Communications
Commission
of Kenya

GUIDELINES FOR INSTALLATION AND MAINTENANCE OF EXTERNAL COMMUNICATIONS INFRASTRUCTURE

CCK 2012

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F O R E W O R D

The economic strength of a country is substantially dependent on the level of development of the transport and telecommunications infrastructures. The faster the growth of the telecommunications sector, the greater the nation's capacity of acquiring, processing, transmitting and storing information. This coupled with the emergence of a wide variety of new services as a result of the convergence of telecommunications and information technologies lays basis of the industrial take off of any developing country.

The government fully cognizant of the need to accelerate the rate of development of the National Telecommunications Networks and infrastructures went through several stages in order to establish a full regulatory body which opened doors to greater private sector participation in the growth of Kenya's telecommunications industrial base.

In 1991, the internal telecommunications wiring and terminal equipment industry was liberalized with 28 contractors and 57 Engineers were registering to provide these services. The rate of registration of contractors and technical personnel has continued to increase with time with statiscs showing a figure of over 500 by mid 2011.

In 1996, the Kenyan government moved a step further by liberalizing the external communications and wiring .This included provision of the local distribution network during the construction of an estate or an institution and it further enhanced the provision of telecommunications services countrywide.

The first edition of this publication was produced in 1996 as guidelines to those contractors who wished to endeavor to venture into the provision and maintenance of external telecommunications wiring. The publication has been revised to suit the current. The publication should also be used in collaboration with "Guidelines to Contractors for Supply, installation and Maintenance of Telecommunications Internal Wiring and Terminal equipment" as released in 2011.

Due to the problems in provision of communications during the existence of monopolistic era, the liberalization itself did not offer easy solutions to the constraints facing the communications sector especially in a developing country like Kenya. Therefore existence of appropriate policies and regulatory framework was deemed essential for any telecommunications development strategy, and hence there was need to create a regulatory body for the regulation of communications sector in Kenya.

Through the Kenya Communications Act, 1998 the defunct Kenya Posts and Telecommunications Corporation was disbanded and three independent bodies namely Telkom Kenya, Postal Corporation of Kenya and Communications Commission of Kenya were created. Communications Commission of Kenya was mandated by the act to deal with regulation matters pertaining to postal and telecommunications sectors. The creation of the Commission has revolutionized the communications sector turning it into the pillar driving Kenya's Economy in great levels. The act has since been amended to incorporate more mandates like broadcasting and electronic transactions.

Kenya being a country with enthusiastic and ambitious people, the rate of development is high and as such there is ever increasing demand for use of sophisticated telecommunications equipment and services. This increasing demand is generally on all facets of

telecommunications services and is accelerated by rapid technological advancement. Therefore CCK as clients' watchdog in the communications subsector has to keep pace by ensuring the availability of efficient, reliable and affordable communications services, most suitable for the clients' requirement.

The Commission has licensed four cellular phone operators and adopted a unified licensing framework (technology neutral approach) that provides opportunity for operators to leverage on their capacities using any technology.

We would like to mention that by the dawn of liberalization in 1991, when only 75 contractors and vendors were registered countrywide, there were between 1500 and 2000 job opportunities created for Kenyans in the communications sector. Today, with several services liberalized in the sector, tens of thousands of job opportunities have been created and this trend is expected to continue. This is in line with the Kenya Government's resolution of achieving middle income economy for Kenya through Vision 2030.

Charles J. K. Njoroge
DIRECTOR GENERAL

1. INTRODUCTION

1.1. PREAMBLE

This document should be read in conjunction with "Guidelines to Contractors for Supply, Installation and Maintenance of Internal communications infrastructure" hereinafter referred to as Volume 1.

1.2. DEFINITION OF EXTERNAL COMMUNICATIONS INSTALLATION

"External Communication Installation" means any communication installations (wired, wireless and associated equipment) on a building i.e. outside the building either on the rooftop or on a wall of a building or between detached buildings in a campus area under one management or across private & public land and providing access to the Public & Private Communications Network.

1.3. DEVELOPMENT OF INSTITUTIONS AND ESTATES

Contractors should advise building developers to provide communication service infrastructure alongside other services like power, water and sewer during the construction stage of institutions, residential and commercial estates. This shall include provision of internal wiring and accessories for each building, local distribution network, cabinets and the main cable to an appropriate jointing chamber at the boundary of the estate or institution. The main cable shall be left stumped at the jointing chamber awaiting connection to the public network by the Network Operator.

This scenario is expected to further improve the communication network quality, enhance subscriber connection and maintenance efficiency and add to the aesthetic beauty of the environment.

1.4. DEMARCATION POINTS

1.4.1. General

It is very important that all contractors are conversant with the relevant demarcation points in the access network.

1.4.2. Demarcation Points

i. Protector Unit

This shall be the demarcation point for wiring in bungalows, maissonettes, single floor go-downs and block of flats served by an external DP.

ii. Internal Distribution Point

The internal DP shall be the demarcation point for a block of flats, compounds, go-downs or office blocks.

iii. Local Main Distribution Frame

This shall be the demarcation point for institutions, large office blocks, compounds, or high-rise buildings.

1.4.3. **Special Cases**

i. Estates

During installation of the external cable network in estates, the jointing chamber at the estate boundary shall be the demarcation point. After the completion of the estate, the demarcation point will shift to the PU, internal DP or local MDF as the case may be, for maintenance purposes.

ii. Institutions

The demarcation point during installation shall be the jointing chamber as for estates. However, during maintenance, the demarcation point shall be the local MDF. It shall be the responsibility of the institution and individuals within the institution to hire a contractor to maintain the local network from the local MDF to the individual buildings.

1.5. CONTRACTOR'S REQUIREMENTS

In addition to the requirements in clause 4.1.2 installation and maintenance of telecommunications External Installations shall only be undertaken by class A technical personnel. Contractors registered for internal telecommunications wiring wishing to provide simple external extensions by use of drop wire may be exempted from this requirement.

1.6. WARRANTY

In institutions and estates, all external telecommunication wiring works involving cables shall have a minimum warranty period of 3 month after the issuance of the provisional acceptance to cover defects in the workmanship. During this period, the contractor shall maintain the cables for malfunctions arising from the quality of his installation work.

2. PROCEDURES

2.1. SUBSCRIBER

A client wishing to have external communications wiring done in his compound will be required to enter into a private agreement with a Contractor licensed by Communications Commission of Kenya

2.2. WAYLEAVE

The contractor shall obtain necessary way leave from relevant authorities.

2.3. DRAWINGS AND PLANS

i. The contractor shall prepare drawings and plans for the proposed project.

ii. All drawings and plans shall have a title block showing project title, originator, verifier, scale, drawing number and date as necessary.

iii. All drawings and plans shall use standard electrical and telecommunications symbols, abbreviations and nomenclature.

iv. The contractor shall submit at least two copies of each of the following proposed cabling drawings and plans together with the approved way leave document to the Network Operator and/or the Commission.

v. Twenty (20) year period schematic plans as shown in figure 2.1. This plan will show:

   a. the existing and proposed cables,

   b. the number of existing and proposed ducts,

   c. five (5) year forecasts for each Distribution Points (DPs) and cable sizes for the twenty year period,

   d. addresses of Distribution Points.

vi. Cable Distribution Diagrams as shown in Figure 2.2 clearly showing:

   a. Physical address and location of cross connection points (CCP), main and local DPs,

   b. Type, size and gauge of cables,

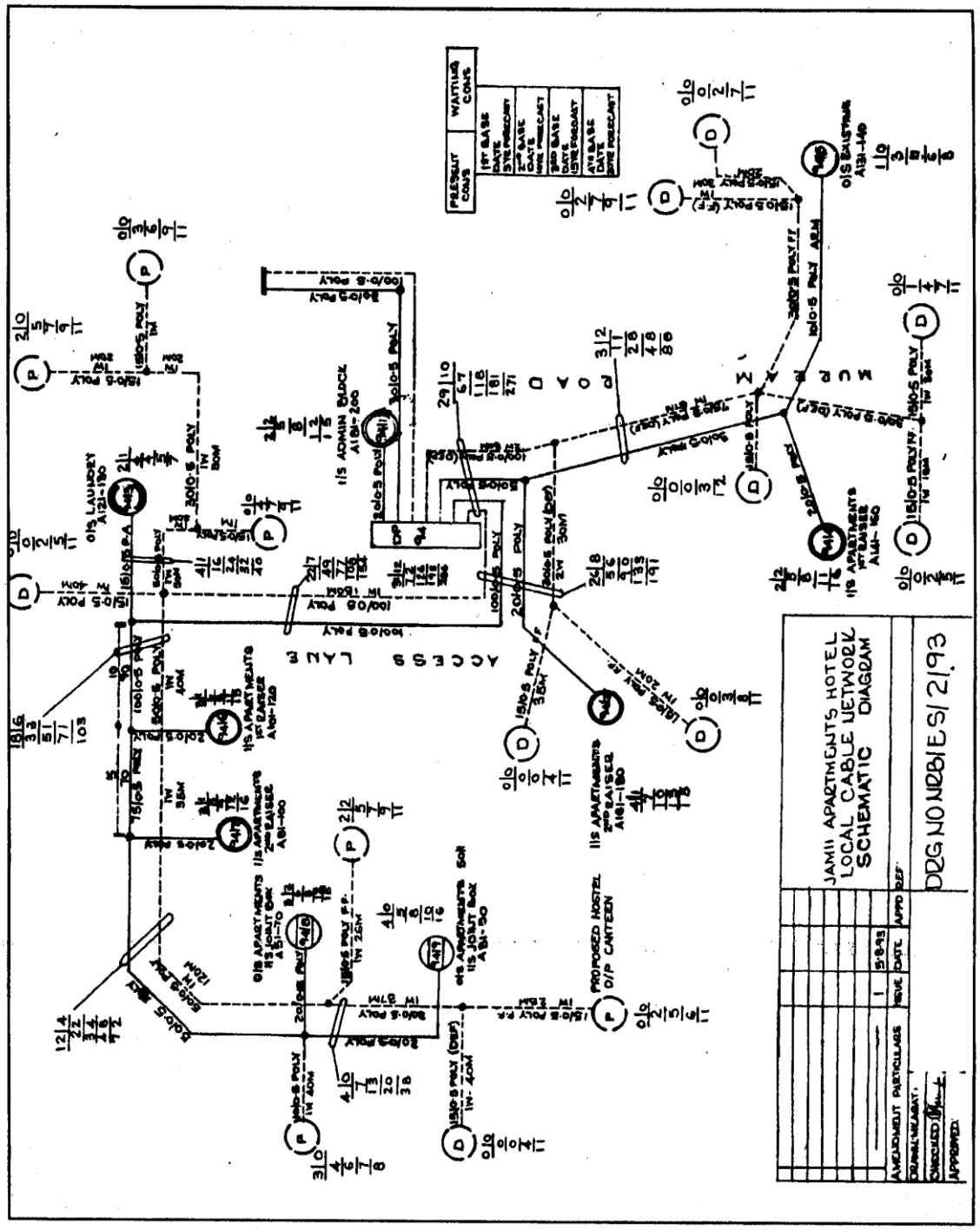


Figure 2.1 Schematic Plan (sample)

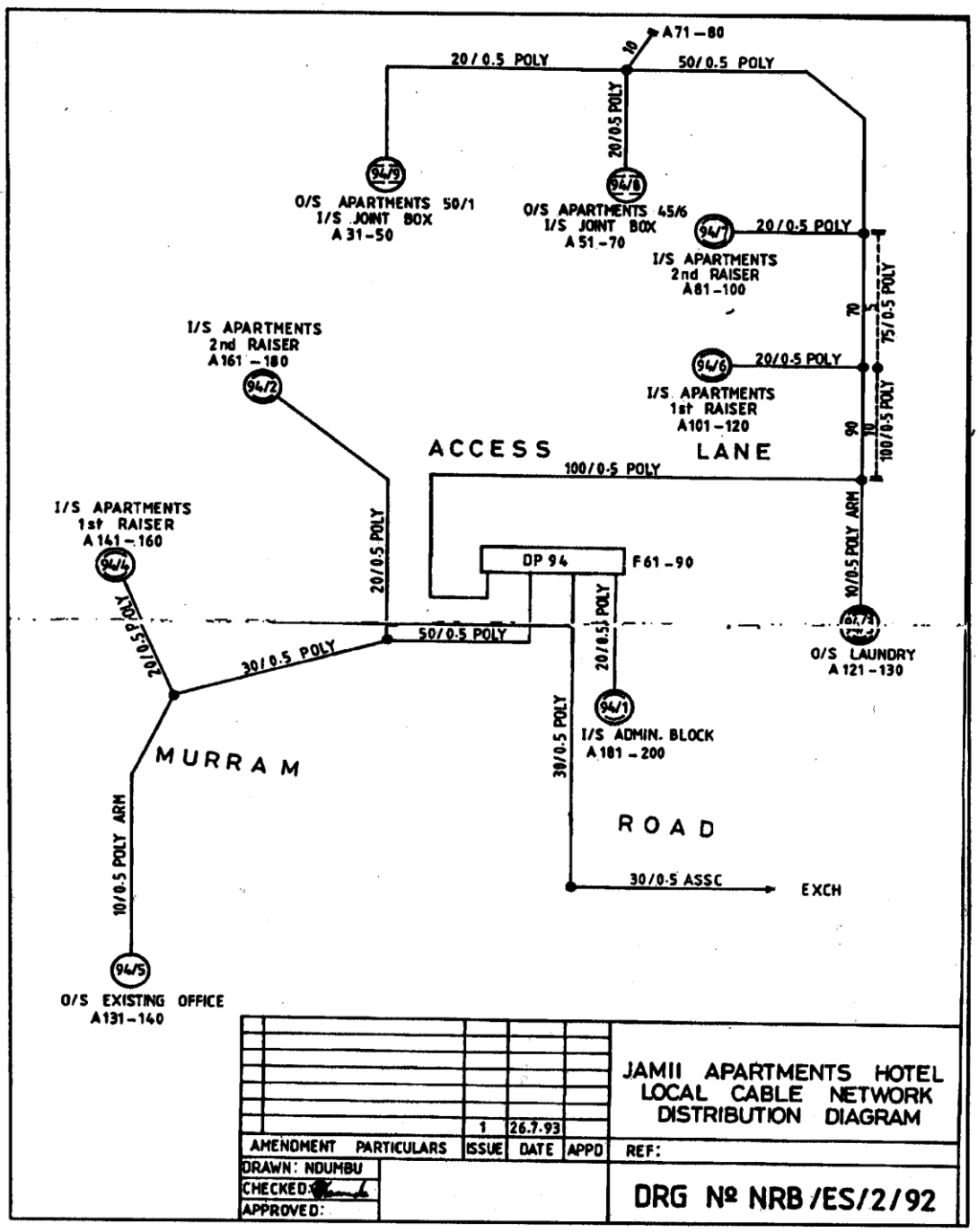


Fig. 2.2 Cable Distribution Diagram (sample)

c. pairs terminated on the local DP,

d. names of local roads or lanes where applicable,

e. local DP pair terminations at the Local MDF,

f. local MDF diagram where applicable. A sample is shown as figure 2.3 for an underground cable.

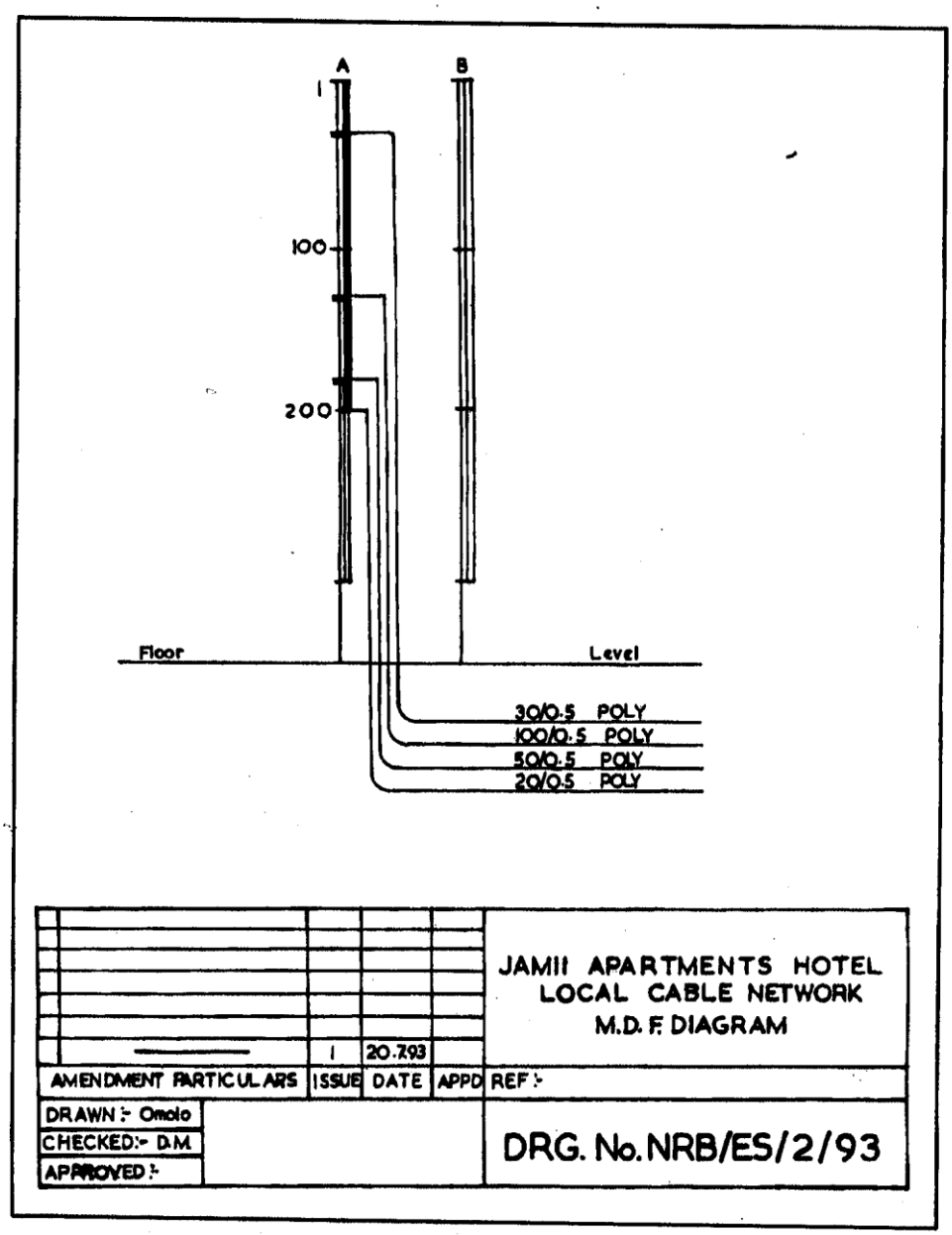


Fig 2.3 MDF Diagram (sample)

vii. Duct Plan

The duct plan shall be to scale and shall show the precise location of the duct-routes. One copy shall show information for duct laying and another copy shall show information for cabling. The duct plan shall in addition show:

a) location of local MDF and DPs,

b) number, physical address and location of the local DPs,

c) centre to centre measurements of jointing chambers, couplings and number of duct-ways,

d) type of jointing chambers,

e) names of local roads or lanes where applicable,

f) jointing chamber serial numbers.

g) Samples of duct plan and cabling plan are shown in figures 2.4 and 2.5.

viii. Duct Space record

Duct Space record, showing details of duct bore number, duct space utilization, type of cable, year of installation, originating and terminating locations should be kept.

ix. True to Scale (TTS) Diagram

This is an ordinance map of the area of scale 1:2500 or in congested areas scale 1:250, 1:500 and 1:1250 which shows:

a) streets, roads, lanes, railways, plot boundaries etc,

b) telecommunications plant with underground and aerial routes in their exact location,

c) proposed plant shown in dashed lines.

A sample is shown in figure 2.6.

x. Straight Line Diagram

The straight line diagram (SLD) shown figure 2.7 shows point to point details of a coaxial, optical fibre etc route as follows:

a) type and size of the cable,

b) repeater and joint positions,

c) repeater to repeater section length where applicable,

d) centre to centre measurements of jointing chambers,

e) Span lengths of pole routes.

2.4. SPECIFICATIONS

Contractors shall be required to use cables, associated materials and accessories that conform to Kenyan specifications as per KEBS, KS 1059

2.5. OTHER PROCEDURES

The same procedures as described in clauses 4.2 in Volume 1 of Guidelines to Contractors will apply.

2.6. ESTATES AND INSTITUTIONS

Certified records pertaining to installations in estates and institutions shall be submitted to the Network Operator after commissioning for purposes of provision and maintenance of telecommunications services.

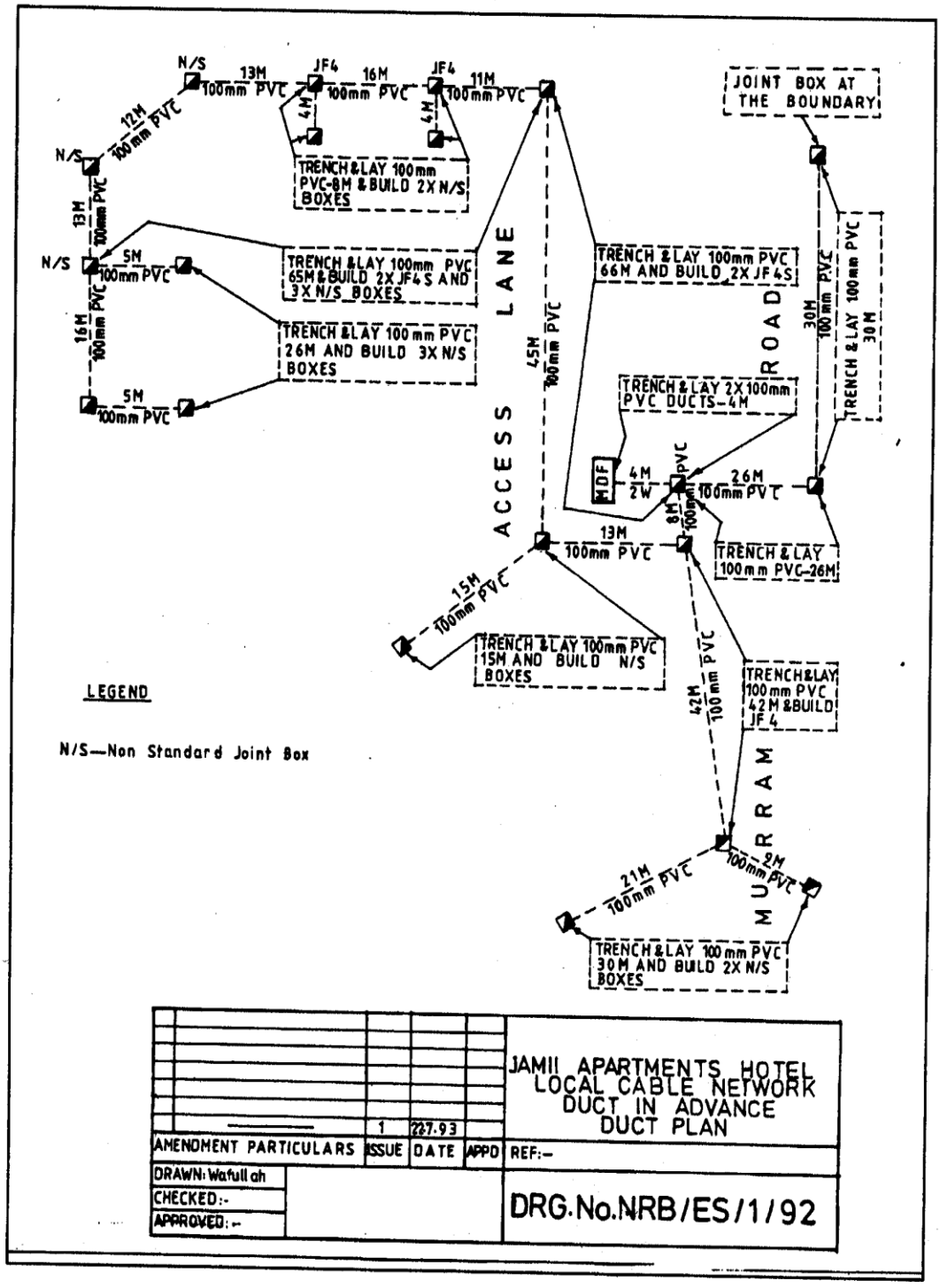


Fig 2.4 Duct Plan (sample)

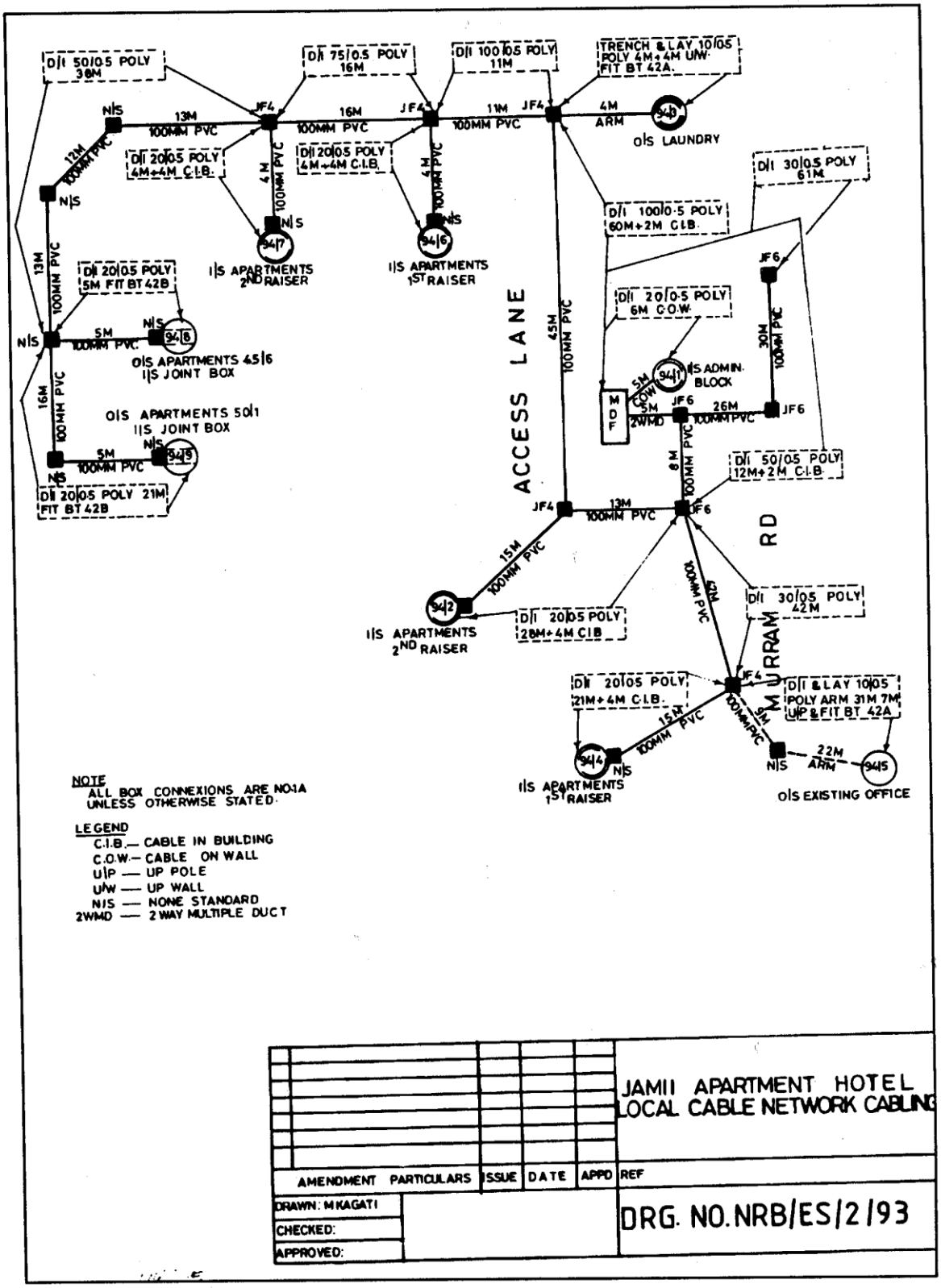


Figure 2.5 Cabling Plan (sample)

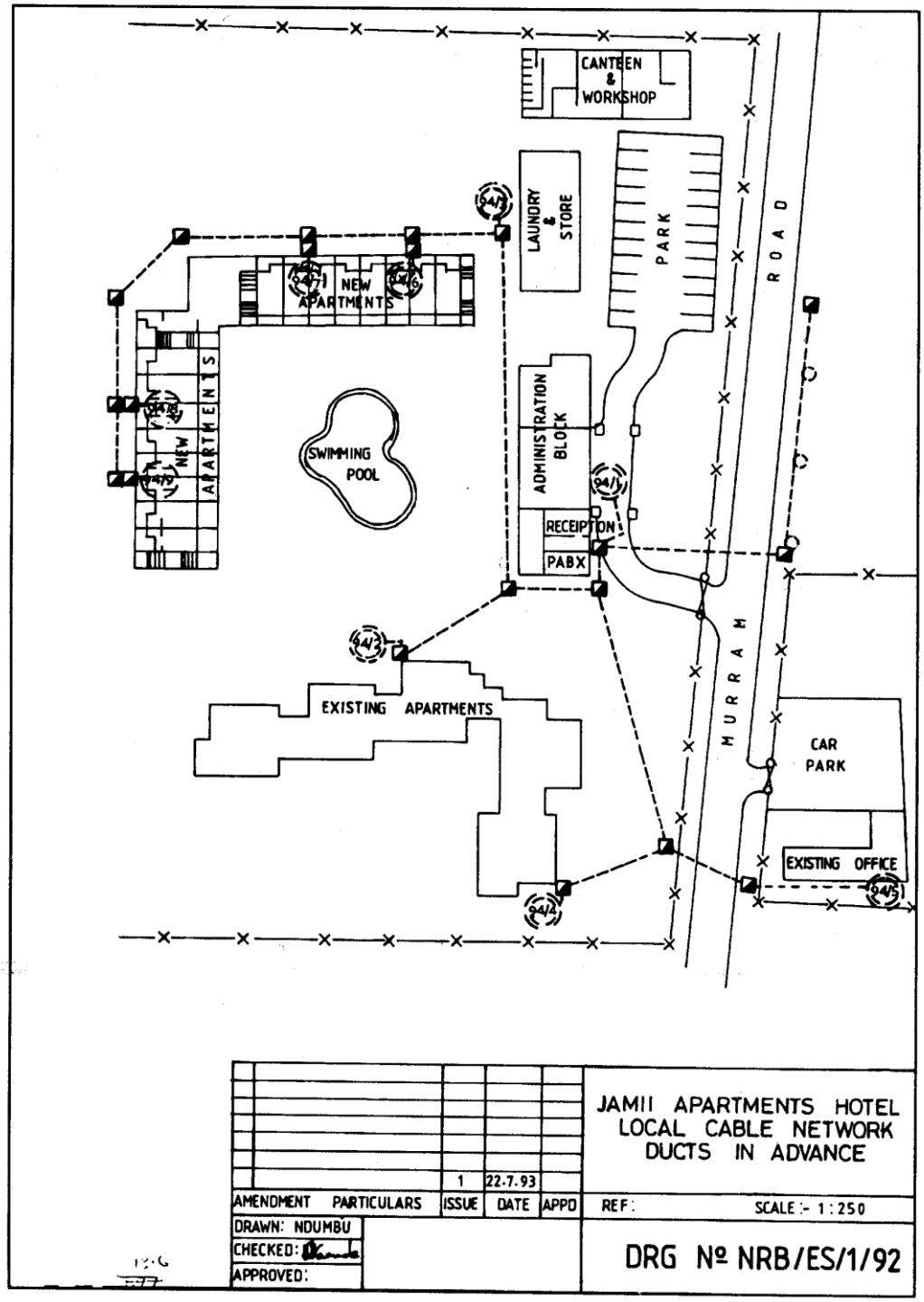


Figure 2.6 True To Scale (TTS) Diagram (sample)

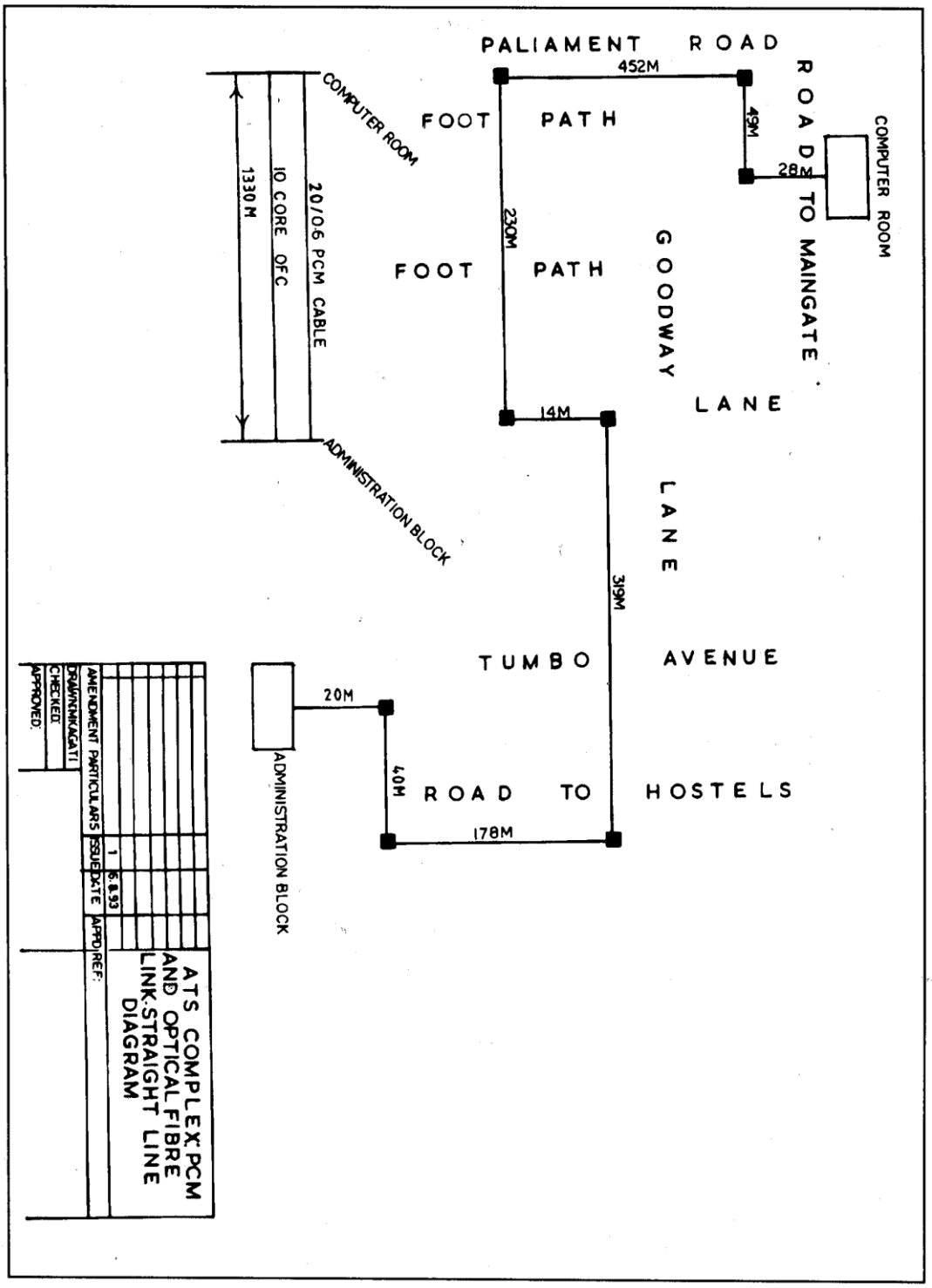


Figure 2.7 Straight Line Diagram (SLD) - sample

3. PLANNING

3.1. INTRODUCTION

The external telecommunications wiring development plans must be designed to meet the requirements for twenty (20) years period. This requirement shall include provision for infrastructure sharing with other operators. The client should therefore provide detailed information on the telecommunications facility requirements for the entire period to enable the planner prepare accurate schematic plans.

These schematic plans will articulate partial implementation of five (5) year phases and will also enable alternatives to be considered before execution.

3.2. PRELIMINARY SURVEY

3.2.1. The survey will commence by ascertaining whether the choice of route will be affected by the following:-

i. Local authority development plans.

ii. Trunk, special roads and future road widening operations.

iii. Underground and overhead power plant.

iv. Water drainage and sewerage services.

v. Nearby airfields.

vi. Playgrounds and other open spaces.

vii. Special features e.g. swampy ground.

viii. Bridges and culverts.

ix. Existing communication facilities.

x. The soil conditions along the route, etc.

3.2.2. After completing this investigation the following activities should be carried out:-

i. Particulars of authorities and organizations controlling the affected services shall be obtained from whom way leave consents shall be sought and to whom plans, sections and notices shall be sent.

ii. Obtain information from the developers, building contractors and proprietors.

iii. Verify records of existing plants as necessary.

iv. Spot existing subscribers and proposed positions for new installations including areas that shall require public services e.g. markets, shopping centres, schools, health centres etc.

v. Make visits to confirm spotting where uncertainty exists due to inadequate records and to verify existing plant locations. At this stage, notes can be taken of possible obstructions - overhead power plants, tree-lined roads, etc.

3.2.3. If there is still doubt as to whether or not a working subscriber exists at an address, reference may be made to any of the following for confirmation:

- Local MDF Records,
- Caretaker's RECORDS

3.2.4. Consultations with Network Operators and CCK shall be made if necessary.

3.3. SCHEMATIC DESIGN

3.3.1. To prepare the Schematic Diagrams the following stages shall be followed:

i. Transfer DP proposals and forecast to either an existing TTS or to a specially scaled cable diagram.

ii. Determine the DP spur cable sizes.

iii. Determine the sizes of distribution cables necessary to cater for proposed DP and the existing DPs ensuring clear layout with simple jointing requirements.

iv. Group DPs into possible CCP areas for large estates full consideration being given to the engineering benefits arising from the introduction of flexibility points.

v. Design the main cable layout within the compound where applicable.

vi. The contractor shall obtain from Network Operator the Transmission Equivalent Ratio and signaling limits for the particular switch/es (exchange/s) in order to determine the conductor gauges for the new cables.

vii. Check twenty (20) year duct requirements.

viii. Complete the Straight Line Diagram (SLD) entering such details as the distance between principal junction points, serial numbers of CCPs, cable codes etc.

3.3.2. Arrange a meeting with local authorities to obtain information on surfaces, foundations, conditions of back-fill, interim and final reinstatements and to enable the proposed location of overhead plant, CCP, to be provisionally progressed or modified where necessary

3.3.3. The location of the route shall be acceptable to the client.

3.3.4. Route selection shall guarantee minimum amount of subsequent tree-cutting and avoid as far as possible trees that would overhang the route. It should be noted that least obstruction is likely to be met if main roads are avoided in preference to subsidiary roads.

3.4. DETAILED SURVEY

3.4.1. Span length

The standard pole span length for aerial cable routes shall be 40m - 55m and 60m - 64m for drop wire routes. Shorter span lengths are normally used when bends and steep terrain are encountered.

i) Take measurements of heights, lengths and angles.

ii) Consider long length cabling.

iii) Confirm positions and size of jointing chambers.

iv) Note any contract works, road surfaces for reinstatement charges and mechanical aid requirements.

v) Establish cable splice points and closure locations.

3.4.2. Survey sheets should be prepared containing the following:

i. span length,

ii. grading of pole,

iii. true and false terminations,

iv. position of other services,

v. separating distances,

vi. position and type of stay or strut,

vii. any special feature,

viii. any special construction method to be adopted,

ix. duct space available,

x. availability of cable supports in existing ducts,

xi. ducts alignment,

xii. angular duct entry, etc.

3.5. DETAILED DESIGN

3.5.1. Spacing of Chambers

The cable chambers should be at a spacing of not more than 150m unless limited by:

a. Length of conduit that can be rodded,

b. Obstructions and change of direction.

3.5.2. Duct Occupancy

Ducts occupancy shall be on the basis of an average of 800 pairs per duct bore and aerial route loading at an average of 200 pairs per route.

3.5.3. Spare Ducts

Provide 75% spare ducts capacity for sharing and future requirement.

3.5.4. Drawings and Plans

All drawings and plans shall use standard electrical and communications symbols, abbreviations and nomenclature.

3.5.5. Forms

The routing and diversion information of each pair shall be properly recorded for ease of reference.

3.5.6. Determination of Conductor Gauge

The local line network should be designed so that the transmission limit for the type of exchange can be met with the minimum amount of conductor. The network therefore consists of large size, light gauge cables near the exchange boundary. The light gauge cables will extend from the exchange to a distance set by the exchange limits. The smaller size, heavier gauge cables start at a distance from the exchange such that when a pair in a light gauge cable is extended to a pair in a heavier gauge cable from the exchange to any terminal equipment within the exchange area, the loss is not greater than the transmission limit of the exchange.

Table 3.1 shows resistance, attenuation constants and limiting line lengths.

Conductor Diameter (mm)	D C Loop Resistance (Ohms)	Planning Attenuation (dB/km)	Length of Limiting 10dB attenuation limit & 1000Ohm signaling Limit (km)

0.4	275	2.4	3.5
0.5	170	1.7	5.9
0.63	110	1.5	6.7
0.9	54	1.0	10.7

Note: column 4 indicates the maximum length of line in km made up of the same type of cable throughout, which will meet the transmission attenuation limit of 10db and signaling limit of 1000ω.

3.5.7. Sequence of Operations Schedule

i. After the design has been completed, works instructions and diagrams that will enable the field staff to carry out the work in as simple and logical fashion as possible shall be prepared.

ii. When preparing the schedule, the aim should be to save the field staff the need to examine the scheme in detail in order to work out their own sequence of operations. Only the main operations should be covered except where special construction methods merit detailed explanations. If mechanical aids are proposed, they should be fully listed, for example:

a. Special staying, strutting or blocking of poles.
b. Use of explosives for excavations.
c. Thrust boring.
d. Well points in wet conditions.
e. Steel piping on bridges.
f. Re-arrangement of cables in jointing chambers.
g. Provisions and recoveries.

3.6. CLEARANCES AND POWER PROTECTION

3.6.1. Aerial

i) Roads and Railways

a. The following minimum clearance should be given at the centre of span when the ultimate number of arms, wires and cables, to be provided along the route are in place:-

- Railway Crossings - 6.1m
- Plantation Railways Crossings - 4.88m
- Road Crossings - 4.88m
- Along-side town road - 3.66m

- Along-side country roads - 3.05m
- Across country - 3.05m

The above clearance should be maintained as the absolute minimum and every effort must be made to provide stays at each side of the road or railway crossing with a base to height ratio of 1.

b. In places where the cables do overhang the roads, the above clearances should be provided. Where there are bends in the road excessive overhang can be avoided by inserting additional poles. This reduces the angles in the route, shortens the span and makes safer construction.

c. If poles are to be planted close to the railway permanent way, the following minimum horizontal clearances from the nearest rail within must be provided as follows:

- Inside stations - 2.44m
- Outside stations - the pole length plus 1.83m.

d. In bushy country, and where there is vegetation of any significant height under the pole routes, poles of not less than 7.32m should be used.
This reduces the necessity for maintenance and bush-cutting operations are reduced to a minimum

ii) Power

a. Communications aerial routes will not normally run on the same side of the street as the power route and under no circumstances will they pass over power wires.

b. Where it is necessary to run power wires and communications cables on the same side of the road or street, the minimum horizontal separation distance, d between any parts of the route shall not be less than 1.5h, where h is the height of the telecommunications pole or H, whichever is greater. H is the height of the power pole.

c. The following are the minimum vertical clearances between the two services:

1. High voltage (HV) exceeding 66 kV measured to earth potential**:** 3050mm or underground as shown in figure 3.1

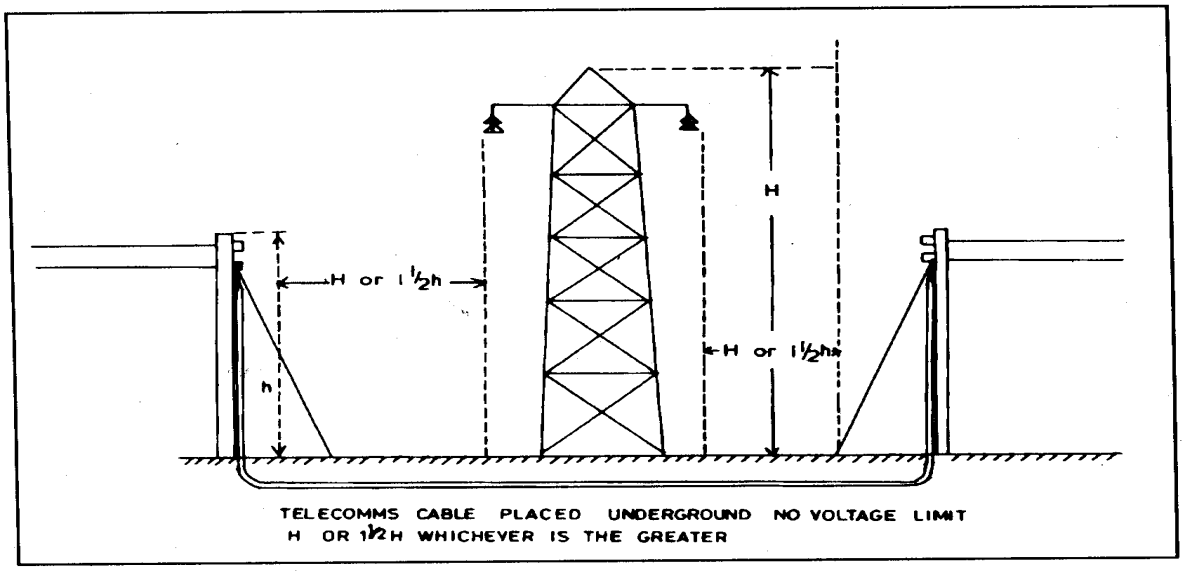


Figure 2.1 HV Vertical Clearance

2. High voltage (HV) exceeding 11 kV but not more than 66 kV: measured to earth potential: 1830mm or underground

3. High voltage (HV) exceeding 650V but not more than 11kV measured to earth potential: 1220mm

4. Medium voltage (MV) exceeding 250V but not more than 650V measured to earth potential: 610mm as shown in figure 4.2. below

5. Low voltage (LV) not exceeding 250V measured to earth potential shall maintain same clearance as for MV. No protection is required when the power line voltage to earth is below 110 volts AC or 160 volts DC.

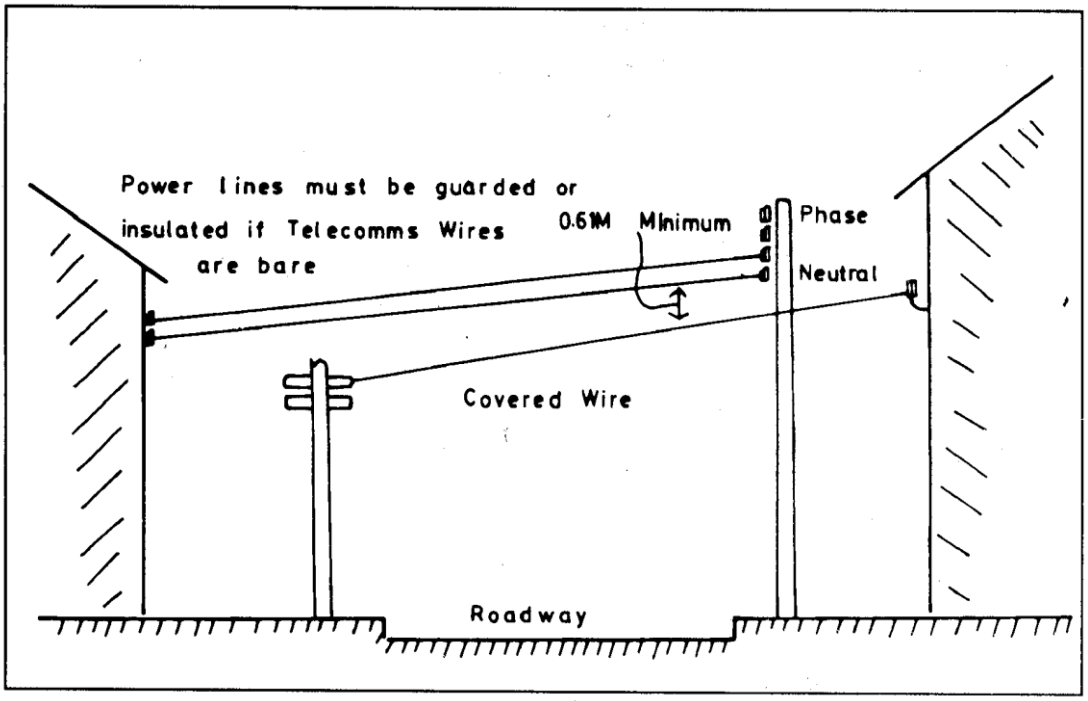


Figure 4.2 MV Vertical Clearance

3.6.2. Radio Base Stations and Power Line Towers

Where Power line towers are used for Radio Base Stations, ITU-T recommendation K.57 shall be observed to ensure safety from any form of risk to the equipment.

3.6.3. Underground Clearances

i) ***Power***

i. **Proximity**

When underground power and telecommunication cables are in close proximity either running in parallel or crossing, the minimum clearances are shown in tables 3.2 and 3.3 respectively.

ii. **General Considerations applicable to all cables*:***

1. When planning a cable run, sufficient clearance must be provided between power plant and telecommunication plant to permit reasonable access for maintenance and renewal without undue risk of damage.

2. Where it is economically and technically possible one side of a road should be reserved for underground power cables and the other side for underground telecommunication plant.

3. When excavating special care must be taken to avoid interfering with plant belonging to other owners or with existing telecommunication plant.

Voltage	**Cable Uppermost**	**Telecom Cable Depth (mm)**	Minimum Separation (mm)		Reference
			Vertical	**Horizontal**	
Low and medium	Either	<915	Any	1220	Fig 14.3a
Low and medium	Telecom	<915	229	458	Fig 14.3b where Fig 14.3a is not feasible
Low and medium	Either	>915	Any	1220	Fig 14.4a
Low and medium	Either	>915	Any	458	Fig 14.4b where Fig 14.4a is not feasible
High	Either	<915	Any	1220	Fig 14.5a
High	Telecom	<915	229	458	Fig 14.5b where Fig 14.5a is not feasible
High	Either	>915	Any	1220	Fig 14.6a
High	Either	>915	Any	458	Fig 14.6b where Fig 14.6a is not feasible

Table 3.2 Both Cables Running Parallel

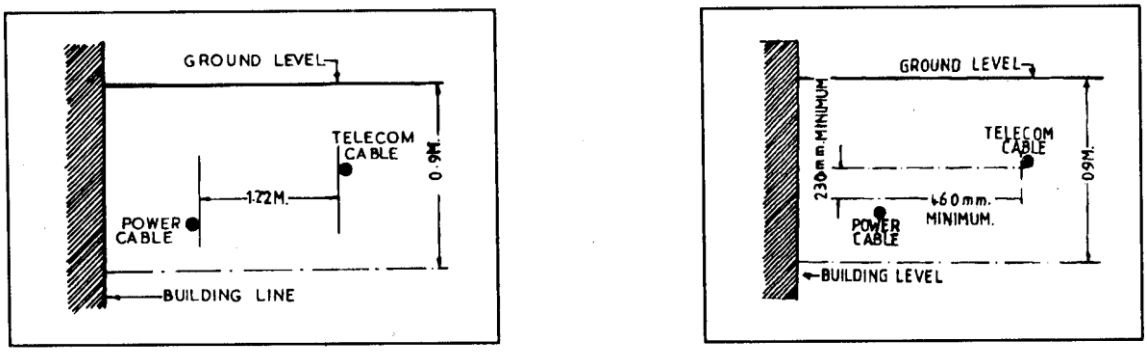


Figure 3.3 LV/MV Power Cables in Parallel with Telecoms Cable at a Depth <900mm

Voltage	Cable Uppermost	Telecom Cable Depth (mm)	Minimum Vertical Separation (mm)	Other Conditions	Reference
Low and medium	Telecomm cable	<915	229	-	Fig 14.7
Low and medium	Telecom cable	>915	229	-	Fig 14.8
Low and medium	Power cable	>915	229	Slab inserted	Fig 14.8a and fig 14.8b
High (Single Core)	Telecom cable	Any	458	-	Fig 14.9
High (Three Core)	Telecom cable0	Any	305	-	Fig 14.9

Table 3.3 Cable Crossing

iii. Low and Medium Voltage Cables

Figures 3.3 and 3.7 show clearances required if telecommunications underground cable is at depths not exceeding 900mm and figures 3.4 and 3.8 at depths exceeding 900mm.

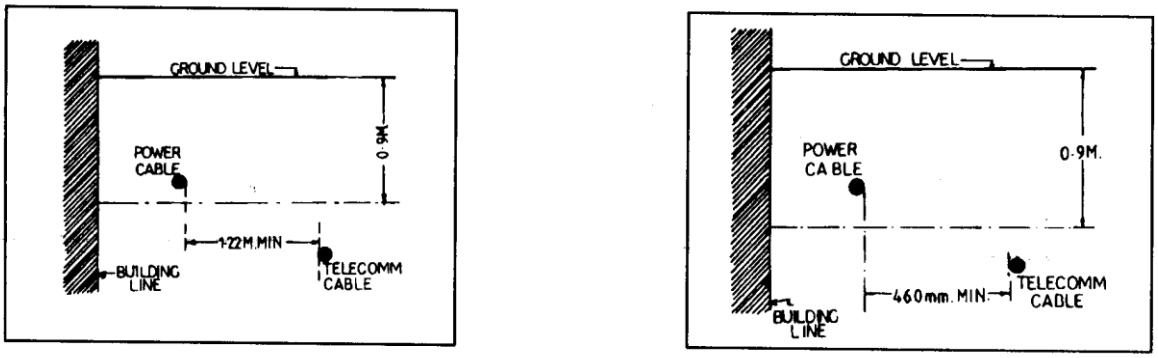


Figure 3.4 LV/MV Power Cables in Parallel with Telecoms Cable at a Depth >900mm

iv. High Voltage

Figure 3.5 shows the clearances required if a High voltage power cable runs parallel to a telecommunications underground cable which is buried at a depth of less than 900mm. Figure 3.6 shows the clearances required if a HV power cable runs parallel to a telecoms cable at a depth exceeding 900mm.

Figure 3.9 shows the clearances required if a telecommunications underground cable and HV power cables cross.

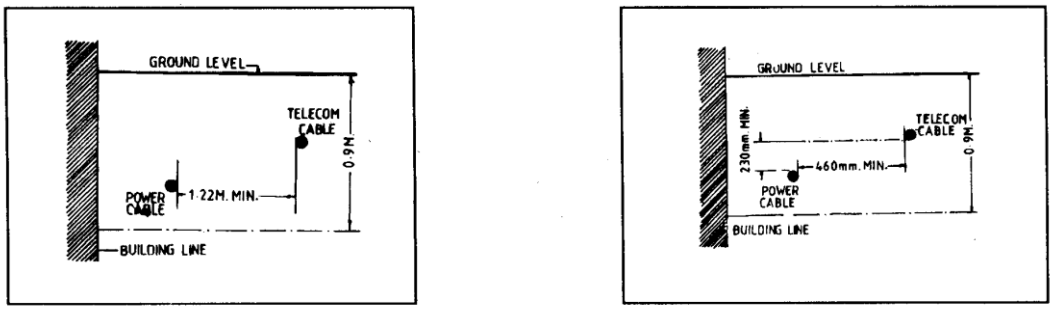
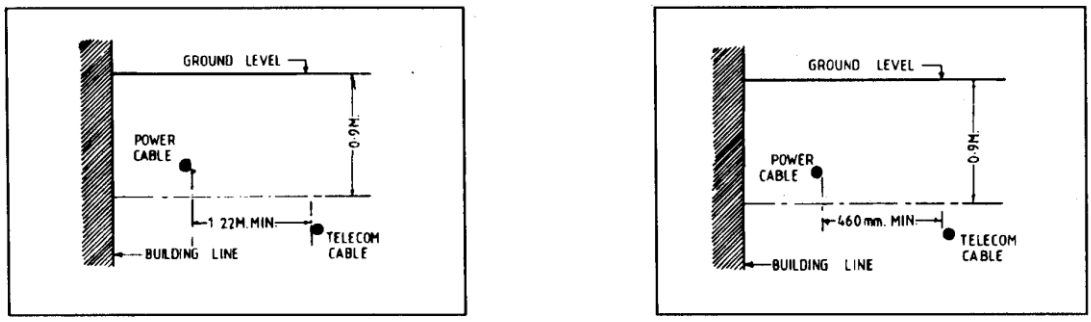


Figure 3.5 HV Power Cable in parallel with Telecom Cable at a Depth <900mm



Fig**ure 3.6 HV Power Cables in parallel with Telecoms Cable at a Depth >900mm**

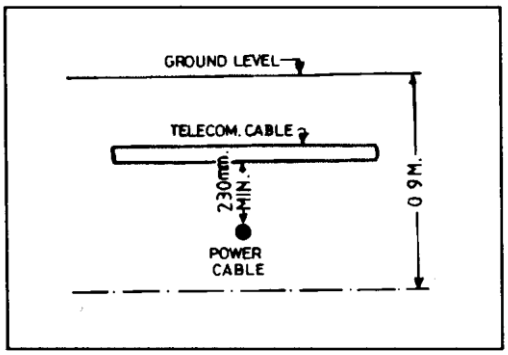


Figure 3.7 LV/MV Power Cables crossing a Telecoms Cable at a Depth <900mm

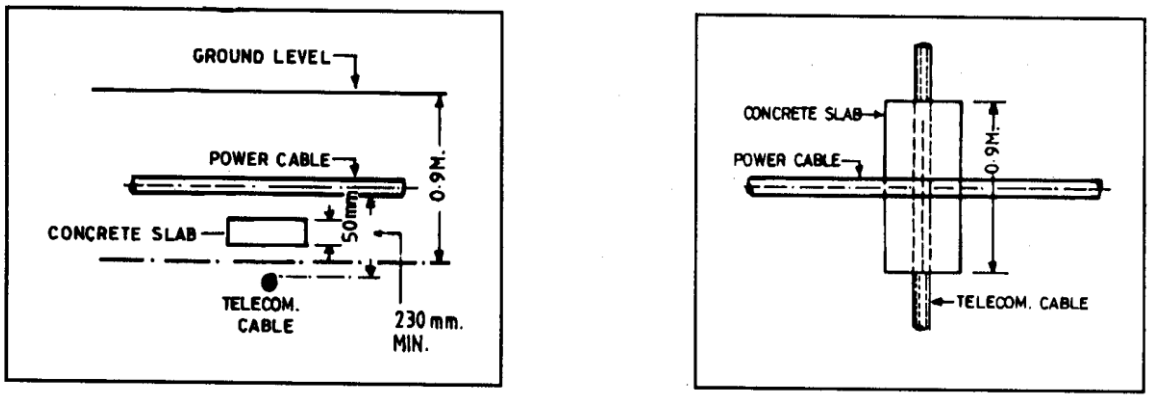


FIGURE 3.8LV/MV POWER CABLE CROSSING WITH TELECOM CABLE AT A DEPTH >900MM

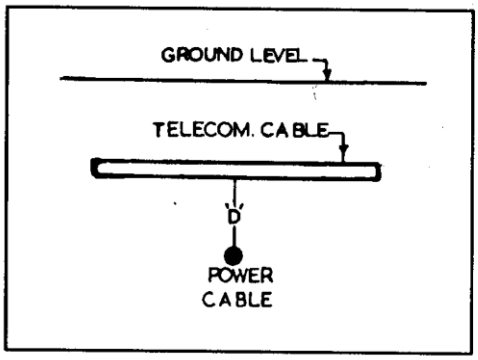


Figure 3.9 HV Power Cables in crossing with Telecoms Cable buried at any depth

3.6.4. Roads, Railways, Water and Sewer

All types of ducts and cables laid direct in the ground shall be kept well clear of water mains, service pipes, sewers, subways and jointing chambers belonging to other utilities. In no case shall the clearance be less than 25mm. Where two sets of plant cross each other, the minimum vertical clearance shall be 50mm. In order to admit the use of "Tapping" machines on water mains at least 150 mm clearance shall be given, to the other classes of plant mentioned above. Ducts laid beneath road or railway tracks shall be so laid as to give a gradual fall from the centre to each side of the truck to prevent water accumulating in the duct. Ducts PVC should be enclosed in concrete of ratio 1:3:6. The concrete at the bottom of the ducts should be 199mm thick. The ducts shall be covered by a concrete layer of 100mm thick.

4. DUCTING

4.1. CAUTION

It is hereby emphasized that line plant works involve highly risky operations and it is recommended that contractors should observe safety precautions detailed in chapter 15.

4.2. EXCAVATION

4.2.1. Pilot Holes and Trial Excavation

Excavations shall be made in the carriageway or footway in positions shown on the approved working plans.

4.2.2. Line of Trench

The line of the trench shall be kept as straight as possible, the walls shall be vertical and smooth and the bottom of the trench shall be level and if necessary punned.

4.2.3. Change of Level

In passing from footway to carriageway and vice versa, or where ducts enter jointing chambers below standard depth, or in any other circumstances where it is necessary to change the level, the bottom of the trench shall rise or fall gradually.

4.2.4. Protection of existing plant

Every endeavour shall be made for the trench or any excavation to be cut clear of other facilities. Where other facilities are exposed they shall be adequately slung or otherwise supported to prevent their damage.

4.2.5. Shuttering

Shuttering shall be provided in deep trenches to prevent loose earth falling into the excavation.

4.2.6. Non-Interference with Traffic

Not more than one-half of the width of any adopted road or street shall be closed to traffic at any time. Where one-half of the street or road is too narrow to allow two carriages to pass not more than 45 meters in length shall be occupied by the work.

4.2.7. Trenchless Excavation

Trenchless excavation technique allows installation of underground telecommunication network infrastructures while minimizing or eliminating the need for excavation**.** It reduces environmental damage and social costs and at the same time, provides an economic alternative to open-trench methods of installation. ITU-T recommendation L.38, on the "Use of trenchless techniques

for the construction of underground infrastructures for telecommunication cable installation" shall be used especially in urban centers for installation of underground facilities.

ITU-T recommendation L. 48 and L.49 are other techniques that can be used over conventional cable laying technologies for their speed of execution, lower cost, significant reduction of environmental impact and limited disruption to road traffic

4.3. DUCT LAYING STANDARDS

Duct laying shall be done in accordance with the following instructions:

4.3.1. Types and sizes of Ducts

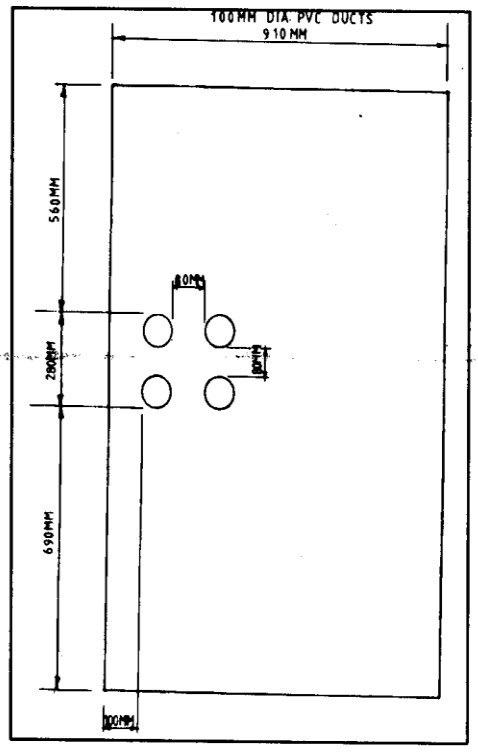
Ducts shall be made of concrete, PVC or galvanized steel. The standard duct bore for a concrete duct shall be 100 mm diameter.

4.3.2. Line of Ducts

The line of ducts shall be kept as straight as possible. Where deviations are necessary they can be achieved, by "setting" the joints of the ducts and/or using "bends" duct. To avoid making cabling difficult, planned deviations should be gradual and not more than 1 in 48.

4.3.3. Duct Formation and Entry

Duct formation shall be uniform along the entire route and shall be neatly arranged as close as possible with the first layer at the bottom of the jointing



chamber to allow space for future expansions. The minimum clearances shall be 560 mm from the top and 690 mm from the bottom and 100 mm from the side wall of the jointing chamber as shown in figure 4.1.

Fig 4.1 Duct Formation

4.3.4. **Concrete Ducts**

All concrete ducts shall be watertight.

4.3.5. **Rocky Soil**

In rocky or stony soils, earth free from stones shall be spread over the trench bottom and rammed to afford a bedding approximately 75mm thick on which to lay the duct. In such cases 75mm of extra excavation of the trench will be necessary.

4.3.6. **Cleaning and Testing**

i. On completion of the duct line between any two jointing chambers or sites thereof, a cylindrical brush connected to the trailing end of a test mandrel shall be passed once through each "duct-way" to clean the duct and remove any foreign matter, which may have entered. The size of the test mandrel shall be as specified for the particular duct. Figure 4.2 shows a mandrel and its attachments.

ii. The contractor shall confirm the continuity of all the duct-ways.

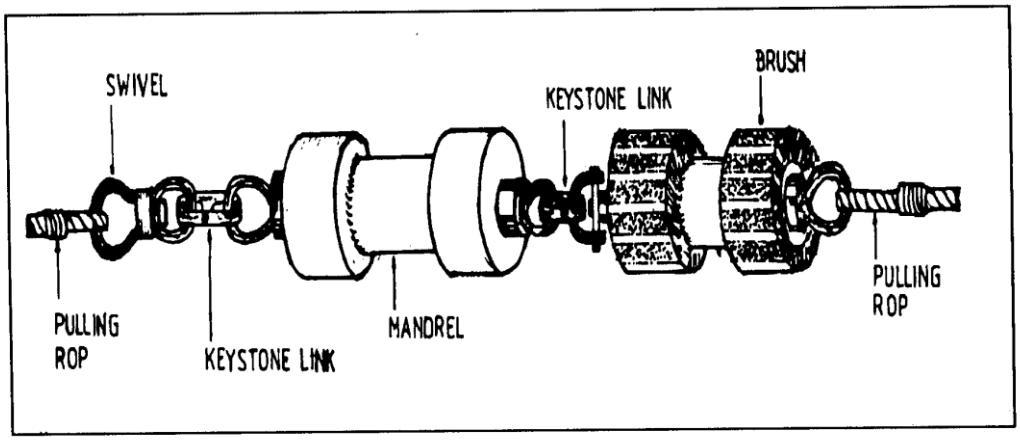


Figure 4.2 The Mandrel and its Attachments

4.3.7. **Deferred Jointing Chamber**

When the building of jointing chamber is deferred until after the completion of a section of duct included in the work, the last 2 meters of each duct-way shall be tested, on completion of the jointing chamber, by means of the mandrel and brush specified for the particular duct.

4.3.8. **Plugs**

A suitable plug shall be inserted in the ends of each duct-way to prevent the ingress of water and/or other foreign matter, until all work has been completed.

4.3.9. **Draw Wire**

After satisfactory tests a draw wire, shall be threaded through each duct-way and left in place.

4.3.10. **Duct Alignment Tests**

When jointing chambers are provided on an existing duct route or when any disturbance takes place which may affect the alignment of the ducts, all spare duct-way shall be tested with a mandrel and any faults rectified.

4.3.11. **Trench Size and Duct Covers**

The Trench shall be excavated to the required width and depth and the bottom shall be level and well punned. The minimum depth of PVC ducts shall be 610mm under footway or verge and 1000mm under carriageway.

4.3.12. **Jointing of ducts**

The method of jointing ducts shall be by pushing spigot home into the socket. The entire duct route shall be watertight.

4.4. JOINTING CHAMBERS

4.4.1. **Types and Sizes**

The sample types and sizes of jointing chambers with code references in current use are shown in tables 4.1 and 4.2. These could be rectangular or triangular. Figure 4.3 shows the sides of triangular jointing chambers.

4.4.2. **Iron and Steelworks**

i. All iron and steel work, except as in paragraph (b) and which has not been galvanised by an approved method, shall be free from mill scale and given one coat of red lead and oil after delivery and two coats of an approved bituminous paint after fixing.

ii. Any iron or steel which is to be embedded in concrete shall have all loose rust particles removed by the use of a wire brush.

iii. Cable bearers, brackets and all accessories shall be fitted in accordance with the approved plans

CODE	INTERNAL DIMENSIONS (mm)			NUMBER OF DUCT WAYS
	Length	Width	Depth	
JF2	818	254	686	1
JF4	902	445	686	2
JF6	1308	610	686	2
JF10 A	2308	760	718	4
JF10 B	2308	760	845	4
JF10 D	2308	760	1084	8
JC1	986	686	760	2
JC9	1596	686	760	2
JC9 B	1596	686	1070	4
BO	1830	1067	1524	Up to 4
B1A	1830	1219	1676	5 to 9
B1B	1830	1219	1981	5 to 9
B2A	3050	1219	1830	to 32
B2B	3050	1219	1981	33 to 36
B2C	3050	1219	2134	37 to 40
B2D	3050	1219	2286	41 to 44
B2E	3150	1219	2438	45 to 48
B11	4115	1676	2134	49 to 60
BT-7	2464	2134	1830	-
BT-8	3378	2743	1830	-
BT-9	3438	1676	1830	-

Table 4.1 - Types of Jointing Chambers

CODE	INTERNAL DIMENSIONS (mm)		NUMBER OF DUCT WAYS
BT-7	A 762 B 610 D 1981 F 2133	1828	Upto 12 at A and 6 each at B. See fig 4.3a.
BT-8	A 1168 B 1066 D 2032 F 2743	1828	12 to 24 at A. 6 to 12 each at B. See fig 4.3a.
BT-9	A 838 B 601 D 2438 E 2032 F 1676	1828	Upto 24 each at A and F. Upto 18 at B. See fig 4.3b.

Note: The number of duct ways shown will assure adequate facilities but local conditions may necessitate some departure.

Table 4.2 - Types of Triangular Jointing Chambers

Figure 4.3 Triangular Jointing Chamber Sides

4.4.3. **Sump**

Where a sump is provided the floor shall have a slight fall thereto.

4.4.4. **Concrete Quality and Finish**

i. Concrete quality 'A' (refer to table 4.3) having a maximum slump figure 100mm shall be used throughout in the construction of jointing chambers.

ii. On completion of a jointing chamber, the floor and the walls shall be rendered with cement mortar in accordance with the relevant drawing.

iii. The concrete or masonry blocks around all ducts where they enter jointing chambers shall be carefully flushed up and rendered in cement mortar.

4.4.5. **Compaction and Tamping**

In construction of concrete or reinforced concrete floors and roofs of jointing chambers, the concrete shall be thoroughly worked and tamped into all parts of the mould of forms and around the reinforcement.

4.4.6. **Footway Channels, Frames and Covers**

The frames shall be bonded on cement mortar as near the correct level as possible. The cross-piece(s) where required, shall then be fitted and the cover(s) placed in the frame. The cover(s) shall be tested for rocking; if rocking occurs, packing of hard material shall be placed beneath the lowest part of the frame until rocking ceases and the cover(s) lie firm and level. All voids below the frame shall then be completely filled with cement mortar to the same level as the packing. In an unmade surface, the frame shall be surrounded with a 50mm wide strip of cement mortar, finished level with the top edge of the frame and the outside edge finished straight and parallel to the frame.

4.4.7. **Carriageway Frames and Covers**

Carriage way frames and covers for joint boxes or manholes are manufactured in units and are machined fit and therefore under no circumstances should covers or

frames be exchanged. The cover shall first be removed from the frame and the fitting edges of both frames and cover greased thoroughly. The red lead normally applied to the edges in the factory should not be removed. The frame should then be bounded on cement mortar as near the correct level as possible. Rocking if any should be eliminated as in clause 4.4.6. The cover should then be placed in the frame.

4.4.8. **Quality of Materials**

Concrete shall be of quality A, B, C, F, H or I and the proportion of the dry ingredients shall be as shown in table 4.3.

Table 4.3 Concrete Ratios

INGREDIENTS	**QUALITY**					
	A	**B**	**C**	**F**	**H**	**I**
Cement	1	1	1	1	1	1
Sand	2	2	3	2	-	-
Aggregate all-in	4	7	9	3	-	-
Aggregate to BS882	-	-	-	-	15	20

Note: Parts by volume.

4.4.9. **Concrete Quality and Finish**

Concrete quality 'A' having a slump figure no greater than 100mm shall be used throughout in the construction of jointing chambers, unless otherwise specified, and shall meet the compressive strength shown in table 4.4

Table 4.4 Concrete Quality

AGE OF CONCRETE (Days)	**CONCRETE STRENGTH (MN/m^2)**		
	Portland and Sulphate Resisting	***Rapid Hardening***	***High Alumina***
7	Over 14	Over 18	Over 35
28	Over 21	Over 28	-

At the discretion of the Network Operator's Inspector, test cubes may be taken from any batch of site mixed concrete quality 'A' as used in the Construction of jointing chambers. The making, curing and testing of all cubes of concrete for compressive strength tests shall be in accordance with BS 1881 or its equivalent. During inspection, the results of concrete quality test may be required for verification.

4.4.10. **Floors and Roofs**

The floors and roofs of jointing chambers shall be constructed throughout with concrete quality 'A'.

Where a course concrete is required for supporting or protecting buried plant, concrete qualify 'C' shall be used.

Concrete quality 'B' shall be used for insertion between power plant and the telecommunications plant where normal separation cannot be obtained.

4.4.11. **Masonry Blocks**

Concrete or quarry blocks size 455mm x 228mm x 152mm may be used. Concrete blocks, if used shall be solid to BS 2028 or its equivalent.

4.4.12. **Cement Mortar**

The cement mortar shall consist of one measure of cement to three measures of sand.

The materials after being gauged shall be thoroughly mixed in a dry state on mixing boards and then thoroughly mixed with sufficient water to form a still mortar.

On no account shall water be added after mortar has been prepared. When the mortar begins to set, it shall not be used or mixed with other cement or sand.

Excess water shall not be used for mixing. If more water than is necessary is used, such mortar if it has begun to set shall not be mixed with a further quantity of sand or cement, but the whole shall be condemned.

4.4.13. **Hardcore**

All hardcore shall consist of concrete or stone graded to a minimum of 75mm. When provided for use in trenches, sufficient hardcore material under 75mm shall be added to fill voids and aid consolidation.

4.5. BACK-FILLING AND RAMMING

The contractor shall leave inspection points of one meter length unfilled at intervals of 25m and at every point of intersection with power, water and sewer systems. The inspection points shall be free from loose earth and guarded.

All spaces outside the walls of jointing chambers and duct laid in trench shall be carefully filled in with earth, free from stones, and rammed. Care shall be taken to ensure that the ramming does not disturb any recently completed work. For black cotton soil areas, red soil shall be used for backfilling.

All ducts not laid in concrete shall be covered by a layer of earth, free from stones and hand punned to a thickness of not less than 75mm.

All materials shall be replaced in 150mm layers, in the reverse order to which they were excavated and thoroughly compacted. Mechanical punners shall preferably be used. If hand punning is employed, there should be at least three punners to one filler.

The contractor shall carry away all surplus or other rubbish, earth etc. leaving the site clean as the work proceeds

4.6. LOWERING OF EXISTING DUCTS

Where lowering of existing ducts is necessary, the duct line shall be suspended and the required excavation taken out down the side and under the duct line. The duct line shall not be moved in anyway without adequate reinforcement in the form of a strong 'back' being firmly lashed to it as shown in figure 4.4.

4.7. SLEWING OF EXISTING DUCTS

When it is necessary to move ducts without changing the level, the ground shall be made level and grooves cut in position to accommodate sockets of the ducts. All movements made with ducts must be very small and uniform along the length of the track being slewed. This is shown in figure 4.4.

4.8. SUB-DUCTING FOR OPTICAL FIBRE CABLES

In order to increase the capacity of the duct system and to allow for future trouble-free installation of optical fibre cable, sub-ducts of PVC shall be inserted into the main duct. These are used not only to obtain clean, continuous high quality paths for optical fibre cables but also to sub-divide a conduit and make space available for additional cables in the future. The sub-ducts will also give advantages if some small section has to be changed for maintenance reasons. Sub-ducting the conventional 100mm main duct is done by pulling in of four smaller ducts of PVC. However, misalignment or collapse of older duct systems may reduce the possibility of pulling in more than three ducts.

All sub-ducts should be pulled in at the same time and be securely fixed at the entrance and exit points. The group of sub-ducts shall not be fixed to each other by means of tape or other bandage during installation. If the end of the sub-duct is not securely attached to the main duct, difficulties may arise when pulling in the cable caused by movement transferred from the cable to the sub-ducts.

Placing problems encountered during the installations of sub-ducts, may indicate poor duct alignment of the main duct or otherwise defective conduit plant and it shall be investigated if restoration work shall be done in-order to secure the function of the duct plant.

To facilitate identification of each sub-duct respectively, coloured tapes should be wrapped round each sub-duct. Following colours shall be used:

- Pipe 1 Blue tape
- Pipe 2 Orange tape

- Pipe 3 Green tape
- Pipe 4 Brown tape

The same colours shall be used for identification in intermediate jointing chambers where the sub-duct package is pulled through.

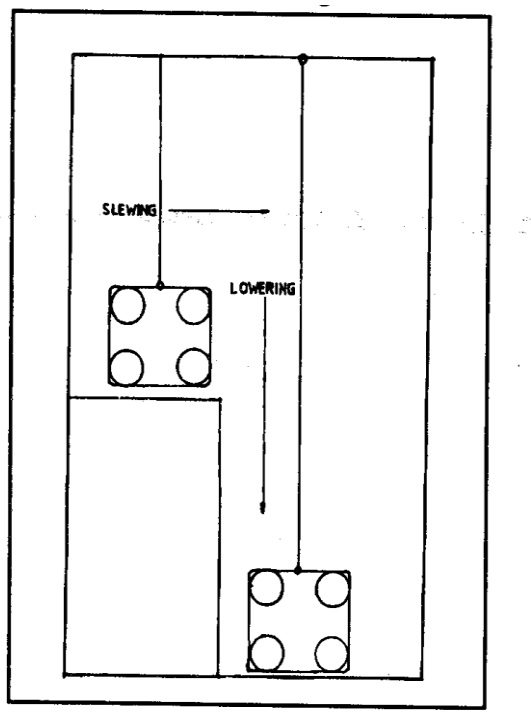


Fig 4.4 Duct Lowering and Slewing

4.9. DUCT/TUNNEL SHARING

To facilitate the use of existing infrastructure and minimize the need for frequent excavations and the environmental impacts that goes with this, utility providers should share infrastructure as much as possible. In this regard telecommunication cables can be installed in sewer ducts as per ITU-T recommendation L.77 while joint use of tunnels by pipeline and telecommunication cables shall be as provided by ITU-T recommendation L.11

5. CABLE INSTALLATION IN DUCTS

5.1. STANDARDS

These standards are for the installation of cables in duct. They cover cables used in the local distribution network.

a) Ducts shall be rodded by an appropriate method and cleaned before the cables are pulled in.

b) Cables shall be drawn into ducts with friction free methods. The cable shall be drawn within an allowable pulling tension and with constant speed.

c) Duct bore allocation shall be carefully made to avoid crossing of cables at the duct entrances, on cable brackets and blocking access to spare bores for future cables. Ducts shall be used by starting with the bore on the bottom row adjacent to the jointing chamber's side wall.

d) Cables shall be placed in jointing chambers and vaults in such a manner that they do not block any spare bores nor restrict the working space.

e) The cables shall be drawn as directed from local MDF to local DPs.

f) The cables shall be un-drummed or payed with due regard to cabling direction on site.

g) Splicing shall be carried out immediately after placing of the cables in the ducts.

h) Under no circumstances shall joints be made within the duct length.

i) All the cable metallic shields shall be electrically continuous throughout the entire cable route. The cable shields shall be bonded to the grounding system at the local MDF and at the local DPs.

j) The cables shall be supported and fixed using suitable cable brackets and binding ropes or equivalent in all the jointing chamber, vaults, and trenches and in the local MDF rooms.

5.2. PRACTICES

5.2.1. General

This instruction covers the standard procedures for installing underground cable into jointing chambers and ducts.

5.2.2. Works on Roads

When cable installations or recoveries are performed close to or on roads, sufficient protection and safety of personnel and vehicles shall be guaranteed.

5.2.3. **Gases within Jointing Chambers or Trenches**

It sometimes happens that coal gas, methane and other poisonous gases are found in a chamber and may result as poisoning or suffocating or even explosions. It is therefore necessary to pay utmost attention to the existence of gases in chambers before commencing work. Testing for the existence of gases shall be done using a gas sniffer or testing meter.

5.2.4. **Precautions for work in Jointing Chambers**

Care should be taken not to damage existing and new cables by stepping or putting weight on them.

5.2.5. **Materials for laying of underground cables are shown in table 5.1.**

ITEM	TYPES	APPLICATIONS
1	Sealing Cap	Protecting the cable end to prevent water penetration
2	Self Bonding Tape	Sealing the cable end and temporary joint
3	Adhesive PVC Tape	Fixing the cable on cable racks or brackets in jointing chambers
4	Cable Binding Rope	Fixing the cable on cable racks or brackets in jointing chambers
5	Water and Lubricants	Reducing the friction between cable and duct when drawing cables
6	Galvanized Iron Wire	Binding the cable grip or sealing the cable end
7	Step Ladder	Aids in entry and exit to and from chambers
8	Cable Bearers	Supporting the cables
9	Anchor Irons	Pulling the cable

Table 5.1 Underground Cable Materials

5.2.6. **Tools and equipment to be used in the installation of underground cables are shown in table 5.2.**

ITEM	TYPES	APPLICATIONS
1	Cable Jack or Trailer	Setting up the cable drum
2	Wire Rope	Leading the cable for pulling
3	Cable Grip	Gripping the cable and for pulling
4	Flexible Tube	Guiding the cable into duct through a chamber smoothly and easily
5	Rods Continuous	Drawing of the mandrel in duct
6	Mandrel and Brush	Clearing of obstruction and protrusions in ducts
7	Water Pump	Pumping up water from jointing chamber trench etc.
8	Roller Cable Guide	Guides cable at pulling end
9	Capstan	Takes up cable pulling load

Table 5.2 Underground Cable Tools and Equipment

5.2.7. **Precautions for Cable Installation**

a) Confirmation of Cable Drum and Duct

The following shall be confirmed before installation:

i. The location, type and span between the jointing chambers from the scheme plans.

ii. Cable length, cable size and kind of cable end (clockwise or counter-clockwise) from the scheme plans.

iii. The position of an allocated duct bore from the cabling diagram.

b) Preparation of Materials and Tools

Materials, tools and equipment required shall be prepared before drawing cable into duct.

c) Protection of Existing Cable

The existing cables and other facilities shall be adequately protected before laying others.

d) Handling of Cable Drums

i. Drums reeled with cable shall be handled with special care to prevent deterioration of electrical and other characteristics.
ii. Drums shall not be subjected to shock by allowing to drop down and shall not be laid sideways during loading and unloading.
iii. Drums shall not be rolled on the ground for transportation purposes, except for short movement at installation sites.

e) Cable Bending Radius

i. When setting cables, the bending radius shall be kept to more than 8 times the outer diameter of metallic cables and not less than 15 times the outer diameter of optical fibre cables.

ii. While installing cables, the bending radius of the cable shall be kept to more than 100cm.

f) Rodding of Duct way

i. After the confirmation of a designated duct, the duct way shall be rodded, cleaned and passed with a mandrel prior to placing the cable.

ii. Usually, the rodding and cleaning of the duct way and the mandrel test are performed in this order. When no remarkable debris is extracted during

rodding work, cleaning the duct way and mandrel test are performed at the same time.

g) Cabling

i. Setting Up Cable Drums

1. Whenever possible, locate the cable drum at the same side of the jointing chamber as the conduit run into which the cable is to be placed.

2. When there are many directional changes in the duct route, the cable drum shall be placed as close as possible to the location of such changes in order to reduce the required pulling force.

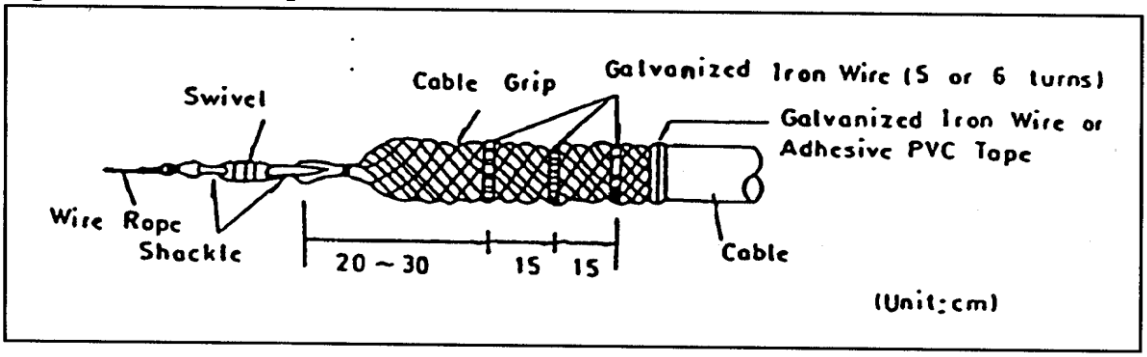
3. To avoid twisting the cables, the cable jack shall be positioned such that the cable is fed in a long arc from the top of the drum to the entrance. The cable shall not be reeled from the bottom of the drum.

4. All cables should be placed counter-clockwise in pair arrangement towards the local exchange.

ii. Cable Grip

Cables with a diameter of more than 10mm shall be pulled by use of a cable grip. Where a pulling force of more than 9kN is anticipated, the cable grip shall be bound tightly with iron wire over the cable end. The **cable grip is shown in figure 5.1.**

Fig. 5.1 Cable Grip



iii. Reeling out of Cable

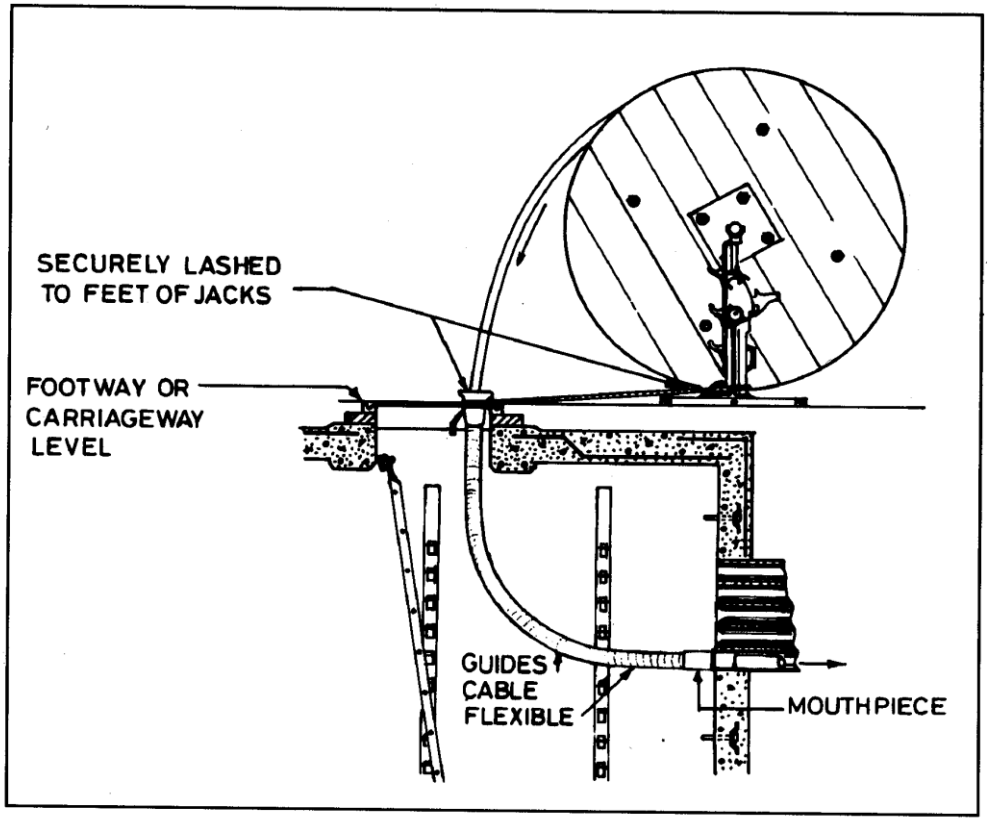
After completion of rodding the duct way, setting up of the cable drum, installing the pulling accessories on a cable end, the cable to be pulled into jointing chambers shall be reeled out carefully as per figure 5.2.

iv. Cable Pulling

1. Cable pulling work shall be carried out in close cooperation with the cable reeling-out work.

2. To reduce tension on the cable, mid-point pulling is recommended. This is a method where the pulling force is distributed at intermediate points along the cable length. Where it is not possible to pull the cable from end to end, the drum is set up at an intermediate point and the longer length cable is drawn in first. The cable remaining on the drum is then removed and piled on tarpaulins, layer upon layer in figure "8" formation about 3m x 6m. The piled cable can then be pulled to the other end.

Fig 5.2 Reeling of the Cable



3. At the end where cable is being pulled out and where the level and direction of the cable changes, light weight pulleys or rollers shall be used. The pulley shall not introduce additional pulling force and the minimum bending radius shall be maintained.

4. The cable shall be lubricated with a suitable approved lubricant for the duct and the sheathing material of the cable.

5. After preparing the pulling tools and devices, pull carefully the wire rope while winding, keeping the pulling speed as for the cable.

6. The pulling team shall stay in contact with the liaison man at the reeling side. .

7. The cable shall be pulled gradually until the cable length necessary for bending, splicing and or testing is obtained.

8. The cable ends shall be sealed with appropriate sealing caps.

9. After the cabling operation is complete all the duct entrances shall be sealed by a suitable sealing compound.

v. **Anchoring**

The cables shall be secured in jointing chambers by use of cable brackets and adjustable straps

5.3. CABLE JOINTING

5.3.1. Setting the Cables and Position of Joint

Polythene sheathed cables are springy and cannot easily be set in relatively small bends nor will the cable stay in a set position without some form of clamp to restrain any subsequent creep movement. To avoid any trouble arising the ideal situation is for the cable and joint in any manhole or joint box to lay in a straight line between the duct mouths. However, the ideal is not always possible and the required bends in the cable shall be held in position by clamps known as restrainers. Small cables up to and including 19 mm diameter are restrained by means of binding the cable to the cable bearer with about 6 turns of insulating tape. Where this is not possible, the least amount of set should be given to the cables by supporting the joint using cable bearers and brackets as long as practicable as shown on figure 5.3 Where movement due to the set of the cable is likely to occur, the cable shall be clamped in the required position on the bearers.

5.3.2. Preparation of the Cable Ends for Jointing

After the **c**ables have been set in place mark the position of the cable butts so that the sleeve will overlap each cable butt respectively but do not remove the sheathing at this stage. Thoroughly clean and de-grease each cable for an appropriate length from the cable butt position and away from the joint with a clean cloth damped with methylated spirit. Do not use any other solvent. Remove any deep scratches from the sheaths with a smooth file, glass cloth or scruff splicer's roll applied longitudinally and then roughen the surfaces of the from the butt marks with a scratch brush or scruff roll applied longitudinally. An example of the operation by use of a polythene sleeve is shown in Figure 5.4. The measurements indicated will vary depending on the type of sleeve and size of cable.

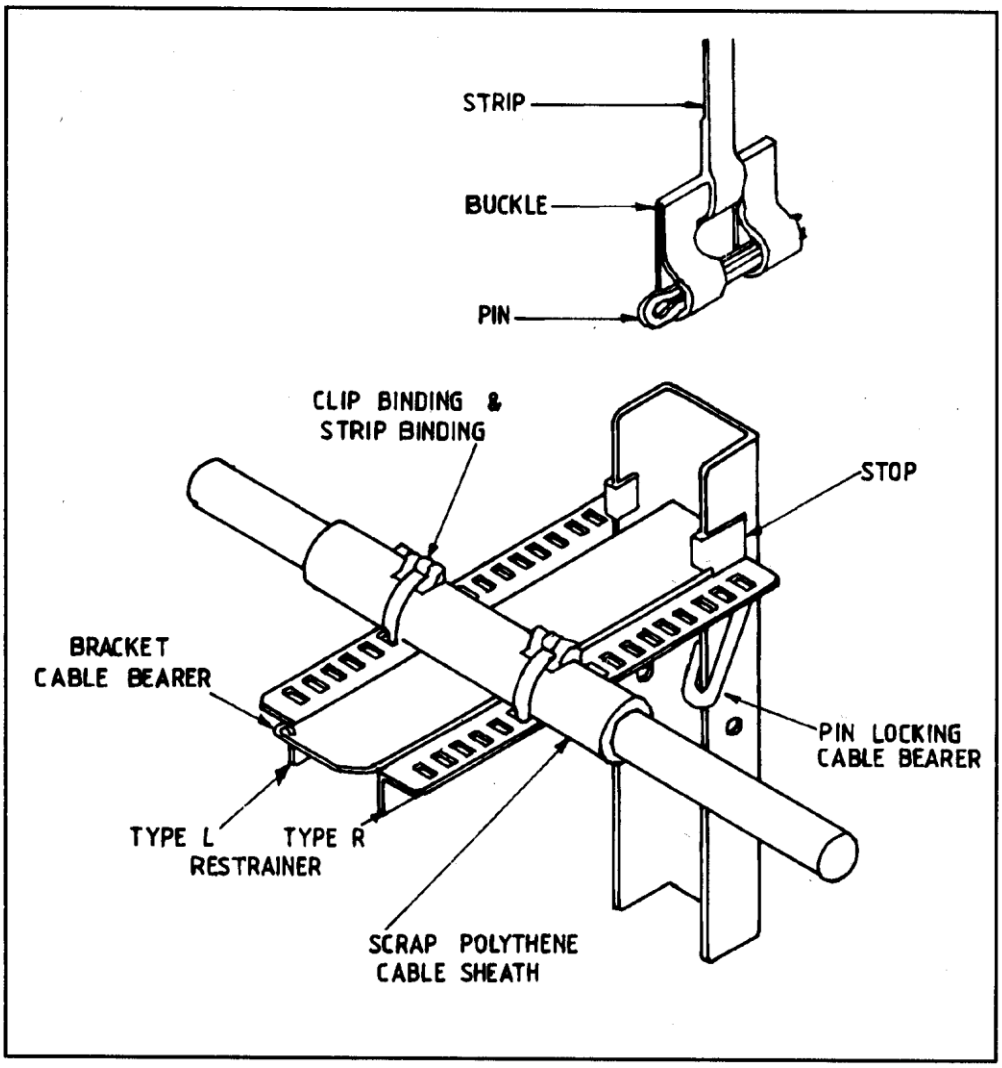


Figure 5.3 Cable Bearers in a Jointing Chamber

5.3.3. **Removal of Polythene Sheath**

a) At the position where the cable butt has been determined, make a circumferential cut round the cable sheath. Make two longitudinal cuts, about 6mm apart from the butt to the end of the cable. The cuts should be made vertically into, but not completely through the sheath.

b) Lift the narrow strip of polythene so formed at the cable end with a pair of wire cutters or long-nose pliers and peel it back to the cable butt. Then open the sheath and completely remove by peeling it off at the butt. Care should be taken when removing the sheath to prevent loss of pair formation and splitting.

c) Degrease the cable butts

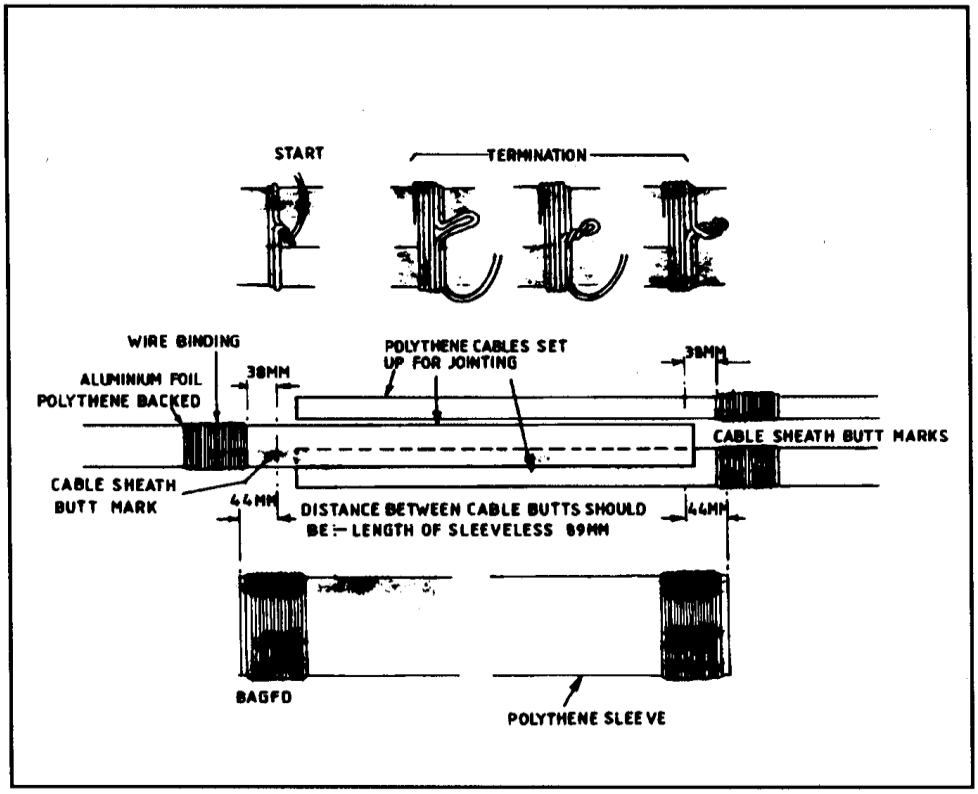


Figure 5.4 Preparation of Cable Ends

5.3.4. **Bonding of Foil to Sheath**

5.3.4.1. It is normally not possible to stick or bond any material to polythene, however a treated aluminum foil has been developed which can be made to bond to degreased polythene

5.3.4.2. A length of suitable aluminum foil is cut to lap round the cable so that the ends of the foil do not overlap by more than 2mm. Wrap the foil round the sheath 38mm from the butt mark with the coloured side of the foil on the outside. Remove the colouring where the overlap occurs.

5.3.4.3. Degrease the cable butts

Hold the foil in position by a temporary turn of scrap wire placed centrally on the foil. Starting at not more than 3mm from one end of the foil make a close firm binding of copper wire round the foil to within not more than 3mm of the further edge, clipping the temporary binding off as it is approached.

5.3.4.4. Secure the binding wire at the beginning and end by twists. Lengths of wire may be joined together to complete the binding.

5.3.4.5. Gently heat the wire binding with a gas torch. Apply the heat uniformly all round the binding taking care not to allow the flame to touch the cable sheath. When carrying out this operation, keep the flame of the torch moving with a flicking action. In this way overheating or localised heating will be avoided. Remove the heat immediately molten polythene oozes and appears as a ring round the sheath at the edges of the foil. Overheating will result in blistering of the foil with an unsatisfactory bond to the sheath. Allow the wire and foil to cool naturally and then remove the binding wire. After bonding, wrap the foil with a 50mm insulating paper to protect the foil from dirt or grease whilst the conductors are being jointed.

5.3.5. **Continuity of Aluminum Foil**

a) Before removing the lapping tapes from the cable core, remove a small piece of sheath from the cable butt as shown in figure 16.5 to expose the aluminum foil of the cable for connection to the continuity wire. Do this by melting away a piece of polythene about 13mm x 13mm from the sheath with a soldering iron heated to the soldering temperature. Great care must be taken to avoid using an overheated iron otherwise scorching of the foil and lapping tapes will occur. Neatly cut off the surplus polythene which collects along the edges of the sheath.

b) Cut a length of earth wire sufficient to bridge the gap between the butts and remove 25mm of insulation at each end. Fix the wire to the aluminum foil at each end.

5.3.6. **Jointing**

The pairs in a polythene Unit Twin (CPT) cable are loosely twisted and therefore great care must be taken when removing the sheath otherwise the pair formation will be lost and pairs will be split. To overcome this difficulty the cable should be set up for jointing as follows:

a) Cut the cable to the required jointing length.

b) At point 150mm from the end of the cable core cut around the sheath and commence to slide the cut sheath over the core but place a tie around the core before completely removing the sheath.

c) Remove the remainder of the sheath using the nylon rip cord. Place a tie around the core at the butt.

d) Place a tie around the butt of any convenient unit before removing it from the bunch. Ensure that the coloured unit identification tape is included in the tie.

e) Remove the unit from the bunch and place a tie about 25mm from the end.

f) Carefully bend back the unit onto the sheath using the finger to form the bend.

g) Continue the procedure (5.3.6.d) and (5.3.6.f) on all other units.

h) In the first unit to be jointed pick any pair and cut it just clear of the end tie then give the pair a cranked twist in the same direction as the original pair twist.

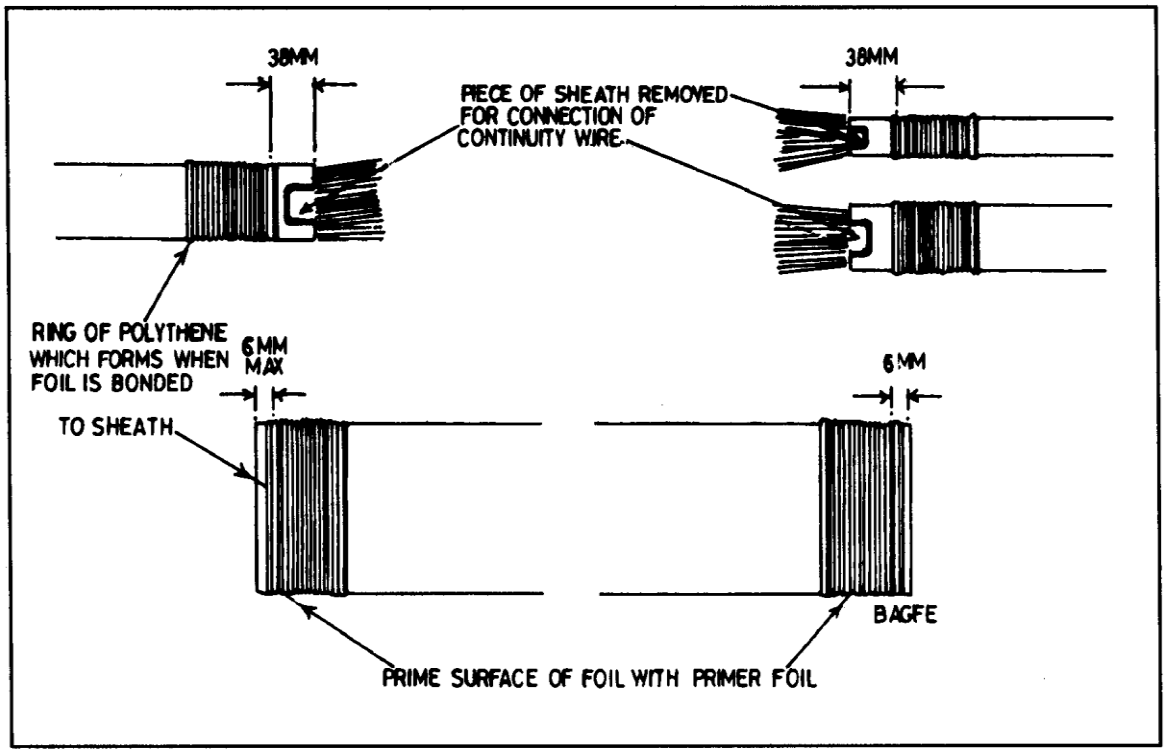


Figure 5.5 Bonding of Foil to Sheaths

i) Repeat this operation with every pair in the unit.

j) Joint or terminate the pairs in accordance with the colour code.

To avoid unnecessary numbering, the colour code should be strictly adhered to during the termination or jointing stage. When terminating on large MDFs where up to 6m of cable core may be exposed at one time, care must be taken to preserve the unit formations. Give each unit a single wrapping of tape at 900mm intervals along each unit length. This extra precaution will prevent the splitting of pairs which can easily occur during the frequent handling the wires must undergo before termination.

5.3.7. Joint Quality

a) The following are the required properties of a completed joint:

i. Good electrical conductivity.

ii. Insulated from the earth and each other.

iii. Dry and kept dry by use of hygroscopic material.

iv. Sealed against ingress of water.

v. Sufficient mechanical strength.

b) When the wires are to be jointed, the proper method should be used so that connection on each joint is electrically good and no breaking of wires when twisting. An improper joint would cause a fault. All conductor joints are insulated from each other and earth by means of paper or polythene sleeves.

5.3.8. **Drying Out Joints**

When all wires have been jointed, the joint should be thoroughly dried out before wrapping as moisture has been absorbed from the air or jointer's hands. Separate the wires by moving the cable together and slackening off the joint. This allows air to circulate around the wires. A gas torch is then placed below the joint and a sheet of stiff paper placed on top of the joint. A few minutes heat from the torch will drive off the excess moisture. The joint must be examined to ensure that all joints are properly covered and that no pieces of scrap wire are lodged in the joint to cause faults. Pockets of the hygroscopic material are placed within and around the completed joint to keep it dry.

5.4. JOINT CLOSURES

5.4.1. The specific methods of preparing joint closures are dependent on the type of sleeve employed. Each joint closure must however meet the design, mechanical and environmental characteristics described in clauses 5.4.2 -5.4.4.

5.4.2. **Design**

Closure designs employ cold or hot processes based on the sealing methods used. Cold processes do not require heat whereas hot processes do. Mastic, tapes, grommets, O-rings, cured rubber shapes, pastes, potting compounds and adhesives are cold processes. Thermo shrinkable materials and polythene injection welding are the primary hot processes. The heat source may be electrical resistance heating, infrared heating, hot air or a gas flame. Regardless of which of these processes is used, the following shall be considered:

a) The materials used for making the cable joint shall be compatible with themselves and with the materials of the sheath. Further, to prevent corrosion or other electrochemical damage, the materials shall be compatible with other materials normally used in the outside plant.

b) A closure shall be mechanically strong.

c) A design may allow for jointing together more than two cable ends. The cables entering the closure may be of differing sizes and or types. For example, some of the cables may be small customer service cables.

d) A design may allow for jointing together cables not at the end of a cable. For example a joint of a branch or customer service cable to a through cable in the middle of a cable length.

e) It is desirable that closures can be reopened when necessary and remade without interruptions to working circuits.

f) A single design which may be used for all of the above applications.

g) If a design is limited to certain applications and environments in the network, any limitations shall be clearly indicated to the user.

h) If joint sealing encapsulant is used, information is required for adjustments in setting time due to variations in ambient temperature and humidity.

i) If heat source is required to seal the closure and or closure to the sheath, a suitable heat source (gas flame or electrical power) needs to be available at the jointing points. Consideration shall be given to control of the heat source to protect personnel and prevent damage to the closure or cable.

j) If the closure is in pressurized plant it shall be able to hold the operating pressures safely and without leaking. In addition a means shall be provided to reduce the pressure for safe re-entry.

5.4.3. **Mechanical Characteristics**

The mechanical characteristics shall be considered according to the conditions of the installation. Wherever appropriate, test methods according to IEC 1073-1 or its equivalent shall be used in this section.

a) Bending

After installation, the closure may be subjected to bending stresses due to dynamic conditions encountered by the cables and shift in the earth in directly buried applications. The closure shall maintain a seal to the cable sheaths and the cable jointing system shall prevent transfer of excess strains to the enclosed conductors or fibres.

b) Creep (Axial Tension)

Dynamic conditions, especially in aerial and duct plant and shifts in the soil in directly buried applications may cause cyclic and static tensile loads in the cable. These tensile loads shall be supported by the closure without losing the seal to sheaths and transferring excessive strains to the conductor or fibres.

c) Crush and Impact

The closure may be subjected to crush and impact both during installation and operational life. The closure shall protect the conductor or fibres and joints under normal crush and or impact loading experienced during the life of the cable system. In certain circumstances for directly buried closures, additional protection may be provided, for instance by placing the closure in a loose sleeve.

d) Torsion

Under dynamic conditions during operation, the cable may be subjected to torsion. The closure shall be able to transmit the torque across the joint while maintaining seals to the cable sheaths. The transmitted torques shall not be transferred to the fibres or joints.

5.4.4. **Environmental Characteristics**

The environmental characteristics shall be considered according to the conditions of the installation.

a) Temperature Variations

During their operational life, cable joints may experience severe temperature variations. The closure shall be able to withstand the temperature variations without loss of function, damage to the conductors or fibres or increase in loss.

b) ***Water Immersion (Moisture Permeation***)

During their operational life cable joints may be immersed in water or exposed to very high humidity for long periods of time. Fibres exposed to very high humidity and or liquid water, may deteriorate in strength and have a reduced time to failure under static fatigue while metallic conductors may suffer low insulation. A desiccative material may also be used to reduce the humidity within the closure.

The closure shall prevent entry of liquid water. A water sensor may be installed in the closure to detect the presence of water.

Fibres shall be arranged within the closure so that their stress levels are sufficiently limited to ensure a satisfactory lifetime taking into account the expected relative humidity within the closure. Various materials such as continuous metallic barrier can be used to reduce the rate of moisture permeation.

c) Lightning

Cables containing metallic elements such as moisture or rodent barrier, metallic strength member or copper pairs are subject to lightning damage.

To prevent or minimize lightning damage, the closure shall be capable of passing the resulting high current through the joint without damaging the joints.

Procedures for selecting protection measures in telecommunication lines are given in ITU-T Recommendation K.72

For radio base stations, lightning discharge protections shall be as provided in ITU-T Recommendation K.56.

d) ***Vibration***

Cable joints may be located on aerial messenger strands, underground in jointing chambers directly buried on bridges and other structures. As a result of their location they may be subject to vibrations from wind, traffic, railways and blasting operations. The cable joints shall be able to withstand these vibrations without loss of function, damage to the conductor or fibre or increase in loss.

e) UV radiation

Cable joints placed in aerial plant will be subject to UV radiation from sunlight. The material of the closure shall be resistant to UV radiation. Any surface degradation shall not result in product(s) that may be harmful to persons handling the closures upon subsequent re-entry or reduce the performance level of the closure.

5.4.5. Cable Routing Records

After the completion of the jointing and cable terminations at the local MDF/CCP and local DP, the routing information shall be recorded appropriately.

5.5. EARTHING SYSTEMS

The earthing provided at **local** MDF shall be extended and made electrically continuous to all local DPs. Two types of earth electrode systems in general use are:

a) The driven rod system.

b) The trench system.

Generally, a trench system shall only be used where it is not economically possible to obtain the low earth resistance required by the use of a driven rod system.

The earth system shall be sited so that as much spacing as possible is obtained from other earthing systems provided for the building.

If a buried telecommunication cable without an insulating layer around the metal sheath is located in the vicinity of a high voltage earth system, a separation distance as provided by ITU-T Recommendation K.8 shall be observed.

The resistance of the earth shall not exceed 4 ohms under the most adverse conditions i.e., after a prolonged dry spell.

5.6. COMMISSIONING TESTS

5.6.1. The fundamental objective of testing is to ensure that the installed telecommunication plant meets the required standards and is free from all faults. Tests shall be carried out as per ITU-T recommendation L.75 or as per any other recognized standard. The common metallic cable faults are shown in table 5.3 below.

5.6.2. **Measurement of Insulation Resistance**

a. Preparatory Operations

The Ohmmeter should be placed on a firm level base, and where the facility is provided, adjusted accurately for level by means of the screws on the base of the instrument. Where an Infinity Adjusting Screw is provided, the handle should be turned at such a speed that the clutch is felt to slip and the screw adjusted until the needle points to the infinity mark

Connect the test leads to the appropriate terminals. Earth the `E' lead and leave the `L' lead free. A reading of infinity should be obtained, failing which the leads should be replaced.

b. Insulation Resistance Tests

In all insulation Resistance measurements, the lines under test should be insulated from each other at the distant end. For measuring the insulation resistance of one wire to another wire earthed, e.g. `A' wire to `B' wire earthed, the earthed wire should be connected in the Earth terminal and the other to the Line terminal. With the test leads connected in this way, the handle should be turned until the clutch is felt to slip.

At first, due to the capacity of the line, a charging current will flow, indicated by the needle swinging towards zero, when the line is fully changed in the needle will take up a position dependant upon the amount of current flowing in the insulation of the line under test.

Due to the charging current which flows initially, readings should not be taken until after a minute of electrification.

For testing the other wire, the conditions on the wires under test should be reversed, i.e. `B' wire to `A' wire earthed. The `A' wire would then be connected to the Earth terminal and the `B' wire to the line terminal, and the test carried, out as before.

c. Use of Megger

When testing cables with the megger, make sure that there are no other technical personnel working on the lines under test. Disconnect the circuit, to be tested, at both end.
Connect the megger making sure that the leads are in good condition. The leads should be of thick wire with good insulation.

The line terminal is connected to the line under test and the earth terminal to the cable sheath or a good earth. The handle is turned at speed until the clutch slips. The resistance of the insulation of the wire under test is read from the meter.

A reading of zero would indicate that the line was faulty. The insulation resistance of a line decreases with the increase in length. The insulation resistance will depend on the length of line under test, the type of cable and the reading of the insulation resistance to be expected at no fault condition.

5.6.3. **Loop Resistance**

The loop resistance shall be measured to ascertain that it conforms to the design requirements.

5.6.4. **Confirmation of Grounding**

Tests shall be carried out to confirm that the screen has been earthed.

TYPE OF FAULT	**CAUSE**	**EFFECT**
Short Circuit	Two wires of a pair touching one another. The wires may be definitely short circuit or intermittently short circuit	Short circuit faults in lines confines the working current to the line on one side of the short circuit, thus the line is out of order
Foreign Battery	Where an EMF exists in a circuit other than the normal EMF required for the operation of the circuit. Caused by faulty insulation or contacts allowing leak of current from other circuits	Foreign battery will affect the operation of the circuits and also make same very noisy
Low Insulation	Where part of the battery current is lost to earth, or an earthed object, caused by faulty insulation and or moisture	Affects operation of circuits and sometimes causes a complete breakdown
Cross Talk	Increase in capacitance between cable pairs or from cross coupling of pairs mainly caused by ingress of water or moisture into the cable	Over-hearing or reproduction of an unwanted sound signal in a transmission channel from other channels
Reversed Pairs	Where one pair is jointed to another pair out of correct position or rotation. Usually caused by careless	This fault will affect incoming and outgoing calls as one subscriber will obtain the other subscriber's calls and

TYPE OF FAULT	CAUSE	EFFECT
	jointing	will also use the other subscriber's calling equipment
Contact	Generally caused by faulty insulation or misplaced sleeves in cable joint, allowing one or both wires of a pair to contact another circuit	The fault may cause over-hearing and faulty operation of one or both of the terminals or circuits concerned
Reversed Legs	Where the legs of a pair are reversed. Usually caused by careless jointing	This will have no effect on an ordinary exchange line, but will put tie lines and shared service circuits out of order
High Resistance	Where the resistance of a wire or circuit is greater than normal. Usually caused by bad contacts dry joint at terminal or loose twisted joints	This fault will often make a circuit noisy and affect the operation of same
Earth	Usually caused when one or both wires of a pair are in contact with an earthed object	This fault may cause a number of out of order conditions such as noisy lines, or permanent operation of the exchange apparatus on common battery and automatic exchanges
Split Pairs	Caused when one wire of one pair is jointed to one leg of another pair and is the result of careless jointing	Split pairs will cause overhearing and faulty operation of both the circuits
Disconnection	May be caused by a cut or broken wire or wires, or a carelessly made joint	Disconnection faults put lines out of order, and prevent both incoming and outgoing call from being made
Cable Breakdown	Where a cable is failing or has failed. Caused by failure of cable sheathing or entry of moisture at some point	According to the amount of moisture, some or all circuits are out of order
Discontinuous Earth	Usually caused when the earth wire is broken at one or more points	This may cause mis-operation of equipment o r noisy circuits

Table 5.3 Common Metallic Cable Faults

5.7. ARMOURED CABLES

6. GENERAL

All buried cables routes shall be staked out and marked prior to construction and depth of existing buried facilities be determined. Equipment and installation methods used shall be such as will minimize soil displacement. Trenches shall be promptly backfilled with earth to ensure that no hazard to motor and pedestrian traffic arises. Trenches shall not be left open at night unless suitably protected with barricades, flashing lights, and other methods. The laying of cable length shall be completed prior to the day's work.

6.1. DEPTH

The minimum depth of buried cable measured from the top of the cable to the surface of ground or pavement shall be as follows:

Carriageway	-600mm
Carriageway paving crossings	-300
Footway	-230mm

In fields, the cable cover shall be adequate to permit other digging operations to be carried out without disturbing the cable.

6.2. CABLE LAYING

6.2.1. **Precautions**

Before handling dry armoured cable, it shall be well wetted to remove the tarry dust which forms on the sheathing and normally causes serious irritations and injury to the eyes.

6.2.2. The cable shall be laid in the trench in the following ways:

a) By being lowered from the cable drum supported in a cable trailer or lorry moving alongside the trench.

b) Where obstructions do not permit the use of method (a) the cable drum is supported at the beginning of the trench on lifting jacks and the cable is drawn off and laid in the trench.

c) The bottom of the trench shall be covered with screened earth or sand before laying the cable to avoid the cable coming in contact with rocks, stones and other heavy and sharp objects in the trench.

d) Where it is necessary to pull the cable over the ground or in the trench, avoid dragging over abrasive obstructions that might damage the outer jacket. When pulling a cable under road pavements or across pipelines, the set-up should be such that undue strain is not placed on the cable or outer jacket.

6.2.3. After each section of the cable has been installed, tests shall be performed in order to verify that no damage has occurred.

6.3. CONDUCTOR JOINTING AND JOINT CLOSURES

Conductor jointing and joint closures shall be performed as detailed in clauses 5.3 and 5.4 respectively. For directly buried optical fibre cables, jointing chambers shall be provided as opposed to metallic cables whose joints can be directly buried. Other specific details for the optical fibre jointing and joint closures are outlined in clauses 11.7 and 11.8.

Bonding of cable screen and armouring at jointing points shall be carried out to obviate damage by electrolytic action of stray currents.

6.4. EARTHING AT THE LOCAL MDF

As detailed in clause 5.5.

6.5. PROTECTION

Concrete troughs or concrete ducts shall be used at the street crossing portions and splicing points of buried cables.

6.6. BACKFILLING

Soil free from stones should be placed between the cable and the trench edge and carefully punned. For the purpose of this punning, it is advisable to use a 150mm x 38mm board one end of which should be shaped to form a handle. Soil should be added as punning proceeds until the surface is level with the top of the cable. Normally there should be three people punning for every one person replacing the soil.

Poor compaction of the soil beside a cable has been known to cause settlement of the soil trench as much as 50mm. A layer of earth free from stones should be placed over cable and compacted to a thickness of between 75mm and 100mm. The excavated subsoil should then be replaced in layers 150mm thick when compacted by punning before further soil is added.

The excavated hard materials should be replaced in 150mm layers, adding fine material (small stones and gravel) as necessary to fill the voids, and compacted. Under asphalt and similarly paved surfaces the level of the hardcore should not be less than 25mm from the surface level in footway, or 50mm from the surface level in carriageway. The remaining space should be filled with a bituminous paving and compacted to have a 13mm crown above the level of the adjoining paved surface.

6.7. INSPECTION POINTS

The contractor shall leave inspection points as detailed in clause 1.4.1.

6.8. CABLE MARKERS

Cable markers shall be placed at locations where the cable route changes its direction and at locations of buried joints. Marker posts shall be placed in such a way that the angle is divided in equal parts.

The distance from the cable marker post and the cable shall be not less than two (2) metres. The marker posts consist of hot dipped galvanized angle iron with a concrete base made in situ. The information regarding cable distances etc. shall be

embossed on an aluminium marker which shall be attached to the marker posts by two galvanized hexagon headed screws.

7. AERIAL ROUTES

7.1. INTRODUCTION

Aerial routes are preferred for distribution purposes in sparsely populated areas where subscribers are scattered. They are faster, cheaper to construct and easier to make alterations to the network layout as opposed to underground routes. It should however be borne in mind that underground routes are more secure, durable, have lower maintenance costs and are more environmental friendly. This chapter details the general principles and practices for aerial route construction.

7.2. MATERIALS, TOOLS AND EQUIPMENT

7.2.1. **Materials**

The materials required to suspend and clamp a self-supporting type of an aerial cable are shown in table 7.1.

ITEM	TYPES	APPLICATIONS
	General Purposes	
1	General Purposes	
1.1	Washer	Accessory of machine bolt and eye bolt
1.2	Galvanized Iron Wire	Binding of cable grip and PVC cap
1.3	Adhesive PVC Tape	Wrapping cable grip and spiral sleeve etc
1.4	Cable Binding Rope	Binding of cable or splice closure
1.5	Staple	Fixing pole plate
2	**Route Construction**	
2.1	Wire grip	Suspending of suspension wire
2.2	Eye Bolt and Nut	Fixing suspension wire on pole
2.3	Spiral Sleeve	Protecting suspension wire of cable to be branched out between poles
2.4	Strand Wire Span Clamp	Suspending suspension wire of cable to be branched out between poles

Table 7.1 Materials for Aerial Route Construction

7.2.2. **Tools and Equipment**

The tools and equipment required for suspending an aerial cable, installing grounding and bonding devices and carrying out the incidental works in addition to these works are listed in table 7.2.

NO	TYPES	APPLICATIONS
1	**General Purposes**	
1.1	Safety Guard and Warning Signs	Warning to pedestrians and vehicles
1.2	Safety Belt and Strap	For safety of working crew
1.3	Rope	Pulling cable along pole line and other items
1.4	Side Pliers	Pressing or cutting
1.5	Ball Pin Hammer	Hammering of earth rods
1.6	Screw Driver	Tightening screw bolts
1.7	Adjustable Wrench	Tightening bolts and nuts
1.8	Knife	Cutting and peeling of sheath or others
1.9	Scissors	Cutting tapes etc
1.10	Wire Cutter	Cutting strand wire
1.11	Thermometer	Measuring temperature of environment to determine cable pulling tension
1.12	Crowbar	Breaking the earth and guiding the pole butt into cylindrical holes
1.13	Tape measure (30m)	Measuring distances
2	**Route Construction**	
2.1	Stout Ladder	Pole lifting
2.2	Clinometer	Measuring heights
2.3	Box-sextant	Setting angles
2.4	Survey rods	Aligning the route and setting of angles
2.5	Surveying chain	Measuring distances
2.6	Sliding Boards	Guides and provides a smooth surface down to which the butts of pole slide without moving any soil, to the bottom of the stepped hole.
2.7	Pole Lifters	Used in conjunction with stout ladders to lift poles
2.8	Twister	Used with a crowbar to twist a pole after erection to obtain alignment.

Table 7.2 Tools and Equipment for Route Construction

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7.3. POLES

7.3.1. Types

There are many materials available for manufacture of poles. The most common ones are steel, concrete and wood. The cost of poles manufactured from steel and concrete vary. The standard types, sizes, holes and applications of poles are shown on table 7.3.

7.3.2. **Erection of poles**

a) The hole to receive the base of the telephone pole should be of the correct size and depth. It should be dug in the correct manner to ease erection of poles. Two types of holes are used for pole erection; namely; cylindrical and stepped.

b) Cylindrical Holes

Where a cylindrical hole is used, a channel of about 600mm long and tapered to 230mm where it meets the hole is used to guide the butt of the pole into the hole as shown in figure 7.1.

The diameter of the hole should be kept as small as possible whilst allowing the base of the pole to slide easily to the bottom of the hole. As little ground as possible shall be disturbed.

In very soft or unstable ground the depths may be increased to give better stability. Where holes are excavated on a slope, the depth should be measured from the lower edge of the slope.

c) Stepped Holes

For the erection of heavy poles, stepped holes should be excavated. Stepped hole shall be used where it is difficult to dig cylindrical hole and where reinforcement is required by attaching a log to prevent the pole from sinking in loose soil. The excavation shall be done as shown in figure 7.2.

The longest vertical wall of the hole shall be positioned so that it supports the pole against the pull of the wires.

d) Placement

i. The cylindrical hole is prepared to receive a pole by placing a crowbar that will allow the pole to be slid into the hole without snagging as shown in **figure 7.3.** The pole shall be dressed by fitting all necessary arms, spindles and stays before placement. Guy lines are also fastened to the pole to steady it during erection and to hold it vertical whilst backfilling. By use of manpower, the pole shall be systematically lifted up and erected upright.

ii. For stepped holes, a sliding board should be placed at the back of the hole, guy lines should be fixed to the head of the pole to steady it until erection is complete. The pole should be brought forward to the hole and the it's base pushed forward until it rests against the sliding board as shown in **figure 7.4.**

POLE NO	LENGTH (m)	DIAMETER AT TIP (mm)	WEIGHT (kg)	TYPE	HOLE DEPTH (mm)	APPLICATIONS
3	6.1	89 - 114	68.1	Light	1070	For drop wire on armswood No 4 in areas entirely free from obstructions
3A	6.1	114 - 140	79.5	Heavy	1070	As for pole No 3 but where extra strength is required
4	7.3	89 - 114	79.5	Light	1220	As for pole No 3 but in bushy and exposed areas
5	7.3	114 - 140	113.5	Heavy	1220	As for pole No 4 but where extra strength is required
8	6.1	89 - 114	63.6	Light	1070	For drop wire on armswood Nos 3 and 4 in areas entirely free from obstructions
8A	6.7	114 - 140	68.1	Heavy	1220	For DPs, angle poles and at power crossings where taller poles cannot be used
9	7.3	89 - 114	79.5	Light	1220	For drop-wire on armswood Nos 3 and 4 on main distribution routes
10	7.3	114 - 140	113.5	Heavy	1220	For DPs, light cables and for drop wire main distribution routes but where extra strength is required
11	7.3	140 - 165	154.4	Extra Heavy	1220	As for pole No 9 but for extra-ordinary strength
12	7.9	127 - 152	147.6	Heavy	1220	For large size cables (CASSC), DPs and drop wire distribution
13	8.5	127 - 152	172.5	Heavy	1580	Poles Nos 13 - 16: As for pole No 12 but for extra strength and height especially at roads, railway crossings and valleys.
14	9.2	127 - 152	209.1	Heavy	1580	
15	9.8	127 - 152	227.0	Heavy	1580	
16	10.7	127 - 152	263.3	Heavy	1680	

17	7.3	114 -140	227.0	Heavy	1220	These are a combination of two poles forming figure "A" and are used in swampy places and areas with space limitation where stays cannot be provided. The hole shall be excavated in form of a slit trench of length 1220mm.
18	7.9	127 - 152	295.2	Heavy	1220	

Notes: 1. Poles Nos 3 - 5: Tips are scarfed and drilled for a maximum of three arms.

Poles No 8 - 16: Tips are unscarfed.
Poles No 17 and 18: Tips are scarfed and drilled.
Holes for poles to be erected in soft soil shall be backfilled with concrete

Table 7.3 Pole Specifications and Applications

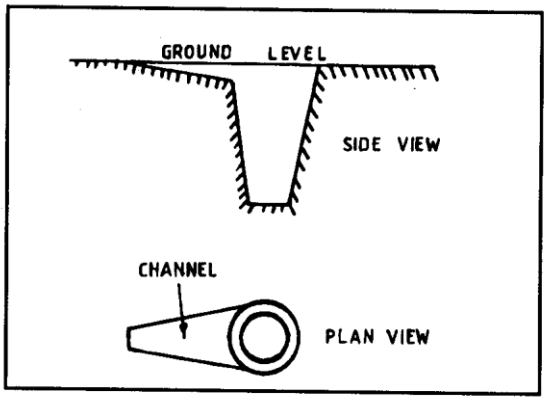


Figure 7.1 Cylindrical Hole Sketch

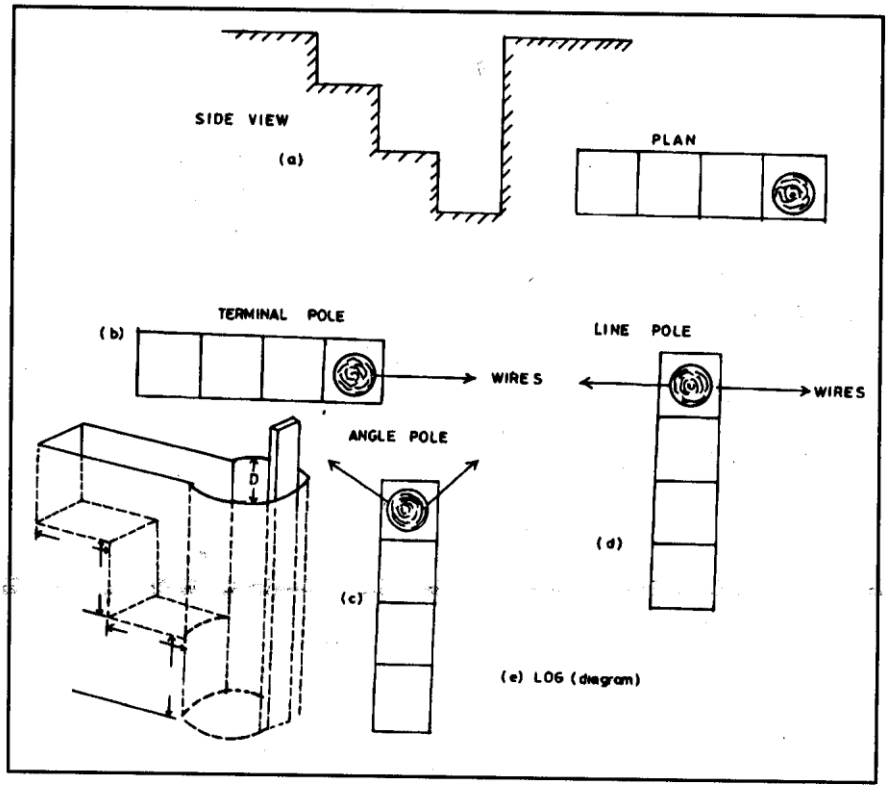


Figure 7.2 Stepped Hole Sketch

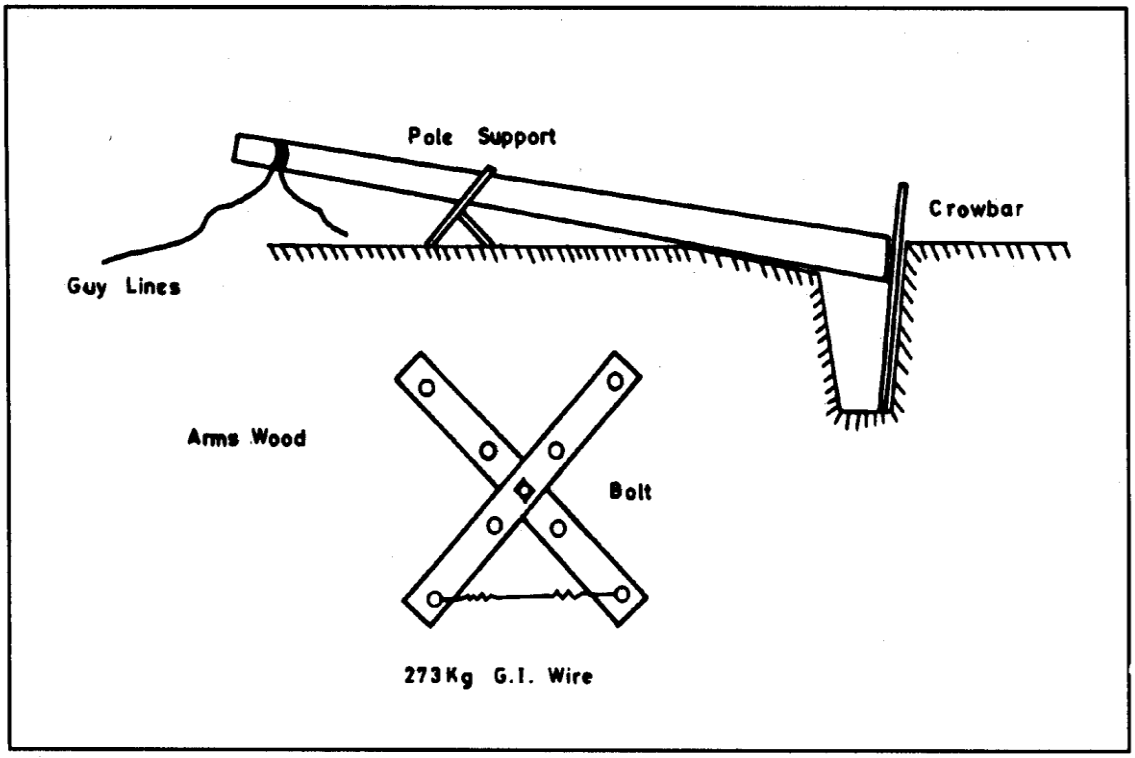


Figure 7.3 Pole Placement in a Cylindrical Hole

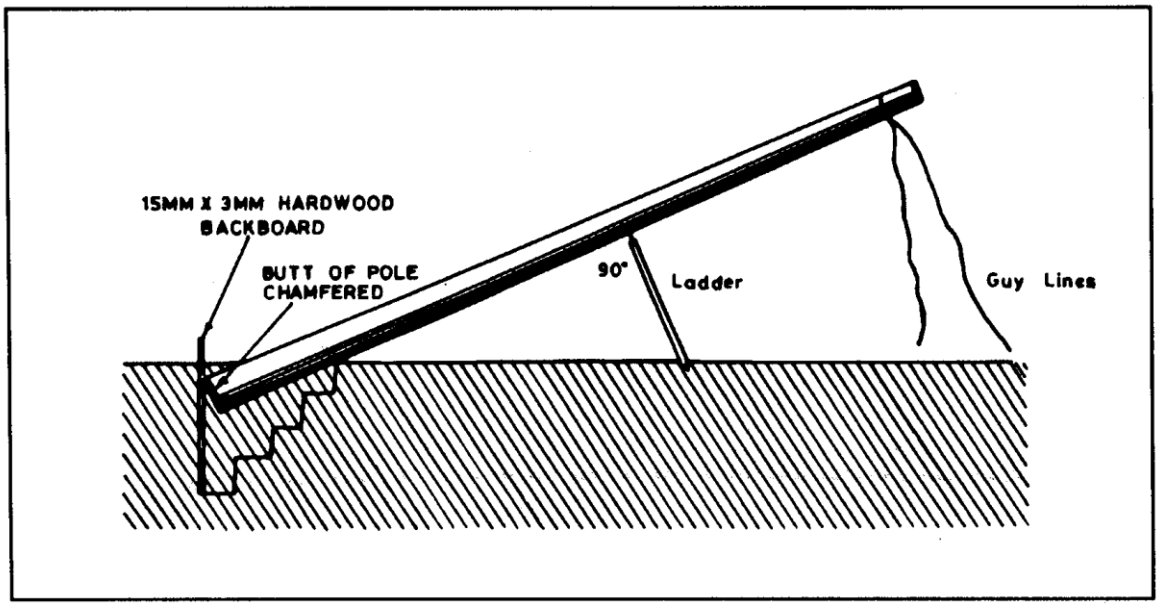


Figure 7.4 Pole Placement in Stepped Holes

e) Setting

The appearance of an aerial route depends, to a large extent, on the care taken in setting. In straight sections the poles shall be made vertical by use of a plumb line. Terminal and angle poles shall be slightly set against the pull of the cables or wires so that as they consolidate, they will become upright under the full load. Arms should face in the direction of the line. It will be generally necessary to twist the pole upon erection so as to place the arms in straight sections at right angles and at angle poles bisecting the angle in the correct position relative to the route.

f) Backfilling and Ramming

Rocks and small stones are now placed in the bottom of the hole and carefully rammed. The remainder of the soil should then be placed in the hole a little at a time, each amount being thoroughly rammed before more is placed. Any excess soil should be removed and disposed of as inconspicuously as possible. If this is not possible e.g. working in a built-up area the surplus earth should be bagged and disposed of at some later time.

g) Number of personnel Required

Pole erection should be carried out with an adequate number of personnel, the first consideration is safety of the staff and public. Without mechanical aids, four persons are enough in straightforward cases. Increase the number of personnel as the situation demands.

7.3.3. **Pole Dressing**

a) After erection, poles are required to carry wires, cables and stays. To achieve this, various fittings are used for different types of routes. Such fittings include hooks and armswood.

b) Hooks

Hooks are used for holding cables at straight through positions as shown in figure 8.2.

c) Armswood

Armswood No 4 is used on scarfed and unscarfed poles and is designed to carry a maximum of 2 drop wires as shown in figure 9.8. Armswood No 3 is used on unscarfed poles and is designed to carry a maximum of 5 drop wires as shown in figures 9.2, 9.3 and 9.4.

7.4. STABILITY

7.4.1. Poles can be made to resist weight of cables, wires, wind, falling objects and other static and dynamic stress by use of the following methods.

a) Staying

i. This is the best and cheapest method and has the following advantages over other methods:

ii. They are easily fixed, no boring of the pole or other treatment is necessary.

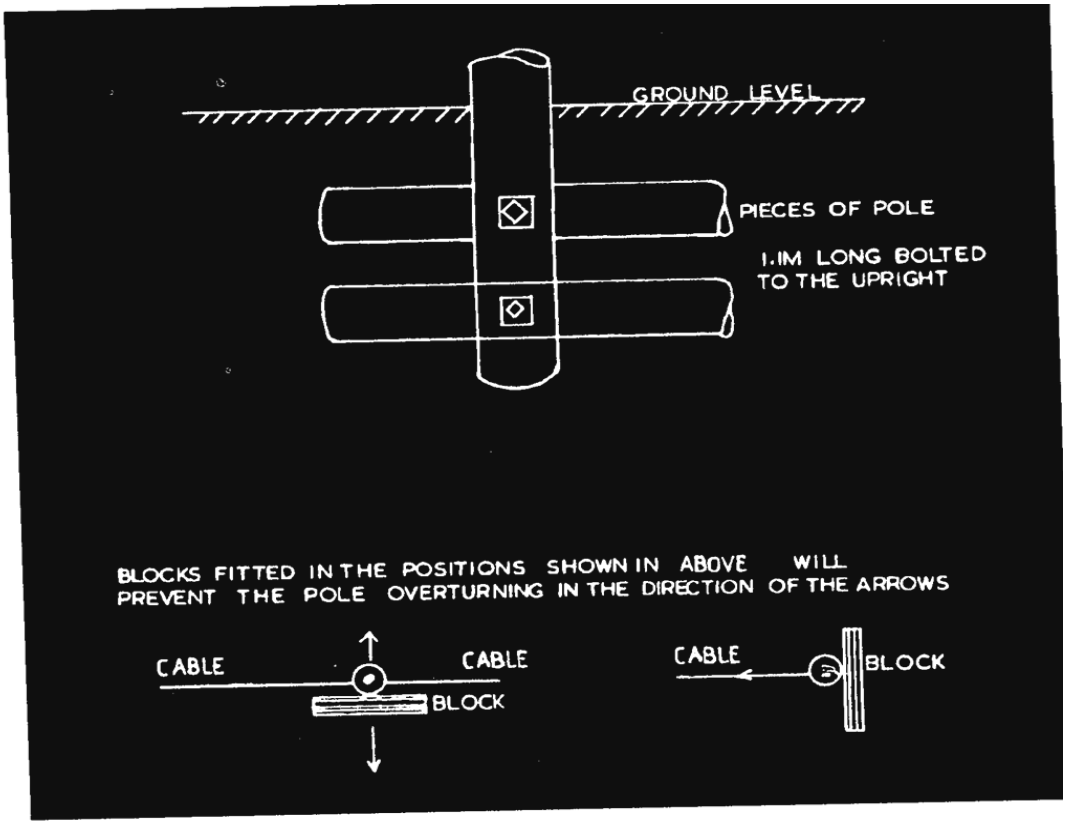
iii. They can be attached at, or very near the resultant point of tension of the bed of cables and wires.

iv. They can be designed for any given load by fixing additional stays.

v. They are easily re-adjusted.

b) **By "blocking"** ***the*** bottom of the pole.

Blocks fitted in the positions shown in figure 7.5 will prevent the pole



overturning in the direction of the arrows.

Figure 7.5 Blocking method

c) By "Strutting" the Pole

A suitable length of pole is fastened to the pole in the manner shown in figure 7.6. The pole can now withstand overturning forces in the direction of the wires. Note that both the pole and strut are fitted with blocks.

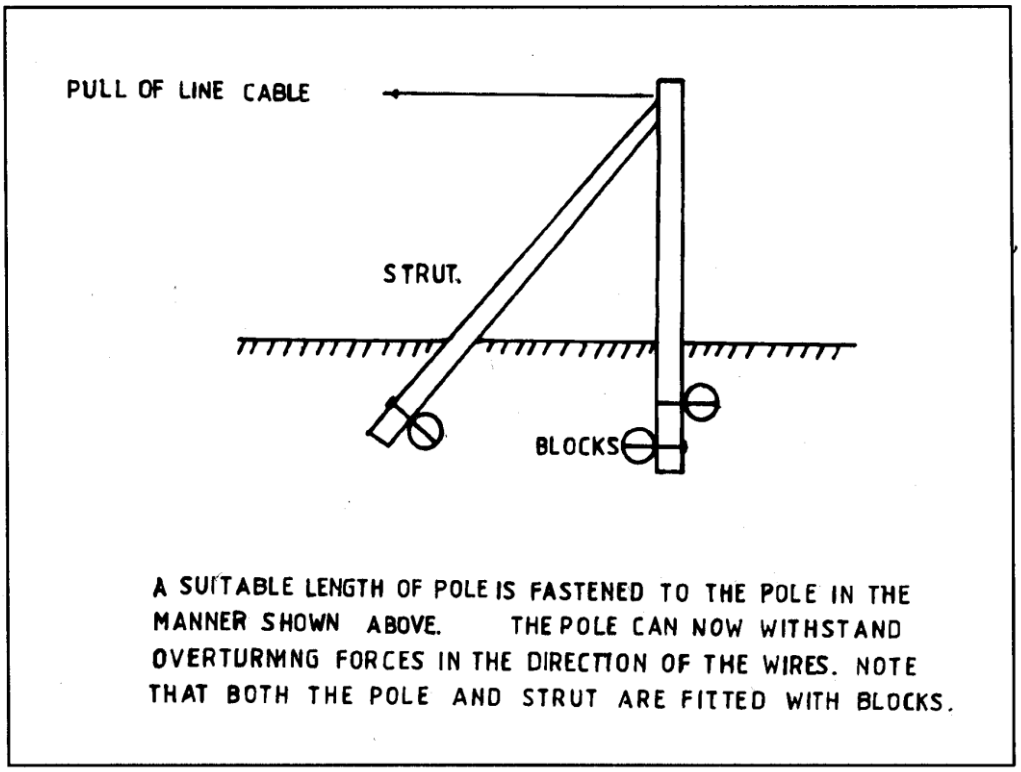


Figure 7.6 Strutting Method

d) By Using "A" Pole Construction

The structure is erected as shown in figure 7.7. This type of support will withstand stress in the direction of the arrows.

e) By using **poles** of extra strength in selected positions.

f) By setting the poles at greater than normal depth.

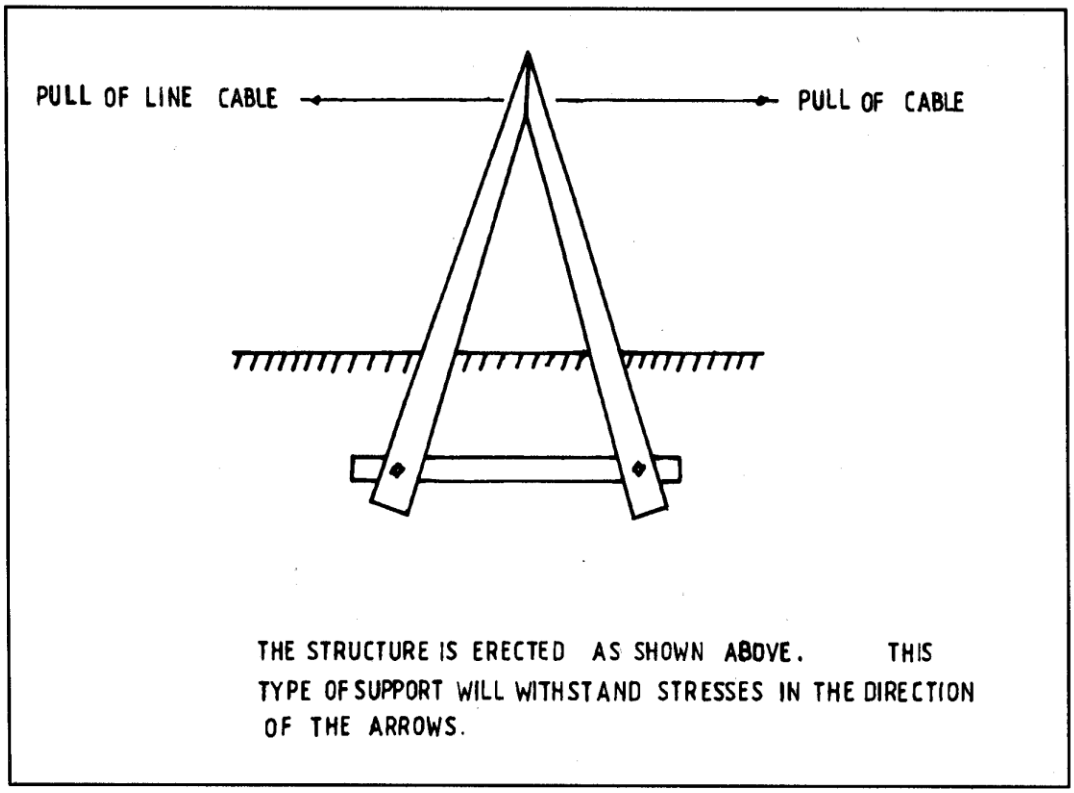


Figure 7.7 "A" Pole Method

7.4.2. **Types of Stays**

a) Terminal Stays

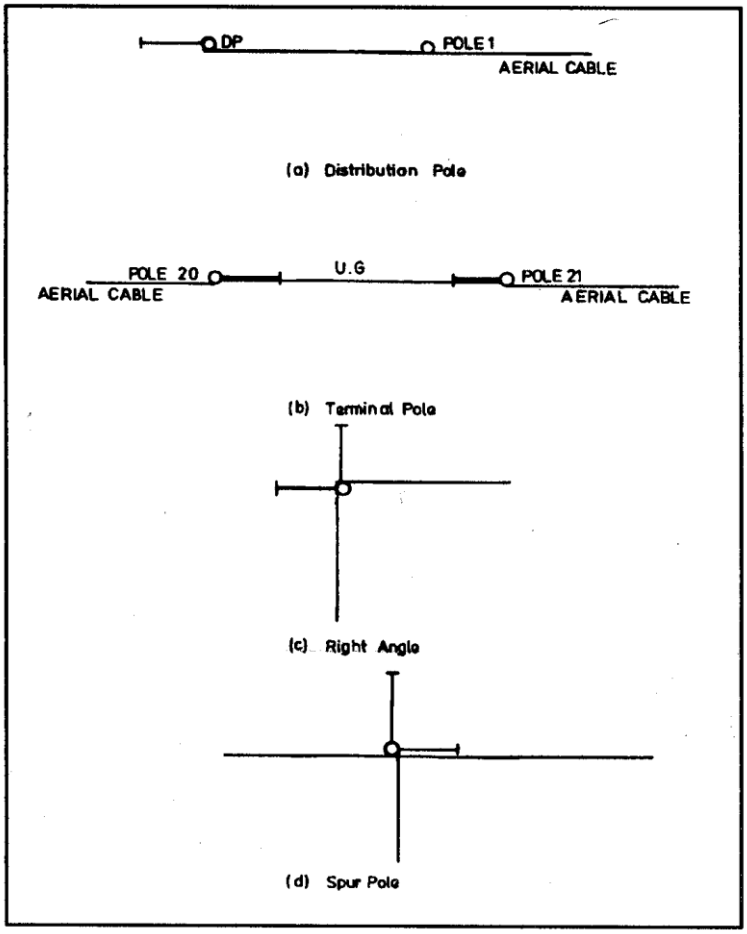
These are provided at the distribution poles, terminal poles for a section of underground or aerial cable, poles where the route changes direction through a right angle and the junction of a spur route as shown in figure 7.8.

b) Line Stays

These are provided at road and railway crossings, terminal and intermediate positions, at angle poles where the route changes by between 30^{o} and 40^{o} and angle poles as shown in figure 7.9.

c) Wind Stays

These are fitted at 800m intervals in straight sections of route exceeding 1600m. In exposed situations or unstable soil conditions they may be



provided at more frequent intervals. They are provided as shown in figure 7.10 to strengthen a line against transverse stresses arising from the action of the wind on the line. These stays consists of two ordinary stays - one on each side of a pole - fixed in a plan at right angles to the direction of the line.

Figure 7.8 Terminal Stays

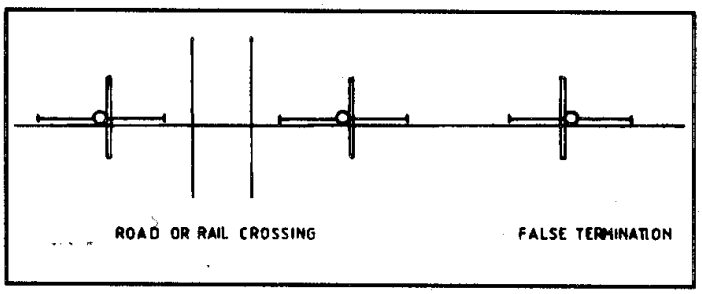


Figure 7.9 Line Stays

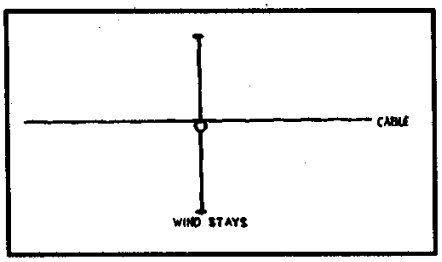


Figure 7.10 Wind Stays

d) Angle Stays

Shall be fitted at all angles except right angles as shown in figure 7.11.

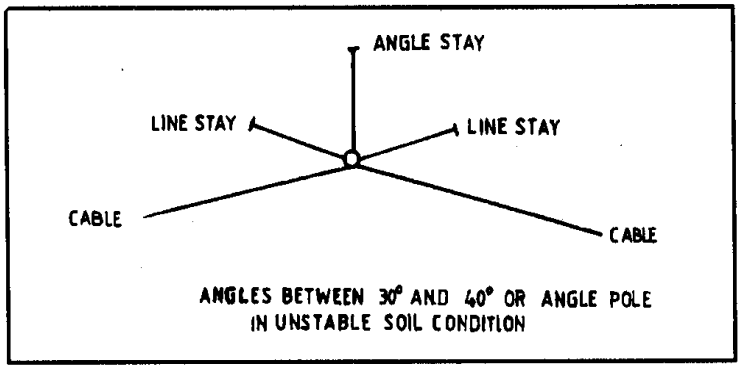


Figure 7.11 Angle Stay

The minimum stay spread shall be as follows:

- Angles up to 15^o - 1830mm
- Angles 15^o to 30^o - 3660mm
- Angles over 30^o - Line stays in addition to the angle stays.

e) Insulated Stays

These are provided in the vicinity of power lines.

f) Overhead Stays

These are provided for over-road stay purposes.

g) Side Stays

These are provided at two or more drop-wire drop off points and spur positions.

7.4.3. **Fitting Stays**

a. Stays should be so placed as to avoid obstruction to vehicles or pedestrians and to incur the least possible risk of being damaged by or causing injury to animals.

The upper end of the stay should be attached to the pole as near as possible to the resultant point; the point at which all the forces acting on the pole can be balanced by a single opposing force. Where additional stay is required and the first stay is above the new resultant point a further stay is fitted below the new resultant point.

For drop wire routes, line, terminal and angle stays should be made off with a double turn around the pole immediately below the arms and fixed on pole using staple (No 3 recommended). Usually no stay is required for a single drop-off but for two or more pairs a side and a line stay shall be provided. The side stay should be made off in the same way as angle stay.
The items used in conjunction with the various sizes of stay rods are given in table 7 .4.

ROD STAY	**CROSS HEAD STAY**	**PLATE STAY**	**TURNBUCKLES (AS REQUIRED)**	**TYPE OF WIRE**	**APPLICATIONS**
No 1	-	See Note	No 3	273 kg GI	Drop-Wire Routes
No 2	No 1	No 2	No 2	2 x 273 kg GI	Line stay, aerial cable
No 3	No 3	No 3	No 2	Wire, Galvanised Stranded 4/8	Line stay aerial cable
No 4	No 3	No 4	No 2	Wire, Galvanised Stranded 4/8	Angle stay, aerial cable
No 5	No 5	No 5	No 2	Wire, Galvanised Stranded 7/8	Angle stay, aerial cable

Note: Blocks Stay No 1 are used with Rods Stay No 1

Table 7.4 Stay Rods and Accessories

b. Stay Wire

The required length of stay wire should be cut from a coil. The length required is the distance between make-offs plus the length given in table 7.5 which also gives the average weight of wire required per stay wire.

c. Stay Spread

The efficiency of a stay depends upon the ratio of the distance from the base of the pole to the point at which the stay rod leaves the ground and the height

above the ground of the stay make-off on the pole, usually referred to as the base/height ratio. The greater the base (also commonly referred to as the spread) of a stay the greater its efficiency. The efficiency increases quite rapidly with increased length of stay base up to a base/height ratio of 1:1 i.e. when the length of the base equals the height of attachment, but more slowly for higher ratios.

For drop wire routes, stays fitted in accordance with table 7.6 provide adequate stability for maximum loading of the routes.

TYPES OF STAY WIRE	**MAKE-OFF AROUND POLE (mm)**	**MAKE-OFF ON ROD, CROSSHEAD, TURNBUCKLE, ANGLE ARM OR SEAT (mm)**	**AVERAGE WEIGHT OF WIRE PER STAY WIRE (kg)**
7/8	1830	915	9
4/8	1525	610	5
273 Kg GI	1373	456	2.3

Table 7.5 Lengths of Stay Wire required for Make-off

TYPES OF POLE	**SPREAD (m)**	**SINGLE OR DOUBLE STAY WIRE**
Angle (up to 45^{o})	Minimum of 2.75	Single
Angle (over 45^{o})	Minimum of 2.75	Double
Terminal	4.5 or Over	Single
Terminal	2.75 - 4.5	Double
Drop-off Side and Line Stays	4.5 Or Over	Single
Drop-off Side and Line Stays	2.75 - 4.5	Double

Table 7.6 Drop Wire Route Stay Spread

d. Stay Guards

Stay guards are provided in the following situations:

i. Where **stays** provided in footpaths may be a danger to pedestrians.

ii. Where stays provided in road side verges may be a danger to vehicles pulling off the road.

iii. In bush where heavy game animals are common.

A stay guard and the method of fitting are shown in figure 7.12.

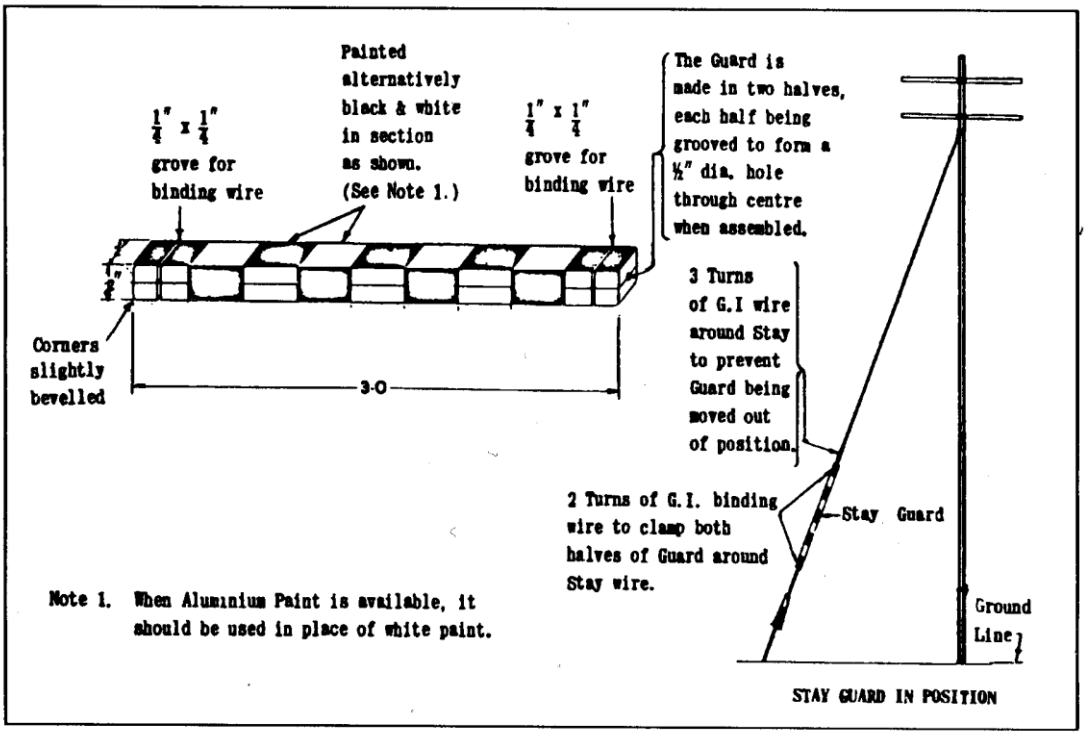


Fig. 7.12 Stay Guard

7.4.4. **Excavation of Stay Holes**

When excavating holes for fixing stays, great care must be taken to make sure that a firm anchorage will be obtained and that the stay will not move when under tension. In order that this can be done, stay holes are undercut into solid, undisturbed soil to provide a firm base for the "block or plate stay", and a narrow slot only is excavated, for the "rods stay".

The "block" or "plate stay" is buried to a depth of approximately 1370mm depending on the length of the "rods stay". "Rods stay (No 1 recommended)" which are a non-adjustable type, are used for slotted arm distribution and for light routes, must be buried so that only 230mm of the rod is above the ground.

"Rods stay Nos 2 to 5" which are adjustable types should be buried at a depth which will leave only a few tens of millimeters of the unthreaded portion of the stay rod above the ground. The depth is also determined by the spread of the stay.

The hole is undercut as shown in figure 7.13 so that the block or plate is at right angles to the direction of the stay and bears against undisturbed earth in order to provide maximum resistance to the upward pull.

A groove, as narrow as possible, is cut from the ground surface to the undercut portion of the hole, to take the stay rod at correct angle. For cutting the groove a pick is most suitable near the surface and crowbar for the deeper portion. When using a

pick, cut from the hole to the shallow end of the groove to prevent displacing soil from the side of the stay hole.

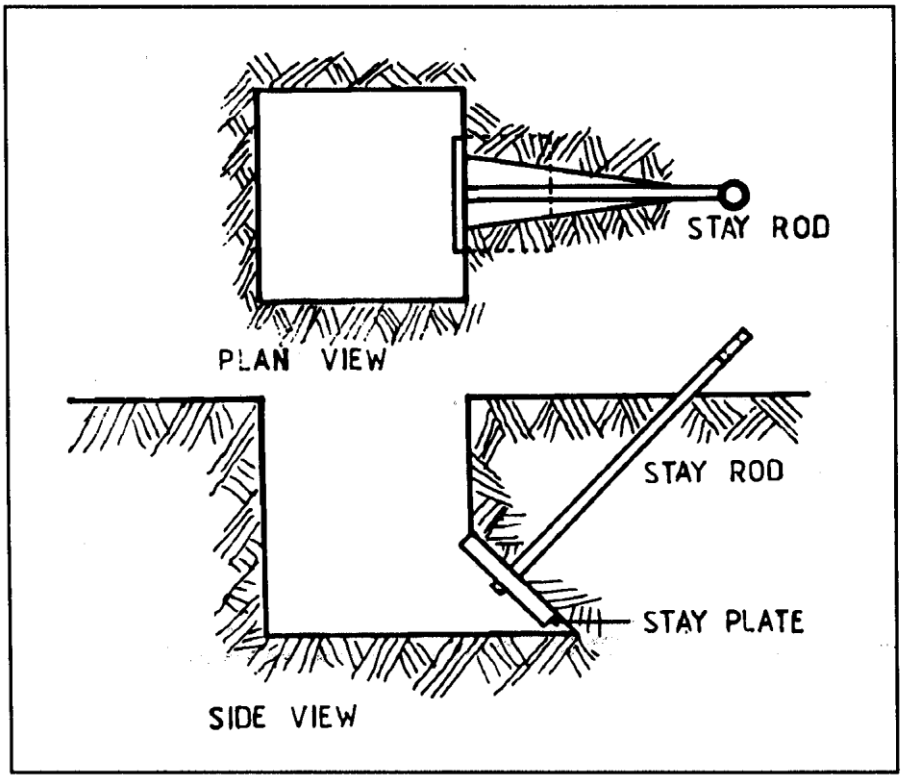


Fig. 7.13 Stay Hole

8. AERIAL CABLES

8.1. INTRODUCTION

Aerial Cables normally referred to as Cable Aerial Self Supporting Combined (CASSC) is a polythene covered cable designed for self supporting on poles. The suspension wire is incorporated in the same sheath as the cable core in a figure `8' formation.

8.2. MATERIALS, TOOLS AND EQUIPMENT

8.2.1. *Materials*

a. The materials required to suspend and clamp a self-supporting aerial cable are shown in table 8.1.

ITEM	TYPES	APPLICATIONS
1	**General Purposes**	
1.1	Washer	Accessory of machine bolt and eye bolt
1.2	Galvanized Iron Wire	Binding of cable grip and PVC cap
1.3	Adhesive PVC Tape	Wrapping cable grip and spiral sleeve etc
1.4	Cable Binding Rope	Binding of cable or splice closure
1.5	Staple	Fixing pole plate
2	**Cable Placement**	
2.1	Suspension Clamp or Hook	Clamping of suspension wire on pole having interior angle within 160^o - 180^o
2.2	Curved Suspension Clamp	Clamping of suspension wire on pole having interior angle with 120^o - 160^o
2.3	Machine Bolt and Nut	Fixing of suspension clamp and curved suspension clamp to pole
2.4	PVC Cable Cap	Sealing cable end for protection from ingress of water
2.5	Self-bonding Tape	As for 2.4 for wrapping on cable sheath
2.6	Pole plate	Fixing suspension wire on pole

Table 8.1 Materials for Aerial Cable Placement

b. Th***e*** materials required to ground and bond to and from an aerial cable and or steel strand are shown in table 8.2.

ITEM	TYPES	APPLICATIONS
1	Earth Rod	Electrode with lead wire
2	Tip Spikes	For use on earth rods
3	600V Grade PVC Insulated Wire	Bonding wire
4	PVC Adhesive Tape	Wrapping on jointing portion of bonding wires for insulation
5	Solder	Soldering for jointing wire
6	PVC Pipe	Protecting bonding wire rise up to pole
7	Staple	Fixing bonding wire on wooden pole
8	Earth Clamp	Jointing bonding wire or bonding braid to suspension wire
9	Strap	Fixing of capping steel

Table 8.2 Materials for Earthing and Bonding

c. ***The*** materials required to install a distribution point are shown in table 8.3.

ITEM	TYPES	QUANTITY
1	Arms wood No 3 or Ring Pole Head	2 1
2	Bolt, Special No 11	2
3	Poles, Wood No 8A or 10	1
4	Washer, Round No 3	4
5	Block Terminal No 41 or 42	1
6	Rod Stay	As required
7	Capping Steel	1

Table 8.3 Materials for DP

8.2.2. ***Tools and Equipment***

The tools and equipment required for suspending an aerial cable, installing grounding, bonding devices and carrying out the incidental works in addition to these works are listed in table 8.4.

NO	TOOLS	APPLICATIONS
1	**General Purposes**	
1.1	Safety Guard and Warning Signs	Warning to pedestrians and vehicles
1.2	Safety Belt and Strap	For safety of working crew
1.3	Rope	Pulling cable along pole line and other items
1.4	Side Pliers	Pressing or cutting
1.5	Ball Pin Hammer	Hammering of earth rods
1.6	Screw Driver	Tightening screw bolts
1.7	Adjustable Wrench	Tightening bolts and nuts
1.8	Knife	Cutting and peeling of sheath or others
1.9	Wire Cutter	Cutting strand wire
1.10	Thermometer	Measuring temperature of environment to determine cable pulling tension
1.11	Crowbar	Breaking the earth and guiding the pole butt into cylindrical holes
2	**Cable Placement**	
2.1	Cable Jack	Setting up cable drum
2.2	Metal Pulley No 4	Supporting temporarily and introducing cable through pole line at starting and ending
2.3	Metal Pulley No 2	Supporting temporarily and introducing cable through intermediate pole line
2.4	Cable Grip	Making grip on pulling end of cable
2.5	Swivel	Preventing cable from twisting when pulling
2.6	Unstrander	Preventing cable form twisting when pulling
2.7	Shackle	Connecting unstrander to cable grip
2.8	Shaft Drive Winch	Pulling rope
2.9	Line Wire Grip	Grasping of sheathed suspension wire on tensioning
2.10	Cable Cutter	Cutting cable
2.11	Protective Gap	Protecting the head of earth rod from deteriorating when hammering
2.12	Driving Rod	Used for driving earth rods
2.13	Dynamometer	Determines the tension force to be applied on cable
2.14	Tirfor puller	Tensioning the cable

Table 8.4 Aerial Cable Suspension Tools and Equipment

8.3. CABLE PLACEMENT

8.3.1. **Termination of Suspension Wire**

The cable suspension wire should be terminated at the following points:

a) At jointing points.
b) At angles greater than 30^{o}.
c) At power crossings.

Where a joint is not required at an angle greater than 30^{o} the suspension wire may be terminated without cutting the actual cable.

The suspension wire should be extracted from the sheathing by slicing the PVC from the top of the suspension wire by means of a sharp knife or appropriate tool, taking care to keep the blade as flat as possible to avoid damage to the galvanising. No attempt must be made to cut away the remainder of the suspension wire sheath. Immediately after freeing the first few tens of millimeters of the suspension wire the end should be bound with adhesive tape to prevent the strands springing apart.

The termination is made as shown in Figure 8.1 by passing the free end of the suspension wire twice round the pole and clamping it to the main strand.

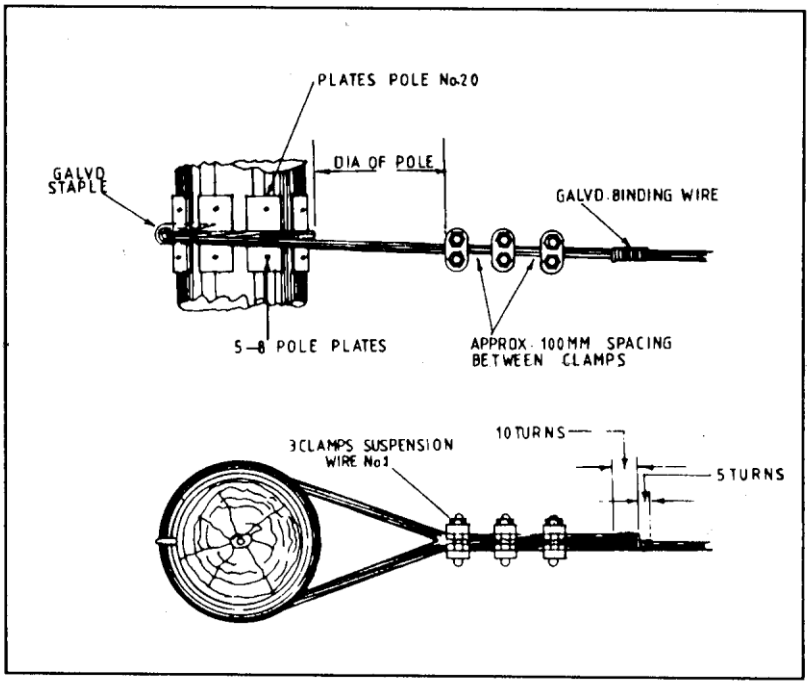


Figure 8.1 End Termination Assemblies

8.3.2. **Straight Through Positions**

This method is applicable for angles up to 6^{o}. The cable is placed on the hook and bolts special No 11 screwed as shown in figure 8.2. At intermediate terminations, the cable shall be bound to the hook using galvanised stranded wire. Clamps suspension may be used in place of hooks.

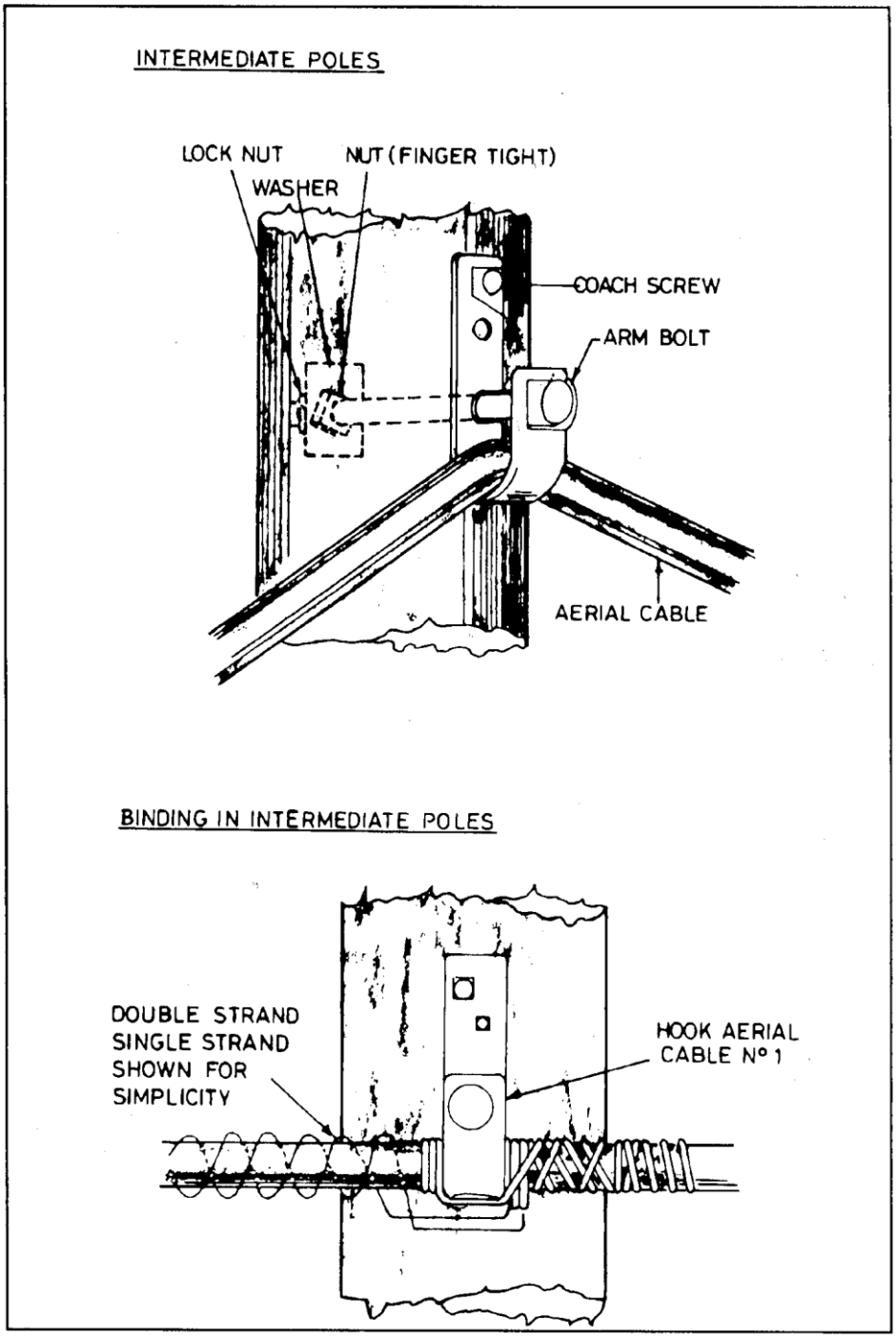


Figure 8.2 Aerial Cable Support

8.4. EARTHING SYSTEMS

The suspension wire of the aerial cable shall be electrically continuous and shall be earthed at the following points:

a) DP positions.

b) Terminal ends of the cable.

c) Regenerator positions for PCM.

d) Regular intervals along the routes in lightning prone areas.

The materials required are listed in table 8.3.

8.5. ANTI-GALLOPING PRECAUTIONS

In harsh wind conditions the aerial cable is liable to high amplitude, low frequency vibrations known as galloping or *dancing*. This is prevented by the insertion of six (6) complete twists in the cable in each span. These twists may be inserted on straight portions of the route at the bracket after tensioning and before the cable is clamped or bound in.

8.6. TENSIONING

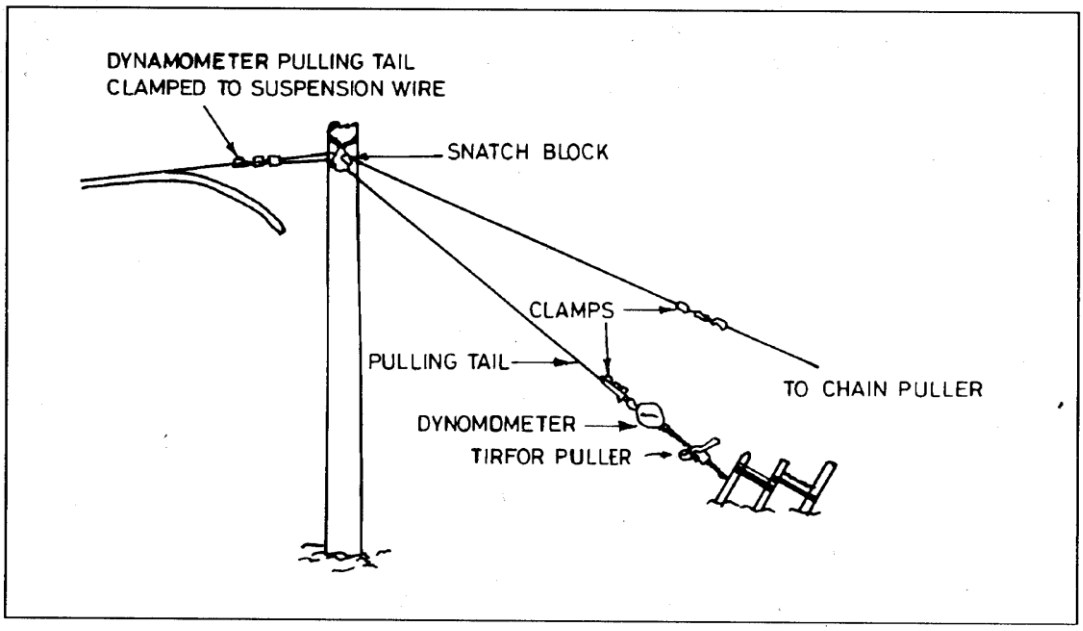
a. At the tensioning end the suspension wire is removed from the sheath and attached to a suitable pulling tail, which is in turn attached to the chain puller which is anchored to the crowbars. The chain puller is used to take up the initial slack in the cable, after which it is possible to estimate accurately the amount of suspension wire that must be removed from the sheath. The tirfor puller is then attached to the dynamometer and the dynamometer tail to the suspension wire at a point beyond where the termination clamps or grips will be fitted, and the final tensioning carried out.

   Initially a tension slightly greater than that recommended by the manufacturer should be applied and left on until the tension has equalized throughout the section. The tension may then be reduced to the specified value and the termination made.

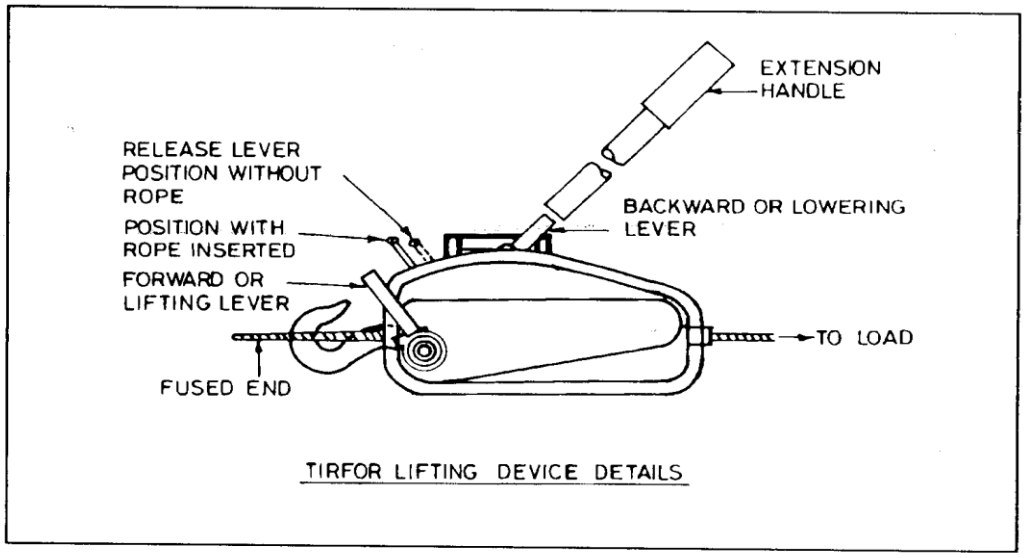
   After a section has been finally tensioned and terminated, the cable must be bound into the supports or in the case of older type fittings clamped into the brackets.

   If a number of sections are being erected then the Tirfor puller should be left in position until the chain puller has taken up the initial slack in the next section of the cable, then it should be removed and the final tensioning in that section be carried out. The cable tensioning arrangement is shown in figure 8.3.

b. It is very important that the correct method of tensioning as described in clause 8.6.a is used. The use of vehicles to tension by eye only must not be employed. This may damage the cable and cause unnecessary strain during and after erection. It will also not allow the necessary twists to be put in the cable to avoid galloping and dancing.



a)



(b)

Figure 8.3 Cable Tensioning Arrangement

8.7. CONDUCTOR JOINTING AND JOINT CLOSURES

The suspension wire is removed from the sheath for the required length of cable to make a joint. The cable is then jointed as described in clauses 5.3 and 5.4. A completed aerial cable joint position on pole is shown in figure 8.4.

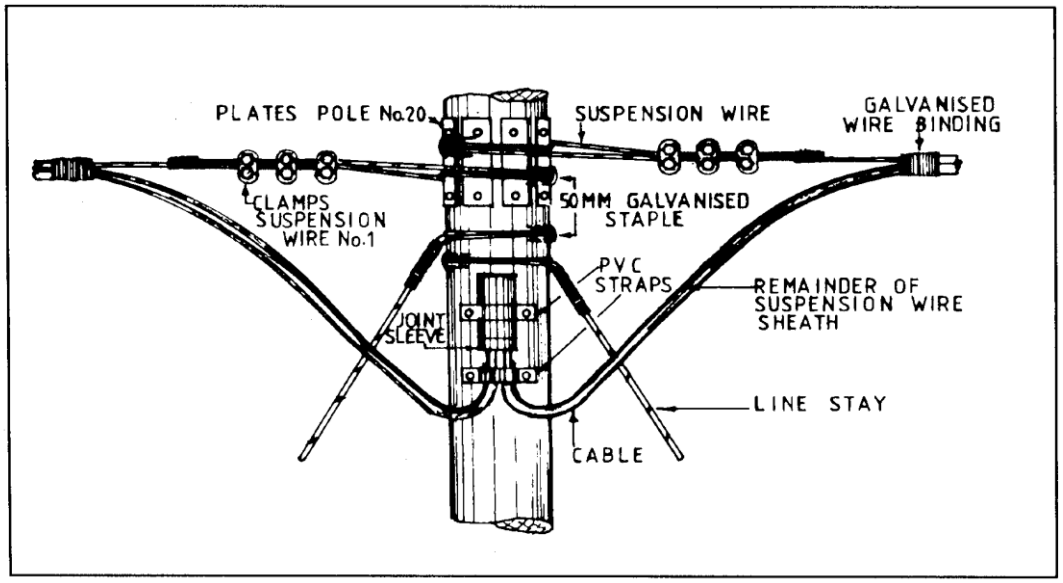


Fig 8.4 Aerial Cable Joint on Pole

8.8. COMMISSIONING TESTS

Details on commissioning tests for metallic cables are contained in clause 5.6.

9. DROP WIRE

9.1. INTRODUCTION

The drop wire is the standard aerial method of providing service to subscribers. There are two types of drop wire namely; Drop wire PVC No 1 and Drop wire PVC No 2 both of which are supplied in 1000 metre lengths on plywood reels. Two conductors are laid up in parallel and insulated with PVC to form a double "D" cross section. Drop wire PVC No 1 is made of cadmium copper conductors and has an electrical resistance of 34 ohms per 1000m of single conductor at 20^{o}C while Drop wire PVC No 2 is made of copper covered steel conductor with a resistance of 148 ohms per km of single conductor at 20^{o}C or about 300 ohms per loop km. Drop wire No 1 is only used when the transmission limits cannot be met by Drop wire No 2 and in humid areas.

9.2. DROP WIRE DISTRIBUTION

a. Distribution poles should be located so that not more than ten drop wires will e required ultimately in any one direction. They should be carefully sited so that subscribers' feeds are kept as short as possible and radiate in runs along roads and/or plot boundaries. Erection of communication poles in front of windows of houses, unless screened by trees, should be avoided. Where a spur pole will be required to reach a subscribers premises, poles should be positioned so that the feed will run along the plot boundary as shown in Figure 9.1.

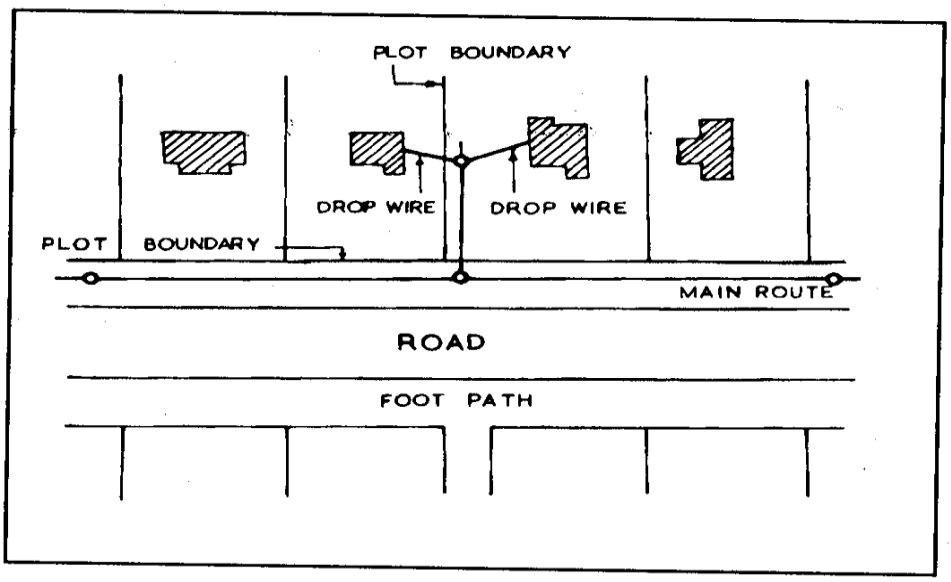


Figure 9.1 Method of Feeding Subscribers' Premises with a Spur Pole

b. Arming the Pole

Poles will be dressed with two Arms Wood No 3 as shown in Figure 9.2 At a DP pole, Arms Wood No 3 are fixed as shown in Figure 9.3.

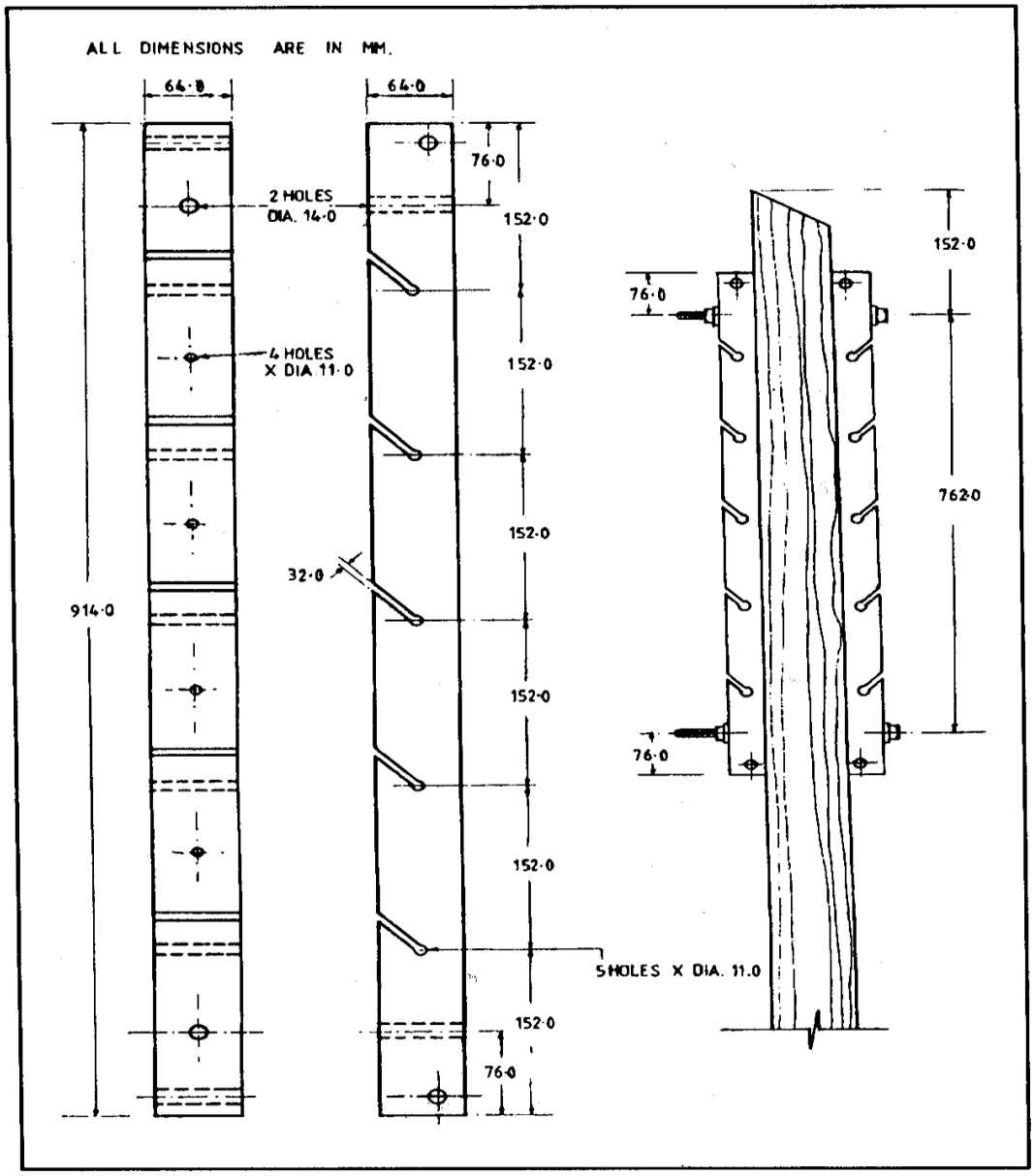


Fig 9.2 Arms Wood on a Pole

c. Drop off to subscribers from Arms wood No 3 is illustrated in Figure 9.4. Spur poles that will not carry more than four feeds ultimately will have the first pole fitted with four brackets, two on each side as shown in figure 9.5

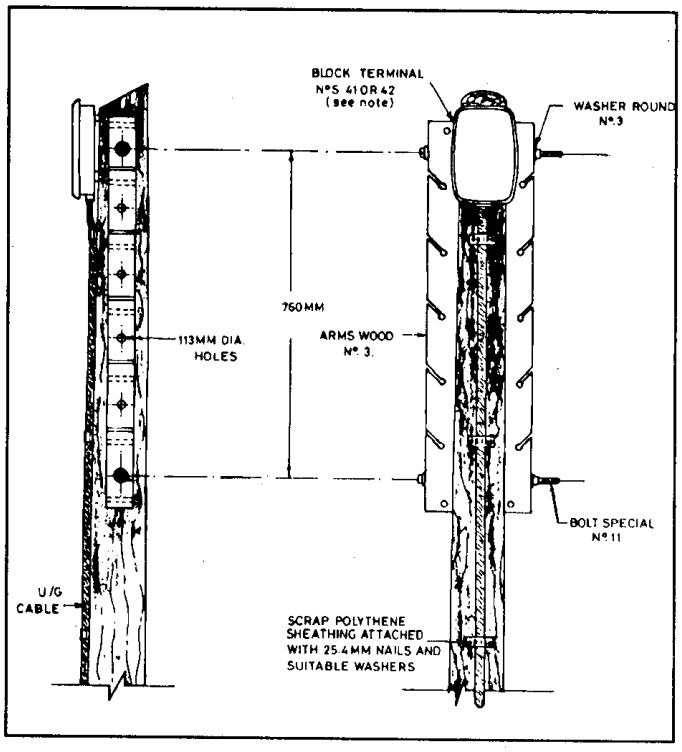
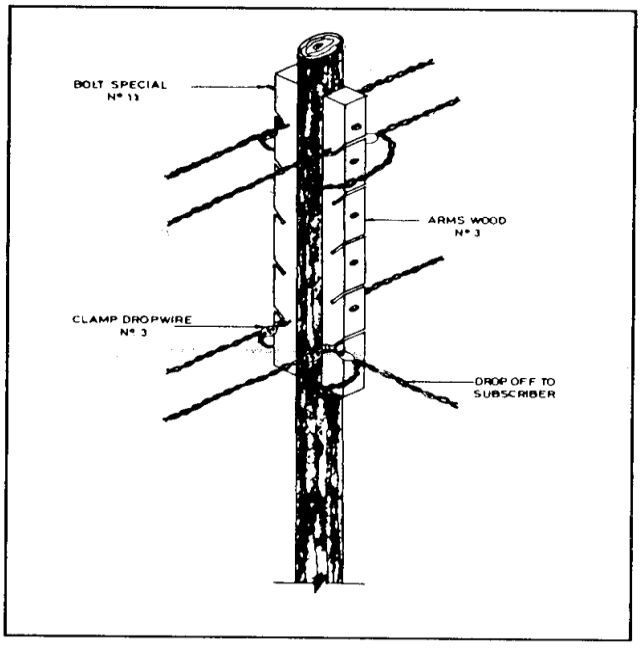


Figure 9.3 Arms Wood No 3 on a DP Pole



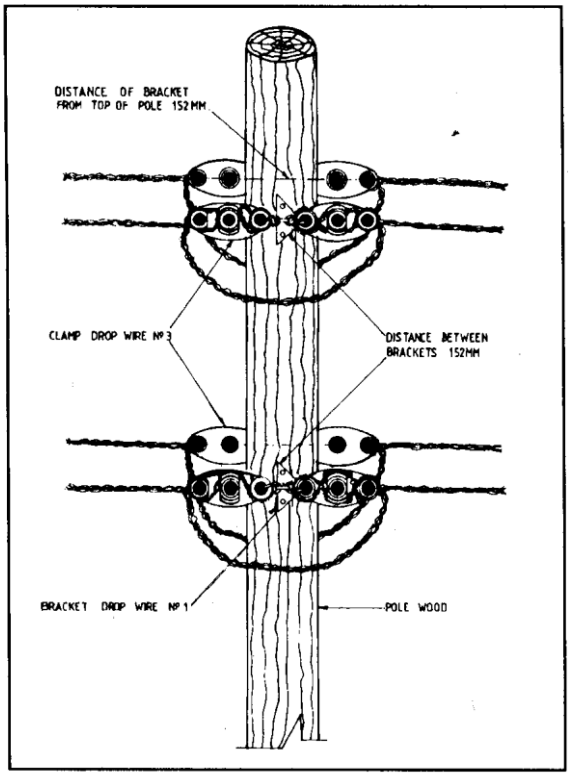


Figure 9.4 Drop off to subscribers

Figure 9.5 Brackets on spur poles

9.3. WIRING

a) Whenever possible the drop wire should be run in continuous length without joint, from the terminal block on the DP to the terminal at the subscribers premises. Wires to the farthest subscribers are run in the uppermost slots of the arm and, if there is likelihood that longer feeds will be required later, spare positions should be left.

b) Where it is absolutely necessary to make joints, they shall be made at a pole to ensure they are not exposed to mechanical strain. If in-span jointing is unavoidable, a loop shall be introduced in the drop wire on which the jointing shall be done.

c) **Drop Wire Termination**

i. The drop wire is terminated by threading through a Clamp Drop wire No 3 or equivalent care being taken not to damage the insulation and the clamp is attached to a Bolt Hook No 1/equivalent or a Bracket, Terminating No 2 or equivalent as shown in Figure 9.6.

ii. When a hook bolt is used without the terminating bracket a Washer Round No 2 or equivalent is fitted under the nut. It is important that the hook of the clamp is closed with a pair of pliers after fitting. Except where a drop off to the subscriber's premises occurs more than one clamp must not be fitted to a hook

bolt. At the point where the subscribers drop off occurs a maximum of two clamps is permitted i.e. one clamp containing the wire from the DP

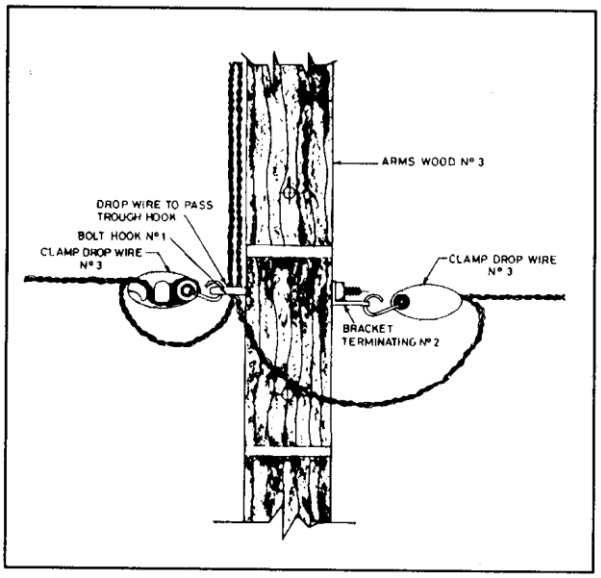


Figure 9.6 Terminating Drop Wire

and the second containing the wire feeding towards the subscribers premises. Only one clamp should be fitted to a Bracket Terminating No 2 or equivalent.

d) At DPs a terminating bracket should be provided with all hook bolts. The drop wire is fed up to the terminal block through the hook bolt as shown in Figure 9.6.

e) The drop wire should be terminated at the following positions between the DP and bracket at the subscribers premises:

i. At every fourth pole on straight runs.

ii. At the last pole before the bracket at the subscribers premises.

At every pole where Bracket Drop Wire No 1 or equivalent are used.

Terminations at the above positions should be made without cutting the drop wire, as shown in figures 9.4, 9.5, 9.6 and 9.7.

f) At intermediate poles fitted with Arms Wood No 3 the drop wire is run in the slots in the arm.

g) Where Arms Wood No 4 are used the wire is threaded through the holes in the arms. A drop off leaves the arm from a hook bolt fixed in the arm slot as illustrated in figure 9.8.

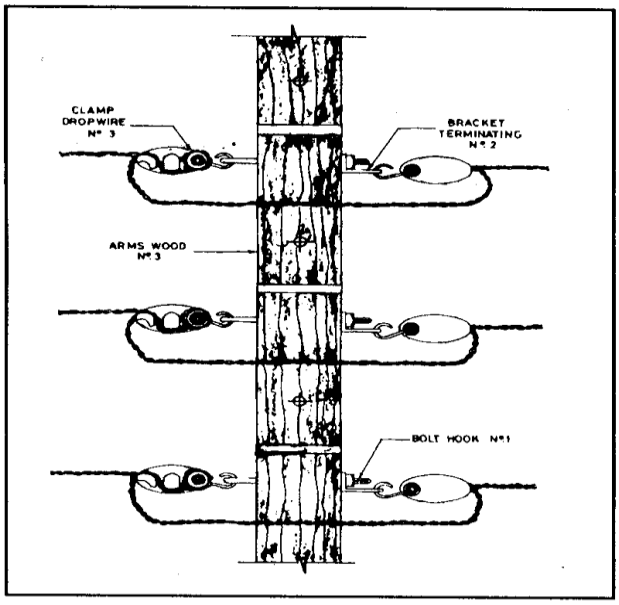


Figure 9.7 Termination on Straight Runs

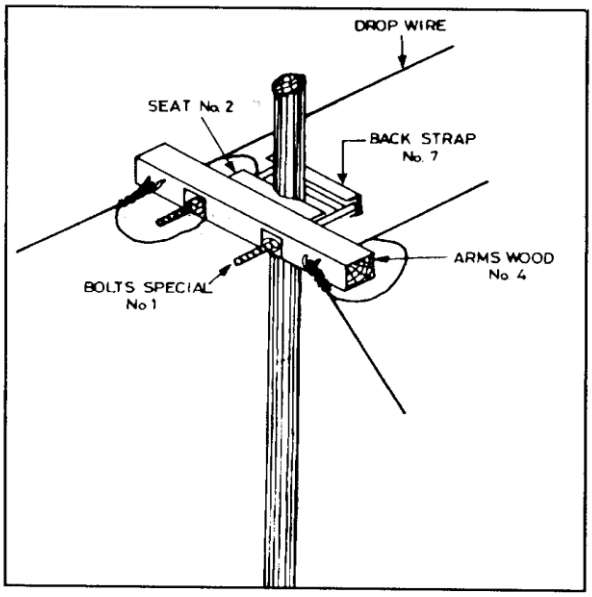


Figure 9.8 Arms Wood No 4

9.4. TENSIONING OF DROP WIRES

The drop wires are pulled up by hand to a sag of approximately 300mm for a span of 40m and 760mm for a 60m span. The hand tension required to give these sags is approximately 16 kg.

9.5. TERMINATION AT SUBSCRIBERS PREMISES

a) The last span from pole to building must not exceed 64m. The wire is terminated in a drop wire clamp attached to a wall bracket so placed that a direct pull on the fixing screws is avoided. A maximum of two clamps may be attached to one wall bracket.

b) The bracket is screwed with diagonal corners placed in a vertical plane as shown in figure 9.9. The length of the screw is determined by the dimensions and nature of the material into which it is to be screwed.

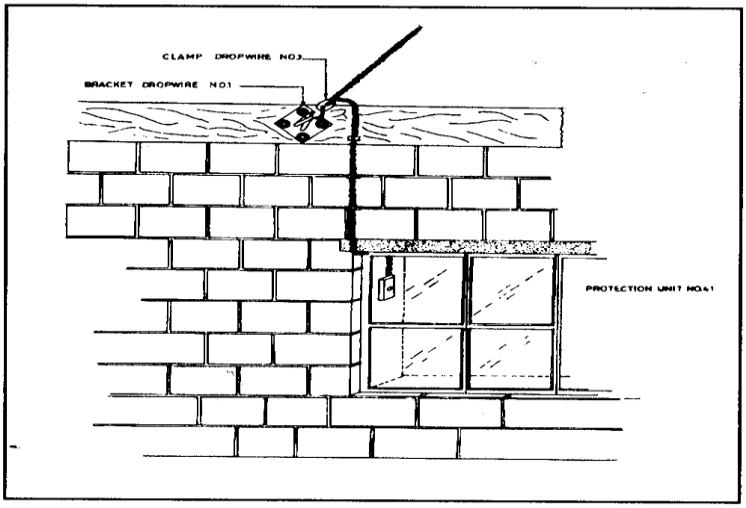


Figure 9.9 Drop Wire Termination

c) From the clamp to the Protector Unit No 41 or equivalent, the wire must be attached neatly in horizontal and or vertical directions along woodwork using Staples Insulated No 1/equivalent or on walls using Clips Wire No 1 or equivalent.

d) The drop wire shall be terminated on the protector unit (PU) No 41 or equivalent; "a" leg to A terminal and "b" leg to B terminal.

9.6. JOINTING OF DROP WIRE

Drop wire joints shall as much as possible be made at a pole to ensure they are not exposed to stresses.

10. PULSE CODE MODULATION CABLES

10.1. GENERAL

The installation methods for pulse code modulation (PCM) cables are similar to those applied in other metallic cables. This chapter will highlight only special features which apply to PCM cables.

A PCM system requires a repeater at every 2 km on the average depending on the type of cable. The design of the route shall therefore ensure that the location of the repeaters is at convenient and accessible points for maintenance.

In geographical areas subject to lightning, protectors shall be installed at the repeater housing and terminal end. If the cables are completely underground and ducted, the incidence of lightning is low and protection is not required. However, if the span includes aerial or buried cable, protection is required at the ends of each section in which all or part of cable is exposed. For the aerial cable, the repeater housing is connected to the suspension wire or armouring and earthed.

10.2. STRAIGHT LINE DIAGRAM

Before installation, a straight line diagram (SLD) shall be prepared showing the following:

Span length.

a) Location of repeaters.

b) Cable size.

c) Details of the route such as stay, type of chamber, joints and repeater.

d) All the branching points.

When determining the span length, the repeater sections should be as uniform as possible throughout the route. This can be achieved by adjusting the end sections which may be less than the 2 km length. A straight line diagram is shown in figure 2.7

10.3. HOUSING AND TAIL CABLE

The capacity of the regenerator housing will depend on the size of the cable and the anticipated maximum number of systems. Regenerator housings are either pole mounted or underground and are always fitted with a joint tail cable.

The position of the housing on the floor of the jointing chamber shall be arranged so that and are the tail cable will have an easy sweep to its appropriate duct outlet.

The anti-clockwise end of the tail cable is connected to the regenerator housing so that the clockwise end shall be jointed in at the main cable joint. It is important that the housing is kept clean to prevent the ingress of dust and grit and after every operation, the housing shall be pressurized to the specified value by the manufacturer to prevent ingress of dirt and grit. Figures 10.1 and 10.2 show an example of a repeater housing and jointing arrangement on pole and in a jointing chamber respectively.

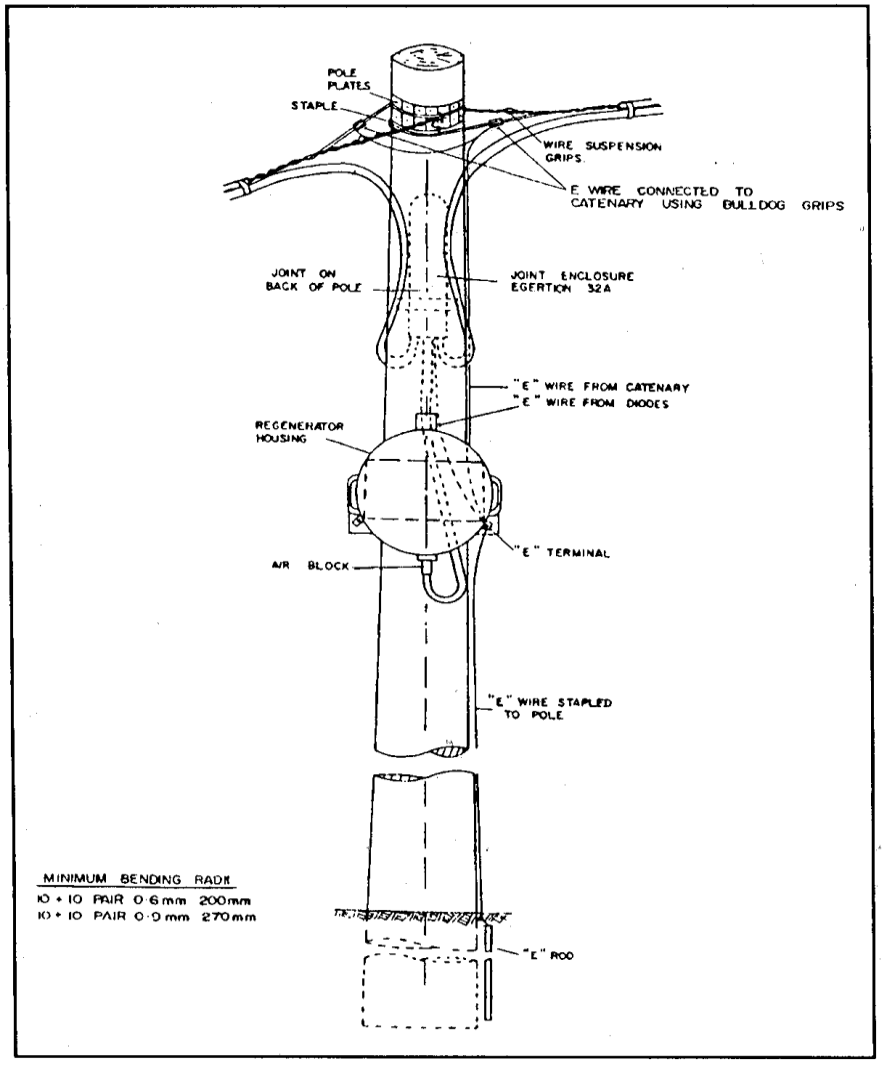


Figure 10.1 Repeater Housing on Pole

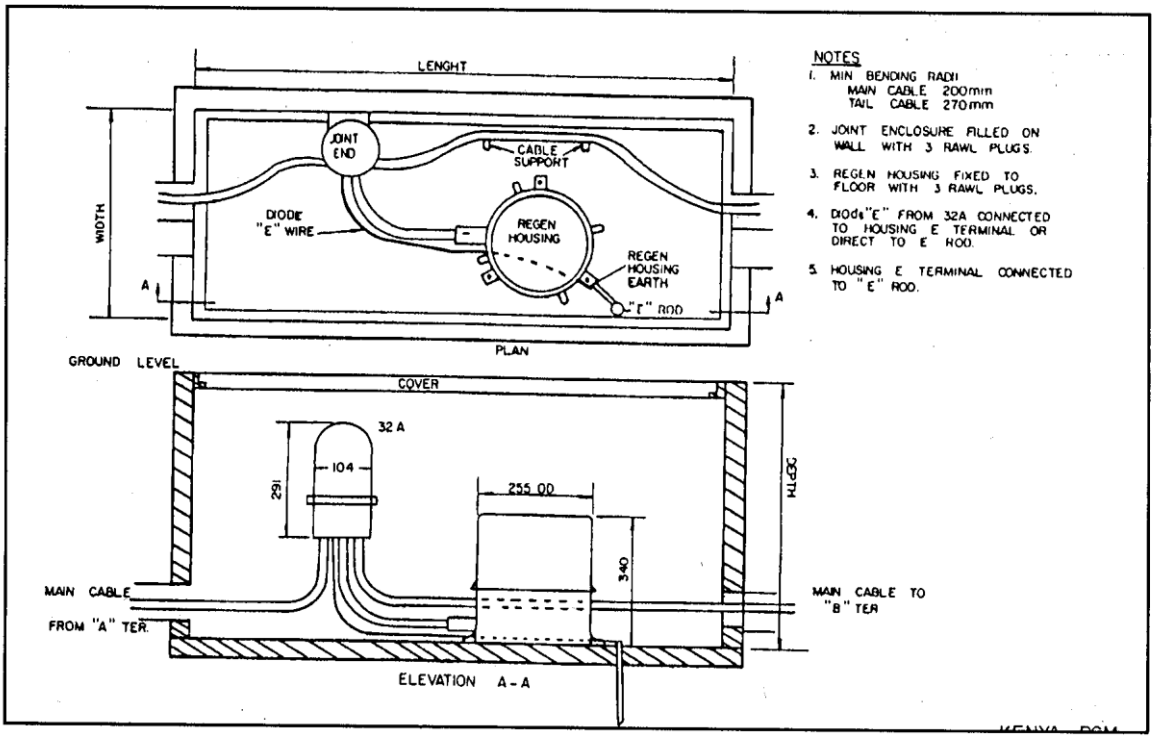


Figure 10.2 Repeater Housing in a Chamber

10.4. SPLICING

To avoid cross talk, the PCM pairs are divided into "GO" and "RETURN" and separated by a metallic screen. It is important that this separation is maintained in all the joints and the screen shall be continuous. The same jointing methods as for the audio cables are used.

All the mid-section joints shall be made first and then the cable jointed at the repeater housing tail cables and tested.

To test the whole route, dummy regenerators shall be used at the housing to establish continuity.

10.5. COMMISSIONING TESTS

The commissioning tests for PCM cables shall be carried out in accordance with clause 5.6.

11. OPTICAL FIBRE CABLES

11.1. INTRODUCTION

Optical fibre cables have become common in telecommunications for trunk, undersea and feeder routes and are now expanding into the subscriber and indoor sections of the network. They are installed in all environments e.g. aerial, duct, cable tunnels, directly buried and in premises. Thus the optical fibre cables are exposed to all of the hazards that copper cables are.

Optical fibre cable has various advantages over the conventional type. It has low loss, broad bandwidth, immunity to induction and no crosstalk. It also has lightweight and smaller diameter.

There are three types of optical fibre cable but only two of them are of practical use namely; the single-mode and multi-mode or graded index.

The single mode optical fibre is optimised for use at wavelength of 1300nm without excluding its use at 1550 nm.
The multi-mode is optimised for use at 850nm and 1300nm wavelengths.
The single mode has higher bandwidth and lower loss but more difficult to splice.
The bandwidth of the single mode is more than 10 GHz per kilometre while that of multi-mode is several hundred megahertz to several gigahertz per kilometre. However, the planning and installation methods for the two types are similar.
The transmitting medium for optical fibre cable is made of glass material unlike that one of the conventional cable which is metallic. In this chapter, special attention will be paid to areas where planning and handling methods differ as well as points, which are generally of importance.

11.2. INSTALLATION ASPECTS

The planning and installation methods for optical fibre cables are similar to the ones used for conventional cables but due to their smaller size, greater flexibility and limited weight, they will allow cable span length up to a couple of kilometres to be installed in one operation. However, optical fibre cables differ from copper cables in the following aspects:

a) The immunity against electrical disturbances allows the optical fibre cable to be installed in the vicinity of electrical power cables without requirements for any special arrangement to equalize different potentials and protection against disturbances.

b) Special precautions must be taken in order to minimize tensile and bending stresses during installation as well as after final placement of the cable.

The maximum tensile load, minimum bending radius and limitation in temperature as normally specified by the cable manufacturer shall not be exceeded because loads exceeding the cable rating can result in fibre breakage.

Fibres may fail immediately or they may fail later during the service life. External signs of damage will not necessarily be evident in either case. Thus the tensile load rating of an optical cable must not be exceeded in any phase of the application.

11.3. SELECTION OF DUCT

Special attention must be paid to the configuration of the conduit system and to the duct allocated for the optical cable in order to minimize the risk of damage.

Selection of duct pipe concerned shall be such that the optical cable is placed in a pipe at very top position and as close to the jointing chamber walls as possible as shown in figure 11.1.

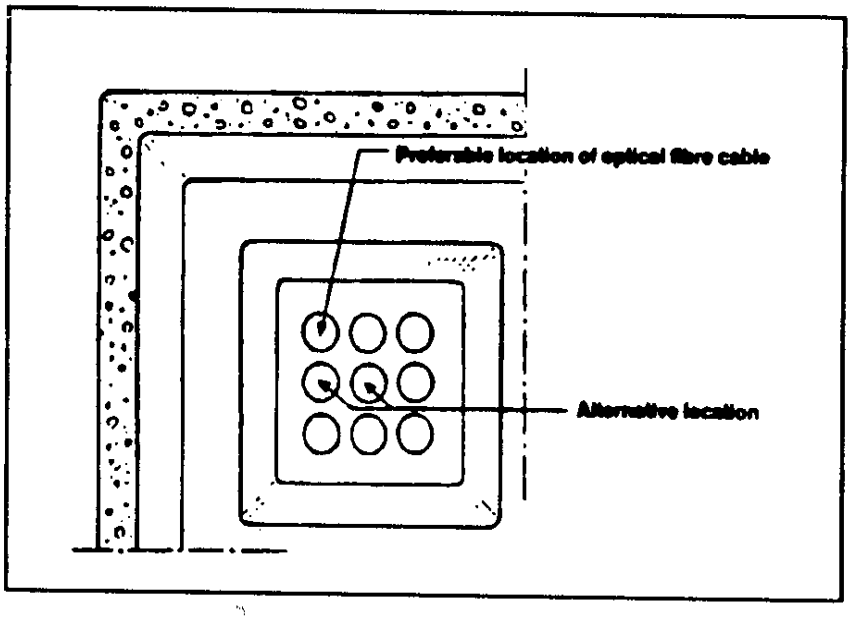


Figure 11.1 Duct Allocation for Optical Fibre Cable

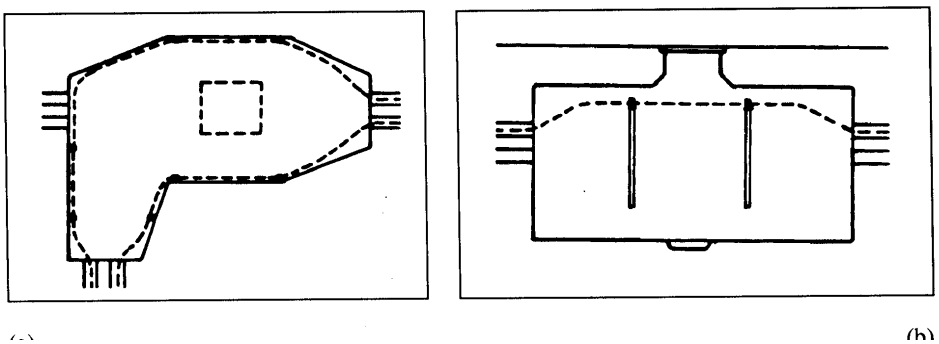
The optical cable shall be placed in the same duct pipe, if possible, along the entire length. It shall normally be installed into an empty duct. If this is not possible, the cable can be installed in ducts already occupied by existing copper cables but only for short distances.

Where the cable enters buildings, the duct to be used shall be selected in such way that crossing of other cables are avoided and that the optical cable can be given a well-protected position.

When passing through jointing chambers the cable shall be placed close to the manhole wall and at a high position so that it is protected from damage when

future splicing work has to be performed in the jointing chamber. An example of the cable routing in a jointing chamber is shown in figure 11.2

Additional cable brackets if missing should be mounted prior to the installation work and can be done when rodding and installation of draw wire is done.



(a) (b)

Figure 11.2 Cable Routing in Manholes

11.4. CABLE PROTECTION IN INTERMEDIATE CHAMBERS

At locations were a large amount of future work is expected, the cable shall be protected by use of a slitted PVC-tube, which shall be slid over the exposed length of cable inside the jointing chamber. The tube shall be securely fixed to the cable bearers with suitable cable clamps.

Self-adhesive warning labels with a printed warning should attached to the cable at all manholes in order to draw attention to the fact that it is an optical fibre cable. In order to avoid accidental damage, the cable shall be fitted with warning labels with "OPTICAL FIBRE CABLE" pre-printed in English on a self-adhesive plastic label. The labels will be attached at each location where the cable is exposed.

Optical cables, shall also be protected from lightning discharges to the line itself or to the structures that the line enters as per ITU-T recommendation K.25. The protection procedure is related to the exposure of the line to direct lightning discharges and includes the selection of cable characteristics/installation, use of shield wires, bonding/earthing of the cable shield, installation of surge protective devices (SPD) and route redundancy

11.5. LABELLING

The optical cable shall be marked in all jointing chambers by a metallic tag. The marking tag shall be made of metal tape 0.15 mm thick and 12 mm wide.

The material shall be corrosion resistant nickel-copper alloy on which cable information is embossed.

The tag with cable information shall be attached to the cable longitudinally and fixed with three plastic straps.

The printed information on the tag can be as the example below:
OFC 4 CLC ADM - LIB
That means Optical Fibre Cable containing 4 fibres, used as Computer Link Cable between Administration (ADM) and Library (LIB).

11.6. CABLES IN BUILDINGS

Optical cables used for indoor installation are normally built up in a different way than cables used for outdoor applications. Many administrations recommend that cables with flame retardant sheath material should be used indoors, in order to minimize the risk of spreading fire. The use of PVC as sheath material is presently common but halogen-free materials are now being more frequently used.

Indoor cables installed in multi-storey buildings are normally placed on cable runways or in internal conduit systems. Care must be taken when planning the cable route in order to avoid excessive crushing forces on the optical cable, especially when it is crossed by heavy electrical cables.

The cable should also be protected against damage caused by trolleys, movable tables, carts, shoes, etc, when the cable passes between different levels in the buildings. The protection must be at least 1500mm high above floor level.

The cable should also be protected at locations where damage can be expected. Warning labels shall be attached to the cable at locations where it is exposed.

In order not to exceed the maximum tensile load for the cable on long vertical runs, the cable must be clamped every meter. Recommended clamps consist of soft material so as not to damage the cable.

11.7. OPTICAL FIBRE JOINTS

11.7.1. General

An important part of any installed optical fibre cable system is the fibre joint, which can have a great influence on the transmission quality and maintenance costs. Unlike metallic splices, the transmission losses introduced by fibre splices can be a very significant factor in the design of optical fibre systems. The loss of a joint can equal the insertion loss of as much as one half to one kilometre of fibre.

11.7.2. **Characteristics of Optical Fibre Joints**

a) Optical Loss Characteristics

i. General:

Joint losses can be divided into two basic categories: extrinsic and intrinsic to the fibres for both multi-mode graded-index and single-mode fibres. Extrinsic losses are related to the techniques used to joint fibres and are caused by parameters such as transverse offset between the fibre cores and separation, axial tilt and fibre end quality. Intrinsic losses are related to the properties of fibres and caused by mismatches in fibre core and cladding diameters, circularity and concentricity of fibre mode field diameters, differences in the cutoff wavelengths of single-mode fibres and differences in the numerical aperture (NA) of multi-mode fibres. Figure 19.3 shows examples of fibre misalignments.

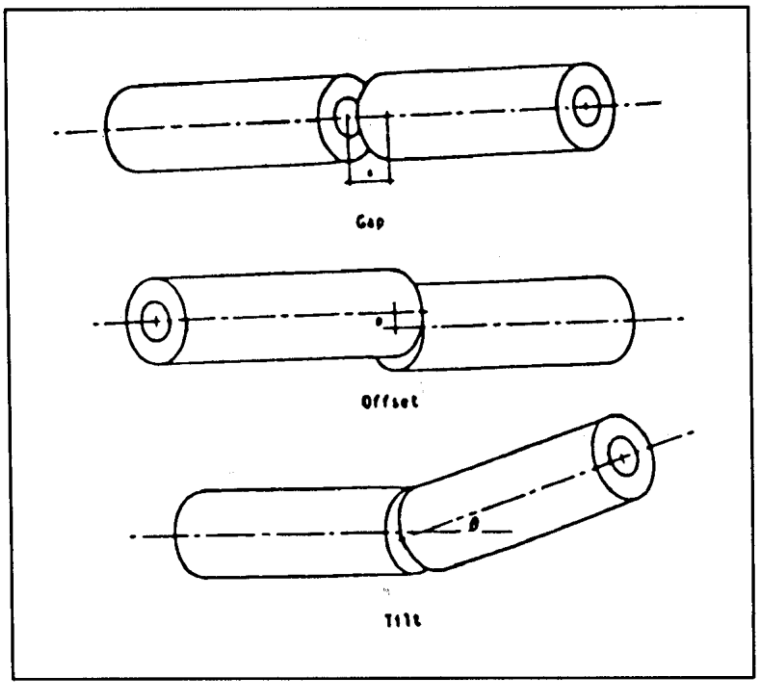


Figure 11.3 Fibre Misalignments

ii. Multi-mode fibres:

Extrinsic loss factors in multi-mode fibre joints are more sensitive to small transverse offsets and angular tilt than to end separation. For example an offset of 0.14 core radius or a 1^{o} tilt will cause approximately 0.25dB loss, while a one core radius end separation only causes approximately O.14dB loss.

Intrinsic loss factors in multi-mode graded-index fibre joints are most sensitive to mismatches in core radius and NA, and less sensitive to mismatches in profile parameters and core circularity and concentricity.

iii.Single-mode fibres:

In single-mode fibres the ***mode***-field diameter is the diameter of the radiated light and equates to the core diameter of graded-index fibres (for an exact definition see the ITU-T Recommendation G.652. Single-mode fibre joints are even more sensitive on an absolute scale than multi-mode fibre joints to mode-field diameter. This is due to the much smaller dimensions of the mode field diameter. For example, a transverse offset of 1.2μm will produce a joint loss of approximately 0.3dB for fibres conforming to ITU-T Recommendation G.652 with a mode field diameter of 8 to 10μm. Sources of transverse offset in single-mode fibres are differences in fibre diameters and core eccentricities.

The angular sensitivity of single-mode fibres is about the same as that of multi-mode fibres for small angles. Single-mode joint loss is less sensitive to small (≤10%) mismatches in mode-field diameter.

b) ***Physical characteristics***

Two basic methods for making an optical-fibre joint are:

i. **Fusion welding** –

Jointing of pre-aligned fibres by a melting process. The welding apparatus may control the core alignment or the cladding alignment. The best joint loss of single-mode fibres is achieved with core alignment. Mechanical splinting is used to strengthen the fused joint and provide environmental protection to the uncoated glass.

ii. **Mechanical –**

The jointing of fibres in which the fibre alignment is determined by the jointing components and the alignment is maintained mechanically or by adhesives. Light injection (local or far end) and detection may be used to position the jointing components to achieve lowest joint loss.

c) Design variations, features and properties are numerous within the two basic methods

The choice of method and design features depends on the balance of properties and features desired in the final installation. Three groupings of properties and features for consideration are shown below:

1. Design features, which include;

i. individual or multiple joint,

ii. integrity of the joint,

iii. joint loss and return loss values,

iv. packing density,

v. complexity of the methods,

vi. universality of installation, and

vii. installation tooling.

2. ***Installed*** properties ***which include;***

i. stability of the joint loss and return loss,

ii. mechanical ruggedness,

iii. environmental stability.

economic factors which include;

i tooling and cost of tooling,

ii. installation labour costs,

iii. cost of materials for the joint,

iv. initial and refresher training required.

11.7.3. **Fusion Joints**

a) Process

Electric arc fusion welders are used to make reliable multi-mode and single-mode fibre joints in the field. This method is used to make both single and multiple fibre joints.

During the fusion cycle the fibre ends shall be fire-cleaned (pre-fused) by the arc, then brought together and fused. It is necessary to continue feeding the fibres together during the fusion to prevent a reduced section at the weld point. These two operations shall be controlled by the welding apparatus. Finally, the joint can be proof tested to assure longevity in the field. The proof test

may be built into the fusion apparatus and be part of the normal jointing process.

The melting point of the glass is an important characteristic when jointing fibres by fusion welding. It may be necessary to tailor the fusion cycle (time and current level for both prefusion and fusion) to the type of fibres which are being joined. Further, fibres with greatly differing melting points may be difficult to fusion-weld.

b) Single Fibre Joints

1. ***Fibre preparation***:

It is necessary to remove all coatings in the region of the fibre ends. The length of the uncoated fibre varies with the jointing apparatus. The coatings may be removed using chemicals or preferably a mechanical stripping tool for operator safety. The stripping tools and procedures shall not scratch the fibre. Scratches can severely reduce fibre strength.

The bare ends of the fibre shall be cleaved cleanly and perpendicularly to the fibre axis; the end surfaces shall be mirror-like without chips or hackle. Typically, end angles shall be less than 1^{o} from perpendicular to achieve a satisfactory joint. There are a number of commercial cleaving (scoring and breaking) tools that consistently produce an end angle of less than 1^{o}. A fibre cleaving tool shall have the following characteristics:-

i. Good control of the blade pressure on the fibre surface to make a consistent-sized flaw.

ii. Assurance that the blade makes contact with the fibre.

iii. A controlled length of the bared part of the cut fibre.

iv. Controlled axial tension on the fibre.

It is preferable that the tool be simple to use and be of one continuous action. A fibre cleaver is shown in figure 11.4.

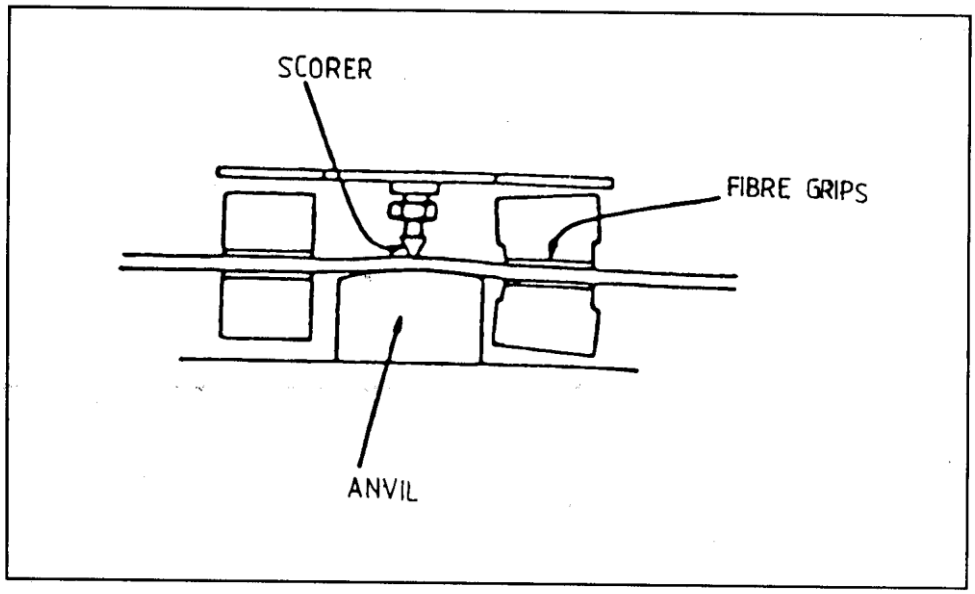


Figure 11.4 Fibre Cleaver

Figure 11.5 shows ideal cleaved fibre ends and illustrations of several cleaved fibre end defects.

2. ***Fibre alignment***:

The fibres are secured in v-grooves of x-y-z axis positioners. In a very basic apparatus the outer diameters of the bare fibre ends are aligned in v-grooves with the aid of a mirror system, which allows viewing in two perpendicular directions. This simple alignment is satisfactory for low loss multi-mode joints, but a more sophisticated apparatus may be required for low loss single-mode joints to compensate for concentricity errors between the core and cladding of the fibre.

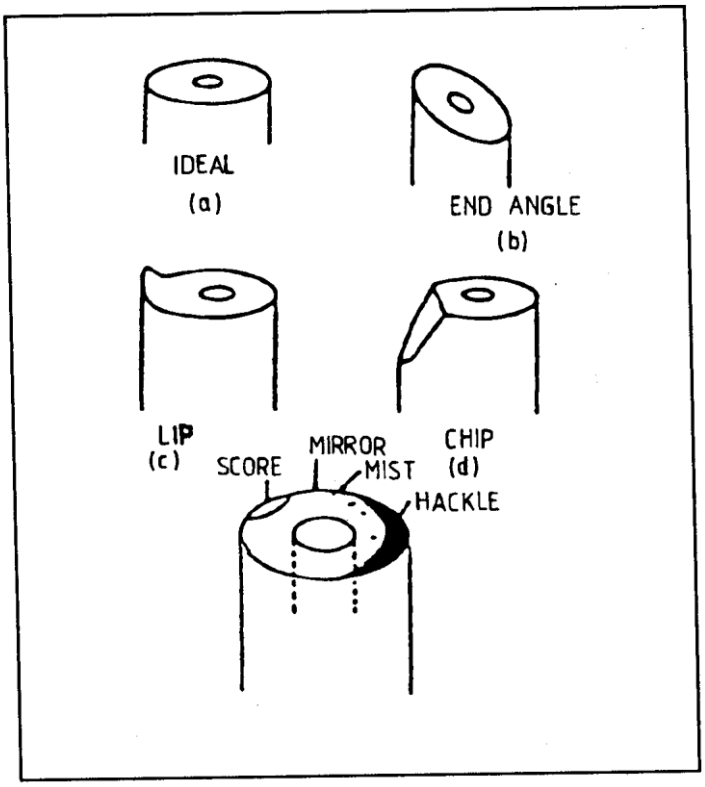


Figure 11.5 Cleaved Fibre Ends

Due to intrinsic fibre properties, the cores or mode-field diameters may not be very well aligned when the outer diameters are aligned which results in larger than minimum joint loss. Joint loss can be minimized by using active fibre core alignment. The jointing apparatus can automatically optimize the light transmitted through the joint, and consequently minimize the joint loss. The optimization may be controlled by a micro-processor. It is desirable that the apparatus gives an estimate of the joint loss.

During the fusion process surface tension and intrinsic fibre properties can cause misalignment of the fibre cores, which will increase the joint loss. Minimizing the amount of free fibre in the melt zone can minimize the fibre core misalignment in the fused joint. Alternatively, compensation programmes can control the fusion parameters and fibre positioners to minimize the shift in core alignment.

3. ***Joint Protection***

The fusion joint requires recoating of the fibre to protect it from the environment, to provide mechanical protection, and to increase the tensile strength of the bare fibre. By splinting the splice with a rod and covering the rod and joint with an adhesive lined thermoshrinkable tube, the joint can be strengthened and protected against moisture damage. Another alternative is to imbed the joint in an adhesive between two rigid parallel plates or in a small housing (case).

c) Multiple Fibre Joints

a) Multiple fibres

(These ***include*** fibre ribbons) can be jointed with mass fusion apparatus that uses the same concepts as those used to joint single fibres above. The following two key parameters shall be controlled:

i. variance suppression of the fibre end face positions by suitable clamps;
ii. the same fusion temperature for all fibres.

The fusion apparatus shall control the fusion temperature for each fibre, this can be done by offsetting the fibres at a prescribed distance from the axis of the electrodes.

Using suitable adapter clamps, single fibres can be mass fused in the same apparatus used to fuse fibre ribbons.

b) ***Fibre preparation***:

To control variance of fibre end face positions, all fibres shall be stripped and cleaved simultaneously. Chemical solvents or a heated mechanical stripping tool can be used for stripping depending on the characteristics of the coating.

c) ***Fibre alignment***:

Multiple fibres are aligned in v-grooves. Optical systems can be used to check the variance of the fibre ends and quality of the fibre cleaves. The fusion apparatus may automatically measure these parameters and compare them to prescribed limits. If an out-of-limit condition occurs, fusion shall not proceed until corrections are made.

d) ***Joint*** protection:

Mass fusion joints can be protected using the same methods as used with single fused joints in clause (11.7.3.b.3)

11.7.4. **Mechanical Joints**

a) A mechanical fibre joint has many physical embodiments but usually all include the following basic components:

i. surface for aligning mating fibre ends,

ii. a retainer to keep the fibres in alignment, and

iii. an index matching material (gel, grease, adhesive, etc.) placed between the fibre ends. Some mechanical joints are re-enterable and provide flexibility to rearrange the cable plant.

There are single fibre and multi-fibre mechanical joints. Some designs can be installed on the ends of the fibres of a cable in the factory for faster jointing in the field.

To reduce Fresnel reflections, it is necessary to use an optical matching material between the ends of mating fibres. These materials shall be chosen to match the optical properties of the glass. Common materials are silicon gels, UV-curable adhesive, epoxy resins and optical greases.

b) Adhesive ***Bonded Joints***

Adhesive bonded joints are a sub-class of mechanical joints. The fibres are aligned using the same methods as other mechanical joints. The ends of the fibres are buffed in an adhesive. The bonded joint adhesive:

i. closely matches the index of refraction of the fibres,

ii. permanently secures the fibres in the aligned position,

iii. provides strain relief and supports the joint,

iv. protects the joint from the environment,

v. provides axial tensile strength, and

vi. requires fully cured resins.

c) Fibre Preparation

It is necessary to remove the coating from a portion of the region near the fibre ends as in clause 11.7.3.b.1

Depending on the mechanical jointing method it may be necessary to cleave the ends of the fibres as in clause 11.7.3.b.1

When a fibre end is bonded in a ferrule, it is necessary to polish the end of the fibre and ferrule to produce a common surface. The Fresnel reflection from the polished ends is dependent on the quality of the end polish and the matching material used between the fibre ends. To get the lowest possible reflection it may be necessary to polish the end of the ferrule and fibre at an angle to the axis of the fibre. For example an angle of 5^0 to 10^0 has been used by Administrations. In a mechanical splice which joints bare cleaved fibres, it is possible to cleave the fibre ends with an angle of 5^o to 10^o to also significantly reduce reflections.

The ends of the fibres of a ribbon or a multi-fibre joint may be polished. The ends may also be angled to reduce reflections.

d) Fibre Alignment

V-grooves in combination with an inflexible plane surface and compliant triangular v-grooves are used to align mechanical joints. The v-grooves may be straight, curved, or result from the forming of the joint material (metal, etc.) as the joint is made.

Multigroove substrates, are used for multiple fibre joints. A joint may be constructed of a sandwich of several substrates. The number of fibres in a single joint matches the number of fibres in a sub-unit of the cable. The substrates shall have excellent geometric characteristics, be environmentally stable and stable over time.

The fibres may be bonded into a secondary component, such as a glass ferrule, for alignment and retention. The ferrules may be inserted into an alignment sleeve which permits active alignment of the fibres. Local injection and detection (LID) of light through the splice may be used to minimize the splice loss.
Prealigned components may be used to reduce joint loss without using active alignment techniques.

e) Joint Protection

Generally, the integral housing of the joint provides mechanical protection. The index matching materials used in the joint may also provide protection against moisture damage.

11.8. JOINT CLOSURES

11.8.1. Characteristics

The characteristics of a joint closure are as detailed in clause 5.4.

11.8.2. Fibre Organizers

*a. The **fibre** organizers :*

An integral parts of an optical fibre cable joint. The organizers are comprised of one or more sheets or trays that have means of holding fibre joints and fibre in an orderly manner, and shall minimize fibre strain.

b. *Characteristics*

<u>The functions of an optical fibre organiser is to:-</u>

i. provide means of storing and protecting fibre joints in a predetermined order and in relation to the sub units of an optical fibre cable, the number

of fibre joints in one organizer may vary according to the size and shape of the fibre joint and the number of fibres in a cable sub-unit,

ii. ensure a minimum fibre bend radius of 30mm so that the residual strain is ≤0.2%. The actual bend radius may be larger for some fibre designs in specific transmission systems to maintain a low loss,

iii. provide easy identification and access to any stored fibre joint for re-jointing without causing damage to any other jointed fibres or interruption of traffic, and

iv. provide means for storing the slack fibre required for jointing and for possible re-jointing in the future. The materials used for making the organiser shall be compatible with the other materials in the cable joint.

c. *Configurations*

The trays or sheets of an organizer may be configured in one of the following ways:

i. Lateral sliding from a frame - similar to removing a book from a shelf,

ii. rotation about a hinge - similar to turning a page in a book,

iii. lifting from a stack - similar to lifting a book from a stack, or

iv. unroll - similar to locationg a page on a scroll.

d. Mechanical and Environmental Characteristics

The fibre organizer shall protect the fibre and shall continue to function without mechanical damage to the fibres or fibre joints or degradation to signals carried by the fibre, when the cable joint is subjected to the mechanical and environmental conditions as discussed in clauses 5.4.3 and 5.4.4.

11.9. CABLE TERMINATION

At the end of the optical fibre link, the fibres in the cable are connected to the transmission equipment. This is done via installation cables.

A cable terminal box is used for splicing between the main line cable and the flexible fibre tails (installation cable). Normally no connectors are used in the terminal box. They would cause optical loss and Fresnel reflections. Cables with flame retardant sheath material should be used indoors in order to reduce spreading of fire. Terminal boxes should therefore be installed near the outdoor cable entrance. The box may also be used as a cable pressuring terminal.

11.10. COMMISSIONING TESTS

11.10.1. Test Items

a) Crossings between Fibres

After cable installation and jointing check the continuity of each fibre.

It is possible in a joint box to connect wrong fibres together, for instance, fibre #1 in one cable length to fibre #2 in the following length.

For transmission characteristics this has no effect. However, mixing of fibres in joints, possibly lead to a considerable inconvenience in cable fault repairing. Therefore checking through each fibre is needed.

b) Joint Loss

The purpose of this measurement is to check the optical quality (loss) of each splice. Further, these splice loss figures can be used as a reference later when monitoring and maintenance measurements will be performed. To have the exact splice loss figures for each joint, the measurement must be carried out from both cable ends. Splice loss is the average value.
Typically, an average splice loss of 0.1dB can be achieved for single-mode fibres with modern splicing equipment. Individual splice loss figures should not exceed 0.3dB.

Splice losses should be measured using the operational wave-length. Additional measurements can be made with a different wavelength to reveal possible "extra" loss in joint chambers. This "extra" loss may be caused by micro or macro bending, i.e. excessive lateral pressure on the fibre or too small bending radius.

c) Distance between Joints

For documentation and maintenance reasons, distances between joints must be measured. Most accurately this can be done during splicing work. The distance to each joint should be measured to a cut fibre end before splicing. However, with lower accuracy, distance measurements can be done after splicing.

From these measurements a jointing scheme is drawn for future use. For instance, distance to a fibre break (cable fault) is determined as relative to the nearest splice.

d) Loss and Homogeneity of Individual Cable Lengths

Loss and homogeneity of each individual cable length (factory length) measured will reveal defects which may result from poor cable construction

(cable manufacturer) or poor installation technique (installation personnel, contractor).

These measurements should be carried out using the operational wavelengths (0.85, 1.3 and 1.55µm). 1.55µm measurement is a very sensitive method to find out for instance, if stones are pressing the underground cable. This measurement is done from one end of the cable only.
Documents created from these measurements will be valuable as a reference in the future, if monitoring measurements will be done.

e) Loss of the Whole Cable Link

Loss measurement of the whole repeater section will give a general overview on the whole link. Average loss in dB/km and major loss steps and discontinuities shall be noted.
Measurement of fibre loss, end to end, is the most important measurement. It should be made at 1.3µm and 1.55µm wavelengths. As mentioned before, 1.55µm measurement is very sensitive to loss increase caused by micro and macro bending. Further, to be sure that 1.55µm region (the third window) can be utilized in the future, this measurement is a must.

11.10.2. Bandwidth or Dispersion Measurements

Bandwidth measurements are normally done for multi-mode fibre links only. Even in case of multi-mode fibres this measurement is usually neglected. In typical use, the bandwidth of a multi-mode fibre link can be calculated from the manufacturer's data. In case of single-mode fibres the bandwidth is so high that typically dispersion measurements will not be done.

12. INSPECTION STANDARDS

12.1. GENERAL

This chapter highlights on responsibility areas and standards to be adhered to during the installation and maintenance of the external telecommunications network.

12.1.1. Contractor's Responsibilities

a) Carry out all installations according to the specific laid down installation guidelines and procedures in chapters 9 – 19 of this publication and the relevant cable specifications.

b) Submit “Commencement and Completion of Works Notices ” to the Network Operator and copies to CCK. Commissioning Inspection by the Network operator should be scheduled to take place within five days but not more than 15 days after the completion notification.

c) Ensure the presence of the licensed engineer/technician during the commissioning inspection who shall sign the inspection document.

d) Rectify the defects found on the inspected works that fail to comply with certification conditions within 90 days after the issuance of "Report Of Defects On Inspected Works."

12.1.2. **Network Operator's Responsibilities**

a) On receipt of "Completion of Work Notice" the Network Operator shall arrange agree with the Contractor of the commissioning inspection date.

b) The commissioning inspection may be e carried out within a minimum of 5 days but should not exceed a maximum of 15days.

c) During commissioning inspection the inspectors shall follow the inspection procedures as described in the relevant clauses in this chapter to ensure that the installation methods and materials used conform to the specific standards and specifications.

d) Complete and issue to Contractors "Report of Defects on Completed Work" for any defective installation and "Provisional Acceptance of Completed Work" for any provisionally accepted installation work.

e) Prepare and submit Monthly summaries of all commissioned and provisionally accepted installations to CCK. CCK will organize and Coordinate certification exercises by the Certification Committee.

12.1.3. **The Commission's Responsibilities**

These are as detailed in clause 6.4 of volume 1

12.1.4. **Mark Sheets**

The Inspection Officer shall use the mark sheets as shown in the example below. Appropriate entries will be made under each column as follows:

Results: (1) Tick (√) if the facility has been provided according to specifications and requirements.

(2.) Cross (x) if the facility has not been provided according to specifications and requirements.

Signature: ***Network*** Operator's Inspection Officer and Contractor's licensed engineer or technician to sign against each requirement.

Remarks*:* (1) Amplify any relevant observations made against any requirement.

(2) Record measured values of tests carried out.

INSPECTION OFFICER'S REPORT

CLAUSE	DESCRIPTION	RESULTS	SIGNATURE N/O's Inspector	SIGNATURE Engineer/Tech	REMARKS

General Remarks .....
.....
.....
.....
.....
.....

N/W Inspection Officer: ..... Office .....
Signature ..... Date .....

Contractor: ..... Reg No .....
Engineer/Technician ..... Licence No .....
Signature ..... Date .....

12.2. STANDARDS

These are the minimum requirements which the Inspection Officer is required to check and confirm before the installation can provisionally be accepted. For each completed work, a separate E364 shall be submitted. Cabling shall not start until the duct works are completed.

12.2.1. Duct Works

The Inspector shall check and confirm that the following items conform to the installation standards and material specifications as detailed in chapter 5.

a) Type and size of ducts

b) Duct alignment

c) Duct formation and entry

d) Depth of trench

e) Clearances:

i. Road and railway

ii. Water and sewer

iii. Power

f) Jointing chambers

i. Types and sizes

ii. Iron and Steel works

1. Mill scale and rust protection

2. Cable bearers, brackets and accessories installations.

iii. Carriageway frames and covers

iv. Concrete quality and finish

v. Quality of floors and roofs

vi. Cleanliness

vii. Mandrel Test and draw wire

viii. Plugs and duct seals

g) Backfilling and ramming

12.2.2. **Cable in Ducts**

a) The MDF and the wiring accessories where applicable have been installed in accordance with clause 6.5.

b) Pair terminations have been properly laced, wrapped or inserted, or soldered and labelled as per specifications.

c) An earth protection system of zero to a maximum of 4 ohms is provided and properly terminated. Indicate exact value measured.

d) Bores are utilized starting from the bottom.

e) Cables are not blocking access to spare bores.

f) Cables are not crossing at the duct entrances.

g) Cable bending radius.

h) Cables and joints are properly supported on cable bearers.

i) Jointing chambers are clean and free from scrap wires, grease and other foreign matter.

j) Duct entrances are sealed.

k) Type of closure and quality of joints.

12.2.3. **Tests**

Random tests shall be performed on the cable pairs to confirm that the cable is free from the following faults:

a) Short circuit

b) Open circuit

c) Earth

d) Split pairs

e) Reversed pairs

f) Reversed legs

g) High resistance

h) Foreign battery

i) Contact

j) Low insulation

k) Loop resistance

l) Earth Continuity, etc

12.2.4. **Armoured Cables**

a) Cable markers

b) Depths of trench

c) Clearances

i. Road and Railway

ii. Water and sewer

iii. Power

iv. Cable and joints supports

v. Random tests as in clause 12.2.4.

12.2.5. **Aerial Routes**

a. Span length

b. Clearances

i. Road and Railway

ii. Power

c. Poles

i. Type

ii. Height

iii. Arms

iv. Brackets

d. Stays and struttings:

i. Types

ii. Spreads and Angles

iii. Make-off

e. DPs

i. Types and sizes

ii. Mounting

iii. Terminations

12.2.6. **Aerial Cables**

a) Terminations

b) Anti-galloping

c) Tensioning

d) Joint supports

e) Type of closure and joint quality

f) Random tests as in clause 12.2.4.

12.2.7. **Drop Wire**

a) Type

b) Terminations and clamps

c) Jointing

d) Distribution

i. Number of drop wires per route

ii. Radiation

iii. Length of drop wire

e) Random tests as in clause 12.2.4.

12.2.8. **PCM Cables**

In addition to the items in clause 12.2.3, the following shall also be confirmed.

a) Repeater section length

b) Regenerator Housing

i. Type and capacity

ii. Mounting on pole and placement in jointing chamber

iii. Cleanliness

iv. An earth system of 0 to 4 ohms is provided and properly terminated. Indicate exact value measured.

c) Random tests as in clause 12.2.4, etc.

12.2.9. **Optical Fibre Cables**

In addition to the items in clause 12.2.3, the following shall also be confirmed:

a) The allocated bore is exclusive and topmost

b) Protection in jointing chambers

c) Labelling

d) Tests

i. Crossings between fibres

ii. Joint losses

iii. Distances between joints

iv. Homogeneity of individual cable length

v. Loss of the whole cable link, etc.

13. MAINTENANCE

13.1. RESPONSIBILITIES

13.1.1. Wiring in Private Compound

a) Network Operators shall maintain their cable network/s from the Public Exchange up to the local MDF at the subscriber's premises. The local MDF, which shall be installed by the Contractor as part of the wiring, shall be the interfacing point between the main cable from the exchange and local cable network in the compound.

b) It shall be the responsibility of the owner of the compound to maintain the local cable network from the local MDF up to the buildings by engaging a registered Contractor.

c) Routine Maintenance
It shall be the responsibility of the compound owner to carry out routine checks on the following:

i. Aerial Networks

1. Replacement of damaged poles and correction of the leaning and fallen ones. Decaying poles are dangerous and should be detected in time by carrying out regular tests e.g. hammer, prodding or boring.

2. Damaged stay and earth wires are immediately replaced.

3. DP covers replaced, cables and drop wire sags corrected.

4. Cutting of overhanging branches over telecommunication routes.

5. On all pressurised facilities, pressure should be maintained at the manufacturer's recommended levels.

ii. Underground Networks

1. Underground facilities such as cable tunnels and plastic ducts maintained and repaired as per ITU-T recommendation L.74 and L.73

2. Ducts that have been accidentally exposed are covered to avoid damage to the cable.

3. Areas around the jointing chambers are cleared of bushes and are free of garbage dumping.

4. All damaged or stolen covers are replaced.

5. The seals or plugs are in place.

6. Jointing chambers are free from scrap, debris, earth, water, rodents, etc.

7. The cables and joints are properly supported.

After the development of an estate, the maintenance of the external cable network within the estate shall be as stipulated in clause 7.1 of Volume 1.

iii. Optical networks

Optical fiber facilities and networks shall be maintained as provided by ITU-T recommendations L.25, L.53 and L.66. The maintenance support, monitoring and testing system for optical fibre shall be as provided by ITU-T recommendations L.40 and L.68. The applicable maintenance wavelengths for fibers carrying signals will be as per ITU-T recommendation L.41

13.2. FAULT REPORTING PROCEDURES

All the procedures stipulated in clause 7.2 (Volume1) shall apply. In case of faults diagnosed in a private compound, the owner of the compound shall immediately be advised accordingly. He shall then call his contractor to clear the fault.

13.3. SECURITY

In addition to clause 7.3 (Volume 1), the owner of the compound shall be responsible for the security of jointing chambers, cables, DPs and poles within the compound.

13.4. SPARES, TOOLS AND TEST EQUIPMENT

- Contractors shall stock maintenance spare parts for the external line plant.

- The Certification Committee shall at any time without notice visit the Contractor's Workshop to confirm adequate maintenance facilities, tools and test gears are available.

13.5. TARGETS

All faults shall be cleared within 48 hours from the time they are reported. Network Operators and Maintenance Contractors shall be expected to adhere to this requirement.

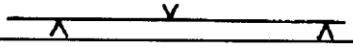
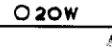
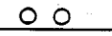
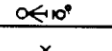
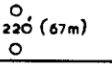
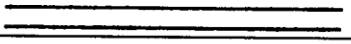
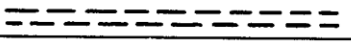
13.6. ENVIRONMENT AND WASTE MANAGEMENT

Wastes from outside plant telecommunication network shall be classified as per ITU-T Recommendation L.24. The effect of such wastes on the environment shall be minimized in accordance to ITU-T Recommendation L.45 and other environmental regulations and laws such as of NEMA

14. SYMBOLS

14.1. LINE PLANT SYMBOLS

14.1.1. Symbols For Survey Books

DESCRIPTION		SYMBOL
Embankment		
Cutting		
Fence		
Power Lines		
Bridge		
Level Crossing		
Trees		
Scrub		
Poles	Iron (Specify Type)	
	Wood (Specify Type)	
	A	
	H	
	Stay (Angle to be quoted)	
	Strut (Angle to be quoted)	
	Line Stay	
	Span Length	
	Mid Span Transposition Bracket	
Railway		
Road		
Track		
River		
Stream (Direction of flow)		
Marsh or Swamp		

14.1.2. **Cables On Duct Plan**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
Plain buried ie. not in duct	110M PLAIN	100/0.63PLAIN
On wall	17M COW.	17M.COW
Protected	55M PTD.	100/0.63 PTD.
Armoured	94M ARM.	50/0.63ARM
Subaqueous	208M.	54/09 ACROSS RIVER

14.1.3. **Cables 0n Cable Plan**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
In duct DSR prepared	10/063	10/0.63
In duct DSR not prepared (type of cable & year of provision to be indicated)	10/0.63 PCTD'60	10/0.63
Protected	100/0.63PTD.	100/0.63PTD
Armoured	100/0.63 ARM	100/0.63 ARM
Aerial	38/0.9 AC	38/0.9AC
Subaqueous	54/0.9 2MM.RAD	54/0.9
Polythene covered	50/0.63 POLY	50/0.63 POLY

14.1.4. **Jointing Points**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
Coupling, split bend or buried joint	3mm SQ 61	C.C. No.3
Buried joint box	3mm SQ 8S	
Surface joint box	3mm SQ JRF 4	JRF 4
Manhole (If congestion occurs on TTS jointing points, symbols may be reduced in size as necessary)	3mm,5mm 75 B1	75 B1

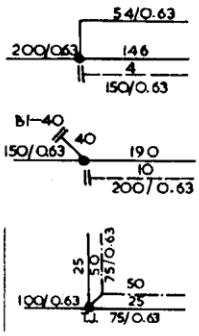
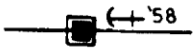
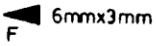
14.1.5. **Cable Joints**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
Change in type of cable	100/0.9 — 100/0.63	100/0.9 — 100/0.63
Numbered (Location to be shown)	800/0.63 — 800/0.63 NJ KASSUMS KIRK ST.	800/0.63 — 800/0.63 NJ KASSUMS KIRK ST.
Branch	54/0.63; 200/0.63 | 100/0.63; 4mm	54/0.63; 200/0.63 | 100/0.63
Flexibility points Tee joint TJ Auxiliary joint AJ Multiple tee joint MTJ	75/0.9; 100/0.63 — 75/0.63 TJ	750.9; 100/0.63 — 75/0.63 TJ
On Duct Plan	50M — 67M UCJ	
On Cable Plan	UCJ	

14.1.6. **Distribution Points**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
On pole (Protected DPs to be specified)	(7) 8mm Dia PROT (7)	(7)
Internal	(18) 8mm, 6mm Dia	(18)
External Block Wiring	107 8mm, 6mm, 5mm Dia	107
Underground	(29) 8mm Dia	(29)

14.1.7. **Distribution Of Cable Pairs**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
Pairs connected to MDF		As for existing plant
Pairs not connected to MDF		
Pairs teed		
Link pairs		
Pairs dead in joint		
Pairs dead in stub		
Examples: (a) Branch cable (b) Pairs dead in joint (c) Teed joint		
Insulating gap (Year of provision to be indicated)		
Anti creepage device (Year of provision to be indicated)		
Call point Fire F Police P Ambulance A		
Kiosk (Only shown when served by UG Distribution)		

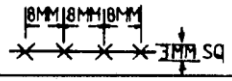
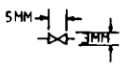
14.1.8. **Ducts**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
Line of duct	56M	56M
Duct single way		
(a) Where DSR prepared	56M / 1 / 32	SAD
(b) Where DSR not prepared Self Aligning Earthenware S.A Asbestos Cement As. C. Wrought Iron Pipe W.I Cast Iron Pipe C.I Steel Pipe Normal St. Wood Troughing W.T. Concrete C P.V.C P.V.C. Unusual dia. other than 72mm to be shown:- W.I.38mm,AsC.51mm,S.A102mm	56M '60 / SA / 32	
Duct Mult. Way		
(a) Where DSR prepared	56M / 3 / 33	3WCB
(b) Where DSR not prepared (Year of provision to be shown on duct plan with allocation of ways to Main Junction & Local. Symbols not to be filled in if duct is empty)	56M '60 / MU CL CJ SA / 33	
Subway or tunnel	32M SUBWAY	SUBWAY

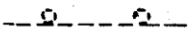
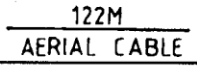
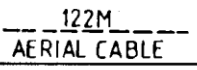
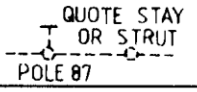
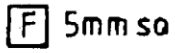
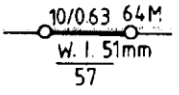
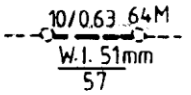
14.1.9. **Flexibility Points (Cabinet)**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
ON TTS & Duct Plan	7 5mm×3mm	7
On Cable Plan	7 Size as required	7
On Distribution Diagram (Type of cabinet, number and type of vertical to be indicated)	C.C.C. Nº1 / 2 Nº4 / 7 Size as required.	C.C.C. Nº1 / 2 Nº4 / 7

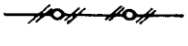
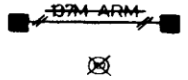
14.1.10. **Pressurised Cables**

DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
Gas seal		As for existing plant
Gas strap		
Schrader valve		
Stop valve		
Contact pressure gauge (alarm type)		
Contact pressure gauge (no alarm)		
Pressure alarm contactor		

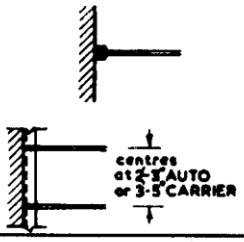
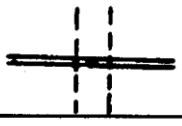
14.1.11. **Aerial Cables**

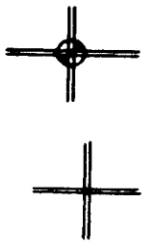
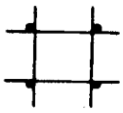
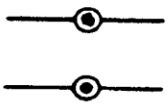
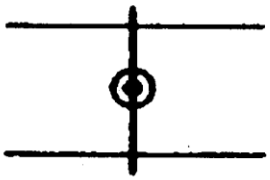
DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
On TTS		
On Duct Plan		
Stay or strut	Not shown	
Filter hut		
UG Section (on TTS only)		

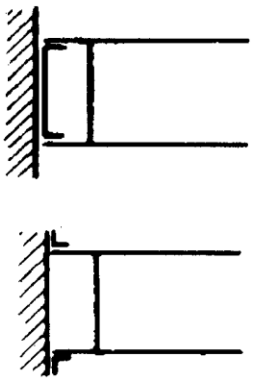
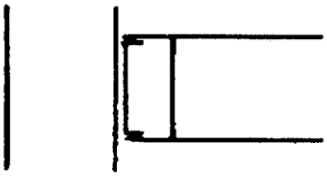
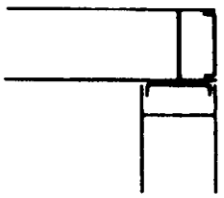
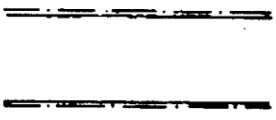
14.1.12. **Recovery Of Plant**

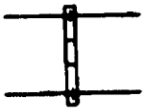
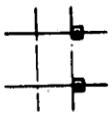
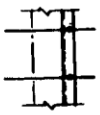
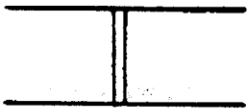
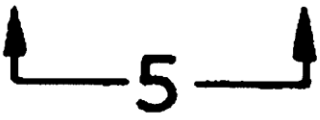
DESCRIPTION	EXISTING PLANT	PROPOSED PLANT
Examples:		
(a) recover O/H route		
(b) recover armoured cable		
(c) recover DP		

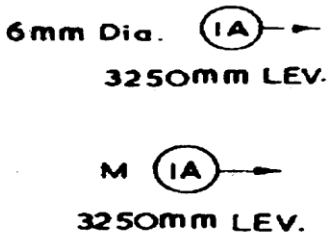
14.2. CABLE RUNWAY PLANS

DESCRIPTION	SYMBOL
Tie Bar tc wall fixing (a) With 50mm Angle Bracket (b) One continuous length of 50mmx50mmx5mm. (Angle may be used alternatively)	
Tie bar joint (one tie bar to be continuous through joint. The other bar ends to butt together at centre line of the clamp)	
Tie bar to equipment (drilled) (12mm bolt and nut with clamp)	
Tie bar to equipment (undrilled) (with hook bolt) MDF.IDF.VFDF.etc	
Tie bar floor support	
Subsidiary tie bar to rack upright (with 50mm angle bracket)	
Tie bar supported by rod from ceiling	
Tie bar supported with rod from auxiliary guides	

DESCRIPTION	SYMBOL
Tie bars supported AUX tie bars (a) with rods and clamps (b) with 12mm bolts and clamps	
Runway joint	
Runway fixed to tie bars with hook bolts	
Runway supported from runway with rods and clamps (four rods and clamps to be used whenever one runway crosses another at a different level)	
Runway supported by rods from ceiling	
Runway supported from ceiling by rod and stirrup	

DESCRIPTION	SYMBOL
Runway fixed to wall (a) runway strap (b) 40mmx40mmx5mm angle bracket alternatively	
Runway tee joint	
Runway right angle joint	
Reducing width of runway	
Runway enclosed by boxing	
Runway supported by rods from tie-bar	

DESCRIPTION	SYMBOL
Runway supported by wall brackets	
Runway fixed to dummy end bay vertical	
Runway or tie bar supported from beam (a) with angle brackets, rods and clamps (b) one continuous length of 50mmx50mmx5mm. (angle may be used alternatively)	 
Equipment below tie bar height supported with straps to tie bars	
Runway vertical drop to floor or equipment	
Cable plan section looking along runway	

DESCRIPTION	SYMBOL
Runway indicated thus: **(a) height from floor to underside of runway is indicated eg. 3250mm** **(b) 'M' indicates that the runway requires trimming to length by installer**	
Cable slats fixed to tie bars	

14.3. ELECTRICAL SYMBOLS

14.3.1. Telephone

DESCRIPTION	SYMBOL
Telephone point, public service	
Telephone board, public service	
Telephone point, internal	
Telephone board, internal	

14.3.2. Earthing

DESCRIPTION	SYMBOL
Earth (general symbol)	
Water main earth	
Tubular earth	
Strip earth	
Earth plate	
Test point for earth	
Surge diverter	

Public Address Systems

DESCRIPTION	SYMBOL
Amplifier	
Control board	
Microphone outlet	
Loud speaker outlet	

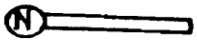
14.3.4. Radio Reception Outlets

DESCRIPTION	SYMBOL
Receiver outlet	
Loud speaker outlet	
Aerial	

14.3.5. Bells
14.3.6. Fire Alarms

DESCRIPTION	SYMBOL
Fire alarm push	
Automatic contact	
Bell connected to fire alarm	
Fire alarm indicator (At N insert number of ways)	
Relay **Note:** **This general symbol is applicable to any system by the addition of an identifying symbol (appropriate to a particular system) in the upper half, eg.** **Bell system relay** **Where items of apparatus are combined, the symbols may be combined eg.** **Indicator and bell (At N insert number of ways)**	  
Bell transformer (May be used for any special L.V. purposes)	

14.3.7. **Fixed Heating Outlets**

DESCRIPTION	SYMBOL
Tubular Heater Notes: 1. Length to be to scale and also to be given in schedule 2. The circle represents the position of connection to the fixed wiring 3. At N insert number of tubes in bank.	
Fixed radiator or heating panel (Details of equipment to be given in schedule)	
Convection heater	
Electric unit heater	
Immersion heater	
Thermostat	
Immersion heater with incorporated thermostat	
Self contained electric water heater	
Humidistat	

14.3.8. **Clocks**

14.3.9. **Control Gear And Distribution Fuse Board**

DESCRIPTION	SYMBOL
Main control	
Main switch	
Change over switch	
Switchboard, distribution board or fuseboard	
Contactor	
Meter	

14.3.10. **Lighting Outlets**

DESCRIPTION	SYMBOL
Ceiling outlet lighting, filament lamp	
Wall outlet lighting, filament lamp	
Ceiling outlet for discharge lamp (When it is intended to use a tubular or other discharge lamp, reference should be made in the drawing or schedule to the exact location of the outlet in relation to lamp position and also to the position of the ancillary apparatus)	
Choke (when installed remote from lamp unit)	
Power factor capacitor (when installed remote from lamp unit)	
Lighting outlet connected to an emergency system	
Exit box with wiring for normal and emergency system	
Street lighting standard	
Ceiling outlet for filament lamps with wiring connected to normal and emergency systems	
Ceiling outlet with wiring for filament and discharge lamps	
Ceiling outlet with wiring for discharge lamp connected to normal system, plus wiring for filament lamp connected to emergency system	

14.3.11. **Switch Outlets**

DESCRIPTION	SYMBOL
General symbol for local switch when considered applicable	
1-way switch	
2-way switch	
Intermediate switch	
Pendant switch	
Pull switch	
Note: Combinations of the above outlets and switch symbols may be used if required. Example: Wall outlet and local switch	

14.3.12. **Socket Outlets**

DESCRIPTION	SYMBOL
Push	
Multi push (figure indicates number of ways)	
Pilot or corridor lamp position	
Indicator (Buzzer may be added if required. At N insert number of ways)	
Relay (see note on clause 25.3.5)	
Reset position	

14.3.13. **Luminous Signal Systems**

DESCRIPTION	SYMBOL	
		Alternative
Socket outlet		
Switch socket outlet		
A reference may be given against the symbol thus: Current carrying capacity reference as required		

14.3.14. **Fixed Apparatus Outlets**

DESCRIPTION	SYMBOL
Fixed point (requirement unspecified, characteristics to be given in drawing or schedule)	
Outlet for motor to fixed fan	
Outlet for motor to ceiling fan	
Fan regulator	
Cooker control unit	

14.3.15. **Special Purpose Signal Outlets**

DESCRIPTION	SYMBOL
Special purpose push	
Special purpose indicator	
Special purpose bell	
Horn or hooter	
Siren	

14.4. GAS SYMBOLS

DESCRIPTION	SYMBOL
Gas point	
Plug in point	
Gas meter	
Gas governor	
Change of pipe size	
Gas cock	
Gas valve	
Gas water heater	

15. SAFETY

15.1. CAUTION

It is hereby emphasized that the information contained herein is by no means exhaustive and is only meant to introduce the subject. It is highly recommended that vendors and contractors should have as many staff as possible professionally trained on safety precautions and first aid.

15.2. INTRODUCTION

Accidents do not just happen they are caused. Almost all accidents are due to carelessness, negligence and want of reasonable precaution by someone. Always use care and common sense.

15.3. MANUAL HANDLING AND LIFTING

15.3.1. Introduction

One industrial accident in three occurs when lifting, lowering, pushing or pulling heavy objects. In many cases the causes of these accidents are due to the lack of knowledge on the correct method of lifting. It is therefore necessary to develop correct lifting techniques to avoid injury.

Strained back muscles slipped or ruptured spinal discs, hernia and other painful injuries result from use of in- correct methods.

15.3.2. Basic principles

a. Position your feet correctly for balance.

b. Maintain a straight back.

c. Keep your head erect and your chin in.

d. Obtain a proper hold on the object.

e. Keep your arms close to your body.

f. Make the maximum use of your powerful leg muscles.

g. Use your body weight.

15.4. ROAD WORKS GUARDING

15.4.1. Introduction

The safety of staff employed on highways and the general public is a matter of the utmost importance. To this end safety equipment shall always be used and in the prescribed manner.

15.4.2. General Principles

The aim of all signs erected on the highways is to give drivers concise and clear information for their guidance and safety. This is particularly true of signs at temporary obstructions where the safety of those working on the road is also dependant on drivers having clear warning in sufficient time to enable them to pass safely. It is therefore necessary to have all warning signs sited sensibly.

15.4.3. Where Guarding is Unnecessary

Whenever a working party can operate from their vehicle while the vehicle is parked at the kerbside in a road where parking is allowed, then no special roadwork guarding is necessary. Only signing to indicate the presence of the vehicle is required.

15.4.4. Where Guarding is Necessary

If it is necessary to park a vehicle for more than 30 minutes at a distance out from the kerb towards the centre of the road or in a street where parking is not permitted, then the vehicle should be guarded as a road obstruction.

Where it is necessary to open either a footway or carriageway jointing chamber, then it shall be considered as a road obstruction.

15.5. UNDERGROUND WORKS

15.5.1. Public Safety

The contractor shall properly fence, watch and light all excavations, openings, obstructions and any portions of thoroughfares which have been disturbed to ensure the safety of pedestrians and vehicles until they are permanently reinstated.

15.5.2. Jointing Chambers

Only the proper keys for raising covers shall be used. Worn out or damaged keys shall not be used. Never put fingers under partly raised covers and a footway cover may be grasped with the hands but only after being firmly supported in a partly raised position by a suitable support.

Protect members of the public against falling into open chambers by fixing guards before lifting covers.

15.5.3. Gas Equipment

a) Precautions

i. The cylinder must not be lifted by holding the regulator.

ii. The cylinder must not be taken into a jointing chamber.

iii. Whenever the flame of a gas appliance is accidentally extinguished or goes out for any reason while being used in a jointing chamber, no attempt must be made to relight it without first carrying out tests for gases, particularly at the floor level in the area around the gas appliance. The appliance may be relit only if these tests are negative.

i. All taps on the equipment must be turned off before the equipment is stored after use.

iv. The equipment should be regularly inspected for damage or wear.

v. Hose clips must be used to secure hoses to the equipment.

vi. Cylinders shall be kept away from heat and shielded from the direct rays of the sun.

vii. Appliances whether extinguished or not, must never be left unattended in a jointing chamber and those not in use must be taken out of the chamber.

b) Method of Use

i. Torches for use in jointing chambers must be lit in the open air.

ii. It will be found that apparatus will light more readily when the escape of gas is only just audible.

iii. When the work is finished, the flame must be extinguished by turning off the gas at the apparatus end. Cylinder valve must be turned off.

c) Emergency Action

i. *Detection of Leaking Cylinder*

Turn off the cylinder valve. If the leak cannot be stopped, the cylinder must be removed to an open space clear of all buildings and people.

The leaking cylinder must be kept with the leak uppermost and as far as possible from drains and any sources of ignition.

ii. Action in the case of Fire

If possible turn off the cylinder valve, using an asbestos blanket or thick clothing to deflect the flame if necessary.

If the fire cannot be extinguished in this way evacuate the area to a distance of 50m if possible and summon the fire brigade and police.

15.5.4. Explosive and Asphyxiating Gases

a) Explosive

Propane may leak from Gas Plumbing equipment. Petrol may leak from underground storage tanks at filling stations.

b) Asphyxiating and Foul Gases

Oxygen deficiency may arise from decaying vegetation. Carbon Dioxide may arise from this source or it may have been left in the plant by other working parties, during desiccating operations.

15.6. AERIAL WORKS

15.6.1. Care of the Eyes

a) Eye injuries are very prevalent on this work and eye-shields should be used whenever there is **any** risk of a foreign matter entering the eye.

b) Before handling wet treated poles, the appropriate gloves must be worn.

c) When painting or scraping poles, eye-shields should be worn, and one should work with the back to the wind. Eyes should not be wiped or touched with fingers when handling bituminous paint.

15.6.2. Handling Poles

a) When transporting poles make sure they are tied to the lorry.

b) During loading, lower each pole gently to the ground by lowering from shoulder to arm level first, then tip to the ground and lower rest gently.

c) Fix guy lines to steady pole during erection or recovery. Do not use light ladders for poling. Always use stout ladders. Do not disturb foundations around the pole while men are working aloft.

d) Test the pole and make sure it is safe before climbing. Provide additional stays if necessary before increasing load on poles.

e) Stack poles in groups and wire them securely if need arise for them to be stored.

15.6.3. Digging of Holes

a) Use warning signs and flags to warn traffic or pedestrians if any obstruction is caused.

b) Special care should be taken when digging in the vicinity of power cables and conduits. Leave protective tiles over power cables.

c) Watch for flying particles when excavating a with road breaker.

d) All excavations should be guarded, especially in towns and suburbs.

e) Do not dig too close to foundations of walls and buildings.

f) Do not interfere with free passage of pedestrians

15.6.4. Ladders

a) Rest ladders again**st** strong and rigid support like poles and not on wires, or tree branches.

b) Two persons should not work on a ladder unless absolutely necessary.

c) The top of the ladder should be securely lashed if erected against an aerial suspension strand. Two ropes should be pass over the strand and secured one to each stile. Other ends of the ropes to be securely held or fastened where one man is footing the ladder.

d) Ladders with wire reinforcement on the stiles should always be used with the wire on the underside, to keep it in tension.

e) Borrowed ladders or steps should always be examined first. ***If unsafe do not use!***

f) Do not leave tools on the treads of steps, they may fall or cause injury. If good foothold is not obtainable and in busy streets have a man at foot, until ladder is securely fastened at the top. If no man is available, fasten at bottom first.

15.6.5. Safety Belt

a) Fasten belt to a firm support, not to wall brackets, spikes, window frames, old chimneys or other fixtures liable to give way.

b) Use both safety slides, to prevent belt slipping in case buckles or stitches break.

c) Take care of your belt, dress it monthly with a leather dressing. Store carefully away from acids and inspect it regularly and always before use.

d) Reject if leather is badly cracked or stitches broken.

e) Always use safety belt when working aloft.

15.6.6. Wiring

a) Display red flags and caution signs, whenever operations may interfere with the free use of the road. Do not interfere with pedestrians.

b) Avoid working single handed across roads, make work safe, and obtain assistance.

c) Get firm foothold aloft to free hands where possible.

d) Use a sash line for passing tools to or from working positions, do not intentionally drop or throw tool from any position and keep tools in a basket.

e) See that there is no danger of sash line being caught by passing traffic especially in windy weather. Do not remain aloft or handle wire during thunderstorm.

f) Hold wire when cutting, to prevent ends springing towards you.

g) Turn back ends of cut wires and coils to prevent injuries.

h) Work from safe side of wires at angle poles and avoid injury to the eyes, from wire dust, keep your back to the wind. Use emery cloth to clean wires never use a knife. Always wear eye-shields when cleaning wires, handling spring wires and on any occasion where there is danger of a foreign body entering the eye.

i) Reduce tension gradually when recovering cables and wires. Lower by means of a sash line if liable to cause injury or damage.

j) Stand clear of men working aloft, to avoid accidents likely to be caused by falling tools or solder.

k) Employ flagmen as additional precaution when working across busy roads, two flagmen may be required at bends or junctions.

15.6.7. Near Power Plant

a) Keep yourself and all cable wires, ropes, etc. clear of all low Medium and High Voltage (HV) lines and plant.

b) Do not touch or allow wires to come into contact with cradle guard under a HV line. Never run telecommunications cables and wires above a HV line or other HV equipment.

15.6.8. Neon Signs

a) Have power disconnected before working near a neon sign.

b) Treat insulated power wires as bare wires.

c) Wear rubber gloves when handling wires and wet ropes etc. which might make contact with a power circuit and see that the gloves are in good condition and dry. Rubber gloves are no protection against HV.

15.6.9. Fires

Whenever it is necessary to light a fire, clear off dry grass and other inflammable materials. On completion of work, wet all embers or cover with soil.

15.6.10. Vehicles

Do not enter or alight from a vehicle in motion. Do not sit on the tail-board or side of a lorry. When in motion, all passengers must be seated. If no seats then on the floor.

15.7. RADIO FREQUENCY SAFETY REQUIREMENTS

The radio equipment installation shall be carried out in consideration to human and equipment safety measures. In this regard, the following ITU-T recommendations shall be observed to ensure all kinds of safety requirements:

ITU-T Recommendation K.70 Mitigation techniques to limit human exposure to EMFs in the vicinity of radio communication stations

ITU-T Recommendation K.52, Guidance on complying with limits for human exposure to electromagnetic fields, Geneva, 2004

ITU-T Recommendation K.61, Guidance to measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations, Geneva, 2003.

ITU-T Recommendation K.21 (2003), Resistibility of telecommunication equipment installed in customer premises to over voltages and over currents

ITU-T Recommendation K.47 (2000), Protection of telecommunication lines using metallic conductors against direct lightning discharges.

[ITU-T K.56] ITU-T Recommendation K.56 (2003), Protection of radio base stations against lightning discharges.

[ITU-T K.66] ITU-T Recommendation K.66 (2004), Protection of customer premises from overvoltages.

15.8. FIRST AID

15.8.1. Introduction

First Aid is the skill application of accepted principles of treatment on the occurrence of an accident or in the case of sudden illness, using facilities or materials available at the time. It is the approved method of treating a casualty until he is placed, if necessary, in the care of a doctor or removed to hospital.

Because of the increasing number and serious nature of accidents of all kinds, the responsibility of the First Aider has become greater. First Aid is the treatment given to a casualty to sustain life, prevent the condition becoming worse and promote recovery.

15.8.2. Responsibility of a First Aider

a) ***To*** assess ***the casualty's situation***.

i. Be calm, take charge.

ii. Give confidence to the conscious casualty.

iii. Talk to him, listen to him and reassure him.

iv. Check the breathing, for bleeding and whether conscious.

v. Check safety of casualty and of yourself.

vi. Tell them what they should do.

vii. If necessary, send for ambulance, police, fire service or other help.

b) To arrive at a diagnosis for each casualty

The history of the incident must be taken into consideration and an examination made to determine the signs and symptoms and level of consciousness.

i. History

The story of how the accident happened obtained from the casualty, "I fell off the pole or a work-mate, “I saw him fall and his head struck the ground".

ii. Signs

Variations from normal, ascertained by the first aider.

iii. Symptoms

Described by the casualty, "I feel pain", “I am cold" "my arm is numb".

iv. Level of consciousness

Any change of level is important.

v. Full consciousness

Able to speak and answer questions normally.

vi. Stupor

Can be roused with difficulty, the casualty is aware of painful stimuli, e.g. a pin prick but not aware of being spoken to etc.

vii. Coma

Cannot be roused by any stimuli.

c) *Action*

To give immediate and adequate treatment, bearing in mind that a casualty may have more than one injury and that some casualties will require more urgent attention than others

i. If the cause of the condition is still active, remove it e.g.

1. a telephone pole on the casualty's leg,
2. contaminated clothing.

ii. Remove the casualty from the cause e.g.

1. traffic,
2. fire,
3. water,
4. poisonous fumes.

iii. Give the treatment you consider essential

iv. Sustain life

1. emergency resuscitation,
2. control bleeding and shock,
3. prevent the condition becoming worse,

4. cover wounds and burns with dry and clean dressings,

5. keep the casualty warm by using clothes below as well as above,

6. place the casualty in a correct and comfortable position.

d) To arrange to put the casualty in the right disposition according to the seriousness of the condition.

15.8.3. Essentials of First Aid

a) Act quickly, quietly and methodically giving priority to the most urgent conditions.

b) Ensure that there is no further danger to the casualty or to you.

c) If breathing has stopped or is failing, clear the airway and start resuscitation.

d) Control bleeding.

e) Determine the level of consciousness.

f) Consider the possibility of poisoning.

g) Give reassurance if necessary to the casualty and to those around to help lessen anxiety.

h) Guard against shock.

i) Position the casualty correctly.

j) Before moving the casualty immobilise fractures and large wounds.

k) Arrange the careful conveyance of the casualty to the care of a doctor or to the nearest hospital.

l) Do not attempt too much.

m) Do not allow people to crowd round; this hinders first aid and may cause anxiety or embarrassment.

n) Do not remove clothing unnecessarily.

o) Do not give anything by the mouth to a casualty who is unconscious, who has a suspected internal injury, or who may shortly need an anesthetic.

15.8.4. Action at an Emergency

a) ***The First Aider must be prepared to take responsibility. This includes***:-

i. an appreciation of the situation,

ii. taking charge until someone more experienced is available,

iii. diagnosis,

iv. treatment and disposal.

b) Where there is more than one casualty, the first aider must decide by rapid assessment which one should receive priority of treatment.

c) And consideration must be given to;-

i. the immediate placing of any unconscious casualties in the recovery position,

ii. temporary control of continuous severe bleeding,

iii. restoration of breathing if necessary.

d) A ***first aider*** working alone must quickly place all unconscious casualties in the recovery position before attending to any others.

e) Note ***<u>that the noisiest casualty need not be the most severely injured!</u>***

16. FEES AND CHARGES

The Communications Commission of Kenya (CCK) charges the following license fees for postal, telecoms, radio operators and also for type approval of the equipment they market or use. This categorization and accompanying fees are reviewed from time to time.

16.1. POSTAL/COURIER OPERATORS

The current charges and fees for Postal / Courier operators are available on the Commission's website at http://www.cck.go.ke/postal_courier_licence_fees/. This may change from time to time and users of this information need to consult this link frequently.

16.2. REGISTRATION AND LICENCING FEES FOR TELECOMMS OPERATORS AND SERVICES

The current registration and license fees for telecoms operators and services are available on the Commission's website at http://www.cck.go.ke/telecomms_licence_fees/ . This may change from time to time and users of this information need to consult this link frequently.

16.3. FREQUENCY SPECTRUM FEE SCHEDULE

The current frequency spectrum fees schedule is available on the Commission's website at http://www.cck.go.ke/spectrum_fees/ . This may change from time to time and users of this information need to consult this link frequently.

16.4. TYPE APPROVAL CHARGES AND FEES

The current type approval fees schedule is available on the Commission's website at http://www.cck.go.ke/type_approval_fees/ . This may change from time to time and users of this information need to consult this link frequently.

17. FORMS

17.1. TELECOMMUNICATIONS SERVICES REGISTRATION AND LICENSING

Forms for telecommunications services authorization and licensing are available on the Commission's website at http://www.cck.go.ke/license_application_forms-telecommunications/ .

The forms may be amended from time to time and users of this information need to consult this link frequently and use the right forms.

17.2. TELECOMMUNICATIONS STANDARDS (INSPECTION & CERTIFICATION)

Forms for inspections and certification purposes are available on the Commission's website at http://www.cck.go.ke/telecomms_licence_enforcement/.

The forms may be amended from time to time and users of this information need to consult this link frequently and use the right forms.

17.3. TYPE APPROVAL

Forms for type approval are available on the Commission's website at http://www.cck.go.ke/type_approval_forms/ . The forms may be amended from time to time and users of this information need to consult this link frequently and use the right forms.

17.4. RADIO AND TELEVISION FREQUENCIES APPLICATION FORMS

Forms for frequency licensing purposes are available on the Commission's website at http://www.cck.go.ke/licence_application_forms/ .
The forms may be amended from time to time and users of this information need to consult this link frequently and use the right forms.

18. SPECIFICATION No CW21 (M) FOR CABLE INTERNAL

18.1. GENERAL

This specification details cable with tinned copper conductors, PVC insulation and PVC sheath used by network operators and wiring contractors for general internal cable distribution and wiring.

18.2. CONDUCTORS

18.2.1. Materials

Each conductor in the cable shall consist of a solid wire of annealed high conductivity copper, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin.

18.2.2. Dimensions

The diameter of the tinned conductor in the completed cable shall be in accordance with Table18. 1.

18.2.3. Electrical Requirement

The resistance of the tinned conductor shall be in accordance with Table 18.1.

18.2.4. Mechanical Requirements

a. The extent to which the tin coating permits easy soldering shall be determined by the solder bath method detailed in Clause 4.6.10.4

b. The elongation at break of any sample of bare conductor taken from the completed cable shall not be less than 14% at 20 degrees C. The test shall be made on a suitable test piece such that the gauge length between the jaws of the testing machine shall be 200 mm or 250 mm. The rate of separation of the jaws shall be about 100mm/min.

c. Joints in the conductor shall be kept to a minimum. The ultimate tensile force of a 250mm length of conductor containing a joint shall not be less than 90% of that of an adjacent length of conductor not containing a joint.

18.3. INSULATION

18.3.1. Material

a. The material shall be coloured and shall comply with requirements of PVC compound type 2 in BS6746.

b. The test for colourfastness to daylight in BS6746 (Test Method L) shall apply to one and two-colour wires.

c. The test for bleeding and blooming of colour in BS6746 (Test Method M) shall apply but only to one colour wires.

d. The heat shock test in BS6746 (Test Method G1) shall be carried out on one and two-colour single wires. The samples shall be wound as specified in a close helix of six turns round the mandrel. The ends shall extend at right angles to the mandrel in opposite directions for a length of 25 mm. After the test, in addition to meeting the requirements of the BS, the retraction on each 25 mm length shall not exceed 1.5 mm and the insulation colours shall remain readily identifiable.

18.3.2. Colours

a. One-Colour Wire: The colour shall be incorporated in the insulating compound.

b. Two-Colour Wire: The colours shall be uniform in the form of either continuous spiral or ring markings, which shall be readily identifiable in every 15 mm of length. The purpose of the marking is to provide easy identification of wires. Markings in the finished wire shall reasonably match the colours shown in BS6746C.

c. Spiral markings shall be effected by the application of one or more ink stripes on a base colour or by direct extrusion.

d. Ring markings shall consist of ink bands applied on a base colour at right angles to the axis of the conductor. The registration of the half bands and complete encirclement of the wire is not critical.

e. Base colours are indicated in Table18. 2 by the use of capital letters.

f. The ink for wires identified by colour combinations incorporating black stripes shall meet the surface leakage test requirement given in para. 10.10.3.

18.3.3. Dimensions

The conductor shall be uniformly covered with the specified PVC having radial thickness and diameter over insulation in accordance with Table18. 1.

18.3.4. Joints

Joints in the insulated conductor shall be kept to a minimum and shall be made only by approved method.

18.4. CABLING ELEMENTS

18.4.1. Cabling Element

A cabling element shall consist of one of the following:

a. A single insulated conductor.

b. A pair of insulated conductors uniformly twisted together and designated the a-wire and the b-wire respectively.

c. A triple of insulated conductors uniformly twisted together and designated the a-wire, the b-wire, and the c-wire, respectively.

d. A quad of insulated conductors uniformly twisted together and designated the a-wire, the b-wire, the c- wire and the d-wire. The conductors shall be so arranged that their sequence is a, c, b and d, coloured BLUE, GREEN, ORANGE and BROWN respectively.

18.4.2. Lay Length

The lay length for pairs, triples and quads in the finished cable shall not exceed 100 mm.

18.4.3. Stranding

The elements shall be laid up in layer construction unless the PO designation in Table 3B has the suffix 'U'. In this case the cable shall be laid up in unit construction.

18.4.4. Layer Construction

a. The elements shall be laid up to form a compact and circular cable.

b. The colours of the wire in the various sizes of cable shall be as given in Table18.3.

c. The sequence of loading of the stranding machine shall be in accordance with Table 3, the first named element being in the centre.

d. Inter-layer tapes consisting of an open lapping of polyethylene terephthalate or polypropylene tape may be applied at the discretion of the manufacturer.

18.4.5. Unit Construction

a. The elements in these cables shall be pairs and shall be laid up as units or sub-units.

b. Each unit shall consist of 20 pairs, coloured in accordance with Table 18.2, cabling elements 1 to 20.

c. The 20 pairs shall be formed into a single unit or into two sub-units of 10 pairs each as specified in Table 4. The first sub-unit shall be pairs 1 to 10, the second, 11 to 20.

d. An open lapping of polyethylene terephthalate or polypropylene tape shall be applied over each unit or sub-unit. The colour of the tape shall be as specified in Table 18.4. For 20 pair cables this lapping may be omitted.

e. The units and sub-units so formed shall be laid up as specified in Table 18. 4 into a compact and circular cable core.

18.4.6. Cable Core Protection

Except for cables containing 12 wires or less when this protection may be omitted, the stranded cable core shall be covered overall, prior to sheathing, with polyethylene terephthalate tape by one of the following methods:-

a. A single tight lapping having an overlap of 25% nominal.

b. Two tapes applied breaking joint

c. One tape applied longitudinally with an overlap of not less than 10 mm or 30% of the tape width, whichever is the smaller.

d. Two similar tapes applied longitudinally with overlaps of 50% of the tape width or 10mm, whichever is the smaller.

18.4.7. Identification

The manufacturer's identification thread (BS Document PD 2379) shall be separately incorporated in the cable. This may be omitted from 1-wire cables.

18.4.8. Rip-Cord

A non-metallic rip-cord which may incorporate the manufacturer's identification colours, shall be laid under the sheath. It shall provide an effective means of slitting the sheath longitudinally to facilitate removal.

The rip-cord may be omitted from 1-wire cable.

18.4.9. Sheath

a. Material

The sheath material shall be coloured and shall comply with the requirements of PVC compound type TM1 in BS 6746.

b. ***Colour***

The sheath shall be cream or grey as ordered.

c. ***Dimensions***

The dimensions of the sheath shall conform to Table 18.3 but in determining the minimum sheath thickness the indentation caused by the rip-cord and/or the identification thread shall be ignored.

d. Mechanical Requirements

The sheath shall be continuous and of a thickness as uniform as possible. The sheath shall be applied to fit closely to the cable core, but shall not adhere to any underlying core protection or to the insulation of the conductors. Any regular marking due to underlying construction shall not be regarded as a defect.

e. ***Stripability***

It shall be possible to strip 50 mm of insulation from the wire taken from completed cable with a force which does not exceed that shown in Table18. 5. The preparation of the sample and the performance of the test shall be based upon the method described in IEC Recommendation 189-1, clause 3.4, second method.

18.5. ELECTRICAL AND MECHANICAL REQUIREMENTS

18.5.1. Capacitance Unbalance

a. Except for quad cables, pair-to-pair capacitance unbalance measurements shall be made at a suitable frequency. The first and second conductor of a triple constitute a pair. All conductors other than those under test shall be connected to earth.

b. The measurements shall be corrected as follows, lengths less than 100m being considered as 1000m.
The measured values shall be divided by 0.5[L/500 + □L/500] where L is the length in metres of the cable under test.

c. Not more than 1% of the corrected capacitance unbalance measurements between adjacent pairs shall exceed the values shown in Table 18. 6.

18.5.2. Insulation Resistance

Insulation resistance measurements shall be made with not less than 500 V dc. After steady electrification for one minute, the insulation resistance measured between each conductor in the cable and the remaining conductors together, shall not be less than the value specified in Table 18.7.

18.5.3. Surface Leakage

Black ink used for either spiral or ring marked cores shall be tested in the "as received" condition. A sample of the ink shall be applied without brushing i.e. by casting or spraying, on to a flat sheet of moulded PVC to form a uniform film. The prepare specimen shall be conditioned at 75 ±2% relative humidity for 24 hours at 20 ±2 degrees C. A surface resistivity test shall be carried out using method 203A of BS 2782. The minimum value of surface resistivity (log 10 ohms) shall be 11. The test on the specimen shall be completed within three minutes of its removal from the controlled atmosphere.

18.5.4. Solder Bath

a. A test piece consisting of a suitable length of wire shall be taken from the cable. One end shall be stripped of insulation to expose 15 ±1mm of the tinned conductor.

b. The solder bath used for the test shall be of sufficient volume to ensure that the temperature of the solder remains constant when introducing the conductor. Precautions shall be taken to maintain a uniform temperature of 270 ±10 degree C throughout the mass of solder and also to ensure that the conductor shall not be heated by direct radiation prior to insertion into the bath.

c. The surface of the bath shall be kept clean and immediately before immersion of the conductor, a piece of solder 12 mm long and 1.6 mm diameter, shall be dropped into middle of the bath. The solder shall be 60/40 tin-lead alloy with a non-activated resin core. No other flux shall be used for this test.

d. As soon as the added solder has melted, the stripped end of the conductor shall be immersed to a length of approximately 10 mm into the bath of a period of 2+/-0.5 seconds.

e. The conductor shall be examined for quality of solder coating. Good quality shall be evidenced by free flowing of the solder with wetting of the conductor end.

18.6. Resistance to Flame Propagation

The cable shall conform to POTH Specification M231.

18.7. Sealing of Ends

After completion of the electrical tests, the ends of the cable shall be sealed to prevent the ingress of moisture.

18.8. Specification No CW21 (M) Reference Tables

These tables are for use with Chapter 4.6 of the "Guidelines to Contractors for Supply, Installation and Maintenance of Telecommunications Internal Wiring and Terminal Equipment"

Conductor		**Insulation**	**Insulated Conductor**
Diameter	**Resistance per 1000m @ 20 deg. C**	**Radial thickness**	**Overall diameter**
Nominal mm	**Maximum Ohms**	**Maximum mm**	**Maximum mm**
0.4	153	0.15	0.85
0.5	97.8	0.15	0.95
0.63	67.9	0.15	1.05
0.9	29.6	0.25	1.6

Table 18. 1: Conductor and Insulation

Cabling Element	**Colour of the insulation**		**Cabling element**	**Colour of the insulation**	
	a-wire	**b-wire**		**a-wire**	**b-wire**
	WHITE	BLU E		RED-Blue	BLU E
	WHITE	ORANGE		RED-Blue	ORANGE
	WHITE	GREEN		RED-Blue	GREEN
	WHITE	BROWN		RED-Blue	BROWN
	WHITE	GREY		RED-Blue	GREY
	RED	BLU E		BLUE -Black	BLU E
	RED	ORANGE		BLUE -Black	ORANGE
	RED	GREEN		BLUE -Black	GREEN
	RED	BROWN		BLUE -Black	BROWN
	RED	GREY		BLUE -Black	GREY
	BLACK	BLU E		YELLOW- Blue	BLU E
	BLACK	ORANGE		YELLOW- Blue	ORANGE
	BLACK	GREEN		YELLOW- Blue	GREEN
	BLACK	BROWN		YELLOW- Blue	BROWN
	BLACK	GREY		YELLOW- Blue	GREY
	YELLOW	BLU E		WHITE -orange	BLU E
	YELLOW	ORANGE		WHITE -orange	ORANGE

	YELLOW	GREEN		WHITE -orange	GREEN
	YELLOW	BROWN		WHITE -orange	BROWN
	YELLOW	GREY		WHITE -orange	GREY
	WHITE-Blue	BLU E		ORANGE -Red	BLU E
	WHITE-Blue	ORANGE		ORANGE- Red	ORANGE
	WHITE-Blue	GREEN		ORANGE -Red	GREEN
	WHITE-Blue	BROWN		ORANGE -Red	BROWN
	WHITE-Blue	GREY		ORANGE -Red	GREY

Note: The e-wire if any shall be coloured turquoise in all triples

Table 18.2a Wire Identification colours (I. E. C. Publications 189- 2 and 189 – 3)

Cabling Element	Colour of the insulation		Cabling Element	Colour of the insulation	
	a-wire	b-wire		a-wire	b-wire
	ORANGE-Black	BLU E		RED-Brown	BLU E
	ORANGE-Black	ORANGE		RED-Brown	ORANGE
	ORANGE-Black	GREEN		RED-Brown	GREEN
	ORANGE-Black	BROWN		RED-Brown	BROWN
	ORANGE-Black	GREY		RED-Brown	GREY
	YELLOW-Orange	BLU E		BROWN-Black	BLU E
	YELLOW-Orange	ORANGE		BROWN-Black	ORANGE
	YELLOW-Orange	GREEN		BROWN-Black	GREEN
	YELLOW-Orange	BROWN		BROWN-Black	BROWN
	YELLOW-Orange	GREY		BROWN-Black	GREY
	WHITE-Green	BLU E		YELLOW-Brown	BLU E
	WHITE-Green	ORANGE		YELLOW-Brown	ORANGE
	WHITE-Green	GREEN		YELLOW-Brown	GREEN
	WHITE-Green	BROWN		YELLOW-Brown	BROWN
	WHITE-Green	GREY		YELLOW-Brown	GREY
	GREEN-Red	BLU E		WHITE-Grey	BLU E
	GREEN-Red	ORANGE		WHITE-Grey	ORANGE
	GREEN-Red	GREEN		WHITE-Grey	GREEN
	GREEN-Red	BROWN		WHITE-Grey	BROWN
	GREEN-Red	GREY		WHITE-Grey	GREY
	GREEN-Black	BLU E		GREY-Red	BLU E
	GREEN-Black	ORANGE		GREY-Red	ORANGE
	GREEN-Black	GREEN		GREY-Red	GREEN
	GREEN-Black	BROWN		GREY-Red	BROWN
	GREEN-Black	GREY		GREY-Red	GREY
	YELLOW-Green	BLU E		GREY-Black	BLU E
	YELLOW-Green	ORANGE		GREY-Black	ORANGE
	YELLOW-Green	GREEN		GREY-Black	GREEN
	YELLOW-Green	BROWN		GREY-Black	BROWN
	YELLOW-Green	GREY		GREY-Black	GREY
	WHITE-Brown	BLU E		YELLOW -Grey	BLU E
	WHITE-Brown	ORANGE		YELLOW -Grey	ORANGE
	WHITE-Brown	GREEN		YELLOW -Grey	GREEN
	WHITE-Brown	BROWN		YELLOW -Grey	BROWN
	WHITE-Brown	GREY		YELLOW -Grey	GREY

Note: The e-wire if any shall be coloured turquoise in all triples

Table 18.2b (Continued) Wire Identification colours (I. E. C. Publications 189- 2 and 189 – 3)

Cable Designation	Cabling Element (Table 2)		Sheath		Maximum Overall Diameter
	Pairs	Triples	**Colour**	**Maximum Thickness**	
Cr 1 Pr W&B	1		Cream	0.4	3.3
Cr 1 Pr. W& O	2		Cream	0.4	3.3
Cr 1 Pr. W&G	3		Cream	0.4	3.3
Cr 1 Pr W&Bn.	4		Cream	0.4	3.3
Cr 1 Pr. W& Gy	5		Cream	0.4	3.3
Cr 3 Pr	1-3		Cream	0.5	5.3
Cr 6 Pr	1-6		Cream	0.6	6.8
Cr 6 Tr		1-6	Cream	0.6	7.9
Cr 10 Pr	1-10		Cream	0.6	8.3
Cr 12 Pr	1-12		Cream	0.7	8.9
Cr 10 Tr		1-10	Cream	0.7	9.6
Cr 16 Pr	1-16		Cream	0.7	9.8
Cr 20 Pr	1-20		Cream	0.7	10.4
Cr 25 Pr	1-25		Cream	0.8	11.1
Gy 25 Pr	1-25		Grey	0.8	11.1
Cr 10 Pr 10 Tr	1-10	1-10	Cream	0.8	11.1
Gy 10 Pr 10 Tr	1-10	1-10	Grey	0.8	11.1
Cr 20 Tr		1-20	Cream	0.8	11.8
Cr 40 Pr	1-40		Cream	0.9	13.8
Cr 50 Pr	1-50		Cream	0.9	14.1
Cr 60 Pr	1-60		Cream	1.0	15.8
Cr 72 Pr	1-72		Cream	1.1	17.3
Cr 100 Pr	1-100		Cream	1.2	20.3

Table 18.3a: Make-up and dimensions of cable 0.4 mm conductors

Cable Designation	**Cabling Element (Table 2)**			**Sheath**		**Maximum Overall diameter**
	Single, or Quad (b-wire colour)	Pairs	Triples	**Colour**	**Maximum Thickness**	
Cr 1 W B	1			Cream	0.4	2.2
Cr 1 W O	2			Cream	0.4	2.2
Cr 1 W G	3			Cream	0.4	2.2
Cr 1 W Bn.	4			Cream	0.4	2.2
Cr 1 W Gy	5			Cream	0.4	2.2
Cr 1 Pr W& B		1		Cream	0.4	3.3
Cr 1 Pr W&O		2		Cream	0.4	3.3
Cr 1 Pr. W&Gn		3		Cream	0.4	3.3
Cr 1 Pr W&Bn.		4		Cream	0.4	3.3
Cr 1 Pr W&Gy		5		Cream	0.4	3.3
Cr 1 Tr W& B&Te			1	Cream	0.4	3.5
Cr 1 Tr W&O&Te			2	Cream	0.4	3.5
Cr 1 Tr W&Gn&Te			3	Cream	0.4	3.5
Cr 1 Tr W&Bn&Te			4	Cream	0.4	3.5
Cr 1 Tr W&Gy&Te			5	Cream	0.4	3.5
Cr 1 Q	See 4.7.4(iv)			Cream	0.4	4.0
Gy 1 Q	See 4.7.4(iv)			Grey	0.4	4.0
Cr 3 Pr.		1-3		Cream	0.4	4.0.
Cr 4 Pr		1-4		Cream	0.5	5.3
Gy 4 Prt		1-4		Grey	0.5	5.8
Cr 6 Pr		1-6		Cream	0.6	6.8
Gy 6 Pr.		1-6		Grey	0.6	6.8
Cr. 8 Pr		1-8		Cream	0.6	7.8
Cr 10 Pr.		1-10		Cream	0.6	8.3
Cr. 12 Pr		1-12		Cream	0.7	9.1
Gy. 12 Pr		1-12		Grey	0.7	9.1
Cr 14 Pr		1-14		Cream	0.7	9.5
Gy 15 Pr.		1-15		Cream	0.7	9.8
Cr. 10 Tr			1-10	cream	0.7	9.8
Cr 16 Pr.		1-16		Cream	0.7	10.0
Cr. 20 Pr		1-20		Cream	0.7	10.7
Cr. 20 Pr	/	1-20		Cream	0.7	10.7

Cr. 20 Pr	/	1-20		Cream	0.7	10.7
Gy 20 Pr U		1-20		Grey	0.7	10.7
Cr 24 Pr IS		1-24		Cream	0.8	11.3
Gy 24 Pr IS		1-24		Grey	0.8	11.3
Cr 25 Pr.		1-25		Cream	0.8	11.4

Table 18.3b Make-up and dimensions of cable- 0.5mm conductors

Cable Designation	Cabling Element (Table 2)			Sheath		Maximum Overall diameter
	Single, or Quad (b-wire colour)	Pairs	Triples	Colour	Maximum Thickness	
Gy 25 Pr.		1-25		Grey	0.8	11.4
Cr 10 Pr. 10 Tr		1-10	1-10	Cream	0.8	11.4
Cr 28 Pr.		1-28		Cream	0.8	11.5
Cr 30 Pr.		1-30		Cream	0.8	12.2
Cr 20 Tr			1-20	Cream	0.8	12.2
Cr 20 Tr. IS			1-20	Cream	0.8	12.2
Cr 35 Pr.		1-35		Cream	0.9	12.9
Cr 25 Tr.			1-25	Cream	0.9	13.4
Cr 40 Pr. U		1-40		Cream	0.9	14.2
Cr 42 Pr.		1-42		Cream	0.9	14.2
Cr 28 Tr.			1-28	Cream	0.9	14.5
Cr 50 Pr.		1-50		Cream	1.0	15.7
Cr 53 Pr.		1-53		Cream	1.0	15.7
Cr 60 Pr.		1-60		Cream	1.0	15.9
Cr 40 Tr.			1-40	Cream	1.0	16.3
Cr 25 Pr. 25 Tr.		1-25	1-25	Cream	1.1	16.3
Cr 46 Tr.			1-46	cream	1.1	16.7
Cr 75 Pr.		1-75		Cream	1.1	17.2
Cr 50 Tr.			1-50	Cream	1.1	17.8
Cr 80 Pr. U		1-80		cream	1.2	17.8
Cr 80 Pr.		1-80		Cream	1.2	21.8
Cr 100 Pr.		1-100		cream	1.4	22.6
Cr 120 Pr.		1-120		Cream	1.5	25.2
Cr 50 Pr. 50 Tr		150	1-50	Cream	1.6	27.2
Cr 100 Tr			1-100	Cream	1.7	28.0
Cr 160 Pr. U		1-160		Cream	1.7	29.8
Cr 320 Pr. U		1-320		Cream	2.2	39.1

Table 18.3b Make-up and dimensions of cable- 0.5mm conductors

Cable Designation	Cabling Element (Table 2)		Sheath		Maximum Overall diameter
	Pairs	Triples	Colour	Maximum Thickness	
Cr 1 Tr		1	Cream	0.4	3.7
Cr 3 Pr.	1-3		Cream	0.5	5.3
Cr 6 Pr.	1-6		Cream	0.6	7.1
Cr 10 Pr	1-10		Cream	0.7	8.9
Cr 10 Tr.		1-10	Cream	0.8	10.1
Cr 20 Pr.	1-20		Cream	0.8	11.2
Cr 10 Pr 10 Tr.	1-10	1-10	Cream	0.9	12.9
Cr 20 Tr.		1-20	Cream	0.9	13.4
Cr 25 Tr.		1-25	Cream	1.0	15.5
Cr 40 Pr.	1-40		Cream	1.0	15.5
Cr 20 Pr. 20 Tr.	1-20	1-20	Cream	1.1	16.5
Cr 50 Pr.	1-50		Cream	1.1	15.5
Cr 60 Pr.	1-60		Cream	1.1	18.0
Cr 40 Tr.		1-40	Cream	1.1	18.0
Cr 25 Pr. 25 Tr.	1-25	1-25	Cream	1.2	18.5
Cr 46 Tr.		1-46	Cream	1.2	19.3
Cr 50 Tr.		1-50	Cream	1.2	19.3
Cr 80 Pr	1—8o		Cream	1.3	22.0
Cr 100 Pr.	1-100		Cream	1.5	24.6

Table 18.3c Make-up Dimensions of Cable- 0.6mm Conductors

	20 Pr	40Pr	80Pr	160 Pr	320
	Number of Units				
Centre 1st Layer 2nd Layer	1	4x½	1 6x½	4x½ 6	1 5 10
Unit No.	**Colours of Unit Lappings**				

1	Orange	Orange	Orange	Orange	Orange
2		Green	Orange	Green	Orange
3			Natural	Orange	Natural
4			Green	Natural	Natural
5				Natural	Natural
6				Natural	Green
7				Natural	Orange
8				Green	Natural
9/10/11/12/13/14/15					Green
16					

NOTE:½ refers to su-units of 10 pairs

Table 18.3d Make-up and Unit Identification Colours

Conductor Diameter	**Maximum Stripping Force N(@ 20 deg. C)**
0.4	4.4
0.5	5.9
0.6	7.3
0.8	9.1
0.9	9.8

Table 18.4 Stripping Force

Conductor Size (mm)	**Capacitance Unbalance (pF)**
0.4 (25, 50 and 100 Pair sizes)	200
0.4	300
0.5	500
0.6	300
0.9	300

Table 18.5: Capacitance Unbalance

Temperature at which insulation Resistance is Measured (deg. C)	**Insulation Resistance Mohms (f0r 1000m)**
10	500

11	400
12	310
13	250
14	190
15	150
16	120
17	110
18	79
19	62
20	50
21	41
22	32
23	28
24	23
25	19
26	16
27	13
28	11
29	9
30	8

Table 18. 6 Minimum Insulation Resistance of Completed Cable

19. GLOSSARY

Angular Sensitivity	A measure of response of our equipment to change angle of waveform
Armouring	Protective metallic covering on a cable
Asphyxiating Gases	Gases that inhibit breathing
Attenuation	A decrease in the signal magnitude in transmission from one point to another measured as a ratio of the input voltage to output voltage when the line is terminated in its characteristic impedance. Unit : decibel or nepers.
Audio Frequency	Frequencies audible to human ear normally 15 to 20000 Hertz
Balanced Pair	A cable pair in which each conductor has an equal impedance to earth and other conductors.
Blocking	The use of a buried pole to stabilise another pole on an aerial route.
Bonding	The act of connecting different materials electrically.
Backfilling	To return excavated to its original position
Cabinet	Waterproof shell, usually made of cast iron or glass re-enforced plastic which contains cross connection facilities and which may be installed at convenient points in the Network.
Cable Hook	A J-shaped piece of metal used for supporting cable on a pole.
Cable bracket	Supporting arm connected to the bearer using pin locking
Cable Bearer	Iron work to support cables in a jointing chamber
Cable Fill	The percentage of pairs in a cable, which it is anticipated, that will be used for working circuits at a given time.
Cable Balancing	The selection of pair combinations for jointing between the cable lengths in order to minimize overall cross talk between circuits
Capacitances unbalance	The difference of capacitance of conductors of a telephone circuit to other conductors and earth.
CASSC	(Cable Aerial Self Supporting Combine). This is a cable used for aerial distribution and having steel wires impended in the sheath to form a figure "8" with the cable core.
Cement Mortar	Mixture of lime or Cement, sand and water.

Characteristic Impedance	The characteristic impedance of a uniform line is the vector ratio of the voltage to current at any point in an infinite line
Coaxial pair	Two conductors arranged such that one is centered within the other but insulated from each other. Also known as concentric line.
Conductor Gauge	The diameter of a metallic conductor
Connection Box	Internal wall mounted box for terminating and cross connecting pair within a building
Contactor	A pressure sensitive switch, normally inserted at a cable joint, which operates at a preset pressure giving indication at a terminal station, via a cable air , of a pressure drop within the cable
Continuous flow Gas pressure System	The application of a gas from a Compressor and desiccator's unit to prevent ingress of moisture at minor leaks in a cable network.
Contractor	A person registered to carry out telecommunications works in the liberalized areas
Couplings	Buried jointing chambers
Cross connection area	The area served by a cross Connection point
Cross-talk near –end	Cross talk which is propagated in a disturbed circuit in a direction opposite to the direction of the propagation in the disturbing circuit. The terminal of the disturbed circuit on which cross talk is measured is at the same location as the energizing of the disturbing circuit.
Cross Connection Point (CCP)	An outdoor equipment in the local cable network, equipment which enables, by use of jumper wires or equivalent an incoming pair to be connected to any of the outgoing pairs.
Cross talk	The unwanted transfer of energy from a circuit known as "disturbing circuit" into another circuit known as "disturbed circuit"
Cross talk Balancing Panel	This panel is located at the high frequency receive terminal to neutralise the capacitance unbalance between carrier pairs. It carries variable capacitors, which are connected between carrier pairs
Cross talk, far end	Cross talk, which is propagated in a disturbed circuit in the same direction as the direction of propagation in the disturbing circuit. The terminal of the d9isturbed circuit at which far-end cross talk is measured will be

	remote from energizing terminal of the disturbing circuit
Debris`	Materials that may correct in a duct and block it.
Decibel	Unit of output to input ratio of Voltage or Current (Symbol dB – expressed as 10 log of the ratio
Dielectric Loss	The energy dissipation in an insulating material when subjected to an alternating voltages
Direct service area	The areas in which subscribers pairs are connected directly to the exchange without passing through cross connection points.
Distribution Pole	Pole used in telecommunications network for distribution of cables and dropwire.
Distribution cable	Cable serving a distribution point or cable between two cross connection points
DP	Distribution Point. A terminal box forming an interface between distribution cables and drop wires or internal cables
Draw wire	A wire drawn in a duct during ducting or rodding to facilitate pulling in of cables into to the ducts or conduits
Dressing or arming of a pole	Fitting of accessories on a pole
Drop wire	A particular type of subscribers lead-in comprising a pair of electrically conductive wires usually laid side by side but sometimes twisted helically and contained in a insulation material.
Duct formation	Arrangement of duct pipes in a trench
Duct way	The channel in a duct in which cable is drawn
Duct Occupancy	Maximum number of pairs/sizes of cable that can be drawn in a duct
Duct	Any passage provided to facilitate installation of cables and to protect them. They can be single or multiple form. Ducts can be made of concrete, PVC or galvanized steel.
Dummy Regenerators	The modules plugged in a repeater housing to make PCM cable pairs electrically continuous when there are no active regenerating circuits
Earth resistivity	Resistance of earth in ****ohm/cm
Eccentricities	The ratio of difference between the minimum and average thickness to the average thickness of annular element expressed in percent

Electrodes	Protective devices fitted within terminal blocks to act as protection against induced voltage or surges
End termination	The act of making a cable end on a pole for purpose of making a joint or entering a building
Engineer	A person qualified in the field of telecommunications engineering as defined by Engineers Registration Board
Excavation	Digging or extraction of soil to make a trench or a jointing chamber.
Extension	A telecommunications line connecting an existing telephone point to another telephone point
Frequency Division Multiplex` (FDM)	Processing of telephone conversation or speech channel containing a band of frequencies from 300- 3400 Hz and separated from other speech channels and transmitted simultaneously over the same circuit.
Flexibility	The ability to connect any pair in the distribution cables to any pair in the main cables at a cross connection point.
Flow meter	A meter registering the flow of gas into the cable connected to a continuous flow system
Four wire working	The use of two pairs of conductors to form a circuit, one pair for 'go' channel and one pair for return channel
Fully filled cable	Plastic insulated cable in which the interstices are fully filled with a compound, usually petroleum jelly.
Fusion welding	Jointing of fibres by means of electric arc
Galloping	The swinging of an aerial cable in windy conditions
Gas pressurization	The application of compressed gas to telephone cable to prevent the ingress of moisture at a sheath fault and to give warning and means of detection of such a fault.
GI (Graded Index) Fibres	Fibres that can transmit more than one wavelength
Halogen	One of the rare gases
Hard rock	A solid mass of virgin rock which may have seams, but is virtually unaffected by a blow of pick-axe and requires a compressor or blasting equipment to execute excavation
Insertion loss	The loss resulting from a line between two known impedances
Inspection points	Points provided in a newly installed plant to facilitate verification of proper installation.

Insulation resistance	The resistance under prescribed conditions between two conductors or system of conductors normally separated unit: Megohm.
Intermediate terminations	Any point between two end points of a cable route
Joint	The connection of two or more lengths of a wire or a cable
Joint Chambers	An underground cavity built with an opening to the surface to facilitate jointing and pulling of under ground cables
Local distribution Point (LDP)	A distribution point within a compound under one management
Loaded Cable	The addition of inductance to a cable pair for the purpose of improving the transmission characteristics over a limited frequency band
Local MDF	The connection frame or block in a Subscribers Premises on which the local cable from the local exchange and local internal and external cables both terminate. It is arranged so that any pair can be cross-connected any exchange multiple number.
Local DF	The connection frame or block on which cable pairs from the LMDF and the local distribution network are terminated
Long Length Cabling	Cabling using maximum length of cable without joints
Loop resistance	The total resistance of GO and RETURN pair of a circuit measured in ohms
Main cable	Cable, usually of a large number of pairs connecting the exchange to a cross connection point
Man hole	A jointing chamber large enough to accommodate large number of cables and permit entry of personnel
Matter	Materials that may collect in duct bore blocking it.
Metallic Screen	A thin sheet of aluminum foil coated with polymer and incorporated in a sheath of cable separating the “GO” and “RETURN” pairs in a PCM cable
Mill Scale	The heavy oxide layer formed during hot fabrication or heat treatment metals especially applying to iron and steel.
Mismatch	The condition in which the impendence of a load does not match the impendence of the source to which it is connected.

Mult-mode fibres	Fibres that can transmit more than one wavelengths of light
Multiple Twin cable	A cable containing a number of qurds, each quad being formed by twisting together two twisted pairs
Multiplexing	The process of combining a number of signals so that they can share a common transmission facility
Mutual Capacitance	The capacitance measured between two conductors of a pair with all other conductors earthed
Non Strategic network	Portion of telecommunications network from the demarcation point to the terminal equipment.
Numerical aperture (NA)	The square root of difference of the square of the index of refractions of the fibre core and the square of the index of refraction of the cladding material.
Overhead (O/H) Plant	Telecommunications plant installed above the ground
Optical Fibre cable	A cable having fibres made of glass material as transmission medium.
Pulse Code Modulation (PCM)	A modulation process having the conversion of a waveform from analogue to digital by means of coding.
Phantom Circuit	A circuit derived from two normal pairs, the two wires of each pair being effectively connected in parallel
Pilot Hole	An excavation taken out during the execution of duct work scheme in order to determine the position of the existing buried plant and/or condition below the surface.
Propagation Constant	Natural logarithm of the steady state vector ratio of the current or voltage at any point, to that at a point unit distance further from the source where the line is infinitely long. Unit neper, Symbol: Y
Protector Unit (PU)	The facility with Protection against lightning fitted at the subscribers' premises
Pulse Testing	Transmitting short duration pulses along the pair and displaying the energy returned on an oscilloscope
Punning	The process of compressing soil by means of a plank.
Ramming	To beat back filled soil to firmness
Reflection Coefficient	The degree of mismatch between two impedances
Repeater Housing	A casing usually made of iron and placed on a pole or placed in an underground chamber to accommodate regeneration circuits on a PCM or

an OFC route.

Return Loss	The value of inverse reflection coefficient expressed in decibels or nepers
Scarfed Pole	A pole that has been planed flat to a maximum of 0.9 metres from the top to take a maximum of three arms.
Screened pair	A pair which is enclosed in a screen to minimize the electrostatic coupling between it and other pairs in the cable.
Screening factor	The ratio of induced voltage in a telecommunication circuit when screening is present to the corresponding induced voltage without screening
Shuttering	All frame work used in concrete construction.
Signalling Limits	Attenuation loss and loop resistance limiting the lengths of a telecommunication line.
Single Mode fibres	Fibres that can transmit only one wavelength of light.
Slewing	To change horizontal position of a duct line
Slump figure	A measure of the quantity of cement mortar
Soft Rock	A bed of virgin rock which requires use of a compressor for excavations
Span length	The distance between two consecutive poles on an aerial route.
Sporting	Identifying and defining locality of a telecommunications plant
Straight Position	All places on a cable route where there no change of angle
Straight Line drawing	A diagram showing distribution of cables in a telecommunications network
Strand	Any of the wires twisted together to form a suspension wire or a wire rope.
Sub-duct	Duct placed in another duct of a bigger diameter mainly used for optical fibre cables.
Subscriber	A person connected to public telecommunications network
Subscriber's Service line	That part of subscriber's line between the distribution point and subscriber's premises, regardless of the material or method.
Sump	A cavity in the floor of a jointing chamber to facilitate draining of water
Survey sheet	A sheet in which details of survey work are recorded

Suspension wire	The wire in an aerial cable used to terminate and support the cable on poles.
Time Division Multiplex (TDM)	Each speech cannel is time sampled and transmitted together with other channels over the same circuit.
Technician	Is a person qualified in the field of telecommunications engineering as defined by the Engineers registration Board.
Telecommunications Point	It is a point in a building where there is access to telecommunications network connected to public exchange.
Transmission Equivalent Ratio (TER)	A term defining loss suffered by a telecommunications signal and expressed as a ratio to a given reference.
Terminal block	Blocks used for terminating under ground or aerial cables at distribution points. They are available for internal and external uses.
Test Cubes	A solid mass of cement mortar taken for test purposes.
Through Positions	Points where a cable passes but where it is neither jointed nor terminated
Trial Excavation	An excavation of an exploratory nature carried out to determine the position of any existing buried plant and/or conditions below the surface.
Tunnel	A cable passage large enough to permit the entry of personnel.
Two wire Working	The provision of "go" and 'return' channels on a single cable pair.
U/G	Under Ground
Velocity Ratio	The ratio of propagation in a cable to the velocity of propagation in free space
Vendor	A person registered to sell telecommunications terminal equipment
Way leaves	Permission to have right of way to install telecommunication facilities.