# RETICULATION STANDARDS FOR ELECTRICITY DISTRIBUTION PLANNING, CONSTRUCTION AND MAINTENANCE

**AUGUST 2020**

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## ACRONYMS

**ABC** : Aerial Bundled Cable
**ACSR** : Aluminium Conductor Steel Reinforced
**ADMD**: After Diversity Maximum Demand
**BDV** : Break Down Voltage
**BS** : British Standards
**CB** : Circuit Breaker
**CT** : Current Transformer
**CU** : Copper
**DB** : Distribution Board
**GoR** : Government of Rwanda
**GPS** : Global Positioning System
**HV** : High Voltage
**Ka** : Kilo Ampere
**kVA** : Kilo Volt Ampere
**kW** : Kilo Watt
**LV** : Low Voltage
**MEN** : Multiple Earthed Neutral
**MPa** : Mega Pascal
**MV** : Medium Voltage
**PG** : Pig Tail
**PT** : Potential Transformer
**PVC** : Polyvinyl Chloride
**REG** : Rwanda Energy Group
**SF6** : Sulfur hexafluoride
**SWA** : Steel Wire Armour
**USB** : Universal Serial Bus
**XLPE** : Cross-linked polyethylene

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## 1. INTRODUCTION

The purpose of this document is to create a Guideline for Construction and Maintenance Standards to be used by REG in-house construction teams as well as external Consultants and Contractors planning and doing construction and Maintenance work for REG. It addresses the standardization of the electrification construction and equipment for electrification of new areas in the REG supply area. The aim is to use simplified construction technology and standards to obtain the best economic value, without compromising standards and safety. The standardization of construction standard will also reduce the amount of different spare parts to be kept for operation and maintenance.

The Document is divided into 2 Parts and Annexes:

**A. Distribution Network Planning and Construction Standards and Guidelines**

**B. Distribution Maintenance Standards**

**C. ANNEXES:**

- **Network Planning and Development Forms**
- **Distribution Network Maintenance Forms**
- **Standard drawings**

## 1. SCOPE

This Reticulation Standard covers electricity distribution lines with Overhead Design and Power Transformers up to 2500 kVA. However, guidelines on underground cables laying are provided herewith. The lines beyond this scope will be referred to relevant National and/or International Standards.

This Standard shall be annually reviewed or at any time user Departments submit a written request to the Director of Energy Planning clearly indicating the points to be amended. Once the amendments are agreed upon, the existing version of the standard shall be updated and sent to the Chief Executive Officer for approval.

## 2. DESIGN CRITERIA

### 2.1 LAND USE

The land use will be used as a guideline for the calculation of the After Diversity Maximum Demand (ADMD) in different areas. As a guideline, typical residential land use categories are identified. This will just be a guideline, and every project should be verified against these criteria with the approval of the Design Engineer.

### 2.2 DESIGN AFTER DIVERSITY MAXIMUM DEMAND

The design household ADMD is calculated as tabled below for new reticulation network. This is calculated at **LV feeder level** and must be diversified for transformer and MV feeder level ADMD. The Design Engineer for each project must however still assess the situation and propose other standards if required.

#### 2.2.1 INITIAL ADMD

| Load Category | Initial Load |
|---|---|
| Rural Residential (Low Income) | 30W |
| Peri-urban (Medium Income) | 60W |
| Urban (High Income) | 300W |
| Urban (Very High Income) | 500W (To be assessed) |
| Schools, Health centers, Workshops, Industries etc. | Calculated per size |

**Table 1:** Initial Consumer ADMD

### 2.2.2 Saturation consumer ADMD

| Load Category | Saturation Load |
|---|---|
| Rural Residential (Low Income) | 100W |
| Peri-urban (Medium Income) | 250W |
| Urban (High Income) | 600W |
| Urban (Very High Income) | 1000W |
| Schools, Health centers, Workshops, Industries etc. | Calculated per size |

**Table 2:** Saturation Consumer ADMD

## 2.3 LOAD FORECAST PARAMETERS

The default growth parameters are listed in Table 3.3 below. This can be changed by the Design Engineer where required, for example urban development or re-settlement of people.

| Description | Parameter |
|---|---|
| % connections in start year | 30% |
| % connections saturation | 90% |
| Duration from start to saturation | 6 years |
| Growth in number of houses short term (5 years) | 3% |
| Growth in number of houses long term (>5 years) | 2% |

**Table 3:** Load Forecast Parameters

## 3. DESIGN PHILOSOPHY

### 3.1 LOW VOLTAGE PHILOSOPHY

Where possible, the design can be scaled down for initial construction and upgraded later as follows:

- The design Voltage will be 400/230 Volt.
- Initial LV feeder is designed for the calculated long-term saturation load on the feeder
- LV Lines can stretch over two transformer zones initially, with only one transformer installed. The structure for the second transformer must be in place, and the second transformer is installed when the load or Voltage on the LV is outside acceptable limits.
- LV Networks and transformers must be designed and installed with easy upgrading in mind.
- The maximum permitted Voltage fluctuation at the end of the LV service connection (Customer supply point) shall not be more than +5% and -10% of nominal Voltage with the calculated saturation load.
- The network's design shall be overhead bundle conductor (ABC) radial systems. The covered neutral carrier system is in use. However, underground design can be recommended as required by the area to be connected and instructed by the Design Engineer.
- Line design shall be in two definite categories namely:
  - Main line construction normally of three phase construction with ABC conductors normally 70 $mm^2$ or 50 $mm^2$ conductor.
  - Spur line construction of three phase construction with conductors normally 35 $mm^2$ or 25 $mm^2$ ABC or single phase 35 $mm^2$ only as instructed by the design Engineer.
- Urban areas with anticipated high density shall be supplied with 3-phase overhead bundle-conductors. Low-density areas can be single phase. Low Voltage designs will indicate where single phase (230 V) can be used.
- Poles used for rural electrification shall be 9m wood poles. Other pole types may be used in urban areas and other locations where the need is justified by the design Engineer.
- The neutral conductor of the low voltage systems shall be multiple earthed (MEN System) at the first pole away from the transformer and after every 4 spans as well as the very last pole on the radial system and spur lines.
- Low Voltage lines can share the same pole with MV to save on construction cost while considering respective span lengths.

## 3.2 SERVICE CONNECTIONS

- Service connections are of the overhead type, connecting directly from the pole to the house and fixed onto the house's roof structure or the wall by means of a suitable tension clamp with eye bolt or pigtail bolt, bearing in mind that the service connections would also have to support the communications cable of the split pre-payment meter.
- Metering shall be done through split pre-payment meters where the metering unit will be situated on the pole and the customer keyboard would be situated at external wall (not exposed to sunlight and rain) of the customer dwelling.
- At each Service Pole, the Neutral wire must be earthed via a 16mm$^2$ copper cable connected to underground spikes and the earth resistance must always be lower than 10Ω.
- For commercial and industrial uses, the metering will be specified by the Design Engineer.
- Initial LV feeder is designed for the calculated long-term saturation load on the feeder and in consultation with the Master Plan. Line routes must be selected to allow for the anticipated Imidugudu to be connected to the feeder in future.
- The minimum distance of Service cable to ground should not be lower than 3 meters (normal terrain) and 6 meters (crossing the road). When this vertical clearance is not respected, intermediate pole between the last LV pole and the house must be inserted. The intermediate pole (9m, 6m or 4m) shall be provided with suitable clamps and in case of metallic pole, it must be earthed.
- Ready boards may be supplied to selected low income customers in Villages where materials for wiring are scarce. When ready boards are provided, the installation and earthing will be done by REG. The supply of ready boards is restricted in order to keep house connection costs low.

## 3.3 MEDIUM VOLTAGE DESIGN PHILOSOPHY

The REG medium voltage design philosophy will have the following basic principles:

### 3.3.1 General

- The medium voltage lines are generally 30kV in rural areas and 15kV in some urban areas. The lines are constructed with a three-wire system and always having an earth-shield wire. The Earth wire will be OPGW or GSW as recommended by Planning Department.
- The pole configuration shall be single pole tension and suspension poles without cross-arms. Tension poles and insulators shall be vertically configured whilst suspension pole insulators shall be pin insulators in a

staggered vertical configuration. However, where more vertical clearance is required, horizontal arrangement with cross-arms shall be used.

- Special applications like long conductor spans will require the H-pole (with 2 or 3 poles) configuration to be used for more strength, ground clearance and conductor spacing. Special steel galvanized cross arms are used in this application.
- Pre-fabricated 14m sectional steel poles can also be used in special conditions to obtain better ground clearance. Specific instruction from the REG Engineer will be given in such situations.
- The phasing configuration shall be X, Y and Z (phase**1**, phase**2** and phase**3**) from top to bottom or where horizontal configurations exist, it shall be Y, X and Z from left to right (the middle conductor in vertical arrangement becomes the upper one in horizontal) facing the direction of the power flow.
- Line design shall be in two definite categories namely:
  - Main line construction normally of three phase construction with ACSR conductors normally 120/20 $mm^2$ conductor
  - Spur line construction of single phase or three phase construction with conductors normally 70/12 $mm^2$ or 35/6 $mm^2$ ACSR as instructed by the design Engineer.
- Overhead lines are insulated for 30kV, even if it is operated on 15kV initially.
- The Single phase (phase to phase) system must be readily convertible to three phases as anticipated with Rwanda's rich agricultural and dispersed hydropower potential, which will likely require pump stations and other three phase loads. However, the construction of Single-phase system shall require approval of the Planning Engineer.
- There is a point in any network development where three phase systems become cheaper than the single-phase systems. This cross-over point must always be calculated when planning single phase systems.
- Single phase systems maintain substantial higher technical losses due to the currents in the neutral, not being neutralised by the phases. Conversion to three phase systems on the MV & LV sides becomes economical at a given point.
- The standard settlement planning designs of the Imidugudu will likely require three phase MV supplies. The GoR is committed to encourage resettlement of the rural population into the Imidugudu, and the probability for three phase connections must be envisaged.
- Low voltage lines can share the same pole with the MV line.

### 3.3.2 Protection

- The HV/MV transformer feeding the 30kV line shall have a secondary star connection or a delta connection with a neutral earth compensator to allow for earth faults to flow and be detected.
- Protection of the lines shall be through auto-recloser or sectionalizer automatic line-break pole mounted switchgear, working in conjunction with a substation breaker with auto-reclosing facilities.
- As a guideline, if more than six transformers are connected on a T-off from the main feeder, a Sectionalizer must be installed to clear faults on this line from the main distributor. This also applies for feeders longer than 10 km. Sectionalizers must be co-ordinated with the auto reclosing breaker in the substation. The Sectionalizer shall isolate the fault with the second trip of the auto recloser in the substation, unless otherwise stated.
- Auto Reclosers must be installed along long radial lines over 40km. Reclosers must be placed at strategic positions (preferably <40km apart) and must be coordinated with the substation breaker.
- Switches used for operational switching shall be mechanical load-break switches or drop-out fuses with fused links as deemed necessary by the strategic importance of the line.
- Drop-out fuse isolator shall be installed at any T-off if there is no any other protection.
- Individual transformer with capacity below 100 kVA installations shall be equipped with drop-out fuse links.
- Transformers with ratings from 100kVA to 630 kVA shall be equipped with air-break switch with fuses holders.
- Transformers with capacity above 630 kVA must be provided with Indoor Switchgear
- In areas with very high risk of lightning, combined surge arrestors and drop out fuses devices may be installed instead of the above mentioned protective Devices as recommended by the design Engineer
- Specific customers will require installation of three phase fuse break switch on transformers.

## 4. STANDARDISATION OF DISTRIBUTION EQUIPMENT

To standardize on electrification equipment and material, and to optimize the economics of the design, the standards for use in the electricity access plan are listed below:

### 4.1. POLES

The following information apply for Wooden Poles. Other poles (Steel, concrete) and towers shall comply with the relevant National or International Standards.

- Wooden poles must be treated to National standard and specifications.
- Anti-climbing devices must be installed on MV strut poles only.
- Pole numbering must be done as a Standard on both MV and LV poles.
- Each MV pole must be equipped with a "danger" warning sign in local Language and English.

Poles will have the following minimum base and top diameters:

| Application | Pole length | Min Diam. at 1.5m from Butt (mm) | Min Diam. at Pole Top (mm) | Planting Depth | Construction | Comment |
|---|---|---|---|---|---|---|
| LV light use | 9m | 200 | 150 | 1.5m | ABC | Intermediate poles |
| LV medium | 9m | 230 | 170 | 1.5m | ABC | Angle poles - supported |
| LV Stout | 9m | 285 | 190 | 1.5m | ABC | Angle pole - unsupported |
| LV and Street Lights | 10m | 210 | 150 | 1.6m | ABC | Road clearance and Street Lights |
| MV light use | 12m | 240 | 180 | 1.8m | Vertical | Rural lines, no LV under |
| MV medium | 12m | 260 | 195 | 1.8m | Vertical | Angle poles - supported |
| MV Stout | 12m | 320 | 200 | 1.8m | Vertical | Unsupported angle |
| Special use | 14m | 240 | 210 | 2.2m | Vertical | Special, long span |
| H-Pole | 12m | 240 | 195 | 1.8m | Horizontal | Special, Extra-long span |
| H-Pole | 14m | 260 | 220 | 2.2m | Horizontal | Special, Extra-long span |

**Table 4:** Standard Pole Sizes

## 4.2 STAYS AND ASSEMBLIES

### a. Stay Wire

A guideline for stay wire for medium Voltage and low Voltage installations will be as per **Table 5** below.

| Application | Strands/diameter |
|---|---|
| LV | 3/3.35mm |
| 15kV | 7/3.35mm |
| 30kV | 7/3.35mm |

**Table 5:** Standard Stay Wire

### b. Stay Rod

Stay rods shall comply with BS 183 Grade 700 and shall be 1100 MPA for both LV and MV stays. Table 6: Standard Stay Rod gives a guideline for the standard stay rod sizes to be used.

| Application | Diameter | Adjustment |
|---|---|---|
| LV | 16mm | Non-adjustable |
| 15kV | 20mm | Adjustable |
| 30kV | 20mm | Adjustable |

**Table 6:** Standard Stay Rod

### c. Base Plate

The size of the base plate is determined by the use. Typical use is given in **Table 7** below. It is the duty of the installing Contractor to ensure that the use is applicable. Soil conditions may require 500mm base plates to be used for lighter conductor, or long spans with light conductor may require a bigger stay plate than indicated below. Base plates must be used with a 50mm diameter 4mm round washer at the base of the stay rod.

| Application | Size |
|---|---|
| Low Voltage | 400x400x6mm |
| MV 35mm² Conductor | 500x500x6mm |
| MV 70mm² conductor or more | 600x600x6mm |

**Table 7:** Stay Base Plate Size

## 4.3. DISTRIBUTION TRANSFORMERS

- All Transformers are mounted on a two-pole structure made of steel or concrete poles. However, transformers up to 15 kVA can be mounted on a single pole structure if the limit state design has proven it is possible.
- Transformer voltage ratings (No-load): 30kV/400/230V and 15kV/400/230V
- The standard vector group: Dyn11
- Off load 5 position tap changer: 95%-97.5%-100%-102.5%-105%. Up to 25 kVA transformers, 3 positions tap changer may be used.
- The REG standard reticulation transformer sizes for 30kV/400V/230V and 15kV/400V/230V are:

| Power Rating (kVA) | Phases |
|---|---|
| 10 | Single Phase |
| 15 | Single Phase |
| 25 | Single Phase |
| 25 | Three Phase |
| 50 | Three Phase |
| 100 | Three Phase |
| 160 | Three Phase |
| 200 | Three Phase |
| 250 | Three Phase |
| 315 | Three Phase |
| 400 | Three Phase |
| 500 | Three Phase |
| 630 | Three Phase |
| 800 | Three Phase |
| 1000 | Three Phase |
| 1250 | Three Phase |
| 1600 | Three Phase |
| 2000 | Three Phase |
| 2500 | Three Phase |

**Table 8**: Standard Transformer Sizes

## 4.4. MV CONDUCTOR

Aluminium Conductor Steel Reinforced (ACSR) standard conductor is used. The Conductor sizes used with their thermal ratings are listed below. It is important in the design to consider $I^2R$ losses when selecting a conductor size, and not operate conductor over its economical limits.

| Standard Conductor Sizes | Continuous Thermal Rating * | Contingency Rating |
|---|---|---|
| 35/6mm² ACSR (small length spur lines only) | 150 A | 203 A |
| 70/12mm² ACSR (spur lines only) | 206 A | 285 A |
| 120/20mm² ACSR ( for all main line ) | 280 A | 392 A |

**Table 9:** MV Conductor Sizes

* Current ratings are based on 50 Hz AC, 75 ºC conductor temperature, and 0.61 m/s (2 ft/s) wind. 0.5 coefficients of emissivity and absorption, temperate rating: 25 ºC ambient, 1000 watts/sq. meter sun.

## 4.5 LV CONDUCTOR

Standard LV Conductor sizes to be used on reticulation networks are listed in **Table 10** below. The typical design continuous thermal ratings are listed with each cable.

| Standard Conductor Sizes | Continuous Thermal Rating |
|---|---|
| 1 X 35mm² + 54.6mm² ABC | 135 A |
| 1 X 25mm² + 54.6mm² ABC | 110 A |
| 3 x 70mm² + 54.6mm² ABC | 210 A |
| 3 x 50mm² + 54.6mm² ABC | 160 A |
| 3 x 35mm² + 54.6mm² ABC | 135 A |
| 3 x 25mm² + 54.6mm² ABC | 110 A |
| 3 x 70mm² +1x54.6mm²+ 1x25mm² ABC | 210 A & 110 A |

**Table 10:** LV ABC Conductor Sizes

## 4.6 LV DISTRIBUTION BOARD

- The LV DB shall contain the main transformer breaker in the incoming compartment as well as the feeder circuit breakers on the exit compartment. A Statistical meter (specifications to be approved by REG) shall be installed on the transformer main cable.
- A low Voltage Surge arrester must be installed on the main incoming cable inside the LV DB, rating 10kA.
- The Neutral connection busbar must be isolated from the enclosure to 1000V and have provision of at least 4 connections
- All busbars are to be pre-drilled and are to be rated for 500A (transformers up to 200 kVA) and for bigger transformers, the busbars shall require special approval of the Design Engineer.
- An earth stud, minimum M12 must be provided on the outside of the box for earthing to the transformer structure.
- Knock-out holes must be provided at the bottom for the cable entry. Sufficient cable support must be provided.

### 4.6.1 For transformers 25 kVA and 50 kVA

- The incoming compartment shall allow for one large frame circuit breaker.
- The exit compartment shall allow for 2 large frame circuit breakers and 3 small frame circuit breakers. Only breakers needed for the specific installation must be installed.
- The galvanized enclosure shall be mounted on two lengths of angle iron mounted between the two transformer poles.

### 4.6.2 For transformers 100 kVA AND MORE:

- The incoming compartment shall allow for two large frame circuit breakers.
- The exit compartment shall allow for 4 large frame circuit breakers and 4 small frame circuit breakers. Only breakers needed for the specific installation must be installed.
- The galvanized enclosure shall be mounted on two lengths of angle iron mounted between the two transformer poles.

### 4.6.3 LV circuit breaker sizes

Circuit breakers for the LV Cables will be rated as per **Table 11** below:

| Standard Conductor Sizes | Circuit Breaker |
|---|---|
| 1 X 35mm² + 54.6mm² ABC | 130 A |
| 1 X 25mm² + 54.6mm² ABC | 110 A |
| 3 x 70mm² + 54.6mm² ABC | 210 A |
| 3 x 50mm² + 54.6mm² ABC | 160 A |
| 3 x 35mm² + 54.6mm² ABC | 130 A |
| 3 x 25mm² + 54.6mm² ABC | 110 A |

**Table 11:** LV ABC Conductor Sizes

### 4.6.2 LV cables to be used on transformer to DB

Low Voltage PVC SWA Copper cables (unarmoured) to be used from the Transformer LV Bushings to the DB Main Incoming Circuit Breaker for different transformer sizes are listed in **Table 12** below.

The design Engineer must decide accordingly to the location of installation.

| Power | Phases | LV Circuit Breaker | Standard Cable Sizes (CU XLPE or equivalent) |
|---|---|---|---|
| 10 kVA | Single Phase | 50 A | 2 x 25 mm² |
| 15 kVA | Single Phase | 80 A | 2 x 25 mm² |
| 25 kVA | Single Phase | 125 A | 2 x 35 mm² |
| 25 kVA | Three phase | 40 A | 4 x 25 mm² |
| 50 kVA | Three Phase | 80 A | 4 x 35 mm² |
| 100 kVA | Three Phase | 160 A | 4 x 50 mm² |
| 160 kVA | Three Phase | 250 A | 4x95 mm² |
| 200 kVA | Three Phase | 315 A | 4x120 mm² |
| 250 kVA | Three Phase | 400 A | 4x(1x185 mm²) |
| 315 kVA | Three Phase | 500 A | 4x(1x240 mm²) |
| 400 kVA | Three Phase | 630 A | 4x(1x240 mm²) |
| 500 kVA | Three Phase | 800 A | 4 x (1x300 mm²) |
| 630 kVA | Three Phase | 1000 A | 2 x [4 x (1x240 mm²)] |

| | | | |
|---|---|---|---|
| 800 kVA | Three Phase | 1250 A | 2 x[4 x (1x300 $mm^2$)] |
| 1000 kVA | Three Phase | 1600 A | 3 x [4 x (1x240 $mm^2$)] |
| 1250 kVA | Three Phase | 1800 A | 3 x [4 x (1x300 $mm^2$)] |
| 1600 kVA | Three Phase | 2300 A | 4 x[4 x (1x300 $mm^2$)] |
| 2000 kVA | Three Phase | 2900 A | 4 x [4 x (1x400 $mm^2$)] |
| 2500 kVA | Three Phase | 3600 A | 5 x [4 x (1x400 $mm^2$)] |

**Table 12:** LV Cable Sizes for Transformers according to IEC 60502-1

**Important Considerations:**

➢ In areas with short peak load duration, the transformer protection circuit breaker is rated 125% of nominal current. In areas with constant load, the breaker is rated 100 % of its nominal current.

➢ **Recommendation for LV conductors colour coding**

- Phases conductors shall be **Brown**, **Black** and **Grey** from Left to Right, and from top downwards, in vertical configuration. The **Blue** being connected to the Neutral (IEC 60245-1).

However, for old cables, the phases configuration will remain **Red, Yellow, Blue** and the Black colour is for the Neutral.

The colours green and yellow, when combined, are recognized exclusively as a means of identification of the core intended for use as earth connection or similar protection

The figure below indicates different cases in Single and Three-phase*:*

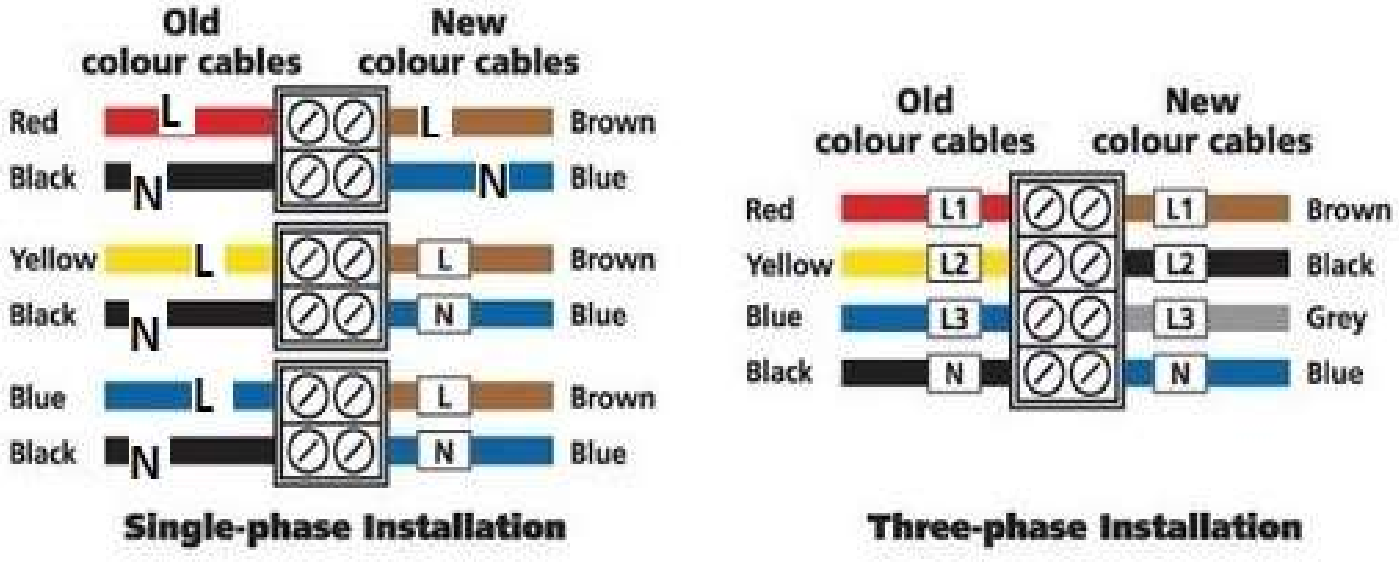


**Figure 1:** Colour coding

## 4.7 METERING

An electronic statistical meter shall be installed in the Incoming compartment of the LV Panel for bulk metering of the transformer zone. Three phase 4 wire smart meters of the capability to be direct or CT-VT connected, (IEC 62052, IEC 62053 and IEC 62056 compliant) 4 Quadrant metering and AMI functionality via multiple wireless communication channels.

Meters shall detect and log not limited to:

a) Phase voltage unbalance
b) Phase current unbalance
c) Neutral disturbances
d) Power failures (Outages)
e) Tamper attempts
f) CT reversals
g) Transformer overload
h) Voltage & Current Phase Diagram
i) Cover open detection
j) Reverse connection detection
k) High/Low-voltage detection
l) Over current detection
m) Abnormal phase sequence detection
n) Power-off/on
o) Parameter configuration
p) Terminal cover-opening
q) Energy reset
r) Demand reset
s) Power reverse
t) Under voltage
u) Over voltage
v) Voltage negative sequence
w) Current negative sequence
x) Current imbalance
y) Each kind of event shall store at least 20 latest records
z) Load profiles

For the customer with other source of electricity like generator, metering system shall be installed to read only electricity from REG Network.

All access on metering system shall be strictly under control of REG.

## 5. EARTHING

The Multiple Earthed Neutral (MEN) system must be used for LV earthing.

### 5.1 MEN SYSTEM FOR LV

- The LV is not earthed at the Transformer Structure.
- The LV is earthed on the first pole away from the transformer, on every fifth pole for each LV feeder and Spur off feeder and at each service pole.

### 5.2 LV EARTHING GENERAL

- LV down earthing is done with 16mm² stranded copper conductor, stapled or saddled to the pole at least every 400mm.
- LV down earthing can be done with 25 mm² steel wire in high theft areas where copper is stolen.
- Bi-metal PG clamps must be used for connecting the earth to the overhead ABC conductor.
- The metallic enclosure of the LV DB on the transformer installation is earthed to the MV side. All LV bus bars inside the DB, including the neutral bus bar are insulated (1000V) from the case of the DB.
- Over all LV Earthing resistance must be lower than 10 Ohm.
- The main incoming cable from the transformer must be connected to a 10 kA LV surge arrestor that must be earthed to the LV Neutral.

### 5.3 MV EARTHING

- Generally, overhead earth conductor shall be installed on the lines. However, where the shield wire was not installed, alternative lightning protection will be installed.
- Where the shield wire exists, it should be earthed at every set of links, switchgear, power transformer locations and at enough additional points with made or existing electrodes to total not less than four grounds in each 1.6 km of the entire line.
- The shielding angle must be less than $45^0$ for structures less than 15m tall with conductor spacing below 2m (reference: IEEE Std 1410). For structures, higher than 15m, the shielding angle shall be less or equal $30^0$.
- On lines where the shield wire was not installed, the earthing system shall comply with the following requirements:
  - MV networks are earthed through surge arresters at each transformer installation, and at each additional set of surge arrestors on the network.
  - Surge arresters must be installed at every set of links, switchgear and transformer.

- No section of the line longer than 1.5 km must be without protection by surge arresters. On long rural lines where there are no transformers or switchgear, surge arresters must be installed every 1.5 km of line length.

- On the Transformer installation, the following items are all commonly earthed to ground.
  - MV Surge arrestors or/and shield wire
  - Transformer bed
  - Transformer earth stud
  - LV DB metal enclosure
- All copper earth work on the transformer installation is done with 25mm² Stranded Copper wire or 25 mm² steel wire in high theft areas where copper is stolen.
- Transformer MV installation is earthed at the transformer structure with 25mm² copper earth spikes. Earthing is done with a continuous earth wire in a 1m deep 3m long trench from the transformer pole. Additional earthing must be installed if the grounding resistivity is not low enough.
- The total earth resistance of the LV network shall not exceed 10 Ω.
- The MV earthing resistance at the transformer and any surge arrestors shall not exceed 5 Ω.
- If the desired earthing is not measured, additional earthing must be installed.
- Every metallic pole must be earthed per the level of voltage of the line

## 6. TRANSFORMER PROTECTION

A main LV breaker with 10kA rupturing capacity is installed in a box mounted on the transformer structure. Feeder circuits shall also be protected by rated circuit breakers.

Transformer Main LV breaker sizes are listed next to the transformers sizes below:

| Power | Phases | LV Breaker[1] | Breaker Poles | MV Fuse (30kV) | MV Fuse (15kV) |
|---|---|---|---|---|---|
| 10 kVA | Single Phase | 50 A | 1 | 1A | 1A |
| 15kVA | Single Phase | 80 A | 1 | 1A | 1A |
| 25 kVA | Single phase | 125 A | 1 | 1A | 1A |
| 25kVA | Three Phase | 40 A | 3 | 1A | 2A |
| 50kVA | Three Phase | 80 A | 3 | 2A | 4A |
| 100kVA | Three Phase | 160 A | 3 | 4A | 6A |
| 160kVA | Three Phase | 250 A | 3 | 6A | 8A |
| 200kVA | Three Phase | 315 A | 3 | 6 A | 10A |
| 250 kVA | Three Phase | 400 A | 3 | 6 A | 16A |
| 315 kVA | Three Phase | 500 A | 3 | 10 A | 16A |
| 400 kVA | Three Phase | 630 A | 3 | 10 A | 20A |
| 500 kVA | Three Phase | 800 A | 3 | 16 A | 32A |
| 630 kVA | Three Phase | 1000 A | 3 | 16 A | 32A |
| 800 kVA | Three Phase | 1250 A | 3 | 20 A | 40A |
| 1000 kVA | Three Phase | 1600 A | 3 | 25 A | 40A |
| 1250 kVA | Three Phase | 1800 A | 3 | 40 A | 80 A |
| 1600 kVA | Three Phase | 2300 A | 3 | 50 A | 90 A |
| 2000 kVA | Three Phase | 2900 A | 3 | 60 A | 90 A |
| 2500 kVA | Three Phase | 3600 A | 3 | 80 A | 120 A |

**Table 13:** Standard Transformers, LV Breakers and MV Fuse values

Transformer MV side is protected by MV fuses and surge arrestors. Surge arrestors must be installed as close as possible to the protected transformer. As the over current protection is done on the LV side, the MV fuse is mainly for fault protection. The recommended fuse ratings are listed in Table 13 above.

[1] All Circuit Breakers must be adjustable within the range from 50% to 100% of the nominal current

## 7. CONSTRUCTION

### 7.1 PLANTING OF WOODEN POLES

- Survey of pole positions must be done by experienced surveyors. Pegged pole positions must be approved by the REG Construction Engineer/Supervisor before excavation or construction commence.
- Pole holes must be excavated to the correct width and depth to ensure stability of the poles.
- Foundation depths are as listed in **Table 14** below.

| Pole height (m) | Hole depth minimum in normal soil (m) |
|---|---|
| 9 | 1.5 |
| 10 | 1.8 |
| 12 | 1.8 |
| 14 | 2.2 |
| 16 | 2.5 |

**Table 14:** Pole foundation Depths

Erection of the pole must be done with the aid of a skid board to guide the butt of the pole into the hole.

- Erection must be done with the correct equipment for the safety of workers and for protection of the pole.
- A pole may not be cut at the top or bottom to obtain the desired height. Planting depth must be measured correctly.
- Different soil types must be considered so that the necessary reinforcement can be done.
- Backfilling must be done with good compactable soil. During backfilling, compaction shall be done after every 200mm of backfill.
- Compaction shall be done to a density of at least 95% of the surrounding undisturbed soil for the full depth of the foundation.
- The Contractor must have a relative compaction tester to compare the compaction to that of the undisturbed surrounding ground. The weight-drop tester will suffice to compare compaction densities. Absolute compaction density is not required.
- Compaction must be done with specialized steel compactors with a flat surface (round or square, at least 150mm diameter or 80mm x 150mm). The compactor shall weigh at least 10kg or more.
- The soil shall be filled up higher against the pole so water can flow away from the pole and to prevent damming of water around the pole. Compaction must be done right to the top of the backfill (above normal ground level).

- Open holes, when not attended to, must be covered or enclosed with barrier tape to prevent accidents.
- Special care must be taken when digging close to existing cables or other services.
- When replacing an old pole, the new pole must be planted next to the old pole. The old pole must be uprooted and the hole properly backfilled and compacted to prevent leaning of the new pole towards the old pole position.
- Danger signs shall be installed on all MV poles at 2m above ground level.
- Storing, loading, off-loading, transport and handling of the pole must be done as per REG specifications. Poles may not be dragged along the ground. No hooks may be used under the ground line.
- Transportation of poles is limited on a standard 10-ton truck to the numbers given in **Table 15** below for safety reasons.

| Pole height (m) | Maximum number of Poles |
|---|---|
| 9 | 14 |
| 10 | 11 |
| 12 | 09 |
| 14 | 06 |
| 16 | 04 |

**Table 15:** Transportation of Poles

## 7.2 MV RETICULATION CONSTRUCTION

- MV Reticulation will be done mainly on wooden single pole construction.
- Special applications like long conductor spans will require the H-pole configuration to be used for more strength, ground clearance and conductor spacing. For very long spans, three pole structures are used. Longer cross arms are used in this application.
- Initial design span shall be assumed at 70-80m. The actual span length is determined by length of the poles used and limited by the terrain and ground clearance upon the results of calculations with appropriate Software. Longer spans must be done using special structures: H-Poles (2 or 3 Poles), steel and concrete Poles and a long cross-arm for conductor clearance.
- As guideline, Spans longer than 100m must be done using H-pole structures for strength of the structure as well as better conductor clearance. Spans longer than 150m must be done using 3 pole structures and a long cross-arm for conductor clearance.

- The pole dressing will be staggered vertical for suspension structures and vertical for strain structures. The required conductor clearances are listed in *Table 8-3* up to *8-5.*
- Pre-formed binding products or rated crimp joints shall be used for tension and non-tension joint configurations, instead of clamps.
- All lines must be constructed with the rated insulators:
  - Composite insulators (Polymer)
  - 70kN tensile strength for tension insulators
  - 40kN tensile strength for tension insulators
  - 10kN tensile strength for suspension insulators
  - Pole & stay strengths to be a single conductor breaking strength with a doubling safety factor
- Spur line construction of single phase or three phase construction with conductors normally 70/12mm², 35/6mm² with insulator strength at:
  - 40kN tensile strength for tension insulators
  - 10kN tensile strength for suspension insulators
- Very long spans must be supported by stayed H-pole structures on both sides.
- Any long stretches of intermediate poles must have a supported strain structure every 0.5 km.
- Lines shall be installed directly from cable drum rollers and un-coiling of the conductor off a drum lying on its side is forbidden. This will lead to rejection of the section of conductor.
- Stringing shall be done with temporary support rollers on each pole. Dragging of the conductor on the ground is not allowed.
- As-built drawings must include the pole number, GPS Coordinate, conductor type, structure type (e.g. intermediate, termination, 90º turn, etc.)

## 7.3 CONDUCTOR SPACING AND CLEARANCES

| CLEARANCE FROM | | MEDIUM VOLTAGE (15 – 30kV) | | | |
|---|---|---|---|---|---|
| | | HORIZONTAL CLEARANCE[2] (m) | | VERTICAL CLEARANCE (m) | |
| | | Bare conductor | Isolated conductor | Bare conductor | Isolated conductor |
| Normal terrain or an agriculture area | | - | - | 6 | 5.6 |
| Road with agricultural vehicles with a height "h" | | - | - | h+1 | h+1 |
| Ways open to public circulation | | - | - | 8 | 8 |
| Highways | | - | - | 8 | 8 |
| Line near silo with H-height | | H+5 | - | - | - |
| Trees and various obstacles | Higher than the line | 5 | 5 | - | - |
| | Lower than the line | - | - | 3 | 1 |
| Buildings | | 3 | 3 | 3.2; 10.6 (Non-fire Resistant roofs and fire sensitive installations like petrol stations, …) | 3 |
| Vicinity of river for sailing | | - | - | 9 | 9 |
| Vicinity of telecommunication lines | | 2 | 2 | 2 | 1 |
| Pyrotechnic plants or installations | | 20 | 10 | - | - |
| Vicinity of LV line on separate pole | | 2 | 2 | 1 | 1 |
| Vicinity of MV line on separate pole | | 2 | 2 | 1.5 | 1.5 |
| Vicinity of HV line on separate pole | | 2 | 2 | 2 | 1.5 |
| Vicinity of HV line on the same pole | | 2 | 2 | 2 | 1.5 |
| Vicinity of educational building or sports equipment | | 4 | 4 | 8 | 8 |

**Table 16:** Clearances from MV lines

[2] For Horizontal clearances, reference must always be made to the Guidelines on Right of Way from RURA

| CLEARANCE FROM | | LOW VOLTAGE | | | |
|---|---|---|---|---|---|
| | | Horizontal[3] clearance (m) | | Vertical clearance (m) | |
| | | Bare conductor | Insulated conductor | Bare conductor | Insulated conductor |
| Normal terrain or an agriculture area | | - | - | 6 | 5 |
| Road surface | | 1.5 | 1.5 | 6 | 6 |
| Trees and various obstacles | Trees Higher than the line | 1.5 | 1.5 | - | - |
| | Trees Lower than the line | - | - | 1.5 | 0.5 |
| Buildings | | 1 | 1 | 2.5 | 2.5 |
| Vicinity of telecommunication lines | | 0.5 | 0.5 | 1 | 1 |
| Vicinity of MV line on separate pole | | 2 | 2 | 1 | 1 |
| Vicinity of HV line on separate pole | | 2 | 2 | 2 | 2 |
| Vicinity of educational building or sports equipment | | 4 | 4 | 8 | 8 |

**Table 17:** Clearances from LV lines

| Design Phase to Phase kV | Phase – To – Phase Clearance in mm | Phase – To – Neutral (Earth) Clearance in mm |
|---|---|---|
| 33 | 450.0 | 400.0 |

**Table 18:** Conductor Clearances

## 7.4 LAYING UNDERGROUND CABLES

- The cable drum shall be properly mounted on jacks, or on a cable wheel at a suitable location, making sure that the spindle, jack etc. are strong enough to carry the weight of the drum without failure, and that the spindle is horizontal in the bearings to prevent the drum creeping to one side while rotating.
- The cable shall be pulled over on rollers in the trench steadily and uniformly without jerks and strain. The entire cable length shall as far as possible be laid off in one stretch. Three single core cables forming one three phase circuit shall be laid in open formation as far apart as allowed by the trench (900mm).

[3] For Horizontal clearances, reference must always be made to the Guidelines on Right of Way from RURA

- After the cable has been so uncoiled, it shall be lifted slightly over the rollers beginning from one end by helpers standing about 10m apart and drawn straight. The cable shall then be lifted off the rollers and laid in a reasonably straight line.
- On completion of cable laying, the cable shall be tested for continuity and insulation resistance per testing procedures laid out in the relevant standards before covering the trench.
- Cables laid in trenches in a single tier formation shall have a covering of dry sand of not less than 20cm above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation, after the first cable tier has been laid, a sand cushion of 20cm shall be provided over the top of the lowest cable before the second tier is laid. If additional tiers are formed, each of the subsequent tiers shall also have a sand cushion of 20cm above the top of the cable. Cables in the top most tiers shall have final sand covering not less than 20cm before the protective cover is laid.
- Whenever more than one cable is laid / run side by side, marker tags as approved, inscribed with cable identification details shall be permanently attached to all the cables in the manholes, cable trenches and entry points into substation plant houses. These shall also be attached to cables laid direct in ground at specified intervals and at proposed cable route marker locations, before the trenches are backfilled.

### 7.4.1 Backfilling

- All trenches shall be back-filled with excavated earth, free from stones or other sharp ended debris and shall be rammed and watered, if necessary in successive layers not exceeding 20cm depth. Unless otherwise specified, a crown of earth not less than 50mm and not exceeding 100mm in the center and tapering towards the sides of the trench shall be left to allow for subsidence.
- The temporary re-statements of roadways should be inspected at regular intervals, particularly during wet weather and settlements should be made good by further filling as may be required. After the subsidence has ceased, trenches cut through roadways or other paved areas shall be restored to the same density and materials as the surrounding area and re-paved in accordance with the relevant building specifications to the satisfaction of the Engineer.
- Where road beams or lawns have been cut out of necessity, or kerb stones displaced, the same shall be repaired and made good to the satisfaction of the Engineer and all the surplus earth or rock shall be removed.
- The above requirements for backfilling shall also apply for trenches with pipes/ ducts at road crossings.

### 7.4.2 Cable protection

A layer danger tape marked "**Danger - High voltage cable below**" shall be laid at a depth of 500mm below final ground level to serve as warning when the ground is excavated in future. The danger tape must be laid across the entire width of the trench. Bricks must be laid at 200mm (of soft backfill) from cable laid.

### 7.4.3 Cable route identification

The start and end positions of each cable trench, as well as all turning points, must be clearly marked with a permanent route marker made of metal with engraving, planted in a small concrete foundation. The cable identification must include the "From" and "To" positions of the cable as well as the voltage and depth.
Road crossings shall be clearly and permanently marked on either side of the road by means of a name plate or engraving in the concrete of the curb. The depth of the cable under curb level must be indicated.

### 7.4.4 Section drawings of cable trenches

**A. Single MV Cable**

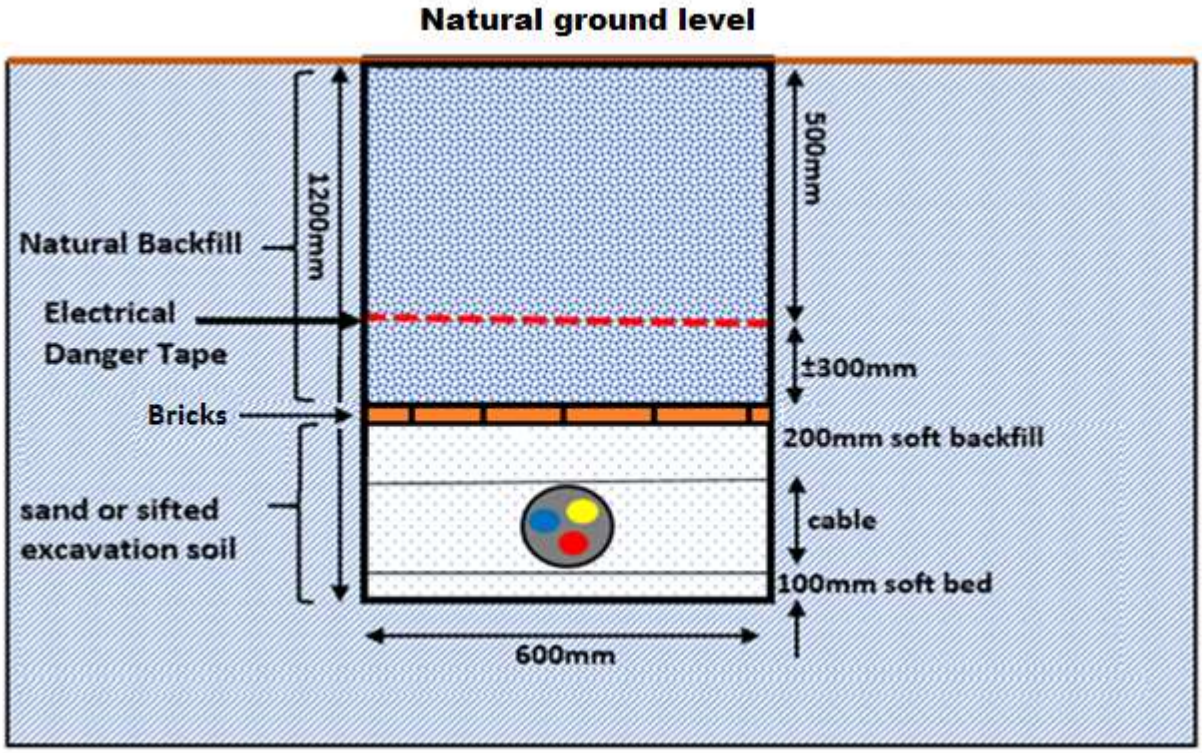


**Figure 2:** Single MV Cable Laying

**B. MV and LV cable**

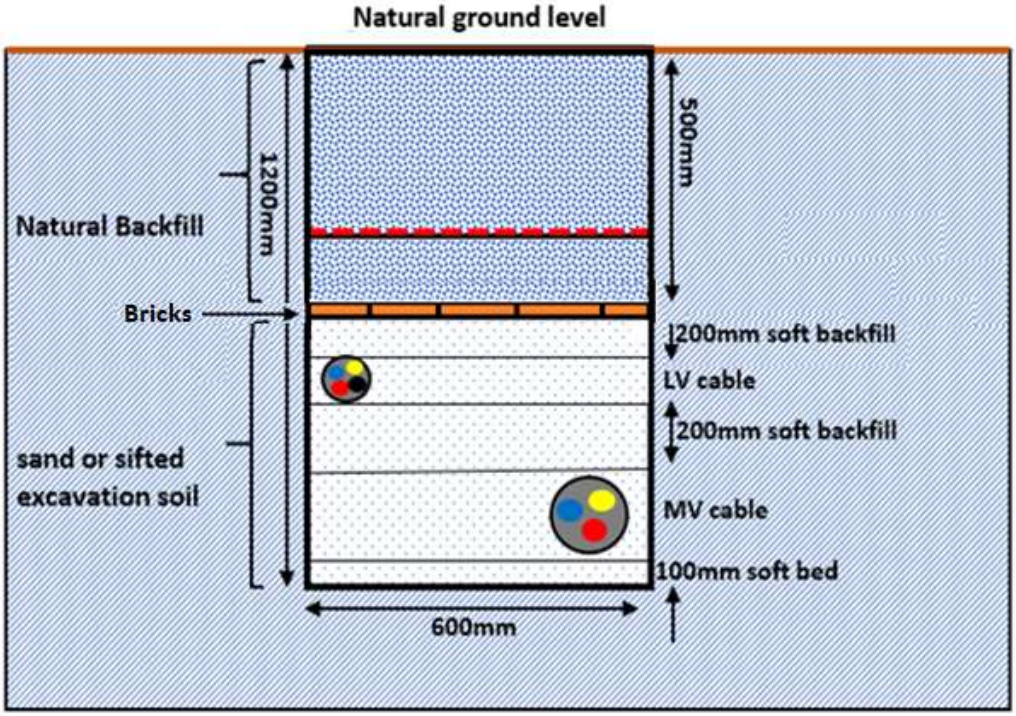


**Figure 3:** MV and LV Cable Laying

**C. Two MV cables**

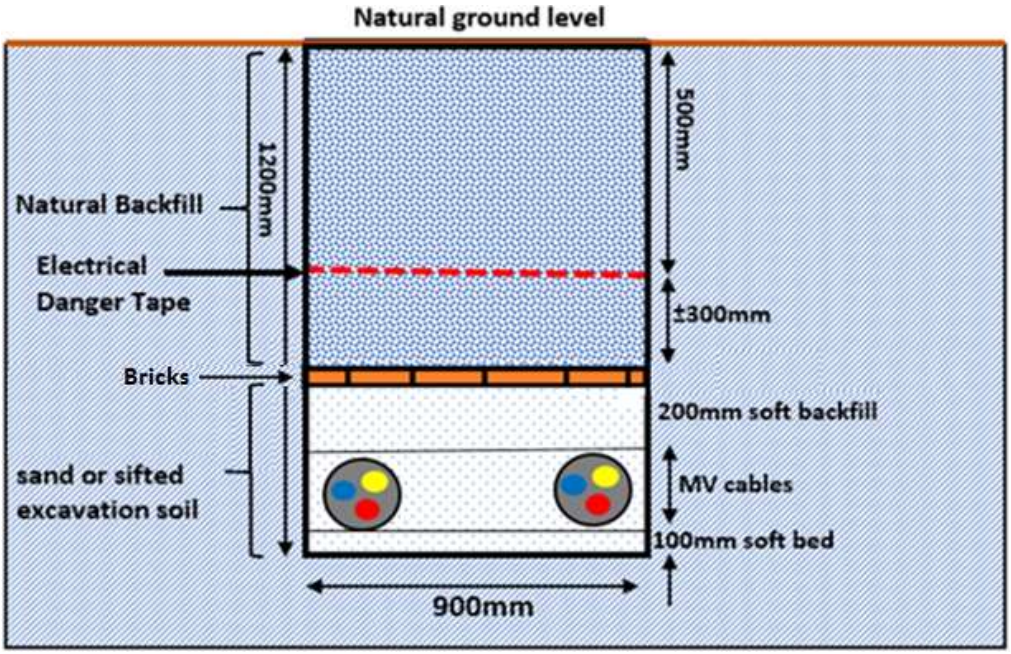


**Figure 4:** Two MV Cables Laying

**D. Single Core MV Cables**

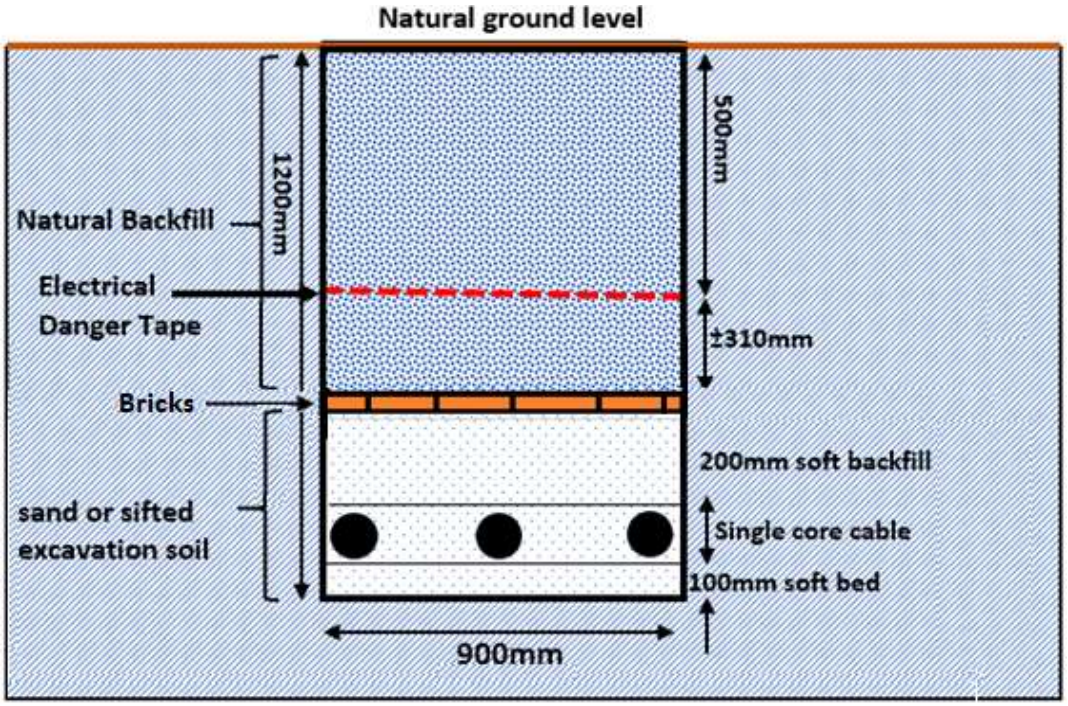


**Figure 5:** Single Core MV Cables Laying

**E. LV Cable**

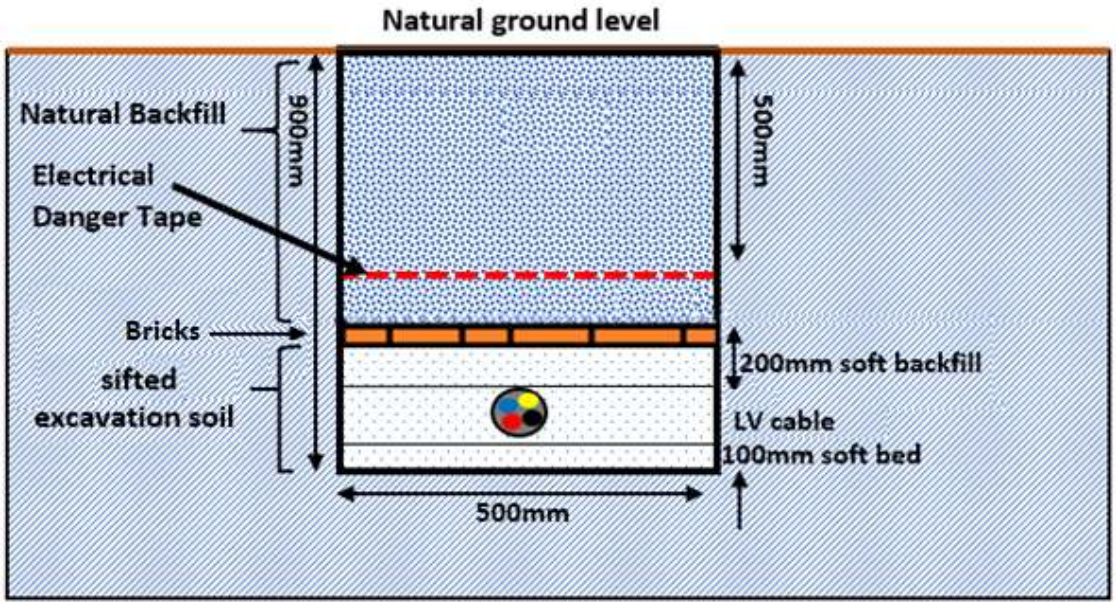


**Figure 6:** LV Cable Laying

## 7.5 LV RETICULATION CONSTRUCTION

- ABC conductor with covered neutral carrier to be used.
- Street light feeder is NOT included, unless otherwise specified.
- Special care must be taken to handle and install the conductor per the manufacturer's specifications (pulley sizes, no dragging of conductor on the ground, etc.)
- Every pole must be numbered as per specification. The numbers will be supplied by REG.
- The average span length for LV ABC construction will be as listed in **Table 25** below. This is mainly to allow for proper ground clearance.

It is the duty of the construction Contractor to verify that the ground clearances are maintained over roads and other obstacles.

| Conductor Used | Span Length (m) |
|---|---|
| 25mm² and 35mm² Single Phase | 55 |
| 25mm² three phase ABC | 50 |
| 35mm² three phase ABC | 50 |
| 50mm² three phase ABC | 47 |
| 70mm² three phase ABC | 44 |

**Table 19:** LV Span Length

- The neutral conductor of the low voltage systems shall be multiply earthed (MEN System) at the first pole away from the transformer, at every five poles (4 spans) for each LV feeder and at the very last pole on the radial system, as well as the first and last poles of any spur lines.
- The LV feeder is NOT earthed at the Transformer installation.
- As-built drawings must include the pole number, GPS Coordinate, conductor type, structure type (e.g. intermediate, termination, 90º turn, etc.)

## 7.6 SERVICE CONNECTIONS CONSTRUCTION

The following guidelines for service connections must be followed:

- Three phase connections to domestic customers are limited.
- Three phase domestic connections are done with Stranded copper conductor 10mm² 4 core cable with communication wire.
- The phase conductor on which to connect a single phase meter must be carefully selected to not cause phase imbalance to the transformer.
- Single-phase connections can be done with 6 mm² stranded copper conductor single core concentric conductor up to 40m distance
- Single-phase connections longer than 40m and up to 60m can be done with 10 mm² copper single core concentric conductor. This may only be done with the approval of the REG Engineer or representative.
- Metering shall be done with split-prepaid meters as far as possible.
- The Consumer has to install a circuit breaker to isolate his system from REG network.
- Where there is no Distribution Board inside the house, an approved Ready Board can be used by the consumer as an electrical installation.
- A Ready Board consist of:
    - Earth Leakage Circuit Breaker
    - Circuit Breaker
    - Distribution board facilities
    - Light fitting and switch
    - Switched socket outlets
    - Earthing terminals
- The service cable is attached to the house using either an eye bolt with strain clamp (wedge clamp) on the house wall, or a pole lug with coach screw and strain clamp connected to the roof trusses. See drawing for details.

## 8. UPGRADING OF EXISTING NETWORKS

The main objective for upgrading will be to normalize problem networks at minimum cost to the required design ADMD, and to make the network safe where such risks are evident.

The Engineer's challenge would be to upgrade existing overloaded networks whilst electrifying the surrounding expansion through the following techniques:

- Split long overloaded lines by creating injection point somewhere in the middle to allow power to flow bi-directionally from the new point of injection.
- Reduce overloaded transformer zone sizes and allocate portions to the newly electrified zones.
- Replace overloaded transformers with bigger ones and upgrade overloaded lines to have a further reach.
- Replace heavily under loaded transformers with units of lower rating to reduce the Iron losses.
- Advocate the use of amorphous core transformers to reduce Iron losses.
- Upgrade single phase lines to three phase lines by the addition of two extra conductors on LV system, and one conductor on the MV system

Where overloaded or under-Voltage networks needs to be upgraded, the following guidelines shall apply:

- The same technology as the existing network shall be used so that all existing poles, conductor and insulators can be re-used while in good condition.
- Single phase lines can be up-rated to three phase lines where applicable and viable.
- Conductor size can be increased where this seems to be the most reliable option. All removed conductor must be carefully rolled on a conductor drum for re-use.
- Where the overload or under-voltage is due to excessive long lines and high loading, the transformer supply area can be split into two transformer zones with a new transformer installed in the best position.
- Installation of Capacitor banks to reduce losses and to improve voltage levels must be looked into where ever necessary.
- Existing transformers may be replaced with bigger ones to supply the estimated ADMD. This may include the installation of a new transformer structure and equipment or part thereof, or making safe of an existing structure.
- The shutdown time for existing customers on a network must be minimized by good planning of the network upgrade.

## PART TWO: NETWORK DISTRIBUTION MAINTENANCE STANDARDS

### 1. INTRODUCTION

The purpose of this standard is to provide service with recommended practices and frequencies that would form the core of a regularly scheduled electrical maintenance program. All work associated with electric distribution power systems and equipment should be performed in accordance with accepted standards and work practices following manufacturers 'manuals.

A maintenance plan should be elaborated showing appropriate maintenance strategies for all types of distribution assets and will be updated every time necessary. Implementation of planned maintenance activities that require outages will be authorized by competent authorities per outage management.

### 2. ACTIVITIES IN ELECTRICITY DISTRIBUTION MAINTENANCE

Maintenance activities here below presented concern distribution system and is divided into major components:

A. MV Distribution Lines
B. Distribution Transformers
C. Switching Devices
D. Protective Devices
E. Protective Relay
F. Earthing Equipment
G. Surge Arrestors
H. LV Distribution Boxes
I. LV Distribution Lines
J. Right of Ways

Breakdown/curative maintenance should be dramatically reduced by implementing preventive maintenance through regular inspections.

### A. DISTRIBUTION LINES ACTIVITIES

Electricity distribution lines both overhead and underground requires regular maintenance of their components to avoid disruption of power lines/power outages.

It is therefore essential to undertake regular preventive maintenance activities as described below and a curative maintenance is programmed accordingly:

- Install temporary grounding leads for safety.

- Remove necessary access and cover plates.
- At completion of inspection and test, remove temporary grounds, restore equipment to serviceable condition and decommission equipment.
- Compare test results to previous maintenance test results

**Overhead conductors and accessories:**

- Check distribution line conductors, jumpers. If less than three strands are found broken repair them by using aluminium spiral sleeves, above three broken strands repair shall be done using junction sleeves (al/st). No more than two joints shall be made in one span; in this case, replace the all span conductor.
- Check looseness of jumper connections, insulator tie points, etc.
- Maintain proper sag tension and clearances of line conductors (ground, internal).
- Maintain the proper bush clearance
- Check that all clamps, nuts and bolt are intact and in good condition.

**Insulators:**

- Check all insulators, if cracks are found, replace them.
- Replace cracked, broken line insulators.
- Check insulators alignment
- Measure insulation resistance

**Supporting structures (Poles, Towers):**

- Check physical defects and mechanical deformations on pole/tower and cross arms
- Check rot/decay and major cracks for wooden poles
- Check verticality of line supports and associated structures.
- Check tower/poles footings and protect them from land sliding, soil erosion etc.
- Clean bird nests, darts, plants growth, on cross arms and structures.
- Check the corrosion on steel poles/tower and components (cross arms, fittings, etc.
- Check tightness of stay wires.

**Underground cables (Underground Cables in Manholes, trenches and ducts)**

- Inspect for sharp bends, physical damage, excessive tension, oil leaks, pits, cable movement, soft spots, cracked jackets, damaged fireproofing, poor ground connections, deteriorated and corroded or weakened cable supports.
- Inspect for wear at entrance point and at supports.
- Inspect manhole for spalled concrete, proper ventilation and excessive moisture.
- Inspect potheads for oil or compound leakage and for cracked / chipped porcelain.
- Examine the manhole and cable grounding system to ensure its integrity.
- Inspect an open manhole for dangerous animals and insects (snakes, bees)
- Check that erosion has not exposed the cable on surface. If yes, dig and burry the cable to safe depth
- Caution: Check for the smell of dangerous gases before entering any confined space such as a manhole.

**B. DISTRIBUTION TRANSFORMERS**

**General**

- Examine the transformer for signs of overheating, deterioration, arcing, lose or broken parts, or other abnormal conditions
- Check connections of bushings on MV & LV sides and cable between transformer & LV DB
- Check Status of power house & Cleanliness in the Substation location/transformer location
- Check earthing system (connection and resistance and ensure a value of 5 ohms or less)
- Check The status of LV distribution panel/feeders pillar
- Status of platform or H-pole (for outdoor installed transformer)

**Liquid-Filled Transformer**

- **Check for physical condition:**

➢ Oil leakages

➢ Oil level in the conservator tank

➢ Breather condition/Silica Gel condition

➢ Oil/winding temperature

- **Check The Transformer Protection (Monthly)**

➢ MV fuses properly installed and sized

➢ LV fuses properly installed and sized

➢ LV Circuit breaker properly installed and sized

➢ MV surge arrestors properly installed and grounded

- **Tests & Measurement (Once a Year)**
  - Insulation resistance
  - Turns ratio
  - Oil Breakdown Voltage (BDV)
  - Earth resistance measurement
  - Load measurement (for all phases)
  - Secondary Voltage measured
- **Overhaul Maintenance (2 Years)**
  - Dissolved gases analysis
  - Oil regeneration/purification
  - Servicing MV/LV bushings

## C. SWITCHING DEVICES

- Check physical appearance of doors, devices, equipment and lubricate in accordance with manufacturer's instructions.
- Examine all bolts and connecting devices for signs of deterioration, corrosion, or overheating. Ensure that bolts and connecting devices are tight, according to manufacturer's specifications.
- Check the operation of the arc blades, if applicable, and ensure proper wipe of the main contacts.
- Ensure that all moving parts are properly secured and lubricated as specified by the manufacturer. Faulty switch is repaired or replaced as soon as possible.
- Check condition of contacts.
- Check condition of bussing for signs of overheating, moisture or other contamination, for proper torque, and for clearance to ground.
- Inspect insulators and insulating surfaces for cleanliness, cracks, chips, tracking.
- Check cable and wiring condition, appearance, and terminations.
- Inspect for proper grounding of equipment.
- Check evidence of severe arcing or burning of contacts.
- Check electrical operation of pilot devices, switches, meters, relays, auxiliary contacts, annunciator devices, flags, interlocks, cell switches, cubicle lighting. Visually inspect arrestors, CT's and PT's for signs of damage.
- Megger test insulators to ground.
- Megger test bussing phase to ground, and phase to phase.

- Test contact resistance across bolted sections of bus bars.
- Check the cleanliness of the Switching device location

**D. PROTECTIVE DEVICES (CIRCUIT BREAKERS, FUSES)**

Circuit breakers (air, vacuum, molded-case, oil and SF6 circuit breakers), Fuses and Surge arrestors are important components in our network. They should be properly maintained.

**Circuit Breakers**

**General**

- Fundamentals maintenance practices shall always be done as recommended by Original Equipment Manufacturer
- Check physical appearance of the device
- Clean all insulating materials. If it is necessary to use cleaning solvents, use only solvents recommended by the manufacturer.
- Examine all bolts and connecting devices for signs of deterioration, corrosion, or overheating. Ensure that bolts and connecting devices are tight, per manufacturer's specifications.
- Check the operation of the arc blades, if applicable, and ensure proper wipe of the main contacts.
- Examine for excessive wear of moving parts.
- Observe that operating mechanisms function properly without binding, hanging, or without delayed action.
- Ensure any lubrication is done per the manufacture's specifications.
- Ensure that all moving parts are properly secured and lubricated as specified by the manufacturer. Faulty device is repaired or replaced as soon as possible.
- Check condition of contacts.
- Inspect insulating surfaces or bushings for cleanliness, cracks, chips, tracking.
- Check cable and wiring condition, appearance, and terminations.
- Inspect for proper grounding of equipment.
- Check evidence of severe arcing or burning of contacts.
- Check electrical operation of pilot devices, switches, meters, relays, auxiliary contacts, annunciator devices, flags, interlocks, cell switches, cubicle lighting. Visually inspect surge arrestors, CT's and PT's for signs of damage.
- Verify the current rating for circuit breakers and fuses as per the application

- Check the cleanliness of the Protective device location
- Check the insulating fluid measurement (level, density, pressure, temperature, moisture…) indicating devices for calibration and proper operation.
- Conduct a dielectric test of the insulating fluid. Based on the results of this test, filter or replace oil as required (per manufacturer's instruction).
- Where applicable, check arc-quenching assemblies for carbon deposits or other contaminates.
- Circuit breakers should be electrically trip tested to ensure proper operation of the trip elements and trip linkages.

**Batteries**

- The maintenance of each battery will be made according to the manufacturer service manual.
- Check voltage of each battery/cell, voltage for the bank, electrolyte level, specific gravity etc. as applicable to each type of battery
- Thoroughly clean all battery surfaces of dust and/or dirt accumulations.
- Remove any corrosion and tighten all terminal connections
- Clean battery studs and cable ends. On stranded cable, if ends are corroded, cut off ends or separate strands and clean internally.
- Clean all vent openings and ensure that they are free from obstructions

**Charger**

- If all cells consistently read low, check charger for proper operation.
- Clean all dust and/or dirt accumulations from charger.
- Clean all vent openings and ensure that they are free from obstructions.
- Check terminals and connections for tightness.
- Check all relays, lights, and other indicating devices for proper operation.
- If electrolyte levels are low, check charger rate settings against the manufacturer's specifications. Consistently low levels may indicate the charge rate is too fast.

**E. PROTECTIVE RELAYS**

- Inspection, maintenance and testing of protective relays should be done as per the Manufacturer's recommendations

- **Notice**: when working on control circuits, all current transformer (CT) secondary should be shorted to ground and never left open-circuited.
- Inspect relays for physical damage and deterioration.
- Inspect gaskets and covers for damage and/or excessive wear.
- Examine and clean the relay and enclosure of foreign materials, such as dust, dirt, and moisture contamination.
- Check mechanism for freedom of movement, proper travel and alignment, and tightness of mounting hardware and plugs.
- Clean glass inside and out.
- Clean relay compartment as required.
- Clean relay plug in contacts, if applicable, using proper tools.
- Remove dust and foreign materials from interior of relay using small brush or low pressure.
- Remove rust or metal particles from disc or magnet poles with magnet cleaner or brush.
- Inspect for signs of carbon, moisture and corrosion.
- Repair or replace as necessary

**Electrical Testing**

- Using an appropriate testing instrument, suitable for the relays being tested, conduct electrical testing of the relays in accordance with manufacturer's recommendations
- For overcurrent relays, test the following functions of the relay at the established settings specified by the system engineer or manufacturer:
- The relays should be tested to ensure that operation of the relay will in fact cause a tripping action of the respective concerned elements.
- Pickup contacts should close when a current equal to the relay tap setting is applied to the induction coil. Adjust the spring as needed to allow for proper operation.
- Timing tests should be performed corresponding to two (2) or more points on the relay's time current curves. One of the tests should be done at the specified time dial setting.
- Strictly adhere to required procedures for system switching operations. Switching, de-energizing and energizing shall be performed by authorized personnel only.
- Completely isolate protective relays to be tested and inspected from sources of power.
- Use manufacturer's instructions for information concerning connections, adjustments, repairs, timing, and data for specific relay.

- Tests for typical overcurrent relays include:
- Zero check.
- Induction disc pickup.
- Time-current characteristics.
- Target and seal-in operation.
- Instantaneous pickup.
- Check CT and PT ratios and compare to coordination data.

**F.** EARTHING EQUIPMENT

Earthing and short-circuiting equipment shall be handled with great care and be thoroughly inspected before each application.

- Earthing equipment must be checked regularly per the checklist below to ensure that the tools work safely and reliably.
- An extensive inspection, shall be carried out periodically:
  - Check for signs of corrosive damage to contact surfaces on Line clamps/Earth clamps. If defected, the surfaces must be cleaned. If heavy corrosion is detected the clamps should be replaced.
  - Check the cable lug's connection to the clamp - the screw must be firmly tightened and the cable lug firmly attached.
  - Check for breaks on cable lugs. Damaged cable lugs must be replaced.
    Twisted (not broken) cable lugs can be adjusted to the correct position. After this, check for breaks and check the tightening torque.
  - Check that no cable strands are damaged. If a strand is damage the cable should be re-pressed.
  - Check for any damage on the cables. A damaged cable (strand breakage) must be replaced.
  - Insulating poles must be free of moisture and contamination.

## G. MV SURGE ARRESTORS

Periodically visual inspect to ensure that:

- The arrester is set at proper spacing and clearance
- The line lead is securely fastened to the line conductor and the arrester
- The ground lead is securely fastened to the arrester terminal and ground
- Check the earth resistance is below 5 ohms
- The arrester housing is clean and free from cracks, chips, or evidence of external flashover

The arrester is in such a manner as not to be subject to:

➢ Excessive dirty or other current-conducting deposits

➢ Excessive humidity, moisture, dripping water, steam, spray abnormal vibrations or shocks

➢ Where an arrester is composed of two or more individually complete units, test each unit separately to allow bad unit replacement and retaining good units

## H. LV DISTRIBUTION BOXES

- Check physical conditions for dirt and other rubbish, locks, rust
- Check safety conditions for public
- Check the main circuit breaker for correct rating as per the installed transformer
- Check the neutral connections and bus bars are insulated from ground
- Check the connections on circuit breakers for loose, burnt conditions
- If installed, LV surge arrestors must be checked and replaced if faulty
- Check cable supports
- Check feeders circuit breaker or/and fuses for correct current ratings and replace the faulty one by the one with correct ratings

## I. LV DISTRIBUTION NETWORK MAINTENANCE

- Maintain standard clearance of LV ABC Cables to ground, buildings, vegetation, bushes, etc.
- Maintain standard span between poles and their standards pole length
- Check physical deformation of cables
- Check cracks, broken and Rotten poles
- Check of pole foundations and poles location dangers
- Check Intact of stay assembly and strut poles

- Maintain voltage and current balancing
- Maintain and Measure the voltage at the farthest client from transformer
- Check looseness/tightens all cables connections and their accessories
- Check the status of all line hardware (clamps, stud bolts, insulators, insulation piercing connectors, etc.)
- Check illegal extensions and connections, Disconnect them
- Check the status and sizes of fuses, CBs, ABC cables and underground cables
- Check operation of metering system
- Check Earthing system for LV DB and for first LV pole

**J. RIGHT OF WAY**

- Cut trees and clean bushes & creepers along corridors of distribution lines.
- Check and report the existence of houses and other obstacles inside the Right of Way corridor

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# PART THREE: ANNEXES

# ANNEXE 1: NETWORK DEVELOPMENT FORMS

**NETWORK DEVELOPMENT FORMS**

- PROJECT SURVEY FORM
- PROJECT DESIGN AND APPRAISAL REPORT
- SITE HANDOVER CERTIFICATE
- REQUEST FOR TESTING AND COMMISSIONING
- TESTING AND COMMISSIONING REPORT FOR LOW VOLTAGE LINE
- TESTING AND COMMISSIONING REPORT FOR MEDIUM VOLTAGE LINE
- TESTING AND COMMISSIONING REPORT OF TRANSFORMERS
- HAND-OVER CERTIFICATE OF LOW VOLTAGE LINE
- HAND-OVER CERTIFICATE OF MV VOLTAGE LINE
- HAND-OVER OF TRANSFORMERS
- GIS AS-BUILT DATA FORMS
- GIS AS BUILT DATA OF CUSTOMER IDENTIFICATION
- MV LINE GIS AS BUILT DATA OF ELECTRICTY NETWORK LINE AND EQUUIPMENT
- POLES SCHEDULE FOR MV LINE
- POLES SCHEDULE FOR LV LINE

**NETWORK MAINTENANCE CHECKLISTS**

- INSPECTION CHECK LIST FOR MV CONCRETE POLES
- INSPECTION CHECK LIST FOR MV STEEL POLES
- INSPECTION CHECK LIST FOR MV PYLON/LATTICED TOWERS
- INSPECTION CHECK LIST FOR MV WOODEN POLES
- INSPECTION CHECK LIST FOR MV CONDUCTORS
- INSPECTION CHECK LIST FOR MV/LV DISTRIBUTION TRANSFORMERS
- INSPECTION CHECK LIST FOR DISCONNECT SWITCH, DROP OUT, FUSE, AUTO-RECLOSER
- LV DISTRIBUTION LINE

| PROJECT SURVEY FORM | | |
|---|---|---|
| **Name of Project:** | | |
| **Project implementer and Owner/beneficiary:** | **Name of Implementer:** | **Name of Owner / beneficiary:** |
| REG Branch name | | |
| Description of location of Energy infrastructures to be constructed (Districts, Sectors, Cells, and Villages | | |
| Length/Capacity of surveyed site or line (MV/LV) | | |
| Name of the main substation that supplies the area | | |
| Main Feeder Name / nearest sub-feeders | | |
| Existing Feeder Conductor type and Size ($mm^2$) | | |
| Distance of new load from the main substation | | |
| Is this Project in line with the Master Plan Guidelines for Network Development? | Yes/No | |

| | |
|---|---|
| Will this Project require expropriation? | Yes / No |
| Is there any potential technical, Environmental and Social risk to be | If yes, briefly describe the risk and proposed mitigation measures |

| FOR APPROVAL | | |
|---|---|---|
| **Surveyor (s)** | | |
| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| | | |
| **Branch Representative** | | |
| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
| | | |

| PROJECT DESIGN AND APPRAISAL REPORT | | |
|---|---|---|
| **Name of Project** | | |
| **High Level Cost Estimates (budget)** | | |
| **Type of support structures (concrete, wood, steel etc.…)** | | |
| **Project implementer and Owner/beneficiary** | **Name of Implementer:** | **Name of Owner/beneficiary:** |
| **Project Investigation Information** | | |
| Name of the main substation that supplies the area | | |
| Main Substation Transformer Capacity (MVA) | | |
| Maximum peak ever recorded on the main Substation/transformer where new load will be connected | | |
| Additional Capacity available to serve the new load (from the main substation/transformer) | | |
| Main Feeder Name | | |
| Feeder Conductor type and Size ($mm^2$) | | |
| Estimated feeder carrying Capacity (MVA) | | |
| Distance of new load from the main substation | | |
| Estimated Load to be added on the network (MVA) | | |
| Medium Voltage (MV) and Low voltage (LV) line length added to the network (km) | MV (km):<br>LV (km): | |
| Number of Distribution transformers added to the Network | | |

| | | |
|---|---|---|
| Estimated number of customers | Customers: …….<br>○ Three phases: ……<br>○ Single phase: …….. | |
| New Conductor type and size to be installed ( mm²) | | |
| Load flow studies performed | Yes/No | Name of the person who did load flow? |
| Simulated voltage at load (kV) | | |
| Simulated voltage at end of the MV line | | |
| Substation peak loading with new load (MVA) | | |
| Is this Project in line with the Master Plan Guidelines for network development? | Yes/No | |
| Additional requirements or conditions for technical approval? | ○ **EIA Certificate:** Required / Not Required<br>○ **Construction permit:** Required / Not Required | |

| **Name of Design Engineer** | **Position** | **Signature and Date** |
|---|---|---|
| | | |
| | | |

| **FOR APPROVAL** | | |
|---|---|---|
| **Is this Project technically approved? If no, please highlight what needs to be done prior to approval with recommendations for re-submittal.** | **Yes/No** | **Required additional details:** |

| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
|---|---|---|
| | | |
| | | |
| | | |

| SITE HAND OVER CERTIFICATE | | |
|---|---|---|
| **Name Of Project** | | |
| **Contract Reference** | | |
| **Name Of Implementer / Contractor** | | |
| **Expected Date Of Completion** | | |
| **REG Branch Name** | | |
| Brief description of the works (high level project scope). | | |
| | | |
| | | |
| | | |
| | | |
| Is contractor's site mobilization and quality plans in place? | Yes /no | |
| Will project require expropriation? | Yes /no | Status of expropriation: |
| Was environmental impact assessment done? | Yes /no | |
| Are Land title/construction permits etc. required and available? | Yes /no | |
| Was a safety briefing done by REG? | | |
| Are there potential safety risks identified on site? Name those. | **Potential risk** | **Mitigation measures** |
| | | |
| | | |
| Were switching procedures explained to the Implementer / Contractor? | | |
| **Declaration** | | |

| Parties declare that information provided in this site hand over certificate is true and correct and provide enough information for the purposes of site hand over | **Observations (if any)** |
|---|---|

**SIGNATURES**

**For REG**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |
| | | |

**For Contractor/REG Project Manager**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |
| | | |

| REQUEST FOR TESTING AND COMMISSIONING | | |
|---|---|---|
| **Project Name** | | |
| **Contract Reference** | | |
| **Name of Contractor/ Implementer** | | |
| **Project budget at completion** | | |
| **REG Branch name** | | |
| **Date of Works Completion** | | |
| Was final inspection done by REG for the works? | | |
| Were the works completed according to specifications and scope | | |
| Were Materials and Labour reconciliation done? | | |
| Are the Works ready for testing and commissioning? | | |
| Will commissioning require an outage? | Yes/No | Where will switching be done? |
| Feeders /sub-feeders that will be affected | | |
| Estimated outage duration | | |
| Is the site restored/cleared to satisfaction? | | |
| Requested date for Testing and Commissioning? | | |
| Does the Contractor have all test Equipment for testing? | | |

| FOR REG | | |
|---|---|---|
| **Request for Testing received by** | | |
| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| **Testing & Commissioning approval** | | |
| **Date for Testing & Commissioning**<br>**From…….. / to ……. …….** | | |
| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| | | |

| TESTING AND COMMISSIONING REPORT FOR LOW VOLTAGE LINE | |
|---|---|
| **Name and capacity of MV/LV Transformer:** | |
| **PROJECT BASIC DATA** | |
| Project Implementer/Contractor: | |
| Project location/REG Branch: | |
| Warranty / guarantee period and start date: | |
| Three phase or single phase (specify) line | |
| Length of the line (km) | |
| Cable type and size ($mm^2$) | |
| Are the foundations proper and aligned to support used structures? | |
| Size of Circuit breaker protecting the cable | |
| Overall LV Earthing resistance (Value in Ohm ≤10 Ohm) | |
| Before connection or Energizing: Resistance in Mega Ohm | |
| Phase 1 - Phase 2: | |
| Phase 1 - Phase 3: | |
| Phase 2 – Phase 3: | |
| Phase 1 - Neutral: | |
| Phase 2 - Neutral: | |
| Phase 3 - Neutral: | |
| After Energizing: Voltage measured at the LV DB (Volts) | |
| Phase 1 - Phase 2: | |
| Phase 1 - Phase 3: | |

| | |
|---|---|
| Phase 2 – Phase 3: | |
| Phase 1 - Neutral: | |
| Phase 2 - Neutral: | |
| Phase 3 - Neutral: | |
| After Energizing: On-load Voltage measured at the end of the line (Volts) | |
| Phase 1 - Phase 2: | |
| Phase 1 - Phase 3: | |
| Phase 2 – Phase 3: | |
| Phase 1 - Neutral: | |
| Phase 2 - Neutral: | |
| Phase 3 - Neutral: | |

**FOR CONTRACTOR / IMPLEMENTER**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

**PROJECT MANAGEMENT / SUPERVISION / USER**

| NAME | POSITIONS | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

**REG BRANCH / HUB**

| NAME | POSITIONS | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| TESTING AND COMMISSIONING REPORT FOR MEDIUM VOLTAGE LINE | |
|---|---|
| **PROJECT BASIC DATA** | |
| Project Name | |
| Contract Reference | |
| Name of Contractor / Implementer | |
| REG Branch name | |
| Three phase or single phase (specify): | |
| Length of the line (km): | |
| Conductor type and size: | |
| MV earthing resistance at the transformer (Value in Ohm ≤ 5 Ohm) | |
| **Before Connection or Energizing: Resistance in Mega Ohm** | |
| Phase 1 - Phase 2: | |
| Phase 1 - Phase 3: | |
| Phase 2 – Phase 3: | |
| Phase 1 – Shield wire / Ground: | |
| Phase 2 - Shield wire / Ground: | |
| Phase 3 - Shield wire / Ground: | |
| | |

| FOR THE CONTRACTOR / IMPLEMENTER | | |
|---|---|---|
| **NAME** | **POSITIONS** | **SIGNATURE AND DATE** |
| | | |
| | | |
| **PROJECT MANAGEMENT / SUPERVISION / USER** | | |
| **NAME** | **POSITIONS** | **SIGNATURE AND DATE** |
| | | |
| | | |
| **REG BRANCH / HUB** | | |
| **NAME** | **POSITIONS** | **SIGNATURE AND DATE** |
| | | |
| | | |

| TESTING AND COMMISSIONING REPORT OF TRANSFORMERS | |
|---|---|
| **Project Name** | |
| **Contract Reference** | |
| **Name of Contractor/ Implementer** | |
| **REG Branch name** | |
| **Transformer name** | |
| **Manufacturer** | |
| Type of Transformer (Single or Three phase) | |
| Transformer size (kVA) | |
| Configuration (H pole mounted/cabin, etc.) | |
| Transformer tap setting | |

**INSULATION RESISTANCE TEST**

Ensure that the earth resistance has been tested and is acceptable **(≤5Ω)**.

a) Ensure all electrical connections have been disconnected, including MEN/N-E connections.

**b)** Measure the insulation resistance test results after 1 minute of testing.

| Insulation resistance test on the transformer winding | | | |
|---|---|---|---|
| **Test Connection** | **Test Voltage** | **Resistance** | **Expected Values** |
| Primary/high voltage (HV) to tank | 2.5 Kv | Ω | >1 GΩ |
| Primary/HV to secondary/LV | 1 kV | Ω | >100 MΩ |
| Secondary/LV to tank | 1 kV | Ω | >100 MΩ |
| | | | |
| **Insulation resistance test on the low voltage (LV) board busbar (LV fuse ways open, including the transformer LV disconnector)** | | | |
| Phase 1 to Phase 2 | 1 kV | Ω | >100 MΩ |
| Phase 1 to Phase 3 | 1 kV | Ω | >100 MΩ |
| Phase 2 to Phase 3 | 1 kV | Ω | >100 MΩ |
| Phase 1 to Earth | 1 kV | Ω | >100 MΩ |
| Phase 2 to Earth | 1 kV | Ω | >100 MΩ |
| Phase 3 to Earth | 1 kV | Ω | >100 MΩ |

## 1. INSTALLATION AND CONSTRUCTION CHECKS

| Item | YES/NO |
|---|---|
| Transformer installed as per construction standards and applicable design drawings. | |
| Transformer matches system voltage. | |
| Transformer tap is at the position as per network planning. | |
| Transformer oil level satisfactory (if visible). | |

| | |
|---|---|
| Transformer bushings and tank in good condition (no oil leaks). | |
| Primary / HV cables properly terminated and connected. | |
| Secondary / LV cables properly terminated and connected. | |
| Neutral connected and earthed and MEN/N-E link connected. (multiple Earthed Neutral/Neutral-earthed) | |
| **2. ENERGIZATION OF TRANSFORMER** | |
| Check the MV Fuses are well calibrated | |
| Open the LV Breaker (Off position) | |
| Energize the transformer as per REG procedures | |
| **Secondary voltage measurements off load (Volts)** | |
| Phase 1 - Phase 2: | |
| Phase 1 - Phase 3: | |
| Phase 2 – Phase 3: | |
| Phase 1 - Neutral: | |
| Phase 2 - Neutral: | |
| Phase 3 - Neutral: | |
| **Close the LV Circuit Breaker: Secondary voltage measurements on load (Volts)** | |
| Phase 1 - Phase 2: | |
| Phase 1 - Phase 3: | |
| Phase 2 – Phase 3: | |
| Phase 1 - Neutral: | |
| Phase 2 - Neutral: | |
| Phase 3 - Neutral: | |

| **Load at commission in Amperes (A):** | |
|---|---|
| $I_1$: | |
| $I_2$: | |
| $I_3$: | |
| **Transformer protection** | |
| MV Earth resistance for Transformer in Ohms (≤5 Ohm): | |
| Earth resistance for Low voltage distribution board in Ohms (≤5 Ohm): | |
| Colour of Silica Gel | |

| **CONTRACTOR / IMPLEMENTER** | | |
|---|---|---|
| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| | | |
| **PROJECT MANAGEMENT / SUPERVISION / USER** | | |
| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| | | |
| **REG BRANCH / HUB** | | |
| **NAME** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| | | |

| HAND-OVER CERTIFICATE OF LOW VOLTAGE LINE | | | | | | |
|---|---|---|---|---|---|---|
| **PROJECT BASIC DATA** | | | | | | |
| **Transformer name and Capacity:** | | | | | | |
| **Project implementer/contractor:** | | | | | | |
| **Project location/REG Branch:** | | | | | | |
| **Warranty/guarantee period and start date:** | | | | | | |
| **Warranty/guarantee period and end date:** | | | | | | |
| Three phase or single phase (specify): | | | | | | |
| Length of the line (km) | | | | | | |
| type and size of cable ($mm^2$) | | | | | | |
| Size of Circuit breaker protecting the cable (A) | | | | | | |
| Wooden poles (length and number) | Type & length | S100 (9 m) | S140 (9 m) | S190 (9 m) | S225 (9 m) | Other indication |
| | Nbr | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Concrete poles (length and number) | Type & length | ..daN …… m | …daN … m | ….daN … m | ..daN … m | ... daN …… (m) |
| | Nbr | | | | | |
| Steel poles (length and number) | Type & length | …..daN …… m | ...daN … m | ...daN … m | ..daN … m | ... daN …… (m) |
| | Nbr | | | | | |

| **Information on service connections (if applicable)** | |
|---|---|
| Number of three phase connections: | |
| Number of single-phase connections: | |
| Number of Households: | |
| Number of Schools: | |
| Number of Administrative offices | |
| Number of Health Centres: | |
| Number of Business Centres | |
| **Details of low voltage distribution panel:** | |
| Dimension (Length x Width x Height): | |
| Ratings of LV fuse for outgoing feeder | |
| Number of outgoing low voltage feeders: | |
| Rated current for Main Circuit breaker (**A**): | |
| Current Setting of Circuit breaker (**A**) | |

| | |
|---|---|
| Size of the cable from transformer to Distribution board | |
| Was As-built drawings with all GIS information submitted? | |

**Other useful information/ Comments / Observations related to the project**:

**CONTRACTOR/IMPLEMENTER**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

**PROJECT MANAGEMENT AND SUPERVISION**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

**REG BRANCH AND HUB**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| Rwanda Energy Group REG | Form Name: …….. | Form Nº: …….. |
|---|---|---|

| HAND-OVER CERTIFICATE OF MEDIUM VOLTAGE LINE | | | | | | |
|---|---|---|---|---|---|---|
| **PROJECT BASIC DATA** | | | | | | |
| **Project implementer / contractor:** | | | | | | |
| **Project location / REG Branch:** | | | | | | |
| **Warranty/guarantee period and start date:** | | | | | | |
| **Warranty/guarantee period and end date:** | | | | | | |
| **Voltage level (kV):** | | | | | | |
| **Length of the MV line (km)** | | | | | | |
| **Size of conductor (s)** | | | | | | |
| | | | | | | |
| Wooden poles (length and number) | Type & Length | S…. ….m | S…. …..m | S…. …..m | S…. …..m | Other indication |
| | Nbr | | | | | |
| Concrete poles (length and number) | Type & Length | …daN … m | …. daN …. m | ….daN … m | ... daN … m | ... daN … m |
| | Nbr | | | | | |
| Steel poles (length and number) | Type & Length | …daN … m | …. daN …. m | ….daN … m | ... daN … m | ... daN … m |
| | Nbr | | | | | |
| Pylon/Tower structures length and number | Type | | | | | |
| | Nbr | | | | | |
| Ground Shield wire installed (yes/No): | | | | | | |

| | |
|---|---|
| **Number of Transformers installed (complete list attached for each transformer)** | |
| Number of three phase transformers installed | |
| Number of single phase Transformers installed | |
| **List of switching/protective devices installed and number (i.e. auto re-closer, line disconnector, Drop out fuse, surge arrestors etc…) (use a separate list if more):** | |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| **Details of the main feeder:** | |
| Main feeder: (where the line is connected) | |
| HV/MV substation where the main line is supplied from: | |
| Conductor type and size of the main line/feeder: | |
| Actual load of the main line | |
| Was As-built drawings with all GIS information submitted? | |

Other useful information

**FOR CONTRACTOR/IMPLEMENTER/USER APPROVAL**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

**FOR REG APPROVAL**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

**REG BRANCH AND HUB**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| HAND-OVER OF TRANSFORMER | |
|---|---|
| Transformer name | |
| Transformer Phases | |
| Transformer size (kVA) | |
| Size of LV Breaker (A) | |
| Current setting of LV Breaker (A) | |
| Configuration (pole mounted/cabin, etc.) | |
| Manufacturer | |
| Serial Number | |
| Cooling System (ONAN/ONAF/OFAF) | |
| Manufacturing Date | |
| Commissioning Date | |
| Vector Group | |
| Number of Taps | |
| Tap positions available (%) | |

**FOR CONTRACTOR/IMPLEMENTER/USER APPROVAL**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

**FOR REG APPROVAL**

| NAME | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

**GIS AS-BUILT DATA FORMS**

To keep the REG GIS Database update, all Contractors and all Departments who touch on the Network must submit as-built data (in GIS format: Shape file and/or GDB) after completion of project in addition to all other required documents. These data should be reported to the Unit in charge of Geographical Information System (GIS). The following projection should be respected as it is the one used in the REG ArcGIS system:

- Coordinate system: GCS_ITRF_2005 or GCS WGS 1984 (as indicated in the contract)
- Projection: Transverse Mercator
- Datum: D_ITRF_2005 or WGS 1984 (as indicated in the contract)
- False Easting: 500,000.0000
- False Northing: 5,000,000.0000
- Central Meridian: 30.0000
- Scale Factor: 0.9999
- Latitude of origin: 0.0000
- Units: Meter

Information to be collected on new assets or lines introduced in Network shall include. But not limited to the following:

| CUSTOMER IDENTIFICATION | |
|---|---|
| Location | District: …….. Sector: ……..<br>Cell: …… Village: …….. |
| Landlord Name | |
| Landlord contact (phone) | |
| Landlord ID | |
| Tenant Name | |
| Tenant contact (phone) | |
| Plot Number | |
| House number | |
| Street number | |
| Customer Segmentation (mark which is appropriate) | Residential |
| | Commercial |
| | Hotel |
| | Apartment |
| | Public services |
| | Small industry |
| | Large industry |
| | Diplomat |
| Meter Number | |
| POC Number | |
| Meter Type | Electromechanical |
| | Electronic |

| | |
|---|---|
| Meter Category | Single phase |
| | Three phase |
| | High current |
| | Connected via current/voltage transformers |
| Payment Method | Prepaid |
| | Post-paid |
| Transformer Name | |
| POC Label | |
| GPS Coordinates of the customer | |
| **POC (POINT OF CONNECTION)** | |
| Pole Type | LV<br>MV<br>HV |
| Pole Number | |
| Pole Structure | Wood<br>Steel<br>Concrete<br>Pylon<br>Local wood<br>Local tube<br>Other |
| Cable Underground | Yes |

| | |
|---|---|
| | No |
| Transformer Name | |
| POC Label | |
| GPS Coordinates of the POC | |

## GIS AS BUILT TEMPLATE FOR THE DISTRIBUTION NETWORK COMPONENTS

| Network Component | Attribute | Data type | Domain |
|---|---|---|---|
| Transformers | Substation | Text | |
| | MV Feeder | Text | |
| | Name TRF | Text | |
| | Pole/Pylon Number | Text | |
| | Capacity (kVA) | Float | |
| | Phases | Text | Single phase |
| | | | Bi-phase |
| | | | Three phase |
| | Support TRF | Text | Single Steel |
| | | | Single Wooden |
| | | | Single Concrete |
| | | | PH Steel |
| | | | PH Wooden |
| | | | PH Concrete |
| | | | Soclet |
| | | | Ground Concrete |
| | | | Pylon |
| | | | Cabin |
| | Serial No | Text | |
| | Barcode /Tag number | Text | |
| | Primary Voltage (kV) | Float | |
| | Secondary Voltage (kV) | Float | |
| | Primary Current (Amp) | Float | |
| | Secondary Current (Amp) | Float | |
| | LV_CB(Amp) | Float | |
| | Type of Switch | Text | Sectionnaire |
| | | | Dropout |
| | | | MV switchgear |
| | Owner | Text | |
| | Manufacturer | Text | |
| | Country Manufacturer | Text | |
| | OIL_INDICATOR | Text | Yes |

| | | | |
|---|---|---|---|
| | | | No |
| | Number of tap position | Text | 3 |
| | | | 5 |
| | Total mass | Float | |
| | OIL_WEIGHT | Float | |
| | Smart meter | Text | Yes |
| | | | No |
| | Smart meter S/N | Text | |
| | COOLING_SY | Text | ONAN |
| | | | OFAN |
| | | | Not |
| | VIDANGE_VA | Text | Yes |
| | | | No |
| | S_SILCAGEL | Text | Yes |
| | | | No |
| | Year_Manufacturer | Text | |
| | Maintenance Date | Date | |
| | Branch Name | Text | |
| | Notes | Text | |
| | Photo_TRF | | |
| | X | | |
| | Y | | |
| **Medium_Voltage_Lines** | **Attribute** | **Data type** | **Domain** |
| | Substation Name | Text | |
| | Feeder Name | Text | |
| | Voltage (kV) | Float | 30 |
| | | | 15 |
| | | | 17.32 |
| | | | 6.6 |
| | Conductor type | Text | ACSR |
| | | | AAAC |
| | | | CU |
| | Conductor Size ASCR_AAAC | Text | 120_20 |
| | | | 70_12 |

| | | | |
|---|---|---|---|
| | | | 35_6 |
| | | | 35_5 |
| | Conductor Size AAAC | Text | 54.6 |
| | Phases | Text | Single phase |
| | | | Bi-phase |
| | | | Three phase |
| | Type | Text | Overhead |
| | | | Underground |
| | Currying capacity (A) | Text | 170 |
| | | | 175 |
| | | | 290 |
| | | | 410 |
| | Fiber optical | Text | OPGW |
| | | | ADSS |
| | Branch name | Text | |
| | Construction date | Date | |
| | Commissioning date | Date | |
| | Maintenance date | Date | |
| | Feeder Smart meter | Text | Yes |
| | | | No |
| | Feeder meter S/N | Text | |
| | Length | Float | |
| | Notes | Text | |
| | X | | |
| | Y | | |
| **LV_Lines** | **Attribute** | **Data type** | **Domain** |
| | Substation Name | Text | |
| | Feeder Name | Text | |
| | Transformer Name | Text | |
| | Voltage (kV) | Float | 400 |
| | | | 242 |
| | | | 230 |
| | Type | Text | Overhead |
| | | | Underground |

| | | | |
|---|---|---|---|
| | Conductor Size OH | Text | 2*16mm2,<br>2*25mm2,<br>2*35mm2,<br>4*16mm2<br>4*25mm2,<br>4*35mm2,<br>4*50mm2<br>4*70mm2<br>4*75mm2<br>4*95mm2<br>4*120mm2 |
| | Conductor size UG | Text | 4*50mm2<br>4*70mm2<br>4*95mm2<br>4*120mm2 |
| | Conductor type | Text | Al twisted<br>Cu |
| | Phases | Text | Single phase<br>Biphase<br>Three phase |
| | Branch name | Text | |
| | Length | Float | |
| | Year of commissioning | Date | |
| | Construction date | Date | |
| | Maintenance date | Date | |
| | Fiber type (ADSS only) | Text | Yes<br>No |
| | Notes | Text | |
| | X | | |
| | Y | | |
| **Optical joint closure support** | **Attribute** | **Data type** | **Domain** |
| | Pole number | Text | |
| | Feeder name | Text | |
| | Fiber owner | Text | MTN |

| | | | |
|---|---|---|---|
| | | | LIQUID |
| | | | ORN |
| | Feeder type | Text | HV |
| | | | MV |
| | | | LV |
| | Fiber type | Text | OPGW |
| | | | ADSS |
| | X | | |
| | Y | | |
| **Medium_Voltage_Support** | **Attribute** | **Data type** | **Domain** |
| | Feeder Name | Text | |
| | Substation Name | Text | |
| | Transformer Name | Text | |
| | Pole Number | Text | |
| | Type | Text | Pylon |
| | | | Pole |
| | Pole Structure | Text | Wooden |
| | | | Steel |
| | | | Concrete |
| | | | Not traited wooden |
| | | | Local tube |
| | | | Others |
| | Conductor Size ASCR | Text | 120_20 |
| | | | 70_12 |
| | | | 35_6 |
| | | | 35_5 |
| | Conductor Size AAAC | Text | 54.6 |
| | Pylon structure | Text | Alignment A, |
| | | | Alignment A+2, |
| | | | Alignment A+4, |
| | | | Alignment A+6, |
| | | | Angle TA, |
| | | | Angle TA1, |
| | | | Angle TA2, |

| | | | |
|---|---|---|---|
| | | | Angle TAT, |
| | | | Special TAS, |
| | | | Special TAS+2, |
| | | | Special TAS+4, |
| | Dressing type/Insulator | Text | Suspension |
| | | | Strain |
| | | | Terminal |
| | | | T-off from strain |
| | | | T-off from suspension |
| | | | Cross from strain |
| | | | Cross from suspension |
| | Pole Height (m) | Integer | |
| | Smart meter | Text | Yes |
| | | | No |
| | DMS Centraliser (default detector) | Text | |
| | Manufacturer | Text | |
| | Year of Installation | Integer | |
| | Appended Cable | Text | Fiber |
| | | | Earthing |
| | | | Stay |
| | | | Flying stay |
| | Construction type | Text | Horizontal |
| | | | Vertical |
| | | | Flat Spacing Arrangement (Nappe Voûte) |
| | Country of Manufacturer | Text | |
| | Year of Manufacturer | Integer | |
| | Construction date | Date | |
| | Maintenance date | Date | |
| | X | | |
| | Y | | |
| **LV_Support** | **Attribute** | **Data type** | **Domain** |
| | Substation Name | Text | |

| | | | |
|---|---|---|---|
| | Feeder Name | Text | |
| | Name TRF | Text | |
| | Type | Text | Wooden |
| | | | Steel |
| | | | Concrete |
| | | | Pylon |
| | | | Not treated wooden |
| | | | Local tube |
| | | | MV Pole |
| | | | Others |
| | Structure | Text | Single wooden |
| | | | Single concrete |
| | | | Single steel |
| | | | HP wooden |
| | | | HP concrete |
| | | | HP steel |
| | Conductor size | Text | 2*16mm2, |
| | | | 2*25mm2, |
| | | | 2*35mm2, |
| | | | 4*16mm2 |
| | | | 4*25mm2 |
| | | | 4*35mm2 |
| | | | 4*50mm2 |
| | | | 4*70mm2 |
| | | | 4*75mm2 |
| | | | 4*95mm2 |
| | | | 4*120mm2 |
| | Dressing type/Insulator | Text | Suspension |
| | | | Strain |
| | | | Terminal |
| | | | T-off from strain |
| | | | T-off from suspension |
| | | | Cross from strain |
| | | | Cross from suspension |

| | | | |
|---|---|---|---|
| | Height (m) | Integer | 9 |
| | | | 10 |
| | | | 12 |
| | | | Other |
| | Appended Cable | Text | Fiber |
| | | | Earthing |
| | | | Stay |
| | | | Flying stay |
| | Manufacturer | Text | |
| | Year_Manufacturer | Integer | |
| | Country Manufacturer | Text | |
| | X | | |
| | Y | | |
| | Notes | Text | |
| **Distribution box** | **Attribute** | **Data type** | **Domain** |
| | Distributer name (end user) 1 | Text | |
| | Distributer name (end user) 2 | Text | |
| | Distributer name (end user) 3 | Text | |
| | Distributer name (end user) 4 | Text | |
| | Transformer name | Text | |
| | LV CB (Amp) /Disjoncteur | Float | |
| | Pole Number | Float | |
| | Notes | Text | |
| | X | | |
| | Y | | |
| **POC LV Pole** | **Attribute** | **Data type** | **Domain** |
| | Pole Type | Text | Wooden |
| | | | Steel |
| | | | Concrete |
| | | | Not traited wooden |
| | | | Local tube |
| | | | Others |
| | Pole Structure | Text | Single wooden |
| | | | Single concrete |

| | | | |
|---|---|---|---|
| | | | Single steel |
| | | | HP wooden |
| | | | HP concrete |
| | | | HP steel |
| | Conductor size | Text | 2*16mm2 |
| | | | 2*25mm2 |
| | | | 2*35mm2 |
| | | | 4*16mm2 |
| | | | 4*25mm2 |
| | | | 4*35mm2 |
| | | | 4*50mm2 |
| | | | 4*70mm2 |
| | | | 4*75mm2 |
| | | | 4*95mm2 |
| | | | 4*120mm2 |
| | Conductor type | Text | Al twisted |
| | | | CU |
| | Service cable type | Text | Overhead |
| | | | Underground |
| | Service cable size | Text | |
| | Transformer Name | Text | |
| | POC Label | Text | |
| | Installation date | Text | |
| | Notes | Text | |
| | Y | | |
| | X | | |
| **MV Protection and MV switching** | **Attribute** | **Data type** | **Domain** |
| | Site name | Text | |
| | Substation Name | Text | |
| | Feeder Name | Text | |
| | Device Type | Text | Autorecloser |
| | | | Disconnector |
| | | | Cutout |
| | | | Load breaker switches |

| | | | |
|---|---|---|---|
| | | | MV circuit breaker |
| | Phases | Text | Single phase |
| | | | Biphase |
| | | | Three phase |
| | Rated Current (Amp) | Float | |
| | Support Type | Text | Tower |
| | | | HP Poles |
| | | | Single Pole |
| | Point of reconfiguration/switching element | Text | yes |
| | | | Not |
| | Pole number | Integer | |
| | Manufacturer | Text | |
| | Country of Manufacture | Text | |
| | Year of installation | Date | |
| | Notes | Text | |
| | X | | |
| | Y | | |
| **Substation** | **Attribute** | **Data type** | **Domain** |
| | Substation Name | Text | |
| | Substation type | Text | Switching |
| | | | T-OFF |
| | Number of Transformers | Integer | |
| | Weight of transformer 1 (Ton) | Float | |
| | Weight of transformer 2 | Float | |
| | Weight of transformer 3 | Float | |
| | Configuration of transformer 1 | Text | |
| | Configuration of transformer 2 | Text | |
| | Configuration of transformer 3 | Text | |
| | Serial number 1 | Text | |
| | Serial number 2 | Text | |
| | Serial number 3 | Text | |
| | Smart meter transformer 1 (S/N) | Text | |
| | Smart meter transformer 2 (S/N) | Text | |
| | Smart meter transformer 3 (S/N) | Text | |

| | | | |
|---|---|---|---|
| | Smart meter line 1 (S/N) | Text | |
| | Smart meter line 2 (S/N) | Text | |
| | Smart meter line 3 (S/N) | Text | |
| | Capacity of TRF /Power rating (MVA) | Integer | |
| | Primary Voltage Transformer 1(kV) | Float | |
| | Secondary Voltage Transformer 1(kV) | Float | |
| | Primary Voltage Transformer 2(kV) | Float | |
| | Secondary Voltage Transformer 2(kV) | Float | |
| | Primary Voltage Transformer 3(kV) | Float | |
| | Secondary Voltage Transformer 3(kV) | Float | |
| | Transformer maintenance date | Date | |
| | Year of Commissioning | Date | |
| | Year of Manufacturer 1 | Date | |
| | Year of Manufacturer 2 | Date | |
| | Year of Manufacturer 3 | Date | |
| | Manufacturer 1 | Text | |
| | Manufacturer 2 | Text | |
| | Manufacturer 3 | Text | |
| | Country of Manufacture 1 | Text | |
| | Country of Manufacture 2 | | |
| | Country of Manufacture 3 | | |
| | MV switchgears | Text | Single busbar<br>double busbar |
| | Busbar | Text | conductor<br>tubular |
| | Auxilliaire supply | Text | transformer<br>earthing transformer |
| | Incoming feeder (Names & number) 1 | Text | |
| | Incoming feeder (Names & number) 2 | Text | |
| | Incoming feeder (Names & number) 3 | Text | |
| | Outgoing feeder (Names & number) 1 | Text | |
| | Outgoing feeder (Names & number) 2 | Text | |
| | Outgoing feeder (Names & number) 3 | Text | |
| | Switchgear maintenance date | Date | |

| | | | |
|---|---|---|---|
| | SCADA | Text | RTU |
| | | | PLC |
| | Optical fiber | Text | BG20 |
| | | | NPT |
| | ODF | Integer | |
| | ODF Used | Integer | |
| | ODF Users | Text | |
| | Transformer tap changer | Text | On load |
| | | | Off load |
| | Tap changer manufacturer | Text | |
| | Tap changer serial number | Text | |
| | Tap changer year of manufacturer | Date | |
| | Tap changer number of positions | Integer | |
| | Transformer mass oil | Float | |
| **Street light Pole** | **Attribute** | **Data type** | **Domain** |
| | Transformer name | Text | |
| | Feeder name | Text | |
| | Type of pole street light pole | Text | Steel |
| | | | Wooden |
| | | | Concrete |
| | Conductor type of street light | Text | Al twisted |
| | | | Cu |
| | Conductor size of street light | Text | 2*16mm2, |
| | | | 2*25mm2, |
| | | | 2*35mm2, |
| | | | 4*16mm2 |
| | | | 4*25mm2, |
| | | | 4*35mm2, |
| | | | 4*50mm2 |
| | | | 4*70mm2 |
| | | | 4*75mm2 |
| | | | 4*95mm2 |
| | | | 4*120mm2 |
| | | Text | 4*50mm2 |

| | | | |
|---|---|---|---|
| | | | 4*70mm2 |
| | | | 4*95mm2 |
| | | | 4*120mm2 |
| | Power of LED | Integer | |
| | Notes | Text | |
| | X | | |
| | Y | | |
| **Capacitor bank / DMS** | **Attribute** | **Data type** | **Domain** |
| | Name | Text | |
| | Id | Float | |
| | Phase | Text | Single phase |
| | | | Bi-phase |
| | | | Three phase |
| | Rated kV | Float | |
| | Base kV | Float | |
| | Connection Type | | |
| | Nominal kVAR1 | Integer | |
| | Nominal kVAR2 | Integer | |
| | Nominal kVAR3 | Integer | |
| **Regulator tap change** | **Attribute** | **Data type** | **Domain** |
| | Name | Text | |
| | ID | Float | |
| | Phase | Text | Single phase |
| | | | Bi-phase |
| | | | Three phase |
| | Rated KV | Float | |
| | Base KV | Float | |
| | Rated Amps | Float | |
| | Connection Type | | |
| | Delta Open Phase | Text | |
| | Standard Rotation | Text | |
| | Regulation Type | Text | |
| | Bidirectional | Text | |

| | | | |
|---|---|---|---|
| | Control Phase | Text | |
| | Desired Voltage | Text | |
| | Tap Side | Text | |
| | Initial Tap1 | Text | |
| | Initial Tap2 | Text | |
| | Initial Tap3 | Text | |
| | Bandwidth | Text | |

# ANNEX 2: CHECKLISTS FOR NETWORK DISTRIBUTION MAINTENANCE

## NETWORK MAINTENANCE CHECKLISTS

- INSPECTION CHECK LIST FOR MV CONCRETE POLES
- INSPECTION CHECK LIST FOR MV STEEL POLES
- INSPECTION CHECK LIST FOR MV PYLON/LATTICED TOWERS
- INSPECTION CHECK LIST FOR MV WOODEN POLES
- INSPECTION CHECK LIST FOR MV CONDUCTORS
- INSPECTION CHECK LIST FOR MV/LV DISTRIBUTION TRANSFORMERS
- INSPECTION CHECK LIST FOR DISCONNECT SWITCH, DROP OUT, FUSE, AUTO-RECLOSER
- LV DISTRIBUTION LINE

| Rwanda Energy Group REG | Form Name: …….. | Form Nº: …….. |
|---|---|---|

## INSPECTION CHECKLIST FOR MV CONCRETE POLES

**Name of Main feeder/Location: ……T-Off Location: ……..**

**Size and type of Conductor: ……Length of the feeder…….**

**REG Branch: ……**

| Sn | Pole Number/ Identification | Length of poles | Apparent defects (Broken, cracked, Steel bars exposed...) | Foundation status (Cracks broken, etc.) | Pole Straightness, bending | Stay wire status (Normal position, Loosened, Broken | Insulators and accessories (Broken or cracked, Missing disc, Not well fitted, Not aligned, Burnt…) | Cross arm apparent defects (Rusted, Not well positioned, loose of bolts & nuts, Rust, Bent) | Surge arrestors (Loose connection, Not grounded …) | Other comments/ recommendations |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |

**DATA COLLECTED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

**APPROVED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| Rwanda Energy Group REG | **Form Name: ……..** | **Form Nº:** …….…… |
|---|---|---|

## INSPECTION CHECKLIST FOR MV STEEL POLES

**Name of Main feeder/Location: ……..…T-Off Location: ……**

**Size and type of Conductor: ……Length of the feeder……..REG Branch: ……**

| Sn | Pole Number/Identification | Pole/Type Length (S140, S190, S255, S315…) | Apparent, defects (Rusted, sheltered by bees and covered by creepers etc.) | Pole Foundation status (Cracks, broken, etc.) | Pole Straightness, bending | Stay wire status (Normal position, Loosened, Broken) | Cross arm apparent defects (Rusted, Not well positioned, loose of bolts & nuts, Bent) | Status of Insulators and accessories (Broken or cracked, Missing disc, Not well fitted, Not aligned, Burnt, etc.) | Other Comment/ Recommendations |
|---|---|---|---|---|---|---|---|---|---|
| **1** | | | | | | | | | |
| **2** | | | | | | | | | |
| **..** | | | | | | | | | |

**DATA COLLECTED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

**APROVED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| Rwanda Energy Group REG | **Form Name: ……...** | **Form Nº:** …….....…. |
|---|---|---|

## INSPECTION CHECKLIST FOR MV PYLON/Latticed towers

**Name of Main feeder/Location: ……T-Off Location: ……**

**Size and type of Conductor: ……Length of the feeder……REG Branch: …….**

| Sn | Pylon Number/ Identification | Pole//Type Length | Apparent defects (vandalized, bird nest, steel bar exposed, cross arms stolen, rusted, covered by creepers, loose of bolts….) | Pole Foundation status | Pole Straightness, bending | Shield wire status (Not installed not grounded) | Status of Insulators and accessories (Broken or cracked, Missing disc, Not well fitted, Not aligned, Burnt, etc.) | Surge arrestors (loose of connection, not grounded….) | Other Comment / Recommendations |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |

**DATA COLLECTED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

**APPROVED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

| Rwanda Energy Group REG | **Form Name: ……..** | **Form Nº:** …….. |
|---|---|---|

## INSPECTION CHECKLIST FOR MV WOODEN POLES

**Name of Main feeder/Location: …….....……T-Off Location.....…**

**Size and type of Conductor: …….....Length of the feeder……REG Branch: ……**

| Sn | Pole Number/ Identification | Pole/Type Length (S140,S190 S255,S315, Etc.) | Apparent defects (Broken, Cracks, Rotten, etc.) | Pole Footing status | Pole Straightness, bending | Stay wire status(Normal position, Loosened, Broken) | Cross arm apparent defects ( Rusted, Not well positioned, loose of bolts & nuts, Bent) | Status of Insulators and accessories (Broken or cracked, Missing disc, Not well fitted, Not aligned, Burnt, etc.) | Other Comment/ Recommendations |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |

**DATA COLLECTED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

**APROVED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| Rwanda Energy Group REG | Form Name: …….. | Form Nº: …….. |
|---|---|---|

## INSPECTION CHECKLIST FOR MV CONDUCTORS

**Length of MV Feeder: .....Name of MV Feeder: .....Location: ……**

**Size and type of Conductor: .....REG Branch name: .....**

| Sn | Conductor Location | Apparent defects (Strands Broken, bird caging, etc.) | Number of Junctions | Conductor on insulator status (Not well fitted, Loosen, | Status of jumpers (Not well fitted, Loosen, | Status of conductor /internal Clearances (Normal, Below normal) | Status of Conductor to ground/external clearance (Normal, Below normal) | Right of way (Bush cleared, bush around lines, bush below lines,) | Other Comment/ Recommendations |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |

**DATA COLLECTED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

**APROVED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| Rwanda Energy Group REG | Form Name: …….. | Form Nº: …….. |
|---|---|---|

## INSPECTION CHECKLIST FOR MV/LV DISTRIBUTION TRANSFORMER

**Substation / Transformer Name: …… ……**
**Transformer Capacity & Type: ……kVA, / ……kV, (Indoor or Outdoor)**
**Transformer Serial / Number: ……Name ……..**
**Manufacturer & Year of Manufacture: ……..... Year of Installation: ……**

**REG Branch /Location……..**

| | Item to be inspected | Good | Fair | Bad | Statement | Action to be taken | Date of Action |
|---|---|---|---|---|---|---|---|
| **A** | **CHECK FOR PHYSICAL CONDITION** | | | | | | |
| **1** | General upkeep and overall cleanliness of substation | | | | | | |
| **2** | Fencing & gate of the substation/ doors & Windows | | | | | | |
| **3** | Danger plate | | | | | | |
| **4** | Status of platform or H-pole (for outdoor installed transformer) checked | | | | | | |
| **5** | Inside & Outside lighting | | | | | | |
| **6** | Condition of insulators/ Condition of MV&LV bushings checked | | | | | | |
| **7** | Condition of conductors | | | | | | |
| **8** | Condition of cables, | | | | | | |
| **9** | Cable Lugs | | | | | | |
| **10** | Arching Horn | | | | | | |
| **11** | Radiator | | | | | | |
| **12** | MT terminals | | | | | | |
| **13** | LV terminals | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **14** | Oil level in the conservator tank checked | | | | | | |
| **15** | Silica Gel condition checked/described by the manufacturer | | | | | | |
| **16** | Oil/winding temperature checked | | | | | | |
| **17** | The status of LV distribution panel/feeders pillar checked | | | | | | |
| **18** | The status of cable between transformer and LV distribution panel checked | | | | | | |
| | | Non-Existing | Existing | Insignificant | | | |
| **19** | Oil leakages checked | | | | | | |
| **20** | Breather condition checked | | | | | | |
| **21** | Others | | | | | | |

| **B** | **TRANSFORMER PROTECTION** | **Ref REG reticulation standards** | **Statement/Existing conditions/values/sizes** | **Action to be taken** | **Date of Action** |
|---|---|---|---|---|---|
| 1 | MV fuses properly installed and sized | | | | |
| 2 | Check if earthing system is proper & intact | | | | |
| 3 | LV CB/fuses properly installed and sized | | | | |
| 4 | MV surge arrestors properly installed and grounded | | | | |
| **C** | **TESTS & MEASUREMENT** | **Reference REG reticulation standards** | **Actual measured values** | **Action to be taken** | **Date of Action** |

| Rwanda Energy Group REG | **Form Name: ……..** | **Form Nº:** …….…… |
|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | Insulation Resistance value | Phases HV-HV<br>Phases LV-LV<br>HV - LV<br>HV - Tank<br>LV - Tank | | | |
| 2 | Load (Amps) | Peak Hours | A-phase<br>B-phase<br>C-phase | | |
| | | Off-Peak Hours | A-phase<br>B-phase<br>C-phase | | |
| 3 | Secondary Voltage measured | | Phase1 –phase2<br>Phase1 –phase3<br>Phase2 –phase3<br>Phases1,2,3 - N | | |
| 4 | Earth resistance measurement | MV: 5 Ohm<br>LV:10 Ohm | | | |
| 5 | Turns ratio tested/ref manufacturer indications | ▪ Tap 1:<br>▪ Tap 2:<br>▪ Tap 3:<br>▪ Tap 4:<br>▪ Tap 5 | | | |
| 6 | Oil BDV tested/ref Oil technical description | 15 kV | | | |
| | | 30 kV | | | |

| Rwanda Energy Group REG | Form Name: …….. | Form Nº: …….. |
|---|---|---|

| D | OVERHAUL MAINTENANCE | Last/previous action | Statement/Existing conditions | Action to be taken | Date of Action |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Dissolved gases analysis | | | | |
| 2 | Oil regeneration/purification | | | | |
| 3 | Servicing HV/LV bushings | | | | |

| DATA COLLECTED BY: | | |
|---|---|---|
| **NAMES** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| **APPROVED BY:** | | |
| **NAMES** | **POSITION** | **SIGNATURE AND DATE** |
| | | |

| Rwanda Energy Group REG | **Form Name: ……...** | **Form Nº:** …….....…. |
|---|---|---|

## INSPECTION CHECKLIST FOR DISCONNECT SWITCH, DROP OUT FUSE, AUTO RECLOSER

**Name of MV Feeder: …… …….. Length of MV Feeder: ……**

**Size and type of Conductor: …… ……**

| Sn | Name of switching/protecting equipment (either disconnect switch, dropout or auto-recloser) | Switching/ protecting equipment location or identification | Disconnector/ support defects (Rusted, Not well positioned, loose of bolts & nuts, Bent) | Cable terminations and connections (Dirty, loosen, etc…) | Status of Switch operating mechanism, blades & contacts, fuse clips (Not well positioned, loose of bolts & nuts, Bent) | Status of Insulators (Broken or cracked, Not aligned, Burnt, etc.) | Status of fuse (Normal, bypassed, defected, etc.) | Status of surge arrestor (Normal, defected, Not well positioned, not earthed, etc) | Other Comment/ Recommendations |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |

**DATA COLLECTED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |

**APPROVED BY:**

| NAMES | POSITION | SIGNATURE AND DATE |
|---|---|---|
| | | |
| | | |

| Rwanda Energy Group REG | Form Name: …….. | Form Nº: …….. |
|---|---|---|

## INSPECTION CHECKLIST FOR LV DISTRIBUTION LINES

**Transformer Name: ……. Name of Outgoing LV Feeder: ……**

**Size & Type of Main Cable/Conductor: …… Number of Poles per Type: Wooden.....Concrete ……. Steel…**

| Sn | Activities | Yes or No | Remarks/Observations | Date of Action |
|---|---|---|---|---|
| **1** | Status of conductor/cable checked | | | |
| **2** | Status of poles checked | | | |
| **3** | Status of pole foundations | | | |
| **4** | Status of stay wires checked | | | |
| **5** | The voltage at the farthest client from transformer measured | | | |
| **6** | All connections checked | | | |
| **7** | All line hardware (clamps, stud bolts, insulators, etc) checked | | | |

| | | | | |
|---|---|---|---|---|
| **8** | Trees and bushes cleared | | | |
| **9** | The size of underground cable from LV distribution panel to the first pole of LV feeders checked | | | |
| **10** | Earth resistance for first LV pole | | | |
| **11** | Balance of three phase voltages | | | |
| **12** | Rotten poles | | | |
| **13** | Cable clearance to ground checked | | | |
| **Check Value of Voltage, Current and Earth resistance** | | | | |
| | **Activities** | **Yes** | **Remarks/Observations** | **Recommendation** |
| **14** | Voltage (V):<br>▪ Phase to phase<br>Ph1–Ph2; Ph1–Ph3; Ph2– Ph3<br>▪ Phased to neutral<br>Ph1 –N; Ph2 – N; Ph3 – N | | | Voltage tolerance -10% to +5% of rated value |
| **15** | Load (A):<br>Each Phase: Ph1, Ph2, Ph3 | | | 95% of rated current |
| **16** | Earth resistance | | | Acceptable value **≤ 5 Ω** |
| **17** | Illegal extensions and connections checked | | | Disconnect illegal connection |

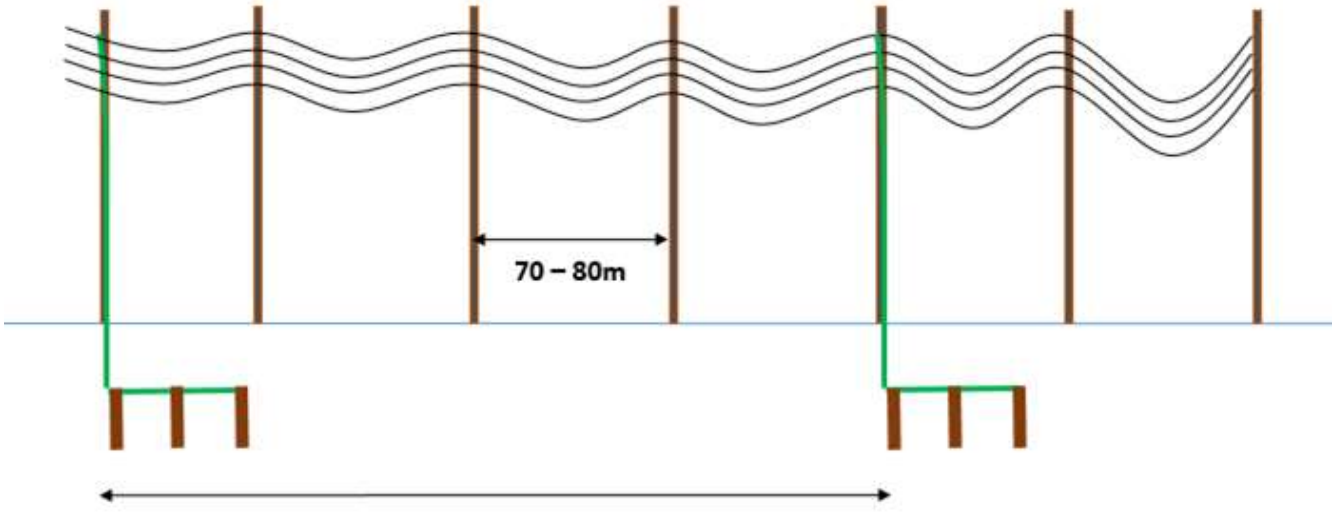
| | | |
|---|---|---|
| Rwanda Energy Group REG | **Form Name: ……...** | **Form Nº:** …….....…. |

| **DATA COLLECTED BY:** | | |
|---|---|---|
| **NAMES** | **POSITION** | **SIGNATURE AND DATE** |
| | | |
| **APPROVED BY:** | | |
| **NAMES** | **POSITION** | **SIGNATURE AND DATE** |
| | | |

# ANNEX 3: STANDARDS DRAWINGS

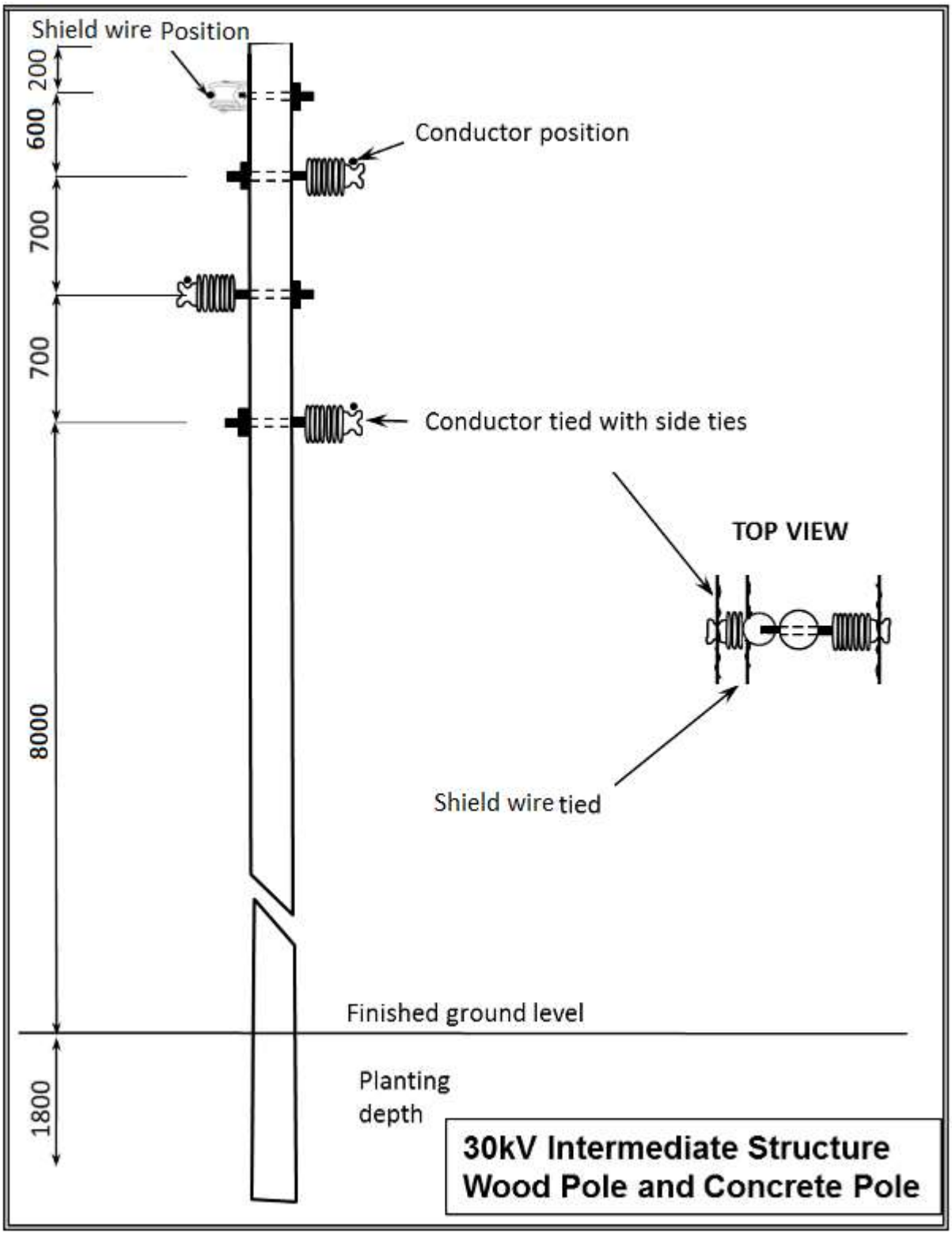
# I. MEDIUM VOLTAGE STRUCTURES

## MEDIUM VOLTAGE CONSTRUCTION PHILOSOPHY

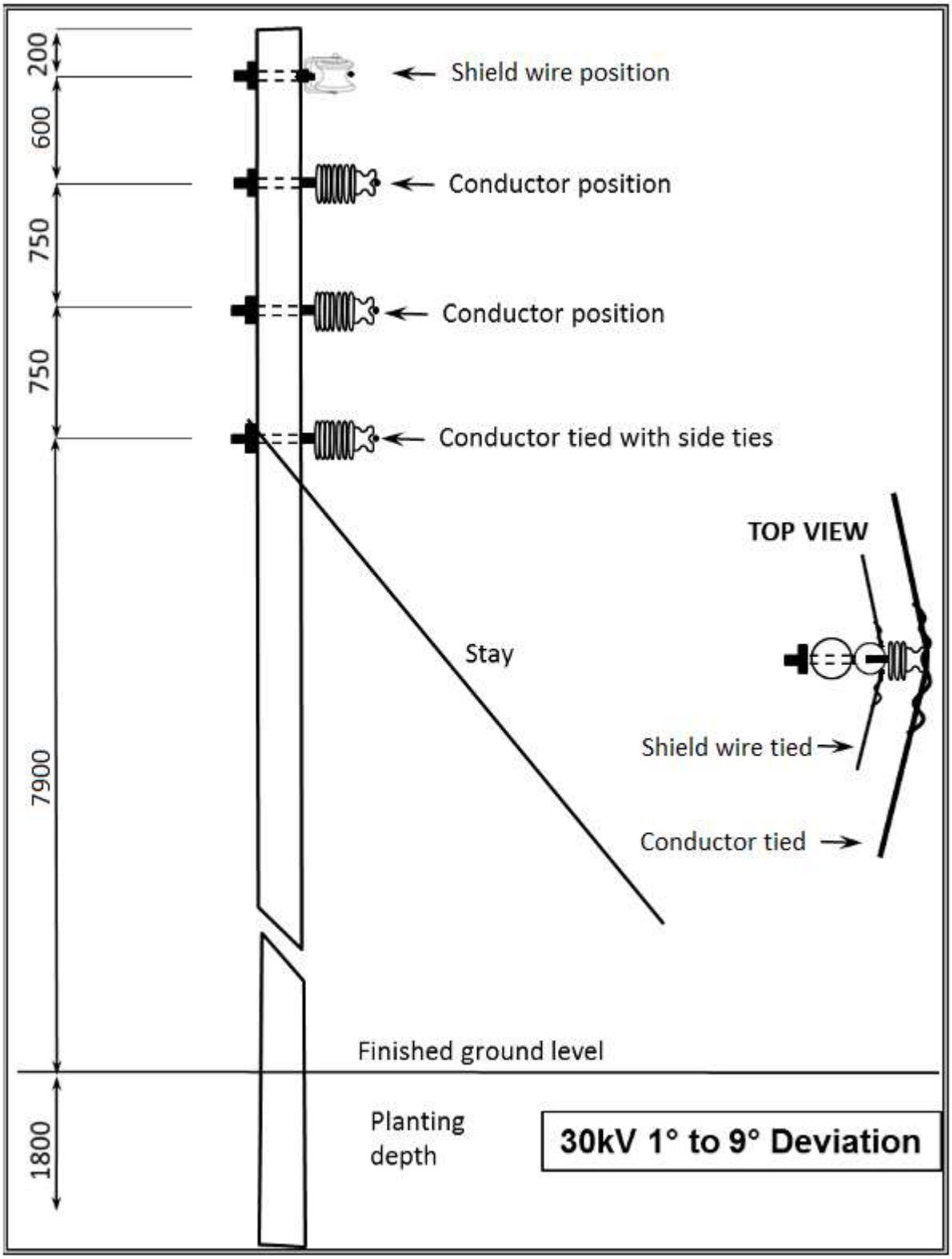



**The shield wire is earthed every 1st and terminal Pole, every steel Pole and after every 4 spans of consecutive Wooden and concrete poles**

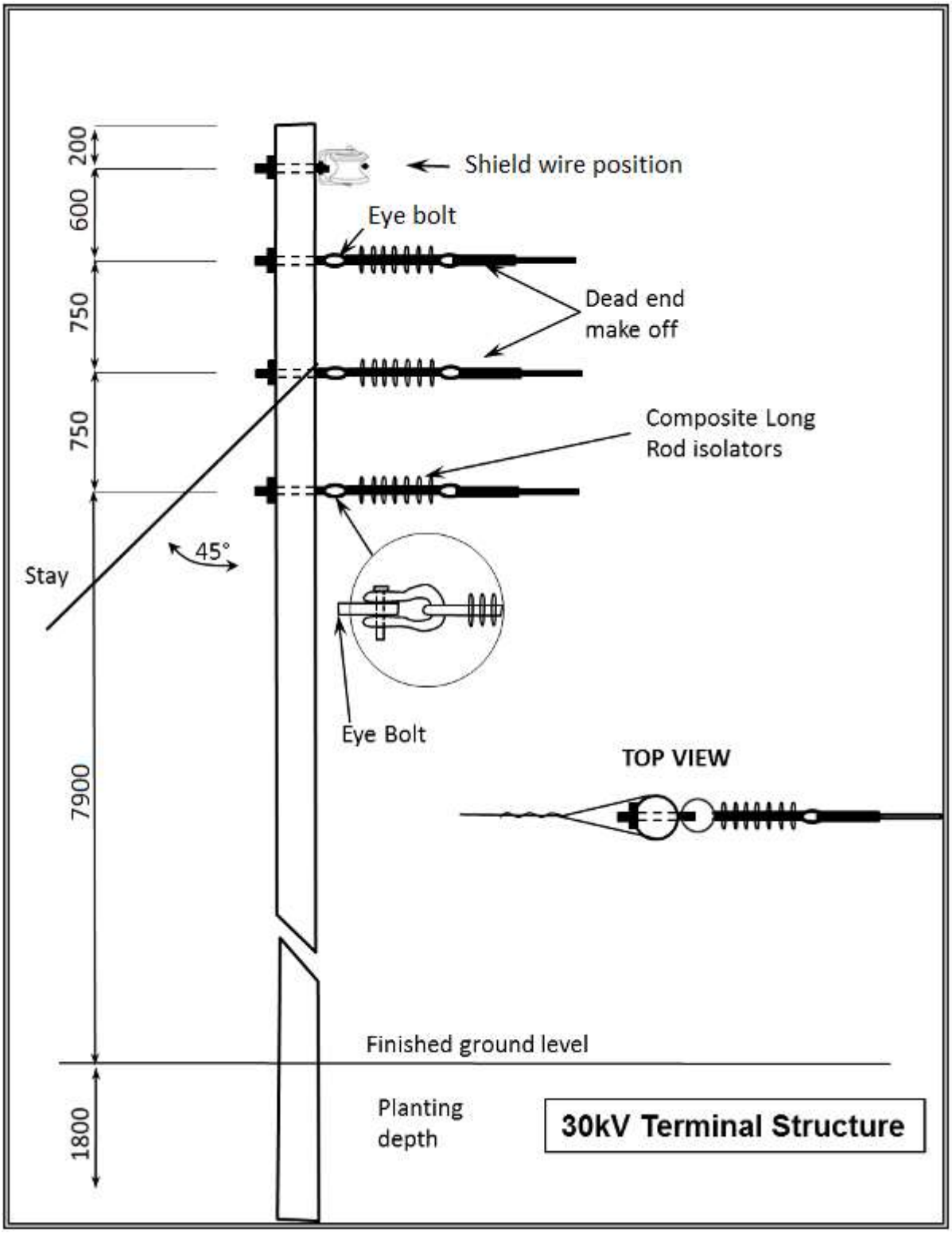
## STRUCTURE TYPE A: 30kV SUSPENSION STRUCTURE



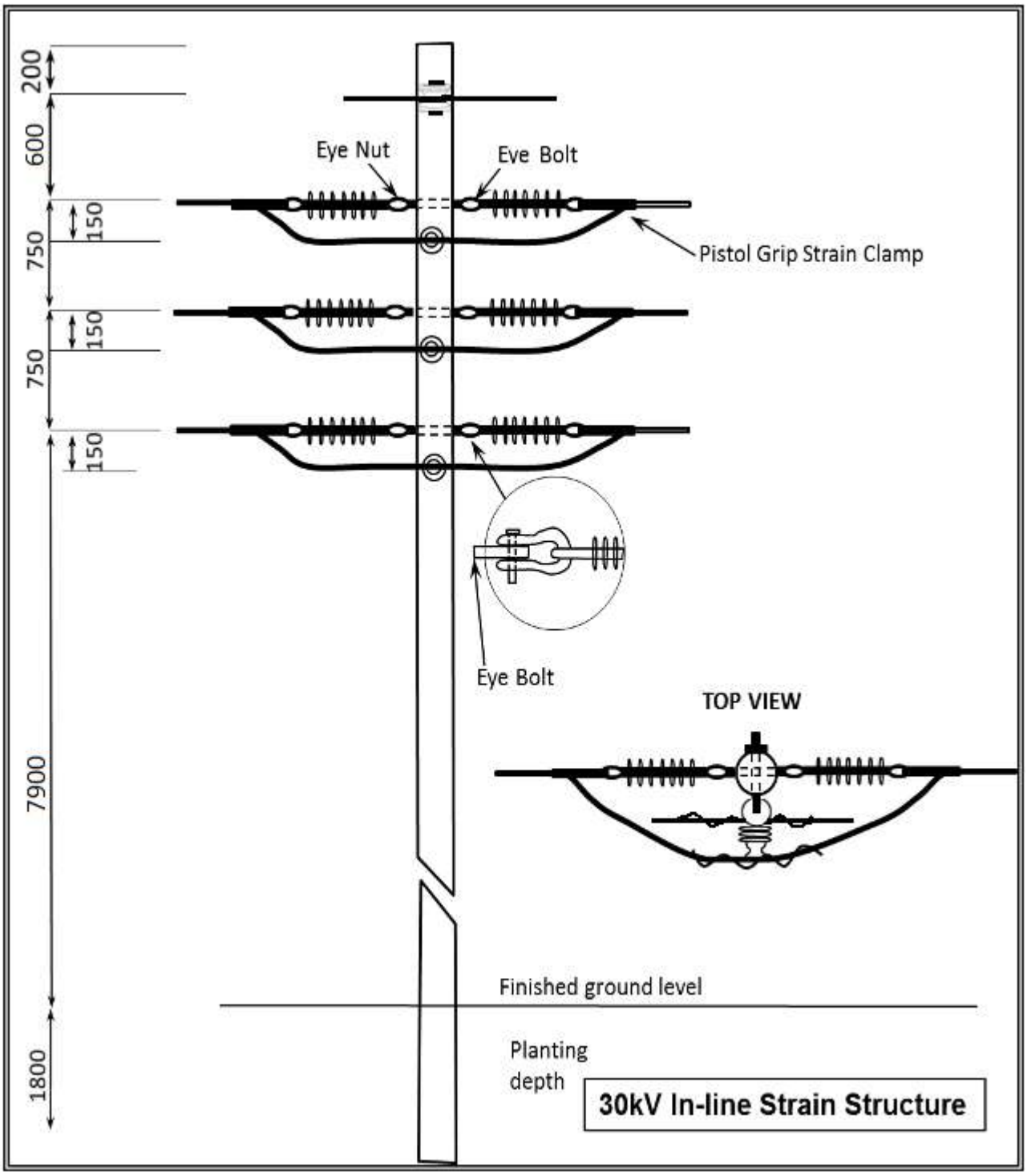
## STRUCTURE TYPE B: 30KV 1º TO 9º DEVIATION



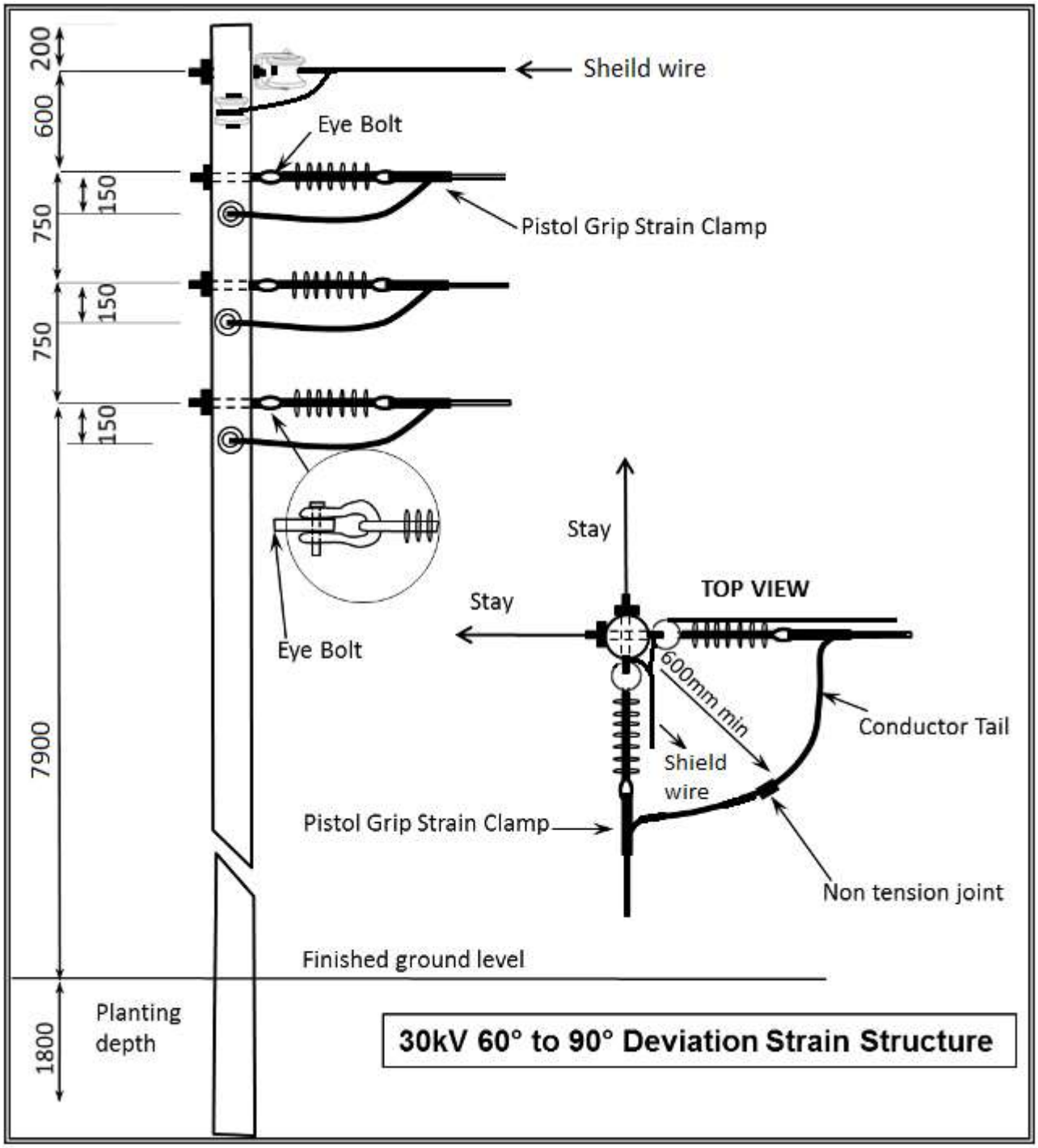
## STRUCTURE TYPE C: 30KV TERMINATION STRUCTURE



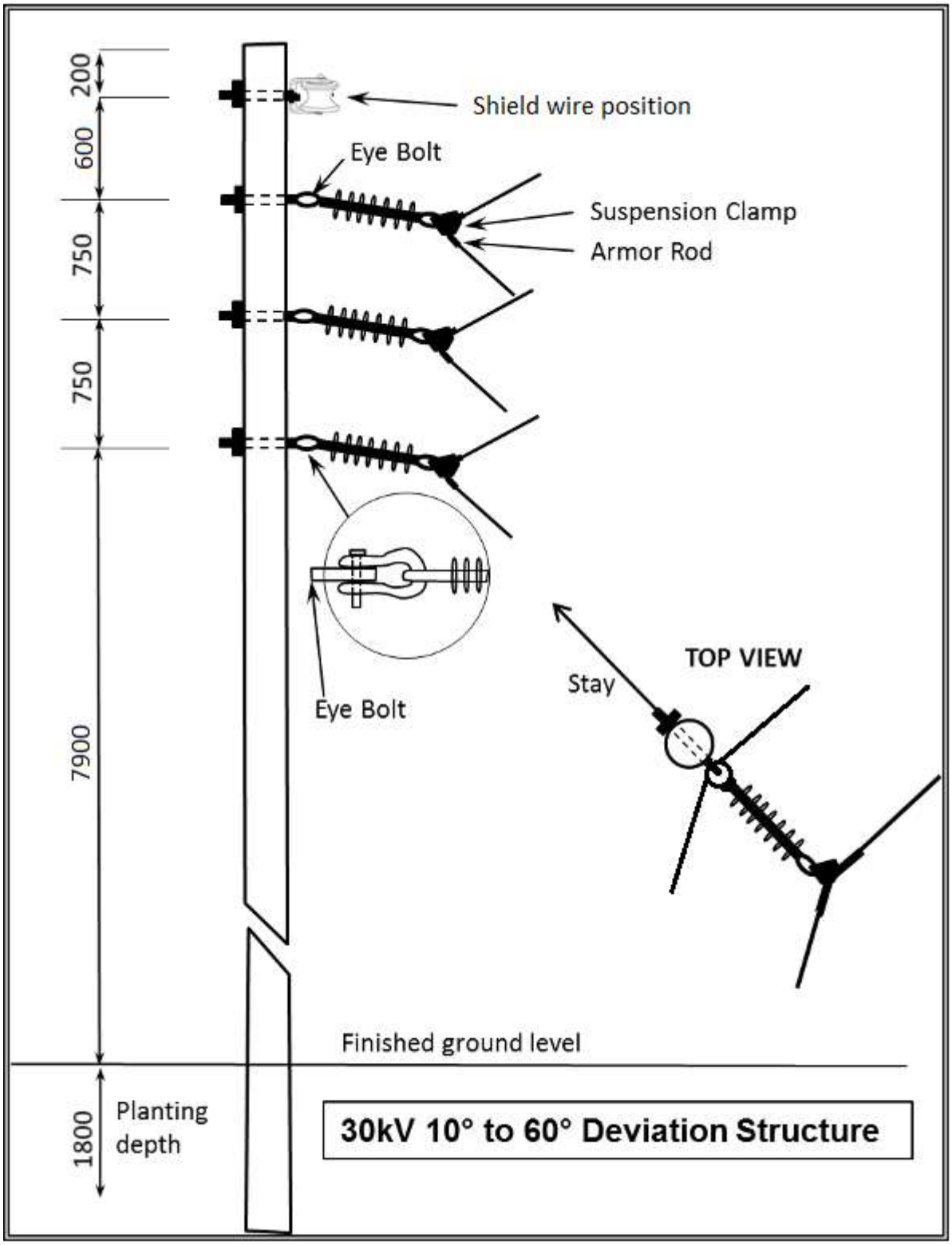
## STRUCTURE TYPE D: IN-LINE STRAIN STRUCTURE



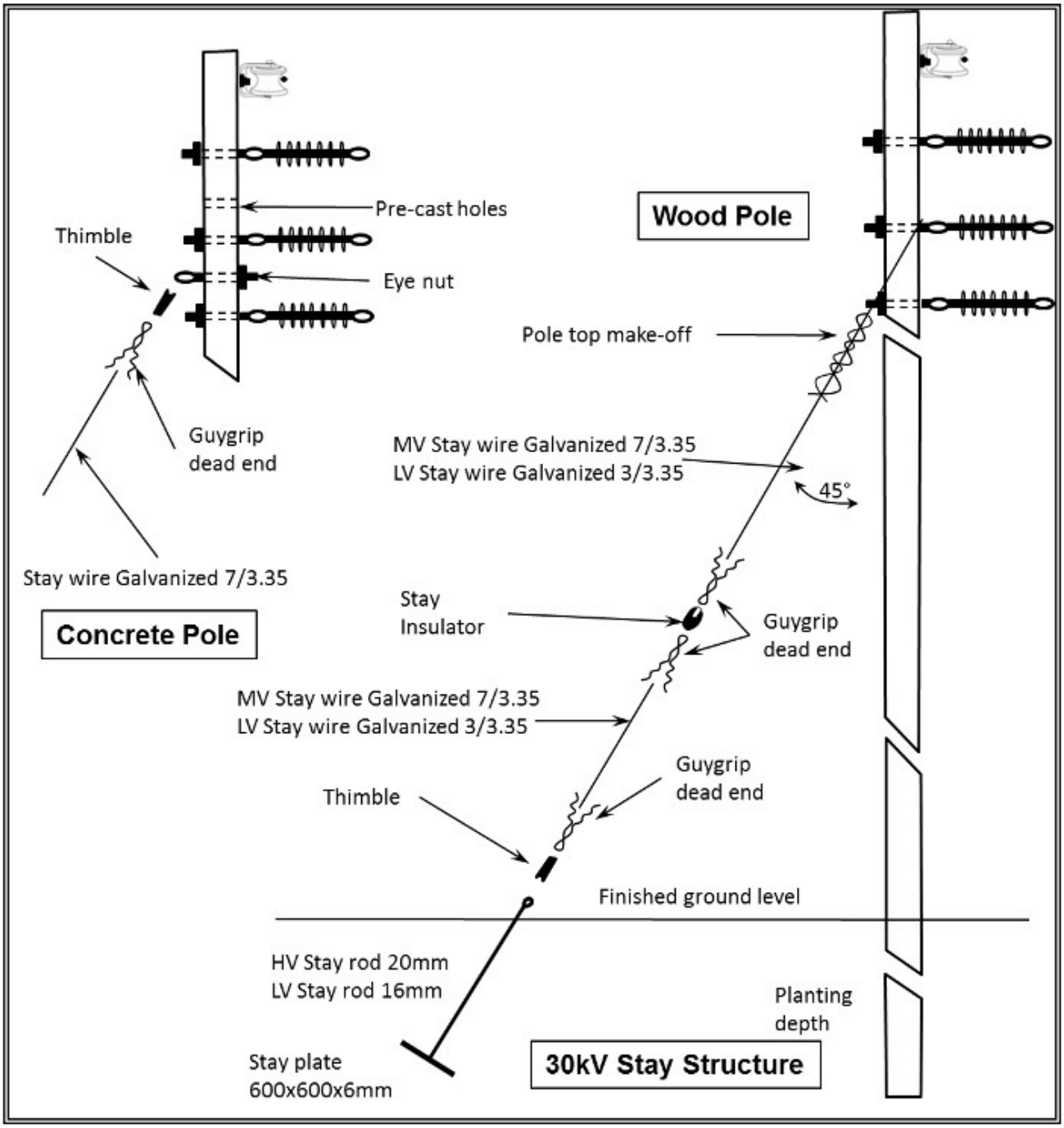
## STRUCTURE TYPE E: 30º - 90º DEVIATION STRUCTURE



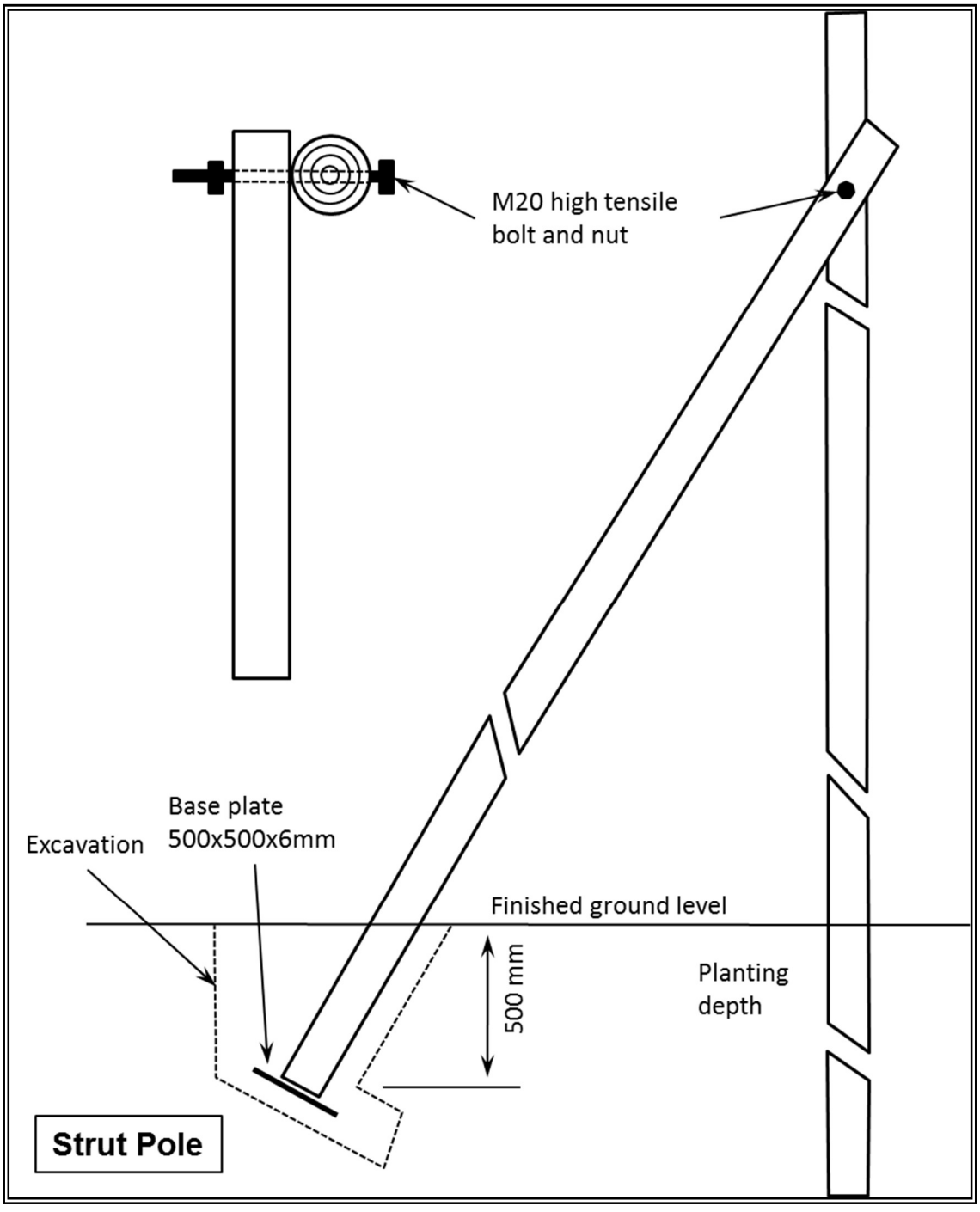
## STRUCTURE TYPE F: 10º TO 60º DEVIATION STRUCTURE.



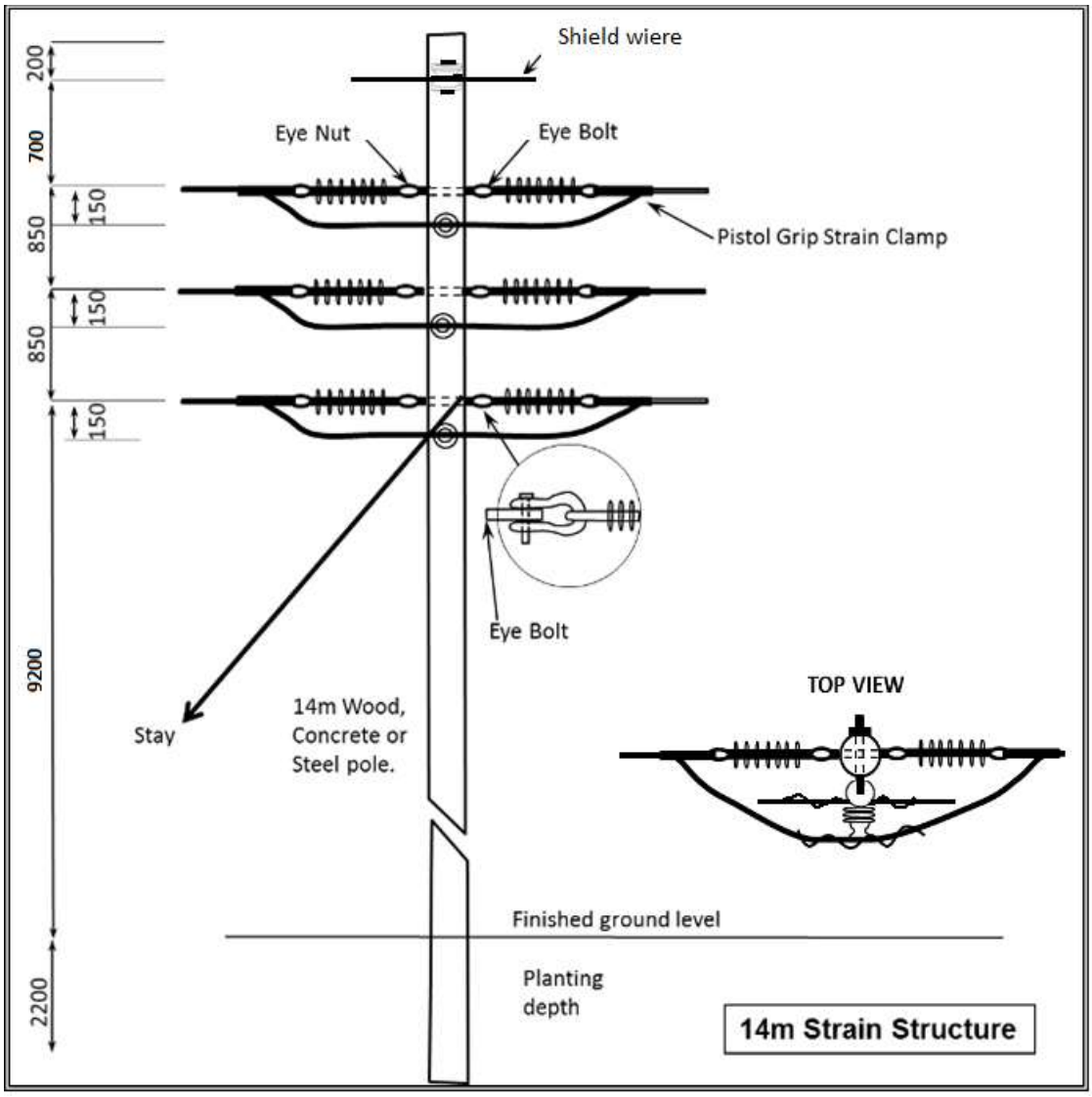
## STRUCTURE TYPE G: MV STAY STRUCTURE



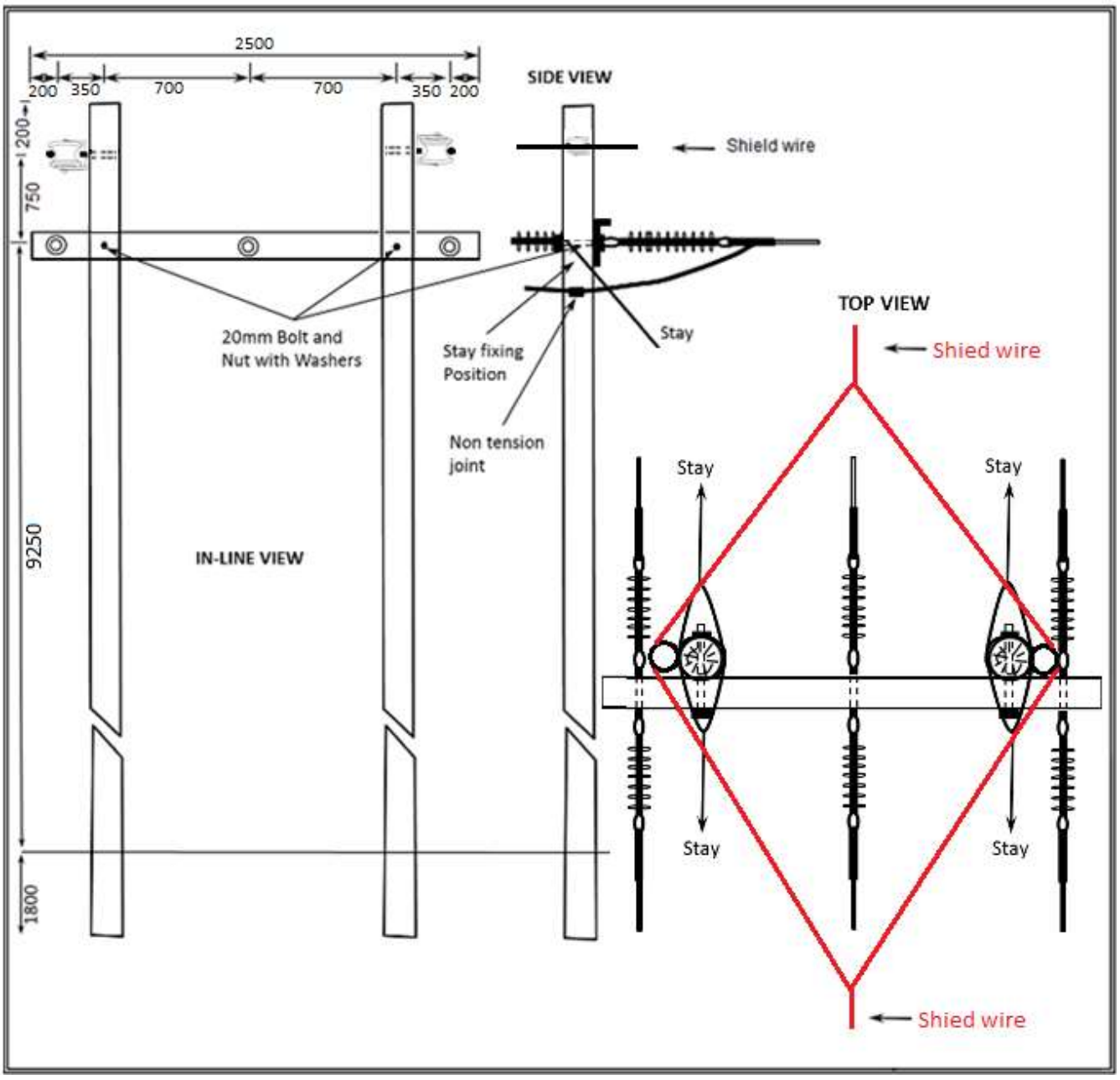
## STRUCTURE TYPE H: STRUT POLE STRUCTURE



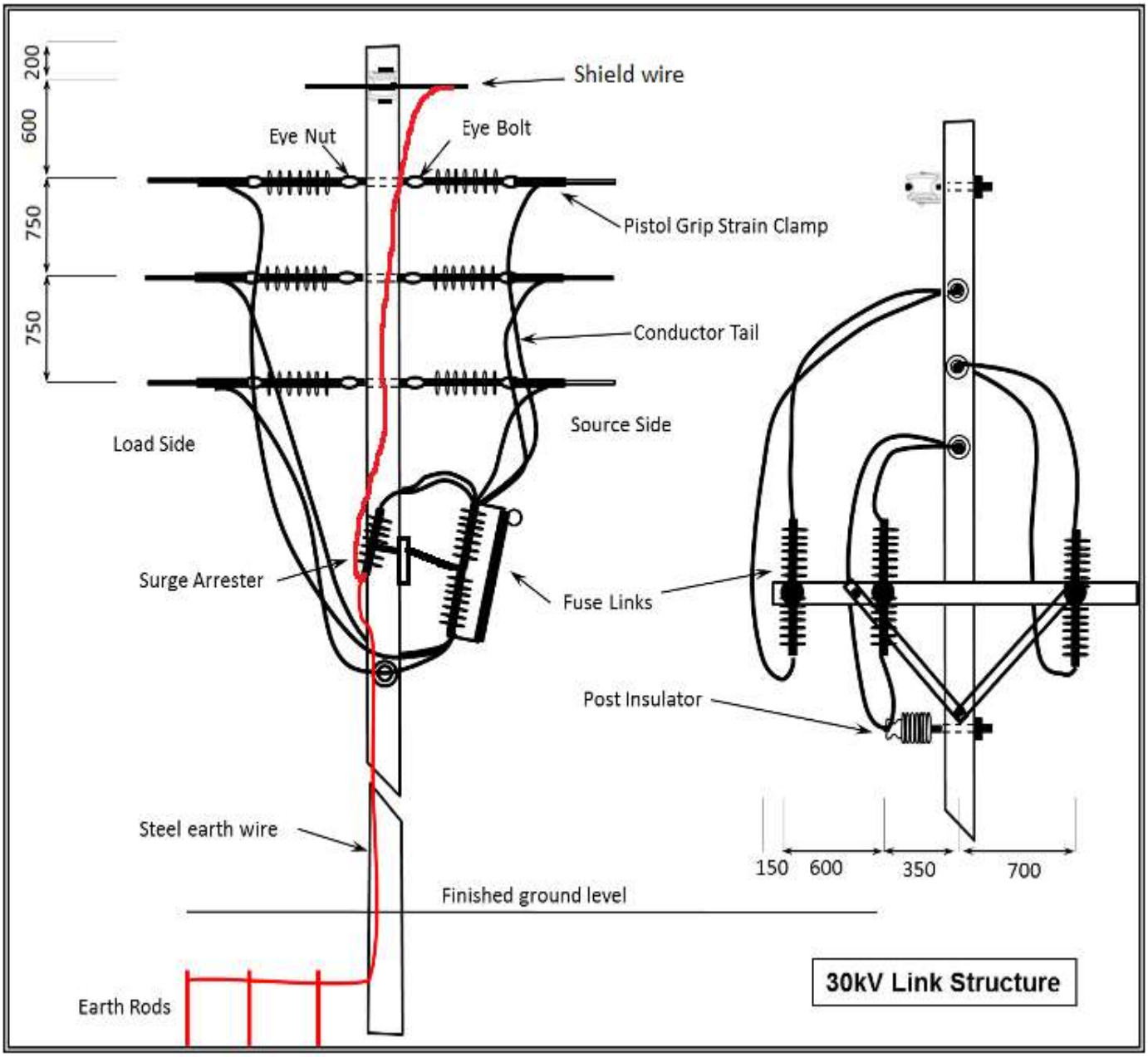
## STRUCTURE TYPE I: 14M POLE STRUCTURE



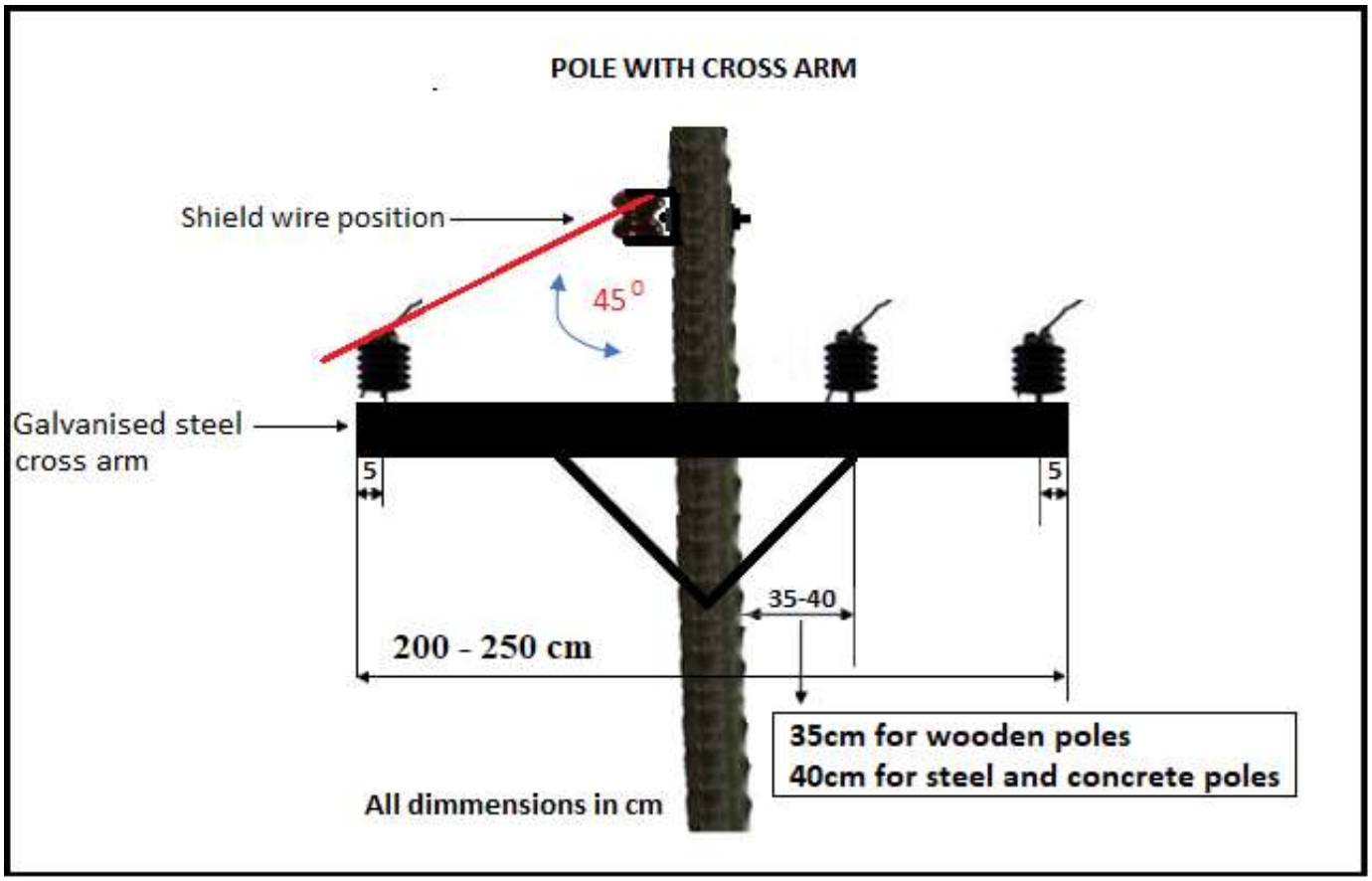
## STRUCTURE TYPE J: H-POLE STRUCTURE



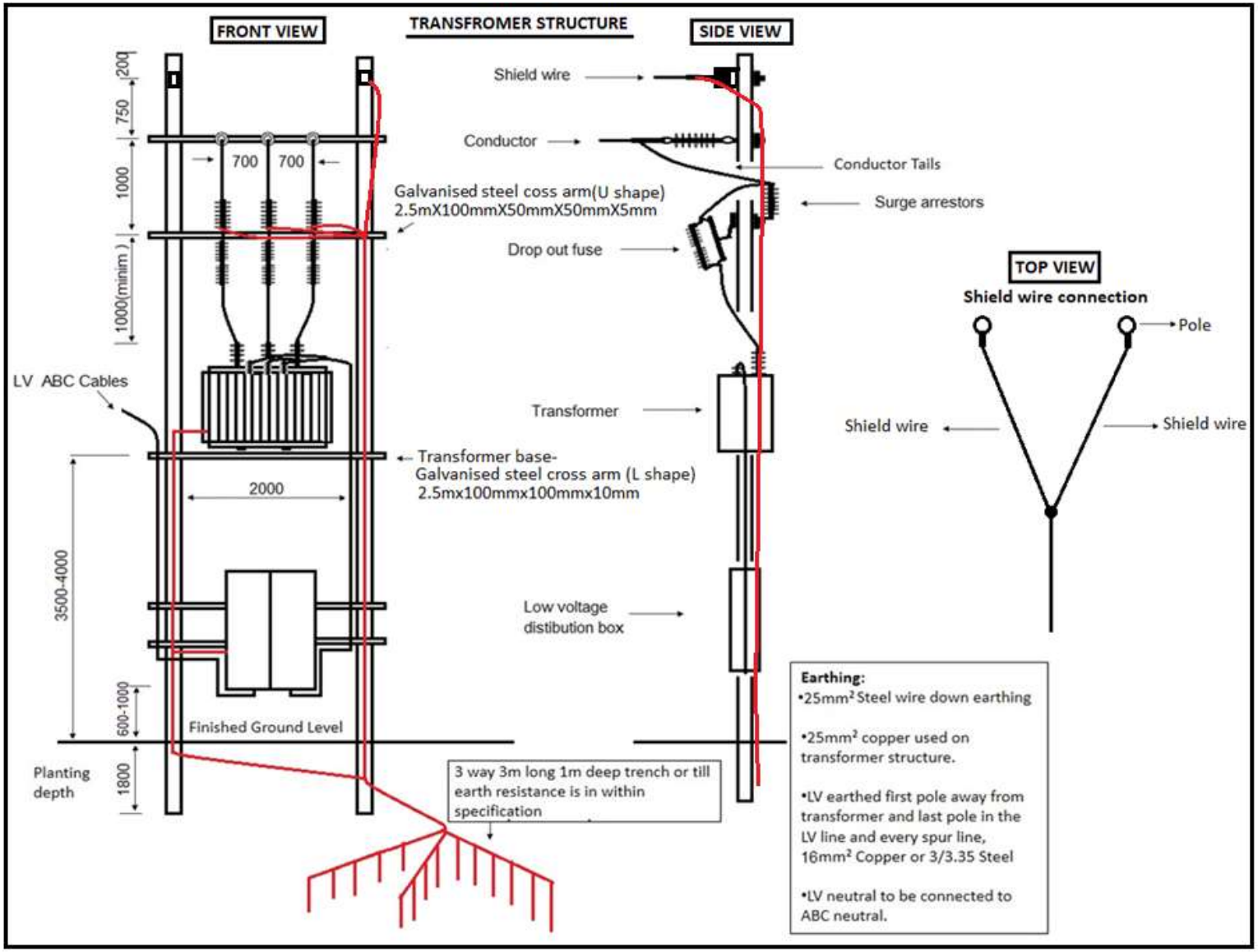
## STRUCTURE TYPE K: LINK STRUCTURE

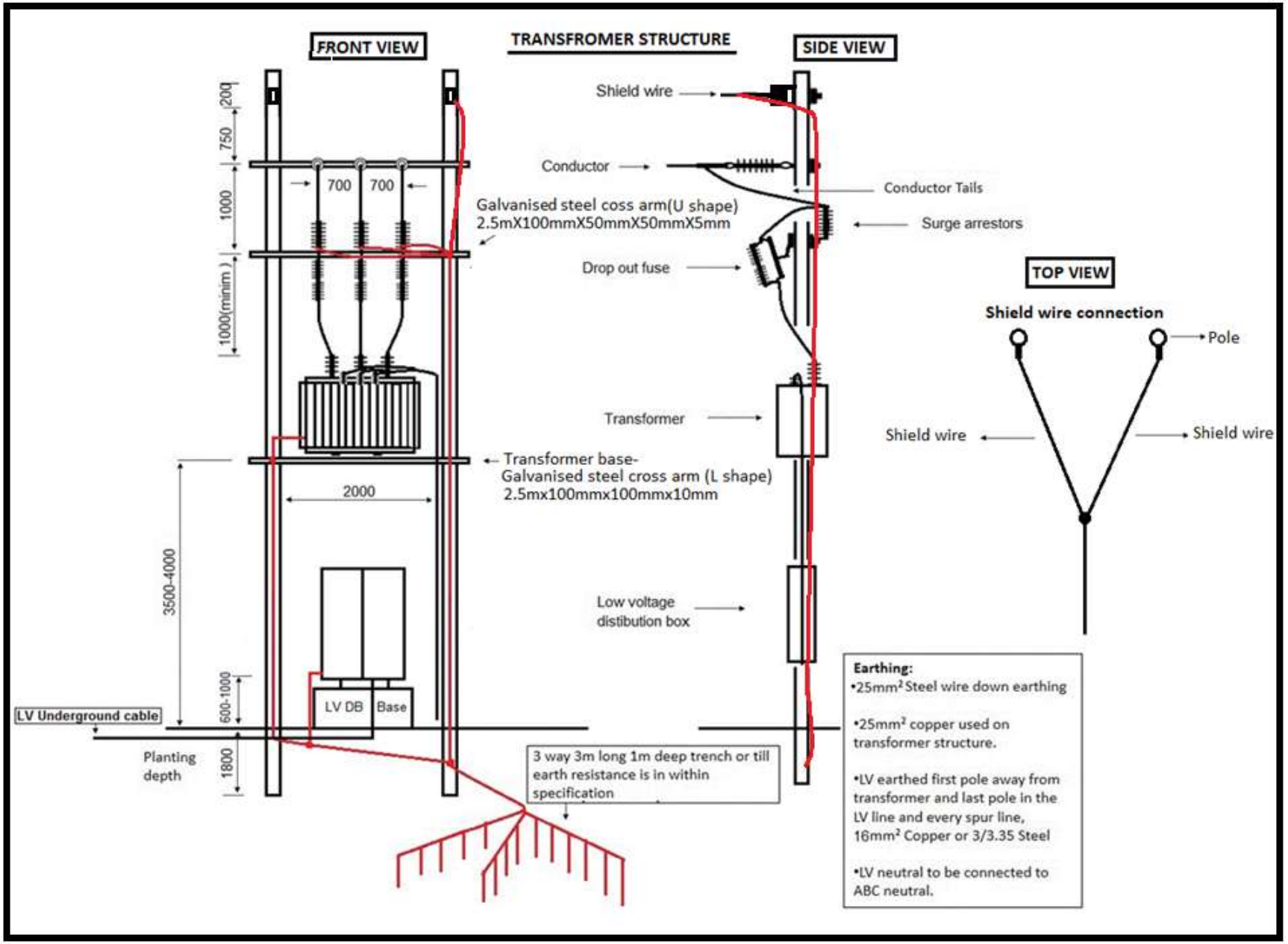


## STRUCTURE TYPE L: SINGLE POLE WITH CROSS ARM



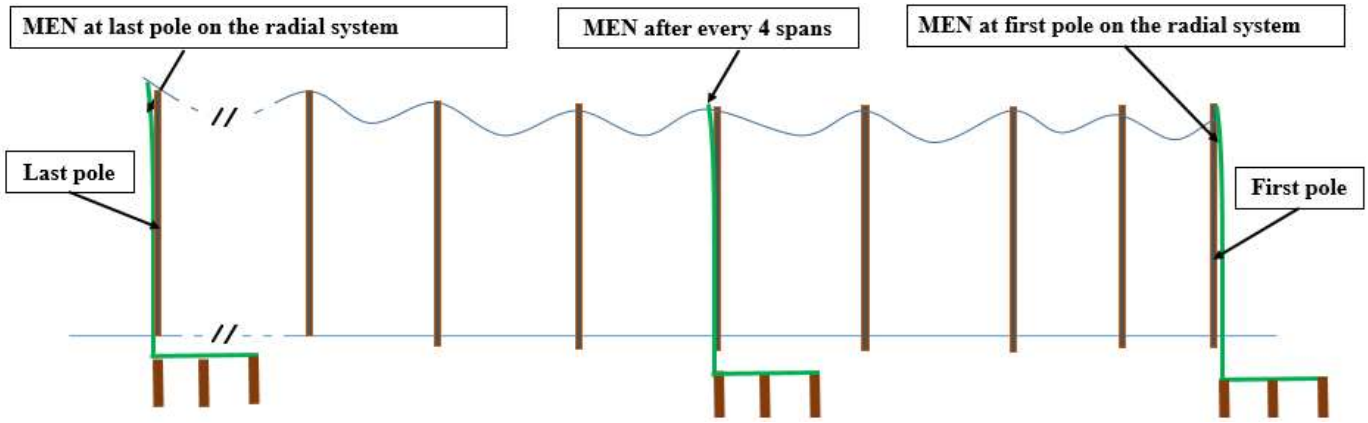
# STRUCTURE TYPE M: TRANSFORMER STRUCTURE



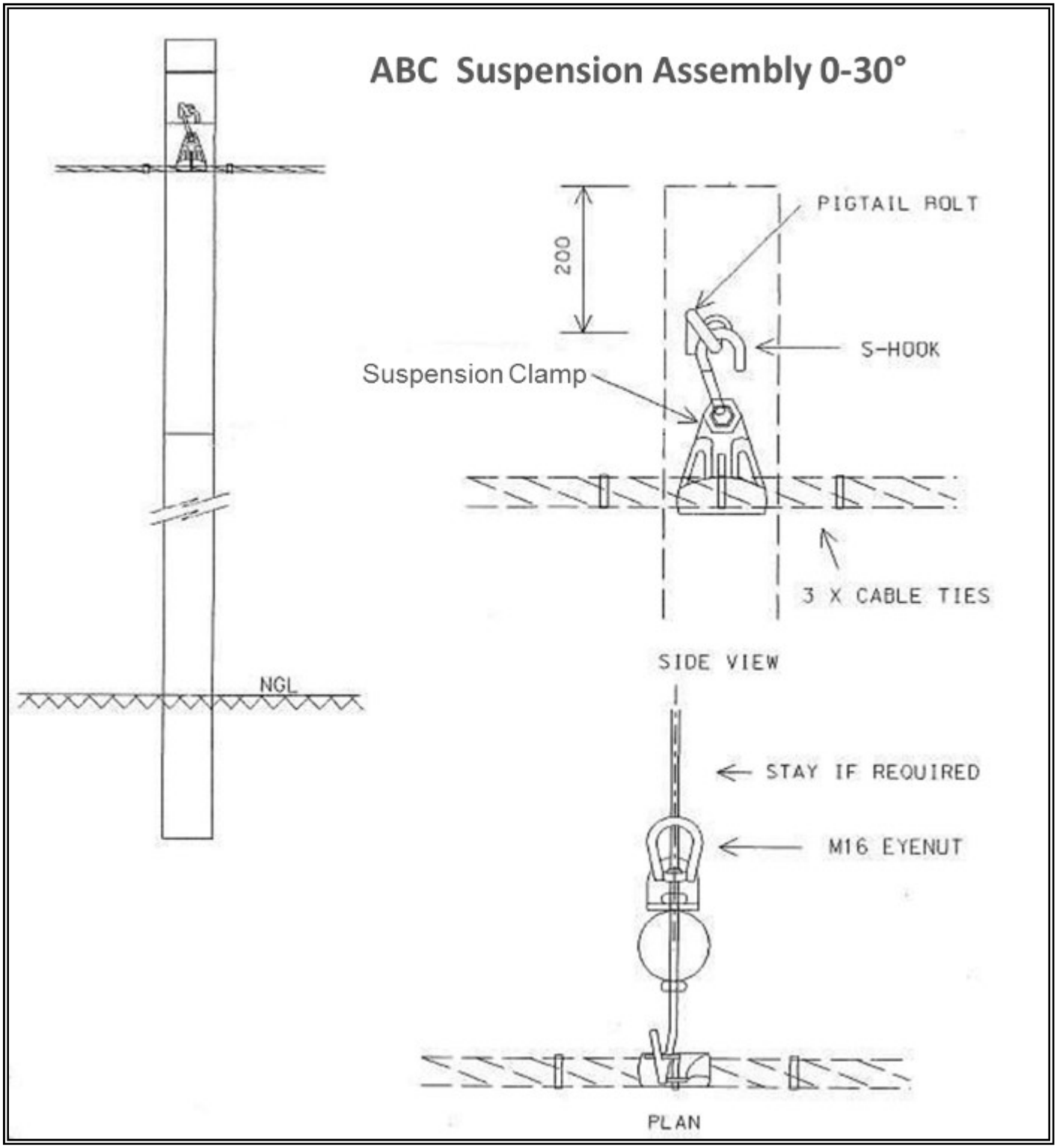

FRONT VIEW
TRANSFROMER STRUCTURE
SIDE VIEW
200
750
1000
1000(minim.)
700
700
Shield wire
Conductor
Conductor Tails
Galvanised steel coss arm(U shape)
2.5mX100mmX50mmX50mmX5mm
Surge arrestors
Drop out fuse
TOP VIEW
Shield wire connection
Pole
Transformer
Shield wire
Shield wire
Transformer base-
Galvanised steel cross arm (L shape)
2.5mx100mmx100mmx10mm
2000
3500-4000
Low voltage
distibution box
600-1000
LV DB
Base
LV Underground cable
Planting
depth
1800
3 way 3m long 1m deep trench or till earth resistance is in within specification
Earthing:
•25mm² Steel wire down earthing
•25mm² copper used on transformer structure.
•LV earthed first pole away from transformer and last pole in the LV line and every spur line, 16mm² Copper or 3/3.35 Steel
•LV neutral to be connected to ABC neutral.

## II. LOW VOLTAGE ASSEMBLIES

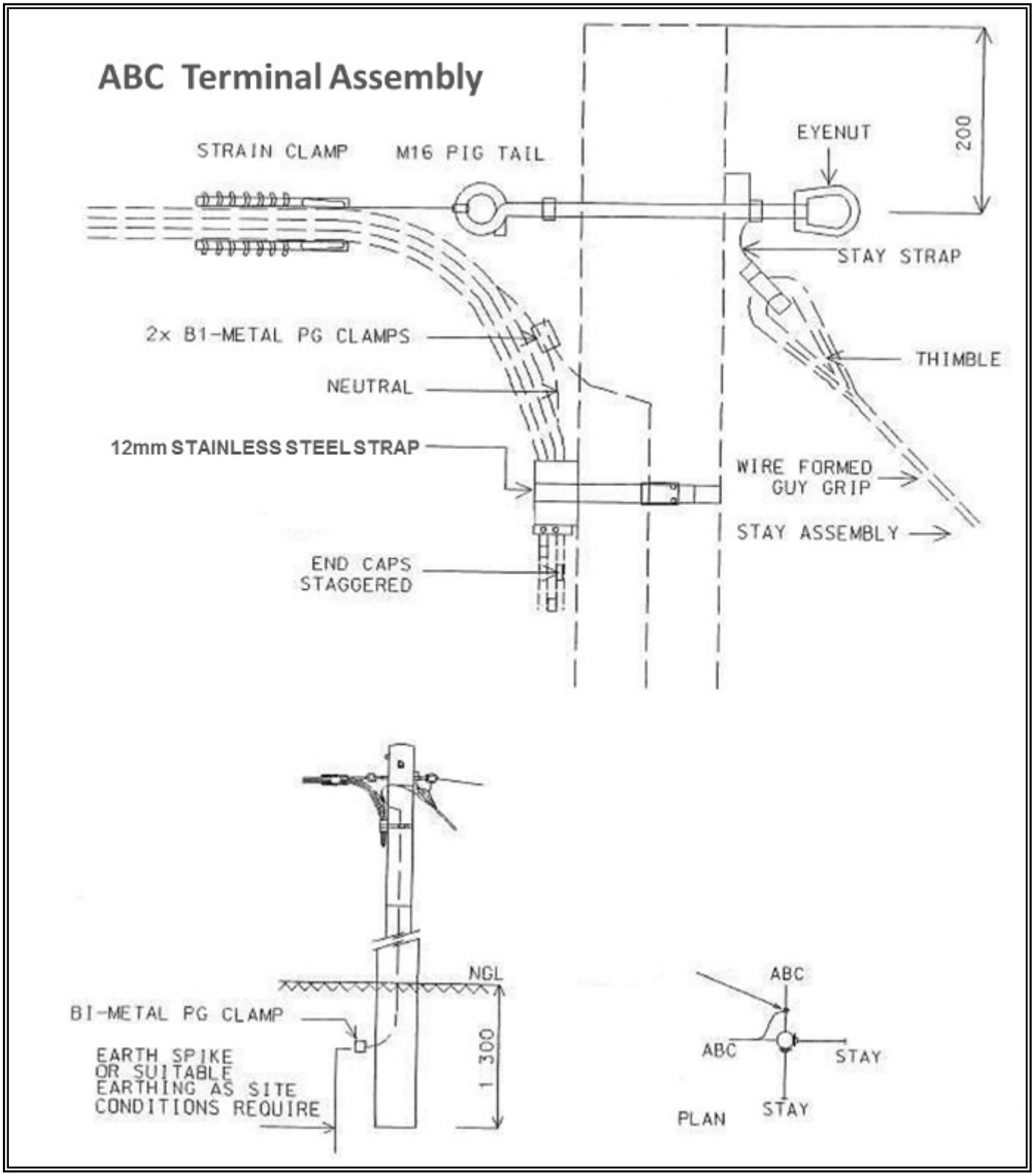
### LOW VOLTAGE CONSTRUCTION PHILOSOPHY



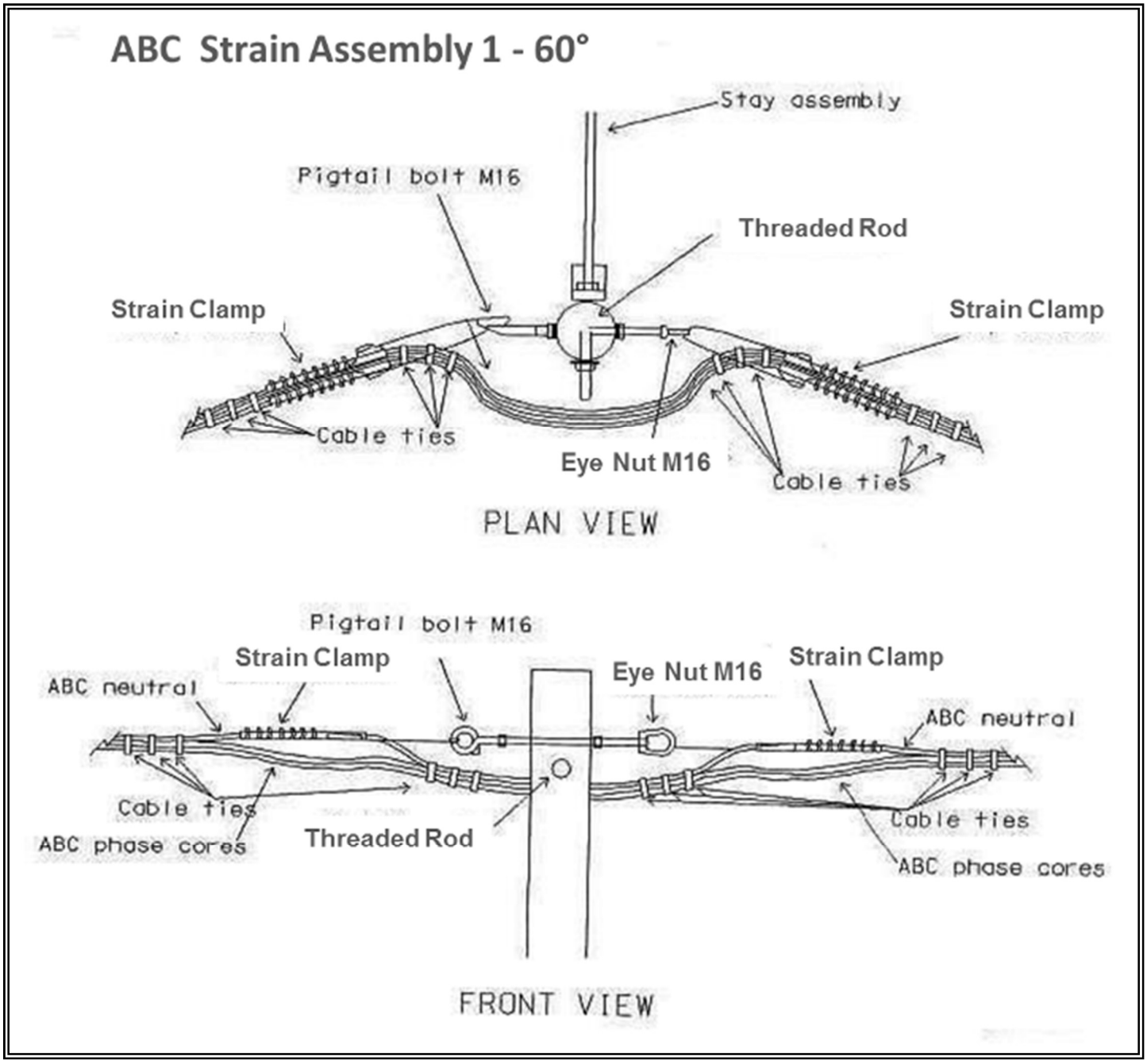
## A) ABC SUSPENSION ASSEMBLY



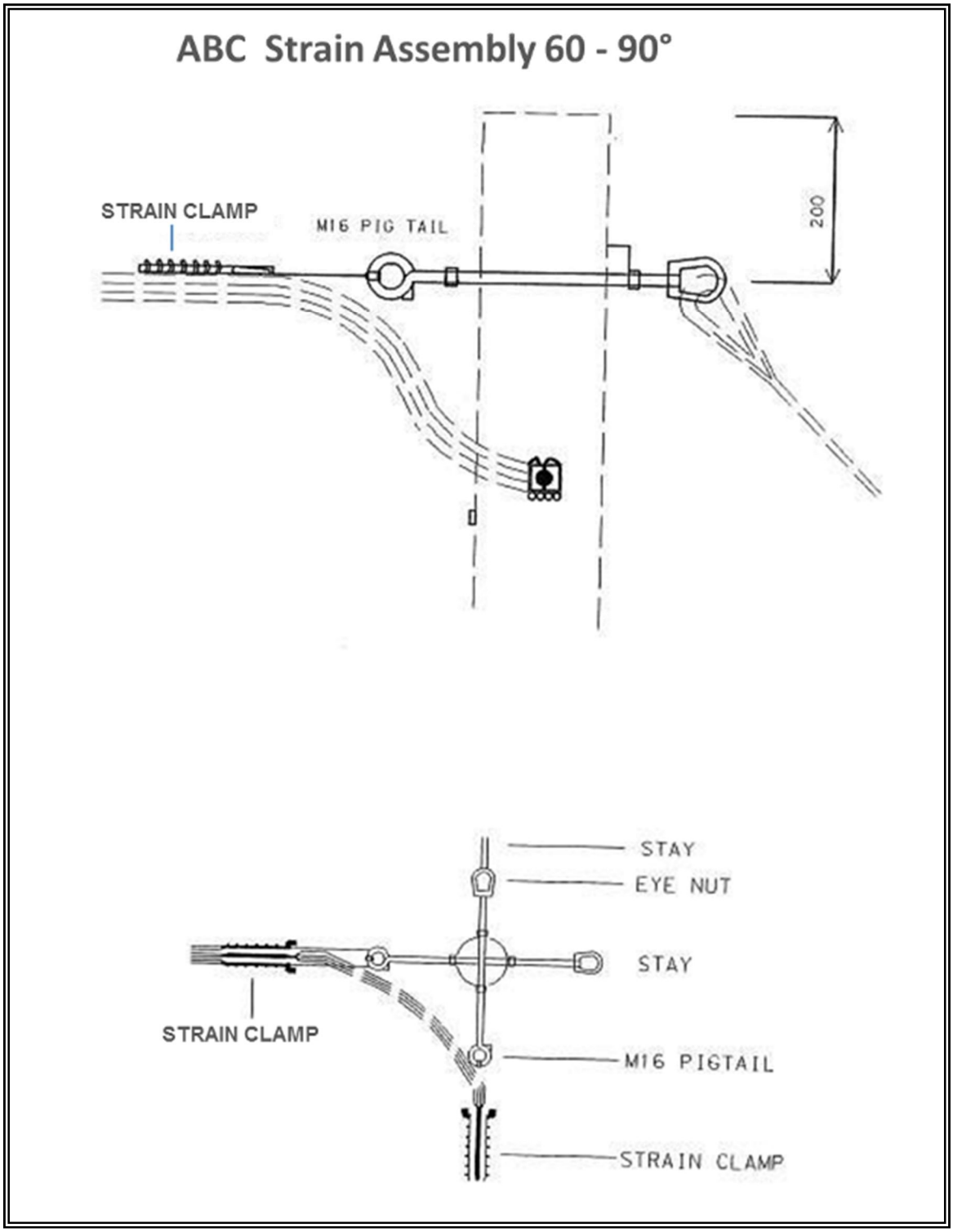
## B) ABC TERMINAL ASSEMBLY



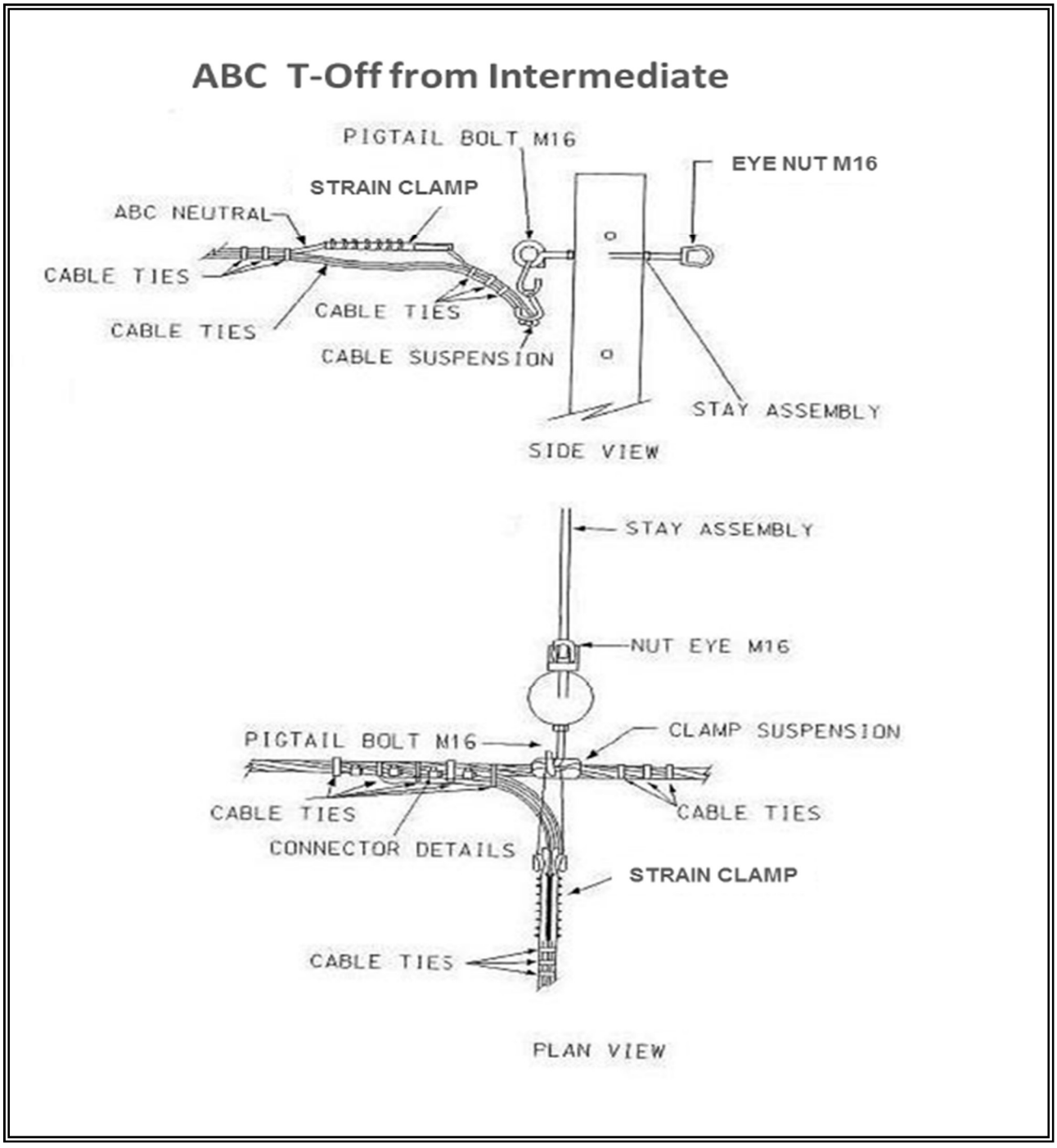
## C) ABC STRAIN ASSEMBLY 1-60º



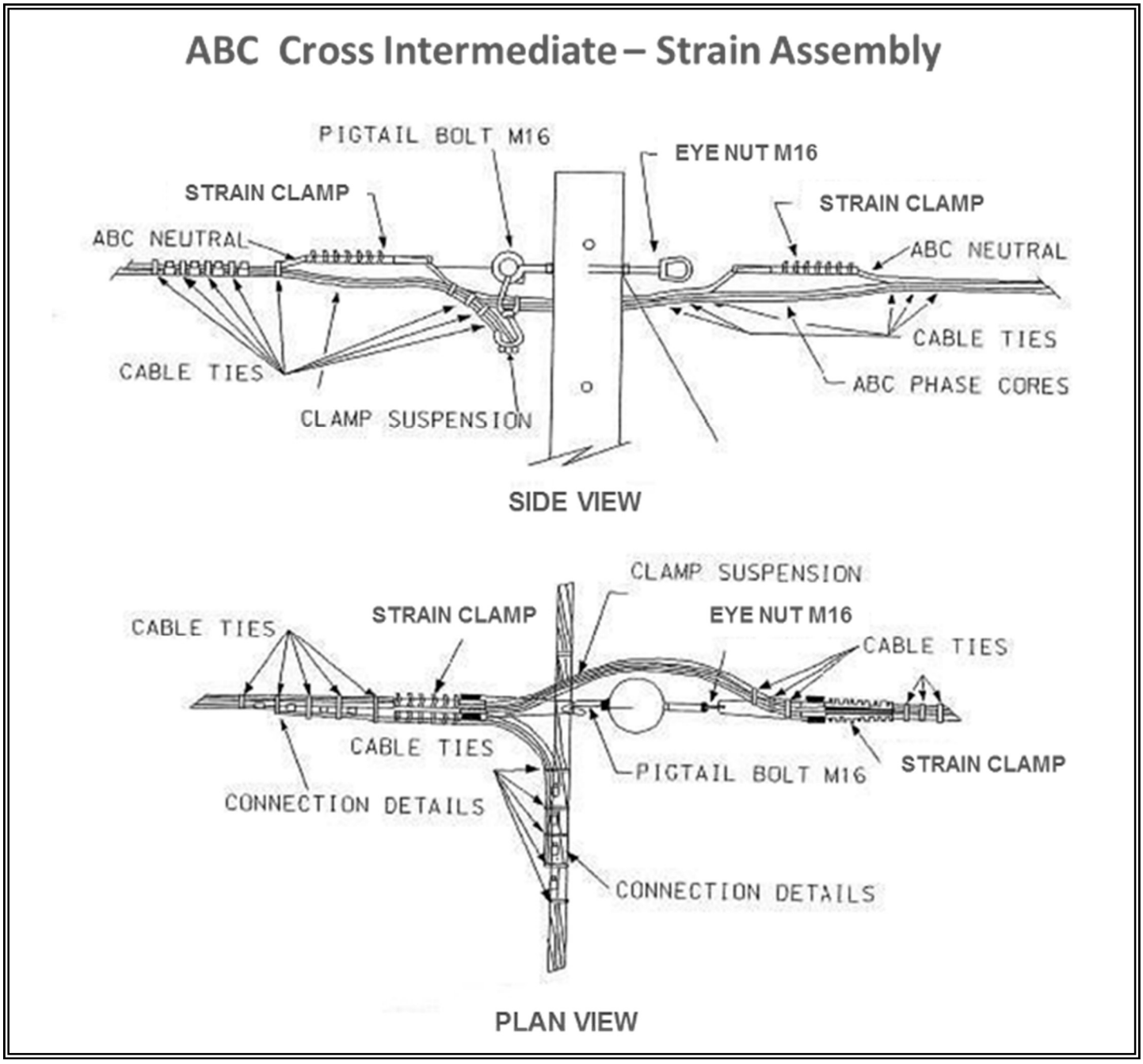
## D) ABC STRAIN ASSEMBLY 60º - 90º



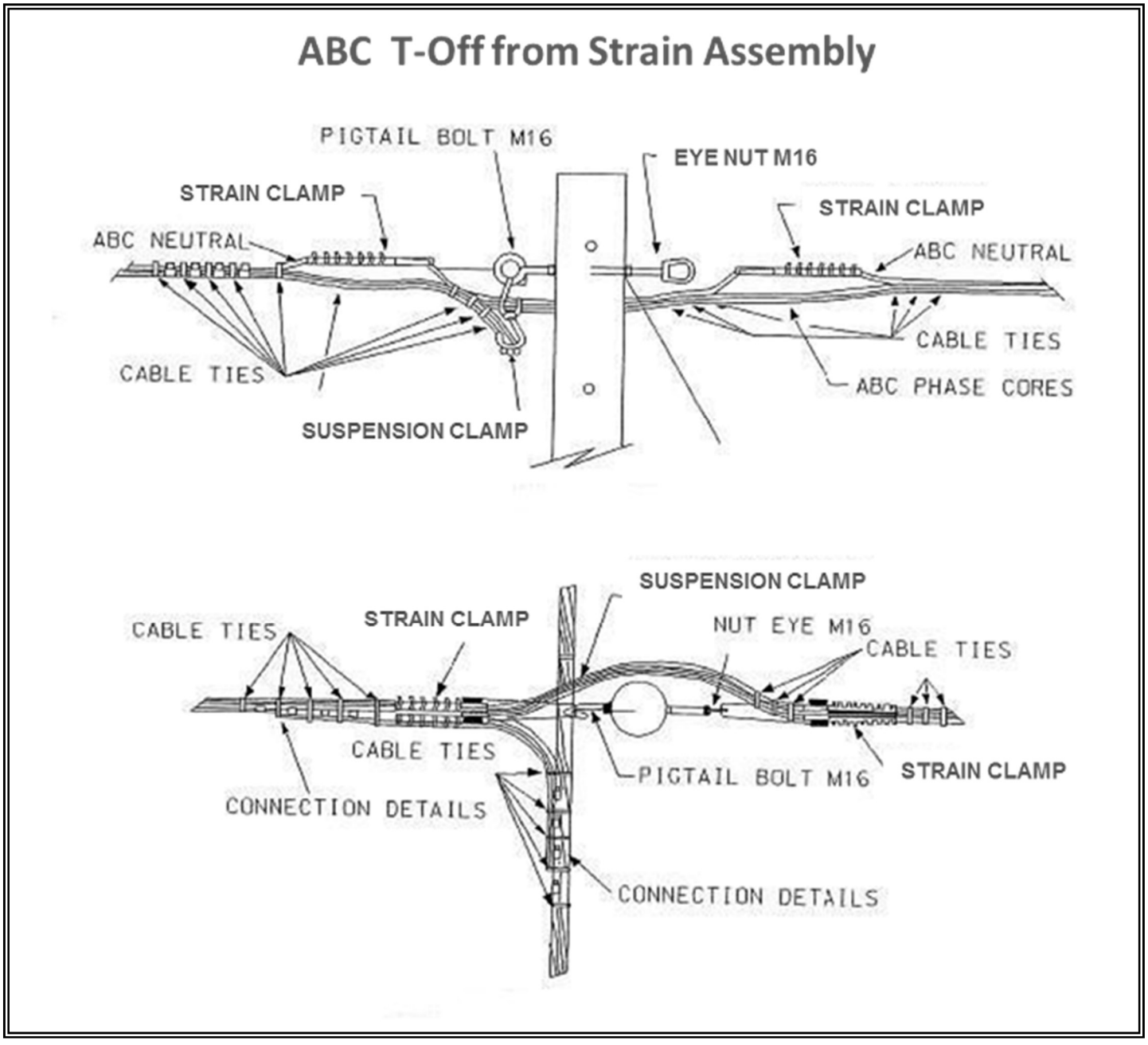
## E) ABC T-OFF FROM INTERMEDIATE



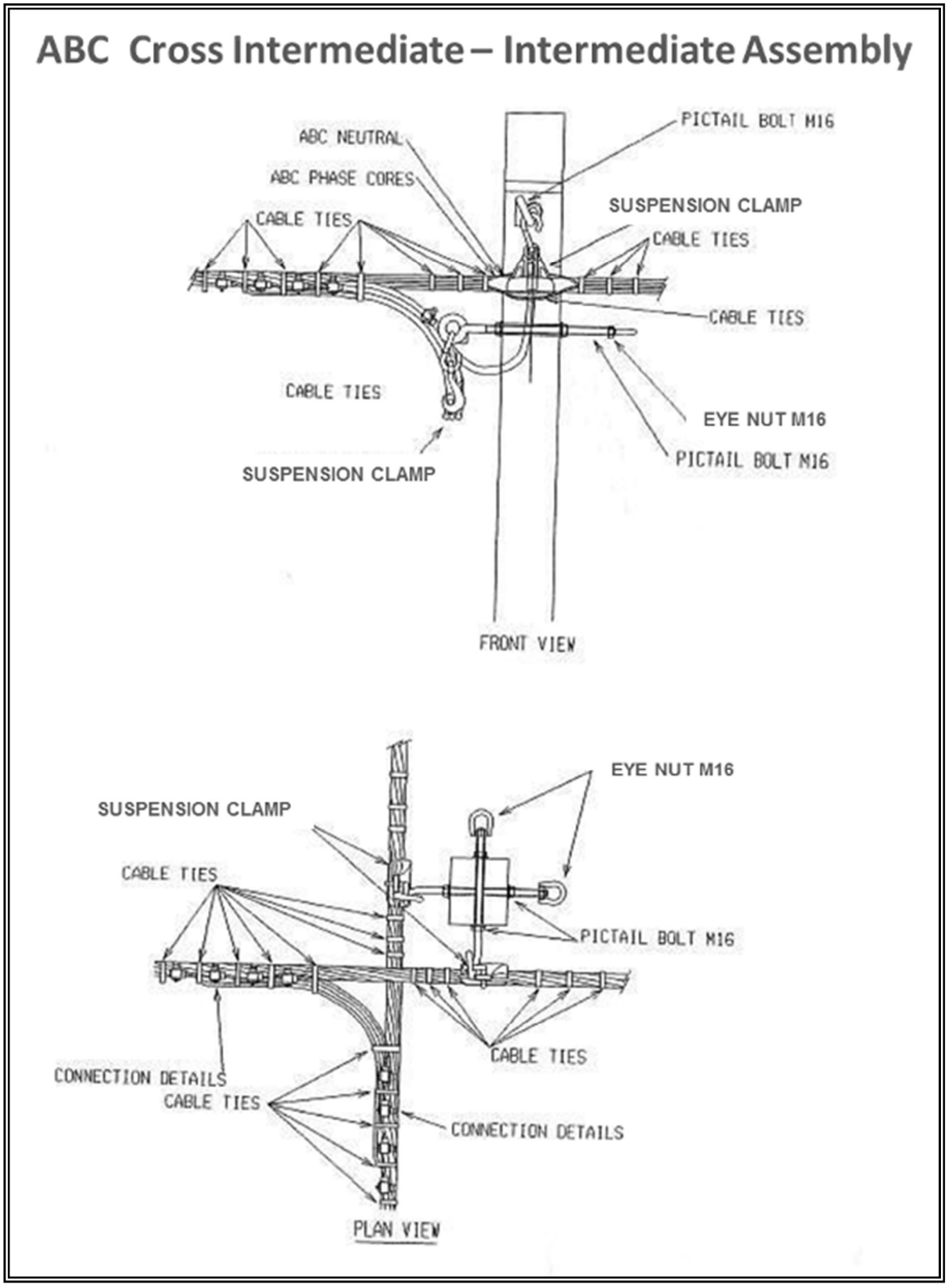
## F) ABC CROSS INTERMEDIATE – STRAIN ASSEMBLY



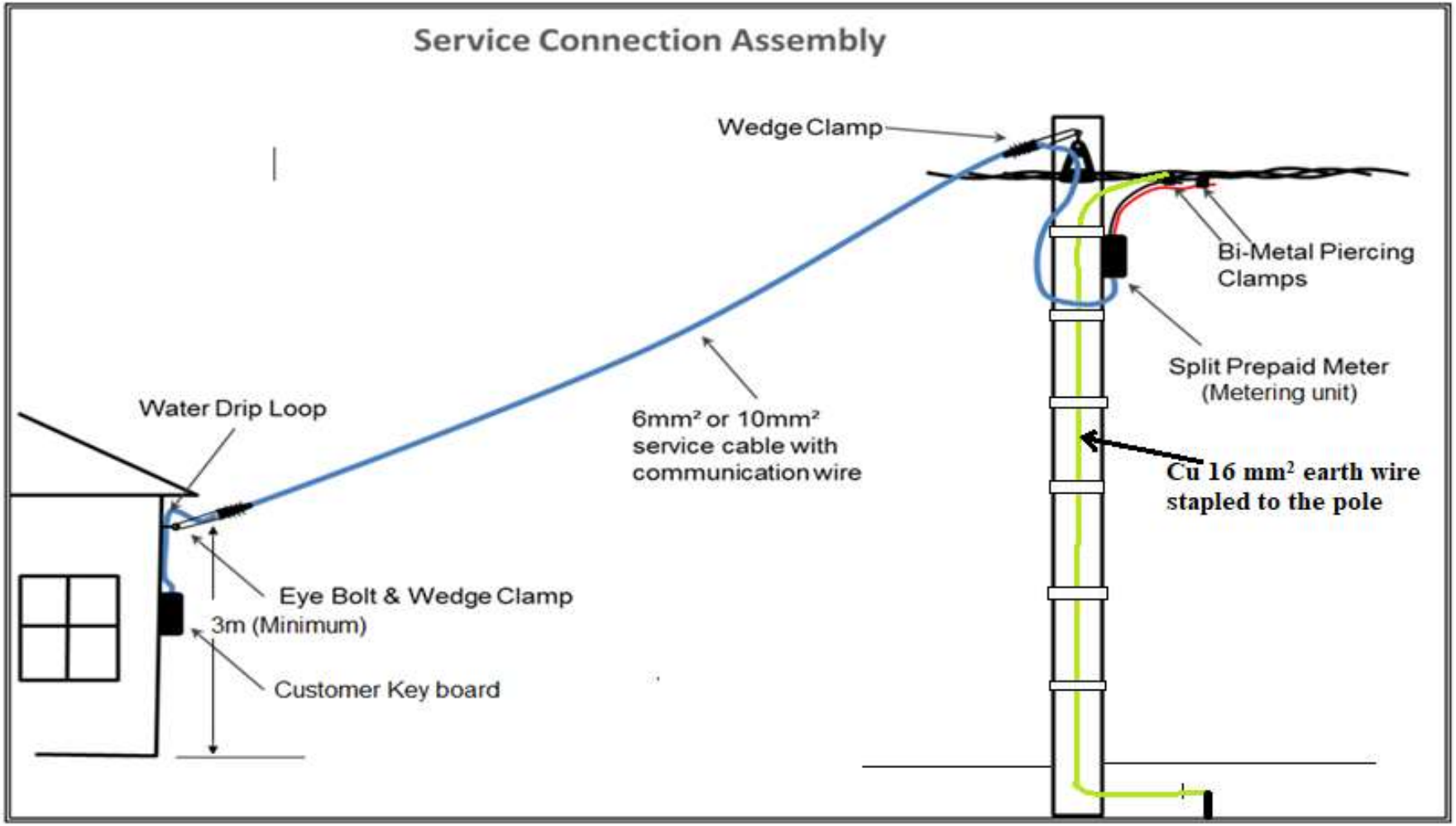
## G) ABC T-OFF FROM STRAIN ASSEMBLY



## H) ABC CROSS INTERMEDIATE – INTERMEDIATE ASSEMBLY

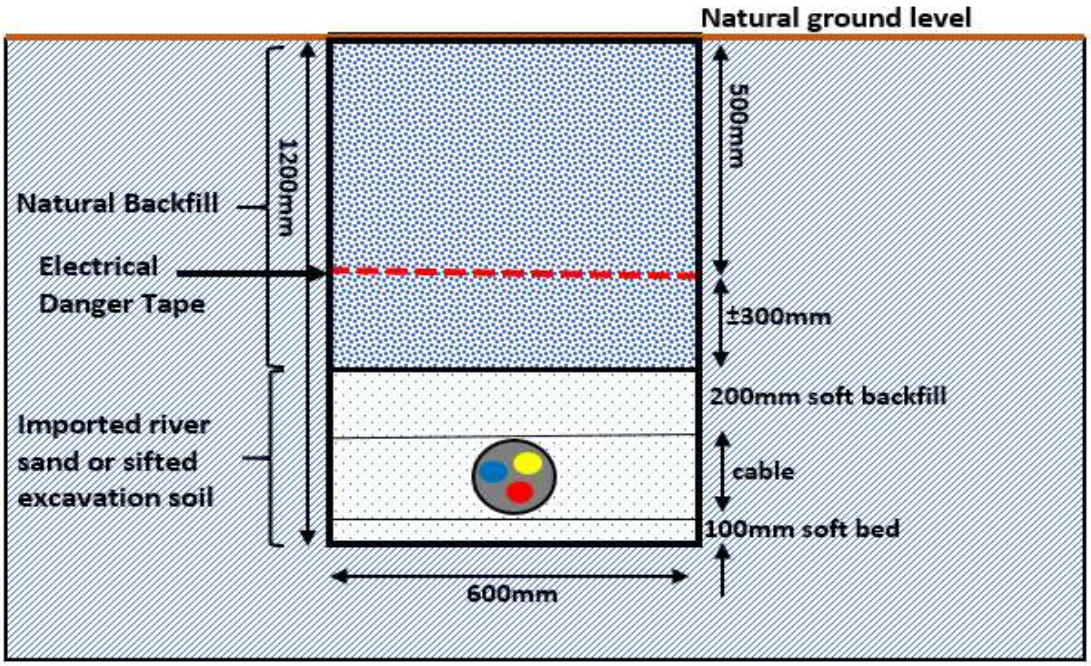


## I) SERVICE CONNECTION

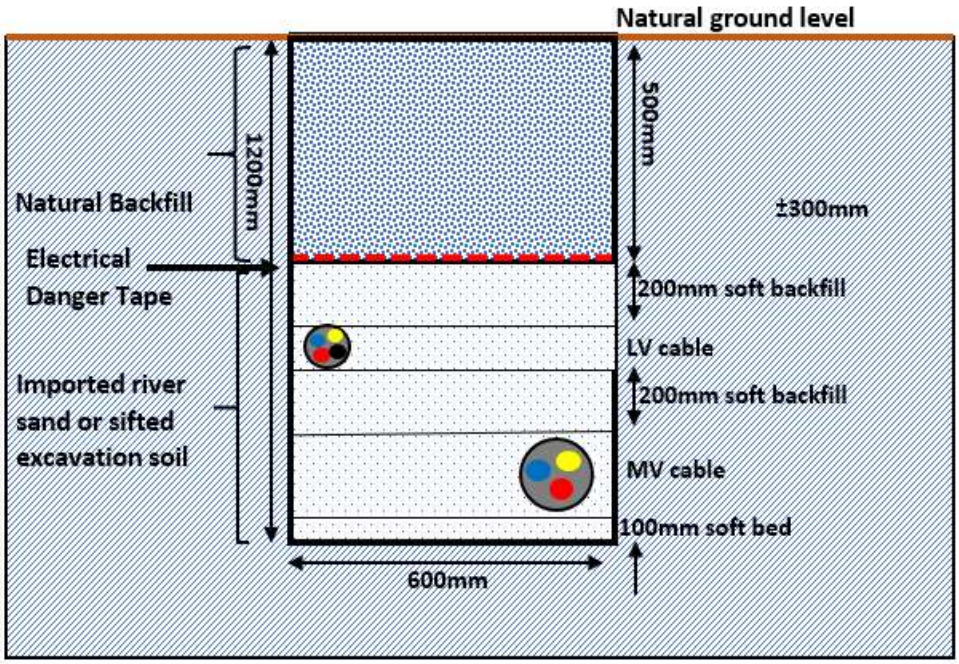


## III. DRAWINGS OF CABLE TRENCHES

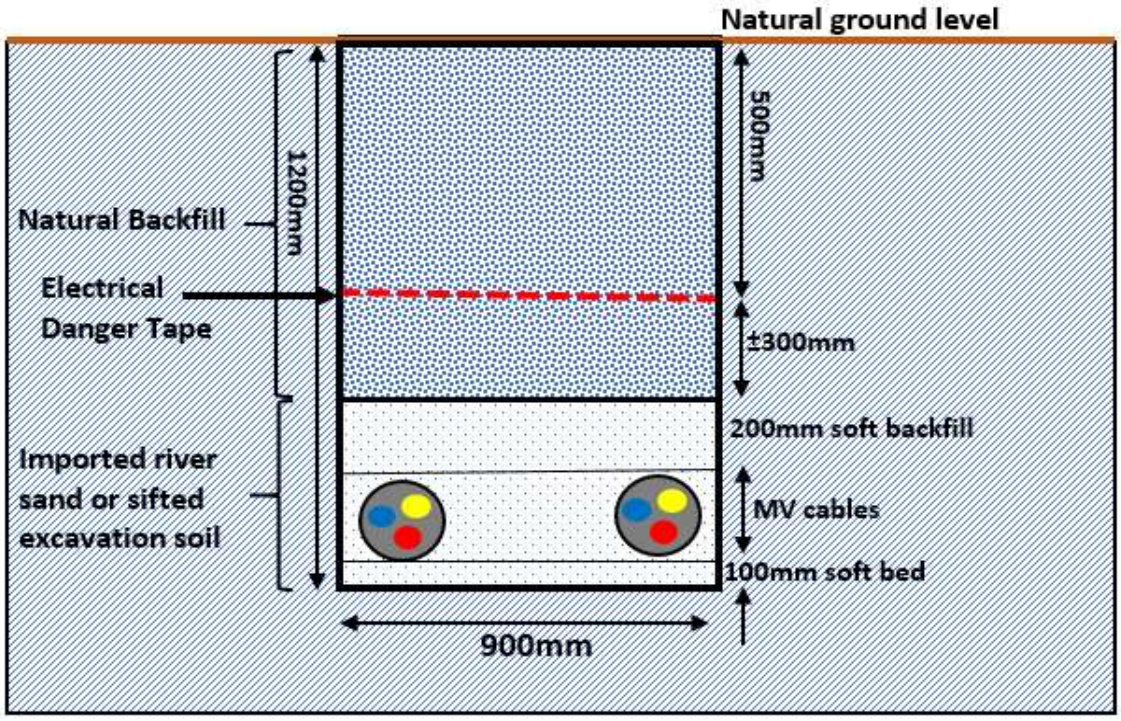
### a. Single MV Cable (fine sand + layer of bricks)



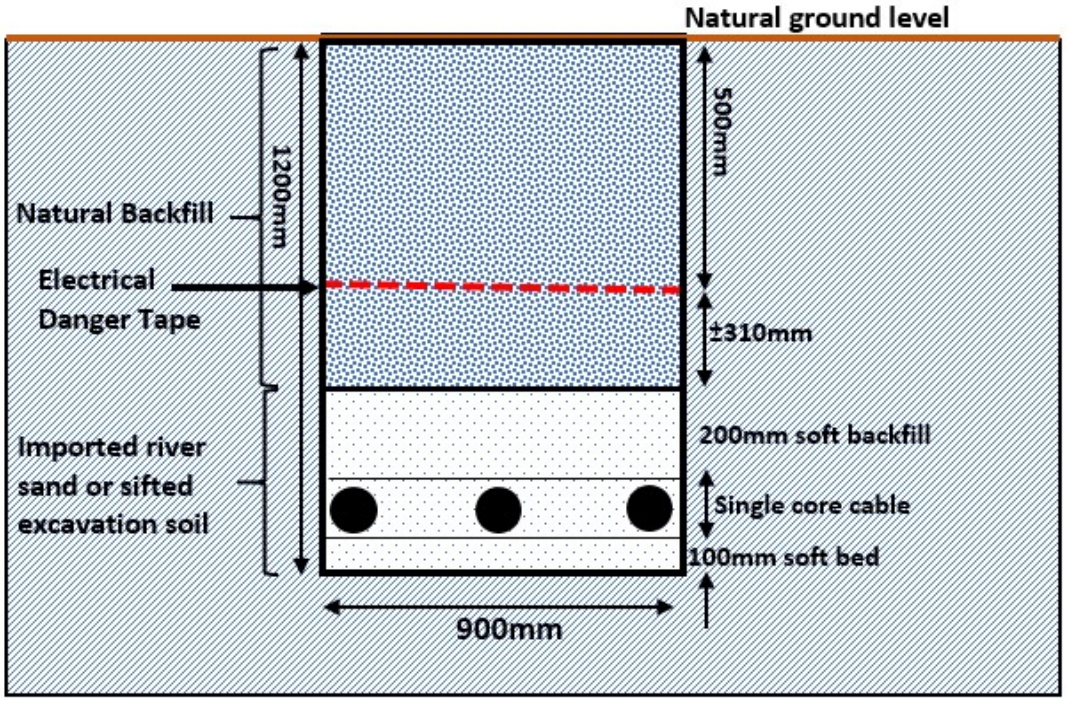

### b. MV and LV Cable



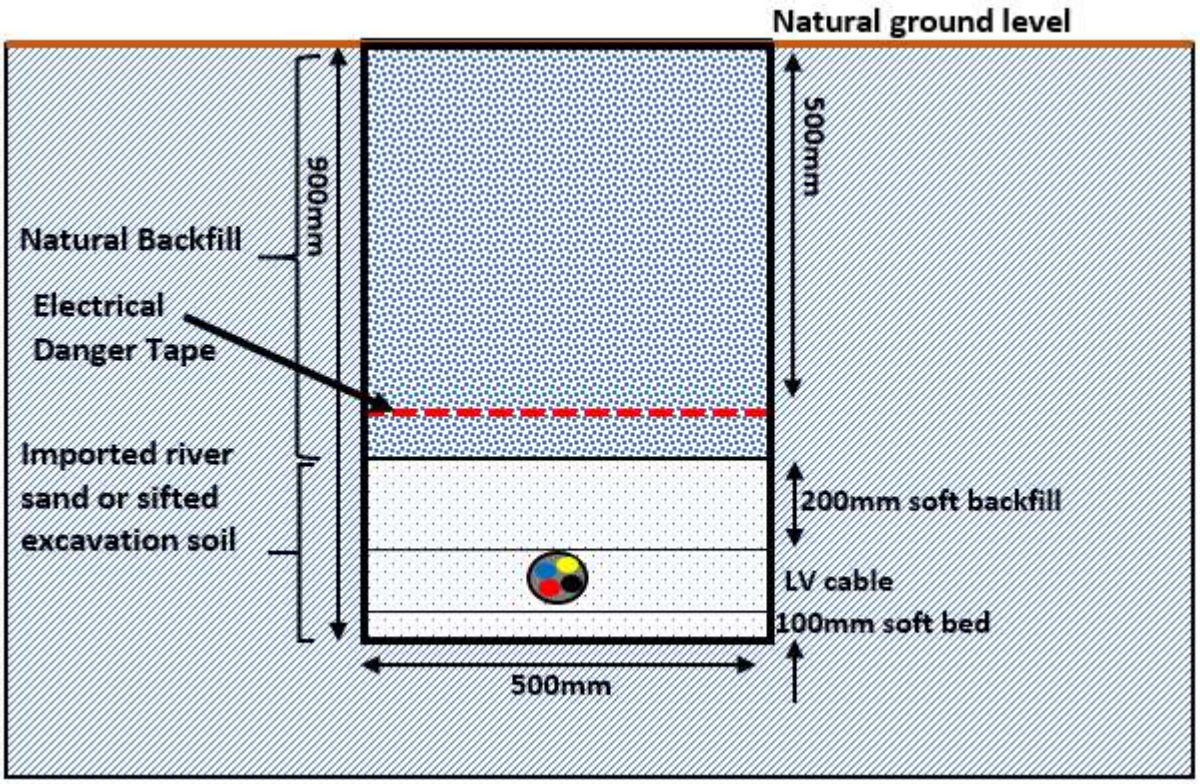
c. **Two MV Cables**




**d. Single Core MV Cables**



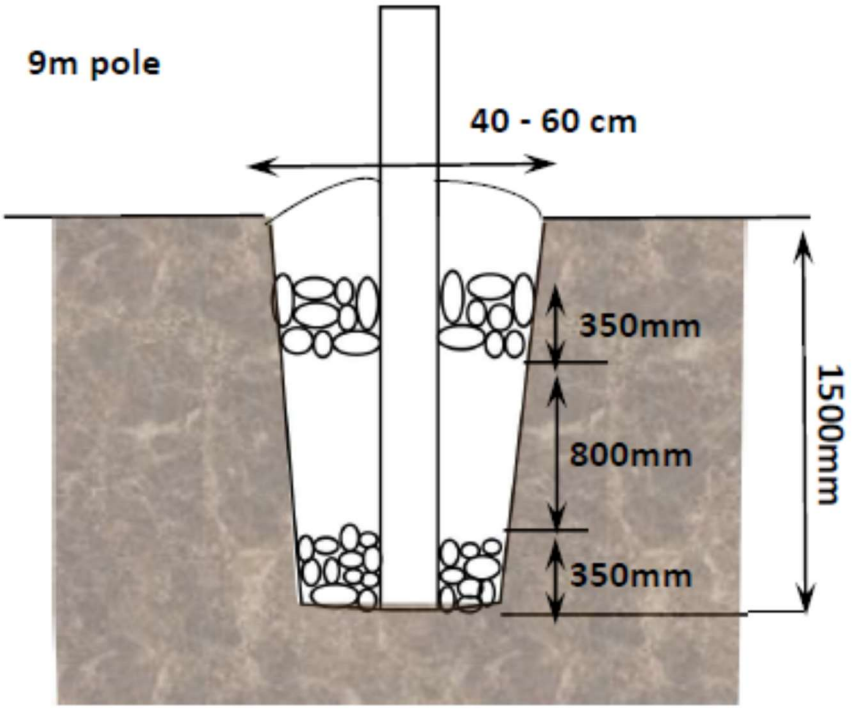
**a. LV Cable (sand not required only bricks)**



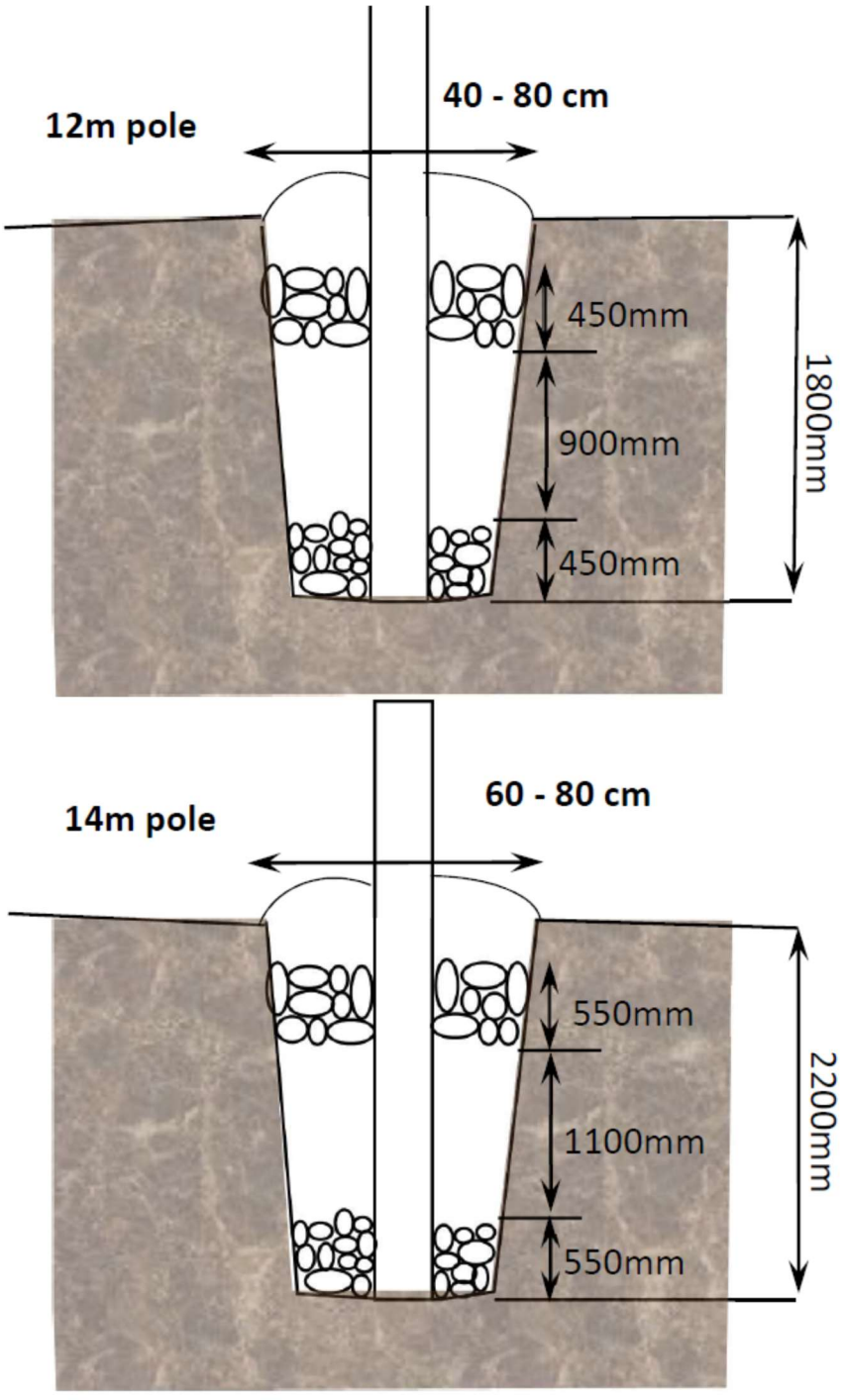
# IV. POLES FOUNDATIONS

- Pole backfilling shall be done using stone wedging as shown in the figure.
- Stones must be wedged in by using a hand compactor.
- Backfill between wedging will be done with excavated materials and consolidated firmly in layers of not more than 20cm at a time

**LV Wooden Poles**

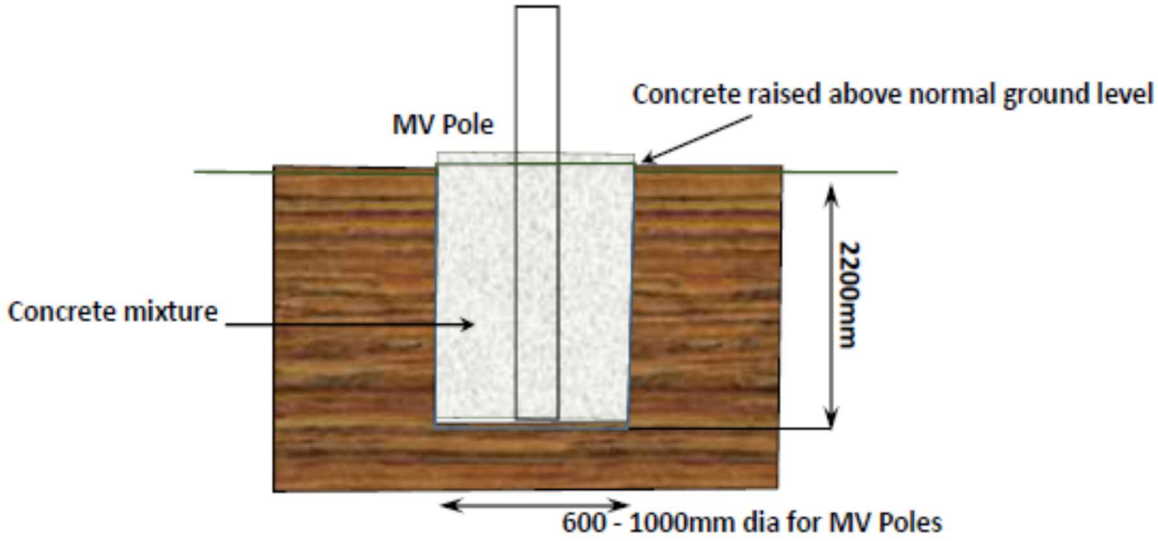


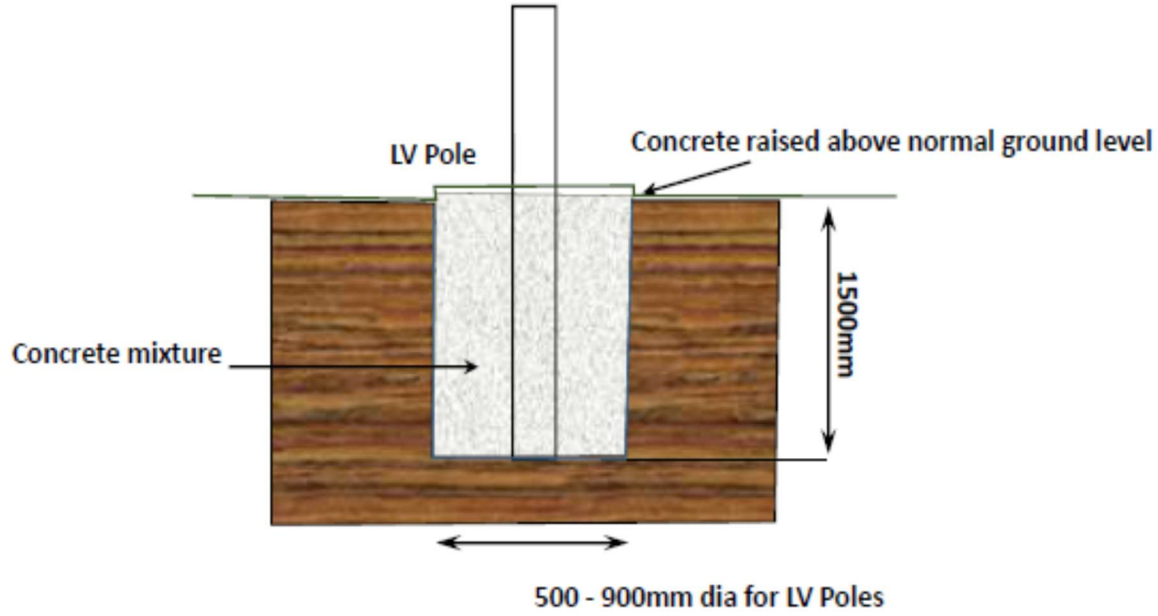
**MV Wooden Poles**



## Concrete and Steel Poles

- Concrete mix shall be minimum 20MPA strength.
- Air shall be removed from concrete mix by use of a suitable vibrator.
- Cement/sand/crushed stone ratio shall be 1/3/4 or as required to achieve the required strength


MV Pole
Concrete raised above normal ground level
Concrete mixture
2200mm
600 - 1000mm dia for MV Poles


LV Pole
Concrete raised above normal ground level
Concrete mixture
1500mm
500 - 900mm dia for LV Poles