TECHNICAL STANDARDS

FOR

EXTERNAL LINE PLANT USING COPPER CABLES

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Chapter 4 – Operations and Maintenance

CHAPTER ONE

DESIGN PARAMETERS

1.0 Scope

The external Line plant network and interconnecting network shall provide communications facilities for multimedia services as well as interconnections between the switches.

The external Line plant network shall constitute the following sub-networks

- The primary network – made up of all the plant from the switch via Manholes, Joint boxes and hand holes to cross-connection cabinets. The primary networks shall be constructed with conduit facilities and cross-connection cabinets.
- The distribution network – made up of all plants from the cross-connection cabinets via the distribution boxes and poles to customer premises.
- Cable Chamber - part of the exchange building and consists of terminal joints, central riser for internal cables, cable routing scheme, and cable chamber below subsoil water level.

- Main Distribution Frame (M.D.F.) - the Cross-connection point between the telephone exchange and the equipment external cable plant. The MDF shall be equipped with cable terminations and protection equipment.

The external Line plant network shall be designed for a minimum life period of

- 15 years for the primary network
- 20 years for the distribution network

2.0 Transmission Standards

2.1 Subscriber Line

- Maximum D.C loop resistance shall not exceed 1,500 ohms

- Insulation Resistance shall not be less than 10,000 M-ohms-km
- Transmission loss (for cable pair only) shall not exceed 8.5 dB measured at 800 Hz.
- Maximum allowable lengths of unloaded cable to satisfy the transmission requirements shall be as follows:

GAUGE	LENGTH OF CABLE
0.5 mm	5.8 km
0.65 mm	8.5 km
0.9 mm	12 km

2.2 Junction Lines

- Maximum loop resistance shall not exceed 2,000 ohms
- Minimum Insulation Resistance shall not be less than 10,000 M-ohms-km
- The line attenuation shall not exceed 6 dB measured at 800 Hz
- Conductor tensile strength shall not be less than 200MN/m^2

2.3 Operating Environment

All the plant shall be designed to operate under:

- Ambient temperature range of 10°C to 65°C
- Relative humidity range of 15% to 95%

2.4 Distribution Network

Telephone exchange areas shall be divided into well-defined cabinet areas each with its own cross-connection cabinet.

- **Direct Feed Area**

Any areas within a radius of 500m of the switch can be serviced directly.

- **Cross Connection Cabinet Area**

Telephone distribution shall be based on the cross connection cabinet system. An exchange area shall be designed into cross connection cabinet areas with clearly defined feeding routes for main cables. Routes should spread out from the exchange in different directions, so as to reach customer premises with minimum cable length routing. Cross-connection cabinet areas shall be designed in a ring around the Direct Feed Area.

- **Distribution Points And Stumped Pairs**

- Consumer premises shall be serviced through distribution points.
- Spare cable pairs not used for connecting customer premises shall be left in the distribution points as stumped pairs. Stumped pairs shall also be left at areas where new developments are expected.
- Crossing of wide roads must be by underground cable duct to an external DP (pole mounted or otherwise).

3.0 Conduit System

Conduit system shall be of PVC, concrete-encased PVC ducts and galvanised steel ducts. Ducts shall be constructed in horizontal layers. The formations shall be 1, 2, 4, 6, 9, 12, 16, 20, 24, 30 and 36 and 48 ways. Manholes, Joint boxes, chambers for the placing and jointing cables shall be placed along the route at street crossings, near cabinets, or otherwise at a maximum spacing of 250 meters on a straight cable run.
Manholes shall be in duct routes having more than 4 duct ways whilst joint boxes are for routes with less than 4 ways.

Conduit system shall meet the following criteria: -

- Water Tightness
- Mechanical Strength
- Correct Shape and dimension
- Effective length of duct – 6 meters
- Minimum Internal diameter – 100mm
- Minimum wall thickness – 3mm

3.1 PVC Ducts

PVC ducts shall be made of unplasticised polyvinyl chloride compound having at most 15 parts stabilizer and lubricant per 100 parts of resin. They shall have good mechanical strength, be water tight and have a minimum internal diameter 100mm and wall thickness of 3mm.

3.2 Duct Space

The cabling space in an empty duct shall be the space which remains when an allowance for duct manufacturing tolerance and duct mis-alignment is subtracted from the normal bore diameter. This allowance shall take into account the space required for cable grip. The cabling space shall be as follows:

Cable Space Diameter (mm)	Nominal Bore Diameter (mm)
89	102
42	51

Duct Space for Proposed Cable

The space left in a duct to accommodate a proposed cable shall be calculated as a function of number and sizes of the cables existing in the duct.

(a) One existing cable

Space Available = Cable Space (in Duct) – Diameter of existing cable.

(b) Two or More Existing Cables (Case 1)
If the sum of the diameters of the smaller cables is less than, ½ (half) that of the largest cable then,

Space Available = Cable Space – diameter of largest Cable.

(c) Two or More Existing Cables (Case 2)

If the sum of the diameters of the smaller cables is more than or equal to a half that of the largest cable, then
Space Available = Cable Space – (Sum of all cable diameter x 0.7).

4.0 Types of Cables

The various types of cables to be used can be divided into two main groupings according to their applications n the field, thus:

- Outdoor cables
- Indoor cables

4.1 Outdoor cables

(a) Underground Cables

These underground cables are fully filled (e.g. petroleum jelly filled), cellular insulated, moisture barrier, polyethylene sheathed cables, containing pairs that can be easily identified by colour codes. The cable shall be safe against damage by insects and rodents. These types of cables are used in duct and buried application.

(b) Cable in Duct

This cable is a polyethylene insulated, jelly-filled, unit twin, unarmoured telephone cable as described in the specifications for cables and wires. All main cables, between Main Distribution Frame at the exchange and the individual cross-connection points as well as Junction cables shall be routed in underground conduits.

(c) Buried Cable

The cable is to be used for direct buried applications and shall be polyethylene insulated, jelly-filled, moisture barrier, unit twin, armoured telephone cable. This type of cable shall be employed on routes where frequent expansions will not be required, in residential areas and other areas where the demand for telephone lines is not expected to grow very rapidly. The buried depth of the cable shall not be less than 800 mm as a standard depth. Where additional protection is required, concrete slabs or warning tapes shall be laid upon the cables. Cables to be installed under major roads, highways and railways tracks shall be laid in galvanized steel duct. Excavation width shall depend on the number of cables to be laid.

(d) Overhead Cables

The overhead cables shall be self-supporting polyethylene insulated cable and Drop wire.

- **Self – Supporting Polyethylene Insulated Overhead Cable**

Cables having a maximum 200 pairs may be constructed aerially in the primary cable network. This overhead cable shall be employed in rural, semi-rural and other areas with a low telephone and low traffic density. The cable shall be of figure 8 structure i.e. with a built-in suspension strand and shall be suspended on poles by means of special fittings.

- **Self-Supporting Drop Wire**

This is a single pair, self-supporting wire. The Drop wire shall be used for overhead applications up to 50m and to run along walls in order to connect the subscribers' premises to the pole-mounted distribution points.

4.2 Indoor Cables

The indoor cables consist of subscribers installation cable and jumper wire.

(a) Subscribers Installation Cable

This cable is PVC insulated and PVC sheathed. Subscriber installation cables shall be used for the distribution of telephone lines from the underground cable feed termination point to the instrument termination point in the subscriber's premises.

(a) Jumper Wire

This wire is a single-wire or multi-wire tinned copper conductor with PVC insulated outer cover. The jumper wire shall be used for interconnections between blocks at Main Distribution Frames (MDFs), cross connection cabinets (CCPs) and other distribution frames or boxes.

Chapter 2

MATERIAL SPECIFICATIONS

PART ONE

CIVIL WORKS - ACCESSORIES

CONCRETE

1.0 SCOPE

For ducting, pedestal bases, manholes, chambers and joint boxes; the bonding strength of concrete to be used must be greater than $30N/mm^2$.

2.0 Concrete Mixture

Dry concrete mixture shall be in the standard 1: 2: 4 ratios.
Concrete must be carefully tamped as to leave no air pockets and properly cured

3.0 Cement

To achieve the bonding strength stipulated above:

- Ordinary Cement shall be used.
- Cement of different types shall not be mixed.
- High Alumina cement may not be used for concrete mixing.
- “Additives” or “improvers” which are intended to hasten the setting of the cement or to give a denser concrete may not be used.
- Cement damaged by moisture may not be used.

4.0 Sand

- All sand shall be clean, sharp, gritty and free from loam, earth, salt, organic impurities and other impurities.
- Sand shall not contain more than 5% clay or silt.
- Sand shall contain grains from the finest sizes up to 4.75mm. Grains smaller than 0.25mm shall constitute a minimum of 15% of the total weight of the sand to be used.

5.0 Aggregate

The aggregate shall be clean screened river ballast, gravel, stones or quarry chippings, of the nature of cubes, not of flakes, graded in size and free from dirt, floury stone dust, loam or earth or any other impurities. No clinker, brick, sandstone or other porous stone shall be used. The maximum size of aggregate to be used shall be 19mm.

6.0 Water

The water to be used for concrete mixing shall be free from oil, salt, and organic substance.

JOINTING CHAMBERS

7.0 Manholes - Manhole Furniture

The manhole furniture consists of Manhole Racking Bolt Assembly, Vertical Supporting Brackets, Cable Brackets, Pulling-In Irons, Manhole Cover Assembly, Ladder Support Hook, Manhole Ladder, manhole number plate, Duct Plugs and Sump Cover Grill.

7.1 Manhole Racking Bolt Assembly

The Manhole Racking Bolt Assembly consists of the following part:

- One Machine Bolt with two (2) Nuts and Washer
- One Machine Bolt with Nut and Washer
- One Cable Rack Support

7.2 Machine Bolt

The machine bolt shall include forged heads and shall be shaped to meet the requirements of ISO recommendations R68, R261, and R724 for coarse metric bolts (before galvanizing) and shall be made of mild steel.

7.3 Cable Rack Support

The Cable Rack Support shall be made of mild steel flat bar without sharp edges

7.4 Vertical Supporting Brackets

The Vertical Supporting Brackets for Manhole shall be fabricated from mild steel or malleable steel. The formed shape shall be provided with slots at intervals of 50 – 80mm in which the cable brackets will fit.

7.5 Cable Brackets

The cable brackets may be manufactured from cast iron, mild steel, malleable steel, and shall have a smooth surface with all edges well rounded off. The brackets shall be designed to be fixed to the Vertical Supporting Brackets securely, and shall have sufficient strength to carry a static load of 200 kg at the top after the installation with a sufficient safety factor. The brackets shall be designed so that the cables may be secured in place on top of the bracket by means of steel tape clamps or some other suitable device.

7.6 Pulling-in Irons

The Pulling-In Iron shall be fabricated from round bars of malleable steel with ultimate tensile strength of 90,000N. It may be formed to a loop with the legs bent 90°. It shall be set into concrete floors and anchored to the reinforcement bars with the legs placed under the reinforcing bars and will be used for attaching pulling-in blocks when pulling-in or removing cables.

7.7 Manhole Cover Assembly

The frame shall be designed so that it may be securely anchored to the shaft of the manhole. The frame shall incorporate four evenly spaced external webs, each of which shall be drilled with a hole of 12 to 18mm diameter to accommodate a shackle for lifting purposes.

The cover shall be designed with sufficient tolerance that it can be accommodated in the frame. The top of the cover shall be designed for concrete infilling. The top face of the cover may be in-filled with concrete and shall be finished with a non-skid pattern, raised 3mm above the surface of the cover and extended to within 25mm from the edges.

The top surface of the cover shall not differ by more than 3mm from the top surface of the frame, when installed.

Holes for insertion of manhole lifting hooks shall be provided at suitable locations on the top of the cover. The cover shall be provided with locking screws.

The frame and the cover shall be manufactured from gray iron and the phosphorous content of the iron shall not exceed 1.75. All castings shall be free from blowholes and cold shuts.

The frame and cover shall be designed to withstand the dynamic load of a 15 metric ton fast moving axle.

7.8 Ladder Support Hook

The ladder support hook shall be set in the concrete shaft at a distance from the floor so that the ladder when attached to the hook will have an angle to the floor of 75°± 5°. It shall be installed in one of the shorter sides of the rectangular manhole shaft and shall protrude 100 – 150 from the surface.

The ladder support hook shall be fabricated from round bars of mild or malleable steel with diameter not less than 18mm.

7.9 Manhole Ladder

A typical manhole ladder shall be about 2 metres in length. The ladder rungs shall have an approximate pitch of 250mm diameter and riveted over. The hook at the top of the ladder shall be securely attached to the Ladder Support Hook and firmly placed on the floor.
The manhole ladder shall be made of aluminium or steel.

7.10 Manhole Number Plate

Manhole cover shall have a name plate made on its upper face as a clear cast which shall have the following information:

a) operator’s name
b) the manhole number as indicated in the cable network map
c) the maximum permissible dynamic load on the cover
d) the manufacturer’s name
e) the year of manufacture.

7.11 Sump Grill Cover

The sump cover grill shall a square shape and the outer dimensions shall be approximately 300 x 300mm. It shall be designed so that it is easily removable and shall be strong enough to withstand a load of 150kg.

The grill shall cover the sump in a manhole. The sump is provided in order to make it possible to pump out most of the water and thus improve working conditions for the staff. The grill shall prevent accidents involving staff and shall also prevent tools falling into the sump.
The grill shall be made of cast iron or steel.

7.12 Duct Plugs

Duct Plugs are to be used for the sealing of underground ducts to completely seal off any annulus between the cable and the duct diameter and also for empty ducts. The following types of duct plugs may be employed:

(a) Rubber Plugs
(b) Rubber Expander Plugs
(c) Split Rubber Expander Plugs
(d) Air blown Rubber Plugs

(a) Rubber plugs shall be of truncated conical shape with a minor diameter (d), major diameter (D) and height (h) as follows:

Fixed Rubber Plugs

Type of Plug	***Inner Diameter of Duct (mm)***	***d (mm)***	***D (mm)***	***H (mm)***
Rubber Plug	102 51	95 48	104 52	100 50

(b) Rubber expander plugs shall be fabricated from soft rubber and fitted with steel plates and steel bolts so that the effective diameter can be increased by tightening the bolts. The outer diameter of the rubber and the steel plates shall be approximately 90mm before tightening of the bolts. The bolts and the steel plate shall be hot dip galvanized.
The plug shall be cylindrical in shape and of approximately 40mm in length.

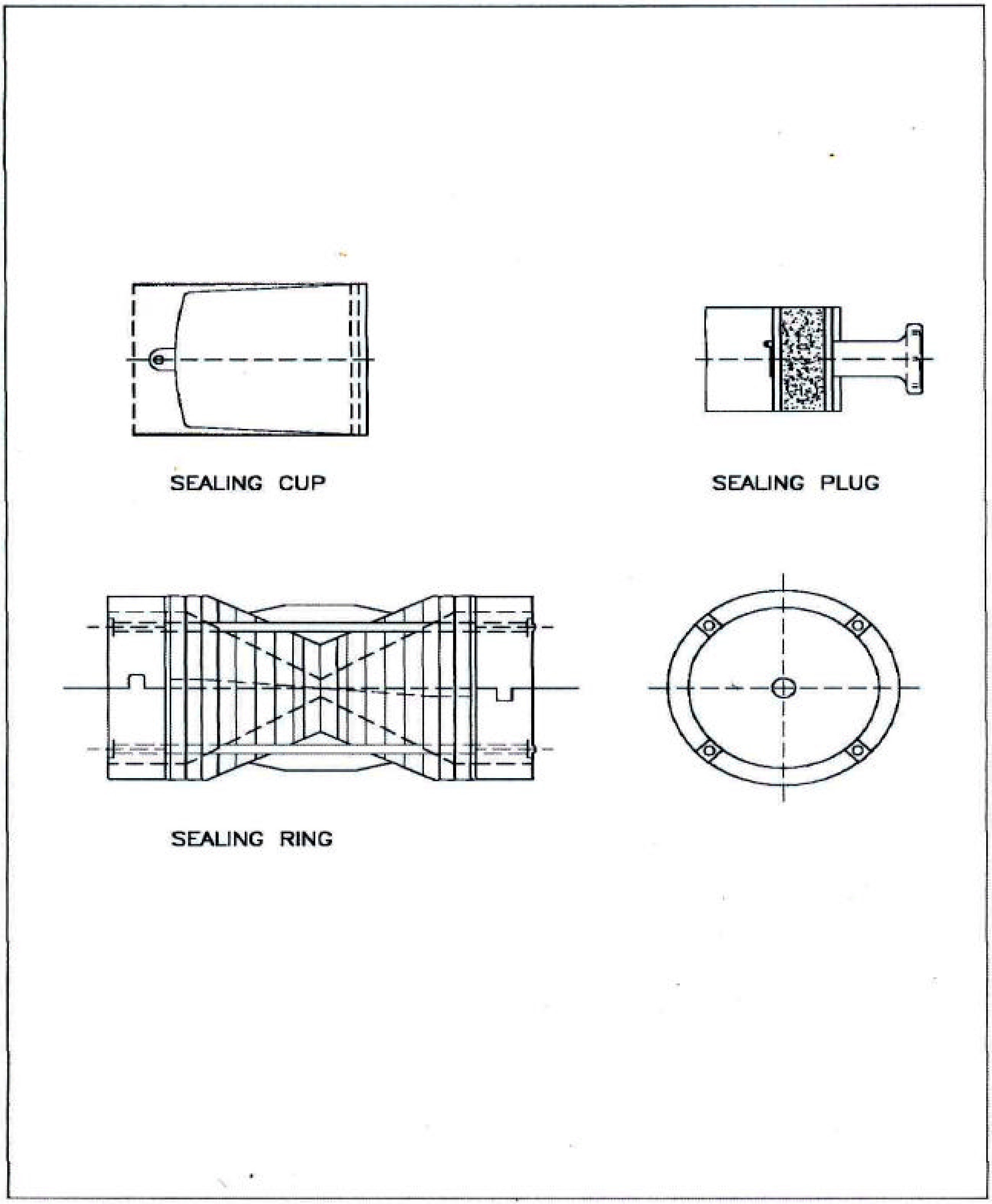
(c) Split rubber expander plugs shall be fabricated from the same material as the rubber expander plugs and galvanized in the same manner. They will be manufactured with a centrally located hole and a split in the rubber and separate halves of the steel plate so that they may be fitted over a telephone cable.
The outer measurement of the plug shall be the same as for the rubber expander plug.
The plug shall be manufactured with a hole in the middle, in five different sizes of 25mm, 40mm, 50mm, 65mm and 80mm

(d) Air blown rubber plug shall be used for sealing the empty duct. The rubber which is in the form of a bag shall be inserted into the empty duct and in flatted by a constant pressure until the air fills the rubber bay thereby forming a bond with the duct. The air pressure shall be constant for at least five years.

(e) Sealing compound shall be used in all cases where the sealing duct plugs described above are not suitable, sufficient or available. The compound shall be durable water resistant plastic material and shall have good adhesive properties. It shall not shrink or decay, or change its sealing properties during the lifetime of the cable.

8.0 Unplasticised PVC Ducts - Materials And Manufacture

Ducts manufactured from unplasticised PVC shall be round, smooth and free from surface imperfections. Each duct and bend shall have a socket formed at one end to allow insertion of spigot. All sockets shall be concentric with the axis of the duct or bend. The sockets and spigot shall be designed so that they will be watertight and securely jointed together by means of pressure, adhesive, washer or other sealing device.
When cast into a manhole wall, the end of the PVC ducts shall be coated with an adhesive compound and covered with sand of a suitable grade in order to prevent leakage of water into the manhole. The manhole bushings shall be designed as a jointing sleeve with a socket.



SCHEMATIC OF DUCT PLUGS

8.1 Dimensions

Ducts and Bends

Item	Approx effective. Length (m)	Nom. Inside diam (mm)	Min. Wall Thickness (mm)	Min. length of socket (mm) approx.
Straight Duct 102	1, 5 & 6	102 ± 2	3.5	120
Straight Duct 51	1, 5 & 6	51± 1	1.5	60
Duct Bend 102 (45°)	3	102 ± 2	3.5	120
Duct Bend 51 (90°)	1.5	51 ± 1	1.5	60
Double Coupling Element 102	double coupling	102 ± 2	3.5	120
Double Coupling Element 51	double coupling	51 ± 1	1.5	120

8.2 Function

The Unplasticised PVC ducts shall be used for the construction of underground duct systems, connecting riser poles to manholes and joint boxes, cabinets to manholes and joint boxes and for underground ducts to buildings under normal conditions, i.e. when the ducts may be laid at normal depth and the duct route is not otherwise exposed to heavy dynamic load.

A double Coupling Element shall be used to connect two spigot ends together. This element shall have a prefabricated coupling at either end and shall be slipped over the two pipe ends to be connected.

9.0 Galvanised Steel Pipe - Manufacture

The Pipes shall be made from Steel Billet or Strip with a tensile strength between 300 and 450MN/m^2 and minimum elongation of 15% over a gauge length of 500mm. They shall be welded or seamless, free from dents and internal roughness. The ends of the tubes shall be reamed to prevent abrasion against the cable.

9.1 Dimensions

Two sizes of Steel Pipes are most suited for telephone system ducting. They are the 50mm and 100mm, nominal outside diameter steel pipes. The overall dimensions of the pipes shall be as follows:

Nominal Outside Diameter (mm)	Minimum Outside Diameter (mm)	Maximum Outside Diameter (mm)	THICKNESS (mm)	Thickness Minimum (mm)
50	50.5	50.8	2.2	2.1
100	99.3	100.0	3.0	2.9

9.2 Packaging

The pipes shall be in lengths of 2m to 6m. Each length of pipe shall be marked with the manufacturer's name and the year of manufacture. The thread at the end of each length of pipe shall be protected by a tightly fitting cap.

9.3 Function

Galvanized, steel pipes shall be used for the construction of underground duct system when the conditions are such that unplasticised PVC ducts are not suitable, like when the laying depth is limited and when heavy dynamic loads are expected. The galvanized Steel pipes are the standard ducting material when ducts are to be laid in the open, across roads, highways, under bridges and such other places where the duct may be exposed to mechanical damage.

10.0 Draw Rope - Description

The Draw rope is designed for underground cabling operations. It is to be placed in an empty duct when the duct is laid and it is to remain in the duct until a cable is pulled into the duct. It may be used for pulling in small cables. Between any two manholes, joint boxes or handholes, the draw rope shall be installed in a continuous length, without joints or splices. The rope shall meet all the requirements set below.

PROPERTY	REQUIREMENTS
Material	Fibrillated film of Polypropylene stabilized against solar degradation
Construction	3 strands (plain or hawser laid). Direction of lay “Z” to BS 4928
Minimum diameter of rope	6mm + /-20mm
10 lay (turns) Length at chuck Load of d/8kg	250 +/-20mm
Mass of rope	1.6kg +/-4% per 250m length
Minimum breaking	5.6KN

Draw rope shall be manufactured in a bright colours typically, Yellow, Green, Blue or Orange.

11.0 Reinforcement Bars - Scope

Reinforcement Bars must be used in concrete structures. Three types of reinforcement bars are specified.

RB 8 with minimum nominal diameter of 8mm
RB 10 with minimum nominal diameter of 10mm
RB 12 with minimum nominal diameter of 12mm

11.1Strength

The reinforcement bars shall comply with DIN 488 or equivalent.

All reinforcement bars shall be free of mill scale, cracks, rust and other defects. A small amount of superficial rust will be allowable.

12.0 Cable Jointing Chambers in Water logged Areas

In the swampy and water logged areas, surface shelters shall be constructed and used as cable jointing chambers – manholes, joint boxes, etc.

13.0 Earth Electrode Spikes - Materials

The earth electrode spike shall consist of a rod or rods of copper, mild steel or galvanized mild steel which may be extendable (utilizing threaded ends) or may be of one section of 1 metre in length.

13.1Utilization

The earth electrode spike shall be designed for use with external line plant, in particular, cross – connection cabinets, pole plant and special joints that house in-line lightning protection devices.

Depending on the depth to which the rod (spike) may be driven, the space available and the mean soil resistively, it may be necessary to drive in more than one spike. In such cases an earthing cable, laid in a trench or duct, should be connected between the tips of the spikes.

The site of the earth electrode spike should be chosen to obtain a minimum separation of 0.6 metres from the line plant of other services like electricity cables, gas pipelines and water pipes. The site should afford a convenient lead-in to exchange cable chambers.

In a high earth resistivity area the earth electrode must have a greater surface area of spike in contact with the soil than the one in a low resistivity area. Copper earth electrode systems corrode very slowly and so should always be looked at every 3 years.

13.2Earth Resistance

The maximum resistance to earth for any telephone exchange shall be below 2 ohms.

14.0 Cable Markers - Warning Tapes and Concrete Slabs

- Cable markers shall be made of High Quality reinforced concrete or other suitable hard wearing material which presents a surface which can be boldly written upon.

- Marker post shall be designed, constructed and laid in a T-shape. On the front view of the marker shall be engraved ‘CABLE’.

- The warning tape shall be made of reinforced PVC tape (or other tough material) and resistive to cutting.

- The colour of the warning tape shall be easily detectable.

- The warning tape shall not be less than 10cm in width

- A warning tape shall carry a warning inscription on the length of the tape at intervals of 3.0m

- The warning tape shall be placed within 30cm distance of the top of the cable.

- The life span of the warning tape employed in each application must not be less than that of the cable itself.

15.0 Wooden Poles - Material.

Wooden Poles shall be made of any suitable specie of durable hardwood.

- Poles shall be sawn square, bark completely removed and all the branches dressed down to flush with the stem. No sapwood shall be removed.

- Poles shall be as straight as possible. A uniform bend in one direction is permissible but shall not exceed 1% of the length. The pole shall be uniformly tapered and free from excessive flare at the butt.

- Pole shall be seasoned to about 12% to 15% of the moisture content.

- The poles shall be free from the following defects:

  a) Decay
  b) Insect damage
  c) Shakes
  d) Transverse fractures
  e) Hollows in the top
  f) Large loose knot and unsound knot of more than 20mm diameter.
  g) Spiral gain of one turn in less than any 6.0m of length
  h) Holes exceeding 12mm in diameter.

15.1Dimensions

Nominal lengths and minimum diameters of the poles shall be as follows:

Nominal Length (m)	**Minimum Diameter At the Top (mm)**	**Minimum Diameter At the Base (mm)**
7	135	190
8	135	210
9	135	220
12	150	250

15.2Impregnation

The poles shall be impregnated with a substance poisonous to mould, fungi and insects and which will not appreciably leak out of the wood in the course of its lifetime. It must also be absolutely non-hazardous to human beings and warm-blooded animals.

15.3Strength

Assuming that the pole has its weakest point at the ground line and that the pole is placed at the depth (h) in the ground, the minimum horizontal force to be applied 300mm below the top of the pole which will cause breakage shall be as follows:

Nominal Length of the Pole (m)	Depth in the Ground **(m)**	Minimum Horizontal Force To Cause Breakage **N**
7	1.2	6000
8	1.3	6500
9	1.4	6500
12	1.7	7000

15.4 Marking

The poles shall be clearly marked with year of manufacture and length

16.0 Concrete Poles - Material

Concrete poles shall be manufactured from High Quality Concrete. They shall be reinforced with any of the following:

a) Hot rolled Steel bars for the reinforcement of concrete.

b). Cold worked steel bars for the reinforcement of Concrete

c). Hard drawn Steel wire for the reinforcement of Concrete. Steel reinforcement shall have a cover of Concrete of at least 19mm.

d). Steel wire for pre-stressed Concrete.

16.1Dimensions

(a) The poles shall be manufactured in standard lengths of:
7m ± 20mm
8m ± 20mm
9m ± 20mm
12m ± 25mm

(b) The pole shall be as straight as possible. The tolerance of the uprightness of the poles shall be no more than 0.5% throughout the length of the pole.

(c) The pole's main reinforcement shall be used for earthing purposes. It shall therefore be continuous or welded and the total cross-sectional areas of the rod, ground of rods or wires shall not be less than 250mm^2. Two suitable galvanized Steel tails shall be welded to each end of the reinforcement for connecting the reinforcement to an earth electrode. The projection of the tails from the surface of the pole shall not be less than 50mm.

(d) The poles shall have a smooth finish and the surface shall be free from honeycombing. All surface shall be clean and through and shall present a neat appearance.

16.2Strength

(a) The compression strength of the concrete shall be a minimum of 30MN/m^2.

(b) The breaking load (horizontal force applied 300mm below the top of the pole to cause breakage) for the poles specified herein will be more than 6000N at a depth as follows:

TOTAL LENGTH OF THE POLE (m)	PLANTING DEPTH FOR THE POLE (m)
7	1.3
8	1.4
9	1.5
12	2.0

(c) The bending load is the minimum horizontal load which when applied for two minutes 300mm below the top of the pole and thereafter removed, gives a deflection. The bending load must not be less than 5000N

(d) The normal working load shall be 3000N.

16.3Marking

The manufacturer's name or trade mark shall be legibly impressed on each pole at such a position that it may be easily read after erection of the pole. In addition, the following information shall be impressed on the pole or on a metal tag securely embedded in the concrete:

a). Year of manufacture
b). Length of the pole
c). Name of Service Provider

17.0 Tubular Steel Poles

Material, Design and Dimensions

- Tubular poles shall be tapered from the base to the top gradually so that no sudden changes of the cross-section occur.

- The cross-section shall be circular.

- The length of the poles shall be:

a)	7.0m	c)	9.0m
b)	8.0m	d)	10.0m

These lengths will have a permissible allowance of 10%.

- The lower portion of the pole which is to be placed underground must always be tarred.

- The poles shall be protected against rust and other corrosion, inside as well as outside. This may be accomplished by tarring the inside of the steel tube and coating the outside with anti-rust paint or by galvanizing the pole.

17.1 Strength

- The poles shall be made of high grade steel having the following properties:

  Tensile Strength 550MNm²
  Elongation 12 – 18%
  Modulus of elasticity approximately 200,000 MN/m²

- The minimum breaking load for the poles specified shall be:

  a). 7m pole: 6000N
  b). 8m pole: 5000N
  c). 9m pole: 4500N
  d). 10m pole: 4000N

  The above breaking load is assumed to be applied when the pole is planted at the following depths:

TOTAL LENGTH OF THE POLE (m)	PLANTING DEPTH FOR THE POLE (m)
7.0	1.20
8.0	1.40
9.0	1.70
10.0	1.80

- The horizontal force applied 300mm, below the top of the pole which gives a deflection of 25% of the length of the pole above ground at the top shall be called the maximum normal work load. The maximum normal work load shall be:

  a). 7m pole: 1350N
  b). 8m pole: 1000N
  c). 9m pole: 750N
  d). 10m pole: 600N

17.2Marking

The manufacturer's name or trade mark shall be impressed or other wise permanently inscribed on each pole at such a position that it may be easily read after erection of the pole. In addition, the following information shall be impressed on the pole.

a). Year of manufacturer
b). Length of the pole.
c). Name of Service Provider

MATERIAL SPECIFICATIONS

PART TWO

CABLES AND WIRES

TELEPHONE CABLES AND WIRES

18.0 Conductors

- Each conductor shall consist of a solid wire of pure annealed copper, smoothly drawn, circular in cross-section and uniform in quality. The conductor surface shall be smooth and untarnished.

- Conductors shall come in three nominal diameters of 0.50mm, 0.65mm and 0.90mm. Cables used in special applications may have diameters different from these. The variations in the diameter shall be restricted to within ± 5% of the nominal value. They shall conform to the following resistance and resistance unbalance measured at 30°C:

Conductor Diameter (Nominal)	Max. Conductor Resistance per km	Maximum Resistance Unbalance per km	
Mm	Ohms/km	Average(ohms/km)	Individual(ohms/km)
0.50	95	2.0	5.9
0.65	56	1.3	4.1
0.90	29	0.7	2.0

- The tensile strength of any conductor shall not be less than 200MN/m2 and the percentage of minimum elongation at fracture shall not be less than the values given below: -

Conductor Diameter Nominal (mm)	0.50	0.65	0.90
% Elongation	15	18	18

- The conductor shall not break when it is turned around its own diameter three times in several tight loops.

- Conductor joints shall be kept to a minimum and shall be completed by butt brazing or equivalent method. The tensile strength of a 25cm length of a conductor with a joint shall not be less than 90% of that of an adjacent sample of conductor not containing a joint.

18.1 Insulation

Each conductor shall be covered with solid insulation of high density polyethylene to a thickness that enables the completed cable to meet insulation resistance of 10,000 Mega Ohm per km at a temperature of 20°C with 500VDC applied for 1 minute.

- The conductor insulation shall be readily identifiable. It shall be colour coded.

- The thickness of the insulation shall be uniform. The estimated ratio of maximum to minimum radial thickness of the insulation shall not exceed 2:1.

- When cut at a point not less than 1mm from the end, the shrink back of the insulation shall not exceed 2.5mm.

- Density, tensile strength, elongation and the melt index of insulation material shall not fall below the following values of insulation and sheath/jacket characteristics: -

	Unit	**Insulation**	**Sheath Insulation**
Density	g/cm	0.94 - 0.959	0.92 – 0.93
Melt Index 2.160g 190℃	g/10mm	1.0max.	0.5max
Tensile Strength	N/cm^2	1000min	1200min.
Elongation at Rupture	%	400min.	400min.
Environmental Stress cracking	Max. no. of failures per 10 samples	2	Nil
Carbon black concentration	% of weight	-	2.5 + 0.5
Dielectric Constant	-	2.2 (max)	-
Dissipation factor	-	0.0002 (max)	0.0002 (max)

18.2 Twinning

- Two appropriately coloured insulated conductors shall be uniformly twisted together to form a pair. The length of the pair twists must be such as to meet the requirements of capacitance unbalance being that no interruption occurs during telephoning. Direction of pair lay must be clockwise.
- The pair lay shall not exceed 200mm.

18.3 Stranding

- A number of twisted pairs shall be laid up to form a group. A number of groups shall constitute a unit. Spare pairs shall form a separate unit. All the units shall then be stranded to form the cable.

- When the pairs are assembled to form units, the lay shall not exceed a length equal to 50 times the diameter of the completed cable core.

- Each unit shall be bound by an open heliax of plastic coloured tape or by threads.

- Markers, plastic tape or thread shall be applied with a lay of not more than 100mm.

18.4 Pair and Unit Identification

- The colour scheme of the pairs and wires in a unit shall be in accordance with IEC 189-2.

- The colour scheme of the unit binders shall be in accordance with IEC 189-2.

Pair / Group / Unit Colour Coding - IEC 189-2

Pair Number	Colour of Conductor Insulation		Binder Colour Scheme	
	A-Wire	B-Wire	Group	Unit
1 2 3 4 5	White White White White White	Blue Orange Green Brown Grey	Blue 1	1 Blue
6 7 8 9 10	Red Red Red Red Red	Blue Orange Green Brown Grey	Orange 2	
11 12 13 14 15	Black Black Black Black Black	Blue Orange Green Brown Grey	Green 3	
16 17 18 19 20	Yellow Yellow Yellow Yellow Yellow	Blue Orange Green Brown Grey	Brown 4	
21 22 23 24 25	Violet Violet Violet Violet Violet	Blue Orange Green Brown Grey	Grey 5	

Cable Colour Coding - IEC 189 – 2

Unit Number	Colour
1st	Blue
2nd	Orange
3rd	Green
4th	Brown
5th	Grey
6th	White
7th	Red
8th	Black
9th	Yellow
10th	Violet

18.5 Core Covering

- The core shall be completely covered with a layer of non- hygroscopic dielectric material. The covering shall be applied with an overlap. The core covering shall provide a sufficient heat barrier to prevent deformation of conductor insulation or adhesion between conductors caused by adverse heat transfer during the sheathing operation.

- Moisture resistant binders may be applied over the core and/or core covering.

18.6 Identification Marker

- Each length of cable shall carry the identity of its manufacturer and date of manufacture. Labelling shall be at regular intervals of not more than 1 metre apart.

18.7 Poly – Al Laminate

- An aluminium tape, with both faces coated with polyethylene shall be applied longitudinally on the core with a suitable overlap. The nominal thickness of the tape shall be 0.3mm comprising of 0.2mm aluminium and 0.05mm polyethylene film on each side of the aluminium tape.

- The Laminate shall be heat-sealed and shall be bonded to the inner surface of the polyethylene sheath that is extruded over it. The poly-al laminate shall be mechanically and electrically continuous.

18.8 Suspension Strand

- The suspension strand shall be a multi-wire strand of high tensile strength galvanized steel with a minimum breaking load of $1600MN/m^2$
- The strand shall be formed with a left hand lay. When the formed strand is cut, the individual wire must not spring out.
- The weight of the zinc coating shall be a minimum of $70g/cm^2$.
- The individual steel wires shall be thoroughly coated with a suitable corrosion inhibiting compound. The compound shall not have any adverse effects upon the polyethylene used in the sheath.

18.9 Sheath

- A polyethylene sheath shall be applied over the poly-al foil and the suspension strand
- The polyethylene compound shall be uniform as well as free from dirt, metallic particles, foreign matter and moisture.
- The polyethylene sheath shall be bonded to the poly-al laminate moisture barrier and shall provide the cable with a tough, flexible protective covering, able to withstand exposure to tropical climate.
- The sheath shall be free from holes, splits, blisters.
- The polyethylene compound of the sheath shall contain carbon black concentration and have evenly dispersed suitable anti-oxidants
- The minimum thickness of the sheath shall be as follows:

CONDUCTOR GAUGE (mm)	MINIMUM SHEATH THICKNESS (mm)
0.50	1.8
0.65	1.8
0.90	2.0

- The average thickness at any cross-section shall not be less than 90% of the thickness specified as the cable gauge.

18.10 Cable Length Marker

Cable shall be labeled with sequentially numbered length markers at regular intervals along the outside of the sheath. The accuracy of measurement of length along the cable shall be held within ± 1%.

** ***Specifications that are peculiar to different types of cables are given under those cables and supersede whatever aspect of these general specifications that would have otherwise applied.***

19.0 Types of Cables and Wires and their use in external line plant

- Self Supporting Polyethylene Insulated Cable
- Polyethylene Insulated, Jelly Filled, Unit Twin Unarmoured Cable
- Polyethylene Insulated, Jelly Filled, Unit Twin Armoured Cable
- Underground Subscriber Feeder Cable
- Indoor Cable
- Screened Cable for Digital Link
- Self-Supporting Drop Wire
- Indoor Frame Wire
- Jumper Wire

19.1 Self-Supporting Polyethylene Insulated Cable

Standard cables for this application are the 0.5mm, 0.65mm and 0.9mm diameter, copper conductor, fully colour-coded, polyethylene – insulated, self-supporting telephone cables having a polyethylene sheath and integral suspension steel strand.
This telephone cable is for aerial installation in the Local Loop Network.

19.1.1 Description

This cable is of individually insulated copper conductors which are twisted into pairs. A number of pairs are stranded to form a unit and a number of units enwrapped in a polyethylene-coated aluminium foil applied longitudinally with an overlap. The supporting steel strand and the polyethylene-coated aluminium foil are encased in a polyethylene sheath with a web portion interlinking the sheathed steel strand and the sheathed cable core.
The cable is fully colour-coded so that each conductor of a pair is distinguishable and each pair is distinctly identifiable from any other pair.

For this cable, a maximum of 200 pair capacity (for all three gauges of 0.5mm, 0.65mm, 0.9mm) is allowed because of its aerial installation in the network.

20.0 Polyethylene Insulated, Jelly Filled, Unit Twin Unarmoured Telephone Cable

This type of cable shall come in covers 0.50, 0.65 and 0.90mm diameter gauge conductor, fully colour-coded, polyethylene-insulated, jelly filled unit twin unarmoured telephone cable suitable for use in ducts.

20.1Field Application

This cable shall be used for underground outdoor installations in local networks as primary and secondary cables. The cable must be laid in ducts in order to protect it from mechanical damage.

20.2Description

This cable shall be made of individually insulated copper conductors twinned into pairs. A number of pairs are stranded to form a unit and a number of units are stranded to form the cable core. The cable core shall be fully filled with petroleum jelly and enclosed in a polyethylene-coated aluminium foil applied longitudinally with an overlap. The aluminium foil shall be bonded on its outer surface with a polyethylene sheath to form the moisture barrier cable sheath.

The cable shall be fully colour coded so that each conductor of a pair is distinguishable and each pair is distinctly identifiable from any other pair.

The conductor shall come in three different diameters of 0.5mm, 0.65mm and 0.9mm. Each cable must have a minimum spare capacity over and above the specified capacity. These are shown in the table below:

NOMINAL	SPARE	0.5	0.65	0.9
50	1	*	*	*
100	2	*	*	*
150	3	*	*	*
200	4	*	*	*
300	6	*	*	*
400	8	*	*	*
600	12	*	*	*
800	16	*	*	*
1000	20	*	*	*
1200	24	*	*	*
1800	36	*	*	*

21.0 Polyethylene Insulated, Jelly Filled, Unit Twin Armoured, Telephone Cable

Cable under this description must come in 0.50, 0.65 and 0.90mm diameter conductor, fully colour coded, unit twin, polyethylene-insulated, jelly-filled and armoured.

21.1 Field Application

The cable shall be used for direct buried underground outdoor installation or laid in ducts in local networks as primary and secondary cables. The installed cable shall be protected by overlaying with bricks or tiles.

21.2 Description

(a) This cable consists of individually insulated copper conductors which are twinned into pairs. The required number of pairs is stranded to form a unit and the required number of units is stranded to form the cable core. The cable core is fully filled with petroleum jelly and is enclosed in a polyethylene-coated aluminium foil applied longitudinally with an overlap.
The aluminium foil is bonded on its outer surface with polyethylene sheath to form the moisture barrier cable sheath. The cable is provided with double steel tape armour helically applied and an outer polyethylene jacket.

(c) The cable is fully colour coded so that each conductor of a pair is distinguishable and each pair is distinctly identifiable from any other pair.

(d) For each cable size, it is mandatory that the manufacturer provide some spare capacity as shown in the table below.

(e) The conductor shall come in three different diameters of 0.5mm, 0.65mm and 0.9mm. The combination of conductor diameters and number of pairs in the cable is shown in the table below:

NOMINAL	SPARE	ACTUAL	0.5	0.65	0.9
10	-	10	*	*	
20	-	20	*	*	
30	-	30	*	*	
50	1	51	*	*	*
100	2	102	*	*	*
150	3	153	*	*	*
200	4	204	*	*	*
300	6	306	*	*	*
400	8	408	*	*	*
600	12	612	*	*	
800	16	816	*	*	
1000	20	1020	*	*	
1200	24	1224	*		

21.3 Steel Armouring

(a) Two layers of polyethylene tape of adequate thickness shall be helically applied with an overlap over the polyethylene sheath. The cable shall then be armoured with two applications of galvanized steel tape, each applied helically with a gap of 25% ± 10% of the width of the tape, the second tape covering the gap of the first.

(b) Alternatively, galvanized steel wire armouring or corrugated longitudinally applied welded galvanized steel tape armouring may be used.

21.4 Outer Polyethylene Jacket

The steel armour shall be covered with an outer polyethylene jacket, tightly fitting over the armour. The polyethylene jacket shall provide a tough, flexible, protective covering, able to withstand exposure to sunlight, atmospheric temperature and stress reasonably expected in normal installations in tropical climates.

22.0 0.40mm Copper Conductor

This type of cable comes in 0.40mm copper conductor diameter, fully colour coded, polyethylene insulated. It could be manufactured as self supporting or jelly-filled armoured or non-armoured cable and will be suitable for field deployment in sympathy with its type.

22.1 Field Application

Use of this cable in external line plant shall be restricted to Direct Feed Areas and High Rise Buildings.

22.2 Transmission Requirements

(a) Transmission loss shall not exceed 8.5db at a maximum distance of 4.5km measured at 800 Hz.

(b) Attenuation of cable at 800Hz shall be 1.68dB/km.

(c) Characteristic Impedance at 800 Hz shall be 1,000 ohms.

(d) Maximum Loop Resistance at 30°C shall be 300 ohms/km.

22.3 Electrical Characteristics

(a) Maximum DC Resistance: 147 ohms/km.

(b) Maximum Resistance Unbalance:

- -3.0 ohms/km (average)
- -7.9 ohms/km (individuals)

(c) Dielectric strength between conductors

In any length of a completed cable, the insulation between conductors shall be capable of withstanding for 3 seconds a D.C potential of 2.4KV. It shall have a minimum sheath thickness of 1.5mm.

23.0 Underground Subscriber (Feeder) Cable

23.1 Field Application

This is polyethylene-insulated service (feeder) cable. It shall be used for extending the direct buried underground connection for the Pillar Distribution Point to Sub-Distribution Point on Wall at the subscriber's premises.

23.2 Description

- The cable shall consist of two, four or six copper conductors individually insulated by solid medium, with high density polyethylene, as two twisted pairs of formation. The cable core shall not necessarily be jelly filled but enclosed in a moisture barrier sheath. The cable shall be provided with a galvanized steel strip and an outer jacket.

- The cable make-up shall include one extra pair as spare irrespective of the cable capacity.

- The cable shall be fully colour-coded so that each conductor is distinctly identifiable.

- The extra pair shall be differently colour-coded from the main pairs.

23.3 Stranding and Forming the Cable

- The insulated conductors shall form two twisted pairs with different lays. The two pairs shall be stranded to form the cable core.

24.0 Indoor Cable

This is the 0.5mm diameter copper conductor, PVC insulated, fully colour-coded, PVC-sheathed cable suitable for indoor installation.

24.1 Field Application

The indoor cable shall be used in indoor installations for the purpose of terminating with jelly-filled, underground cables on MDF Terminations and other similar terminations.

24.2 Description

The numbers of pairs in indoor cables shall be 10, 30, 50, 100, 150, 200, 300 and 400.

24.3 Sheath RIP Cord

A rip-cord of non-hygroscopic material shall be laid parallel to the core under the sheath.

25.0 Screened Cable for Digital Link

Screened cables are to be of the standard 0.65mm diameter copper conductor designed essentially for digital working. They are to be fully colour-coded, polyethylene-insulated jelly-filled, unit twin and suitable for use in duct.

25.1 Field Application

Solid link (junction) between two (2) Digital Exchanges shall be provided with screened cables. They shall be designed for a speed of up to 2Mb/s (30 Channels) per system.

25.2 Description

(a) The capacities of the screened cable shall be 50, 100, 150 pairs, standardized for 0.65mm diameter conductor.

(b) Pair Selection

- One (1) pair shall be used for each direction of transmission i.e. The total number of pairs to be used for digital working shall be:

  (2n + 4), where n = number of systems

- The selection shall be as follows:

- 2 pairs for one system
- 2 pairs as standby for every 10 system
- 1 pair for remote supervision
- 1 pair for Engineering Order Wire facility

25.3 Screening

The cable shall be screened to provide cross-talk suppression for 2Mbit/s data speed. Screening method can be either transverse or diametrical.

25.4 Construction

Each conductor shall consist of a solid wire of commercially pure annealed copper smoothly drawn, circular in cross-section. The nominal diameter of the conductor shall be 0.65mm.

25.5 Electrical Characteristics

The electrical characteristics of screened cable pairs used for digital transmission up to 2Mb/s at 20°C is shown as follows:

S/N	CHARACTERISTICS	DATA
1.	Operating bit rate (Kbit/s)	2048
2.	Conductor Diameter (mm)	0.65
3.	Conductor loop resistance (ohms/km)	109 (max)
4.	Insulation Resistance M-ohm km	10,000
5.	Near End Crosstalk at 1MHz (dB)	81 (min)
6.	Attenuation at 1 MHz (dB/Km)	14 (means)
7.	Impedance at 1MHz (ohms)	120 (mean)-balanced
8	Repeater Gain (dB)	35

25.6 System Installation and Accessories

(a) Transverse –Screened Cable

- The medium sized screened cable (100 pairs) has an overall diameter of about 32mm and therefore can easily be handled and be accommodated in the 100mm bore duct.
- The cable drum length shall be 1000 metre (max) which shall easily be installed.
- All Joints involved shall be straight joint
- Screen continuity shall be maintained.

(b) Line Terminating Unit

- The line terminating unit (sometimes called "Drivers") shall be provided at both ends of the junction link.
- The line terminating unit shall be connected to the MDF terminal blocks (LSA-type) by means of PVC sheathed screened cable.
- The LT shall incorporate supervisory circuits for Engineering Order Wire (EOW) and System Supervision.

(c) Line Repeaters

- The line repeaters shall house regenerative repeaters installed in the Manhole at a nominal spacing of 2km distance (± 0.2km) subject to a maximum section loss of 35dB.

- The line repeaters shall reshape, retime and regenerate incoming weak digital signals.

- Near the switches, repeater spacing shall be half normal values to compensate for the exchange equipment noise.

(d)Regenerator Cable Tails (stubs).

- Regenerator Cable Tail shall be used to connect the junction screened – cable by making an appropriate straight or in-line joint.

- Two cable tails shall be fitted to each regenerator and the cable tails shall be transverse screened (PVC sheathed) to reduced crosstalk effect.

- A cable tail shall not be more than 5 metres in length.

(e) Power Feeding

- Power shall be fed to the cable system including repeaters through 'phantom' circuit derived from the pairs used for transmission. The system power feeding shall be in sections.

- The power for the repeaters shall be derived from the drop across a zener diode.

- The power feeding requirements shall cover a distance of 30km but this shall be subject to the minimum DC resistance that allows power feeding.

- For standard gauge cables (0.65mm), not more than 20km distance shall be exceeded due to the loop resistance limitation of the conductor.

(f) Attenuation Co-efficient

The attenuation co-efficient shall be measured at one frequency only (f_0) near the timing half-frequency:

System	f_0	Value
2048 Kbit/s	1MHz	= 14KB/km

(g) Near-end Cross-talk (NEXT)

- Sinusoidal measurement for Near-end crosstalk shall be made between pairs in opposite directions, at a frequency near the half-frequency.

- Digital Measurement shall be carried out by estimating the total noise on an elementary section either in factory or on installed cables.
  In both cases, Near-end cross-talk shall not be less than 81 dB.

- Characteristic Impedance (Z_0) shall not be more than 120 ohms.

26.0 Self Supporting Drop wire

26.1 Field Application

The self supporting drop wire shall be used to extend telephone connection from the pole mounted distribution points into the subscribers' premises.

26.2 Description

The drop wire shall consist of two conductors laid parallel, insulated and sheathed in a figure 8 configuration such that it can be separated into two fully insulated conductors by cutting it along the interconnecting web.

26.3 Conductor

- Each conductor shall consist of copper-coated, steel wire with a minimum diameter of 0.90mm.
- Each individual conductor shall have a minimum breaking strength of 680N and the elongation measured on a 250mm specimen at the time of rupture shall not be less than 1.5 percent.
- The conductors shall be suitable for termination on terminal blocks.
- The maximum resistance per kilometer of each conductor shall be 91 ohms at 20°C.
- The drop wire must never be installed with joints.

26.3 Conductor Insulation

Each conductor shall be covered with solid high-density polyethylene or the two conductors may be covered by a solid sheath of polyethylene with an interconnecting web so as to form a combined insulation and sheath for the drop wire in a figure 8 or dumbbell configuration

26.4 Dielectric Strength between Conductors

The insulation between the conductors shall be capable of withstanding a D.C. potential of 7kv.

The finished drop wire shall withstand for five seconds, a potential of 2500 Volts DC

The attenuation of the drop wire when measured at 800 Hz shall not exceed 1.10dB/km.

26.5 Packaging

(a) Drop wire shall be packaged in bound coils of continuous length conductors. Both ends of the conductor shall be accessible.

(b) The nominal length of a bound coil shall not be more than 500m. .

(c) The coil shall be bound and wrapped in heavy weather-proof material,

Each coil shall be suitably marked on the outside of the package to show the length of the wire, conductor diameter, the Manufacturer's name and year of manufacture.

27.0 Indoor Wire

27.1 Field Application

The indoor wire shall be used for interconnecting the termination point of the subscribers' lead-in wire or internal distribution point and the cord terminal box of the subscriber's apparatus.

27.2 Description

- The indoor wire shall consist of two or more conductors, separately insulated and sheathed of PVC to form a figure 8 or dumb-bell configuration.
- Alternatively, the two conductors shall be covered by combined insulation and sheath of PVC to form a figure 8 or dumb-bell configuration.

27.3 Packaging

- Indoor wire shall be packaged in bound coils of continuous length conductors. Both ends of the conductor shall be accessible.

- The nominal length of a bound coil shall not be more than 500m. .

- The coil shall be bound and wrapped in heavy weather-proof material, Each coil shall be suitably marked on the outside of the package to show the length of the wire, conductor diameter, the Manufacturer's name and year of manufacture

28.0 Jumper Wire

Jumper wires are pick insulated, colour coded, single pair cables made of tinned copper wire conductors.

28.1 Field Application

The jumper wire shall be used for linking the switch termination blocks to the termination blocks of outgoing cables at main distribution frames, and for interconnection at cross connection cabinets.

28.2 Description

The jumper wire consists of individually insulated, colour coded, tinned copper wires, which are twined into pairs. The pair lay shall not exceed 70mm. Colour combinations of white, red and black are standard.

29.0 Conductors

- Each conductor shall consist of bright tinned solid wire of annealed copper, smoothly drawn, circular in cross-section, uniform in quality and free from all defects.

- The nominal diameters of the conductors shall be 0.6mm.

- Conductor joints shall be kept to a minimum and all the joints shall be carried out by a cold welding technique or an equivalent method.

- The tensile strength of a 25cm length of conductor containing a joint shall not be less than 90% of that of an adjacent sample of conductor not containing a joint.
- The electrical resistance of a 15cm length of conductor containing a joint shall not be less than 105% of that of an adjacent sample of conductor not containing a joint.

30.0 Line Repeaters

Regenerative repeaters shall be installed in the Manhole at a distance of 2km subject to a maximum section loss of 35dB. They shall be housed by Line repeaters.
The line repeaters shall perform the function reshaping, retiming and regenerating incoming weak digital signals. The spacing of the repeaters near the Exchanges shall be one km to compensate for the Exchange noise.

31.0 Cross Connection Cabinets

The cross-connection cabinet shall comprise of inner racking with terminal blocks and an outer casing suitable for installation on a concrete pedestal. It is a flexibility point between the main cable pairs and the distribution cable pairs. Quick termination method based on Insulation Displacement Contact (IDC) technique which eliminates the need for soldering, screwing and wire strapping shall be the standard for cable pair termination in cross connection points. It shall comprise of inner racking with terminal blocks and an outer casing suitable for installation on a concrete pedestal.
The cross-connection cabinet shall be made from glass re-in forced flame retardant material. There shall be provision for maintaining cable pair records in the cabinet.
Cross connection cabinets shall be designed to operate under the following environmental conditions:

Ambient Temperature:	10ºC - 45ºC.
Relative Humidity:	15% - 95%

31.1 Casing

The outer casing shall be designed to provide the cable terminations with adequate protection from environmental hazards like dust, moisture, high temperatures, salt laden humid air, mechanical damage etc. It shall be robust in construction, be easily replaceable without the need to alter the cabling and wiring in the cabinet. It shall have a swing door on the front face and a reliable lock. The inside surface of the door shall have a holder frame, in which cable records of size A4 may be located.
The outer casing shall prevent the access dust and insects inside the casing. It shall have adequate ventilation inside the casing to prevent the formation of condensation within it.

31.2 Racking

The racking shall be provided with guides for jumper wiring. It shall have provision for numbering of the terminated pairs. It shall provide firm support to all earth bars required to provide an earthing system to the cabinet.
The racking shall be made of steel and provided with adequate corrosion protection. The racking shall be suitable for embedding in and fixing to the concrete base. The bottom panel of the cabinet shall be designed and constructed to provide adequate entry space for the underground cables and have adequate provision for firm anchoring of the cables at the cable entry holes, so that cables do not shift after installation.

32.0 In-Door Frame

Indoor frames are used as Internal Cross-Connection Points in the local line plant to enable incoming pairs to be connected to outgoing pairs by the use of jumper wires or equivalent.
The capacity of the indoor frame is the maximum number of incoming pairs and outgoing pairs, which can be accommodated in the frame. Indoor frames may be of various capacities but the smallest indoor frame shall have a capacity of 100 pairs.
The terminal block shall be adequately provided with over-voltage arrestors and the termination on the block shall be by the Insulation Displacement Contact **(IDC)** technique.

32.1 Outer Casing

The outer casing shall be designed so as to prevent the entry of dust and insects and the formation of condensation within the frame. It shall be easily exchangeable without the need to alter the cabling and the wiring inside. Its door shall be fitted with sturdy and reliable locks. The inside surface of the door shall have a holder frame, in which cable records of size A4 may be located
The outer casing shall have adequate provision for firm anchoring of the cables at the cable entry holes, so that cables do not shift after installation.
The front of the outer casing shall be marked with the Operator's name.

32.2 Racking

The racking shall be made of steel and shall be rust proof. The racking shall be designed to give a firm support to Terminal Blocks.
The racking shall be provided with guides for jumper wiring. It shall have provision for numbering of the terminated pairs. It shall provide firm support to all earth bars required to provide an earthing system to the cabinet.

33.0 Main Distribution Frame (M.D.F)

The Main Distribution Frame (MDF) is the Internal Cross-Connection Point in the Main Exchange System. It serves as the flexibility point for the linking of the subscriber cables to the Exchange lines by the use of jumper wires. Its capacity is sum of the incoming pairs at the Exchange side and the outgoing pairs at the subscriber side that can be accommodated on the housing frame.

Terminal blocks shall be mounted on the frame and shall be installed with over-voltage protection and lightning arrestors. The termination on the block contact slot shall be Insulation Displacement Contact (IDC) type.

33.1 Housing Frame

The frame (racking) shall be made of steel and shall be rustproof and fire proof. The frame shall be designed to give a strong support to the terminal blocks and accessories. The nominal height of the housing frame from ground level shall be 2.90 metres. The frame shall include cable holders for numbering of the terminated pairs and wire guides for wiring.

33.2 Insulation Displacement Contact (IDC) Termination

Terminal Blocks utilizing IDC terminations are specified for distribution points, cross-connection points and the MDF.

Terminal Blocks shall serve three functions:

a) Link subscriber cables with the Exchange lines at the Main Distribution Frame (MDF) and the Cabinets.
b) Terminate primary and secondary distribution cables.
c) Provide terminations for jumper wires between primary cable pair and any distribution cable pair

Terminal blocks are to be equipped with the following Over Voltage Surge protection with the following characteristics:

- Insulation Resistance greater than 5 x 10^4 M ohms
- Contact Resistance 1 M ohm
- Dielectric Strength greater than 2 KV (RMS)
- Ability to withstand impulse voltage greater than 3.6 KV
- Coupling capacitance between neighbouring pairs less than 1 microfarad
- Speech current / Voice frequency cross talk attenuation at 600 Ohm terminating load as:

Frequency Range	Cross talk Attenuation
300 Hz to 3400 Hz	$\leq$ 110 dB
3.4 KHz to 10 KHz	$\leq$ 100 dB
10 KHz to 1.2 MHz	$\leq$ 60 dB
Insertion loss	$\leq$ 0.1 dB

CHAPTER 3

INSTALLATION AND TESTING

INSTALLATION

1.0 Manhole

The following fittings and hardware shall be installed in a manhole:

Manhole racking bolt assembly
Pulling-in Irons

Manhole cover assembly

Ladder support hook

Vertical supporting brackets

Sump cover grill

Cable Brackets

Galvanized steel pipes

Duct plugs, rubber or wooden

Manhole number plate

Manhole ladder

1.2 Dimensions

Manholes shall have a rectangular shape, vertical walls and a sump placed directly below the shaft of the manhole with the floor sloping slightly towards it. Manhole shaft shall equally have a rectangular shape, a clear opening of approximately 900mm x 750mm.

Clearances

- between the top of the manhole roof and the surface - 650mm
- between the lowest cable bearer and base of the manhole – 1500mm
- between the top bearer and the ceiling – 375mm

- Headroom must be a minimum of 2m to allow for underground works by personnel.
- depth must be sufficient to accommodate the required layers of ducts.
- Width must allow a minimum central working space for jointing and pulling the cables. The standard width shall be:

  1.5m for manholes with up to 20 ducts
  1.8m for manholes with up to 28 ducts
  2.2m for manholes from 32 ducts and above
- The length of the manhole will vary depending on the number of ducts entering the manhole, the size of the cables to be installed, the type of joints envisaged. A one meter section is required from each cable layer at one wall.

1.3 Manhole Construction

The location and size of manhole shall depend on:

- Maximum length of cable duct
- Branching of routes
- Location of Cabinets and Distribution Points
- Overall conditions of the site

The maximum distance between two manholes shall not exceed 250m on a straight cable run.

- Manholes shall be constructed of doubly reinforced concrete.

- Manhole shall be constructed to withstand a minimum dynamic load of 35 tons.

- In order to prevent the collapse of the surrounding surface and structures timbering and shoring shall be employed.

- Reinforcement bars shall be covered with a minimum of 30mm concrete in walls, floor and roof.

- Concrete floor shall be roughened to minimize hazards.

- Floor, walls and roof must be treated with waterproofing materials and all construction joints given 150mm PVC water barrier.

1.4 Manhole Frame

The frame shall be designed so that it may be securely anchored to the shaft of the manhole. The frame shall incorporate four evenly spaced external webs, each of which shall be drilled with a hole of 12 to 18mm diameter to accommodate a shackle for lifting purposes.
The cover shall be designed with sufficient tolerance that it can be accommodated in the frame. The desired inscriptions shall be clearly cast into the upper face of the cover. The top face of the cover shall be designed for concrete in-filling and shall be in-filled with concrete and shall be finished with a non-skid pattern, raised approximately 3mm above the surface of the cover and extended to within 25mm from the edges.

The top surface of the cover shall not differ by more than 3mm from the top surface of the frame, when installed. Holes for insertion of manhole lifting hooks shall be provided at suitable locations on the top of the cover. The cover shall be provided with locking screws.

The frame and the cover shall be manufactured from gray iron. The phosphorous content of the iron shall not exceed 1.75. All castings shall be free from blowholes and cold shuts. The frame and cover shall be designed to withstand the dynamic load of a 15 metric ton fast moving axle.

1.5 Manhole racking bolt assembly

Using the vertical supporting brackets together with cable rack supports as a template, the 12mm x 150mm.machine bolts shall be fixed to the shuttering (one nut inside and one nut outside) so that there is an equal distance from the top of the vertical supporting bracket to the ceiling and from the bottom of the same to the floor.
The bolts shall be set so that approximately 30mm of the threaded bolt will protrude from the inside surface of the wall. The bolts shall be positioned so that the supporting brackets will be vertical.

1.6 Pulling-In Irons

The pulling-in irons shall be anchored to the reinforcement bars and set so that approximately 50% of the iron is embedded in concrete. The pulling-in irons shall be aligned towards a point located 1meter above the floor level and in the center of the manhole.

1.7 Manhole cover assembly

The manhole cover frame shall be anchored securely to the manhole shaft using appropriate mechanical construction pattern. Covers shall be equipped with appropriately sized sealing rings to prevent ingress of water.

1.8 Manhole Ladder

A typical manhole ladder shall be approximately in length 2m. The steps shall have an approximate pitch of 250mm diameter and riveted over. The hook at the top of the ladder shall be securely attached to the Ladder Support Hook and firmly placed on the floor.
The manhole ladder shall be made of aluminium or steel.

1.10 Ladder support hooks

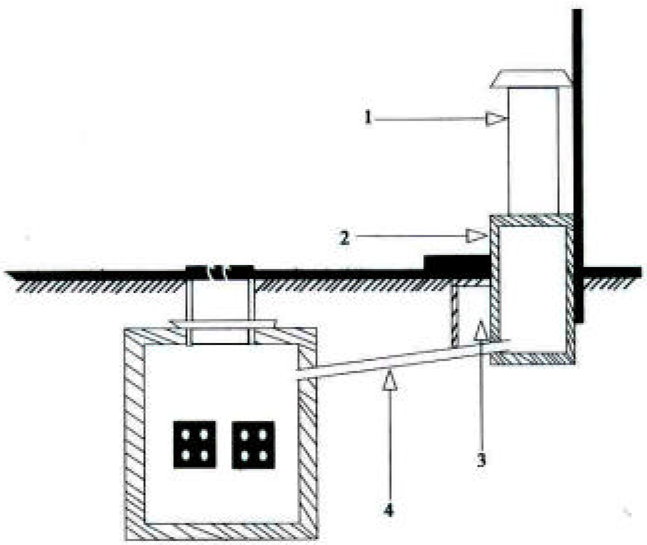
The ladder support hook shall be set in the concrete of the shaft at such distance from the floor that the ladder when placed on the floor and attached to the hook will have an inclination angle to the floor of 75^0. It shall be installed in one of the shorter sides of the rectangular manhole shaft and shall protrude 100mm – 150mm from the surface.

1.11 Vertical Supporting Brackets

The Vertical Supporting Brackets shall be fabricated from mild steel or malleable steel. The formed shape shall be provided with slots at intervals of 50 – 80mm into which the cable brackets will fit

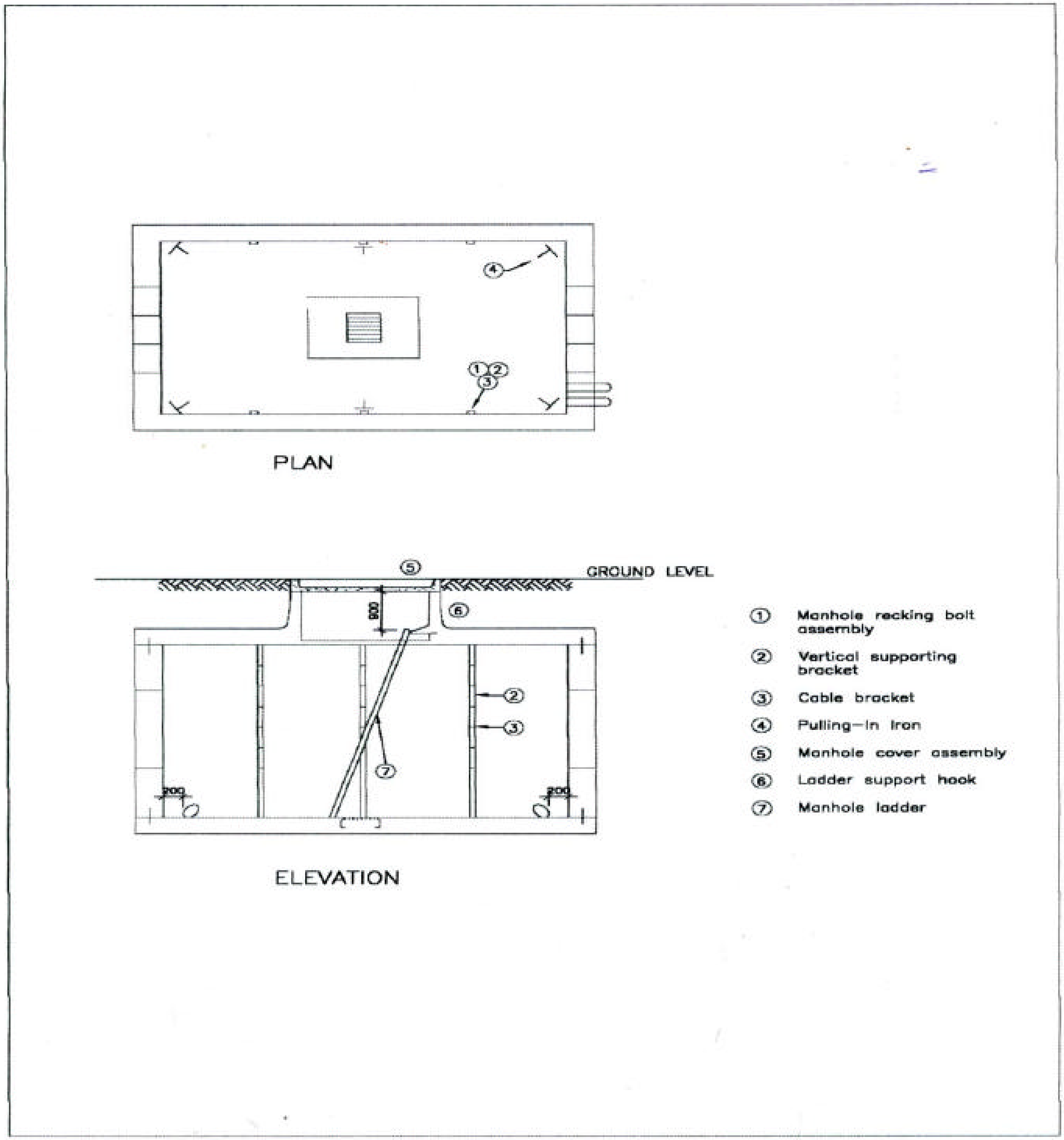
1.12 Manhole Sump Cover Grill

The sump cover grill shall a square shape and the outer dimensions shall be approximately 300 x 300mm. It shall be designed so that it is easily removable and shall be strong enough to withstand a load of 150kg.
The grill shall cover the sump in a manhole. The sump is provided in order to make it possible to pump out most of the water and thus improve working conditions for the staff. The grill shall prevent accidents involving staff and shall also prevent tools falling into the sump.
The grill shall be made of cast iron or steel.



1 - CABINET
2 - CONCRETE BASE
3 - JOINT BOX
4 - DUCTS

CONNECTION BETWEEN CABIN AND CONDUIT



Manhole showing manhole furniture

2.0 Joint Box

The joint box is used for the pulling of underground cables in ducts and for siting of joints. Sizes of joint boxes will vary depending on particular applications.

2.1 Dimensions

- The joint box shall have a rectangular shape and the walls set vertically.

- The joint box shall be fitted with a number of duct entrances. Duct entrances will be constructed as for manholes.

- The joint box shall be constructed with reinforced concrete. The joint box shall be reinforced so as to withstand a dynamic load of 35 tons.

- Basic constructional details in relation to materials, material quality, etc will be exactly as for manholes.

- Joint box furniture shall consist of racking bolt assembly, vertical support brackets and vertically adjustable cable brackets.

- All ducts and steel pipes shall be sealed with duct plugs of wood or rubber.

- A number plate shall be fitted to one of the inner walls in a position where it can be easily read.

2.2 Hardware and Fittings

- Racking Bolt Assembly, and two Vertical Supporting Brackets and two Cable Brackets shall be installed in the joint box. The cable brackets shall be made vertically adjustable.
- A frame and cover with a clear opening of approximately 900 x 750mm shall be installed on the top of the box. Cover shall be fitted with a good rubberized sealing ring to prevent ingress of water. Cover shall be fitted with a good rubberized sealing ring to prevent ingress of water.

- All steels items to be installed shall be hot dip galvanized.

- PVC pipes and steel pipes shall be used for ducting. Not more than four ducts shall enter from each direction. All rough edges shall be smoothened out from the ends of the steel pipes

- All ducts and steel pipes shall be sealed with Duct Plugs made of wood or rubber.

- A number plate shall be affixed to one of the inner walls in a position where it can be easily read.

3.0 Hand Holes

Hand Holes shall be used in pillar system secondary distribution networks. They are also used in the local network where the construction of joint boxes is uneconomical.

3.1 Dimensions

The hand hole shall have a rectangular shape with the walls set vertically. It is to be fitted with few duct entrances not exceeding four especially in direct buried constructions for pillar system of distribution. Hand holes are small sized. Typical dimensions are: -

Length	-	500mm
Width	-	400mm
Depth	-	700mm

3.2 Hardware Fittings

- A frame and cover with a clear opening of approximately 400 x 300mm shall be installed on the top of the hole. Cover shall be fitted with a good rubberized sealing ring to prevent ingress of water.

- Distribution cable network employing conduit system shall not have more than two ducts entering or leaving the Handhole along the distribution route.

- A shinning number plate shall be affixed to one of the inner walls in a position where it can be easily read.

4.0 Distance between Jointing Chambers

The maximum distance between jointing chambers shall be determined by the maximum practicable cabling length and the terrain. This shall not be more than 250 meters for a straight duct or a duct with a single bend but when two bends are required the distance shall be reduced to 150 meters.

5.0 Ducts

PVC pipes and steel pipes shall be used to provide ducts into manholes. All rough edges shall be smoothened out from the ends of the steel pipes. All ducts shall be sealed with duct plugs made of wood or rubber. Not more than 24 ducts shall enter a manhole from any one direction.

5.1 PVC Ducts

The following materials shall be standard accessories for installing unplasticised PVC Ducts.

Straight Duct	-	102mm & 51mm lengths
Duct Bend	-	102mm (45^0) & 51mm (90^0)
Double Coupling Element	-	102mm

5.2 Duct Line

A site plan showing the entire duct route and capacity in good scale shall be prepared and the line of the Duct track shall be marked out on the physical site using the drawings.
Consent to the duct route and construction plan must be obtained from relevant authorities like the roads authority, local governments, state governments and proper coordination must be made with providers of services that employ underground routing in the area.
The operator will provide these to the NCC as a necessary documentation to seek approval of the external line plant execution plan.

5.3 Trenching

Trenches shall be dug in such a way that the minimum cover over the uppermost layer of ducts is 1.50m in carriageways and 1.0m in footpaths. The bottom of the trench shall be level and free from stones and rubbish, or other objects, which may damage the ducts. The bottom of the trench shall be covered with sand free from stones and compacted to a thickness of 25cm.

5.4 Duct-laying

Ducts may be laid in a single duct or multi-duct formation.
The spigot end of one duct is offered to the socket of the other. In jointing the individual lengths of duct, the outside of the spigot and the inside of the tapered socket shall be cleaned and the end 100mm of the spigot coated with PVC solvent, before being inserted into the cleaned socket of the adjacent length. The spigot end is pushed into the socket of

the other duct by hand but an installation procedure suitable to the circumstance must be employed to achieve proper engagement.
The ducts shall be cut and jointed in accordance with the method recommended by the duct manufacturer. All joints must be made watertight.
Care shall be taken at all stages to ensure that the ducts do not suffer damage or deformation. Duct ends shall be closed during construction with wooden or rudder plugs to prevent ingress of dust and water.
All ducts not laid in concrete encasement shall be covered by a layer of sand free from stones, hand punned to a minimum thickness of 75mm and all spaces between the duct and the sides of the trench shall be filled with stone-free sand.
In rocky or stony soil, sand free from stones shall be spread over the trench bottom and rammed to afford a bedding of 75mm thick on which to lay the ducts. In such cases, extra excavation may be necessary to achieve the required depth.
Special attention must be paid to all ducts leading into Exchange buildings to ensure they are water tight Suitable plugs shall be provided and inserted into the end of each duct to prevent the ingress of water and of foreign matter.

5.5 Duct Laying In Rectangular Formation

(i) The first layer of ducts shall be laid on the trench bottom, side by side and touching each other in formations of 2, 4, 6, 9, 12, 16, 20, 24, 30, 36 or 48 ways.

(ii) Mild steel rods 12mm diameter and of required length shall be driven approximately 150mm into the ground at both sides of the layer of duct and at about 2 meters interval so as to keep the ducts in the correct formation.

(iii) All spaces alongside and between the ducts shall be filled with earth free stones by treading down to provide 25mm of compacted earth above the duct layer.

(iv) The next layer of ducts and subsequent ones shall be laid between the mild steel rods so that they are vertically above the ducts in the lower layer. Sand free of stones being place between the layers of ducts and also alongside the duct.

(v) At approximately 3 meters from the jointing chamber at each end of the track the duct formation shall be opened out to provide a horizontal and vertical gag of 25mm between each duct. All spaces between the ducts shall be filled with sand free of stones and compacted by treading down.

(vi) On completion of an assembly of ducts, a 6mm steel rod shall be placed horizontally across the uppermost layer of ducts and tied to the vertical rods.

(vii) Backfilling and road re-surfacing shall be carried out in accordance with the requirements of the appropriate authorities.

(viii) At road crossings where heavy dynamic loads are expected, at river crossings, or in swampy and water logged areas when the ducts should be encased in concrete or galvanized steel pipes shall be laid.

5.6 Laying of PVC duct in Concrete Encasement

Arrange the PVC Ducts in the required formation. The coupling of the PVC ducts shall be done as already prescribed.

The concrete separators shall be placed at intervals of approximately 3 meters. The entire assembly shall be bound together with steel binding tapes at the location of these separators and encased in concrete, maintaining 50mm separation between ducts and 75mm cover on all exterior surfaces. A small mechanical vibrator shall be carefully used to ensure compaction of the concrete.

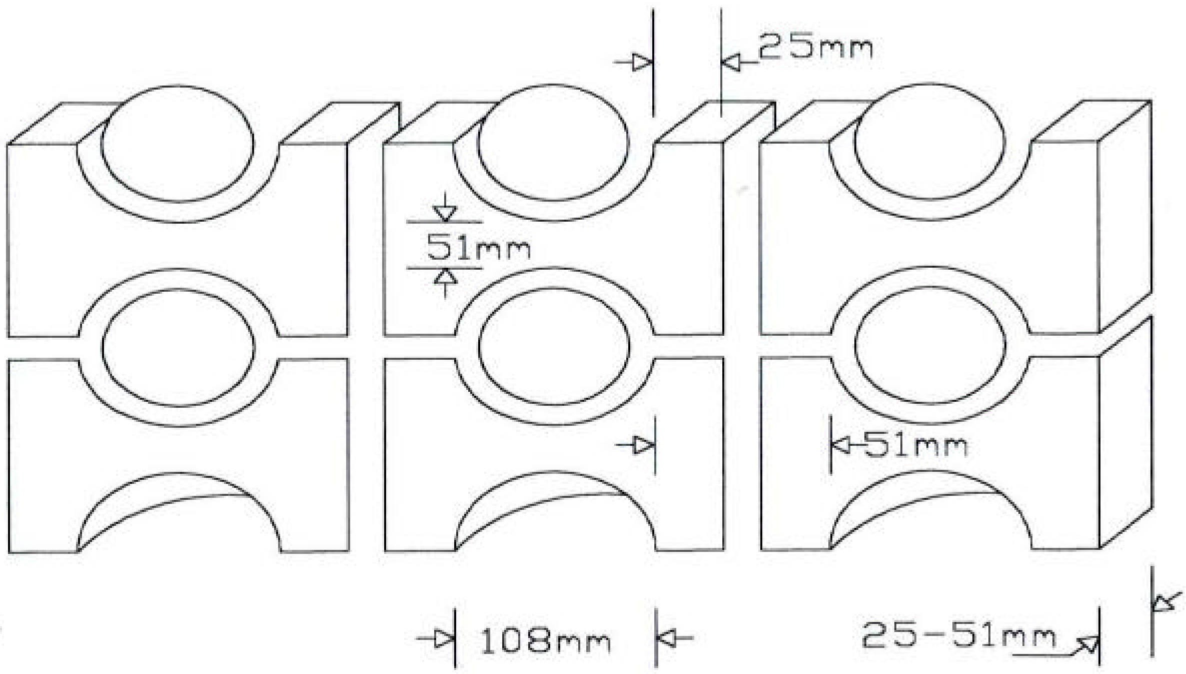
The concrete shall have a minimum compressive strength of 250 kg/cm after curing for 28 days.

Alternatively

(a) Concrete posts 50mm x 50mm and 1.5 meters long are used as spacers between each vertical row of ducts and are driven into the ground to depth of about 0.5 meters. The posts are spaced apart every 6 meters approximately along the completed trench.

(b) Concrete is poured to a depth of 75mm along the base of the trench strengthened to support the whole encasement should ground erosion take place.

(c) The first layer of PVC ducts are placed in between the concrete posts and concrete is poured to cover the duct layer to depth of 50mm, ensuring all voids are filled by the use of a suitably small vibrator. Then the next layer of duct is laid and covered with concrete and so on, until all layers are laid. The top layer should be covered with a 75mm layer of concrete.



NOTES:

Separators may be of plastic, concrete or any material adaptable to enclosure in concrete.

5.7 Laying of Galvanised Steel Pipes

Steel Pipes shall be installed in the following cases:

a) When crossing open sewer ditches

b) When ducts cannot be covered e.g., when attached to bridges and similar structures.

c) Under Railway Tracks

d) When a minimum coverage as specified for PVC Ducts cannot be obtained.

The installation shall follow laid down conditions as described in “Excavation and Backfilling” except that:

- When buried, the minimum depth of cover over the uppermost Steel Pipe shall be 500mm.

- Pre-formed bends will be compulsory at all bends. Where it is inevitable, bends shall be effected in the line of the duct rack with nominally straight pipe using such a method as will not result in any deformation to the cross section of the pipe.

5.8 Backfilling

All ducts not laid in concrete encasement shall be covered by a layer of sand free from stones, hand punned to a minimum thickness of 75mm and all spaces between the duct and the sides of the trench shall be filled with sand free from stones.
Backfilling shall consist of sifted soil to a minimum depth of 100mm above the uppermost duct layer. The backfilling shall be well compacted so as to leave no voids around or between the ducts. Where sifted soil is not readily available, sand may used. Normally the previously excavated material may be used above the sifted soil (or sand).

6.0 Draw Rope

A draw rope shall be threaded through and left in every route following duct laying operations and satisfactory tests. Draw ropes may not be joined. They must be laid in a continuous single length between manholes, joint boxes, chambers, hand holes, etc. Jointing of draw ropes to provide the necessary length between jointing chambers is prohibited.

7.0 Clearance from Other Services

When ducts are being laid in proximity to plant of other services special care must be exercised to maintain the integrity of those services even while work is going on. An effective means of supporting such plant should be provided whilst the excavation remains open.
All ducts laid in the ground shall have the following minimum clearance from other services:

Electric Lamp Posts	-	150mm
Traffic Signal Posts	-	150mm
High Voltage Single Core	-	300mm
Cable carrying up to 1 KV above	-	450mm

8.0 Cross-Connection Cabinet

The cross-connection cabinet shall be installed on a suitable concrete pedestal. The racking shall be firm and mechanically strong. Each terminal block shall be mounted firmly on the racking.

Each terminal block shall be fitted with a jelly-filled stub cable. The capacity of the terminal block shall be used as that of the stub cable. The sheathed cable shall be brought up to the cable entry ferrule of the terminal block.
The stub cable conductors shall be accommodated in the rear compartment of the terminal block and terminated on the cable terminals sequentially.

After terminating all the stub cable conductors, the compartment shall be filled with cable filling compound. The stub cable shall be suitably supported on the vertical racking. The stub cable shall be anchored on the cable entry ferrule of the terminal box by means of thermo-shrinking sleeves so that the cable core is protected from the environment and to prevent the oozing out of the filling compound.
The cable screen shall be connected to the earth wire by a good electrical bond. The other end of the earth wire shall be terminated on the earth terminal of the terminal block.

After inserting the stub cable, the cable entry hole at the base of the cabinet shall be sealed suitably against the entry of dust, water or rodents etc. through the concrete base into the cabinet.

9.0 Cable Markers

The cable markers shall be used to indicate the position of buried cable and joints. They shall be installed at every 200 meters along the cable route and at joint positions or any other strategic points in the route.

10.0 Poles

The span for poles used for installation of aerial line plant shall not be more than 50 meters depending on the size of the aerial cable. The planting depth for each size of pole is as given below: -

TOTAL LENGTH OF THE POLE (m)	PLANTING DEPTH FOR THE POLE (m)
7	1.3
8	1.4
9	1.5
12	2.0

The pole's main reinforcement shall be used for earthing. Two suitably galvanized steel tails shall be welded to each end of the reinforcement for connecting the reinforcement to an earth electrode. The projection of the tails from the surface of the pole shall not be less than 50mm.

10.1 Pole Line

Poles and stays shall be sited as not to constitute an obstruction on traffic. The length of the pole shall be such that the distribution lines and cables are unobstructed by trees or any other obstruction and are suspended at a height above the carriageway at street crossing to allow adequate passage of vehicles. Overhead crossing of streets that are excessively wide should be avoided.

The pole line should run along one side of the road. Poles, stays and struts shall be placed at such a distance from the road sufficient to avoid obstruction to traffic or to road maintenance work.

Poles shall be located at street intersections. They shall be located away from busy sections of the roadways.

10.2 Vertical Clearance

The minimum vertical clearance from the ground to the lower point in the aerial cable span shall be as follows: -

Location	Min Clearance In Metres
Crossing over rail roads	7
Over streets - Streets, or right-of-way	5
Industrial areas - where heavy trucks, cranes ply.	7

Minimum vertical separation of telephone cable from power line shall be as follows: -

Separation Measured Between	Low Voltage 0.415KV to earth	11KV to earth	330KV and above to earth
(a) Bare power conductor and telephone cable	1 metre	1.5 Metre	1.9 Metre
(b) Insulated power Conductor and insulated telephone line	0.3 Metre	0.6 metre	1.9 Meter (Bare Power Conductor)

10.3 Pole Setting

The depth of the hole shall be 1/6 of the length of the pole with a minimum pole excavation of 1.35m. Where the soil is firm, pole planting depths for different pole lengths and the standard attachment for Drop-wire Hook on them are as given in the table below.

Length of Pole	Depth of Poles Hole (m)	Height of Drop-Wire Hook above ground level (m)
7	1.35	5.00
8	1.35	6.00
9	1.35	7.00
12	1.50	9.65

Additional reinforcement shall be provided for pole holes in loose soil.

10.4 Pole Staying

The bending load on a pole carrying aerial cable could be quite reasonable and as such the pole must be strengthened by staying. The stay shall be applied to pole at the horizontal load centre and secured to a buried stay block in the ground. The weakest section of the pole shall be taken as the ground line.

Stay shall be required chiefly in the following cases: -

- Terminal Stay

A terminal stay shall be fitted at a terminal pole and shall have a spread equal to the stay height. As much as possible, terminal stay shall be designed with a Factor of Safety of at least 5.

- Straight-line Stay

These stays shall be used at intermediate points along a route to limit the effect of breakdowns and counteract unbalance stresses. The stays shall be designed for a Factor of Safety of 3 and with a ratio of spread to height of 1 and usually installed at every eight pole.

- Angle Stay:

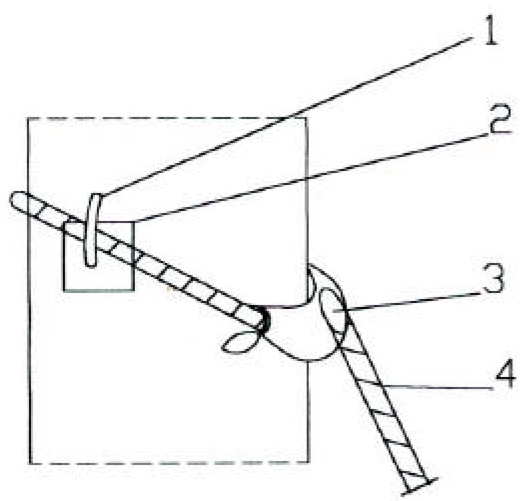
These stays shall be installed where the route changes direction to counteract the inward pull of the aerial cable. One stay shall be provided on the bisector of the external angle or alternatively two stays shall be provided, placed at each angle on either side of the bisector. This agreement depends on the angle of deviation (usually greater than 30^0) and the load strength. The stay shall be designed with safety factor of 5 with the spread of half of the height.

10.6 Pole Strutting

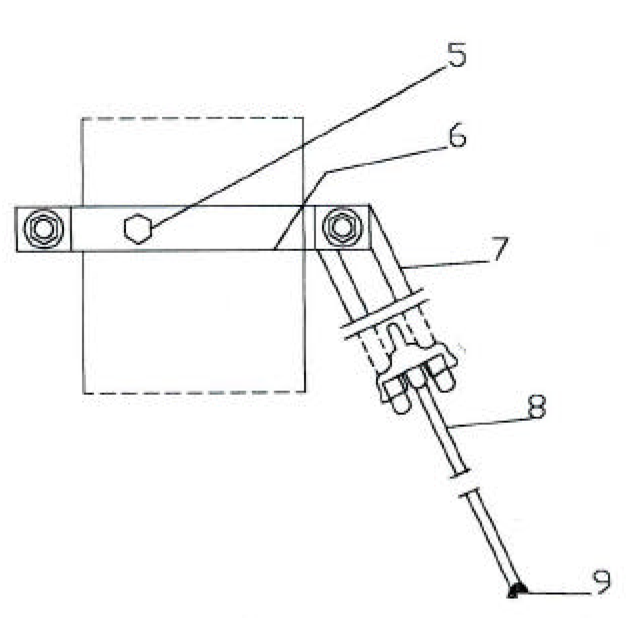
Pole strutting shall be employed only when there is no possibility of staying. The strut shall be nailed to the pole. The pole shall not be notched for attachment of the strut.

The three nails which are knocked through the tip of the strut into the pole should be directed obliquely upwards through the strut and pole as the nails are driven in. The strut shall be down slightly below ground level so as to be rigidly secured at the bottom and on the sides.

The strut should be wedged into the ground and surrounded at ground level with a pile of small stones.



Pole Stay – Type A



Key
1. Stay Staple
2. Stay Washer
3. Stay Clip
4. Stay Wire
5. Large Screw
6. Pole Ring
7. Tightener
8. Binding Wire

Pole Stay – Type B

11.0 CABLES

11.1 Buried Cable

Buried cables shall be installed such that the burial depth of the cable shall not be less than 800 mm. The width of excavation shall depend on the number of cables to be laid but should typically not exceed 500mm. Concrete slabs or warning tapes shall be laid upon the cables as additional protection. All the same, cables to be laid under heavy vehicular traffic roads and ways shall be laid in galvanised steel duct.

Extreme care must be exercised at any cable bends to avoid cable kinking. Bends must be made to follow a smooth bend. Cables must be placed on cable jacks and rolled out from there during laying.

11.2 Cable in Duct

Cables to be placed in ducts shall be placed on cable jacks. They shall be guided through the ducts by means of the draw rope where possible. Threading shall be from one manhole or joint box or handhole or chamber to the adjacent one, one span at a time. Cable shall not be allowed to rub excessively against the walls of the duct whilst being threaded in to avoid damage. The cable ends must be properly sealed. Any joints when necessary must be made at the manhole or joint box only and on no account will there be a joint outside these. Cables must have straight runs between manholes or chambers.

Tension above that specified by the cable manufacturer for any particular type of cable shall never be put on a cable whilst pulling it into a duct.

11.3 Overhead Cable

The standard attachment of cable hooks on different length of poles shall be 35cm above the DP mounted on the pole. The hook shall be installed at the time of planting the pole.
Distribution Point (DP) shall be mounted at different heights depending on the lengths of pole.

This is shown below

Pole Length (meters)	**Attachment of DP from Ground Level (metres)**	**Attachment of Dropwire Hook from Ground Level (metres)**
7m	4.65m	5.00m
8m	5.65m	6.00m
9m	6.65m	7.00m
12m	9.3m	9.65m

The cable shall be mounted on the pole by means of the hook hanging the built-in cable suspension and strengthening strand and shall be suspended on poles by means of special fittings.
Standard spanage for aerial cables shall be 50 meters. Overhead cables may not be installed across dual carriage or very wide roads.

11.4 Cable Jointing

Joints shall be made with wire connectors to produce electrically reliable and consistent joints. Connectors shall be types that eliminate the need to strip the conductor insulation prior to jointing.
Jointing materials shall be: -

- Closure body [half-shell sleeves] made of hard plastic [ethylene –propylene] material.
- Sealing tape made of a reliable, adhesive and durable plastic compound.
- Clamping bands made of stainless steel.
- Insulating caps made from hard plastic.
- Protective sleeve made of cast metal consisting of two [2] half –shells –a bottom section and a top section (for direct buried armoured cables).
- Sealing paste, Jelly and epoxy insulating dielectric material

- Conductor splice locks
- Metal bar
- Desiccant

The protective sleeve shall consist of four (4) plastic shells, (2) plugs and screws with washers and nuts. It is used as additional casing for ordinary closure in direct buried [around cable] application where the closure is not provided with a protective device.
The armouring of the cable shall be electrically through-connected and supported in a tension-relieving manner.
No power or heat shall be to the cable installation during jointing.

The correct size of closure to be used shall depend on:

- The capacity of the cable (pairs)

- The diameter of cable and the main distance between cables for branch joint.

- The number of cables (in and out) to be spliced in case of branch splice.

The Sheath Closure shall be such that the degree of impermeability and resistance to attack is for all practical purposes, equal to that of the sheath itself.

11.5 Cable Termination

High quality termination block shall be used cable terminations at the cabinets or the MDF. All wire terminations shall have high grade of electrical connection and measures to effectively eliminate insulation resistance problems prevalent with electrical termination in high humidity environment must be embodied in the installation.

11.6 Distribution Lines

Distribution lines are the individual lines between the distribution point (DP) and the subscriber premises.
For outdoor installation on walls, or for subscriber distribution from a pole mounted block terminal, self-supporting insulated lines shall be used. In high class residential districts or other areas where no poles are to be provided, an underground cable distribution system on concrete pedestals (pillow system) shall be installed. The distribution point (DP) on pillow should be sited 1.5 metres above the ground level and a 2 pair, armoured, black PVC buried cable shall be used to provide service to the subscriber’s sub-distribution point on wall.

11.7 Distribution Boxes

A (10 pair) block terminal shall be the standard for distribution boxes. This same type and size of box should be used for outdoor installation on poles and walls.

12.0 Earthing System

An entire external Line Plant must be configured, designed and implemented as a single earth system. Suitable earth bars, both horizontal and vertical, shall be provided with the racking. These bars shall be mechanically coupled with the racking to form a rigid structure.

The earth bars shall provide the means of extending the exchange earth, through the cable sheath and cable armour and interconnecting earths electrically. The earth bars shall provide reliable earth connections with negligible resistance.
In many cases, it is always necessary to drive in more than more than one electrode into the earth. In such cases an earthing cable, laid in a trench or duct, shall be connected between the tips of the spikes.
The site of the earth electrode spike should be chosen to obtain a minimum of 0.6 meters separation from telecommunications cables and also from electricity cables, gas pipelines water pipes.
Copper earth electrode systems are specified. They offer a life span of between 15 to 20 years in the soil conditions in Nigeria.

12.1 Earthing of the Telephone Exchange

The Exchange equipment, the Main Distribution Frame, the exchange battery rack, the electrical panels, the Distribution Points, the exchange entry cables all must be earthed and tied together to the general earth of the external line plant. The earth must be implemented with lightning spikes in a well-designed and implemented system that must give a resistance to earth of 2 Ohms or less.
The earthing method to be implemented has been described above.
The NCC will inspect the general earthing of the network at the network acceptance tests.

12.2 Earthing Of Cross Connection Cabinet

Suitable earth bars, both horizontal and vertical, shall be provided with the racking.
These bars shall be mechanically coupled with the racking to form a rigid structure.
They shall provide the means of extending the exchange earth, through the cable sheath and interconnecting all the cable sheath earths electrically. The earth bars shall provide reliable earth connections with negligible resistance, typically less than 2 ohms.

A connecting point on the earth bars shall be used to connect each terminal block to the cabinet earth systems on the earth bars using suitable earth wires. The length of the earth wires shall be kept to a minimum.

13.0 Cable Jointing Chambers in Swampy and Water logged Areas

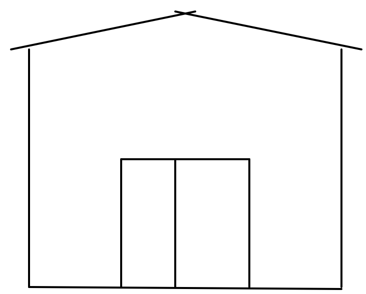
In salt water laden areas of the delta region and in all areas where the water table is generally shallow, of the order of less than one metre below the surface, use of underground cable jointing chambers is beset with intractable problems of water-filled chambers and consequent ingress of water into the cable joints.

In these areas, all jointing chambers shall be constructed as surface shelters. Surface built shelters will replace underground manholes, joint boxes and hand holes. All surface shelters shall be constructed as follows: -

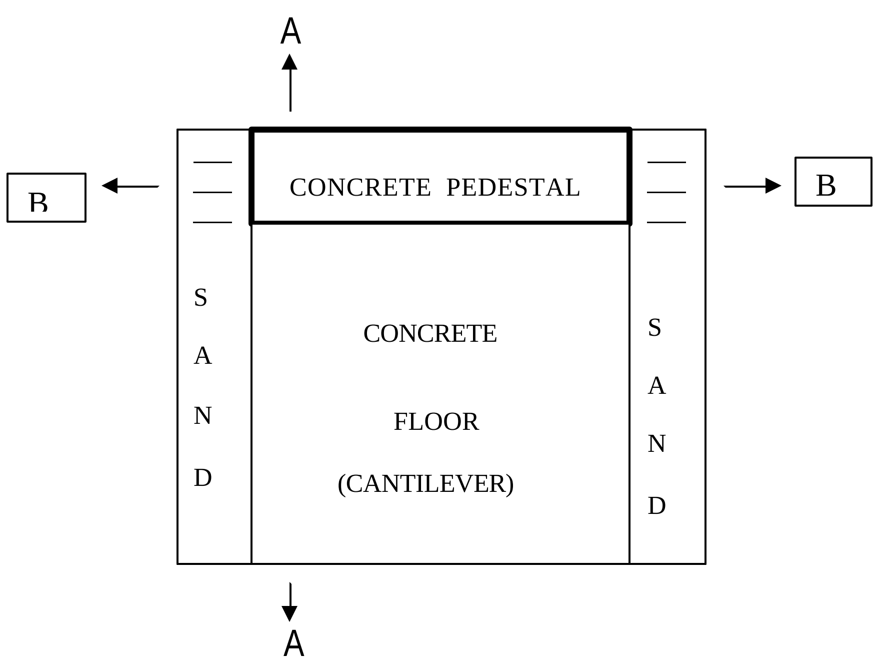
- Shelters shall be sited in places secure from road traffic and in any circumstance must not be less than 3000 mm away from the road shoulder.
- The shelter foundation shall be designed and constructed as micro piles with the micro piles well clear of the duct lines and bestriding them.
- The finished shelter floor level shall be at least one metre above the general ground level.
- The walls and roof of the shelter shall be constructed from doubly reinforced concrete and shall be so strengthened as to withstand impact from errant motor traffic.
- The entry door to the shelter shall be made of galvanised steel members and shall be provided with security locks.
- The shelter must be adequately ventilated to discourage the settlement of dew within it but its construction shall be such as to disallow entry into it by rodents, insects, birds, etc
- The dimensions of the floor of the shelter shall be such as to conveniently accommodate all the cables that come into it and leave ample working room for a minimum of two technicians at any one time. Standard internal dimensions shall be 2.5 m width, 3.5 m length and 4.5 m high.
- A void shall be left on the sides of the shelter where cable bearing ducts exist. The void shall be just wide enough to allow the cable to be maneuvered into the shelter, be jointed and placed to rest on the cable hangers without kinking.
- Multi layered vertical cable racks made from galvanised iron whose layers are in sympathy with the layers of the duct shall be installed in the shelter and shall be used as cable hangers inside the shelter.
- The lowest cable bearer on the vertical rack shall be 1500 mm above the finished floor level inside the shelter.
- The highest cable bearer on the vertical rack shall be 500 mm below the shelter ceiling
- All duct entrances to the shelter must be appropriately sealed with sealing plugs as in the case of manholes or joint boxes.

- Shelter shall be provided with a ladder as for manholes
- Shelter shall be labeled with name of operator and the serial number of the shelter as is shown on the network installation map.
- A safe position shall be provided inside the shelter for keeping documentation on all the cables that are inside the shelter.

Typical Surface Shelter



FRONT ELEVATION



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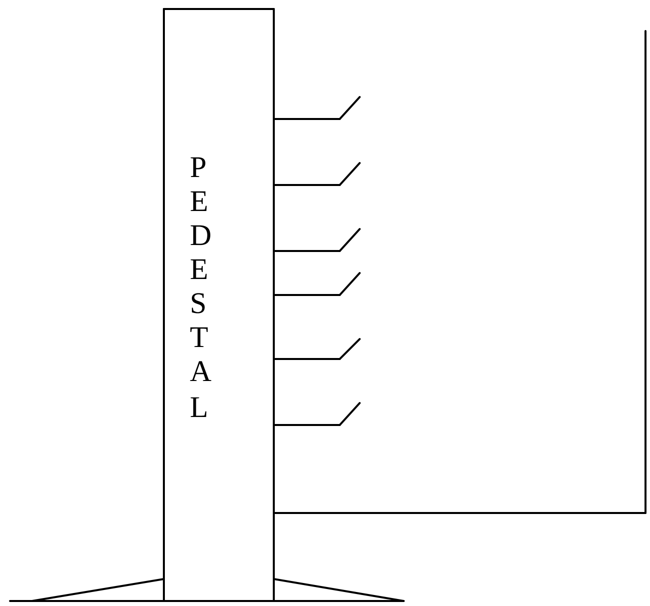
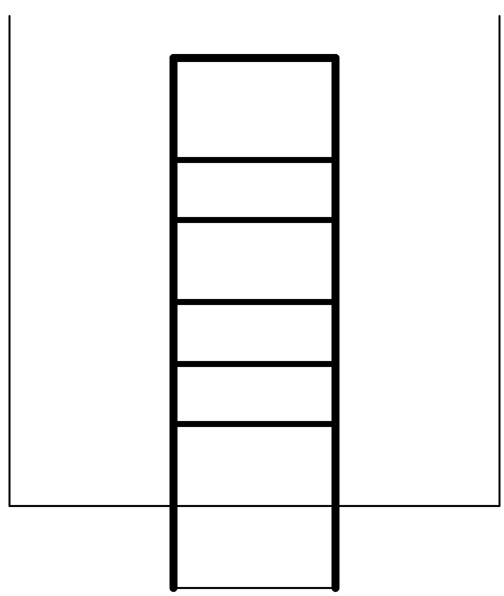


SECTION – AA



SECTION -- BB

14.0 Cable Map and Jointing Plan

When all the works on the Local Line Plant have been completed, the ‘as built’ drawings must be produced and made available for inspection at the operator’s premises and shall constitute the core maintenance document.
The cable map and jointing plan shall consist of one complete set of reproducible details. These shall show the “as built” construction details of the entire external plant.

The ‘as built’ drawings shall be provided in a convenient scale and shall be made available in soft copies as well.
They shall provide the following information:

- Distance between centers of all manholes, sizes and type of manholes.
- The location of manholes, referenced to some fixed easily identifiable point.
- The exact route of pole lines, dimensioned to affixed reference point.
- The length and type of every pole
- The distance between poles
- The location of stays; guy and anchors.
- The location of all terminals including the cable pair count
- The exact length of each cable (splice to splice), the gauge and number of pairs.
- The locations of all loading coils and the exact distance between loading points.

15.0 TESTING

Material tests shall be divided into two broad groups viz: -

(a) Field Tests

These are tests that can be performed on the field to ascertain the correctness of the installation of systems , materials or both or the quality of the materials being used for installation. These tests are to be carried out as installation progresses and during network acceptance.

(b) Laboratory Tests

These are the tests which will be conducted by the regulator in his laboratories for the purpose of determining whether a particular product from a particular manufacturer meets the stipulated standards in material quality and or manufacture to be admitted for use in the Nigerian telecommunications industry.

These tests are to be conducted for **Type Approval** purposes.

Field Tests

15.1 Sand

The following tests shall be carried out:

- Freedom from organic impurities
- Checking of clay and silt content
- Checking of grading (sifting test)

Several small quantities roughly 1kg each shall be collected from various parts of the sand pit. These samples shall be mixed thoroughly.

15.2 Test for Organic Impurities

A transparent glass jar with a wide neck shall be filled to one third full with the sand. An aqueous solution of sodium hydroxide (Na OH) shall be poured over the sand in the jar. This solution shall exceed the level of the sand by 50% above the depth of the sand. The jar shall then be corked and shaken vigorously and left untouched for 24 hours. If the sand contains humic acids, the solution will become coloured.

The sand is suitable for use if the solution is transparent, light yellow or yellow. If the solution is light reddish brown or dark red, the sand is unusable as it contains humic acids in quantities harmful to the concrete.

15.3 Test for Clay and Silt Content in Sand

To determine the quantity of clay and silt pour into the jar sand from the samples, up to a height of 50mm and then add water up to a height of 100mm. Agitate the mixture and leave for a few hours. If the sand contains clay and silt, a clearly noticeable layer will form on top of the sand. The layer shall not exceed 1.5% of the sand. If this is the case, the sand must not be used.

15.4 Grading of Sand

Permissible sand grains shall be within the grades of 0.5mm and 8.0mm. Grading shall be done by the use of appropriately sized screens.

15.5 Grading of Aggregate

The aggregate shall be within the grades of 20.0mm and 63.0mm. Grading shall be done by the use of appropriately sized screens.

15.6 Testing Of Concrete

For each day's production of concrete, three test cubes of 20cm sides shall be taken, marked with the date and tested on the seventh day. The compression strength of the concrete shall be 22 N/mm$^{2.}$ This guarantees that the final strength of the concrete (after 28 days) will be higher than 30 N/mm^2.

If the compression strength of the first test cube is less than 22 N/mm^{2,} another cube shall be tested. The average strength of the two cubes must be higher than 19 N/mm^2. The third cube shall be left as a control to be used in case any errors occur with measurements using any of the other two.

15.7 Tests and Inspection of Manholes, Joint boxes and Hand holes

Manholes, joint boxes and hand holes shall be tested for the presence of gas, water and adequate ventilation.

The manhole cover assembly shall be tested for strength by placing centrally on it, a 300mm diameter disc. It must withstand a load of 35,000kg for 5 minutes.

15.8 Galvanized Steel Pipe

Outer Diameter

The outer diameter of each sample shall be checked along the entire length by means of suitable gauges.
Three test specimens each of approximately 25mm length shall be cut, one from a randomly selected length. The threaded ends of the pipe shall not be used for thickness measurement. The ends of the specimens shall be cut at right angles to the longitudinal axis of the pipes and shall have clearly finished edges. The wall thickness shall be measured by a suitable method having accuracy better than 0.02mm. Three measurements of wall thickness at points approximately 120^0 apart shall be made on each end of the specimen. The average of these measurements shall be taken as wall thickness.

15.9 Reinforcement Bars - Bending Test

Samples of the bars shall be bent through 180^0 around a mandrel of the same diameter. Cracks must not develop along the outside of the bend.

15.10 Cable Tests

Three types of tests will be carried out in the field. These are as follows:

- Test During Construction
- Provisional Acceptance Test (PAT)
- Final Acceptance Test (FAT)

15.10.1 Tests during Construction

The following tests shall be carried out as jointing proceeds.

- Continuity of each wire
- Correctness of the jointing by ascertaining that there are no crosses
- Earth faults.
- High voltage tests. This test is to ensure that insulation resistance can be maintained.

- Test for any case of imperfect conductor joints.
- Tests to detect presence of crosstalk.

16.0 Provisional Acceptance Test (PAT)

On the completion of the installation works on each route of the network, series of tests shall be carried out to demonstrate the completion and satisfactory performance of the system.
The parameters to be tested during the Acceptance test are as follows:

a. Junction cable pairs

- Insulation resistance
- Conductor resistance
- Frequency – Impedance characteristics
- Frequency attenuation characteristics
- Near – end Cross talk
- Far –end Cross talk

b. Distribution Network Cable Pairs

- Insulation Resistance
- Conductor Resistance
- Mutual Capacitance
- Tests for wire crosses
- Tests for routing/continuity
- Cross Talk Attenuation

17.0 Final Acceptance Tests

This comprises of all the tests mentioned above as the Provisional Acceptance Tests but are made in the presence of the NCC regulators as a condition precedent to the commissioning and acceptance of the network.

Electrical Tests on Cable

(a) Continuity of Conductors

Conductors shall be tested for continuity with D.C. potential to ensure they are free from open and short circuit defects. Continuity tests shall be carried out on all pairs of cables terminated on Main Distribution Frames, Distribution Cabinets and Distribution Points.
The cable foil shall also be tested for continuity. Continuity and insulation tests must be made on cable across every joint. It is the measure of the quality of the jointing work at the site

(b) Open Circuit Test

The open circuit test on a conductor is made with a buzzer. Each wire in a cable shall be individually tested. Whilst any one wire is being tested, all other are looped at both ends and kept clear of contact with battery and earth. If the wire being tested has an open circuit, the buzzer will not sound.

(c) Short Circuit Test

The short circuit test on a conductor is made with a buzzer. Each pair in a cable shall be individually tested. The two legs of each pair shall be tested for "Shorts". While a pair is being tested, all other wires are looped at both ends and earthed. A short circuit condition is indicated by a "Buzz".

(d) Continuity of the Shield

The shield of each length of cable shall be electrically continuous. Shield shall be tested with a D.C. potential.

(e) Crosses Test

Wire crosses in a pair shall be tested with a buzzer. The two legs of each pair shall be tested for "Wire Crosses". All other wires are looped and kept clear of contact wit battery or earth. "Wire Crosses" are indicated by the condition of "No Buzz".

(f) Insulation Resistance

All wires under test shall be disconnected and clear of earth at the far end.
The selected number of 'A' wires are bunched and connected to the Megger, all other wires and the shield are connected to earth. After electrification for at least five (5) seconds with a 500V D.C., the Megger reading is taken. The reading on the Megger

multiplied by the total length of all the wires under test in kilometer gives the reading in Mega-ohms-km.
Expected values are 10,000 M-Ohm-Km or greater at 30°C.

For example: -
If 100 wires tested (A legs pair 1 to 100), the length of each wire is 5km and the Megger reads 8mega Ohms, then
Insulation resistance = 100 x 5 x 8 Mega ohm km = 40,000 Mega ohms-km.

All wires (both ‘A’s and ‘B’s) are tested against all other with the aluminum foil earthed and the individual results recorded in Acceptance Test. The insulation resistance of the foil against earth shall also be taken and recorded.

(g) Immersion Test for self-supporting Drop wire

Self-supporting drop wire shall withstand 2500 volts D.C. for 5 seconds at a temperature of 15°C±1°C.

(h) Attenuation

This test is carried out at the MDF using an Oscillator and decibel (dB) meter. The output of the Oscillator should be 0dB and both apparatus should be correctly matched to the impedance of the line. The Oscillator frequency should be set at 1 kHz. The two pairs are looped at the distant end and all test apparatus are kept at the near end. The reading so taken will be divided by two to give the attenuation of one pair in one direction for the cable length.
Alternatively, a sweep generator and Oscillator combination, covering the frequency band form 200 Hz to 4,000 Hz may be used to sweep the band and directly record the attenuation frequency responses of the section on the screen. This method is preferred where suitable test equipment is available.
The attenuation shall be measured on 10% of the pairs of each junction cable and for at least 5% of every primary subscriber’s cable to each CCP and for one pair to the furthest DP for secondary cables from each cabinet.
The value at a frequency of 150 KHz shall not be less than 68 dB/km.

(i) Transmission Test

Transmission loss shall not exceed 8.5dB at a maximum distance of 4.5km with cable attenuation of 1.68dB/km at 800Hz. The characteristic impedance at 800 Hz shall be 1000 ohms while the maximum loop resistance shall be 300 ohms/km at 20°C.

18.0 Summary of Electrical Tests on Cables.

TEST	MEASURING METHOD ETC	INSTRUMENT
(a) Leakage to earth problem	Testing of Conductors	Resistance and capacitance bridge
(b) Insulation Resistances	The insulation resistance of each conductor in the cable measured with all other conductors connected to earth.	Insulation resistance tester
(c) Contact between Conductors	"Varley loop test" or Pulse Echo method.	Resistance and capacitance bridge/pulse echometer
(d) Open Circuit on one or more Conductors	Capacitance measurement	Resistance and capacitance bridge/pulse echometer
(e) Crossing of Pair	Capacitance measurement	Resistance and capacitance bridge/pulse echometer.
(f) Continuity of wires (routing)	Testing of Conductor continuity and identification of cable pairs	Resistance and capacitance bridge

Applicability of Tests

S/N	Test Description	Junction Cables	Primary Cables	Secondary Cables
1	Continuity-Opens	C	C	C
2	Continuity-Shorts	C	C	C
3	Continuity-Crosses	C	C	C
4	Continuity-Earth	C	C	C
5	Insulation-Resistance	C	C	C
6	Loop-Resistance	C	C	C
7	Resistance-unbalance	C	C	C
8	Attenuation	C	C	O
9	Cross Talk-Near End	C	O	O
11	Cross Talk-Far End	C	O	O

Legend: C = Compulsory, 0 = Optional

19.0 Mechanical Tests on Cables

(a) Cable Bending Test

- The test specimen shall be bent at room temperature with the shielding overlap on the outside of the bend, in a 180° arc around a mandrel, the diameter of which shall be 20 times the outside diameter of the cable.

- The specimen shall then be straightened and then bent 180° in reverse direction, completing one cycle. The specimen shall then be rotated 90° and a second cycle of bending performed. On completion of the above, the specimen shall then be examined. The shield and the sheath shall show no evidence of fracture visible to the unaided eye.

(b) Fastness of Cable Colour and Marking

Rub the insulation and markings on the cable lightly 10 times using a wet piece of soft cloth. If the colours or markings do not rub off by this process, the cable passes the colour and marking test.

20.0 Tests on the Conduit System

Conduit systems of PVC, concrete-encased PVC and galvanised pipe ducts shall be tested for: -

- Water Tightness
- Mechanical Strength
- Correct Shape and dimension
- Effective length of duct – 6 meters
- Minimum Internal diameter – 100mm
- Minimum wall thickness – 3mm

(a) Earth Resistance Test

The earth resistance of exchange up to 1000 subscriber line shall be less than 2 ohms while that of exchange more than 1000 subscriber line shall be less than 1 ohm. Earth resistance shall be measured with a megger.

(b) Junction Line Test

The junction line test shall be such that loop resistance does not exceed 2,000 ohms, installation resistance not less than 10,000 M-ohms-km and line attenuation not exceeding 6 dB measured at 800 Hz.

21.0 Tests on Wooden Poles

Wooden poles shall be tested to ensure that they are free from decay, insect damage, shakes, transverse fractures, hollows, large loose knots and unsound knots of more than 20mm diameter, spiral gain of one turn in less than 6.0m of length and holes not more than 12mm in diameter.

22.0 Laboratory Tests

(1) Cable

(a) Water Penetration Tests

A circumferential portion of the sheath and core wrappings 25mm wide shall be removed from the middle of a 2-meter length of cable and a water-tight gland shall be applied over the exposed core so as to bridge the gap in the sheath. The cable shall be supported horizontally and a 1-meter head of water containing adequate quantity of water soluble fluorescent dye shall be applied to the core for 14 days at a temperature of 20°C ± 5°C.
The sheath shall be removed at the end of the test, the core carefully dissected and examined under ultra-violet light for water penetration.

Cable has passed the test if water penetration does not exceed 850mm in either direction.

(b) Cable Drip Test

A test specimen, 30cm in length shall be cut from the completed cable. One end of the sheath shall be stripped for approximately 5cm and the conductors, with the jelly wiped clean, shall be flared out at approximately 45° angle.

The sample shall be suspended in an oven vertically, with the flared end, downwards and maintained at 65°C ± 1°C for 24 hours. A pre-weighed glass disc shall be placed below the flared end. At the end of the test, the glass disc shall be examined for the presence of the filling compound, which might have dropped.

Cable passes the test if there is no dripping.

(c) Immersion Test for self-supporting Drop wire

A sample coil shall be selected and completely submerged in water for a minimum period of 12 hours. The tank and water shall form the ground side of the testing circuit. After the minimum period, the line potential shall be applied to both conductors of the drop wire simultaneously. The measurement shall be made at or corrected to 15°C ± 1°C.
The finished drop wire shall withstand for five (5) seconds a potential of 2500 volts D.C.
The insulation resistance between conductors or between each conductor and the surrounding water shall not be less than 500M-ohm kilometer when measured at or corrected to 20°C. The D.C. resistance of any conductor shall not exceed 91 ohms/Km at 20°C.

(d) Measurement of Insulation thickness

A sample of cable is taken from three places separated by at least 1m. The conductor is withdrawn, taking care not to damage the insulation. The insulation is cut with a sharp knife along a plane perpendicular to axis of the conductor, and placed under a measuring microscope or in a profile enlarger of at least x10 magnification, the measuring of the cross section being perpendicular to the optional axis. Measurements are taken with a microscope shall be accurate to 0.001mm. Six measurements of radial thickness are taken on each piece of insulation at places where the insulation is thin, i.e. between the ridges caused by the strands. In all cases, the first measurement shall be made at the place where the insulation is thinnest.

The mean of the 18 values obtained on the three places of insulation is computed and rounded to two decimal places. This is the mean value of insulation thickness.

(e) Measurement of overall diameter

A sample of cable is taken from three places separated by at least 1mm. For cables with an overall diameter not exceeding 15cm, measurement is taken from the circumference of the cable by means of a measuring tape. The diameter is calculated from the mean of the three values obtained as the mean overall diameter.

(f) Adhesion Test for self-supporting Drop wire

The test samples shall be approximately 1 meter long single conductors separated from the figure of 8 configurations. Half of the samples shall be tested untreated or unaged and the other half shall be tested after accelerated aging.

Accelerated aging shall be carried out by leaving the sample in air oven at a temperature of 100° ± 1°C for 96 hours.

The adhesion test shall be done with a standard tensile strength testing machine having a rate of separation (without load) between the fixed and movable heads of approximately 100mm/minute. The gripping surface of the parallel plate toggle or wedge-type jaws shall be 6.3±0.3cm long and the surfaces shall be corrugated with not less than 4 corrugations per cm. The specimen shall be held in place with the inside ends of the jaws at least 300mm apart and at least 300mm of the free end of the specimen extending beyond the jaws of the fixed head. The temperature of the specimen test equipment and room at the time of testing shall be between 15°C and 30°C.

(2) Galvanised Pipes

(i) Test of Galvanizing for Pipes

Three samples, each of about 200mm length is taken from three different randomly selected lengths.

Each sample shall be cleaned with cotton soaked in benzene and dried. It shall then be placed in a pot with a diameter of not less than 70mm, which is filled to a height of about 100mm with a solution of one part per 100 by weight of water and copper sulphate at a temperature of 30^{o}C to 35^{o}C. The sample shall be left undisturbed in the solution for one minute. It shall then be taken out quickly and the loose precipitated copper shall be removed by means of cotton under running water. The sample shall one more be immersed in the solution and the procedure shall be repeated. Each of the samples shall withstand four immersions without the occurrence of copper formation that cannot be removed as described above. The lower 30mm of the sample shall be left out of consideration of the test sample; the sample shall be tested one at a time fresh copper (II) tetraoxosulphate(VI) solution shall be used for each sample.

(ii) Bending Test for Galvanised Pipes

Three samples, each of about 200mm length is taken from three different randomly selected lengths. The sample shall have sufficient length to ensure free bending. The pipes shall be bent through an angle of 90^{0} so that the inside radius of the bend is equal to six times the nominal outside diameter.

After the bending, it shall be checked that:

(a) The outside of the pipe shows no visible crack and the seams of welded pipes, if any, are not open.

(b) There are no flaws and the coating does not show any damage

(c) The shape of the pipe does not show any alteration, which will cause damage to the cable when installed.

CHAPTER 4

OPERATIONS AND MAINTENANCE

1.0 Operations and Maintenance

Network operations and maintenance shall be organised so as to deliver to the telephone customer very efficient services whilst the operator keeps an eye on costs at the same time.

1.1 Organisation

- The Operation and Maintenance Organisation shall be set up in such a way that it is not top heavy and therefore response to faults can be fast. Distributed management, responsibility and authority structure is advocated.

- An external line plant network serving an Exchange Area shall be divided into maintenance areas which shall be attended to by maintenance gangs.

- A maintenance gang shall consist of three technicians.

- A maintenance vehicle equipped with a ladder, maintenance tools and test equipment shall be attached to each of the maintenance gangs.

- Each Exchange area shall have fault-reporting desk and a customer care desk. These desks shall be equipped with enough telephones as to make it easy for customers to reach the attendants.

- Fault log register shall be provided the fault reporting desk. In the register shall be recorded the date, time and nature of the fault as well as the date and time of clearance of the fault and remarks that may help the network manager to device a system to avert such faults in future.

- The Customer Care Desk shall attend to: -

  - Customer Enquires
  - Service Provisioning
  - Credit Control

1.2 Practice

Preventive and Corrective maintenance procedures shall be the standard maintenance practice.

- **Preventive Maintenance**

This shall consist of daily checks and tests to determine faults such as short circuit, contact fault, earth faults and low insulation. Many times it should be possible to detect a fault early enough and correct it before it manifests as a problem to the customer. All measurements to be taken in preventive maintenance procedures are compared to standard values and any noticeable deviations are immediately taken care of.
Enough spares especially of parts that have long replacement lead times must be kept in stock.

Routine regular preventative maintenance shall be carried out on:

a) Manhole Covers – once in a quarter, sealing rings shall be checked for integrity and be replaced if necessary but in any case must be replaced once in a year.
b) All joint boxes and hand holes covers - as for manholes above.
c) Cross Connection Cabinets - once every month. They shall be blown all over with warm air to clear any dampness and keep all contacts dry.
d) All DPs - same as for the Cross connection cabinets above.
e) Tests for continuity and insulation shall be carried out on underground cables especially cross joints every quarter.

- **Corrective Maintenance**

Maintenance teams shall be equipped with adequate facilities and tools to enable them respond quickly and positively to reported faults. All minor faults that impair a customer's service must be cleared within 24 hours of report.

Maintenance teams shall be equipped with adequate communication facilities to enable them be reached by the network managers and also by the customers they maintain their service.

The maintenance Technician must keep a log of all faults referred to him for clearance, the action taken to clear the fault, the length of time taken. This information shall be passed on to the plant Manager and shall be used for network planning and management purposes.

1.3 Operations and Maintenance Literature

Network layout plans, cable jointing schemes, cable routing schemes, MDF and Cross Connection Cabinet termination schemes shall all be kept and made readily available to technicians as an operations and maintenance tool. The technicians shall be trained on these literature and must have a good mastery of how to use them.

Soft copies of all literature shall be made and kept safely for use in replacement as the hard copies age.

1.4 Operation and Maintenance Skills.

Operations and maintenance technicians must have basic academic formal electrical science training to the minimum level of the National Diploma or equivalent.

In addition, they will also undergo skill acquisition training in the fields of cable jointing, cable termination, fault tracing and clearing, all aspects of outside line plant construction, protection, earthing and lightning protection. Technicians must be given adequate training on any specialized equipment deployed in the network. Technicians shall also be trained to acquire skills in the areas of taking accurate measurements, interpretation of those measurements and the use of relevant test and measuring instruments.

These skills shall be acquired through guided training programmes.

Technicians must keep accurate log of all faults and the action taken to clear them. Regularly these data are to be analysed by engineering staff to determine weak links in the network, regularly failing parts / materials / equipment for purposes of future planning

1.5 Spare Parts

Spare parts management is a vital part of maintenance. The skill to know what spares to keep handy, the quantity of such parts, the accurate forecast of breakdowns and the knowledge of expected lifetimes of network components is acquired in practice and are the skills required of Network Managers.
As a rule of thumb jumper wires, cable jointing kits, service wires, surge protectors, line protectors, terminal blocks and poles shall always be kept as running spares in varying quantities depending on the size of the network.

1.6 Tools and Test Equipment

Tools and test equipment required for the operation and maintenance of the outside line plant are very basic and shall include the following: -

- Level meters
- Cable fault locator
- Cable track locator (Radio detection)
- Insulation resistance tester
- Resistance/Capacitance bridge
- Pulse echometer
- Jointing tools
- Cable winch
- Water pumps
- Portable generators
- Vehicles including, cable-reel trailers

GLOSSARY

External Line Plant Network	-	Entire cable network linking all telephone subscribers to the telephone exchange.
Cross Connection Cabinet	-	An interchange point where primary cables are jumpered to secondary, tertiary or feeder cables. Serves as a branching point for cables in different directions.
Main Distribution Frame	-	Interconnection point between the switch and the outside line plant
Clinker	-	a very hard kind of brick made glassy by heat and fusion
Direct Feed Area	-	Areas around the telephone exchange which are serviced directly, usually about 500 m radius of the exchange
Distribution Point	-	The point from where service cables are strung to subscriber premises to deliver service
Twining	-	Twisting together
Attenuation	-	Reduction in strength
Galvanise	-	Protection from rust by electroplating with zinc
Steel Armouring	-	Protection and strengthening by use of steel wires wrapped around formed cables
Manhole	-	A hole into which a technician can get to access the cable ducts and the cable laid therein for the purposes of jointing, maintenance or repair works
Unplasticised	-	Non- plastic
Jointing Chambers	-	Includes all of Manholes, joint boxes, Hand holes, etc
Loop Resistance	-	Resistance of a complete circuit
Poly-Al Laminate	-	An aluminium tape with both faces coated with polyethylene
Transmission Limit	-	Maximum allowable loss over a defined length of cable and a defined size of cable
PVC	-	Poly Vinyl Chloride
Suspension Strand	-	Steel wire incorporated in aerial cables for strength
Dielectric Strength	-	The minimum voltage that will break the insulation capabilities of a non conductor and make it conduct electricity
Screened Cables	-	Cables protected from the effects of external electrostatic fields. Screens are usually of aluminum