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SECTION-IV

Section - IV

Technical Specifications

1.0 General

All the works should be carried out strictly as per the contract document, specifications and drawings, etc. Any modification/changes pertaining to the work should not be carried out without the prior written approval from the Employer. Any modification/changes done without the prior approval will be asked to be dismantled / demolished at the cost of the Contractor and the Employer will not be responsible for any cost whatsoever associated with the modification of works. All approval shall be in writing and no verbal approval will be entertained. However, during the ambiguity between drawing and write up of technical specification, the write up of technical specification of the contract shall govern.

Prior to start of work, the Contractor is obliged to study the route and possible location of various poles, double pole, angle pole, etc. Any change in the route or modification should be made, if required only after obtaining necessary approval of the Employer. The scope of works to be carried out under the contract covers all the works associated with the:

a) Construction, Testing and Commissioning of 33 kV (Three phase & two phase) and 11 kV (three phase & two phase) overhead MV lines, LV ABC (three phase & Single phase) lines and service connections including line route finalization, transportation of materials from the designated stores to the work sites, erection of poles, fixing of pole caps, fixing of insulators, line stringing, clamping, earthing, erection of anti-climbing devices, danger plates, painting of poles, etc.

b) Erection, Testing and Commissioning of distribution transformers including transportation of material from the designated stores to the work sites, mounting of the transformers, distribution boards, associated pole-top equipment like lightning arrestor, drop-out fuses, earthing work, etc.

c) Felling of trees including cutting of trunks and branches, clearing jungles/bushes and removal of trees & branches and disposal.

d) Materials required for the execution of the Contract shall be collected from the designated stores as specified under Article III, Clause 6 of Conditions of Contract.

The Bidder shall note that supply of sand, stone chips, cement, charcoal, salt and other miscellaneous material required for the construction work is in the Bidder's Scope. Bidder shall also note that any excess materials procured by the Bidder for the construction works will not be taken by the Employer on completion of the project.

The work shall be carried out with full diligence and in accordance with the general guidelines listed herein. It is imperative/mandatory that the workers and the Supervisors wear safety helmet, safety belts and other kits for their own safety. The Bidder shall note that the actual work associated with the construction of lines may vary with respect to the number of spans/poles (provided as an estimate of materials enclosed with this section) and the unit price per km quoted by the Bidder shall govern irrespective of the actual number of overhead line structures.

The survey work shall be carried out in close coordination with the Employer's Engineer and the line route and the pole locations, angle points, etc. finalized and approved by the Employer's engineer. All the works associated with the erection shall be carried out under the general supervision of the Employer's Engineer/Supervisor.

2.0 Construction of 33 kV, 11 kV and Low Voltage Lines

2.1 General

This section covers the procedures to be adopted during the construction of 33 kV & 11 kV MV lines, LV lines, service connections, mounting of distribution transformers, etc. Before start of construction works, the persons in charge shall familiarize with the line route and acquaint themselves with the Local Rules, so that necessary provisions thereof may be adopted.

2.2 Distribution line voltages, locations and clearances

2.2.1 Standard voltage

Proposed Medium Voltage (MV) construction:

33 kV (Three Phase, 3 wire & Two Phase, two wire)
11 kV (Three Phase, 3 wire & Two Phase, two wire)

Proposed Low Voltage (LV) construction

LV ABC (Three phase, 415 Volts)
LV ABC (Single phase, 240 Volts)

2.2.2 Choice of route

The route selected for the proposed overhead line should be the one that will give the lowest cost over the life of the line. Route selection therefore involves consideration of a number of factors, including the cost of landowner compensation, the cost of transporting materials to the site, construction cost and the cost of ongoing maintenance requirements including vegetation control. As a general rule, line routes should be as short as practicable and should run as close to a road as possible since this facilitates access for both construction and maintenance. Consideration should also be given to the location of possible future line extensions, either to supply potential new loads or to service towns and villages that are currently un-electrified.

Where possible, line routes should avoid steep hills or valleys, swamps, lakes, thick forests, rivers or other locations where access is difficult or long spans are required. When building along a road, pole positions should not cause a traffic hazard or be in locations where there is a higher probability of vehicle impact.

The following should be avoided wherever possible:

(a) Areas likely to be used for future urban development;
(b) Routes incorporating sharp changes in line direction;
(c) Routes close to aerodromes;
(d) Religious monuments;
(e) Special trees of religious significance;
(f) School playgrounds;
(g) Cemeteries;
(h) Buildings containing explosives;
(i) Taking lines through individual/private plots; and
(j) Not considering the aesthetic of the land use.

Construction of lines over private land involves negotiation of a right of way which is to be avoided if a cost effective alternative route along public roads is available.

2.2.3 Approval of Line Routes

Prior to the erection of lines along public roads, the authority responsible for the road should be contacted and approval obtained for the location of all poles, road crossings, tree cutting or trimming and guying locations. Where overhead distribution lines are to be constructed in urban areas, it will also be necessary to contact the local Town Planning Authority for approval. Where appropriate, approval should also be obtained from authorities such as the National Environment Commission, Department of Forestry, etc.

Once the line route is finalised, a detailed line survey should be undertaken and the pole locations finalized and marked. Poles should be located well clear of water and other areas of potential land subsidence. Poles for lines that cross-agricultural fields should, wherever possible, be located at bunds.

2.2.4 Tree clearances

The width of line route to be cleared of trees will depend upon the voltage and the importance of the line concerned. While no rigid limits are provided, the following clearances should be adhered to, as far as possible.

Voltage	Comment
33 kV lines (Bare ACSR, 3 phase & 2 Phase)	The route should be cleared of all growth within 6 m on either side starting from the centre of the line and, in addition, of trees that could fall and contact the line.
11 kV lines (Bare ACSR, 3 phase & 2 Phase)	The route should be cleared of all growth within 4.5 m on either side starting from the centre of the line and, in addition, of trees that could fall and contact the line.
33 KV Lines (Covered Conductor, 3 Phase & 2 Phase)	The route should be cleared of all growth within 4 m on either side starting from the centre of the line and, in addition, of trees that could fall and contact the line.
11 KV Lines (Covered Conductor, 3 Phase & 2 Phase)	The route should be cleared of all growth within 3 m on either side starting from the centre of the line and, in addition, of trees that could fall and contact the line.
Low voltage ABC	Left to the discretion of the Supervisor. Aerial bundled low voltage conductor is insulated so contact with vegetation should not cause a fault. However, the route should be cleared so the risk of trees falling across the line is minimized.

2.2.5 Crossing of Telecommunication Lines by Power Line

While crossing a telecommunication line, minimum clearance of 1.80 metres shall be adopted.

3.0 Construction, Testing and Commissioning of 33 kV, 11 kV and LV overhead Lines

3.1 Erection of supports for Telescopic pole

Telescopic poles are already hot galvanised and pre-painting of the poles are not required.

Steel poles that are not hot dip galvanised should be delivered to site with the exterior of the pole pre-painted with bituminous paint from the base of the pole up to ground level. If the pole is not so painted, bituminous paint must be applied before the pole is installed.

Pits for pole supports should be excavated in the direction of the line. The depth of the foundation shall be 1400 mm for 7.5 metre poles (LV), 1900 mm for 11.2 metre (11& 33 kV without shielding wire) poles and 2100mm for 12 metre (11 & 33 kV with shielding wire) poles, while the area of the foundation will be 1000x1000mm.The ground line position shall be at approximately 1/6 of the total pole length.

Before the pole is put into the pit, a stone base at least of 10mm thick shall be placed at the bottom of the pit. When the pole is erected inside the pit, wooden dead men may be utilized to facilitate lifting of the pole. Once planted into the pit, the pole should be kept in a vertical position with the help of ropes, using them as a temporary anchor.

As the poles are being erected, say from an anchor point to the next angle point, the alignment of the poles is to be visually checked and set right. The verticality of the poles shall be checked with a spirit level in both transverse and longitudinal directions. In case of LV lines, the holes for fixing hook brackets should also to be checked to ensure they are facing the proper direction.

Since concrete foundations are not required for telescopic poles, so in this case the foundation should be backfilled with excavated soil. The backfill should be progressively compact as the foundation is filled. Do not simply refill the foundation and compact at the surface.

After the poles have been set and the excavated pit backfilled and compacted, the temporary anchors may be removed.

3.2 Erection of supports for Steel Tubular pole

Steel poles that are not hot dip galvanised should be delivered to site with the exterior of the pole pre-painted with bituminous paint from the base of the pole up to ground level. If the pole is not so painted, bituminous paint must be applied before the pole is installed.

Pits for pole supports should be excavated in the direction of the line. The depth of the foundation shall be 1400 mm for 7.5 metre poles (LV), 1600 mm 9.0 metre (11 kV) poles and 1900 mm for 10 metre (33 kV) poles, while the area of the foundation will be 600x700mm.

Before the pole is put into the pit, a stone base of 100 mm thick shall be placed at the bottom of the pit. In lieu of 100 mm PCC base, base plate is being used. When the pole is erected inside the pit, wooden dead men may be utilized to facilitate lifting of the pole. Once planted into the pit, the pole should be kept in a vertical position with the help of ropes, using them as a temporary anchor.

As the poles are being erected, say from an anchor point to the next angle point, the alignment of the poles is to be visually checked and set right. The verticality of the poles shall be checked with a spirit level in both transverse and longitudinal directions. In case of LV lines, the holes for fixing hook brackets should also to be checked to ensure they are facing the proper direction.

Once the verticality and alignment are satisfactory, the pit shall be backfilled and compacted to a distance of 450 mm below ground level. A 500 x 500 mm concrete foundation shall then be constructed around the pole and extending to 300 mm above the ground level as shown in the relevant drawings. The concrete shall be a mixture of cement, granite chips of 20/30 mm mesh and sand in the ratio of 1:2:4. The top of the foundation shall be tapered to allow water to run away from the pole.

Concrete foundations are not required for poles that are hot dip galvanised. In this case the foundation should be backfilled with excavated soil. The backfill should be progressively compacted as the foundation is filled. Do not simply refill the foundation and compact at the surface.

After the poles have been set and the excavated pit backfilled and compacted, the temporary anchors may be removed.

3.3 Erection of Double Pole Structures for Angle Locations (33 kV and 11 kV Lines)

On medium voltage lines, where the angle of deviation is more than 10 degrees, a double pole structures as shown in drawing BPC-DCS-010 shall generally be erected. The pits are to be excavated along the bisection of the angle of deviation.

Before the pole is put into the pit, a stone base of 100 mm thick shall be placed at the bottom of the pit. In lieu of 100 mm PCC base, base plate is being used. After erection of the poles the pits will need to be temporarily backfilled so the poles can be climbed and the horizontal bracing fitted. The structure should then be set for verticality and alignment and the supports held in position with the help of temporary rope guys.

The temporary backfilling should be removed and permanent foundations constructed by backfilling, compacting and, if necessary, concreting each pit as described in Section 3.1and 3.2. Concrete foundations are not required if the poles are hot dipped galvanised.

Guys along the bisection of the angle of deviation, as required by the conductor size and angle of deviation, are to be provided. These shall be constructed in accordance with Section 3.5.

3.4 Special Foundation in Unstable Soil

Special care has to be taken where foundation in unstable soil is encountered.

In such locations, mass concrete foundations, extending up to the ground level, are to be adopted to avoid collapse of foundation in the unstable soil. The concrete is to be a mixture of cement, granite chips of 20/30 mesh and sand in the ratio of 1:2:4.

3.5 Anchoring and providing guys for supports

One or more guys installed in accordance with the guy arrangement shown in Drawing BPC-DCS-010/1 shall be provided for all supports where there is an unbalanced force on the support that may result in tilting/ uprooting or breaking of the support. Normally, these guys are provided at the following locations:

(i) angles;
(ii) dead end locations;
(iii) tee-off points; and
(iv) steep gradient locations to avoid uplift on the poles.

Guy wires shall be angled at 45^o from the vertical for 33 kV and 11 kV lines and 30^o from the vertical for low voltage lines.

Single guys shall be provided for single poles with line deviations from 5˚ to10˚ and also for double poles with line deviations not exceeding 30˚. Where the angle of deviation exceeds 30˚, two guys along the resultant angle of line deviation or one guy in each direction of the line shall be provided. When two or more stays are fixed to the same support, each stay should be attached separately to the pole.

The installation of guy will involve the following works:

(i) Excavation of pit and fixing guy rod;

(ii) Backfilling and compacting the guy foundation;

(iii) Fastening guy wire to the support; and

(iv) Tightening guy wire and fastening to the anchor.

After completion of installation work the foundation shall be allowed to consolidate for at least 7 (seven) days before installation of the guy wire.

When installing the guy wire, the turnbuckle shall be mounted at the pole end of the stay and guy wire so fixed that the turn buckle is half way in the working position; thus giving the maximum movement for tightening or loosening. Where the existence of guy wire may be hazardous, it should be protected with a suitable PVC pipe, filled with concrete of about 2-metre length above the ground level, duly painted with white and black stripes.

No guy insulator shall be located less than 3 metres from the ground.

3.6 Fixing of Cross Arms and Insulators

The practice of fixing the cross arm and top hamper before the pole is erected is acceptable. If the cross arm is mounted after the support is erected, all the materials or tools required should be lifted or lowered by means of the hand line.

Horizontal cross arms and pole top brackets (hamper assemblies) for 33 kV and 11 kV lines are standardized. They shall be fitted as shown on the drawings.

3.7 ACSR Conductor

The sizes of conductors for the proposed 33 kV and 11 kV overhead line is DOG (ACSR-100 mm^2) and RABBIT (ACSR-50 mm^2)

During running out, the conductor drum should be securely supported on drum jacks with an axle, so that the conductor is pulled from the top of the drum. The drum jacks should be on a firm foundation and the axle of the drum jack should be levelled horizontally. Care must be taken to ensure that the conductors are not damaged by contact with the ground or pole hardware during running out and that kinking, twisting or abrading the conductor is avoided. The conductor should not be trampled on, run over by vehicles or dragged over the ground.

Extreme care must be taken to avoid contact with the conductors of any other live line in the vicinity when running out or stringing conductors, and if necessary neighbouring lines should be de-energised during the stringing operation.

Stays shall be installed and kept in position before conductors are strung to avoid over straining of poles. Stringing pulleys shall be used while stringing conductors.

3.8 Mid-Span Jointing of Conductors

Mid-span jointing of conductors shall use compression joints, appropriately sized for the conductor and made with a proprietary compression tool using appropriate sized dies.

3.9 Sagging and Tensioning of Conductors

After completion of conductor stringing and making any mid-span joints, conductor tensioning operations can commence. The conductors are first attached to the insulator string assembly at the non-tensioning end of the section, using preformed dead-ends. Further, before tensioning commences, temporary guys should be provided as necessary for the anchoring supports at each end of the line section to be tensioned to avoid over-stressing the strain poles due to unbalanced loads.

The centre conductor should be tensioned first followed by the outer two conductors. At the tensioning end, the conductor being tensioned is pulled manually up to a certain point and then a come-along clamp is fixed to it. The grip to the come-along clamp is attached to a double sheave pulley block or a pull-tight machine and the conductor is gradually tensioned.

The conductor should then be sagged in accordance with the sag-temperature chart for the particular conductor and span. These are given in Section 3.10 below. The correct sag should be measured in the middle span of the section.

The stretch of the conductor has to be taken out before sagging in order to avoid the gradual increase in sag, due to the setting down of the individual wires. There are two ways of accomplishing this:

(i) Pre-stressing

Using the prestressing method, the conductor is pulled unto a tension considerably above the correct figure, but never exceeding 50% of breaking load for a period of about twenty minutes. As this method requires more time and involves the use of stronger tackle to secure the higher tension, it is not commonly used.

(ii) Over tensioning

The over tensioning method consists of pulling up the conductor to a tension of 5%-8% above the theoretical tension for the prevailing temperature and fixing the conductor at that tension with correspondingly reduced sag. Over time, the conductor will settle down to the correct sag and tension.

Conductors can be sagged correctly only when the tension is the same in each span throughout the entire length of the section. Use of snatch blocks during sagging reduces the friction and chances of inequality of tension in various spans.

Measurement of conductor sag can be accomplished by several different methods but most commonly used method is 'sighting'. Targets are placed on the supports below the cross arms. The targets may be light strips of wood, which are clamped to the pole at each end of the sagging span at a distance below the conductor when the conductor is placed in snatch blocks that is equal to the required sag. A lineman sights the sag from the next pole and the tension of the conductor is reduced or increased, until the lowest part of the conductor in the span coincides with the lineman's line of sight.

When sagging is completed, the preformed dead end should be fixed to the tension end. The dead-end and socket thimble can be fitted to the conductor without releasing the tension. A mark is made on the conductor at a distance from the cross arms equal to the length of the complete strain insulator to indicate where the dead-end should be installed.

After the dead-end has been installed and the insulator string attached to the top hamper or cross-arm, the conductor is pulled in sufficiently using the come-along clamp, to allow the insulator assembly to be fitted to the socket thimble. After the conductor is attached, the conductor tension may be released gradually. If the tension is released with a jerk, an abnormal stress may be transferred to conductor and support, which may result in the failure of the cross arms, stay or pole.

After the stringing is completed, all poles, cross-arms, insulators, fittings, etc. should be checked to ensure that there have been no deformities, etc.

The conductor is then placed on the pin insulator on each pole ready for tying and to remove the snatch blocks. On straight line poles the conductor should be tied to the top groove of the insulator and on angle poles the conductor should be tied to the side groove. The conductor is then fastened to the insulator using aluminium helities or binding wire.

In fastening the conductor to pin insulators, the following points should be observed:

(i) The correct size of binding wire, which can be readily handled, and with adequate strength should be used.

(ii) The length of tie wire should be sufficiently long for making the complete tie including end allowance for gripping each end.

(iii) A good tie should provide a secure binding between the line conductor and insulator, and should reinforce the conductor on either side of the insulator.

(iv) The use of cutting pliers for binding the tie wire should be avoided.

(v) A helitie or binding wire that has been used previously should not be reused.

(vi) Before tying the conductor to the insulator, it shall be ensured that only the portion of helities wrapped with chloroprene pad (where applicable) touches the insulator.

(vii) At section poles correctly sized parallel groove (PG) clamps must be used to connect the two conductor tails.

3.10 Conductors Sag and Tension

The following sag-span tables are provided for the guidance of field staff when stringing conductors.

3.10.1 Bare ACSR Conductors

Sag-Span Chart – 33 kV, DOG

Conductor : Bare ACSR DOG
Voltage : 33 kV
Design Tension : 1.95 kN kg at 15^{o}C, no wind (approx 5% of MBL)

Temp	**10^{o}C**	**15^{o}C**	**25^{o}C**	**30^{o}C**	**50^{o}C**
Span (m)					
40	0.34	0.40	0.50	0.55	0.88
50	0.56	0.62	0.73	0.79	1.17
60	0.83	0.89	1.01	1.07	1.49
80	1.52	1.59	1.72	1.78	2.26
100	2.38	2.45	2.59	2.65	3.19
150	5.44	5.52	5.66	5.73	6.33

Sag-Span Chart – 33 kV, RABBIT

Conductor : Bare ACSR RABBIT
Voltage : 33 kV
Design Tension : 1.04 kN kg at 15^{o}C, no wind (approx 5% of MBL)

Temp	**10^{o}C**	**15^{o}C**	**25^{o}C**	**30^{o}C**	**50^{o}C**
Span (m)					
25	0.125	0.157	0.231	0.266	0.389
30	0.187	0.227	0.310	0.350	0.488
35	0.262	0.308	0.400	0.443	0.595
40	0.352	0.403	0.501	0.547	0.712
60	0.845	0.907	1.023	1.078	1.280

Sag-Span Chart – 11 kV, DOG

Conductor : DOG
Voltage : Bare ACSR 11 kV
Design Tension : 5.71 kN kg at 15^{o}C, no wind (approx 17% of MBL)

Temp	**10^{o}C**	**15^{o}C**	**25^{o}C**	**30^{o}C**	**50^{o}C**
Span (m)					
40	0.12	0.14	0.18	0.22	0.65
50	0.19	0.21	0.28	0.33	0.84
65	0.27	0.31	0.40	0.45	1.03
80	0.49	0.54	0.68	0.75	1.46
100	0.76	0.84	1.01	1.11	1.93
150	1.76	1.88	2.14	2.26	3.33
200	3.20	3.35	3.65	3.80	5.05
250	5.06	5.23	5.57	5.74	7.13
300	7.35	7.54	7.90	8.07	9.57

Sag-Span Chart – 11 kV, RABBIT

Conductor : Bare ACSR RABBIT
Voltage : 11 kV
Design Tension : 3.02 kN kg at 15^{o}C, no wind (approx 17% of MBL)

Temp	**10^{o}C**	**15^{o}C**	**25^{o}C**	**30^{o}C**	**50^{o}C**
Span (m)					
25	0.047	0.054	0.076	0.093	0.220
30	0.068	0.078	0.108	0.131	0.280
35	0.093	0.106	0.146	0.174	0.344
40	0.122	0.139	0.188	0.222	0.412
60	0.278	0.313	0.404	0.460	0.720

3.10.2 Covered AAAC Conductors

Conductors shall be tensioned by evenly tensioning each conductor. The sag and tension tables and recommendations of conductor manufacturer should be utilized.

3.11 Supports at Different Elevation

Where the supports at each end of a span are at different elevations the following formula can be used for sagging the conductor.

$$d_1 = d(1-h/4d)^2$$

where:

d_1 = vertical distance between the conductor at the lower support and the lowest mid-span point.

d = sag for a level span equal to the slope distance between the poles. The slope distance is the distance that would be measured by a tape stretched between the two poles. Once this is known the value of d can be taken from Sag-Span chart above.

h = difference in height between the conductor at each end of the span.

The above formula can be used to determine the value of d_1. A sighting board can then be attached to the lower support pole and the conductor sagged be sighting horizontally through it. One way to do this would be to attach a second sighting board to the next pole. Check that the two sighting boards are level using a taut line and spirit level. The sag can then be sighted using the two sighting boards.

3.12 Good Conductor Stringing Work Practices

DO:

Use proper equipment for handling aluminium conductors at all times.
Use skids, or similar method for lowering reels or coils from transport to ground.
Examine the reel before unreeling for presence of nails or any other object, which might damage the conductor.
Rotate the reel or coil while unwinding the conductor.
Unwind the conductor in the direction of the arrow on the side of the drum
Grip all strands when pulling out the conductor.
Control the unreeling speed with a suitable braking arrangement.
Use wooden guards of suitable type to protect the conductor when pulling it over barbed wire fences, sharp rock edges or similar obstructions.
Use long straight, parallel jaw grips with suitable liners when pulling the conductor in order to avoid nicking or kicking of the conductors.
Use free-running sheaves or blocks with adequate grooves for drawing/paying conductors.
Measure temperatures accurately with an accurate thermometer.
Use proper sag charts.

Mark conductors with crayons or adhesive tape or such other material which will not damage the strand.
Make all splicing with the proper tools.

DO NOT

Do not handle conductors without proper tools at any stage.
Do not pull conductors without first ensuring that there are no obstructions on the ground.
Do not pull out a greater quantity of conductor than is required.
Do not make jumper connections on dirty or weathered conductor. Instead, clean the conductor with sandpaper. Alternatively apply a chromite or graphite conducting oxide-inhibiting grease to the point of connection and then clean the conductor with a wire brush.
Do not handle aluminium conductor in a rough fashion but handle it with care it deserves.

At road crossings, a flagman should be in attendance to that traffic is not unduly interrupted. The running of conductor across roads should only be carried out in with the approval of the Authority responsible for the road.

Conductor drums should be transported to the tension point without injuring the conductor. If, it is necessary to roll the drum on the ground for a small distance, it should be slowly rolled in the direction of the arrow marked on the drum.

When running out conductor the drum should be so supported that it can be rotated freely. For this purpose, the drum should either be mounted on the cable drum supports or jacks or hung by means of chain pulley of suitable capacity, suspended from a tripod. If it is not possible to raise the conductor drum by any of the above methods, a trench of suitable depth slightly bigger than the conductor drum may be dug, so as to facilitate free rotation of the drum when it is suspended above the trench using a steel shaft. While running out the conductor, care should be taken to ensure that the conductor does not rub against any metallic fitting of the pole or on the uneven or rocky ground. Wooden trusses may be used for this purpose to support the conductor when running out.

Should the length the conductor be less than the length of the section, the conductors should be run out from both ends and joined where they meet with a mid-span full tension joint.

On no account, should any part of the conductor shall be left overnight at a height of less than 5 metres above the ground. The work should be so arranged that before the end of the day, the conductor is raised to a minimum height of 5 metres above the ground by rough sagging.

3.13 Low Voltage Aerial Bundled Conductors (ABC)

Sag-Span Chart for Low Voltage ABC Conductors

Conductor Size	**50mm^2**		**95mm^2**	
Design Tension at 15^{0}C (kN)	**2.52**	**5.04**	**4.79**	**9.58**
Span (m)	**Sag (m)**			
30	0.15			
40	0.26			
50	0.41			
60	0.59			
70	0.80			
80	1.04			
90	1.32			
100	1.63			
110	1.97			
120	2.35			
130	2.75			

Maximum Spans for Aerial Bundled Cable

Pole Length (m)	**Maximum Span (m)**	
	Across Street	**Elsewhere**
7.5	50	80 (4 core)
		100 (2 core)

In installing aerial bundled cable, the cable must be pulled from the top of the drum and should not be dragged along the ground. A suitable ‘drum brake’ mechanism shall be used to prevent conductor overrun. Stringing pulleys compatible with bundled conductor shall be installed on every pole. During running out, the cable should be pulled out by hand or by using a nylon-pulling grip designed for bundled cables. Insulated conductor grips designed to prevent damage to the insulation of the conductor shall be used for tensioning. Every care must be taken to avoid damage to the conductor insulation.

Dead-end (termination) fittings shall be fitted to the conductor after tensioning at each termination point. Intermediate fittings shall then be fitted at major angles and then at smaller angles. After all fittings are in place the sagging should be checked at two places and corrected if necessary.

Insulation straps (cable ties) shall be used to tie the conductor at each supporting point.

3.14 Earthing of Distribution Lines

All 33 kV and 11 kV steel poles should be separately earthed. The earth pin is a 2.5 m galvanised steel rod, which must be driven into undisturbed ground clear of the pit excavation. It is not acceptable to insert the earth rod in the pit excavation as the backfill used often does not provide a good earth connection.

The earth pin is connected to the pole using No 8 SWG galvanised steel wire as shown in the drawings. Lugs and bolts must be used for both the connection to the pole and to the earth pin. Wire wrapped connections are not acceptable as a good electrical connection cannot be assured. A special steel plate is used to ensure a proper connection between the earth wire and the pole. The plate is bolted to the pole using the earthing hole provided about 300 mm above ground level.

The earth resistance of the pole and earth pin connected together should be as low as possible and ideally should not exceed 10 ohms. Additional earth pins, spaced at least 1 metre apart, should be used in difficult locations, to reduce the resistance.

Drawing BPC-DCS-015 shows the pole earth components. The earthing stake for pole earths is also used for earthing LV distribution pillars.

The earth resistance of the earth stake and pole connected together should be measured and recorded every tenth pole. The earth resistance of a greater percentage of poles should be measured if earth resistances are high or if there is high soil variability.

3.15 Final Completion and Commissioning

Before a line is energised for the first time pre-commissioning installation work must be completed on each pole. This comprises:

(i) The painting of non-galvanised poles with aluminium paint with the bottom two metres above the ground to be painted black;

(ii) The attachment of barbed wire to medium voltage pole where required by BPC to discourage unauthorised pole climbing. The barbed wire is wrapped around the pole just below the mid section pole joint; and

(iii) Fixing of danger notices to the bottom of each pole where required by BPC. The danger notices should be fixed about 1 metre above ground level and, where appropriate, should face the road or any track or other pedestrian walkway.

Before commissioning a line into service, the line shall be visually checked over its full length to ensure that all structures are correctly installed, all pole earths are installed and connected, all conductors are correctly bound and terminated on all structures and all tools and other equipment have been removed.

The line shall be energised with all distribution substations isolated and unloaded on the low voltage side. Where the line is directly connected to a zone substation supply bus, rather than to an upstream line, the protective relay settings should be reduced. Once the line has been successfully energised, the correct protection relay settings should be applied and the distribution substations connected to the load one at a time.

In energising distribution transformers for the first time, the MV drop out fuse should first be closed to liven the transformer on no load. The transformer can then be loaded by closing the incoming MCCB in the LV feeder cubicle.

4.0 Installation of Pole Mounted Distribution Transformer Substations

4.1 Selection of Site

The location of pole mounted distribution transformer substations should ideally be:

- as close as possible to the centre of the load, in order to reduce the voltage drop in the low voltage circuits;
- in a location that is clear of obstructions and is that provides satisfactory access for the incoming medium voltage overhead distribution line;
- readily accessible for transportation of the distribution transformer to site;
- above a road rather than below it where this is practical; and
- in a location likely to provide a low resistance to earth.

4.2 Substation Structure and Earthing

Distribution substations shall be constructed in accordance with BPC's arrangement drawings.

Particular care should be given to the construction of the earthing system as proper earthing of distribution transformer substations is necessary to ensure safe operation of the supply system. The earth pits should be located as shown in Drawing BPC-DCS-018 and the earth connections to the substation structure are shown in Drawing BPC-DCS-020.

BPC's standard earthing conductor for transformer substations is 25x6mm galvanised iron strap.

Three separate earth straps are used, one to earth electrode. These are connected as follows.

- One earth electrode is connected to each lightning arrestor and the transformer tank. It is important that the earthing conductor is kept as short as possible.

- The second earth electrode is connected to the transformer LV neutral bushing, the transformer tank and the crossarms supporting the dropout fuses.

- The third earth electrode is also connected to the transformer tank and LV neutral and also to the earth in the low voltage distribution cabinet.

The three earth electrodes should be connected together by an equipotential earthing ring embedded at least 100 mm below ground level.

Earth resistance tests of the three earth electrodes connected together should be undertaken on installation and subsequently at intervals of no greater than 10 years. The maximum permissible earth resistance is 5 ohms. Bentonite soil and salt can be used inside the earthing pipes to reduce the earth resistance. In extreme situations additional earth electrodes should be installed.

4.3 Transportation and Handling of Transformers

Distribution transformers should be stored in such a way that 'first in first out' becomes a normal procedure. Care must be taken to place the transformers in store in such a fashion that no damage occurs to tank, bushings, etc. due to movement of personnel and materials.

Transformers should be loaded and unloaded with care. Prior to loading a transformer for dispatch to site, the transformer condition (bushings, fittings, tank, oil level, etc.) should be checked. If any damage is noticed, the in-charge should be notified immediately, and transformer should be loaded only after the written approval of the person in charge.

Every transformer dispatched to site should be entered individually in store register. This register should have the following:

(i) Serial Number
(ii) Date of receipt
(iii) Transformer capacity (kVA)
(iv) Manufacturer's name
(v) Date of Despatch to site
(vi) Name of site
(vii) Technical test reports

Transformers should be lifted using the lifting lugs provided on the transformer tank and the lifting arrangement should not cause unbalance of the transformer. Before lifting the complete transformer, it should be ensured that all cover bolts are tightened. The slings, lifting tackle, etc. to be used in hoisting of transformers should have adequate strength to handle the weight.

During transport of transformers, they should be rigidly secured to the transport vehicle and packing materials put on either side of the base of the transformer to prevent skidding. A responsible official shall supervise the loading. Rollers, if provided, should be removed.

Care should be taken in transporting transformers to site to prevent the transformers moving when going up and down hills and around corners.

Transformer should be brought just adjacent to the double pole structure for hoisting it on the transformer platform. Lifting tackle should be used for hoisting transformer on structure.

In case, it is not possible to bring the vehicle carrying transformer near the double pole structure, it should be unloaded at a nearest safe place and carried to the double pole structure manually with great care and under proper supervision or shifted on platforms fitted with rollers.

While hoisting transformers on the transformer platform, safety precautions by way of fixing additional clamps and bolts should be taken.

Readymade slings to suit the capacity of transformer should be available.

4.4 Protection of Distribution Transformers

The pole mounted distribution substation arrangement has been standardised to the extent possible with the structure and the high voltage connections being identical for all transformer sizes. Dropout fuses are provided on H.V side of the transformer for isolating and protection. The size of fuse link used in these drop out fuses will vary with transformer rating. Acceptable fuse link sizes for BPC's existing transformer capacities are given below. For transformers located at the remote end of rural feeders, where the short circuit levels are potentially low, fuse links at the lower end of the allowable range should be used.

Acceptable Transformer Medium Voltage Fuse Link Ratings

MV Rating (kV)	Phases	Capacity (kVA)	Rated Current (A)	Fuse Link (A)
33	3	63	1.1	2 to 4
33	3	125	2.2	4 to 7
33	3	250	4.4	9 to 16
33	3	500	8.7	16 to 32
33	1	10	0.3	1 to 2
33	1	16	0.5	1 to 2
33	1	25	0.8	2 to 3
11	3	16	0.8	2 to 3
11	3	24	1.3	2 to 4
11	3	63	3.3	7 to 9
11	3	125	6.6	16 to 25

11	3	250	13.1	32 to 40
11	3	500	26.2	50 to 100
11	3	1250	65.6	150 to 300
11	1	10	0.9	2 to 3
11	1	16	1.5	3 to 7

On the low voltage side of the transformer the supply cable is run into a 4-way feeder cubicle mounted on the transformer structure. The cubicle's incoming cable is terminated into a circuit breaker which can be used to offload the transformer. Three pole moulded case circuit breakers (MCCBs) shall be used for transformer sizes up to and including 500 kVA. Air circuit breakers may be used for larger transformers.

4.5 Installation of Distribution Pillars

Distribution pillars are used to connect LV ABC Cable to the feeder poles. LV UG Cables are used to connect Transformer LV side to Distribution pillars. Distribution pillars must be effectively earthed. An earthing stake should be installed at the pillar location and this should be connected to an earthing terminal on each side of the pillar using 25x6 galvanised iron strips. Drawing no. BPC-DCS-019 may be referred for connections.

4.6 Connection of Supply to Consumer's Premises

Supply to consumer premises through a 2 or 4 core overhead cable in situations where consumers are fed from the overhead system and a 2 or 4 core underground cable when fed from an urban underground system.

Drawing BPC-DCS-022 shows the connection arrangement for a single phase consumer. The residual current circuit breaker (RCCB) shown in the drawing is optional but the remainder of the circuit is mandatory. All components except the energy meter shall be provided by the consumer. The energy meter will be provided by BPC.

A new connection should not be livened unless;

- The consumer has installed an MCB as a point of isolation;
- The consumer has installed a stake earth, which is connected to a main earth terminal on the consumer's distribution board;
- Each and every power point is properly earthed;
- There is a link between the earth terminal and the incoming neutral. As shown in the drawing, the configuration of this connection will depend on whether or not the customer chooses to connect an RCCB.