Saudi Electricity Company		الشركة السعودية للكهرباء

SEC DISTRIBUTION CONSTRUCTION STANDARD	SDCS-01
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SDCS-01

CONSTRUCTION STANDARD

FOR

OVERHEAD LINES

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1 INTRODUCTION

This standard specifies the design, materials, and installation practices to be applied in the construction of MV and LV single and double circuit lines of over head distribution system with the use of octagonal steel poles as line supports.

It is intended to assist the engineers and field personnel to achieve standardization in construction and to ensure a satisfactory and economical level of service without operating restrictions so that the operational errors should be minimum for safety and reliability.

2 SERVICE CONDITIONS AND CONSTRUCTION PARAMETERS

For construction and operation of overhead distribution network, the service conditions and system requirements shall be as given in the latest revision of SEC General Specification No.01-SDMS-01.

Design and construction parameters for single and double circuit lines shall be as specified in the latest revision of SEC Specification of the Octagonal Steel Poles for Distribution Lines No. 20-SDMS-01.

3 REVISION AND ADDITIONS

The standard is subject to revision as new materials and methods of construction are developed. The latest revision of this standard shall be applicable. Revised sheets shall be issued from time to time and should be inserted as soon as these are received. Superseded or obsolete sheets shall be removed immediately upon receipt of revised sheets. The date of the latest issue of each sheet is printed at the top corner under the standard number.

4 DEFINITIONS

4.1 Intermediate Pole (IMP)

Intermediate Poles are used only at positions where the conductor size or its tension is unaltered or where there is no change in line direction. These poles must support, weight of the conductor, and take wind force on the pole, cross-arm and insulators and also wind force on the bare conductor for half the adjacent spans.

4.2 Angle Pole

Angle Poles are used where the line direction is altered, and must be capable of taking weight of conductor and resultant of the maximum conductor pull, wind force on the pole and cross-arm and also wind force on half the adjacent spans.

Angle poles are divided into four main classes:

a. Light Angle Pole (LAP) : ranging from 6° to 15°
b. Medium Angle Pole (MAP) : ranging from 16° to 60°
c. Heavy Angle Pole (HAP) : ranging from 61° to 90°
d. Double Terminal Pole (DTP) : 90° only

4.3 **Section Pole (SEC)**

Section Poles are used where the line is terminated and started and must be capable of taking weight of conductor and full maximum pull of all the conductors, the wind force on the pole and cross-arm and also the wind force on half the end span.

4.4 **Terminal Pole (TER)**

Terminal Poles are used where the line is terminated and must be capable of taking weight of conductor and full maximum pull of all the conductors, wind force on the pole and cross-arm and also wind force on half the end span.

4.5 **Span**

Span is the horizontal distance between any two consecutive poles.

4.5.1 Basic Span

Span lengths should be kept as near as possible to the basic span for economical construction. Basic span in this standard is 100m for MV lines and 50m for LV lines.

4.5.2 Weight Span

Weight span is the horizontal distance between the lowest points of the conductor in two spans adjacent to a structure under minimum temperature conditions. On level ground between structures of the same height, this is equal to half the sum of the adjacent spans. If one support is higher, the portion of the conductor it supports increases.

4.5.3 Wind Span

Length of conductor on which the conductor wind forces are supported by a structure is called the wind span. The wind span is equal to half the sum of the two spans adjacent to a structure.

4.5.4 Ruling Span

Ruling span is the assumed design span that will produce between dead ends the best average tension through out the line of varying span lengths with changes in temperature and loading. The section as a whole will react to load and temperature changes as a single span. This single span is referred to as ruling or equivalent span. In this standard the average span is used as an approximation for ruling span.

4.6 **Tension**

When a wire / conductor is anchored at supports which keep it clear above the ground a force is generated in the wire / conductor which tends to pull the supports towards one another.

4.7 **Ultimate Strength**

Ultimate strength is the maximum load which a material will sustain when the load is gradually increased until the rupture or failure takes place, for example in case of ACSR conductor ultimate strength will be the load gradually increased until the Aluminum strands rupture.

4.8 **Sag**

Sag is the vertical distance of the conductor below the line joining the points of support. The term usually refers to the maximum sag which on a level span occurs at mid-span.

4.8.1 Initial unloaded sag

Initial unloaded sag or stringing sag means the sag of a wire prior to the application of an external load.

4.8.2 Final unloaded sag

It means the sag of wire after it has been subject to its maximum loading for an appropriate period and then the load removed.

4.9 **Transverse Loading**

Maximum transverse loading shall be assumed to be the sum of transverse wind load and the resultant of the loads imposed by the maximum tension in the conductors due to any change of direction.

4.10 Longitudinal Loading

Longitudinal loading is the resultant unbalanced pull due to the tensions in the conductor. Terminal and section structures are designed for broken wire conditions.

4.11 Vertical Loading

Vertical loads upon supports, crossarms, insulators, fittings, conductor fastenings and the foundations shall be their own weight plus super imposed weight which they support including all conductors and stays. Vertical component of the maximum tension in stays shall also be included in vertical loading.

4.12 Lay Direction

The lay direction of the conductor tie must be the same as that of the outer layer of the conductor to which it is applied.

5 ROUTE SURVEY

Survey for ascertaining the shortest correct possible route of line is the primary need. Any mistake in the field or office work which may pass undetected shall cause extra expenditure at an advanced stage during construction of the line. Utmost care should be taken in survey, leveling and plotting the profile of the MV line route in sections of not more than 4km. An overlap of 0.5km shall be provided between adjacent sections. In case of composite lines, the profile of LV line should also be plotted with that of MV line.

For economical construction the shortest practicable route be selected. Proposing more angle positions should be avoided. As far as possible the line route be along the roads, transport tracks and streets so that the line should be readily accessible for construction, inspection, patrolling and maintenance.

Planned sites and other expected future developments be taken into consideration.

Careful survey should be made to obtain accurate data of population, other utilities, trees, wadis and any other obstructions. This data can be supplemented by other information as available from Municipality, Highway Authorities and Utilities record.

Route near to Chemical plants and Pollution areas should be avoided due to the likelihood of insulator flash over.

Avoid crossing of the following.

a. Hills (e) Valleys / Wadis
b. Buildings (f) Telephone lines
c. Farm lands (g) Private Power lines
d. Railway tracks

During route surveying concerned utilities must also be coordinated. Before line survey local road department and Highway Authorities must be consulted about spacing to be maintained from the centre of the road.

Tap-off lines should be from the nearest pole of the main line.

In profile plotting it is necessary to know distance from ground to the lowest conductor position at the support for all poles from the minimum height upwards

Transformers should be proposed at plain and accessible locations at the load centre.

Stays should be proposed at 37 degree angle with pole. While determining the pole location near private property and road sides, availability of sufficient space for stays should be considered. If less space for angle / side stays, the angle is subject to revision and approval by the Engineer of Distribution Engineering Department.

6 RIGHT OF WAY

Before execution of work, approval from Government departments / local authorities like Municipality, Ministry of Communication and Rural Affairs, Road Department, Sheikh of Tribe etc. should be obtained.

Undertakings from land owner duly signed by local Sheik should be taken wherever any stay or pole is necessary to install at the edge of the private land, before starting installation activities.

Trees on the proposed route or beyond the right of way which would strike the line in falling, shall either be removed or topped except that shade, fruit or ornamental trees shall be trimmed and not removed unless other wise authorized.

7 NETWORK ROUTE MAPS

The Construction Engineer should ensure that the following details have been furnished in the MV line route map drawings:

a. Main line MV poles
b. T-off line MV poles
c. Transformer locations
d. Roads / tracks
e. Valleys (Wadis)
f. Pipe lines
g. Farm lands
h. Villages
i. Power lines
j. Hills
k. Private lands
l. Other Utility crossings

Voltage drop calculations for MV and LV feeders shall be carried out by the Planning Division / Contractor.

The pole & stay locations marked on the drawings should be cross-checked by the Construction Engineer for design spans and ground clearances before execution. All the clearances should be maintained as per SEC standards. Separate sag templates shall be provided showing the sag at 80 ºC and 10 Cº for each type of conductor. Schedules / stacking sheets for poles of MV & LV network should be prepared showing the following details:

a. Pole Number
b. Angle of deviation
c. Pole Type
d. No. of stays
e. Span length
f. Section length
g. Earthing
h. Transformer No.
i. Transformer capacity
j. Summery of all type of poles & equipment

Construction Engineer shall ensure that updated as built data and drawings as required in Mapping & Recording Standard are prepared by contractor and transferred to the concerned Electricity Department.

8 OCTAGONAL STEEL POLES

8.1 Types of Steel Poles

SEC standard steel poles are tapered octagonal and hot dip galvanized complete with top cap, base bearing plate, earthing nut, colour marking, pre-drilled holes conforming to the latest revision of SEC specification # 20-SDMS-01. Standard lengths of steel poles are 12,13,14 and 15 m for MV single and double circuit lines and 10 m for L.V lines & the short pole of H-pole structures of pole mounted transformers (PMT). For achieving higher vertical clearances, 14 and 15m steel poles can also be installed.

Self support poles shall be used only when there is absolutely no option for stay or strut pole. Types of steel poles are detailed below in Table 5.1.

Pole Type	Description
OC10	10 meter Steel Pole, Low Voltage
OC12S	12 meter Steel Pole, Medium Voltage, Single Circuit
OC13S	13 meter Steel Pole, Medium Voltage, Single Circuit
OC14S	14 meter Steel Pole, Medium Voltage, Single Circuit
OC14D	14 meter Steel Pole, Medium Voltage, Double Circuit
OC15S/D	15 meter Steel Pole, Medium Voltage, Single & Double Circuit
OC10SFS	10 meter Steel Pole, Self Support, Single Circuit
OC12SFS	12 meter Steel Pole, Self Support, Single Circuit
OC13SFS	13 meter Steel Pole, Self Support, Single Circuit
OC14SFS	14 meter Steel Pole, Self Support, Single Circuit
OC15SFS	10 meter Steel Pole, Self Support, Single Circuit

Table 5.1: Types of Standard Steel Poles

8.2 Handling And Transportation

Special care shall be taken during loading, hauling and unloading to prevent any damage to the galvanizing of the poles. Poles shall not be dropped off vehicles when being unloaded in the field, but shall be carefully rolled, one at a time, with skids or lifted off the vehicle with suitable straps or slings.
Any damaged pole shall not be installed.

8.3 Holes

Holes spacing for bolts is based on installations and lines configurations. Holes drilling are prohibited. If any additional hole is required, refer to the Distribution Engineering Department.

9 OVERHEAD LINE ACCESSORIES

The overhead line accessories shall be as specified in the latest revision of SEC specification No. 20-SDMS-02. All accessories shall be installed in quantity as specified in the list of material of the construction drawings.

9.1 Bolts

Machine bolts and shoulder eye bolts with nuts and washers shall be as specified in the latest revision of SEC Specification No. 20-SDMS-02 for line accessories.

10 GENERAL DESIGN

10.1 Soils Classification

The soils are classified according to the A. B. Chance test probe method. The Chance test probe is a mechanical tool to identify soil in a simple and quick way from the earth surface without core samples. To find out the soil bearing capacity the soil test probe is screwed into the soil. As it displaces the soil, probe torque readings are measured in inch-pounds on a torque gauge. The torque values obtained are translated into soil classification using the Chance Soil Classification Data chart. The table 10.1 below shows the soil classification as per A. B. Chance method and the relevant SEC soil classification to be followed.

Class	Description of Soil Type	Probe Values lbs (N-m)	SEC Soil Type Classification
0	Sound hard rock, un-weathered	N.A.	Rock / Dense Soil
1	Very dense and / or cemented sands, coarse gravel and cobbles	750-1600 (90-208)	
2	Dense fine sand, very hard silts and clays (may be preloaded)	600-750 (78-98)	
3	Dense clays, sands and gravel, hard silts and clays	500-600 (65-78)	
4	Medium dense sandy gravel, very stiff to hard silts and clays	400-500 (52-65)	Medium soil
5	Medium dense coarse sand & sandy gravels, stiff to very stiff silts and clays	300-400 (39-52)	
6	Loose to medium dense fine to coarse sand, firm to stiff clays & silt	200-300 (26-39)	Loose Soil
7	Loose fine sand, Alluvium, loess, soft firm clays, varied clays, fill	100-200 (13-26)	

Table 10.1: Soil Classification

For special type of foundation for more than two meters planting depth, such as long span, valley crossing etc; the soil bearing capacity of such cases shall be defined by an independent testing laboratory.

10.2 Foundations

10.2.1 Steel Pole Foundations

In general lateral strength of foundation shall be at least equal to the cantilever strength of the unstayed pole. Total vertical loads of a stayed pole shall include the vertical component loads of the stays.

Thus pole foundations shall be designed against vertical load applied as well as the overturning moment.

Foundations design of steel poles and guy anchors depends on type of the soil, average diameter of pole below ground, planting depth and design of the line (single or double circuit). In this standard the planting depth for MV line steel poles is 2.0m, for LV line steel poles and for short pole of H-Pole structure is 1.5m.

Foundation details for each type of steel pole for single and double circuit MV line and LV line are given in table 10.1, 10.2 & 10.3 and drawing No.04. These foundation details are also applicable to both MV line and composite construction (MV+LV lines).

For all type of tap-off poles Heavy angle pole foundations are applicable.

Lean concrete 50mm thick shall be provided. For height 300 mm, stones / boulders of size 150-250mm are to be filled in pit below foundation to reduce the bearing pressure.

To prevent water stagnation, foundation top surface must be slopped while concrete capping height above ground level should be at least 300mm. For valley / wadi crossing poles, the capping height should be 500mm against rain water flow.

For foundations near hill side and wadis which are easily eroded, the protection shall be arranged with retaining walls or boulders stacked around the pole foundation.

Curing shall be strictly done for all the pole and stay foundations for minimum 3 days.

10.2.2 Foundation in Rock / Dense soil

Sound rocks / dense soil have sufficient resistance against lateral bearing pressure and lateral deflection. The pole foundation excavation depth in rock / dense soil shall be 2m and to be backfilled with small size boulders mixed with 20-30% sand.

10.2.3 Foundation in Medium soil

The resultant forces on pole are resisted by the bearing area of butt on the excavation wall. The soil should be fairly backfilled and well rammed, especially at the surface. The greatest stress on the foundation is at ground line and decreases towards the butt of pole. Concrete shall be cured for at least three days before load is applied.

10.2.4 Foundation in Loose Soil

In loose soil foundation should be strengthened by increasing the footing area. The split barrel should be used only where digging of hole is difficult due to collapsing of sides such as for very loose fine sand. The method uses shuttering made up from split barrels or straight side steel oil drums with the bases removed. The shuttering should have a diameter of at least 1 m so it may be necessary to split the barrels down the sides and join two or three together to form the required shuttering.

In situation where above methods may not be applicable such as if soil is very loose and with water, cased foundation type may be used.

10.2.5 Poles set along the canal

The foundation depth (direct embedment type) of poles that are set on the slope of canal or within 1200 mm from the edge of canals, shall be the standard depth plus 1100 mm as detailed in Drawing 10.1 (depth measured from the lower side of pole hole). In cases where depth of canal is more than 1.60 m and slope is steeper than IV:3H, 2200 mm (instead of 1100 mm) should be added to the standard depth. In situation where digging of hole to attain the required embedment depth is impossible, such as when soil is not proper and there are chances of collapsing, cased foundation type as detailed in Drawing 10.2 may be used.

10.3 Stay Anchor Foundations

Stay anchor foundations shall have same strength requirements as specified for guys. The anchor resistance shall be calculated as the projected surface area multiplied by allowable compressive resistance of the soil. Area of the anchor must be sufficient to prevent cutting through the earth; i. e; the earth immediately above and in contact with the anchor must not fail in bearing. The anchor must be buried deep enough to prevent the vertical component of the pull from lifting cone of earth body. Therefore the stay foundations shall be designed against the uplift forces as well as sliding forces.

10.3.1 Stay Assemblies

Stays shall be installed before the conductors are strung. The steel poles are designed for 37º angle between the stay wire and vertical pole. However due to the site restrictions stay angle may be in the range of 33º - 45º. Such range of angle is reflected to distance (projection to foundation) in the stay assembly foundation drawings 300 – 308, both for single and double circuit lines. The structures are designed based on the following type of stay assemblies.

a. LV Stay Assemblies
   - One stay LV assembly with 16mm dia. anchor rod.
   - Two stay LV assembly with 19mm dia. anchor rod

b. MV Stays Assemblies
   - One stay SC- MV assembly with 19mm dia. anchor rod.
   - Two Stay SC-MV assembly with 24mm dia. anchor rod
   - Section stay SC- MV assembly with 19mm dia. anchor rod
   - One stay DC- MV assembly with 19mm dia. anchor rod
   - Two set of single stay DC-MV assembly with 24mm dia. anchor rod
   - Two set of double stays DC-MV assembly with 24mm dia. anchor rod
   - Section stay DC- MV assembly with 24mm dia. anchor rod

10.3.2 OTHER TYPE OF STAYS

The following type of stays must be considered prior to taking the decision for erection of self support pole.
- Slack Pole (reducing span)
- Strut Pole (Push Pole)
- Flying stay (Pole to Pole)
- Cantilever stay (Side walk)

10.3.3 STAY GUARD

Bright yellow color stay guard should be installed when stay falls directly on or along the path of pedestrian and within vicinity of roadways where there are chances of damage by the vehicles due to poor visibility. Drawing 10.3 shows the installation of stay guard.

10.4 Excavation

a. Before any excavation is commenced for foundations soil investigation shall be carried out by using the A. B. Chance Probe Method for its classification.

b. Pole demarcation should have been identified by some visible way (steel or wooden bars / pegs marked in red.)

c. No excavation shall be made with backhoe. Where the soil permits excavation shall done with an auger, power compressor or by hand so that the soil disturbance should be minimum. If excavation has been done by using backhoe, the entire surrounding area of pit shall be filled with concrete at contractor's cost. The depth should be carefully checked. On sloping grounds excavation on pole side of the slope must be taken out to the full design depth.

d. Where rock is encountered, Construction Engineer should check that the excavation is up to the required planting depth.

e. For excavation in sand and peat, shuttering should be provided and continued down with excavation, if it is not done, the excavation will cave in.

f. Excavation in waterlogged areas is done as in ordinary soil. But in order to keep water sufficiently low, suction pumps are to be used.

g. In populated areas, for public safety warning tapes and signs shall be provided where excavating pits.

10.5 Backfilling

a. Backfilling is expected to be minimum in case of pole foundation. Backfilling shall be done around the pole and stay anchor foundation after curing. Backfilling shall be free from all sorts of salts, grass weeds and other similar organic material. Mixing with gravel is allowed. For rock pits, 20% - 30% of soil and sand shall be mixed to diminish void and to ensure that back filling is more compact.

b. The backfill shall be tamped to a dry density equal to the surrounding soil. The backfill shall be well banked and tamped around pole and stays. The backfill shall be rammed preferably with mechanic compactor. Back fill shall be shovelled back in 150mm layers.

10.6 Concrete

a. Cement shall be type 1 and in areas having water logging and salinity, Sulphate resistant cement type 5 may be used. SEC Engineer shall direct to the type of cement to be used.

b. Water shall be free from silt, organic matter, alkalies or other impurities.

c. The average grain size of sand is 0.35 to 0.50 mm and the mud content shall not be more than 5%.

d. The size for natural gravel or the artificial crushed stone shall be determined according to the grading. Crushed stone of 10 to 40mm grain can be used. The aggregate shall conform to ASTM A23.1. Concrete shall be of minimum strength M20 (210Kg/cm²).

   Mud content in gravel shall not be more than 2% otherwise the gravel containing mud should be washed with water.

e. The sand, coarse aggregate and cement shall be proportioned according to the design mix approved by the design department. The measurement of material for ready mix concrete shall conform to specification for ready mix concrete ASTM C 94. The minimum cement content per cubic meter of concrete shall not be less than 250kg.

   The concrete shall be uniform in composition and consistent through out the mixed batch. Concrete temperature when being placed shall be not more than 38 °C and not less than 2 °C in moderate weather.

f. Where forms to be used, these shall be sufficiently tight to prevent loss of mortar from concrete and shall be maintained rigidly in position until concrete has hardened enough to prevent damage by the removal.

g. The contractor shall be paid only for SEC approved foundation size, if the pit not dug with auger and more soil disturbed, extra consumed concrete shall be the responsibility of the contractor.

h. If required by SEC Engineer, the concrete foundation sample test of pole and anchor shall be carried out. The concrete sample to be crushed after seven days.

10.7 Conductors

10.7.1 MV Conductor

Two standard sizes of ACSR/AW bare Aluminium conductors, conforming to SEC Specification No. 10-SDMS-01, are used for overhead primary distribution system as below:

a. Merlin
Merlin ACSR/AW conductor 170.45 mm² (336.4 MCM), rating 361 Amp.
Breaking strength = 38.22 kN
Maximum Design load = 9.55 kN.

Weight = 0.543 kg/m.
Diameter = 17.35 mm.

b. Quail
Quail ACSR/AW conductor 67.44 mm² (133 MCM), rating 207 Amp
Breaking strength = 23.62 kN
Maximum Design load = 5.91 kN
Weight = 0.273 Kg/m
Diameter = 11.34 mm.

i. The usage of conductor depends on the load flow. Marlin is used for primary lines and Quail is used for lateral lines.
ii. Quail 67.44mm2 ACSR/AW also to be used as continuous earth wire for MV lines.

10.7.2 <u>LV Conductor</u>

Two standard sizes of Quadruplex Aluminium conductors conforming to SEC Specification No. 11-SDMS-02, are used for overhead secondary distribution system as below:

a. Quadruplex XLPE insulated 3x120 +1x120 mm² with bare messenger ACSR/AW as neutral, rating 290 Amp for main feeder.
Breaking strength = 37.06 kN
Maximum Design load = 12.23 kN
Weight = 1.69 kg/m
Diameter = 41.60 mm

b. Quadruplex XLPE insulated 3x50 +1x50 sq. mm with bare messenger ACSR/AW as neutral, rating 125Amp for service drop.
Breaking strength = 15.32 KN
Maximum Design load = 5.11 KN
Weight = 0.675 Kg/m
Diameter = 28 mm

10.8 Splicing

There shall not be more than one splice in any span. Splicing sleeves shall be located at more than 3m away from the conductor support. No splice shall be located in crossing spans and in adjacent spans.

All conductors shall be cleaned thoroughly by wire brush before splicing, installation of a connector or clamp. A suitable oxide inhibitor shall be used before splicing or applying connectors over Aluminium conductor.

10.9 Overhead Conductor Clearances

Conductor spacing, clearances from other structures and ground for overhead conductors shall not be less than the values given in the following table 10.2. To achieve required clearances across high ways, steel poles of more height may be used.

VOLTAGE (Nominal)	33kV	13.8kV	LV
Between Rigid Conductors	0. 550	0. 460	0. 035
Between Rigid Conductors and Grounded Metal	0. 550	0. 460	0. 035
Overhead Line Conductor Spacing			
− Horizontal Configuration	1. 000	0. 760	0. 300
− Vertical Configuration	1. 200	1. 000	0. 410
Conductor Spacing Between Circuits (two circuit lines)			
− Double 33 K V	1. 200		
− Double 13.8 KV		1. 000	
− 33KV and LV			1. 200
− 13.8KV and LV			1.000
Ground Clearances			
− Above normal ground / Pipe lines	6.7	6.7	5.0
− Above roads / Wadi (above max. water level)	7.0	7.0	6.0
− Above rail tracks / Parking lots / Truck traffic	8.5	8.5	8.5
− Above high ways / high clearance roads	12.0	12.0	12.0
Horizontal Clearance From			2.0
− Buildings	2.0	2.0	
− Clearances from other structures	2.0	2.0	2.0
− Vertical clearance at crossings with Power Lines			
33KV	2.5	2.5	2.5
13.8 KV	2.5	2.5	2.5
LV	2.5	2.5	2.5

TABLE 10.2: Minimum Conductor Clearances (in meters)

10.9.1 NOTES FOR CLEARANCES

a. To achieve required minimum 2 m horizontal clearance of conductor from buildings, the recommended minimum distances of MV line poles from buildings shall be 4m for normal span horizontal construction and 2 m for short span vertical construction in medium soil.

b. Horizontal clearances refer to distances from the nearest conductor when conductors are operating at 80 ºC and highest wind pressure 600 N/m².

c. Vertical clearances between crossing and overhead conductors measured when conductors are operating at 80 ºC with no wind.

d. High voltage circuits shall always cross over lower voltage circuits. As far as possible the crossing should be perpendicular to the existing line and near to the structure.

e. Any distribution or service overhead conductors shall not cross over the roof of building, swimming pools, sports area and oil refinery under any circumstances.

f. From radio and television antennas, water tanks, signs, chimney and other installations (not classified as buildings), the minimum horizontal clearance of distribution lines shall be 3 m.

g. With reference to the normal ground clearance for LV service drop Quadruplex cable, the ground clearance may be reduced to 4m over streets.

h. Guys should not cross under an adjacent line.

i. Minimum clearance for MV lines from all other structures including trees shall be 2 m.

10.10 Pole Rake

Poles on which conductor tension forces (permanent transverse load) act, such as angle or terminal poles, should be raked. The direction of rake is such that the conductor tension forces try to straighten the pole. The angle of rake from vertical should be approximately 3º.

10.11 Long Straight Line

On long straight lines, every 10th pole should be a section pole. This strengthens the line and can facilitate maintenance of the line at a later stage.

10.12 Danger Sign And Number Plate

All 13.8 kV and 33 KV poles must have a high voltage danger sign fitted before the line is energized. This sign should be placed about 2m above the ground and on the side of the pole which is facing road or direction from which the public is likely to pass. All the poles and equipment must have a number plate which is placed immediately underneath the danger plate.

Danger sign and number plates should be as given in the latest revision of Specification No. 20-SDMS-02 of overhead line accessories. Drawing 10.4 shows details for mounting of danger sign and pole numbering assembly.

10.13 Protective Barrier

Protective barriers are used to protect poles, guys or equipment which is considered highly vulnerable to vehicular damages where the poles, guys or equipment can not be relocated to safer locations. Where the protective barrier could not be installed due to space limitations, surface of steel pole within1.25m above ground may be painted with two coats of high gloss, durable, weather resisting paint. Paint shall be yellow RAL 1018 and black stripes (each stripe 183 mm wide). Color of top most stripe shall be yellow followed alternatively by black and yellow color stripes up to ground level.

10.14 Sectionalizing and Disconnect Switch

Sectionalizing and disconnect devices shall be provided on the primary distribution lines where appropriate. Overall coordination of these devices and also the circuit breakers at the respective substations shall be ensured. Dropout fuse cutouts, load break switches and autoreclosers, if required, should be used to sectionalize lengthy laterals as given in the SEC Distribution Planning Guide. All the sectionalizing and switching devices shall be easily accessible and located so as to minimize service interruption to important loads.

10.15 Surge Arrestors (33KV &13.8KV)

Surge arresters shall be installed to all distribution transformers, autoreclosers, capacitors, regulators and junction between overhead line and cable.

10.16 Anti-Climbing Devices.

Anti climbing device shall be installed on all the poles and pole mounted transformer (PMT) structures to avoid climbing by unauthorized persons. Minimum fifteen (15) turns of barbed wire should be wrapped up for 750mm height around the steel pole about 3 meters above the ground level. Details for installation of anti-climbing device are shown in Drawing 10.5.

10.17 Grounding

Grounding practice shall be as being carried out by each Operating Area in their respective zones. However Drawing 10.6 shows the typical grounding arrangement of steel pole.

11 CONDUCTOR ERECTION

Conductors must be handled with care. Conductors shall not be run over by vehicles. Each reel shall be examined and the wires shall be inspected for cuts, kinks or other injuries. Injured portion shall be cut out and the conductor spliced. Adequate safety precautions are taken particularly while existing lines running parallel during construction. Grounding sets should be installed at both ends of the section and shall remain in place until completion of the work. For supporting the conductor reels during pulling out, jacks or special drum carriage vehicles are used. While the conductors are pulled out, they are raised at pole cross-arms and placed in stringing blocks or rollers.

11.1 Tensioning Of Conductors

It is important that the conductors are correctly tensioned during erection. Incorrect tension can lead to phase clashing and insufficient ground clearances, or premature structure failure and vibration failure of the conductors. Sagging is a means of measuring tension. Dynamometer may be used for sagging overhead lines. However it is difficult to measure tension accurately due to friction and inaccuracies of the meter.

11.2 Stringing

Time can be saved by mounting stringing blocks on poles during erection, together with pilot ropes (to pull the conductors through the wheels from ground level). The stringing blocks should be clean and running freely. If the section being strung ends on an angle pole, a temporary guy should be required to cater for the tensioning load. It should be noted that a stringing section cannot end on a LAP structure.

When stringing under an existing overhead line, a temporary stay should be installed at the exact crossing point. A nonrun loop of fiber rope should be placed over the conductors being strung and tied to the stay. This rope should be of such length that the new conductor cannot go higher than their specified height under the existing line as shown in Drawing 11.1. When stringing over an existing line, it should be switched off and a temporary structure may be required to help string the line over the existing line. The conductor is lifted into position on the stringing blocks and the line is ready for sagging.

11.3 Choosing Sagging Span

The average span length between the stringing points should first be calculated. This is done by dividing the total length between stringing points by the number of spans. The actual level span nearest this figure is used to sag the line. This span, when possible, should be near the centre of the line. Where this is not possible, the sag in a span near the other end should be checked before final termination. The sagging span should be measured on site with a tape.

11.4 Sagging

Conductors expand on warm days and contract on cold days. Because of this the sag and consequently the conductor tension varies with temperature. Before sagging takes place, the temperature of the conductor will be noted in order to calculate the sag. It is important that the temperature is measured as close as possible to the position the conductor will be in, during sagging and the thermometer should therefore be hung on one of the conductor supports of the sagging span. The thermometer should be allowed to settle for a minute before taking reading.

When the temperature is known, the corresponding sag for the sagging span is read off the sag charts. A sag lath is fixed on each of the poles in the sagging span. This lath is a straight length of wood and the vertical distance between this lath and the point at which the conductor runs through the stringing wheel is the value read off the table or sag chart.

The person who is appointed to do the sagging will position himself behind one of the sagging laths and take a sight line from the top of one sag lath to the top of the sag lath on the other pole as shown in Drawing 11.2.When the sag of the conductor is level with his line of sight, it is at the correct sag. It is recommended practice to over-tension the conductor by 10% (i.e. decrease sag by 10%) and allow to settle for about fifteen minutes before finally slacking back to the correct sag.

11.5 Sagging Non-Level Spans

Non-level spans shall only be used as sagging spans when there are no level spans between stringing points. Sags for non-level spans are determined by means of the "Non-Level Span Sag Formula" given in Drawing 11.3 which express the sag in terms of the sag of a level span of the same length. The same method as for measuring sag specified in section 16.4 is used except the vertical distances between the sag lath and the point at which the conductor runs through the stringing block shall be the values calculated from the non-level span sag formulas.

11.6 Binding

When the sagging operation is finished, the conductor is transferred to the insulators and the conductors terminated. The post type insulators shall be tightened on the pins. The conductors are placed in the top groove of post insulators on IMP structures. Top ties should be used with armour rods on these poles and the lay direction of the tie must be the same as the lay direction of the outer strands of the conductor. For LAP structures, the conductors shall be placed on the side of the post insulators and side ties with armour rods should be used.

11.7 Taps and Jumper Connections

Jumpers and other leads connected to the line conductors shall have sufficient slack to allow free movement of the conductors. Where slack is not shown on construction drawings, it will be provided by at least two bends in a vertical plane, or one in a horizontal plane, or the equivalent. In areas where Aeolian vibration occurs, special measures to minimize effects of jumper breaks shall be used as specified.

Parallel groove compression type connectors shall be used as connectors. Bolt type parallel grove connectors shall be used only at terminal locations. An approved oxide inhibitor shall be applied after cleaning the conductor surface by wire brush.

11.8 Sag and Tension Calculation

$$\{F^3 + \{E\left(\frac{W_1^2 L^2}{24 F_{01}^2} + a(T - T_{01}) - G\right) - F_{01}\} F^2 - E\frac{W_2^2 L^2}{24} = 01 \qquad (1)$$

Where:

F = Stress at T ° conductor temperature
F_{01} = Initial Stress at T01° conductor temperature such as at extreme condition
L = Ruling span
E = Modulus of Elasticity
a = Coefficient of Elasticity
W_1 = Equivalent weight of conductor at T01° conductor temperature
W_2 = Equivalent weight of conductor at T ° conductor temperature
G = Creep

$$d = \frac{W L^2}{8F} \qquad (2)$$

Where d = Sag at F tension

12 NORMAL SPAN CONSTRUCTION - HORIZONTAL CONFIGURATION

12.1 Application

This design is intended for use over long distances of 13.8 kV and 33 kV 4-wires overhead system where along the route there is enough space for horizontal clearance from the buildings or only scattered houses exist away from the line. This design when installed on high poles, can also be used to attain required clearances from trees (if trimming is not allowed) on narrow roads in farming area.

12.2 Configuration

The circuit configuration is 3-phase 4 wires through out the line (3 phase wires above and 1 earth wire below). Arrangements for single circuit horizontal configuration are shown in construction Drawings 001 to 028 and 29 to 48 for self support poles with the materials listed for each structure.

Standard conductor phasing shall be R,Y, B from North to South or East to West.

12.3 Span Length

The basic span length between different structures shall be 100 meters for Merlin or Quail conductors. The basic span lengths are based on the pole strength and phase separation. Actual span lengths should be kept as close as possible to this value.

12.4 Clearances

Ground clearances should be in accordance with table 10.2 for different height of poles (IMPs and LAPs) across level ground at maximum operating temperature. 12 m poles should give adequate ground clearance in the majority of situation. Branch poles for Merlin, however, normally should be not less than 13 m. For every 5m reduction in span length, ground clearance increases by approximately 0.15m.

12.5 Poles/Stays

One type of pole is used for different structures. IMP up to 5º line angle does not require to have stay with Merlin or Quail conductors. For angle, section, terminal and tap-off pole structures, the number of stays required shall be as follows:

Design	Structure				
	LAP	MAP	HAP	TER / BP	SEC
Merlin	1	2	2	2	2
Quail	1	2	2	2	2

TABLE 12.1: No. of Stays for Normal Construction

In case of section poles the stays shall be along the poles, refer to Sec-10 for details of stays.

12.6 Foundation Depth

MV distribution overhead line's support steel poles have a standard foundation depth of 2m.

12.7 Crossarm installation (Facing)

a. On straight lines of approximately equal span lengths, crossarms shall face alternately toward and away from each other on successive poles.

b. Crossarms shall be placed on the side of the pole away from long spans and crossings.

c. Crossarms shall be placed on the side of the pole facing the curve, angle, corner, steep grade and terminal pole.

13 MV DOUBLE CIRCUIT CONFIGURATION

13.1 Application

This design is intended for use in the construction of 13.8KV or 33 double circuit overhead lines

13.2 Configuration

The configuration consists of two circuits of 3-phase conductors, with each circuit in vertical formation and one earth wire below throughout the line. Arrangements are shown in drawings 108 thru 129 with the required materials listed for each structure. The standard conductor phasing shall be R, Y, B from top to bottom.

13.3 Span Length

The basic span length between different structures shall be 100 meters for Merlin and Quail conductors. The span length is based on pole strength and phase separation. Actual span lengths should be kept as close as possible to this value.

13.4 Clearances

The ground clearances on 100 m span at maximum operating temperature across level ground should be in accordance with table 10.2 for 14m and 15m poles (IMPs and LAPs) across level ground at maximum operating temperature. For every 5m reduction in span length, ground clearance increases by approximately
0.15m.

13.5 Poles/Stays

Steel poles type OC14D and OC15S/D are to be used for different structures. IMPs up to 5° line angle with Merlin or Quail conductors do not require to be guyed. For angle, section, terminal and tap-off pole structures, the number of stays required shall be as follows:

TABLE 13.1
No. Of Stays For Double circuit Construction

Design /Structure LAP MAP HAP TER / BP SEC

Merlin 2 4 4 4 4

Quail 2 4 4 4 4

In case of section poles the stays shall be along the poles, for the details of stays refer to Sec. 10.

13.6 Foundation Depth

The double circuit structure shall have a standard foundation depth of 2.0 m.

13.7 Crossarm Installations (Facing)

(a) On straight lines of approximately equal span lengths, cross-arms shall face alternately toward and away from each other on successive poles.

(b) Crossarms shall be placed on the side of the pole away from long spans and crossings.

(c) Crossarms shall be placed on the side of the pole facing the curve, angle, corner, steep grade and terminal pole.

14 SECONDARY OVERHEAD LINES

14.1 General

The secondary distribution lines distribute energy from the low voltage side of the transformer. The secondary overhead distribution voltage is normally 220/127 volts for residential and commercial area, and 380/220 volts for industrial area.
Service drop cable is the portion of the system which makes the final connection from the secondary to the consumer's premises..

14.2 Conductor And Span Length

The standard secondary conductor is Quadruplex 120 sq.mm with a rating of 290 Amps. Drawing 14.1 shows the relationship between the length of secondary line and KVA to give a voltage drop of 4 %. Basic span length is 50 m.
Service drop cable is Quadruplex 50 sq. mm.

14.3 Poles / Stays

The standard low voltage network pole is OC10 of 10 meter length for all pole positions. Foundation depth is 1.5 meter.
One stay is required for medium angle poles for angles 16º to 60º. Angles over 60º to 90º require two stays. Refer to sec.10.0 for the details of stays.

14.4 Construction

The neutral of Quadruplex is bonded 50 mm below the top of the pole as shown in construction drawings 130 to 138 for normal LV OC10 poles and drawings 141 to 145 for self support OC10SFS poles.

14.5 Connection To Overhead Service

Quadruplex XLPE insulated Aluminium.3x50mm² with ACSR/AW 1x50mm2 bare neutral is used for overhead service drop cable having current rating 125 Amp. Drawings 139 & 140 are showing the details of overhead service connection. Compression type PG aluminum connectors with insulated covers are used for the secondary network connections.