Laying direct in ground:

This method involves digging a trench in the ground and laying cable(s) on a bedding of minimum 75 mm riddled soil or sand at the bottom of the trench, and covering it with additional riddled soil or sand of minimum 75 mm and protecting it by means of tiles, bricks or slabs.

Depth: The desired minimum depth from ground surface to the top of cable is as follows:

a) High voltage cables, 3.3 KV to 11 KV rating : 0.9 m.

b) High voltage cables, 22 KV, 33 KV rating : 1.05 m.

c) Low and medium voltage and control cables : 0.75 m.

d) Cables at road crossings : 1.00 m.

e) Cables at railway level crossings (measured from bottom of sleepers to the top of pipe) : 1.00 m.

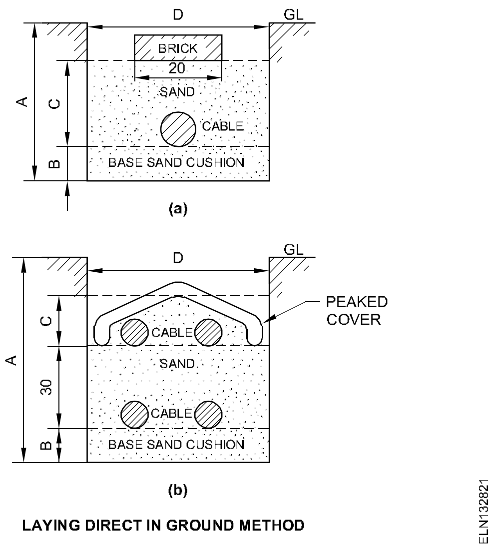
Width: The width of a trench for laying a single cable should be minimum 35 cm. When more than one cable is laid in the same trench in horizontal formation, the width of the trench shall be so increased that the inter-axial spacing between two cables is 20 cm.

Clearance from the terminal cable to the sides of a trench should be 15 cm.

Cable is protected by sand or layer of brick as shown in Fig 1a. Bricks should be second class bricks of a size not less than 20 cm x 10 cm x 10 cm and laid for full length for one cable (bricks to be laid breadthwise).

When more than one cable is to be laid in the same trench, this protective covering shall extend atleast 5 cm. over the sides of the end cables. An alternative to this covering can be earth ware or R.C.C. or fire-bricks of peaked covers section as shown in Fig 1b.

Fig 1



LAYING DIRECT IN GROUND METHOD

It is good practice to leave about 3 metres of cable spare in a loop formation near poles and joints, so that in case joint fails, this additional cable comes to rescue. Cable should be laid 0.4 metre away from water and power mains.

For cable of rating

Ref.	Upto 1.1 kV	Exceeding 1.1 kV
A	75	120
A1	(75+n1x30)	(120+n1x30)
B	8	8
C	17	17
D	35	35
D1	(30+n2x20)	(30+n2x20)
E	15	15

n1 = Number of additional cables in vertical formation.

n2 = Number of additional cables in horizontal formation.

For road crossings cast iron, or 2nd class RCC pipes or M.S/G.I. Pipe of medium class having an appropriate diameter should be laid during construction of the road to avoid damage to the road later on. The top surface of the pipe should be at a minimum depth of 1m. Pipes provided for entry to a building shall slope upward to prevent entry of water into the building. After laying of the cable they should be sealed.

Advantages

1 It is a simple and less costly method.

2 It gives the best conditions for dissipating the heat generated in the cables.

3 It is a clean and safe method as the cable is invisible and free from external disturbances.

Disadvantages

1 The extension of load is possible only by a complete new excavation which may cost as much as the original work.

2 The alterations in the cable network cannot be made easily.

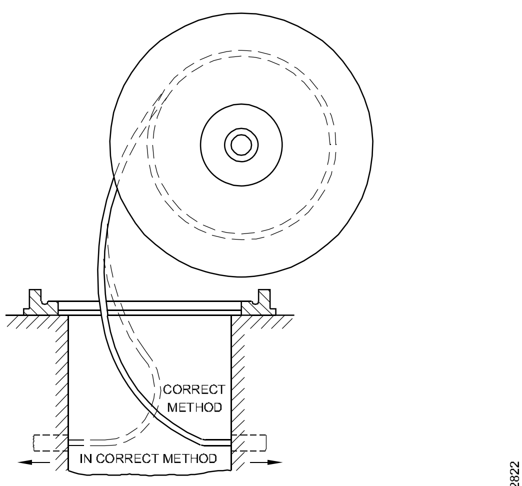
3 The maintenance cost is very high.

4 Localisation of fault is difficult.

5 It cannot be used in congested areas where excavation is difficult.

Drawing the cables into duct pipes: When drawing the cables through ducts, lack of space in the drawing pits usually restricts the distance from the cable drum to the duct mouth. It is essential that the direction of curvature of the cables is not reversed as it enters the duct. If the cable drum is on the same side of the drawing pit, as shown in Fig 2, this condition is fulfilled.

Fig 2



METHOD OF PULLING CABLES INTO DUCTS

Advantages

1 Reparis, alterations or additions to the cable network can be made without opening the ground.

2 As the cables are not armoured, therefore, joints become simpler and maintenance cost is reduced considerably.

3 There are very less chances of fault occurrence due to strong mechanical protection provided by the system.

Disadvantages

1 The initial cost is very high.

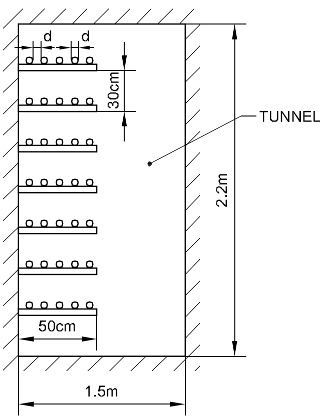
2 The current carrying capacity of the cables is reduced due to the close grouping of cables and unfavourable conditions for dissipation of heat.

This method of cable laying is suitable for congested areas where excavation is expensive and inconvenient, for once the conduits have been laid, repairs or alterations can be made without opening the ground. This method is generally used for short length cable routes such as in workshops, road crossing where frequent digging is costlier or impossible.

Laying cables on racks in air: Inside buildings, industrial plants, generating stations, substations and tunnels, cables are generally installed on racks fixed to the walls or supported from the ceiling. Racks may be ladder or perforated type and may be either fabricated at the site or pre-fabricated. Considerable economy can be achieved by using standard factory made racks. The necessary size of the racks and associated structure has to be worked out taking into consideration the cable grouping and permissible bending radii. Fig 3 shows the method of laying cables inside a tunnel on racks.

Laying cables along buildings or structures: Cables can be routed inside the building along with structural elements or with trenches under floor ducts or tunnels. The route of the proposed cable should be such that intersection with other cables will be minimum. The route should not subject these cables to any vibrations, damage due to heat or other mechanical causes. All adequate precautions should be taken to protect the cables.

Fig 3



LAYING OF CABLE INSIDE TUNNEL

Precautions while handling cables

1 Prevent the cable from dragging on the floor.

2 Prevent kinking of the cable.

3 After laying the cable in the ducts it should be immediately covered or suspended.

Cable jointing methods: This process consists of the following steps.

a) Exact measurement of the cable for insulation removal.

b) Removal of insulation.

c) Replacing of the original insulation with high grade tapes and sleeves.

d) Dressing the cable ends and conductor joints through sleeves/split sleeves.

e) Providing separators between cables.

f) Fixing a cast iron or any other protective shell around the joint and filling the joint boxes with molten bitumen compound.

g) Plumbing metallic sleeves or brass glands to the lead sheath of the cable to prevent moisture from entering the joint in case of cast iron joint boxes or tape insulation in case of cast resin kit joint boxes.

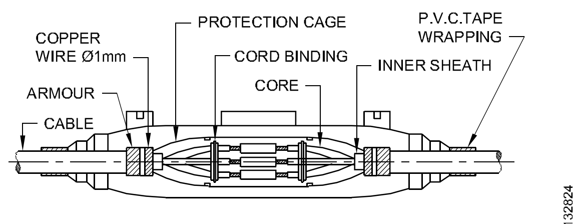
Straight through joints

The emphasis should be laid on quality and selection of proper cable, cable accessories, proper jointing techniques. The quality of joint in cable should be such that, it does not add any resistance to the circuit. The material and techniques employed in joining the cables should give adequate mechanical and electrical protection to the joint under all service conditions. The joints should further be resistant to corrosion and other chemical effects.

For PILC cable: For paper insulated lead sheathed cables, straight joints are made either by using sleeve joints or crimping joints up to voltage grade 11 KV. Above 11 KV, compound filled copper or brass sleeves, along with cast iron, fibre glass protection boxes are used.

Fig 4 shows such a joint.

Fig 4



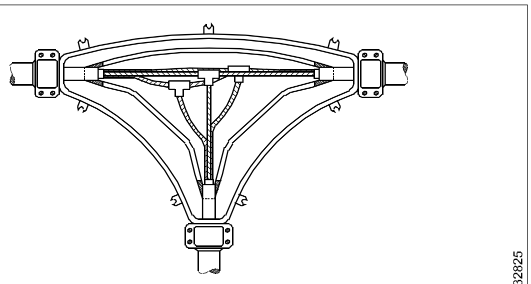
STRAIGHT THROUGH JOINTS FOR CABLES 3.3 KV GRADE

The cast iron protection boxes used up to 11 KV or moulds used for 1.1 KV joints in cast resin joints should conform to the relevant Indian Standard. Above 11 KV cast resin system is not yet standardized.

Tee joint: These joints are to be restricted up to 11 KV.

These joints are made either using cast resin kits or C.I. boxes with or without sleeves for PILC cables and cast resin kits for PVC and XLPE cables. (Fig 5)

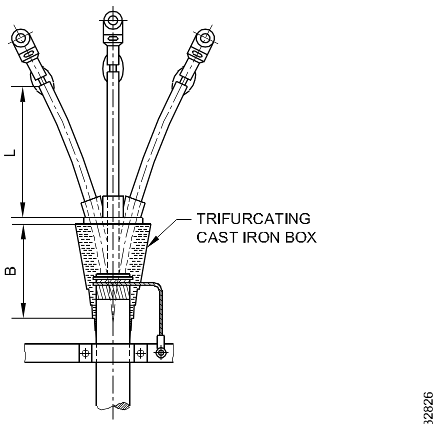
Fig 5



TEE JOINT OF 11 kV PAPER INSULATED CABLE

Tri-furcating end connections: In order to connect UG cables to the air break switches etc. tri-furcating boxes are used. They can be either cast resin type up to 1.1 KV or cast iron type for 11 KV and above. This type of box is shown in Fig 6.

Fig 6



TERMINATION FOR PVC CABLE

Method of preparing and filling compounds

– Hot pouring

– Cold pouring

Hot pouring compounds: A bituminous compound of melting temperature 90°C and pouring temperature 180°C - 190°C is used for hot pouring.

Properties: The bituminous compound has the following properties.

a) High electrical strength

b) High resistance to moisture

Compounding process: Heat the compound in a special bucket on firewood or charcoal fire, stir with a clean metal rod to have even melting of the compound. Check the temperature with a thermometer and heat the compound up to 180° to 190°C.

Heat the sealing box to 70°C with a blow torch. Open all air escape plugs. Fit a heated funnel to the pouring hole. Pour the compound carefully and evenly in 2 or 3 stages with an interval between them to allow the compound to solidify. Take care that no air bubble is trapped inside.

Cold pouring compound: Cold pouring is used by using cast resin system for PVC cable jointing. This has been developed for application up to 11 KV grade cables. The compound consists of a resin base and a polyamino hardener. The two component liquids are mixed at the site in accordance with the recommendation of the manufacturer.

Typical epoxy straight joint for PVC cable: In this system of jointing the insulation is removed and conductors are joined. The core joints in the case of LV/MV cables should be kept apart to avoid any flash over between them. Spacers are provided between the cores for H.V. cables.

No insulation is applied over the core joints. A cover earth ring is placed tight over the two cut ends of the armour and soldered to the armour wires. The two rings are then jointed by a copper wire and the cut ends of the armouring are bent over the rings to have continuity of armour as earth conductor.

Sandpaper is applied to the inner sheath surface and is cleaned by using methyl chloride. The joint is enclosed by plastic mould, which is in two parts, whose ends are duly cut to match the size of cable. PVC tape is wrapped at the two places where the mould will touch the cables. The two halves are pasted together and kept clamped to avoid any air gap. The mould ends are enclosed with putty which is supplied in the joint kit.

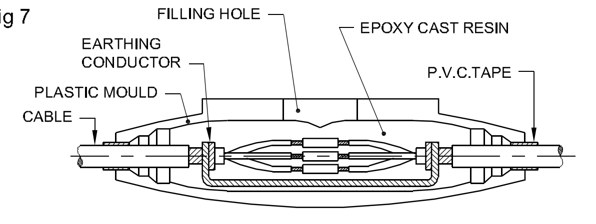
The expiry date of resin is checked and the hardener added to resin. The mixture is churned thoroughly for about 15 to 20 minutes till the colour of the mixed compound becomes grey. The mix is poured slowly into the mould taking care to avoid formation of air bubbles till the mould is filled and it comes out at the risers.

Allow the joint to set for a minimum of three hours till it becomes a solid mass before charging the cable. The mould may be removed, if desired.

Normally all the components required for joints are supplied as kits for various sizes of cables.

Fig 7 illustrates a typical straight through and outdoor termination of PVC cable with epoxy resin respectively.

Fig 7



TYPICAL EPOXY STRAIGHT JOINT FOR PVC CABLE

Types of cable faults and testing procedure

The common faults which are likely to occur in cables are:

1. **Ground fault.** The insulation of the cable may breakdown causing a flow of current from the core of the cable to the lead sheath or to the earth. This is called "Ground Fault".

2. **Short circuit fault.** If the insulation between two conductors is faulty, a current flows between them. This is called a "short circuit fault".

Methods for locating ground and short circuit faults.

The methods used localizing the ground and short circuit faults differ from those used for localizing open circuit faults.

In the case of multi core cables it is advisable, first of all, to measure the insulation resistance of each core to earth and also between cores. This enables us to sort out the core that is earthed in-case of ground fault; and to sort out the cores that are shorted in case of a short circuit fault. Loop tests are used for location of ground short circuit faults. These tests can only be used if a sound cable runs along with the faulty cable or cables.

The loop tests work on the principle of a Wheatstone bridge. The advantage of these tests is that their setup is such that the resistance of fault is connected in the battery circuit and therefore does not effect the result. However, if the fault resistance is high, the sensitivity is adversely affected. In this section only two types of tests viz., Murray and Varley loop tests are being described.

Murray Loop Test. The connection for this test are shown in Fig 8a relates to the ground fault and Fig 8b relates to the short circuit fault.

In both cases, the loop circuit formed by the cable conductors is essentially a wheatstone bridge consisting of resistances P, Q, R and X. G is a galvanometer for indication of balance,

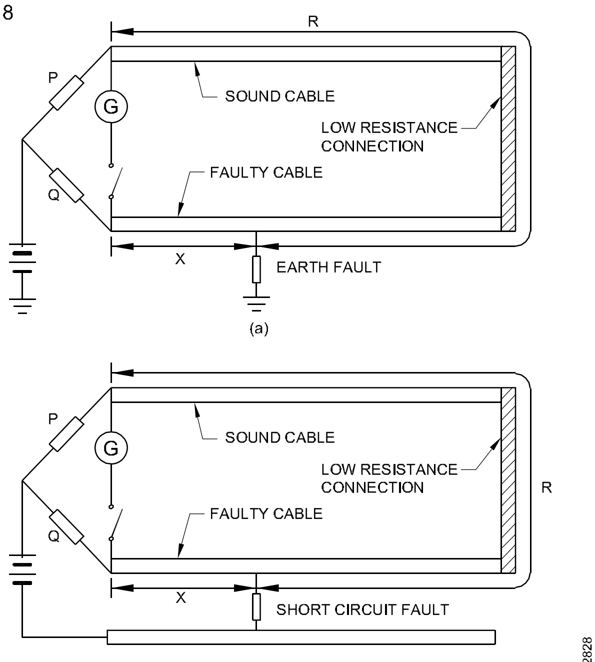
The resistors P, Q forming the ratio arms may be decade resistance boxes or slide wires.

Under balance conditions :

$$\frac{X}{R} = \frac{Q}{P} \text{ or } \frac{X}{R+X} = \frac{Q}{P+Q}$$

$$\therefore X = \frac{Q}{P+Q}(R+X)$$

Fig 8



MURRAY LOOP TEST
(b)

Where (R+X) is total loop resistance formed by the sound cable and the faulty cable. When the conductors have the same cross-sectional area and the same resistivity, the resistance are proportional to lengths. If l_1 represents the length of the fault from the test end and 'l' is the length of each cable. Then

$$l_1 = \frac{Q}{P+Q} \cdot 2l$$

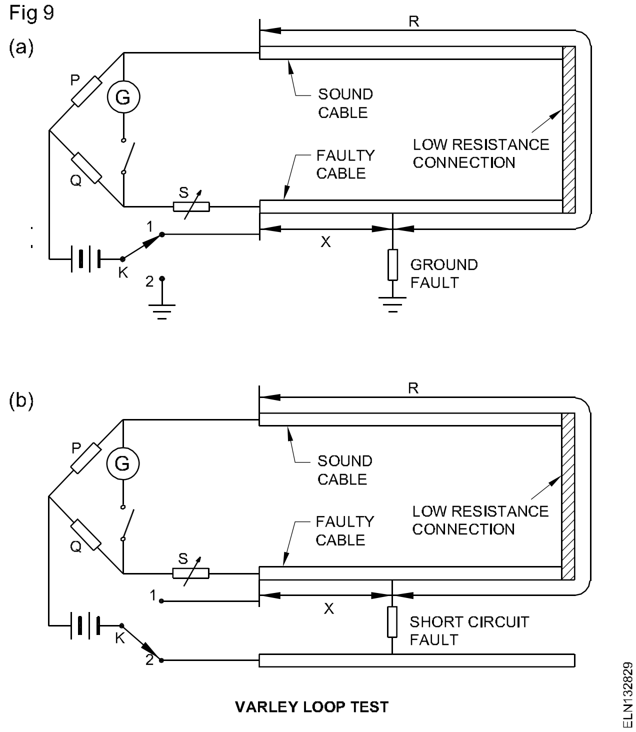
The above relation shows that the position of the fault may be located when the length of the cable is known. Also, the fault resistance does not alter the balance condition because its resistance enter the battery circuit hence effects only the sensitivity of the bridge circuit. However, if the magnitude of the fault resistance is high, difficulty may be experienced in obtaining the balance condition on account of decrease in sensitivity and hence accurate determination of the position of the fault may not be possible.

In such a case, the resistance of the fault may be reduced by applying a high direct or alternating voltage, in consistence with the insulation rating of the cable, on the line so as to carbonize the insulation at the point of the fault.

Varley loop test. In this test we can determine experimentally the total loop resistance instead of calculating it from the known lengths of the cable and its resistance per unit length. The necessary connections for the ground fault are shown in Fig 9a and for the short circuit fault in Fig 9b. The treatment of the problem, in both cases, is identical.

A single pole double throw switch A is used in this circuit. Switch K is first thrown to position 'I' and the resistance 'S' is varied and balance obtained.

Fig 9



VARLEY LOOP TEST

Measurement of resistance

Let the value of S for balance be S. The four arms of the Wheatstone bridge are P, Q, R + X, S_1 at balance:

$$\frac{R+X}{S_1}=\frac{P}{Q}$$

This determines R + X i.e. the total loop resistance as P, Q and S_1 are known.

The switch K is then thrown to position '2' and the bridge is rebalanced. Let the new value of S for balance be S_2. The four arms of the bridge now are P, Q, R, X + S_2.

At balance

$$\frac{R}{X+S_2}=\frac{P}{Q}$$

$$\frac{R+X+S_2}{X+S_2}=\frac{P+Q}{Q} \text{ or } X=\frac{(R+X)Q-S_2P}{P+Q}$$

Hence, X is known from the known value of P, Q, S_2 from this equation and R+X (the total resistance of 2 cables) as determined from Eqn. knowing the value of X, the position of the fault is determined.

Now

$$\frac{X}{R+X}=\frac{l_1}{2l} \text{ or } l_1=\frac{X}{R+X}2l$$

Where

l_1 = length of fault from the test end and

l = total length of conductor.

Equations for murrary loop test and varley loop test are valid only when the cable sections are uniform throughout the loop. Corrections must be applied in case the cross-sections of faulty and sound cables are different or when the cross-section of the faulty cable is not uniform over its entire length.

Since temperature affects the value of resistance, corrections must be applied on this account if the temperatures of the two cables are different. Corrections may also have to be applied in case the cables have a large number of joints.