0,2	0,3	0,4	0,6	1,0	2,0	3,0
	Fault current, kA						
35	8,5	7,0	6,0	4,9	3,85	2,7	2,2
70	15,0	12,0	10,2	8,3	6,3	4,4	3,6
120/150	22,0	18,0	15,6	12,8	9,7	7,0	5,7
185	25,0	20,5	17,7	14,3	11,0	7,9	6,5
240	28,0	23,0	19,8	16,0	12,5	8,8	7,2

**Note:** Ensure that the prospective fault current is below the thermal damage curve of the cable specified in table 9.

**Table 6: Continuous current rating for 600/1000 V extruded solid dielectric-insulated armoured cables with copper conductor– max. conductor temperature 70 °C**

1	2	3	4	5	6	7
Nominal conductor size, mm <sup>2</sup>	Standard rating, A					
	In ground		In pipes		In air	
	2-core	3- or 4-core	2-core	3- or 4-core	2-core	3- or 4-core
16	107	91	88	75	96	82
25	142	119	116	96	128	109
35	171	143	139	116	156	133
70	-	210	-	171	-	205
120	-	285	-	234	-	291
150	-	320	-	263	-	334
185	-	361	-	298	-	383
240	-	416	-	344	-	451

**Table 7: Continuous current rating for 600/1000 V extruded solid dielectric-insulated armoured cables with aluminium conductor– max. conductor temperature 70 °C**

1	2	3	4	5	6	7
Nominal conductor size, mm <sup>2</sup>	Standard rating, A					
	In ground		In pipes		In air	
	2-core	3- or 4-core	2-core	3- or 4-core	2-core	3- or 4-core
25	106	90	86	73	92	80
35	128	108	104	87	113	99
70	-	158	-	130	-	151
120	-	219	-	179	-	216
150	-	245	-	201	-	250
185	-	278	-	229	-	287
240	-	324	-	268	-	342

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- o) The above tables have been compiled from data given in SANS 10198-4 based on standard installation conditions. The standard installation conditions are as follows:
- 1) maximum sustained conductor temperature for cables laid in ground or single way ducts = 70 °C;
  - 2) soil temperature at depth of burial = 25 °C;
  - 3) ambient air temperature = 30 °C;
  - 4) thermal resistivity of soil = 1,2 Km/W;
  - 5) depth of laying to top surface of cable or single way duct in ground = 0,5 m (see D-DT-0854);
  - 6) load factor = 1; and
  - 7) each cable is assumed to be thermally independent;
- p) Where actual installation conditions differ significantly from the standard conditions the sustained current-carrying capacity given in table 5 and table 6 shall be modified by the appropriate de-rating factors.

### **3.9.2 Route Selection**

- a) The cable route shall be the most practical and economical route available. Where possible, cables shall be installed on the northern and western sides of the street. Electrical services shall be kept on opposite side of road to other services like telecommunication and water services where practically possible.

#### **Notes:**

- 1) The sustained current-carrying capacities calculated in table 5 are based upon the standard installation conditions proposed by SANS 10198-4.
  - 2) Additional capacity made available due to cyclic load profiles should only be used for contingencies.
  - 3) IEC 60853-1 allows the engineer to capitalize on the fact that cables have a long time constant and thus overloads can be applied for limited periods without the insulation reaching its temperature limit
- b) The power cable installation shall be within the road reserve at a distance of 1 m from the property boundary where practically possible.
- c) Provision shall be made for the following:
- 1) At joint bays and at terminations, an additional coil of cable shall be provided to make provision for the replacement of a faulted joint or termination;
  - 2) At terminations to overhead lines, an additional 2 m of cable shall be provided below the natural ground at the pole to make provision for the replacement of a faulted termination.

### **3.9.3 Location of Existing Services**

- a) The excavation of trial holes or cable and services locators shall be used to identify and to establish the positions of existing services on the cable route that may affect the depth of burial or spacing of the cables.
- b) Where applicable, make use of cross trenching and other methods stipulated in 240-86845625 to identify the cable(s) and other services.
- c) Use hand excavation tools up to the warning tape depth i.e 300 mm from natural ground. No pick shall be used beyond this depth.
- d) Any bridge crossings shall be designed by a professional civil/structural engineer and shall include precautions to cater for the expansion and vibration of the bridge.

**3.9.4 Trenching and Backfilling**

- a) Where the surface to be excavated requires a permanent re-instatement by a local authority or contractor, it is preferable to use a tar cutter or any other suitable tool.
- b) LV cable trench details shall be in accordance with D-DT-0854- Annexure B shall be consulted for any deviations.
- c) Where a change in trench level is necessary, the bottom of the trench shall rise or fall gradually and smoothly.
- d) For road or rail crossings, the depth of cable shall be increased in accordance with D-DT-0854 or as per the wayleave conditions.
- e) Trenches shall be kept as straight as possible and the bending radius shall be tight, however never less than the minimum bending radius of the cable given in table 8.

**Table 8: Installation minimum bending radii for LV cables**

Installation minimum bending radii for Copper/Aluminium Cables					
<10 mm <sup>2</sup>	10– 25 mm <sup>2</sup>	25– 40 mm <sup>2</sup>	>40 mm <sup>2</sup>	Unarmoured Cable ≥ 70 mm <sup>2</sup>	Armoured Cable ≥ 70 mm <sup>2</sup>
3 × D	4 × D	6 × D	8 × D	8 × D	10 × D
<b>Notes:</b> 1) D refers to the overall diameter of the cable.					

The transport, storage and the use of explosives shall comply with the provision of the Explosives Act No 26 of 1956 and the Explosives Regulations of the Occupational Health and Safety Act No 85 of 1993. A copy of blasting permits issued to workmen and permits issued to the contractor to cover the purchase, storage and transport of explosives shall be given to the project clerk of works.

- a) The material excavated from the trench shall be placed adjacent to the trench. This shall be done in such a manner as to prevent interference or damage to adjacent hedges, trees, drains or other property along the cable route. Where site conditions make this impossible, the excavated materials may, with the approval of the Design Engineer, be removed from the site and returned for re-filling the trench on completion of laying. All surplus material, from whatever source, shall be disposed of by the contractor.
- b) The trench bedding and blanket soil around the cable shall be in accordance with SANS 10198-8 requirements for bedding. A sieve having a mesh size of no larger than 12 mm may be used to sift the excavated soil. Alternatively, suitable bedding and blanket soil shall be imported.
- c) The trench backfilling shall be in accordance with SANS 10198-8 and D-DT 0854.
- d) The bedding soil shall be installed and compacted prior to cable installation. Blanket soil shall be compacted using hand compaction tools. Backfill material shall be compacted in layers of maximum thickness 200 mm. The level of compaction (see D-DT-0854) shall be measured at appropriate intervals in accordance with 240-45683927.

**Notes:**

- 1) SANS 10198-5 contains descriptions of the various types of soils and their respective suitability for cable surround soil (bedding and blanket soil) and backfill material.
- 2) A dynamic cone penetrometer (DCP) detailed in 240-45683927 may be used to measure the level of compaction.
- e) Warning tape (see D-DT-8013) shall be installed at a depth of 300 mm below natural ground level in accordance with D-DT-0854.
- f) The backfilling requirements and required level of compaction for road surface re-instatement shall be in accordance with the relevant road agency specification and shall take precedence over the requirements of D-DT-0854 and 240-45683927.

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- g) All pavements, roads and driveway crossings shall be re-instated to their original state.
- h) When re-instating surfaces, a compacted crown shall protruding 50 mm above the natural ground level (NGL) must be catered for to allow for erosion.

### **3.9.5 Excavated Trenches**

- a) If steel plates are to be used to allow vehicular access across a trench, these should be manufactured and erected as per the professional civil/structural engineers design.
- b) The plates shall be either installed flush with the road and supported on 'I' beams or, if used as a plate across a trench, then the plate shall be pinned to the road surface with suitable spikes to prevent it from moving. The plate shall provide a skid-proof surface for motor vehicles.
- c) Excavated trenches that are accessible to the public, or that are adjacent to public roads or thoroughfares, or where the safety of persons and animals may be endangered, shall be adequately and effectively protected by a barrier or fence of at least one meter in height and as close to the excavation as is practicable possible. Additional reflector should be added for more visibility at night.

### **3.9.6 Cable Pipe Ducts**

- a) Cables crossing roads or railways shall be installed in PVC/PE pipes (see D-DT-8018). The spacing of the pipe ducts shall be at least equal to the cable spacing on the direct-buried sections.

**Note:** Non-ferrous pipes must be used for single core cables to avoid the effects of magnetic induction.

- b) The internal diameter of the pipe shall be at least  $1,5 \times D$  ( $D$  = outer diameter of cable) with a minimum clearance of 35 mm in accordance with SANS 10198-8 i.e 110 mm<sup>2</sup> PVC pipe.
- c) Where pipe ducts are installed along the road by means of excavations, the pipe ducts shall have a minimum surround of 75 mm of concrete to prevent collapsing or deformation after backfilling and the concrete strength shall be at least 15 MPA.
- d) If underground directional drilling or bulleting has been used to install the pipe ducts, the concrete surround is not required.

**Note:** Underground directional drilling or bulleting equipment is used to drill holes that correspond to the pipe diameter being installed.

- e) Pipe ducts shall, project a minimum of 1 m beyond the kerb lines (or other services) so as to completely clear the surface of the carriageway. For dual carriageways and divided highways the pipe ducts shall continue in an unbroken line under the central divider. For railway crossings, the pipe ducts shall project a minimum of 3 m beyond the outermost rails.
- f) PVC/PE pipes may be bent in accordance with the manufacturer's instructions however; the radii shall not be less than the cable minimum bending radii given in table 8.
- g) All pipe ducts shall have a suitable draw wire and be sealed using an end cap until the cable is installed.
- h) Before commencing to draw a cable into a pipe duct, a cylindrical wire brush followed by a mop and a close-fitting mandrel shall be drawn through to clean out any dirt and ensure that the pipe duct has not collapsed.
- i) The cable shall be de-rated to the rating of a cable installed in a pipe if more than 10 percent of cable is installed in a pipe.
- j) One spare PVC/PE pipe ducts shall be installed for road, railway, river and other service crossings and be sealed with the end cap. The number of spare pipe ducts shall be determined by the Design Engineer in addition to the minimum requirement.
- k) Spare PVC/PE pipe ducts shall always be sealed at the ends to prevent ingress of water, vermin and backfill material.

- l) Where three single-core cables are to be laid in one pipe, use a pipe having an inside diameter of about four times the outside diameter of the cable and draw all three in together.
- m) Single-core cables shall be laid into three separate non-ferrous pipes installed in close trefoil formation.

### **3.9.7 Cable Installation**

- a) Contractors installing cable shall be in possession of all parts of SANS 10198 and shall work according to that code of practice and this standard. Where a situation arises that is not covered by SANS 10198 or this standard the contractor shall consult the Design Engineer.
- b) The LV cable depth and positioning within the trench shall be in accordance with D-DT-0854.

**Notes:**

- 1) Where more than one cable is installed in the same trench, a minimum spacing of 300 mm between cables should be maintained where possible. De-rating factors are applicable.
- 2) When trenching in rocky ground, a minimum of 150 mm should be kept between the cable and the trench side wall in order to prevent damage to the cable when the trench is back-filled.
- c) Cable laying and installation shall be in accordance with SANS 10198-2 and SANS 10198-8 and, unless otherwise specified, shall be by direct burial in accordance with D-DT-0854.

**Notes:**

- 1) Adhere to minimum bending radii during cable installation;
- 2) Cables outer sheaths must not be damaged or scratched during cable installation; and
- 3) Cable twists must be prevented during cable installation.
- d) MV and LV cables laid in the same trench shall be installed in accordance with D-DT-0854.
- e) Cables crossing roads or railways shall be installed in pipe ducts (see D-DT-8018).
- f) Cables running parallel to or crossing other services shall be installed in accordance with D-DT-0854.
- g) Prior to cable pulling, pipe ducts shall be fitted with bell mouths at both ends to prevent damage to the cable and a suitable lubricant shall be applied to the inside of the pipe.
- h) Prior to cable pulling, the cable shall be inspected for damage and both ends checked to verify that the cable ends were suitably capped. Damaged or uncapped cables shall not be installed.
- i) Prior to cable pulling, the cable inner end shall be cut free from the cable drum flange.
- j) The cable outer end shall be fitted with either a cable pulling sock or a pulling eye.

**Note:** A cable pulling sock applies tension to the cable outer layers. For longer lengths, use a pulling eye to prevent damage to the outer sheath of the cable.

- k) A swivel (fitted with a bearing to reduce friction) shall be used between the pulling rope and the cable pulling sock or pulling eye.
- l) When nose pulling the cable, the pulling tension shall not exceed the manufacturers recommendations.
- m) Cables shall be pulled either by hand (only where the conditions are suitable and by using a team and leader) or by using a winch.
- n) When a winch is used, it shall be fitted with a reliable and accurate dynamometer whether the cable is nose pulled or bond pulled and it shall be monitored throughout the pulling.
- o) Cable rollers shall be carefully positioned in the trench in the line that the cable is to follow, the rollers shall be spaced so that there is no appreciable cable sag between rollers, a spacing of 2 m is normally suitable but this distance shall be reduced if appreciable sagging is seen to occur and where appropriate, skid plates or corner rollers shall be used.

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- p) Laid cable that is not immediately jointed or terminated (whether prior to being laid, already laid, still on the cable drum or in transport) shall be sealed by means of cable end caps (see D-DT-8015).

**Note:** Only in emergency conditions (i.e. only if no end caps or heat shrink equipment is available) may 'DENSO' tape be used to temporarily seal the end of a cable (see D-DT-3213). If DENSO tape has been used, the cable shall be capped within 24 hours.

- q) Cable end caps shall be inspected for damage prior to and after cable laying. Damaged end caps shall be removed and replaced.
- r) Cable outer sheaths damaged during installation shall immediately be repaired using a cable repair sleeve (see D-DT-8077).

**3.9.8 Cable Terminations to Overhead Lines and Pole-Mounted Transformers**

When terminating LV cables onto overhead networks the following shall apply:

- a) The cable shall be securely strapped to the pole at 1 m intervals using 12 mm stainless steel strapping (see D-DT-3131) and strap buckles (see D-DT-3110). Additional off-cuts from the cable outer sheath shall be applied around the cable in order to protect the cable outer sheath from being damaged by the strapping.
- b) The LV cable shall be installed against the pole in a galvanised steel pipe in accordance with D-DT 0831, D-DT 0832, D-DT 0833, D-DT 0834 or D-DT 0835 and applicable buyers guide drawings.
- c) For terminations onto overhead networks, an anti-climbing measure / device shall be installed consisting of barbed-wire (see D-DT-3170) wrapped around the pole and secured using galvanised steel staples (see D-DT-3129). The barbed wire shall be installed at least 3 m above ground level. Additional off-cuts from the cable outer sheath shall be applied around the cable in order to protect the cable outer sheath from being punctured by the barbed wire in accordance with D-DT 0832.
- d) An electrical warning / hazard sign (see D-DT-3202) shall be fitted to the pole. The warning sign shall be installed at a height of 3 m or immediately below the barbed wire anti-climbing device.

**Table 9: Summary of various terminations of cable onto ABC, open wire and transformers**

Application	Termination Connectors	Termination Drawing	Eskom Assembly Drawing	1 Termination for Cables Less than 70 mm <sup>2</sup>	2 Termination for Cables greater than 70 mm <sup>2</sup>
Termination onto Open Wire (Fused)	For Neutral conductor using two bi-metallic PG and AL PG clamp for phases	D-DT-3148 for 1 and D-DT-3147 for 2.	D-DT 0835	70 mm <sup>2</sup> 3C ABC phase conductors for 160 A LV fuse-holders	ACSR Hare or equivalent AAAC Oak conductors covered with MDPE/LDPE pipe for 400 A LV fuse-holders
Termination onto Open Wire (Unfused)			D-DT-0832		
Termination onto ABC (Fused)	For the neutral conductor of ABC using two IPCs and one IPC for phase conductors using and PG Clamps for neutral	D-DT-3148	D-DT 0834	70 mm <sup>2</sup> ABC phase conductors for 160 A LV fuse-holders	Not Applicable
Termination onto ABC (unfused)			D-DT 0831		
Termination onto Transformer (fused)			D-DT 0836		

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Application	Termination Connectors	Termination Drawing	Eskom Assembly Drawing	1 Termination for Cables Less than 70 mm <sup>2</sup>	2 Termination for Cables greater than 70 mm <sup>2</sup>
Termination onto Transformer (unfused)	Transformer bushing / flags using pre-insulated ABC lugs having M12 fixing holes or bi-metallic lugs having M12 fixing holes.	D-DT-3148 for 1 and D-DT-3147 for 2. For termination onto the transformer D-DT-3116 and D-DT-3166	D-DT 0833	70 mm <sup>2</sup> 3C ABC phase conductors for 160 A LV fuse-holders	70 mm <sup>2</sup> 4C or ACSR Hare or equivalent AAAC Oak conductors covered with MDPE/LDPE pipe for 400 A LV fuse-holders

### 3.9.9 Termination onto Open Wire

- For cables  $\leq 70 \text{ mm}^2$  3-core, a cable end cap (see D-DT-3148) and tubing set (see D-DT-3138) shall be used in accordance with D-DT 0832 for unfused application or D-DT 0835 fused application.
- For cables  $\geq 70 \text{ mm}^2$  4-core, an outdoor termination kit (see D-DT-3147) shall be used in accordance with D-DT 0832 for unfused application or D-DT 0835 fused application.
- LV cable terminations to open-wire lines (un-fused) shall be in accordance with D-DT-0832. The cable phase conductors shall be connected to the open wire line phase conductors using PG clamps (see D-DT-3058). The cable neutral conductor shall be connected to the open wire line neutral conductor using two bi-metallic PG clamps (see D-DT-3058).
- LV cable terminations to open wire lines (fused) shall be in accordance with D-DT-0835. The cable phase conductors shall be connected to the 160 A LV fuse-holders using pin connectors (see D-DT-3057). Where 400 A fuse-holders are used, the cable phase conductors shall be connected using the 400 A built-in fuse-holder conductor clamps.
- 70 mm<sup>2</sup> ABC phase conductors (see D-DT-3141) shall be used as jumpers between the 160 A LV fuse-holders and the open wire line phase conductors.
- ACSR Hare or equivalent AAAC Oak conductors (see D-DT-3136) covered with MDPE/LDPE pipe (see D-DT-3127) shall be used as jumpers between the 400 A LV fuse-holders and the open wire line phase conductors.
- The jumpers shall be connected to the open wire line phase conductors using PG clamps (see D-DT-3058) and connected to the LV fuse-holders using the LV built-in fuse-holder conductor clamps. The cable neutral conductor shall be connected directly to the open wire line neutral conductor using two bi-metallic PG clamps (see D-DT-3058).

### 3.9.10 Termination onto Arial Bundled Conductor

- For cables  $\leq 70 \text{ mm}^2$  3-core, a cable end cap (see D-DT-3148) and tubing set (see D-DT-3138) shall be used in accordance with D-DT 0831 for unfused application or D-DT 0834 for fused application.
- For cables  $\geq 70 \text{ mm}^2$  4-core, an outdoor termination kit (see D-DT-3147) shall be used in accordance with D-DT 0831 for unfused application or D-DT 0834 for fused application.
- LV cable terminations to overhead ABC lines (un-fused) shall be in accordance with D-DT-0831. The cable phase conductors shall be connected to the ABC phase conductors using IPCs (see D-DT-3039). The cable neutral conductor shall be connected to the ABC neutral conductor using two IPCs suitable for connection onto either a bare or insulated neutral conductor (see D-DT-3039).
- LV cable terminations to overhead ABC lines (fused) shall be in accordance with D-DT-0834. The cable phase conductors shall be connected to the 160 A LV fuse-holders using pin connectors (see D-DT-3057). ABC phase conductors (see D-DT-3141) shall be used as jumpers between the LV fuse-holders and the ABC phase conductors.

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- e) The jumpers shall be connected to the ABC phase conductors using IPCs (see D-DT-3039) and connected to the LV fuse-holders using the LV built-in fuse-holder conductor clamps.
- f) The cable neutral conductor shall be connected directly to the ABC neutral conductor using two IPCs suitable for connection onto either a bare or insulated neutral conductor (see D-DT-3039).

### **3.9.11 Termination onto Transformer**

- a) For cables  $\leq 70 \text{ mm}^2$  3-core, a cable end cap (see D-DT-3148) and tubing set (see D-DT-3138) shall be used in accordance with D-DT 0833 for unfused application or D-DT 0836 for fused application.
- b) For cables  $\geq 70 \text{ mm}^2$  4-core, an outdoor termination kit (see D-DT-3147) shall be used in accordance with D-DT 0833 for unfused application or D-DT 0836 for fused application.
- c) LV cable terminations to pole-mounted transformers (un-fused) shall be in accordance with D-DT-0833. The cable phase and neutral conductors shall be connected to the transformer bushings using lugs having M12 fixing holes (see D-DT-3102). Add TS Lugs to LV Term kit and indicate this on D-DT-0833
- d) Where the LV cable run is  $> 10 \text{ m}$  from the termination pole, the cable shall be fuse protected using LV 'NH' type fuses (see D-DT-3181) and fuse-holders (see D-DT-3182). The fuse-holders shall be mounted using a LV fuse-holder bracket (see D-DT-3182) and secured to the pole using coach screws (see D-DT-3090).
- e) LV cable terminations to pole-mounted transformers (fused) shall be in accordance with D-DT-0836. The cable phase conductors shall be connected to the 160 A LV fuse-holders using pin connectors (see D-DT-3057). Where 400 A fuse-holders are used, the cable phase conductors shall be connected using the 400 A built-in fuse-holder conductor clamps.
- f)  $70\text{mm}^2$  ABC phase conductors (see D-DT-3141) shall be used as jumpers between the 160 A LV fuse-holders and the transformer.
- g) ACSR Hare or equivalent AAAC Oak conductors (see D-DT-3136) covered with MDPE/LDPE pipe (see D-DT-3127) shall be used as jumpers between the 400 A LV fuse-holders and the transformer. ABC jumpers shall be connected to the transformer bushing / flags using pre-insulated ABC lugs having M12 fixing holes (see D-DT-3116) and connected to the LV fuse-holders using the LV built-in fuse-holder conductor clamps. ACSR jumpers shall be connected to the transformer bushing / flags using bi-metallic lugs having M12 fixing holes (see D-DT-3166) and connected to the LV fuse-holders using the LV built-in fuse-holder conductor clamps.
- h) The cable neutral conductor shall be connected directly to the transformer neutral bushing / flag using lugs having M12 fixing holes (see D-DT-3102). Check ABC ratings to check when a 400 A fuse can be used. Check all cable termination drawings

#### **Notes:**

- 1) Outdoor LV cable terminations do make provision for earthing of the cable armouring. Earthing of the cable armouring is done at the equipment to which the cable is connected.
- 2) The 160 A LV fuse-holders (suitable for 'NH 00' size fuses) have built-in conductor clamps on the line and load sides that are suitable for the direct connection of aluminium conductors (one incoming and two outgoing). The 400 A LV fuse-holders (suitable for 'NH 2' size fuses) have built-in conductor clamps on the line side that are suitable for the direct connection of aluminium conductors and built-in conductor clamps on the load side that are suitable for the direct connection of copper conductors (one incoming and two outgoing).
- 3) The pin connector used to terminate Copper conductors unto the LV Fuse holder must be a bi-metallic connector while the connector used to terminate Aluminium cables should be an Aluminium pin connector as per D-DT-3057.

### **3.9.12 Cable terminations to Minisubstations and LV Kiosks**

- a) For mini-substations of rating  $\leq 500 \text{ kVA}$ , LV feeder cable protection shall be in accordance with the requirements of table 10 and be terminated to the breakers.
- b) Torque shear ferules shall be used in accordance with SANS 61238-1.
- c) Lugs (see D-DT 3102) shall comply with the requirements of SANS 61238-1.

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- d) Where crimp lugs are used, it shall be compressed using a hexagonal die crimping system.

Table 10: LV feeder cable protection requirements

1		2	3	4
LV feeder cable size [mm <sup>2</sup> ] (Cu)	LV feeder cable size [mm <sup>2</sup> ] (Al)	MCCB rating [A]	Fuse-rating [A]	LV jumper cable size [mm <sup>2</sup> ] (Cu) – MCCBs only
70	120	225	200	70
120	185	300	250	185
150	240	300	315	185
185	2x120	350	355	185
<b>Note:</b> A maximum number of 5 LV feeder cables can be supplied from a Type A mini-substation and 6 LV feeder cables from Type B mini-substation.				

- e) The protection of LV Service cables shall be in accordance with 240-75661043. Where LV MCCBs are used, it shall be supplied from the mini-substation LV busbars using flexible single-core jumper cables (see D-DT-8026) and lugs (see D-DT-3102).
- f) LV feeder cables shall be terminated using mechanical glands with shrouds (see D-DT-3070) and lugs (see D-DT-3102). Where applicable, cable gland reducers (see D-DT-3229) shall be fitted. The size of cable gland and reducer (if applicable) shall be in accordance with table 11.

Table 11: LV feeder cable gland requirements (mini-substations, kiosks, meter kiosks)

1	2	3	4
LV feeder cable size [mm <sup>2</sup> ]	Hole size	Mechanical gland size	Gland reducer size
70	M63	No. 5	M63-M50
120	M63	No. 5	M63-M50
150	M63	No. 6	N/A
185	M63	No. 6	N/A
240	M63	No. 7	N/A
<b>Note:</b> The customer's electrical installation (from the point of supply) is required to comply with the requirements of SANS 10142-1.			

- g) Locks shall be fitted to mini-substations in accordance with 240-70500880 and shall be done as follows but not limited to:
- 1) The MV and LV doors of a B-Type mini-substation and the outdoor sub-switching station enclosure door shall be locked using "Restricted Area" locks.
  - 2) Operating points on the RMU of the B-Type Minisub shall be locked using an "Operating lock".
  - 3) The MV door(s) of a A-Type mini shall be locked using a "Live chamber" lock, while the LV doors shall be locked with a "Restricted Area" lock.

### 3.10 Meter Kiosks

- a) SPU and LPU customers shall be supplied using either meter kiosks or meter panels (see D-DT-3236).
- b) Meter kiosks and meter panels shall be selected and applied as described in 240-75661043.

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- c) Meter panels as well as meter kiosk are supplied fitted with either MCBs or MCCBs for the protection of customer cables.
- d) SPU Meter kiosks, unless otherwise specified, are supplied fitted with MCBs or MCCBs (for the protection of customer cables) and meters. If empty meter kiosks are specified and the installation of MCBs shall be in accordance with D-DT-3034 and meters shall be in accordance with D-DT-9420.
- e) The Design Engineer shall ensure that optimal load balancing between phases is achieved at each metering kiosk. MCBs in the same group, with a maximum of 4 MCBs per phase, shall be connected to the same phase.
- f) LV feeder cables shall be terminated in meter kiosks using mechanical glands with shrouds (see D-DT-3070) and lugs (see D-DT-3102). Where applicable, cable gland reducers (see D-DT-3229) shall be fitted. The size of cable gland and reducer (if applicable) shall be in accordance with table 11(see 240-75661043 for further details).

Table 12: LV feeder cable gland requirements (meter panels)

LV feeder cable size [mm <sup>2</sup> ] (Cu)	Hole size	Mechanical gland size
16 mm <sup>2</sup> 2-core	M25	No. 2
16, 25 mm <sup>2</sup> 4-core	M32	No. 3
70 mm <sup>2</sup> 4-core	M50	No. 5
150 mm <sup>2</sup> 4-core	M63	No. 6
185 mm <sup>2</sup> 4-core	M63	No. 6
240 mm <sup>2</sup> 4-core	M63	No. 7

- g) Locks shall be fitted to meter kiosks, meter panels in accordance with 240-70500880.
- h) The incoming LV feeder cable onto the back of the kiosk shall be terminated on top part of the bus bar and the outgoing LV feeder cable onto the back of the kiosk shall be terminated at the bottom part of the bus bar in accordance with drawing D-DT 0830 relevant sheet and figure below.

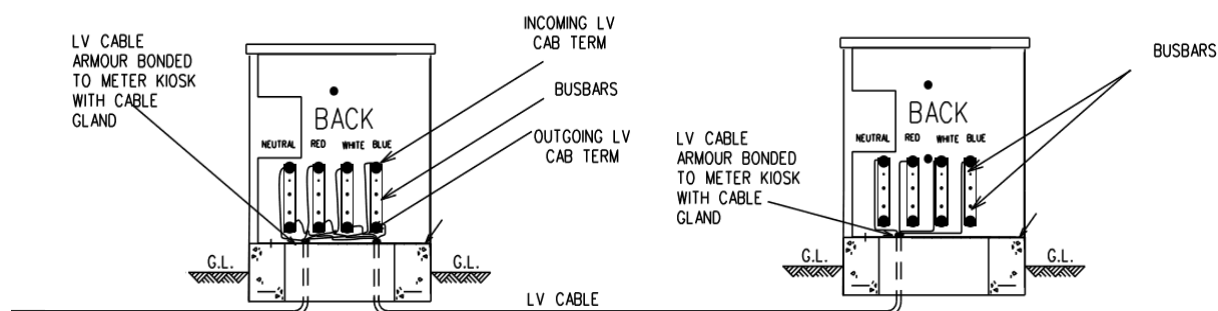


Figure 1: LV cable termination onto kiosk

- i) Where LV cables, customer cables or service cables are used, these shall be terminated in accordance with Drawing D-DT 0830 (relevant sheet) onto the minisub.

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- j) Where LV cables, customer cables or service cables are used, these shall be terminated in accordance with Drawing D-DT 0830 (relevant sheet) onto the Kiosk.
- k) Where aluminium customer cables or service cables are used, these shall be terminated in accordance with Drawing D-DT 0830 (relevant sheet) onto the Kiosk.

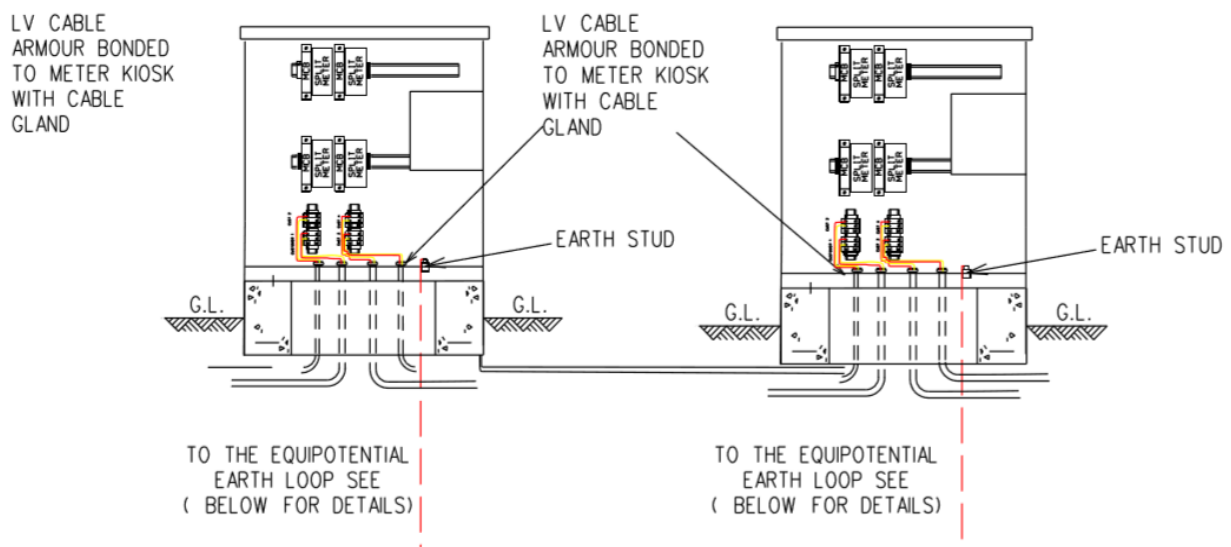


Figure 2: Service/customer cable termination onto kiosk

Notes:

- 1) Meter kiosk front doors and meter panels shall be locked using "General" locks.
- 2) Meter kiosk rear doors (for access to the LV bus bars) shall be locked using "Prohibited Area" locks.

### 3.10.1 Low Voltage Single Large Power User

#### 3.10.1.1 Minisubstation

- a) Mini-substations of rating 1000 kVA shall only be used to supply single large power user (LPU) customers. The customer shall have access to the customer and control panels. The customer's point of supply shall be the LV bus bars in the customer panel of the mini-substation.
- b) The Type A or B Mini-substations shall comply with D-DT 1016 and D-DT 0868.
- c) The customer shall provide and ensure that his/her over-current protection is adequately rated and selected to provide full discrimination with Eskom's upstream protection. The customer shall either:
  - 1) Install his/her own over-current protection in the customer panel (i.e. circuit breakers / vertical fuse-holders) for each LV feeder cable supplied from the mini-substation, or
  - 2) Install his/her own LV distribution assembly (panel / kiosk) which shall be supplied using adequately rated LV cables terminated directly onto the mini-substation LV bus bars in the customer panel. The LV distribution assembly shall include the customer's over-current protection for the customer's electrical installation
- d) The installation shall be done in accordance with D-DT 0830 (relevant sheet).
- e) The earthing shall be done in accordance with D-DT 0830 (relevant sheet).

**3.10.1.2 Ground Mounted Transformer**

- a) Ground-mounted transformers shall be used to supply SPU and LPU meter panels.
- b) Service cables shall be terminated directly into the transformer LV cable termination enclosure using mechanical glands with shrouds (see D-DT-3070) and lugs (see D-DT-3102). The size of cable gland shall be in accordance with the requirements of table 11.
- c) The ground mounted transformer installation shall be treated as a live chamber and shall consist of the perimeter fence and the lockable gate as per ORHVS.
- d) The whole installation and earthing shall be in accordance with D-DT 0639 (relevant sheet).

**Table 13: LV feeder cable gland requirements (ground mounted kiosk)**

Transformer Rating (kVA)	Size and type of LV Cu Cable	Size and type of LV AL Cable	Number of cable gland holes	Cable gland type and size (see D-DT-3070)	Size of gland hole and clearance around hole (mm)
25 kVA	70 mm <sup>2</sup> Cu 4-core PVC/SWA/PVC	120 mm <sup>2</sup> Al 4-core PVC/SWA/PVC	1	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
50 kVA	70 mm <sup>2</sup> Cu 4-core PVC/SWA/PVC	120 mm <sup>2</sup> Al 4-core PVC/SWA/PVC	1	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
100 kVA	70 mm <sup>2</sup> Cu 4-core PVC/SWA/PVC	120 mm <sup>2</sup> Al 4-core PVC/SWA/PVC	1	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
200 kVA	70 mm <sup>2</sup> Cu 4-core PVC/SWA/PVC	120 mm <sup>2</sup> Al 4-core PVC/SWA/PVC	2	Adjustable Mechanical No. 5	Ø 65 mm (hole), Ø 100 mm (clearance)
315 kVA	150 mm <sup>2</sup> Cu 4- core PVC/SWA/PVC	185 mm <sup>2</sup> AL 4- core PVC/SWA/PVC	2	Adjustable Mechanical No. 7	Ø 65 mm (hole), Ø 100 mm (clearance)
500 kVA	150 mm <sup>2</sup> Cu 4- core PVC/SWA/PVC	185 mm <sup>2</sup> AL 4- core PVC/SWA/PVC	3	Adjustable Mechanical No. 7	Ø 65 mm (hole), Ø 100 mm (clearance)
1000 kVA	500 mm <sup>2</sup> Cu 1- core PVC/PVC (unarmoured)	Not applicable	7 (2 per phase, 1 for neutral)	Compression Type A2 No. 5	Ø 50 mm (hole), Ø 85 mm (clearance)

**Note:** The number, type and size of LV cables are based upon the standard LPU meter panel service cable requirements.

**3.10.1.3 Jointing and Terminations of Underground LV Cable**

- a) LV cable shall be joined using resin joints (see D-DT 8014) or heat shrink joint in accordance with D-DT. All LV joints shall comply with the requirements of 240-56062542 and NRS 074-2.
- b) Where LV cables shall be terminated to equipment using lugs, the lugs shall have M12 fixing holes.
- c) Joint shall have Ferrules (see D-DT 8018) and shall comply with the requirements of SANS 61238-1.
- d) All LV cable accessories shall be installed according to the manufacturer's installation instructions and SANS 10198-9. LV cable jointers shall be trained and accredited based upon SANS 10198-9.

#### **3.10.1.4 Cable Transportation and Storage**

- a) Cable shall be transported and stored in accordance with SANS 10198-6.
- b) Cable ends on cable drums shall be sealed by cable end caps (see D-DT-8015).
- c) Cable end caps shall be regularly inspected for damage or cracks that may have occurred after any handling, transport, storage. Damaged end caps shall be removed and replaced.
- d) Cable on damaged drums shall be re-drummed on a drum having a barrel diameter no smaller than the original to avoid over bending.
- e) Drums shall be stored on a hard-surface that has an efficient draining system.
- f) Cable drums shall be so arranged that they are easily identifiable, accessible and that they may be released on a "first in – first out" basis.
- g) Drums shall be rolled only in the direction indicated on the drum.
- h) Drum bolts shall be tight at all times.
- i) Before off-loading, drums shall be checked for damage.
- j) Drums shall be lifted by a crane or forklift of suitable size and carrying capacity.
- k) If a crane is used, the correct lifting bar (spindle) and slings shall be used and these shall be in good condition. A spreader bar shall be used to prevent the slings from damaging the drum flanges.
- l) If a fork-lift is used, the forks shall extend to both flanges to ensure that the weight of the drum is evenly distributed on both flanges. If necessary, fork extensions shall be used. Care shall be taken in order to prevent the forks from damaging the cable drums (battens and flanges). The forks of the forklift shall not be used to push or pull the cable drum along the ground.
- m) Cable drums shall not be dropped or laid flat.
- n) If rolled off the truck, the maximum ramp slope shall be 1 in 4.
- o) LV cable drums shall be transported using a cable trailer. If this is not possible, drums may be transported by truck.
- p) When transporting by truck, all cable drums shall be secured (e.g. chained) to the truck bed to prevent them from rolling or sliding.

**Notes:**

- 1) Any defects should be reported to the site supervisor and should include a written statement and photograph. Experience has shown that this is the best method of ensuring a successful claim for the damages from the transporters insurance company
- 2) The gross mass is indicated on the cable drum.

#### **3.10.2 Cable Anti-Theft Mitigation**

When working in areas with a high risk of LV cable theft, the Design Engineer shall consider but is not limited to the following:

- a) An investigation needs to be performed for each cable theft case to determine the mode of cable theft;
- b) The mode of cable theft categories will include but not limited to the following:
  - 1) Dig open, cut and remove on cable route;
  - 2) Partially open at cable cut position, cut and pull out on cable route;
  - 3) Theft at cable outdoor terminations; and
  - 4) Theft at cable indoor terminations.



- c) Consider one of the following theft mitigation methods for implementation:
- 1) Concrete covering slab on top of cable;
  - 2) Cable clamping methods every 2 m to 10 m on cable route;
  - 3) Secure piping at outdoor terminations in combination with concrete slabs;
  - 4) Cable theft alarm technologies in combination with armed/Eskom response notification;
  - 5) Surveillance camera technologies with armed/Eskom response notification; and
  - 6) For LV cable systems only - Aluminium cable options may be considered to investigate and test if the area of concern is less prone to aluminium cable theft.

Once the theft mitigation method or methods have been selected per case, consult the Research Innovation Centre department to initiate a project to perform a commercial enquiry to evaluate and award a suitable solution.

### **3.10.3 Installation of Meter Kiosks**

There are several options of kiosk installation i.e pole mounted metering kiosk; wall mounted; and the underground metering kiosk (tapered base and common base) with the design and installation requirements elaborated on below.

#### **3.10.3.1 Pole Mounted**

The installation shall be carried out in accordance with services standard 240-75661043 and the relevant drawings on D DT 1000 series.

#### **3.10.3.2 Wall Mounted**

The installation shall be carried out in accordance with services standard 240-75661043 and the relevant drawings on D DT 1000 series. They shall be installed on the common boundary or in the middle of customer properties which it is supplying, with the doors parallel to street as per and D-DT1010 sheet 2.

#### **3.10.3.3 Ground Mounted Kiosk**

There are two options to install the SPU ground mounted kiosk which are through the base supplied with the kiosk alternative on the kiosk plinth. The installation shall be done as follows:

- a) Install the LV cables with sufficient slack and thereafter install the kiosk;
- b) Meter kiosks shall be positioned at least 0,5 m from all ERF boundaries and at least 1 m from the road kerbing;
- c) Before the installation, the ground shall be excavated and levelled in accordance with relevant sheet of drawing D-DT 1010 and compacted to 90 % MODAASHTO;
- d) After the installation, the surrounding soil shall be levelled and compacted to 90 % MODAASHTO.

##### **3.10.3.3.1 Tapered Base Meter Kiosk**

- a) Excavate in accordance with D-DT 1010 (relevant sheet) and install the base at the depth of 300mm;
- b) The base of meter kiosks shall be installed by direct burial at a depth of 300 mm and protrude with 100mm;
- c) The meter kiosks shall be installed to the base installed in a).

##### **3.10.3.3.2 Rectangular Base Meter Kiosk**

- a) The plinth of the Meter kiosks shall be installed by direct burial at a depth of 150 mm in accordance with the details specified in D-DT 1010;

### **3.10.4 Road Crossing**

The road crossing shall be done in accordance with D-DT 0854 and the 2 x 110 mm PVC pipe per cable; one for the main and the other one for spare, and then seal the spare PVC with end cap for all options as follows:

- a) Excavate 2 m wide x 2 m long x 1.5 m deep start and exit pits;
- b) After installation, the pits shall be levelled and compacted to 90 % MODAASHTO at intervals of 300 mm.
- c) The road crossing shall be done through 110 mm PVC pipe for both LV and customer cables through bulleting.
- d) On the tarred road it can be achieved by cutting the road, installation of a 110 mm PVC and backfilling according to the local authority's specification.
- e) On gravel road it can be achieved by trenching and the installation of a 110 mm PVC and backfill according to the local authority's specification.

### **3.10.5 Reticulation Studies**

The Design Engineer shall ensure that the reticulation studies fully comply with SANS 10142 and Distribution Voltage Regulation and Apportionment Limits Zip File Standard (240-70465489).

### **3.10.6 Metering Accessories**

The Design Engineer shall ensure that the data concentrators and its accessories are installed in accordance with Authorisation Procedure for The Engineering and Data Concentrator Solution (240-146295021).

## **3.11 Public Lighting**

The materials for, and the construction of, low-voltage street lighting in residential areas shall be in accordance with 240-75561041. The Streetlight control circuits shall not be installed inside a minisub but a dedicated LV feeder to supply a dedicated LV metering kiosk.

## **3.12 Construction**

General construction shall be carried out in accordance with the new works production work instructions under Part 24 of the Distribution Standard.

## **3.13 Marking and Labelling**

### **3.13.1 General**

It is a requirement of the OHS Act that all controlling apparatus is permanently marked or labelled so as to identify the system or part of the system on the electrical machinery that it controls. Where the control apparatus is accessible from the front and back, these markings shall be on both the front and the back.

### **3.13.2 Labelling of Equipment**

- a) The safety/warning labels of meter kiosks and meter panels shall be in accordance with the pertinent clauses in the relevant Distribution standards.

**Note:** The relevant equipment specifications require that they be supplied fitted with all notices, signs and, where possible, labels.

- b) The metering kiosk shall be labelled outside and clearly visible from the road as follows and the examples for respective Clusters are contained in document 240-120804300:
  - 1) The supply minisubstation name;
  - 2) Feeder identification from the minisubstation; and
  - 3) Kiosk number or stand number;

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- c) The meter panels shall be labelled outside and clearly visible as follows and the examples for respective Clusters are contained in document 240-120804300:
- 1) The supply minisubstation name;
  - 2) Feeder identification from the minisubstation; and
  - 3) Kiosk number or stand number.
- d) Each LV cable circuit and protective device (circuit breaker / vertical fuse-holder) fed from a mini-substation shall be uniquely identified and labelled in accordance with 240-120804300, i.e. A, B, C, D and E or 1,2,3,4 and 5.
- e) Inside the metering kiosk, the label indicating the customer's unique identification (e.g. stand number; house number; or customer name, etc.) shall be included directly below the corresponding meter.
- f) Protective devices (e.g. circuit breakers) supplying customers via service cables or customer cables shall be labelled in accordance with 240-120804300 and operating unit requirements.

### **3.14 Labelling of Cables**

The labelling of LV equipment shall be in accordance with 240-120804300. All LV cables shall be labelled at both ends. The label shall be a flat aluminium plate of dimensions 150 mm x 25 mm x 0,9 mm (see D-DT-3049) tied to the cable with tinned copper binding wire onto which the information is scribed/punched in a font size of 7 mm. The kiosk shall be labelled with a unique name preferable stand number.

#### **3.14.1 At the Minisubstation**

The following information shall appear at the minisubstation LV compartment on the MCB/MCCB/vertical fuse holders:

- a) Feeder Name (e.g. 'Feeder A' or 'Feeder 1')
- b) System voltage (e.g. '400 V BKR');
- c) Cable size (e.g. '70 mm<sup>2</sup>') or higher conductor sizes.
- d) Conductor material ('Cu' for copper and 'Al' for aluminium)
- e) Where the LPU is supplied from the minisubstation, the feeder shall be given a unique name that identifies the customer (e.g. stand number; house number; customer name, etc.)

#### **3.14.2 At the Back of the LV Kiosk**

At the back of the kiosk, the incoming and outgoing feeders shall be labelled as follows:

- a) One leg of LV feeder cable labelling shall include the word "To kiosk number/name" at the bottom of the kiosk i.e next to the gland plate.
- b) One leg of LV feeder cable labels shall include the word either "From minisub number or name/ kiosk number or name" at the bottom of the kiosk i.e next to the gland plate.

#### **3.14.3 In Front of LV Kiosk**

The following information shall appear in the inside of single phase or three phase LV kiosk. The LV customer/service cables supplied from meter kiosks shall be labelled at the end that terminates into the meter kiosk with unique name that identifies the customer (e.g. stand number; house number; customer name, etc.) and the rest of labelling shall consist of the following:

- a) Cable voltage (e.g. '230 V BKR or 400 V BKR');
- b) Cable size (e.g. '16 mm<sup>2</sup>');and
- c) Conductor material ('Cu' for copper and 'Al' for aluminium).

#### **3.14.4 Labelling of Cables Terminated onto Overhead Lines**

All LV cables that are terminated onto an overhead line shall be labelled at the corresponding pole using an overhead line equipment labelling standard. The label is required in order to identify the electrical address of the equipment or pole connected at the other end of the cable. The information on the label shall include the following:

- a) The unique pole number; followed by
- b) System voltage (e.g. 400 V); followed by
- c) The words "CABLE TO"; followed by
- d) The words "CABLE FROM"; followed by
- e) The unique pole number or name of the equipment at the other end of the cable.

The information shall be stencilled using black lettering on a white background with a minimum font height of 50 mm. The label shall be visible from the ground and shall be installed on the pole below the cable termination.

### **3.15 Documentation**

As-built drawings that show the position of the cable, relative to boundaries and position of LV kiosks shall be produced for all cable routes. An example of the required drawing is shown in D-DT-0858. The completed cable installation and test certificate (see Annex A), cable accessory installation instructions and quality control check sheets shall be kept for quality control purposes and stored with the project file.

### **3.16 Inspection and Testing**

#### **3.16.1 General**

To ensure the safe and reliable operation of a cable system, visual inspections shall be made and electrical tests performed before energizing. The results of the inspections and tests shall be recorded.

#### **3.16.2 Visual Inspections**

The relevant commissioning visual inspection checklist shall be complete from the requirements of this standard and shall be used by the Clerk of Works (COW) for routine inspections made during construction. The handover document i.e 240-75884058 in Distribution Technology website contains all quality checklists. The list is in the form of questions and the answers to these questions shall be in the affirmative before the system may be energised. The routine visual inspection shall be done in accordance with 240-75884478.

#### **3.16.3 Electrical Tests**

- a) All newly installed LV feeder cables shall be subjected to a 3 kV d.c. (or 2 kV rms a.c.) test voltage in accordance with table C-2 of SANS 1507-1. The contractor and person appointed to carry out the tests shall certify the new cable installation by completing a test certificate in accordance with Annex A.

**Notes:**

- 1) The test voltage shall be applied between all three phase conductors in parallel and the metallic armour / neutral conductor (to test the integrity of the insulation of each phase conductor to earth/neutral) and between each phase conductor (to test the integrity of the insulation between phases).
- 2) The test voltage should be increased to the full appropriate value, and maintained at this value for 15 minutes – unless a D.C. insulation tester is used.
- 3) A 1000 V<sub>DC</sub> insulation tester may be used if suitable equipment is not available to perform this test.
- 4) Where applicable, the LV feeder circuit breaker (MCCB) or vertical fuse holder and all the miniature circuit breakers (MCBs/MCCBs) installed in LV kiosks connected to the LV feeder cable being tested shall be open and the LV cable shall be disconnected from the bus bar of the kiosk.

Phase rotation test shall be performed prior the restoration of the supply. This test shall be required after installation or replacement of a minisubstation or any three phase LV kiosk as well as installation, jointing or termination of any 4 core LV cable. The cable fault location shall be done in accordance with SANS 10198-13 where necessary.

### **3.17 Operating**

All LV operating shall be carried out in accordance with 240-61523882 and 34-673.

#### **3.17.1 Commissioning Tests**

The following tests shall be conducted on the cable:

- a) Continuity Test;
- b) Insulation resistance (between neutral and live conductor); and
- c) Voltage at available the load.

#### **3.17.2 Phasing Conventions for LV Equipment**

The convention used for the phase order for three-phase LV equipment shall be as follows:

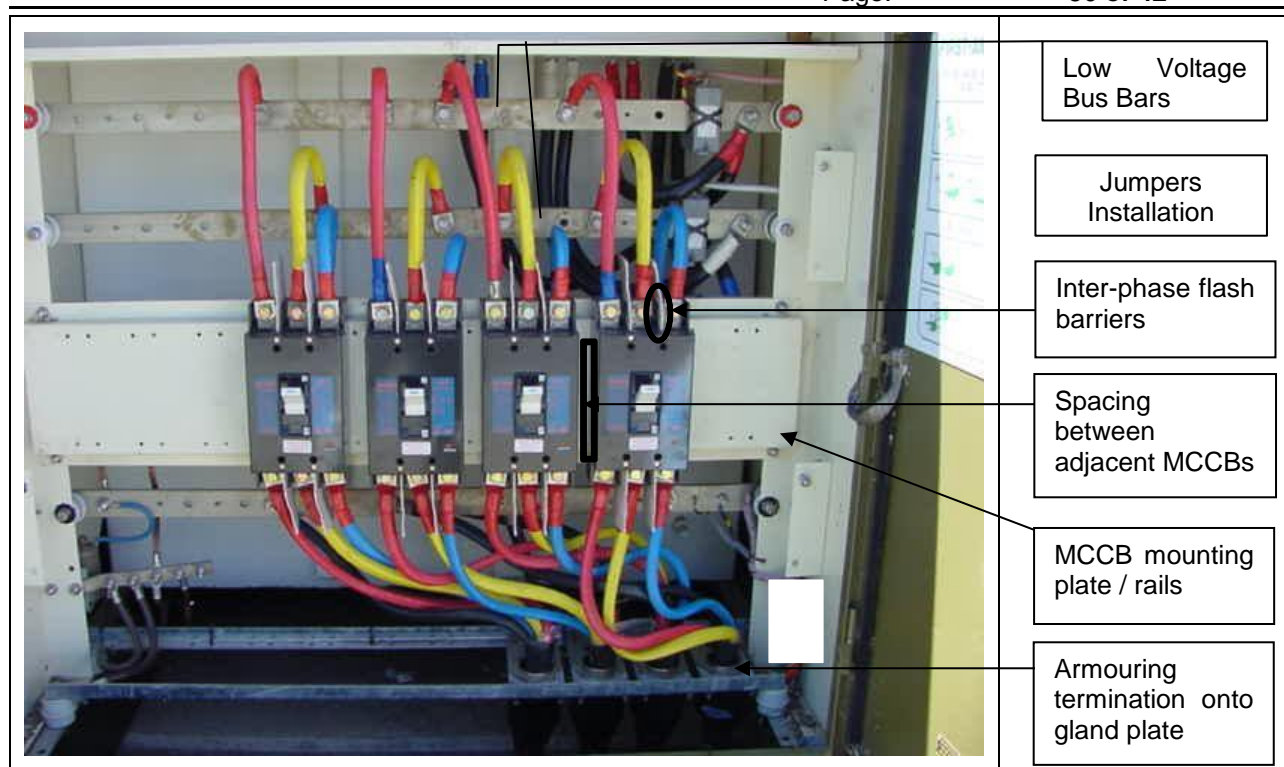
- a) Horizontal LV busbars: RED, WHITE/YELLOW, BLUE and NEUTRAL from top to bottom i.e at the LV Kiosk;
- b) Vertical LV busbars: RED, WHITE/YELLOW, BLUE and NEUTRAL from left to right (facing the busbars) i.e at the LV kiosk; and
- c) LV circuit breaker / vertical fuse holder terminals: RED, WHITE/YELLOW and BLUE from left to right (as seen by the operator facing the front of the equipment).

#### **3.17.3 Safety**

##### **3.17.3.1 LV MCCBs Installed in Minisubstations**

The following minimum requirements shall be adhered to at all times in order to reduce the probability and risk of a line-side flashover occurring at the terminals of an LV MCCB installed within a mini-substation:

- a) All LV MCCBs shall be securely mounted on the appropriate mounting plate / rails provided in the mini-substation LV compartment as shown in figure 1.



**Figure 3: Picture illustrating installation in the LV compartment of a mini- substation i.e LV MCCBs installed (MCCB safety barriers)**

- b) Inter-phase flash barriers shall be installed on all MCCBs on the line and load sides as shown in figure 3.
- c) The LV flexible single-core jumpers from the busbars to the MCCBs shall be adequately rated for the MCCB being supplied. Flexible jumpers in accordance with D-DT-8026 are available for this purpose. The correctly sized lug in accordance with D-DT-3102 shall be used for each jumper.

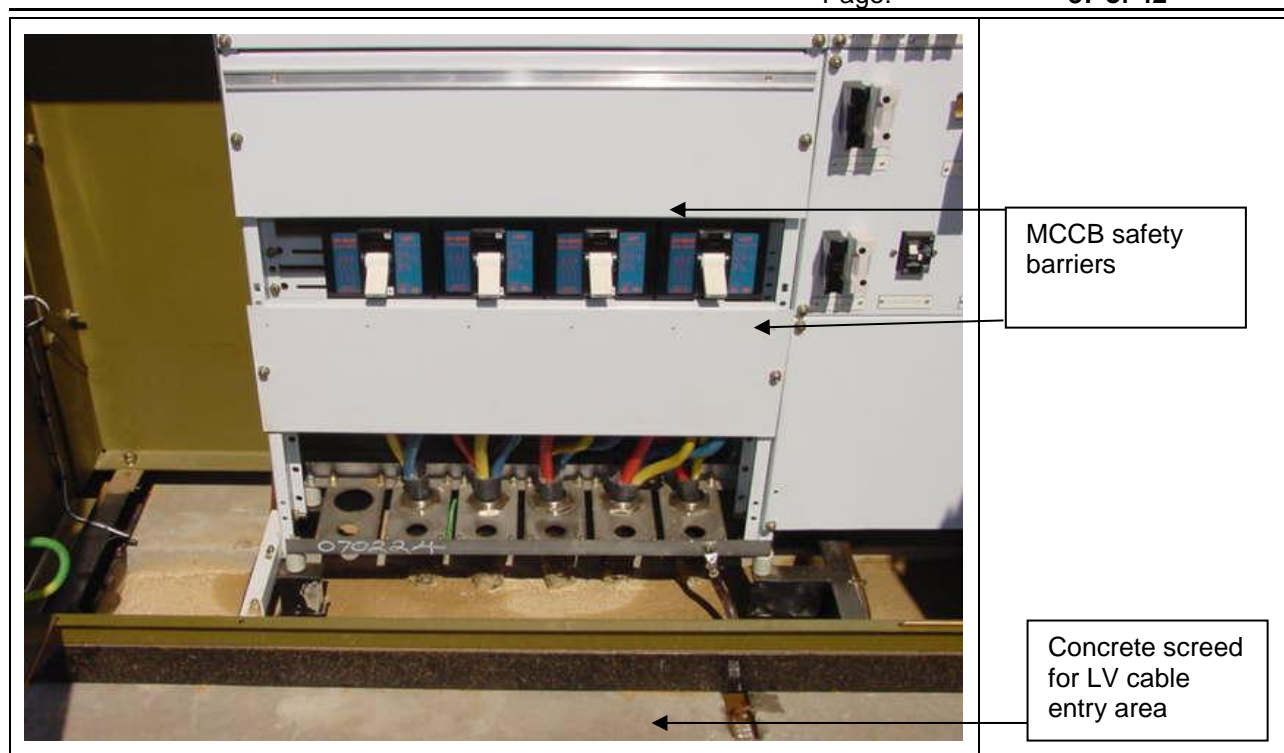
**Notes:**

- 1) The use of MCCB terminal 'extensions' should be avoided unless they are adequately insulated and suitably rated for the particular MCCB.
- 2) This is to ensure that the risk of a flashover occurring between adjacent MCCBs (i.e. between the blue and red phases) is minimised during a short-circuit interruption event.

The conductor insulation shall only be stripped in accordance with the lug barrel length – in order to ensure that there is no exposed bare live conductor beyond the lug barrel.

Where possible, adjacent MCCBs shall be installed so that the air clearance between the outer terminals of adjacent MCCBs is at least 25 mm as shown in figure 3.

The mini-substation MCCB safety barriers used to prevent inadvertent contact with the live LV busbars and terminals of the MCCBs (as shown in figure 4) shall be securely re-fitted prior to energising the LV compartment of the mini-substation. These barriers also serve to protect the operator during switching operations.



**Figure 4: LV MCCBs installed in the LV compartment of a mini-substation (MCCB safety barriers fitted)**

The concrete screed for the LV cable entry area shall be installed and all the mini-substation doors securely closed during normal service operation in order to prevent the ingress of dust and other pollution into the mini-substation.

The current rating of an MCCB shall not be increased unless the LV feeder cable, LV single core flexible jumpers and lugs are suitably rated for the MCCB.

### 3.17.4 Road Safety Precautions

When working within road reserves, the road safety precautions and requirements of the local road agency / authority i.e. wayleaves shall be complied with at all times. Comply with the latest guidelines as set out in the site manuals entailed in the national or provincial road safety standards.

### 3.17.5 Safety of Foundations, Buildings and Structures

Care shall be taken to ensure that excavations do not endanger the foundations of adjacent buildings. All the necessary precautions shall be taken so as to prevent subsidence of soil which could result in damage to foundations.

Where applicable, the installation of LV cable shall be 1 m from the road kerbing and ERF boundaries.

Where excavations may unavoidably endanger the stability of fences or other structures, the Design Engineer shall assess the situation and develop the site specific solution.

### 3.17.6 Safety of other Services

Where excavations may unavoidably endanger the stability of above ground services, such services shall be adequately and suitably supported and / or stayed.

Where excavations expose any underground services, such services will be adequately and suitably supported to avoid their subsidence and suitable protected against damage.



### **3.17.7 Barricading and Lighting**

In terms of the Construction Regulations of the Occupational Health and Safety Act 85 of 1993, all excavations which are accessible to the public or which are adjacent to public roads or thoroughfares, or whereby the safety of persons may be endangered, shall be:

- a) Adequately protected by a barrier or fence of at least one metre in height and as close to the excavation as is practicable; and
- b) Provided with warning lights or any other clearly visible boundary indicators at night or when visibility is poor.

### **3.17.8 Accommodation of Traffic and Access to Properties**

In addition to complying with the relevant requirements as applicable, where the work affects the operation or safety of public traffic, the following shall be applicable:

- a) By-pass(es), as may be required to deviate traffic from portions of the road that are to be affected by the construction, shall be constructed and put in order;
- b) Access ways, as may be required by persons requiring access to properties that fall within or adjoining the area where construction work is taking place shall be provided. If, for any reason, such access has to be closed for certain periods during the construction period, the persons affected shall be given reasonable notice in writing of each construction period; and
- c) Official communication shall be issued by the relevant Communications Office to advise the affected public of all details regarding any traffic deviations and/or access restrictions that may be put in place during the construction period.

### **3.17.9 Cables on a Shared Trench**

When external damage to a cable has been located and exposed following a cable feeder protection operation (e.g. due to contractor damage / theft), the damaged cable shall be visually identified and spiked in accordance with 240-86845625 before any work is carried out on the cable. This will ensure that a permanent fault is created and the possibility of the cable being incorrectly identified eliminated.

- a) Where applicable, prior to working on a cable, it shall be positively identified and spiked in accordance with 240-86845625.
- b) Prior excavation the excavation task manuals 240-100176167 shall be adhered to.

## **4. Authorization**

This document has been seen and accepted by:

<b>Name and surname</b>	<b>Designation</b>
Vinod Singh	Middle Manager DBOUS
Alex Ndlela	Senior Manager: Dx Engineering
Amelia Mtshali	Senior Manager: Dx Ops Support DBOUS

## 5. Revisions

Date	Rev	Compiler	Remarks
Aug 2021	2	M Mathonsi	Added the following requirements: a) Aluminium cables installation; b) Termination of LV cables kiosk; c) Detailed installation of LV kiosk; d) Details of road crossing; e) Commissioning tests; f) Cable theft mitigation; g) Labelling requirements; h) Reticulation studies; i) Annex B; j) Added excavation task manual; k) Removed cable flash blanket; and l) Removed distribution kiosk.
June 2017	1	Bheki Ntshangase	The document was stabilized without revising the content.
October 2008	0	RA Kelly and AJ Maudu	First Issue document.

## 6. Development team

The following people were involved in the development of this document:

- Barto Olivier: Dx WCOU SI
- David Ntombela: DBOUS
- Henri Groenewald: Dx Engineering PTM&C
- Imraan Moolla: Dx NED GOU
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- Malusi Mathonsi: Dx MOU SI
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- Sandisiwe Mtshaulana: Dx GOU SI
- Taelo Phali SI: Dx ECOU SI
- Vusi Cele: Dx NED GOU

## 7. Acknowledgements

Not applicable.

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## Annex A – Cable Installation and Test Certificate

PROJECT NAME: .....

PROJECT ID: .....

PROJECT LOCATION: .....

NAME OF INSTALLATION CONTRACTOR: .....

NAME AND ORGANISATION OF PERSON PERFORMING TESTS: .....

NAME AND ORGANISATION OF PERSON COMPLETING QUALITY CHECKLISTS.....

### CABLE DATA

MANUFACTURER: .....

SPECIFICATION: (SANS 1507): .....

VOLTAGE (600 / 1000 kV): .....

CABLE INSULATION (PVC): .....

NUMBER OF CORES : .....

CONDUCTOR SIZE (mm<sup>2</sup>): .....

SERIAL / ORDER / DRUM NUMBER: .....

DATE OF INSTALLATION: .....

AS-BUILT DRAWING NUMBER: .....

CABLE ACCESSORY INSTALLATION INSTRUCTIONS ATTACHED (YES / NO): .....

ALL RELEVANT QUALITY CHECKLISTS COMPLETED AND ATTACHED (YES / NO): .....



TEST EQUIPMENT USED

BRAND:

.....

TYPE:

.....

AC / DC / VLF:

.....

TEST VOLTAGE AND RESULTS

FEEDER NAME	TEST VOLTAGE (kV)	DURATION (minutes)	RESULT (pass/fail)

PERFORMED BY:

.....

NAME, SIGNATURE AND DATE

WITNESSED BY (CLERK OF WORKS / PROJECT CO-ORDINATOR):

.....

NAME, SIGNATURE AND DATE

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**Annex B – De-Rating Factors**

Number of Cables in a group	Direct in Ground					In single way duct			
	Axial spacing (mm)					Axial spacing (mm)			
	Touching	150	300	450	600	Touching	300	450	600
2	0,81	0,87	0,91	0,93	0,94	0,90	0,93	0,95	0,96
3	0,70	0,78	0,84	0,87	0,90	0,82	0,87	0,89	0,93
4	0,63	0,74	0,81	0,86	0,89	0,78	0,85	0,89	0,91
5	0,59	0,70	0,78	0,83	0,87	0,75	0,82	0,87	0,90
6	0,55	0,67	0,76	0,82	0,86	0,72	0,81	0,86	0,90

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