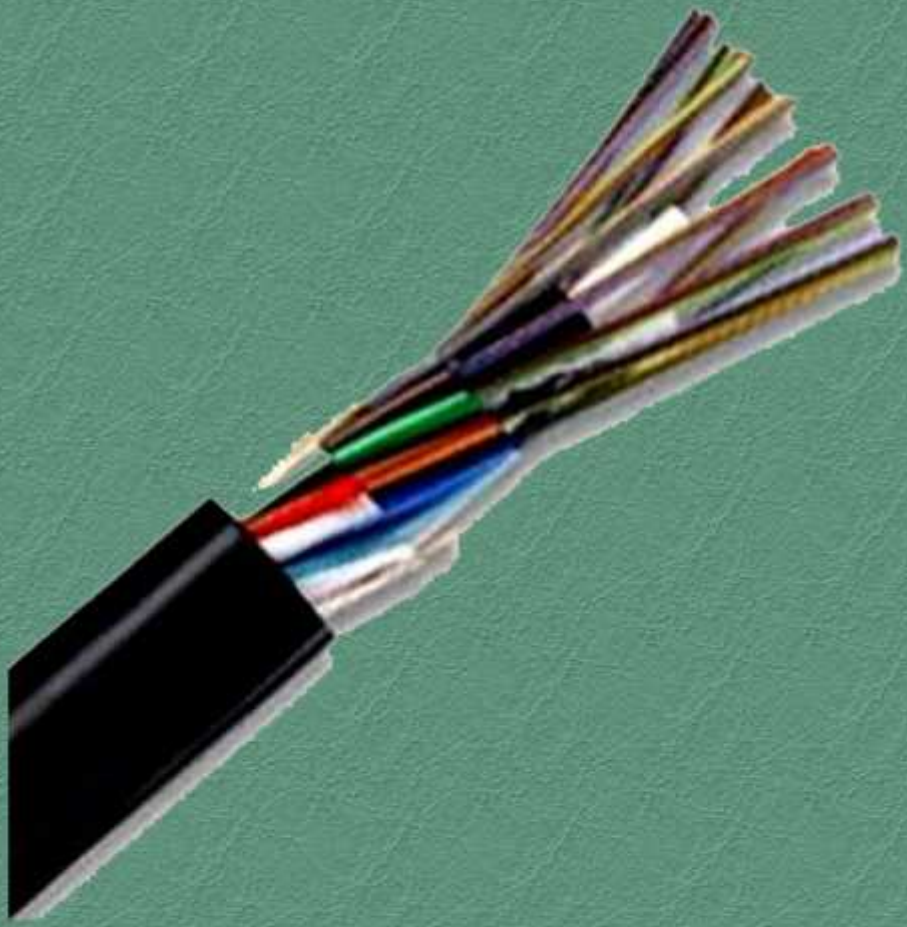
इरिसेट IRISET

TC1

TELECOM CABLES (COPPER)



Indian Railways Institute of
Signal Engineering and Telecommunications
SECUNDERABAD - 500 017

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INDIAN RAILWAYS INSTITUTE OF SIGNAL ENGINEERING & TELECOMMUNICATIONS, SECUNDERABAD - 500 017

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TELECOM CABLES (COPPER)

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CHAPTER-1

INTRODUCTION OF TELECOM CABLES

1.1 Introduction of Telecom Cables (Copper)

In Indian Railways different types of Telecom networks are exists and plays a vital role by providing clear and distant voice and data services. Various types of telecommunication cables with RDSO specification are being used depending upon the requirements of Telecom and safety related Signalling circuits, which are under utilisation for functioning of administrative and train operation activities.

For administrative purpose Telephone exchanges network, Railnet (Intra net), FOIS (Freight Operations Information System), MIS (Management Information System) MMIS (Material management Information and IRPSM (Indian Railway Projects and Sanction Management) etc are in use. Where as for Train operation various safety circuits like Block, LC gate communication, IB Phone (Intermediate Block), BPAC(Block Proving Axle Counter), EC (Emergency Communication) and Train Traffic Control communication etc. are in use.

For above all types of Telecom networks, different types of Telecom links are established by using Telecom trunk cables and tail cables.

The Telecom transmission media over Indian Railways is as follows:

1. Aerial Lines (Over Head Lines): GI wires & ACSR (Aluminium Conductor Steel Reinforced) are in use for Section Control Communication, Block Communication and LC gate Communication etc. These ACSR lines are under replacement with 6 Quad Underground Cables.

2. Micro Wave System: Analog & Digital Systems are in use for Radio Patching for Control Communication and long distance Administrative trunk circuits. Analog MW systems became obsolete and closed down. However Digital MW systems are still in use. MW system functionality is under replacement with OFC system.

3. RE Main Telecom Underground Cable: 0+12+2, 0+17+3, 0+18+2 etc. are in use in RE areas for Section Control, TPC, RC, EC, Block etc circuits. Due to non availability and Foreign exchange currency involvement, these cables are under replacement with 6Quad with OFC cables.

4. Underground 4 Quad and 6 Quad Cables: These are in use as standalone or along with OFC in many Zonal Railways.

5. OFC Cable: 24 Fiber Underground OFC Cable is in use for high bit rate Telecom traffic with enormous applications over Indian Railways. Railway is using only 4 fibers in which 2 fibers for working and 2 fibers for standby and remaining 20 fibers handedover to RCIL (Rail Tel Corporation of India Ltd.) as a policy between Railways and RCIL.

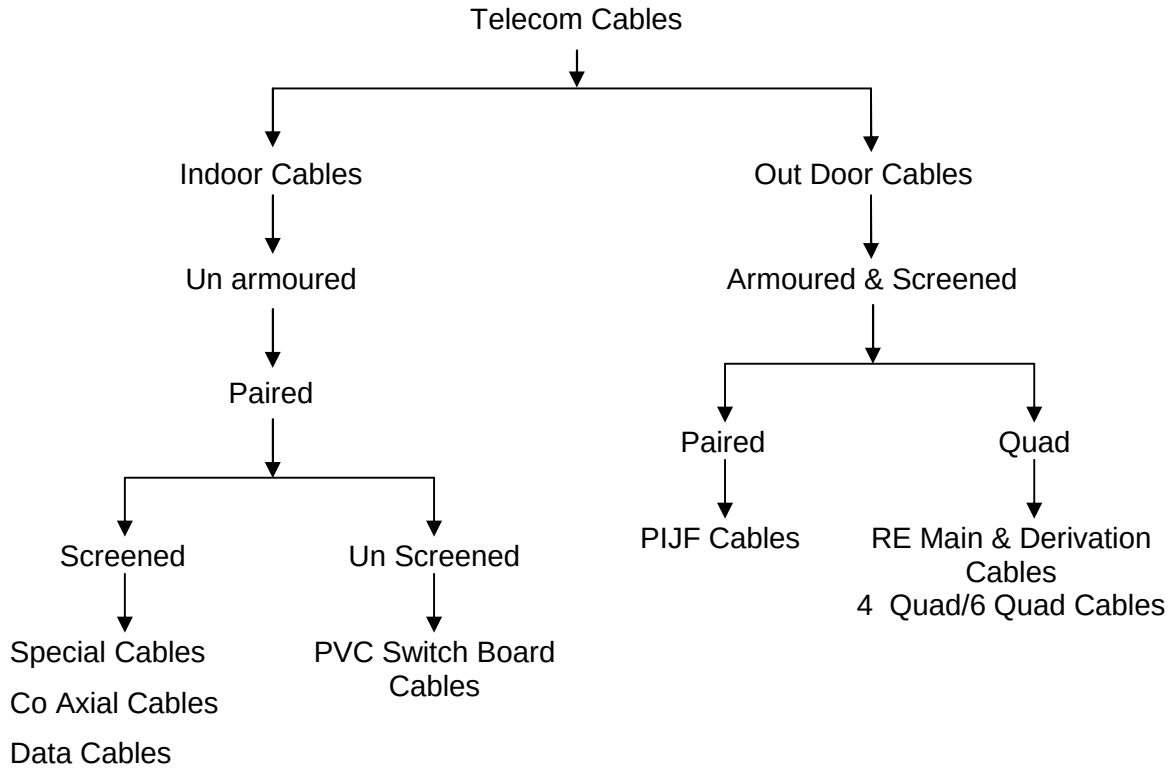
1.2 Advantages of U/G cable over O/H lines.

1. Overhead lines may come in contact with trees, bushes, etc. and cause low insulation.
2. Due to natural calamities and ravages of humans beings, overhead lines are Prone to a higher fault incidence.
3. Due to headway considerations, the maximum number of pairs on a pole route in Over Head Alignment is limited to 16.
4. Due to induced voltage effects from 25 KV OHE system, Over Head lines are not fit for Tele communication circuits in RE area.

1.3 Comparison between Under Ground Cables and Over Head Lines.

Under Ground Cables	Over Head Lines
Number of circuits are more.	Number of circuits are limited.
No noise and no cross-talk	Prone to noise and cross-talk
Less number of failures.	More number of failures.
For Long distance circuits-4wire system is required.	For Long distance circuits- 2-wire system is required.
Maintenance Cost is less.	More maintenance Cost .
Thefts are minimum.	Thefts are maximum.
More secrecy.	No secrecy.
Used in RE and- Non RE areas.	Cannot be used in RE area

1.4 Types Telecom Cables:



1.5 Special Features of Telecom Cables

Telecom cables are:

a) PVC or Paper insulated
b) Twin Twisted paired / star quad cables
c) Screened cables
d) Balanced cables
e) Loaded Cables and
f) Colour coaded

Unlike electrical noise, cross talk is the main criteria in telecom circuits. Cross talk arises mainly from unbalanced electrostatic and electromagnetic couplings between the pairs of conductors and sheath with respect to earth. These effects are respectively be measured in terms of capacitance unbalance and mutual capacitance. At voice frequencies, capacitance unbalance is the major source of cross talk. In order to reduce the cross talk in cables, **insulated wires are twisted together at regular intervals on their own axis helical throughout its length. Different twist lengths are used to transpose the circuits continuously with respect to one another pairs/quads**. After laying the cable, if capacitance unbalance is persisting, it can be reduced by introducing the external fixed capacitors. This process is called as "**BALANCING OF CABLES".**

In star quad cables diagonally opposite conductors are formed as one pair and two wires of the pair are kept at an equal distance from the conductors of the remaining pair.

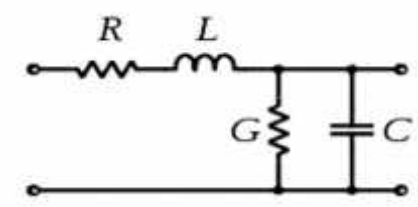
1.6 Electrical characteristics of Telecom Cables

1.6.1 The four primary elements

The four primary elements of cable should be taken into Consideration while designing the circuits.

R = Series Resistance
L = Series self inductance
C = shunt capacitance
G = Shunt conductance [Leakage]

These four quantities per unit length of a pair of telephone lines are called primary elements of the lines.



Dig: Schematic representation of the elementary components of a transmission Line.

where R-is the resistance per unit length,
L- is the inductance per unit length,
G- is the conductance of the dielectric per unit length,
C-is the capacitance per unit length.

When alternating current flows through the lines, there will be voltage drop due to both resistance and inductance and so they may be assumed to be present in series in the lines and as capacitance and leakage are present between the lines, current is lost through them during transmission.

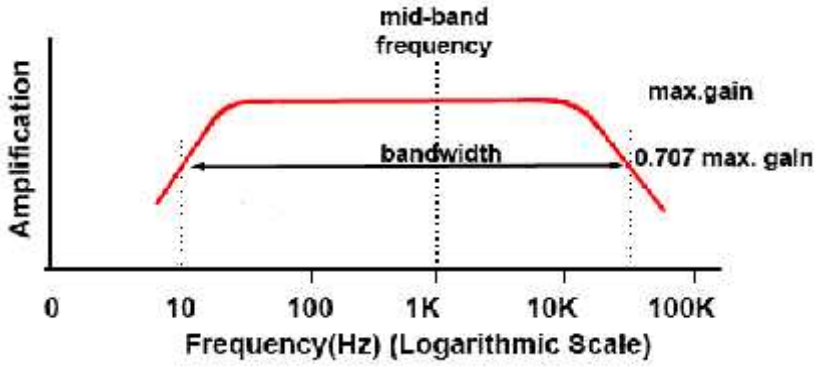
Z0 = (L/C) are independent of frequency and as such all the frequency components are equally attenuated during propagation through line. All the different types of distortions that are likely to be introduced during transmission through long lines are thus eliminated when the condition **GL = RC** is satisfied.

Telephone line is a balanced twisted pair transmission line and its characteristic impedance **Z0** can be calculated from the data which was given by manufacturer.

1.6.2 Defining the Impedance Vs Frequency.

The impedance, which describes the combined effect of resistance (R), inductive reactance (X_L) and capacitive reactance (X_C) in an AC circuit, whether it occurs in a single component, or in a whole circuit.

Because impedance is affected by reactance (X), as well as resistance (R), it is also affected by frequency (f) and the value of impedance will change at different frequencies.



The component or circuit will not have the same impedance at all frequencies. It is common for inputs and outputs on many types of equipment to have their impedances quoted in Ohms and to assume a common frequency for that particular type of equipment. For example, audio commonly uses a frequency of 1kHz as the standard for measuring impedance. This is because 1kHz is approximately the centre of an audio amplifier´s bandwidth, measured on a logarithmic scale, as shown in above figure.

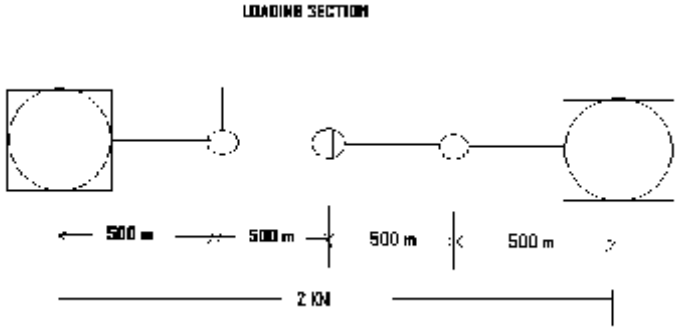
The wiring to the subscriber in telephone networks is generally done in twisted pair cable. It is possible to manufacture this kind of cable to have a 600 Ω characteristic impedance but it will only be this value at one specific frequency. This might be quoted as a nominal 600 Ω impedance at 800 Hz or 1 kHz. Below this frequency the characteristic impedance rapidly rises and becomes more and more dominated by the ohmic resistance of the cable as the frequency falls. At the bottom of the audio band the impedance can be several tens of kilohms. On the other hand, at high frequency in the MHz region, the characteristic impedance flattens out to something almost constant.

1.6.3 Loading of underground cable

The distortion less condition, GL=RC, is not satisfied in usual cables. In telephone cables as the conductors are necessarily of thinner gauge and as the conductors are run side by side, **both the values R and C are large compared to values L and G.** Usually the cables contain a large number of conductors, and the dia of the conductors are necessarily of smaller dimensions and so the value of R is much high. From expression, GL=RC, the capacitance, C value is much higher and inductance, L value is much lower. The L value has to be increased to satisfy the equation GL = RC.

When the diameter of the conductors is increased, the value of R is reduced. This is not possible considering it's size and cost. If the value of G is increased, the transmission loss will be increased which is not be acceptable to a long distance transmission line. Therefore, there is one way to increase the value of GL by increasing the value of L. This is achieved by using the coils of suitable inductance value wound on dust cores are placed in series with the lines at suitable intervals. This is called coil loading or lump loading.

Loading Section of 4/ 6 Quad Cable



1. Loading section– 2000 Mtrs.
2. Normal & Derivation joint -500 Mtrs
3. Condenser joint– 1000 Mtrs.
4. Nomal Joint..

(At present quad cables drum length of 1000 mtrs are in use, hence number of Normal Joints have been minimised)

1.6.4 V.F balancing of underground cable

V.F balancing of underground cable is done to reduce noise and cross talk in cables. This is necessary in 6 Quad Cables because the cables carry a number of important circuits.

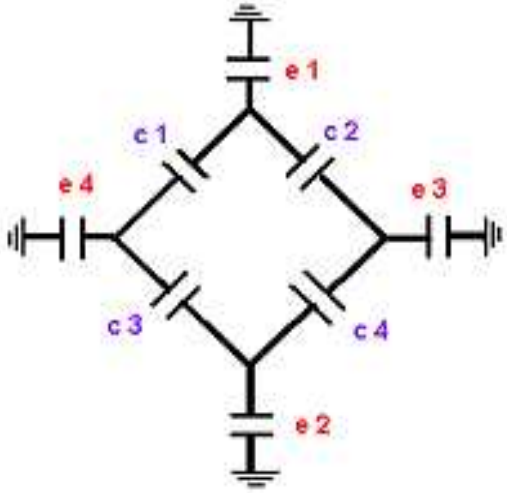
The process of measuring the capacitance unbalances between various quads and earth, within the quad and with adjacent quads and minimising the unbalances by connecting condensers is called V.F. balancing.

Permissible limits of capacitance unbalance for full and half loading sections are 40 pF and 20 pF respectively.

The capacitance unbalance exists between,

a) Conductors of a quad and sheath(Earthed). This is called “Earth Coupling”.
b) Conductors of a quad and between adjacent quads. This is called “Cross-talk Coupling”.

Capacitive couplings causes cross-talk and Earth couplings cause ‘Noise’ in VF circuits.



e1,e2,e3,e4 - earth couplings & c1,c2,c3,c4 - capacitive couplings

1.6.5 Scope

Balancing of cross-talk capacitive couplings between side circuits of a quad and those of adjacent quads and also of earth couplings, namely, the capacitance unbalances between cable conductors and the cable metallic sheath (Earth).

1.6.6 Purpose

In any manufactured length of a cable, the capacitances between conductors of a quad, between conductors of adjacent quads and those between conductors of a pair and the cable sheath (Earth) are not perfectly balanced which gives rise to the capacitive interference between various circuits and the circuits and earth. Balancing of these capacitances is hence necessary to limit the cross-talk and to bring the cross-talk attenuation within permissible values.

In the electrified sections, the capacitance unbalances between cable conductors and the cable sheath (Earth) introduce appreciable noise in the circuits. It is, therefore, necessary to reduce, as much as possible, the noise in the circuits.

(I) Earth Couplings:

el = Capacitance unbalance of side-circuit-1 with respect to sheath (Earth).
e2 = Capacitance unbalance of side-circuit-2 with respect to sheath (Earth).

(II) Cross-talk Couplings within a quad.

K1 = The capacitance unbalance of a side-circuit of a quad with respect to the other side-circuit of the same quad.
K2 = The capacitance unbalance of phantom circuit with respect Pair-1
K3 = The capacitance unbalance of phantom circuit with respect to pair- 2 of a quad.

(III) Between adjacent quads:

K9 = The capacitance unbalance of side-circuit- 1 of quad- 1 with respect to side-circuit 1 of quad -2.
K10 = The capacitance unbalance of side-circuit- 1 of quad- 1 with respect to side-circuit- 2 of quad -2.
K11 = The capacitance unbalance of side circuit- 2 of quad- 1 with respect to side circuit- 1 of quad- 2.
K12 = The capacitance unbalance of side-circuit-2 of quad- 1 with respect to side circuit -2 of quad -2.
Where quad -1 and quad- 2 are adjacent quads.

The capacitance unbalances shall not exceed the values indicated in the Table below:

Capacitance unbalance	For full loading	For half loading
K1	40 pF	20 pF
K9 to K12	40 pF	20 pF

Table : Capacitance unbalance permissible limites

Note: While balancing by connecting balancing condensers the attempt should be to reduce Kl and K9 to K12 values to the maximum possible extent.

Glossary

1. Core: Everything inside the sheath of the cable.
2. Pair: Two wires forming a single circuit, held together by twisting, binding, in Common jacket.
3. Quad: A structured unit employed in cable. A quad consists of four separately insulated conductors twisted together.
4. Unit: A Unit is made up of number of pairs stranded together in layers.
5. Marker Pair/Quad: The conductors having different markings on there insulation to distinguish them from other conductors. The counting and numbering of a pair/quad of a layer commences from the marker pair/quad.
6. Paper-Insulated Cable: Cable in whom the conductors are insulated with a paper ribbon. Either spirally or longitudinally is applied.
7. Plastic-Insulated Cable: Cable in which the conductors are insulated with Plastics, such as polyethylene and polypropylene.

Note: PVC insulated conductors are not referred as Plastic-Insulated Cables.

8. Insulated: A non-conducting material that can offer a high and permanent resistance, for separation from other conducting surfaces to the passage of current.
9. Interference: Any electrical or electromagnetic disturbance, man-made or natural, which causes, or can cause, undesirable response.
10. Jacket: A covering over a cable. It is usually the outer component of a composite sheath.
11. Dielectric: Any material used in a cable that will insulate one conductor from another or from shield.
12. Dielectric Strength: The maximum voltage that a dielectric can withstand with out rupturing. Also called “electric strength” or “break-down strength.

13. Phantom Circuit: A superimposed circuit derived from two suitably arranged pairs of wires called side circuits. Each pair of wires is a circuit itself and, at the same time, acts as one conductor of the phantom circuit.
14. Twisted Pair: A cable composed of two small-insulated conductors twisted together without a common covering.
15. Cable : An assembly of one or more insulated conductors or optical fibers or combination of both, within an enveloping jacket.
16. Underground Cable: A cable installed below the surface of the earth in conduit or ducts.
17. Unit-type Cable: A cable in which the pairs are first formed into bound units and then the units are formed together to make the completed cable.
18. Moisture Barrier: In a cable, the material, usually in the form of an axially laid aluminium foil/polyethylene laminated film, placed immediately inside the sheath. Generally called as Poly Aluminium laminate moisture barrier.
19. Filling Compound (Jelly): It is a water resistance compound. The cable core shall be fully filled with jelly and this will be used in joints also.
19. Sheath: A protective covering made of metals or plastics over the cable core.

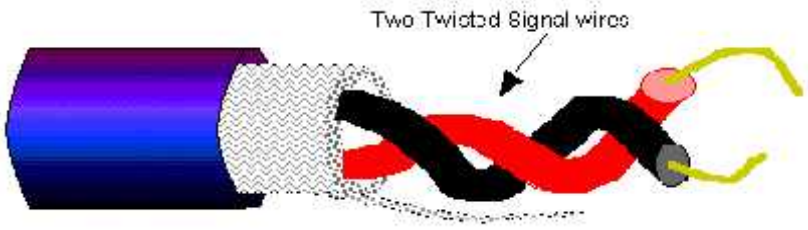
CHAPTER-2

PAIRED TELEPHONE CABLES

2.1 Paired Cables

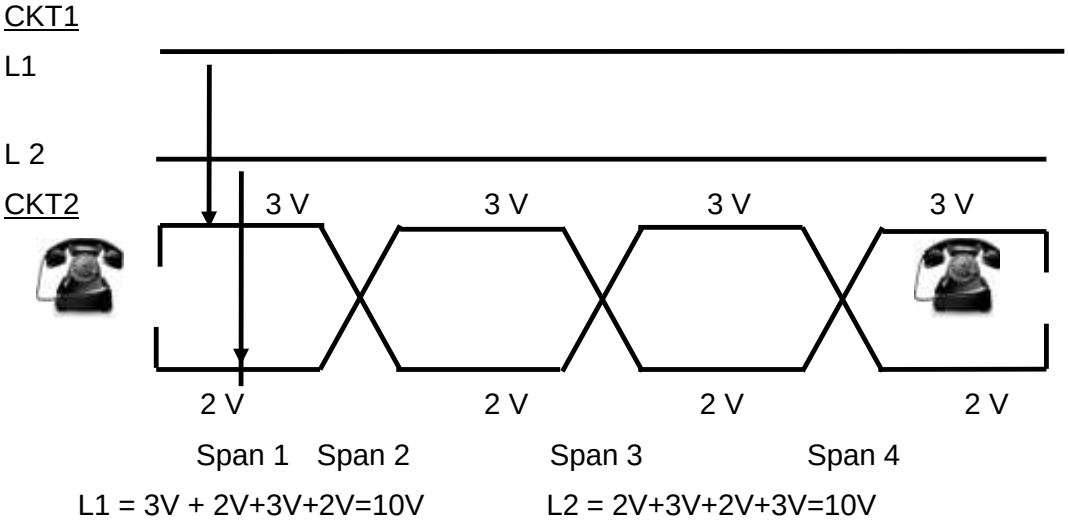
Paired cables are balanced, by using two closely spaced conductors twisted together. The flows of induced emf on both wires are equal hence, no potential difference, no current flow at telephone and no cross-talk from adjacent circuits.

A ground shield is used to prevent high frequency noise and balanced wires also reject noise coming from ground loops.



How Cross Talk is being eliminated in Twisted Pair

Example:



Net induced voltages in CKT 2 on L1&L2 are the same, no potential difference, no current flow at telephone and no cross-talk from adjacent CKT1

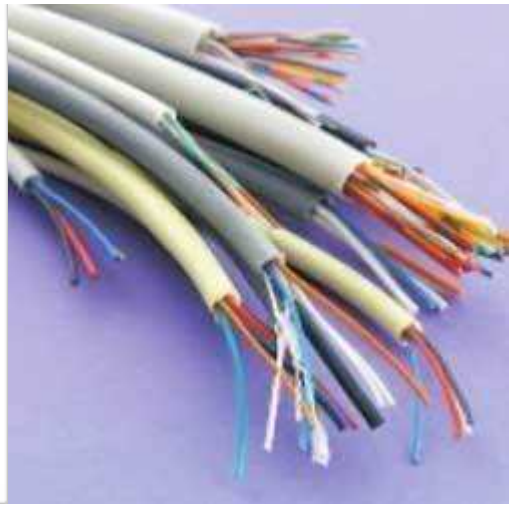
2.2 Types of Paired Cables

Switch board cables	Underground PIJF cables
PVC Twin flat-2 core	
10 pair-0.4/0.5/0.63mm (dia of conductor)	10 pair-0.4/0.5/0.63mm (dia of conductor)
20 pair-0.4/0.5/0.63mm (dia of conductor)	20 pair-0.4/0.5/0.63mm (dia of conductor)
50 pair-0.4/0.5/0.63mm (dia of conductor)	50 pair-0.4/0.5/0.63mm (dia of conductor)
100 pair-0.4/0.5/0.63mm (dia of conductor)	100 pair-0.5/0.63mm (dia of conductor)
These cables are used for Indoor extension	These cables are used for outdoor extension
TEC Spec.No: GR/WIR/06/03 of March 2002	RDSO Spec. No:IRS:TC 41/97 (Amd. 2)

2.3 Telecommunication Switch Board Cables

TEC Specification: GIR/WIR – 06/03 March 02



2.4 Applications in Railways: These cables are used for indoor installation for the interconnection of telephones & electronic equipments, Telephone switching exchanges, Switch board & telephone wiring (MDF, SDH, DWDM, and DSLAM etc.) PDH/SDH systems, RS-232 Communication Systems and Digital Transmission networks.

2.5 Standard make of Switch Board Cables : Delton cables, Reliance cables, Finolex cables, Havells cables *etc.*

2.6 Technical Data

Parameter	Construction	Technical Data			
Conductor	Solid Annealed Tinned Copper in 0.4,0.5 & 0.6 mm sizes.	Conductor dia (mm)	0.4	0.5	0.6
	Max. loop Resistance at 20°C	(Ohms/Km.)	286	184	128
Insulation	Polyethylene. Pairs are Colour coded as per specification.	Min. Insulation Resistance at 50°C/Km. Mega ohm/Km.	50	50	50 5

Capacitance Unbalance	For 200 meter length	in pF (pair to pair) at 800/1000Hz	230	2 230	2 230
Assembly	Pairs/units to laid up to form a round and compact cable.				
Core Wrap	Non-Hygroscopic polyester tape with min. 15% overlap of width of the tape.				
Screening (Optional)	If required, shall be of Aluminium tape. The Al tape of min. 0.04mm thickness and a drain wire of solid tinned copper of 0.125 sq.mm shall be laid parallel touching the Al.surface throughout the length.				
PVC Sheathing	Extruded PVC Type. It will be in Grey Colour.				
Rip Cord	A non-metallic suitable Nylon thread shall be longitudinally placed under the sheath for the removal of sheath.				
Length	Standard lengths of packing : 100 mtrs / 500 mtrs. + or - 5%				

2.6.1 Conductors

Each conductor shall consist of a solid wire of annealed high conductivity tinned copper approximately circular in cross section, uniform in physical, mechanical and electrical properties. The conductor shall be free from spills, splits and defects of any other kind and shall conform to specification IS: 8130.The conductor shall be uniformly coated with tin. Characteristic impedance is 600 Ohms

2.6.2 Insulation

Each conductor shall be insulated with PVC type 2-Hard insulation conforming to IS-5831. The PVC shall be applied by extrusion process and shall form a compact homogenous uniform core. The PVC insulation shall have distinct colour (Single colour or multicolour) for identification of each conductor.

The colour of PVC insulation for the twisted pairs in the Switch Board cable is:

Colour of PVC insulation for identification of 20 pairs cable.(Scheme:1)

Pairs	Conductor-1 Main colour	Conductor -2 Mate Colour	Pairs	Conductor-1 Main colour	Conductor -2 Mate Colour
1	Blue	White.	11	Blue-Orange	White.
2	Orange	White.	12	Blue-Green	White.
3	Green	White.	13	Blue-Brown	White.
4	Brown	White.	14	Blue-Slate	White.
5	Slate	White.	15	Orange-Green	White.
6	Blue-White	White.	16	Orange-Brown	White.
7	Orange-White	White.	17	Orange-Slate	White.
8	Green-White	White.	18	Green-Brown	White.
9	Brown-White	White.	19	Green-Slate	White
10	Slate White	White.	20	Brown-Slate	White

Pair No.	Lead A	Lead B	Pair No.	Lead A	Lead B
1	Blue	White	11	Blue	Black
2	Orange	White	12	Orange	Black
3	Green	White	13	Green	Black
4	Brown	White	14	Brown	Black
5	Slate	White	15	Slate	Black
6	Blue	Red	16	Blue	Yellow
7	Orange	Red	17	Orange	Yellow
8	Green	Red	18	Green	Yellow
9	Brown	Red	19	Brown	Yellow
10	Slate	Red	20	Slate	Yellow

Colour of PVC insulation for identification of 20 pairs cable.(Scheme:2)

For sixty pairs cable, each unit consists of 20 pairs and there are all-together three units. Mate colour of each unit is White, Red and Yellow respectively. The colour scheme of 1st wire of all other units is same as shown above for the first unit.

2.6.3 Twining:

Two insulated conductors shall be uniformly twisted together with a right hand lay which shall not exceed 100mm.Twisted pair shall be laid up to form a compact and symmetrical cable. The lay of any two adjacent pairs shall be so chosen as to reduce the cross talk to the minimum possible extent. The cable core consisting of the required number of twisted pairs shall be stranded in concentric layers. The cable core shall be lapped with polythene tape.

2.6.4 Ripcord:

A non-metallic suitable ripcord shall be laid longitudinally under the PVC sheath. It shall provide an effective means of ripping the PVC sheath longitudinally to facilitate the removal of PVC sheath.

2.6.5 Sheath: The cable shall be sheathed with PVC ..

2.6.6 Identification mark: The PVC sheath shall be prominently embossed on the outside with IRS cable and the name/code of the manufacturer at intervals not exceeding 30cms to enable identification of the cable.

The cables shall be supplied in standard lengths of 100/200/500 meters. A tolerance of + or - 5%of the standard real coil length is permissible.

The cable shall be wound on suitable wooden drums/rolls /coils and shall be strong enough to withstand the stress and strain of transportation and handling.

2.7. Double Drop wire / Twin Flat Wire (IS 434-Part-1/1964)

This wire is used to extend one Telephone connection from outside distribution box to inside the house up to the Telephone instrument. It is available in copper conductor of 0.5mm and 0.9mmdia.The standard lengths of the cable's coil are of 100 Mtrs, 200 Mtrs and 500 Mtrs.
In this wire L1 and L2 are separated by PVC insulation to prevent short circuit.

2.8. Field Service (FS) Cable (IS-694-Part /1964)

This wire is used to extend telephone connection from outside DB to telephone instrument for outdoor applications. During emergencies like Railway accidents, Floods, Cyclones, etc., this cable is extensively used to provide temporary connections of the telephones as per requirement. This is single core twin twisted of size 7/0.375mm. Out of 7 strands three strands are steel and four strands are copper with single PVC core called as L1. One more length has to be taken as L2. This is available in length of 500Mtrs. and 1Km drum lengths. Steel strands will provide additional mechanical strength. This FS cable is also called as D8 Cable.

2.9. Data Communication Cables

For data communication, two types of cable are used for LAN network:

i. UTP : Unshielded twisted pair
ii. STP : Shielded twisted pair

2.9.1 UTP Cable

This type of cable used in I.E.E.E (Institute of electronic and electrical engineering) 10BaseT Ethernet LANs. UTP wire offers an economical alternative for both Ethernet and Token ring networks.

This cable is less expensive than shielded twisted pair, less bulky and is also easier to work with. It is, limited to segments no longer than 100 meters and generally does not transmit as fast as its shielded relative. Unshielded twisted pair cabling comes in different grades that are assigned to six standard categories created by the Electronic Industries Association and the Telecommunications Industries Association (EIA/TIA).

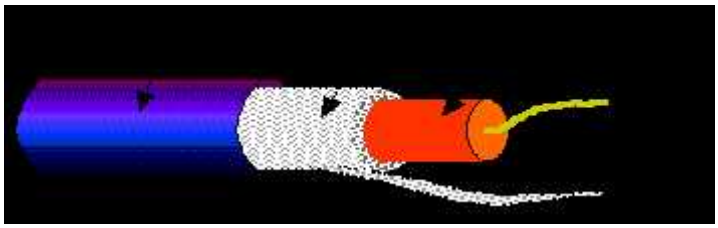
1. Category-1 covers voice grade UTP i.e, it carries voice but not data. This is typical telephone cable.(0.5 or 0.63mm in dia)
2. Category-2 covers data grade UTP that transmits at up to 4 Mbps. This type of cable is used in some ring topologies.
3. Category- 3 covers data-grade UTP that transmits at up to 10 Mbps. This is the cable required for 10Base T Ethernet.
4. Category-4 covers data grade UTP that transmits at up to 16Mbps. This is used in some Token Ring networks.
5. Category- 5 covers data grade UTP that transmits at up to 100Mbps. This is the type of cable required for 100Base X Ethernet based on twisted pair wiring.
6. Category- 6 This is a standardized cable for Gigabit Ethernet Compared with Cat 5 and Cat 5e, Cat 6 features more stringent specifications for crosstalk and system noise. The cable standard provides performance of up to 250 MHz and is suitable for 10BASE-T, 100BASE-TX (Fast Ethernet), 1000BASE-T/1000BASE-TX (Gigabit Ethernet) and 10GBASE-T (10-Gigabit Ethernet).

Conductor: Each conductor is made up of annealed copper of dia. 0.5mm.and PVC insulated.
USE: UTP cable is connected with the connector known as RJ-45 and IO box. Eight no. of wires are connected to these RJ 45 connector or IO box. Thick Ethernet cable is also used to connect 15-pin connector known as DB-15 or DIX **.**

2.9.2 STP Cable

For high-speed data, the STP cables are used. The application of this cable is widely found in SDH rack wiring. In this cable each twisted pair is shielded and an earth wire is drawn along with it. Ten twisted pairs are to be bundled together and enclosed in a protective jacket to form a thicker cable. Below the jacket a tape of aluminium foil is used as a screen. Each conductor is made up of annealed copper of 0.9mm.or 0.6mm dia. and PVC insulated.

2. 10. Coaxial Cable



Coaxial cable often called coax is the round and flexible cable. Four separate elements are identified, by the cross-sectional view. In the center there is a copper wire, carrying the signal. Encasing this wire is a layer of non-conducting insulation made up of PVC or Teflon. Outside the insulation, forming a protective sleeve around the conducting wire and its insulation, another layer made up of a braided mesh of copper or Aluminium. This layer protects the transmitted signal from the electromagnetic interference known as noise that can distort the transmitted signal. Finally outside the braided sleeve is an outer shield or jacket, made of either PVC or a fire resistant material such as Teflon.The coaxial cable comes in various forms for networking

a. Thin Ethernet or thin wire: Ethernet is based on the 3/8-inch coaxial cabling known as RG-58. This Thinned cabling can carry a signal for about 185 meters. Above this the signal begins to degrade.

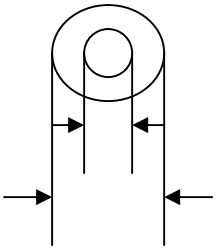
Thin Ethernet LANs Coaxial cable is connected with the BNC (Bayonet Neill Concelman) connector to make connection with the equipment.

b. Thick Ethernet: is based on less flexible coaxial cabling about ½ inch thick. Also known as RG-8. Thick net cabling can carry signals farther than Thinned cabling about 500meters and thus is often used as the backbone connecting.

2.11. RF Coaxial Cable

The co-axial cable radiates the least power and picks up interfering signals to the least degree. The usual impedances are 40-50 ohms and 70-80 ohms, so the diameter remains reasonably small. The optimum conductor diameter ratios for different transmission line properties will vary from one to infinity, if the outer diameter “D” of the outer conductor is kept constant and inner diameter “ d’” is varied.

Cross sectional view of co-axial cable



A single compromise ratio is also desirable for certain fields of use because it simplifies manufacturing and merchandising problems. These considerations have led to standardization, in effect, of a single co-axial conductor diameter ratio for high frequency and microwave application. This ratio (2.3) results in a nominal characteristic impedance of about 50 ohms. The medium between conductors is assumed to be a gas.

CHAPTER-3

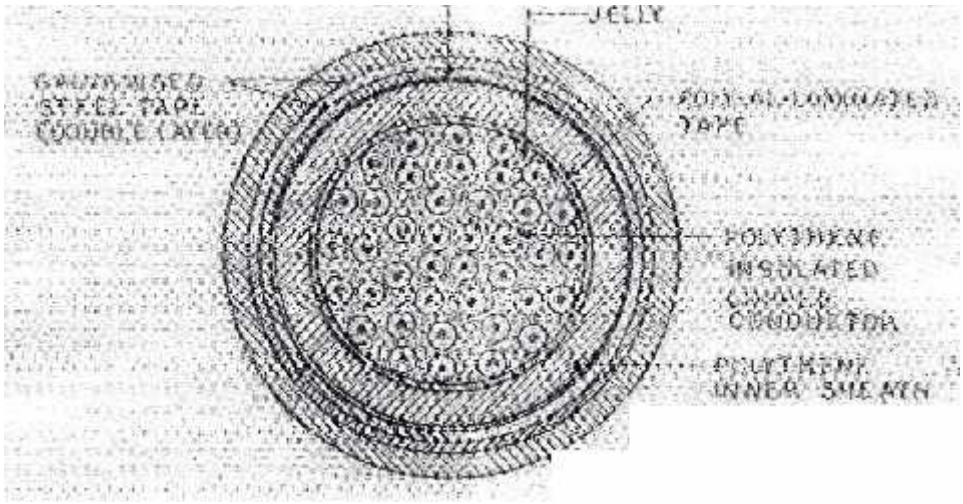
UNDER GROUND PIJF CABLES

POLYETHYLENE INSULATED, POLYETHYLENE SHEATHED, JELLY FILLED, UNDERGROUND CABLES (ARMOURED or UNARMOURED)

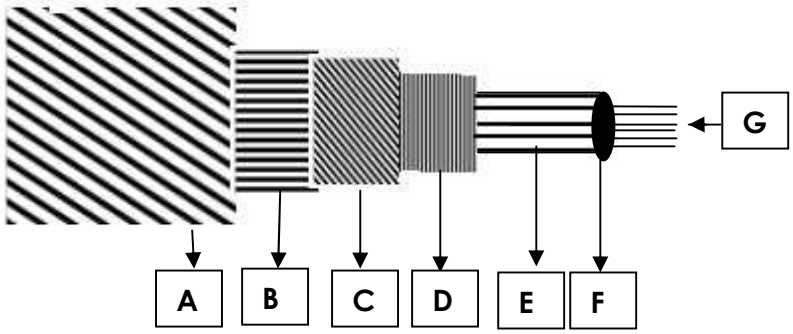
3.1 Introduction

PIJF telephone cables are widely used in Railways for local loop and other networks due to improved technology and simplicity in installation and maintenance.

Indian Railway Standard specification for Polythene insulated polythene sheathed jelly filled telephone. cable with Poly-Al Moisture Barrier is IRS-TC: 41/97 (RDSO spec)



Cross section of PIJF Telephone Cable



A : Polythene Outer jacket **B** : Galvanised Steel Tape **C** : Polythene Tape
D : Polythene Inner sheath **E** : Poly-Al-Laminated Tape
F : Core wrapping (Polyester) tape **G** : Polythene Insulated Copper Conductor

Construction of PIJF Telephone Cable

3.2 Brief Description

Jelly filled cable is an underground cable having polythene as insulation on conductors and the inter-spaces between the conductors is fully filled with petroleum jelly. Petroleum jelly prevents ingress of moisture and water inside the core in the event of any damages to the cable. The Cable is circular throughout its length and is free from any physical defects.

Jelly filled cable is wound on strong wooden drums. The length of cable on any drum is of 500 / 1000 meter + 10% unless single longer lengths are specified by purchaser for specific application. The diameter of the yoke of the drums is not be less than 20 times of the overall diameter of the cable. Both ends of the cable is kept inside the drum to get access to the cable ends battens are is painted by red colour arrow.

Number of pairs: The cable shall be of different sizes varying from 10 to 200 pairs and above with nominal conductor diameter 0.5mm or 0.63mm or 0.9mm.The Standard cable sizes shall be 10,20 50 100 and 200 pairs armored / unarmored.

Conductor: Each conductor shall consist of a solid round wire of annealed high conductivity copper, smoothly drawn, normally circular in section, uniform in quality and free from defects.

Insulation: Conductor insulation shall be polythene insulating grade and 100% virgin material as per ASTM (American Society for Testing and Materials) -D883.

Twining/Pairing: Two insulated conductors shall be twisted together with uniform lay to form a pair. The length of the lay of any pair shall be different from the adjacent pairs. The lay of various pairs shall be so chosen as to satisfy the capacitance unbalance.

Filling compound: (Petroleum Jelly): A cable core shall be fully filled with suitable water resistant compound like jelly, which is fully compatible with the polyethylene insulation, binders, and tapes used in the cable.

Core wrapping: After application of water resistant filling compound, a closed helical or longitudinal lapping of a non hygroscopic and non wicking polyester tape or tape of any other suitable materials shall be laid over the cable core.

Poly-Al Laminate moisture Barrier/Screen: Polythene coated aluminium tape shall be applied longitudinally on the core with a minimum over lap of 6mm. Thickness of the aluminium tape shall be 0.2mm + or –10% and that of polythene/ co-polymer coating on each side 0.05mm nominal. Thickness of composite tape shall be 0.3mm + or - 15%.

Sheath: Cable shall be sheathed with polythene and containing a suitable anti oxidant system. The material shall be virgin and meet required specification. The sheath shall be reasonable circular and free from pin holes joints and other defects. The thickness depends on the size of cable.

Armour: The sheathed cable shall then be armoured with two applications of galvanized steel tape conforming to IS: 3975 each applied helically in the same direction with gap in the first tape of 25% + or – of the width of the tape, the second tape evenly covering the gap of the first tape. Thickness of the galvanized steel tapes used in two applications including zinc coating on each tape shall not be less than 0.5mm.

Jacket: The armoured cable shall be tightly jacketed with polythene conforming to the requirements as specified for sheath.

3.3 The colour code of conductors:

In 5 pair,10 pair, 20 pair cable, colour code specified as below in para 3.4

Stranding: A 50 pair cable consists of 5 numbers of 10 pair units

A 100 pairs cable consists of 5 number of 20 pair units.

3.4 Colour Code Scheme of 20 pair Under Ground cable

Pair	1st Wire Main colour	2nd Wire Mate colour	Pair	1st Wire Main colour	2nd Wire Mate colour
1	Blue	White	11	Blue	Black
2	Orange	White	12	Orange	Black
3	Green	White	13	Green	Black
4	Brown	White	14	Brown	Black
5	Grey	White	15	Grey	Black
6	Blue	Red	16	Blue	Yellow
7	Orange	Red	17	Orange	Yellow
8	Green	Red	18	Green	Yellow
9	Brown	Red	19	Brown	Yellow
10	Grey	Red	20	Grey	Yellow

3.4 The colour code scheme of polythene insulated cables

Blue, Orange, Green, Brown & Grey are called as main colors. White, Red, Black and Yellow are called mate color. The five pairs make one unit. In this way there are four units in twenty pair's cable. A cable of 50 pairs and 100 pairs, the twisted pairs shall be arranged in units of 10 pairs and 20 pairs respectively. 4 No of 50 pairs super unit shall be assembled to form a 200 pair cable.

Colour of binding tape: The different colours of the binding tape shall be used for identifying each unit as given in Table 3.4

Unit number	1	2	3	4	5
Colour binder	Blue	Orange	Green	Brown	Gray

Table 3.4 Colour of binding tape

3.5 Application: These cables are used for in transmission and distribution of networks designed to use in underground, not inside the water. 0.5 mm conductor diameter are used for short distance distribution network, cables having 0.6 mm. conductor diameter are used for long distance networks.

In Railways Polythene Sheathed Jelly Filled Cable with Ploy-Al moisture barrier is used for providing telephone connections to the subscribers and local lead / last mile connectivity of various circuits of both voice and data. These PIJF cables will be used in both RE and non RE area depends upon application.

Where as in RE area the usage of PIJF telephone cable may be limited to maximum of 2 Km length due to induced voltage effects.

3.6 Technical Data

Parameter	0.51 mm dia conductor	0.63 mm dia conductor
Conductor resistance (20 C)	92 Ohms/Km	64 Ohms/Km
Loop Resistance of pair(20 C)	184 Ohms/L.Km	128 Ohms/L.Km
Insulation resistance (500 V Megger)	5000 M Ohms/Km	5000 M Ohms/Km
Mutual Capacitance (800 Hz)	52 nF/Km	50 nF/Km
Operating Voltage	300 V	300 V
Attenuation at 800/150 KHz	0.4 / 8.25 dB/Km	0.4/6.3 dB/Km
Min. Bending radius	15 X Cable diameter	15 X Cable diameter
Weight	1.83 Kg/Km	2.81 Kg/Km
Application	Up to 5 Km for Sub. loop	5 to 10 Km for Sub. loop

3.7 Advantages of Polythene Insulated Jelly Filled Cables.

1. Counting of pairs is easy and human mistakes are avoided.
2. Jointing is easy and require no additional place.
3. Failures are less.
4. Entry of moisture / water is prevented by Jelly in the core.
5. Cables can be directly terminated on MDF/CTB/Tag Block/Equipments, thus avoiding additional joints decreasing the cost and time.
6. Handling of cable is easy not delicate like paper insulated cables.
7. Life of cable is more.

3.8 Marking on Cable

To enable proper identification of the cable, the following information is embossed, engraved or printed on the polythene jacket in case of armoured cable, and on the sheath in case of un-armoured cable. All the marking is in white or yellow colour.

a) Name/Trade mark of the manufacturer
b) IRS Specification number
c) Year of manufacture
d) Length (Sequential marking)
e) Cable drum number
f) No. of pairs/conductor size (Example: 20 pairs/0.63mm)

This marking exists throughout the length at intervals of one metre.

CHAPTER-4

EFFECTS OF RAILWAY ELECTRIFICATION ON TELECOM CIRCUITS

4.1 Effects of 25 KV 50 Hz AC Traction on Telecommunications

In the system of electric traction adopted by the Indian Railways, the catenary wire is fed at 25,000 V, 50 c/s, and single phase. The rails are being employed as the return conductor. Such an arrangement while resulting several advantages in respect of power transmission and traction engineering, the power feed being inherently unbalanced, produces certain undesirable effects on communication circuits in the neighbourhood of the tracks, rendering them unsafe and unworkable.

4.2 Mechanism of Induction

The mechanism of induction from the 25 KV AC traction system is due to electrostatic coupling and electromagnetic coupling.

4.2.1 Electrostatic Coupling (Capacitive coupling)

Electro static induction:- cable conductor insulated from earth and situated in this field will get charged to certain potential with reference to the earth due to capacitance coupling. The magnitude of this potential depends on the catenary current and distance between track and conductor.

- With the catenaries maintained at 25,000 V an electric field is created in the vicinity of the tracks.
- An electric conductor, such as a communication wire insulated from earth and situated within this field will get ‘charged’ to a certain potential with reference to earth due to capacitance coupling.
- The magnitude of this potential depends on the voltage of the catenary and distance.

4.2.2 Electromagnetic Coupling

Electromagnetic induction:- Due to vicinity of AC Traction and length of parallelism, the currents flowing in the Catenaries return to the feeding point via Rails, the rails are not specifically insulated from the earth therefore some portion of currents field a path or induces emf in cable sheath and conductors. It is Dangerous to working people and Equipment.

- The currents flowing in the catenary returns to the feeding point via the rails.
- The rails are not specifically insulated from the earth, therefore, provides an alternate path for the currents.
- Some portion of this current penetrates deeply into the earth, to find a path in other rails, cable sheaths, metal pipes and similar conductors parallel to the track.
- Near the feeder points the whole of the current must return to the secondary windings of supply transformer.
- The current in the catenary is the source of an alternating magnetic field.
- This field cuts any conductors parallel to the track and induces e.m.f.’s in them.
- The catenary system acts like a primary winding and each other parallel conductor acts like the secondary winding of a transformer.

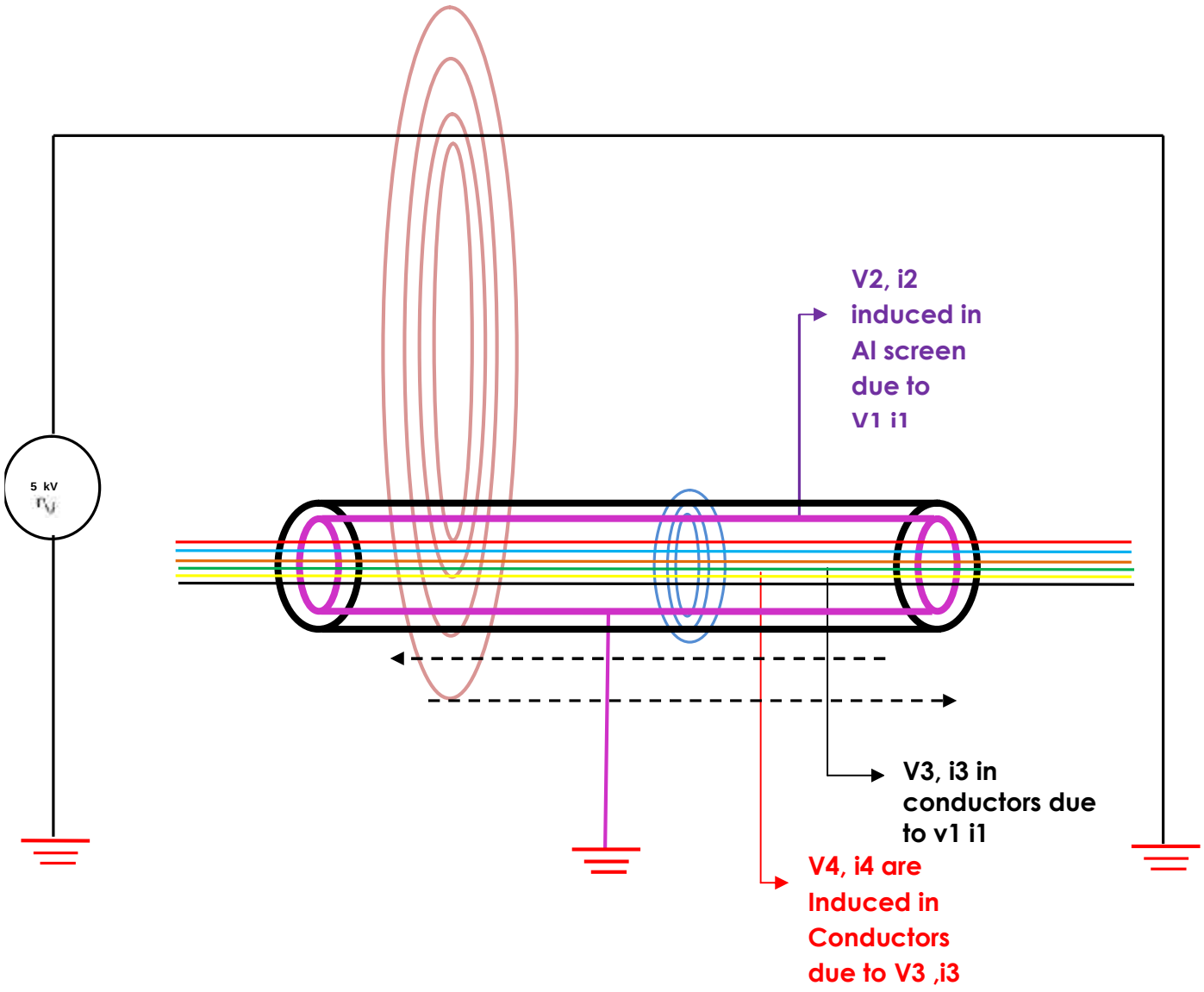
Therefore, from the above, it should be evident that the inductive interference constitutes a hazard to personnel using or working on the lines as also to the connected equipment. The induced voltages also seriously interfere with the signalling arrangements on the telecommunication circuits causing them to be unworkable. Apart from the induction at the fundamental frequency 50 c/s another source of trouble is on account of the harmonic components of the catenary currents.

4.3 Screening factor

The reduction in induced voltages that is effected by the various conductors parallel to the catenary system is expressed by saying that each such conductor has a screening factor. This is defined as follows: -

Screening factor, K is the ratio of Voltage induced into the conductors of the cable core in the presence of the metallic sheath of the cable to which the screening factor refers **to** voltage that would be induced to the conductor of the cable core if the metallic sheath of the cable to which the screening factor refers, is absent.

- It follows from this definition that the screening factor is normally less than unity.
- Generally this value is as low as possible.
- The screening effect of current is the consequence of the magnetic field produced by current in that conductor (sheath).
- This conductor (sheath) can only provide a screening factor when it is carrying current. To achieve, it must be a part of complete circuit.
- By considering the screening effect of a cable sheath, clear distinction should be made between "the voltage of the core to the sheath," and “the voltage of the core to earth".
- If the sheath is insulated from earth, identical voltages are induced in sheath and core, the voltage between them is zero.
- At the same time the sheath does nothing to reduce the voltage between core and earth.
- To do this the sheath must carry a return current, the field of which opposes the field induced by the current in the catenary.
- To carry such current the both ends of the sheath have to be earthed.
- According to the above mentioned phenomenon, it is very clear that, an induced voltage developed due to the difference of primary & secondary magnetic fluxes in the cable conductors as shown in fig. shown below.



4.4 I.T.U-T. Recommandations

- Recommendations on permissible voltages, calculating method and protective measures have been issued by the **I.T.U-T.**
- Accordingly the following voltages may not be exceeded in the circuit formed by cable conductors and ground.
  a) As regards electrostatic induction, the critical figure recommended by the **I.T.U-T** is 15 mille amperes current.
  b) When a person is in contact with both the earth and with the conductor of a telecommunication line. During the normal functioning of the power line, or electric traction system, the longitudinally induced voltage in the telecommunication circuits should not exceed 60V.
  c) During the abnormal functioning of traction power line, the longitudinal induced voltage shall not exceed more than 150 Volts.
  d) During traction power line short circuit condition, the induced should not exceed more than 430V rms.

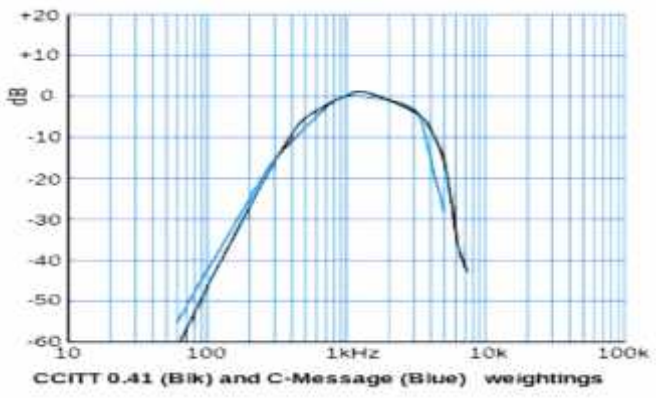
e) As regards interference to speech transmission, the psophometric voltage in the communication circuits should not exceed 2mV.

- By the way of sectionalising all the communication circuits to break the metallic continuity of the conductors to prevent cumulative build up of induced voltages with the introduction of isolating transformers at every 17 Km on long distance communication networks and adoption of special maintenance precautions.
- The cables to be laid along the tracks should have aluminium sheath and steel tape armouring so as to have a screening factor of less than 0.1 in the anticipated range of magnetic field intensity.

4.5 Psophometric noise

• When cable is in close proximity to strong electromagnetic fields, unwanted current and voltage may be induced on it. If the power level is high enough, the electrical "noise" can interfere with voice and data applications running on the cabling. In data communication, excessive electromagnetic interference (EMI) hinders the ability of remote receivers to successfully detect data packets. The end result is increased errors, network traffic due to packet retransmissions, and network congestion. For analog voice communication, EMI can create psophometric noise, which degrades transmission quality. This will be measured with psophometric meter.

• Psophometric voltage readings, *V*, in mill volts, are commonly converted to dBm (psoph) by dBm (psoph) = 20 $\log_{10} V$ - 57.78.



Psopho curve

4.6 Effects of 25 KV 50 Hz AC Traction on Telecommunication cable may be reduced by

- Changing over Overhead system to Under Ground Cables.
- It is consider that a normal field strength of 87.5 V/Km exists in vicinity of telecom cable .

This induces a voltage of 8.75 V/Km in each wire of cable ,because of its screening factor is 0.1. As cable length increases this voltage also increases proportionately. If this longitudinally induced voltage exceeds 150 V the safety of working personal and equipment becomes hazardous as per the recommendations of ITU-T. It is essential to isolate all circuits from induced voltage, so that its value will not raise above 150volts. For that divide 150V by per-kilometer induced value i.e., 8.75V/Km of the cable, gives 17 Km of max. permissible length for cable circuits. Hence, Isolating circuits are providing physically by Isolation Transformers at distance of 17 Km on each circuit at cable Hut. By doing this accumulation of induced voltage on the cable pairs is brought to Zero.

- Provision of Earthing and SPD‘s for all telecomm Equipments as per RDSO guidelines.
- By using Aluminum Sheathed/Screened cables which are having good screening factor (0.1).
- Screening factor is the ratio of voltage induced in presence of metallic sheath and voltage induced in the absence of metallic sheath.

4.7 Precautions to be taken for protection of staff and equipment in 25 KV 50 Hz AC traction territory.

Precaution are required on account of the following.

1. Proximity of Live Conductor
2. Pressure of return current in rails.
3. Induction in all metallic bodies situated close to overhead equipment.

Precautions to be taken are :-

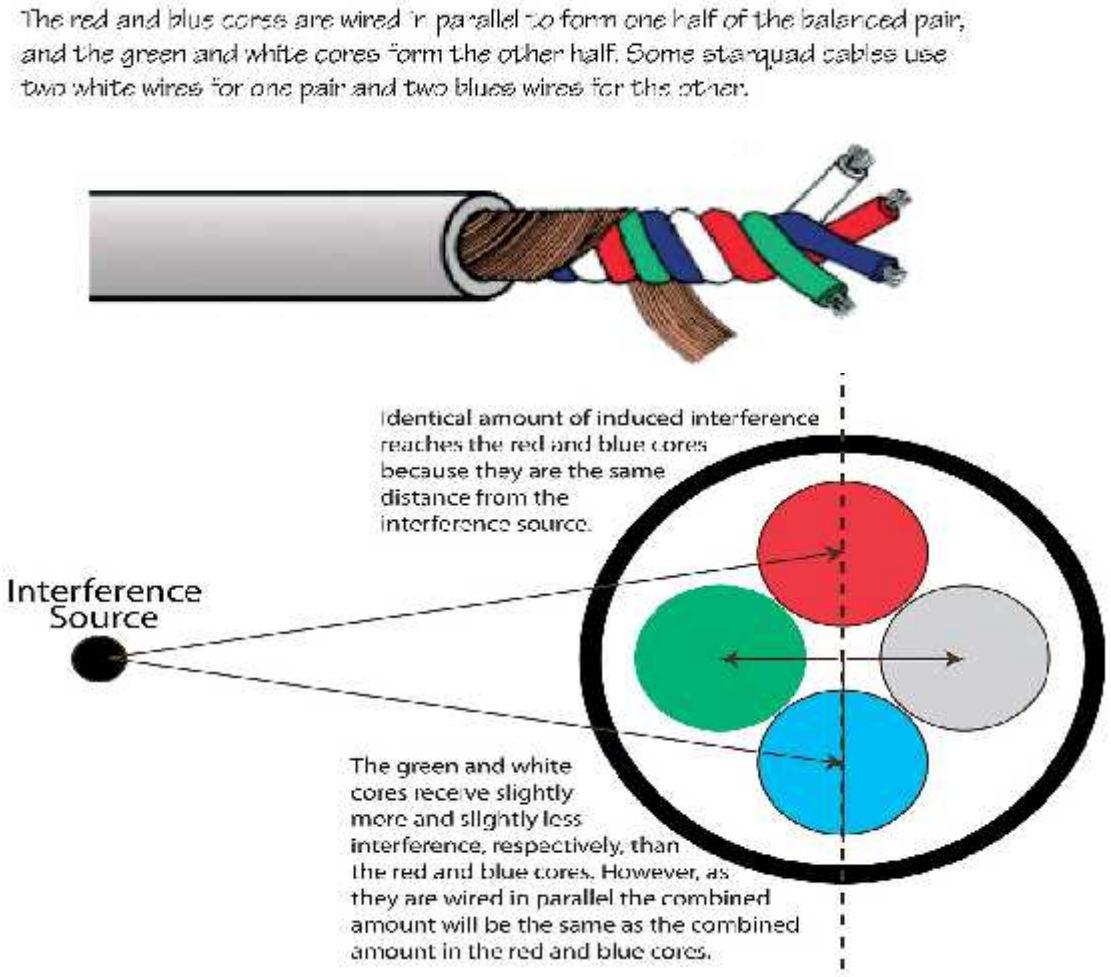
1. Use Insulated Tools.
2. Use Rubber Gloves.
3. Use Rubber Mats.
4. Before cutting the armour or sheath of cables an electrical connectivity to be established between two ends of the cable through an external wire.

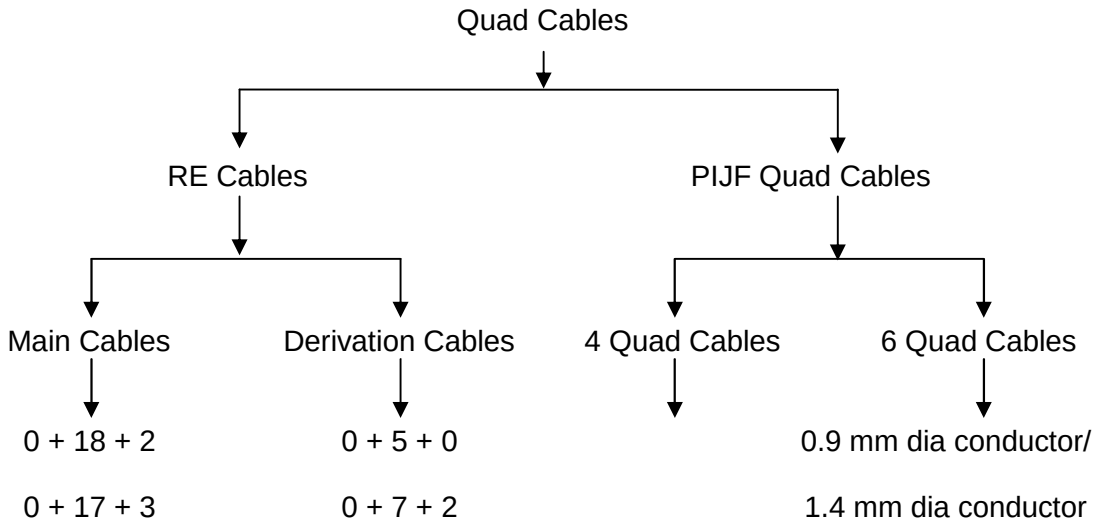
CHAPTER-5

TELECOM QUAD CABLES

5.1 Introduction: At the time of conversion of Non RE Area into RE(Railway Electrification) Area of 25KVAC Traction Line, the Underground Quad Cables are utilized in place of Over-Head transmission line of metallic wires to avoid the effect of induced EMF on Over Head Alignment running parallel to the electrified traction lines. The existing PIJF cables are not fit for long distance communication; hence underground quad cables have been introduced. These underground Quad cables work excellently for good quality of speech. In non RE area the Telecom circuits are working on Over Head ACSR wires and its over all dia of the line wire is 4.5 mm with 0.038 dB loss per Km. The long distance Telecom networks on ACSR wire were working on 2 wire since no amplifier is used upto the length of 350-400 Km of Telecom network. Because of tremendous induced voltage effects in Railway Electrification area the Telecom networks are changed to screened under ground quad cables. Here the dia of the under ground quad cable conductor is 0.9 mm with the loss of 0.63 dB per Km for unloaded cable and 0.25 dB per Km for loaded cable, due to this high attenuation of the conductors in cable, the amplification of the speech and signal became essential at every 40-50 Km length of cable section. Hence, 2 wires for Trans and 2 wires for Receive are used for amplifiers, totally four wires are used known as quad and circuit is modified as 4 wire circuit in RE area.

“STAR QUAD” is Four conductor balanced cable, four wires form a tighter, more consistent pack then two wires can and can resist even more noise.



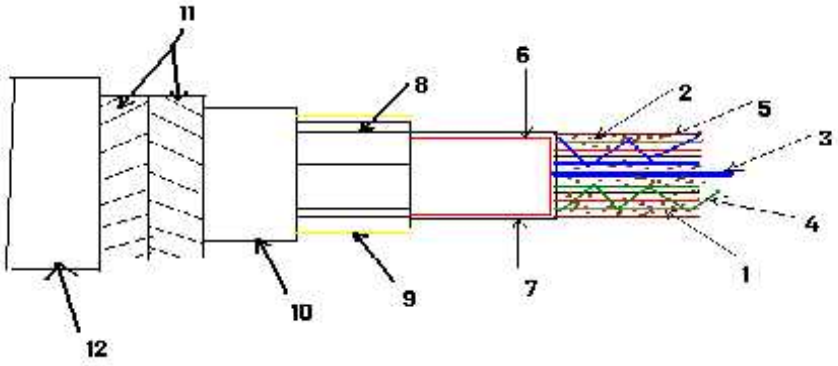


RE Cable

These RE Main Cables were specially designed for long distance communication networks in Railway Electrified areas. This cable is combination of Paper and PVC insulated quads. Being paper is a very good insulator, these paper insulated quads are used for long distance Telecom circuits such as Section Control (CTO), Dy Control, Traction Power Control (TPC), Traction Loco Control (TLC), Remote Control (RC) and Emergency Control(EC). PVC insulated quads (PET) are used for signalling applications such Block, IB etc. In present scenario the RE cable is phased out due to its limited bandwidth with limited route diversity and introduction of OFC with 4 quad /6 quad cable. All the long distance Voice Frequency (VF) circuits as mentioned above are transferred into OFC network and existing signalling circuits, such as Block, BPAC, IB, TAWS and Telecom circuits such as LC gate communication, EC sockets are working in 4 quad/6 quad underground cable. In addition to this, data circuits such UTS/PRS, FOIS, Railnet, MIS, MMIS and Telephony trunking etc., are switched over to OFC network.

The 4/6 quads Jelly filled cable of IRS-Specification No- 30/2005 version-2 (0.9mm dia conductor) affected from 1/1/2006 has been introduced. In addition to this, 1.4 mm dia copper conductor underground Railway jelly filled 6 or 4 quad cables for Signalling & Telecom installations have been introduced by RDSO under specification no: RDSO/SPN/TC/72/07 for long (more than 25 Km) distance Block sections.

5.2 Construction of PIJF Quad cable



1. Conductor, 2. Petroleum jelly, 3. Dummy tube, 4. Binder, 5. Polyester tape
6. Poly aluminum tape, 7. PVC inner jacket, 8. Aluminum wire/tape screen
9. Woven tape (yellow colour), 10. PVC intermediate jacket, 11. G.I. Steel armour
12. PVC outer jacket

5.2.1 Polythene Insulated conductor

The conductor is composed of plain annealed high conductivity copper wire. The conductor is circular in cross-section, free from splits, cracks and corrosion. Each conductor is insulated with solid polythene. The insulation is applied closely and homogeneous on the conductor. The insulation resistance between each conductor shall not be less than 5000 Mega ohms per kilometre at room temperature.

5.2.2 Jelly

The cable core is fully filled with a water resistant compound of jelly which is fully compatible with the polythene insulation of the conductors.

5.2.3 Polyester Tape

After application of the filling compound a close helical or longitudinal lapping of a polyester tape is applied over the cable core. The tape is impregnated or flooded with jelly.

5.2.4 Poly Aluminium Moisture Barrier

Polythene coated aluminium tape is applied longitudinally on the core with a minimum overlap of 6mm.

5.2.5 Inner Sheath

Cable is sheathed with polythene. Sheath is circular, free from pin holes, joints and other defects.

5.2.6 Screen

The cores with inner sheath is surrounded by a reasonably close fitted screen of aluminium in the form of wires/strips.

5.2.7 Woven Tape

The aluminium screen is wrapped with a single layer of woven tape impregnated with barium chromate to protect screen from oxidation.

5.2.8 Intermediate Sheath

Further protection for the screening is provided by extruded PVC circular sheath over screening. The colour of this intermediate sheath is grey.

5.2.9 Armouring

The galvanised steel tape armouring is applied tightly over the intermediate sheath with two layers. The direction of the lay of the armour is opposite to that of the outer most layer of screening.

5.2.10 Outer Sheath

The outer sheath is applied over the armouring. The colour of this outer sheath shall be black.

5.3 Colour Code scheme for PIJF Quad Cable

5.3.1 4-Quad cable

The colour code scheme of 4 Quad polyethylene-insulated quads

Quad No	Colour of insulation of conductor				Colour scheme of the quad whipping
	A-Wire	B-Wire	C-Wire	D-Wire	
Quad 1	Orange	White	Red	Grey	Orange
Quad 2	Blue	White	Red	Grey	Blue
Quad 3	Brown	White	Red	Grey	Brown
Quad 4	Green	White	Red	Grey	Green

5.3.2 6-Quad cable

Colour code scheme of conductor insulation of 6-Quad cable

Quad No	Colour of conductor insulation				Colour scheme of the quad whipping
	A-Wire	B-Wire	C-Wire	D-Wire	
Quad 1	Orange	White	Red	Grey	Orange
Quad 2	Blue	White	Red	Grey	Blue
Quad 3	Brown	White	Red	Grey	Brown
Quad 4	Green	White	Red	Grey	Green
Quad 5	Yellow	White	Red	Grey	Yellow
Quad 6	Black	White	Red	Grey	Black

Wire A and B shall form a pair and similarly Wire C and D shall form another pair. Conductors are diagonally opposite forming one pair and the remaining two diagonally opposite conductors forming the second pair of the quad. The quad shall be held together firmly by means of an open helical whipping of nylon yarn or coloured tape of suitable material of appropriate thickness.

5.4 General specification of 4/6 Quads cable

Sl.No.	General Specifications	0.9 mm dia conductor	1.4 mm dia conductor
1	Characteristic impedance at 800 Hz	470 Ohms (Unloaded) 1120 Ohms (Loaded)	310 Ohms (Unloaded)
2	Max. Loop Resistance	56 Ohms / Km	23.2 Ohms / Km
3	Insulation resistance of the PET Quad measured with 100V DC. Megger	>100 M Ohms / Km	>100 M Ohms / Km
4	Transmission loss in VF range	0.63 dB/Km. (Unloaded) 0.25 dB/Km. (Loaded)	0.3 dB/Km. (Unloaded)
5	RDSO spec.	IRS:TC: 30/2005 ver.2	RDSO/SPN/TC/72-07

5.5 Specifications of 6Quad Cable

RDSO spec. no: IRS-TC 30/2005 Ver. 2. (w.e.f:1-1-2006)

1. Loop resistance: 56Ω/L.Km
2. Transmission loss: 0.25 dB/L.Km (loaded), 0.63 dB/ L.Km (un loaded)
3. Impedance: 470 Ω (unloaded) / 1120 Ω (loaded)
4. Insulation resistance: >100 MΩ /Km with100V Megger
5. Conductor diameter nominal : 0.9 mm
6. Minimum diameter of insulated conductor : 1.5 mm
7. Thickness of PVC outer sheath : 2 mm
8. Thickness of G.I. Armour tape : 0.8 mm
9. Thickness of PVC intermediate sheath(Grey colour) : 1 mm
10. Thickness of inner PVC sheath: 2 mm
11. Thickness of Aluminum tape: 0.2mm±10%
12. Aluminum wire screen dia of each wire1.4 mm (36 No of wires)
13. Mutual Capacitance of the pair: 50 pF/Km.

5.6 Present Status of 6 Quad Cable System used in various Railways

1. Conventional 6 quad cable system with loading, balancing and V.F repeaters at regular intervals of 40-50 Kms.
2. Equalizer Amplifier System at all stations with unloaded 6 quad cable, balancing of cable at the stations.
3. 6 Quad cable with OFC.

5.7 Quad cable along with OFC / without OFC.

The Railways are presently following two schemes of laying 6 quad underground Telecommunication Quad cables as under:

a) 6 Quad cable only b) 6 Quad cable along with OFC

Where the section is non-RE area only 6 quad cable was used for Train operational communication arrangements. However, additional Signalling sub-systems like BPAC, TAWS, IB Phone to improve safety and reliability are gradually being integrated into the Signalling systems. Railway board have considered this emerging need and decided that 6 quad cables shall be provided along with OFC in all future works on sections where communication based Signalling schemes are being planned.

5.8 Guidelines for use of Optical Fibre System and 6 quad cable on various routes in Indian Railways.

(a) New Railway Projects – Gauge Conversion/New lines/Doubling/Railway Electrification.
On A, B, C, D & D Spl Routes, following configuration should be used.
24 Fibres Optical Fibre Cable (as per RDSO Specification IRS.TC.55/ or latest) with Six Quad cable (as per RDSO Spec. IRS.TC30/2005 or latest).

(b) Replacement of existing overhead /RE quad cable for control communication.
(i) Existing RE Telecom Cable, whenever it is due for replacement on age cum condition basis, it should be replaced by Optical Fibre System with 6 quad cable
(ii) Existing Overhead alignment on A, B, C & D-special should be replaced with Optical Fibre System with 6 quad cable.

Tentative Quad allocation of a 6 Quad Cable, when laid along with OFC or without OFC is as under:

a) 6 quad cable with OFC

Quad No	Name of the circuits
1	**Block Circuit**
2	Spare
3	**Emergency Control**
4/1	LC gate telephone
4/2	BPAC
5	**BPAC**
6	TAWS

b) 6 quad cable without OFC

Quad No	Name of the circuits
1	**Block Circuit**
2	Section Control
3	**Emergency Control**
4/1	BPAC
4/2	LC gate telephone
5	**BPAC**
6	TAWS

Quad allocation of 6 quad cables

5.9 Difference between PIJF underground Paired and Quad Cables:

Sl.No	PIJF Telephone Paired Cable	PIJF Telecom Quad Cable
1	Conductors are available in the form of Pairs. Twin Twisted.	Conductors are available in the form of Quads. Twin Twisted pairs.
2	Available in 10/20/50/100 pairs	Available in 4/6 quads
3	Dia of conductors : 0.5/0.6 mm	Dia of conductors : 0.9/1.4 mm
4	Characteristic Impedance of the pair : 600 Ohms	Characteristic Impedance of the pair in the quad: 470 Ohms (0.9 mm dia) / 310 Ohms (1.4mm dia)
5	Induced Voltage reduction done in two stages by earthing Al foil & armour	Induced Voltage reduction done in three stages by earthing Al foil, Aluminum screen & armour.
6	Used for short distance Telephony/ Data Circuits applications in Railway station area as last mile connectivity.	Used for long distance Signalling and Telecom safety circuits between two Block stations.
7	Loop Resistance of the pair is important criteria.	Transmission loss in pair of quad is important criteria.
8	RDSO spec. of Cable: IRS-TC: 41/97	RDSO spec. of Cable: IRS-TC: 30/2005
9	Jointing is in the form of Straight Through Joints.	Jointing is in the form of Straight Through/ Derivation/Transformer/Condenser/Loading Coil Joints(as required in the section).
10	Thermo Shrinkable Jointing Kits for different size of cables used as per RDSO spec. no: RDS0/SPN/TC/57/2006	Thermo Shrinkable Jointing Kits for 4/6 underground Quad Cable as per RDSO spec. no: IRS:TC:77/2012
11	Terminated in Krone/Wago type modules and terminal strips.	Terminated in 10 Pair/20 Pair CTBs and Wago type modules
12	Generally used by all Telecom Service providers.	Exclusively designed for Signaling and Telecom applications of Indian Railways.

CHAPTER-6

CABLE LAYING PRACTICES

This Chapter deals with the Specifications under which the various works for trenching and laying of under ground telecommunication cables.

The 6quad underground communication cable and OFC HDPE duct are to be laid in the same trench.

6.1 Survey Work

a. Surveying of the route and submission of proposed cable route plan
b. Preparation of soil strata report and data collection.
c. Submission of Cable route plan.

6.1.1 Route Survey: After allocation of work, foot inspection has to be carried out to arrive the approximate route plan of the alignment of cable route. The tentative cable route plan shall be submitted to Concerned S&T officials like DSTE and on approval of the same; the detailed survey of the section has to be started. While carrying out the survey it is expected to identify the P. Way, Signal & Electrical authorities of Railways, to find out the boundaries, availability of other Signal/ Electrical cables, water pipes etc. In case of obstruction or availability of other cables, alternative routes has to be selected. Detailed survey should be done as per the guidelines issued.

6.1.2 Soil strata report: After getting the clearance, carry out the soil strata analysis. For carrying out the analysis, the programme has to be informed to the concerned Railway departments / agencies and obtain prior approval in writing from them before the start of work. The soil strata analysis has to be carried out by digging a pit of 1 Mtr x 1 Mtr x 1.2 Mtrs (L xW x D). After taking the necessary reading the pit has to be back filled to the originality. In addition to the above at every 500mtrs the pits have to be excavated and readings to be recorded and incorporated in the report as well as in the drawings.

6.2 Preliminary Cable Route Survey

The Objective of this survey is:

a) Designing and finalizing drawing for the proposed route of the 6 Quad cable.
b) Planning Location of crossing tracks, over bridges, culverts etc.,
c) Deciding the cable hut/drop and insert location under the system design.
d) Deciding system for communication to LC gates, Block working, Emergency communication etc.,
e) Planning for extending control communication from drop/insert location to various users in station area and electrical location etc.

6.2.1 Points to be covered under the preliminary survey for cable route

1. Avoiding underground structures, signalling cable, power cables and pipe lines etc.
2. Avoid rodent/termite infested or infected side of the alignment.
3. Off set of the cable trench from the central line of the track such as having burrows.
4. Avoiding proximity to chemical, paper and such other industries, which discharge chemically active affluent.
5. Avoiding areas prone to water logging.
6 . Avoiding large rock cutting thick jungles and areas difficult to approach etc.

7. Avoid the side of the alignment which is likely to be affected due to addition/alteration of earth work, super structures such as doubling, shifting of alignment of the existing track etc., For this, cable route should be discussed with construction and doubling organization.
8. The orientation of the route i.e. left or right side of the track in the sections to be decided on following: -
   a. That side of main line, which is away from other, cables such as signalling and power.
   b. Side which is likely to involve least track crossings and likely to be more convenient for crossing the track, bridges culverts etc.,
9. Figure out and scale crossing of roads, tracks etc.
10. Scale out proposed arrangement of crossing bridges, culverts etc. out of the many alternatives available.
11. Assess special problems if any in the section such as undulating surfaces, long cuttings, tunnels etc.
12. Scale out the cable entry or exit arrangement at the cable huts of drop insert locations. Avoid built up areas including those area where buildings etc. are likely to come up in future.
13. With engineering drawing already in hand, verify pathways/pedestrian crossing and other lateral clearances.
14. Scale out the special work required if any and the manner of the cable route in approach of the existing bridges locations.
15. Identify, if any special lengths of cable is required to avoid joints on bridges/culverts etc.,
16. For the straight runs as far as possible a separation of 10 Meter should be kept from the nearest track.
17. **No OFC or Quad Cables shall be laid close to the existing track. It shall be laid close to the Railway boundary on one side of the Railway track to the extent possible to avoid any interference with the future works.**
18. As a rule a minimum distance of 5.75 M should be maintained between the OHE masts and the cable. In Yards etc., where observance of this rule may be difficult, a minimum distance of 3 Meter should be maintained. In exceptional cases where the cable trench depth is less than 0.5 Meter the lateral distance may be reduced to 1Meter. In such trenches, which are in close proximity to OHE masts, the cable should be laid in PVC/RCC Pipe.
19. Location of traction sub stations, feeding posts and other OHE switching posts.

6.3 Proposed Cable Route Plan

Based on above survey the cable route plan should be prepared.

1 .6 Quad Telecom Cable route plan 5 Km charts with horizontal scale at 1Km = 10Cm offset at each OHE Mast. ASM' s Office cabin etc.,are to be marked on the chart.

2. Drawings of the laying of the cable in the special terrain viz station yards, approaches of cable huts, long bridges and culverts etc., are to be made as 1 Km. 50cm to show the details.
3. The name of the location should be put in the LOC column and the chainage in the CH column. At every 10 Cm the Km post number should be written and its exact equivalent chainage as per OHE Survey plan entered in the CH column. The equivalent chainage is required for working out the length of the main cable required. The name of stations should be shown against the location of the Station Master's Office.
4. Based on the OHE Survey, the Serial No and the length of the Culverts, Bridges, and Level Crossing should be marked on the "Track Line" of the cable route plan.

5. The actual measurement of the separation distance from the central line of the track (the adjacent main line) initially to be shown keeping the minimum clearances from OHE masts mentioned above. This is to be complied on the 5 Km charts.
6. The requirement of tapping of different control circuits is assessed based on the existing communication arrangement in consultation with open line Railway users and a tentative tapping chart prepared.
7. All the plans and drawings shall be neatly prepared using Computer Aided Design System and plotter etc. The drawings shall be in A3 and A4 size and suitably filed for ease of handling. Further, a soft copy of AutoCAD drawings shall be submitted along with required installation software to all concerned officials.

6.3.1 Information in Cable Route Plan

The cable route plan shall contain following information:

1. Whether the cable route is on the up or down side of the Railway Tracks.
2. Approximate location and length where the cable shall be laid in GI pipes and GI troughs and under the bed on culverts.
3. Locations of sections where the cable shall be covered by burnt bricks positioned breadth wise @ nine bricks/meter (average).
4. Location of track crossing and the number of tracks to be crossed.
5. Location of road crossing and the number of RCC pipes to be provided.
6. Locations and length for protection of cable in rocky area and platform cutting etc.
7. Approximate locations of derivation Joints for L.C. Gate or emergency socket posts will be provided on 6-Quad cable. EC posts will be installed exactly at KM Zero markings.
8. The size length and route of derivation / PIJF cables from OFC cable hut to various subscriber points.

6.4 Detailed Cable Route Survey

The purpose of the detailed survey is to undertake the closer study of the various existing telecommunication facilities, to workout the exact requirement of the Optical Fibre. 6 Quad and Derivation/PIJF Cables and materials required for different items of work, finalise all the drawings and site plans required for the execution of work as also to examine the details collected during preliminary survey and to effect necessary changes/modification if any.

6.4.1 Main Items of work in Detailed Survey

The following are the main items of work; which should constitute the detailed survey.

1. Closely examining the proposed cable route and prepare cable route plans.
2. Setting up the cable hut, drop insert equipments buildings, and the preparation of the site plans.
3. Setting and preparation of site plans for other buildings required for the execution of the work such as Telecom Depot at different stations SSE Stores and ASTE Office etc.
4. Setting of areas for loading /unloading of cable drums.
5. Preparation of route charts for derivation, PIJF cables with the size and length of cable for each tapping and termination arrangements.
6 Estimating of requirement of special cable lengths for long girder bridges.
7 Deciding locations of each joint and preparation of a joint schedule.
8. Determining earth resistivity measurements for each cable section along the proposed cable route.

9. Working out the exact length of 6 Quad Telecom. Cable.
10. Working out the exact length of PIJF derivation cables required.
11. Preparation of the material schedule required for different protective works.
12. Arranging isolated telephone circuits to be provided in the Cable.
13. Investigation on special problems of the section and finding out proposed solution thereof.
14. Examination of Chemical composition of soil to see whether any special precautions are to be taken to protect cable from soil corrosion.
15. Examination of Soil Composition to see the type of soil whether it is soft, hard or rock etc.

6.4.2 Finalisation of Cable Route Plan

The following are the guidelines for finalizing the route and preparation of the cable route plans.

1. Prepare the “5 Km charts” as explained above and collect the latest copy of approved OHE Survey plan to enter the relevant chainages and details in the “5 Km charts”
2. Actual measurement by 30M tape or chain along the route is necessary only in case of important locations, to be termed as “Special terrains”. For example approach to station/cable hut/OFC hut, long bridges, big yards, sharp diversions in the cable route from its parallel course along the main railway tracks due to obstruction, cuttings etc,.
3. Inspect and decide the portions of route falling in category of “Special terrains” where actual longitudinal measurement is necessary.
4. The remaining portion of the route i.e. other than the portion decided as special terrain is to be termed as “Straight runs”. Actual chaining along the route is not necessary for such straight runs and these can be marked on the 5 Km charts by taking chainages from the OHE plan.
5. For the “straight runs” on the cable route an allowance of 3.5 mtrs of the drum length should be made for the contours, jointing etc., and each drum length should be considered to cover a route length of 0.965 x cable drum length.
6. It should be ensured that both “special terrains should consist of full drum lengths, so that the position of joints (other than T joint) is fixed without difficulty in both cases.
7. Actual measurements of the separation distance from the centre line of the reference track (a reference track Special Terrains). On Straight runs this measurement should be made where necessary. In case of special terrains the separation distance at some points on the route may also have to be reckoned from some other permanent structures depending upon the site conditions.
8. The separation distance of the cable route from the nearest track on the “straight runs” should be 10M. The deviation from this standard separation of 10M should be kept to the minimum and as soon as any obstruction has been negotiated, the route should again follow this standard separation distance. It is desirable from the point of view of calculating the induced voltage that the uniformity of separation is maintained for the maximum possible length of the main cable route.
9. Separation distance should be marked on the “Straight runs” portion of the cable route plan (5 Km charts) at intervals of not more than 250m. In addition, the separation distances at points of change in the cable route such as diversions, track crossings approach to bridges, culverts etc., should invariably be marked on the cable route plan in such a way as the intended cable route is clearly defined for “special terrains” the separation distance should be marked at as close intervals as is considered necessary depending on the site conditions.

10. The route should be decided by walking along the track. On long stretches of straight runs a push trolley moving slowly may be used. The trolley should be on the track close to the proposed route.
11. Actual measurement should be made for the protective works required for the cable passing over the culverts, under tracks, over long girder bridges, arch bridges, level crossings, rocky areas, under the bed of culverts and near OHE switching posts etc,.
12. Once the cables are laid, the actual length of cable as per the printed marking on the cable is required to be indicated at every km of cable route, at diversions, crossings, approaches of bridges and joints for Optical and 6 Quad Cables. This is necessary for fault localization subsequently the cable length from cable hut can be corroborated with OHE mast Nos.

6.4.3 Finalisation of Tapping Diagram

1. The Survey Party should visit each location such as cabins, SM's offices, Loco Sheds, Pump Houses, Gate Lodge etc., and verify the details collected during the preliminary survey of all the existing telecommunication facilities, and additional telecommunication facilities to be provided due to RE such as tapping of Traction Power Control, Traction Loco Control, Remote Control, Engineering Control and Emergency Control circuits.
2. For emergency control circuits in addition to the general tapping to be provided at every 1 Km marking the details of tapping specifically required by the Electrical Department for their switching posts such as sub sectioning posts, sectioning posts, traction sub stations and isolated locations etc., should be collected well in time.

   The exact location of the various tapping on the emergency control should then be worked out taking into consideration the tapping to be essentially provided at specific locations for Electrical Engineering Department so as to ensure that the distance between the consecutive emergency socket posts does not exceeds one Km.
3. The position of each tapping should thus be finalized and a final tapping diagram prepared.

6.4.4 Isolated Telephone Circuits

It is necessary that all telephone circuits such as isolated pump houses, gate lodges etc., is taken note of and provision made for transferring the existing circuits into cables wherever considered necessary.

6.5 Length of 6 Quad Cables

The Quad cable length is worked out on following basis to arrive at the location of the straight joints.

a) Route length as per actual measurement plus contour allowances of 2.5%.
b) Extra length for track crossing including 2.5-meter loop on each side etc.
c) Extra length on approach crossing of the bridges and 5 meters on measurement in the detailed survey.
d) 10 meter of cable to be kept on either side of major steel bridges and 5 meters on minor bridges.
e) At every joint a loop of 10 meters on either side.
f) In cable hut / Station a loop of 10 meters in the cable pit.

6.5.1 Size and length of Derivation

The Derivation cables are required to be laid from OFC Cable Hut to ASM's office, Cabin,Depot, and Electrical location, supervisor residence etc., for extending control tapings. The plan and requirement of different sizes of PIJF derivation cables shall be suitably worked out. As far as possible PIJF derivation cables shall be laid in the trenches for 6 Quad telecom cable and branched off at suitable locations.

6.6 Material required for Protective Works

1. The Quad cables are meant for direct burial underground. For building, masonry platforms, culverts, crossing of tracks, level crossings and roads etc., special protection for the cables is required shall be provided as specified by site engineer.
2. Actual measurement should be made for the length for which special protection is necessary and the requirement of materials for the protective works should be worked out. The requirement of materials based on the actual measurement should be shown in the cable route plan at the appropriate place.

6.7 Communication arrangement in major yards and stations

In big yard and major stations involving large number of Cabins/Depot/Tapping points, it may not be practicable to lay independent derivation cables for various locations. Therefore one main cable shall be laid to transverse in a zigzag way through the yard involving frequent tapping points. 6 Quad or higher size PIJF cable may be laid for this purpose. The circuits shall be preferably be tapped through V.F. Transformers.

6.8 Special problems of the section

1. Certain Sections may present special problems such as presence of chemically active soils, marshy areas, deep cuttings in the rocky areas, requirement of specially constructed platforms for distribution of cable drums along a high embankment etc.
2. Approaches to large bridges may also present special problems due to high embankment as well as deep ravines.
3. At the junction points of electrified and non-electrified areas, the cabling as also the linking arrangements of circuits from electrified to non-electrified sections may also present special problems.
4. The survey party should inspect and report to Engineer, such problems at the very outset so that suitable solutions can be worked out.

6.9 Materials required for survey works

The following are the essential requirements of materials for the survey party:

i) Motor Trolley:
ii) Push Trolley.
iii) Jeep
iv) Measuring tapes 30 m & 50m.
v) Road measure.
vi) Earth resistivity meter with accessories.
vii) White paint and brushes.
viii) Torch Lights.
ix) Spade, pick axe and earth digging tools for soil samples.
x) Necessary reference drawings, maps, charts and registers etc., to record the details of survey.

6.10 Methods of laying underground cables

a) Laying direct in the ground
b) Drawing through ducts
c) Laying solid

6.10.1 Laying direct in the ground

This method of laying cables is comparatively simple and cheap, and is the one that is widely used. It involves digging a trench in the ground and directly laying the cable on a bedding of soft earth free from corrosive elements at the bottom of the trench, covering the cable with a layer of soft earth, placing warning bricks centrally over the soft earth covering and finally filling up the trench. When the soil contains appreciable quantities of stones or pieces of rock 1.25 mm layer of sand may be used for the bedding and covering below the layer of bricks.

6.10.2 Drawing through ducts

In this system, also known as the draw in system, one or more ducts are laid together, according to anticipated requirements and a single or more cables according to size are drawn through each pipe or duct. Manholes are provided at definite intervals. The initial cost of laying of ducts is high. The system is generally used only in difficult location such as crossings, railway bridges, culverts and in such situations where subsequent excavation of a trench is both very expensive and inconvenient.

6.10.3 Laying solid

This method involves laying a cable in trough made in the excavated trench, filling the trough completely with molten bituminous compound, providing warning bricks on top after the compound has set and then back filling with earth. Laying solid is higher cost than laying direct.

6.11 Technical specification and instructions for trenching and laying of 6 quad underground Telecommunication cables and special protective works.

6.11.1 Instruction for excavation and back filling of trenches

a. The SSE/JE in charge of the work has to mark the route of the cable in white chalk or lime as per the tapping and route plan and to meet the requirement of local conditions at site, if any. The marking will be given on the trackside of the trench at a distance approximately 1 metre away from the centre line of the trench. In the difficult terrains such as water logged areas the position of the cable route will be specified by offsets from the centre line of the nearest track.
b. Trenches for telecommunication cable shall be dug to a depth of 1 metre. The width of the trench shall be 400 mm at the bottom of the trench. In places where under ground pipes, electric main, etc., come in the way trenches deeper than 1 metre shall be dug as necessary and RCC or DWC pipes as applicable, shall be placed to protect the telecommunications cables.
c. The bottom of the trench where cable is to be laid shall be thoroughly prepared and shall be free from any stones. The bottom of the trench shall be horizontal and shall in no case be undulating. When the cable bed changes from solid to soft surface or from the bridge to soft soil, fill at the transition point shall be provided so that the cable is not pressed against the edge of a hard surface.
d. The back filling of the trenches shall be done by ramming and consolidating the excavated soil in layers of 15 - 20 CM at a time. All the soil that is excavated shall be put back to the trench and care should be taken in consolidation to ensure that the back filling does not

suffer any sinkage in monsoon. The left out earth, if any within station limit has to be taken away from the railway premises by the Contractor at his own cost.

e. The excavation shall include, excavation of trial holes clearing bushes.
f. Where the direction of the trench has to change, it should be done in a gentle curve of not less than one-meter radius and not at sharp angles.
g. Places where back filling is not done properly or likely to get water logged with the first rains after completion of the work, the SSE/JE in charge will inspect the entire section soon after the first monsoon and to arrange to set right such areas.

6.11.2 Track Crossings

a. All cable crossings across the Railway track in station yards shall be done in DWC pipes, threading the cable through these pipes. The Contractor shall do the trenching to the required depth wherever necessary, such as approaches to track crossing and the length in between the adjacent tracks. Two G.I Wires of 10SWG size shall be threaded through DWC pipes, one to pull the cable and one for future use. The arrangement of cable and DWC pipe trunking under track crossings has been shown in Drg.No. RDSO/TCDO/COP/19.
b. At locations other than specified above, as directed by site engineer, Track crossing shall be done by horizontal boring for DWC pipe provision.

6.11.3 Road Crossings

a. Metalled, macadamised, concrete and stone paved roads shall also be cut to a depth of 1 metre. The cable shall be laid through RCC or DWC or GI pipes as applicable as per Drawing No. RDSO/TCDO/COP/20. The road surface shall be restored to original.
b. When crossing Roadways, it is necessary to lay the cable in such a manner as to avoid the necessity of handling the cable sharply and minimize the excavation of road surface as far as possible. Where cable is laid in the surface, trunking, trunking aligning should be curved down to the pipes and proper brick or concrete joint should be made between trunking and pipe.
c. The crossing of main roads often involves difficulties especially if traffic is heavy. Precautions to avoid accidents to workmen, pedestrians and the vehicles should be taken. On minor roads, which can be temporarily closed to traffic, it is possible to open up and cross the entire width of the road. Pipes should be installed quickly in the cutting, which is then filled in thereby reducing to a minimum time for which the road is closed.
d. Some roadways, which are broad, may be opened for half the width first allowing the other half for use by Road traffic. Pipes are laid in the opened half. After the back filling the opened portion, the other half is opened and the first half will be used by the road traffic. After the pipes have been laid in the second half, they must be linked with those laid in the first half. DWC pipes shall be used for road crossings. In all cases, pipes shall be laid at a depth of one meter below the formation level or lower as may be required.
e. Wherever a cable is laid across an important road particularly one with special surface it is good investment to provide for future expansion. The following methods may be adopted.
f. The size of the pipe shall be so chosen that other cables may be drawn subsequently. Two lengths of G.I. wire 10 SWG shall be used as lead wire. Two such lengths of G.I. wire shall be laid through the pipe. One wire shall be used for leading in the cable and the other shall be kept with suitable over lay to enable cable pulled out at later stages if required. At road crossings, RCC or DWC pipes of specified dia shall be used.

6.11.4 Culverts and Bridges

a. Wherever possible, the cable shall be laid under the bed of the culvert through RCC pipes as applicable at site. Similar arrangement shall be provided for taking the cable in water logged areas and drains.
b. In case of wet culverts or unfriendly terrains where it is not possible to lay cables under the bed of culverts, the cable may be laid over the culverts and GI pipes as per the Drawing No. RDSO/TCDO/COP/13 &14.
c. When laying cable on long bridges, the question of longitudinal expansion caused by temperature differences should be taken into consideration and suitable cable loops should be provided at the pillars of the Bridges. The cable should also be laid sinuously inside the GI pipe.
d. The laying of the cable on the bridges is to be done with much care and planning. It is necessary that the cable drum to be laid on the bridge is inspected and tested thoroughly so that damaged cable cannot be installed.
e. As laying involves movement of large number of staff over the bridge, the line should be blocked if necessary and flagman posted on other side.

6.11.5 Laying of Cable in Solid & Rocky soils and Residential & Marshy areas

a. If the terrain is rocky normal dimensions of the trench cannot be ensured. In such cases trenching to be done as per Railtel diagrams enclosed.
b. In marshy areas, where it is not possible to divert the cable route, the cable should be suitably laid and protected as per the decision of the Railway
c. Representative depending on site condition, like laying cables in RCC pipes of suitable dia concreted at every Meter.
d. The cable will have to be led inside any masonry buildings such as ASM's Room at a depth of 0.75 m by cutting the Masonry structure of the wall. After the cable has been led inside the masonry wall, the floor inside shall be duly repaired and Plastered.
e. Laying of Cable near Power cable: When the contractor comes across any other cable already laid, he shall first report the fact to the engineer. Should the cable be identified by the Engineer as a Power cable (LT / HT), the trench shall be dug as far away from the route of the power cable as practicable.
f. Crossing of Telecommunication cable with another cable shall be avoided wherever possible. Where, however, this is not possible the telecommunication cable shall be laid in RCC pipe. The length of the RCC Pipe to be provided on either side of the crossing shall be at least one meter.
g. The cable shall be laid through GI pipes at the location marked on the tapping and route plan and as required by SSE/JE. .
h. Laying the cable through pipes, galvanized steel wires of a cross section not less than 10 SWG shall be used as a lead wire. Two such lengths of wires shall be laid through the pipes so that after the cable is threaded through the pipe one led wire is permanently left in the pipe with a suitable over lay at two ends to enable the cable to be pulled out at a later stage if required to do so.
i. On arch bridges and culvert bridges, the cables will be threaded through the GI pipes etc.
j. Damages to cables is likely if care is not taken in laying cables where the bed changes from solid support such as the foundation pipe or bridge to soft support such as soft soil. The cable must not press against the edge of the solid support.
   The soft soil near the edge must be tamped and the cable raised slightly.

k. Special Soil Condition: Cable should not be run through high acidic or alkaline soil or through sewage. If this is unavoidable, special measures should be taken against Corrosion.
l. **Laying of 6 quad Cable near Feeding Posts/TSS**: In the vicinity of feeding posts as far as possible the cable shall laid be on the side of the track opposite to the feeding post.Further the cable shall be at least one meter away from any metallic part of the OHE and other equipments at the substation, which is fixed on the ground and at least one meter away from substation earthing. In addition the cable shall be laid in RCC pipes for a length of 300 meters on either side of the feeding point.

6.11.6 Handling of Cable Drums and Paying off Cables

a. The drums shall be unloaded by the side of the Railway track from either a crane or any other suitable means very carefully so as not to cause any damage to the cable. The drums at site shall be protected until they are laid.
b. The drum shall always be kept upright i.e., axle in parallel position to the base. The drums shall not be set by jerks but shall be handled slowly and with care. The walls of the drums should not be damaged while moving the drums if required for
c. unrolling.
d. The drum shall be unrolled at the same place and the cable carried by workmen near the trench. The drums shall not be dragged in any case but where drums of cables have to be moved, the drum should always be rolled in the direction of the arrow,otherwise the coils tend to unwind and the cable may get battered. In case no direction arrow is marked on the drum, remove some battens and determine the direction in which the cable is coiled. The arrow should then be painted on the drum pointing in the opposite direction in which the upper cable end is coiled, so that future handling of the cable drum is facilitated and then replace the battens carefully.
e. The drum should be properly mounted on jacks on the cable wheel making sure that spindle is large enough to carry the weight without bending and that it is laying horizontally in the bearings so as to prevent the drum creeping to one side or the other while it is rotating. Before attempting to pull off the cable, remove the end protection box attached to the flange of the drum and cut the security ropes so as to leave the cable end free to move.
f. If a portion of the cable only is taken out from the cable drum the batten should be immediately replaced to prevent damage to the balance of the cable. This is important.
g. With armoured cables having Hessian serving it is possible under extreme conditions for the bitumen to soften and cause adjacent turns of the cable on the drum to stick to each other. In such cases particular care must be taken to pull the cable of these drums very slowly and to free the cables carefully from the adjacent turns on the drums. Snatching of the cable to cause it to break away may result in kinks and damages; small size cables require care in this respect.
h. The use of steel bars between the bolt heads to 'jump' or turn the drum around is dangerous to staff and likely to damage the drums. A better method is to use two steel plates with grease between them by standing the drum on these greased plates, it can be easily elevated round to the desired position.
i. All care should be taken in handling cable drums with a view to ensure safety not only of the cables but also of the working people handling them. The men should not be allowed to break the cable drum by standing in front but only from the sides.

j. REWINDING AND REDRUMMING OF CABLES: If for any reason, it is found necessary to rewind the cable on a drum, cable drum with a proper barrel diameter not less than that of the original drum should be chosen.
k. The drum should be mounted on cable jacks during rewinding operations using proper size of spindles passed through the flange holes, which will not buckle under the lead. The cable should not be bend opposite to the set it has already.
l. In the re-drumming operations, the full and empty drums should be so turned that the cable passes from the bottom of the original set as little as possible. Replace all the lagging on the cable drum.

6.11.7 Cable Laying

a. Before the quad cable is laid, a visual inspection of cable shall be made and it shall be tested for insulation and continuity of conductor. The insulation resistance of new cable shall not be below 1000 Mega Ohms per KM at 20 degrees centigrade with 500V Megger.
b. If there is wide disparity between insulation of different conductors, the conditions of the cable should be thoroughly checked before permitting its use. Bedding and armouring shall be inspected to see that there has been no damage during transit or in storage.
c. It is advisable to employ the same people at the same place or job while cable is being laid.
d. Before commencement of the laying, inspection of the trench and inspection of protection works should be carried out so as to ensure the conformity with the specification. The trench bottom should be clean, smooth and free of small stones. When the soil contains stones or pieces of rock and therefore cannot be levelled, sieved earth about 10 cm thick should be used both for the bedding on which cable is laid and for covering the trench.
e. The cable should be brought as close to the cable trench as possible. It should be lifted with the aid of cable jacks firmly mounted on a support of stone or wood. The spindle should be minimum of 55mm dia of the ground by 5 to 10cm.
f. Where necessary the cable drum may be placed at such a point so that 2/3 of the cable is laid directly and the balance in other direction. Care should be taken in such a case to see that there are no kinks or loops in the cable.
g. The wooden battens on the drums should be carefully removed just prior to laying and before the drum is mounted on the jack. The nails on the lagging should be carefully be removed. If any damage is detected at the sealing end, the cable should be tested for insulation before laying. The defective end should be carefully preserved and Engineer in charge should be informed about it immediately.
h. While rolling a cable drum for laying, the drum shall be supported on an axle running through its centre. The height of the axle being such that the end frames are free to rotate and do not touch the ground at any point. The cable shall be carefully
i. uncoiled by gently pulling the cable assisted as necessary by carefully turning the drum, quickly pulling of the cable or turning the drum shall be avoided at all costs. Each drum shall be broken while laying is in progress to prevent short bending or buckling, particularly when the cables are sticking together.
j. When drums are turned for change of direction, wooden blocks shall be carefully put under the drum bolts, which stand out form the drum discs.

k. It is customary for the mate to stand in a commanding position where he can view the entire route and shout evenly timed calls to his men to pull. If there is proper synchronization between the mate's calls and the pulling by the men, the cable will leave the drum without any difficulty. It is important that the cable should be pulled with steady and even pulls and not to be unnecessarily jerked or strained. On no account should a cable be allowed to twist or kink, as this is likely to spring the armour and fracture the paper insulation and outer serving of the cable. When pulling cable around bends one or two men should be stationed to give the cable the correct bend when it passes.

l. When the cable drums are exposed to great heat before laying, then danger exists that the individual coils and layers stick together in spite of the half overlay. Special attention should be paid to see that no buckling of the cable occurs while pulling the cable. A man should stand near the drum and loosen the cable carefully by hand and shout a warning whenever the cable cannot be loosened. Separation must be affected as close to the drum as possible otherwise kinks may result. The rate of pulling should also be slow to prevent possible damage to cable that is being carried, when the paying out stops. The drum should be kept in shade where possible.

m. For laying the cable adequate men should be employed so that they can conveniently carry the cable in both hands without stretched arms. The distance between any two persons carrying the cable shall be from 2 to 10 meters depending upon the weight of the cable such that the maximum sag of the cable between any two persons is not more than 0.5 meters.

n. The cable shall be gently drawn by pulling the cable this may be assisted as required by smoothly and slowly turning the winch. The cable shall not be twisted on any account.

o. Before laying is commenced the cable shall be uncoiled first in a straight line supported by men and then carried to the trench gently and carefully.

p. While laying work is in progress, a person must continuously observe the cable and foot along its length in order to determine any inundation, holes or other damaged parts are apparent. Such damaged parts have to be protected immediately by the cable jointer provided with the laying party.

q. When two or three turns of cable are left on the drum, the pulling should be stopped and the inner end of the cable removed from the slot in the drum. Pulling should then be continued. If this is not done, the cable end is likely to be stretched and damaged.

r. The ends of the telecommunication cable should have an overlap of 3 meters for jointing purpose.

s. The condition of the cable shall be visually inspected throughout its length and if any damage or defect is noticed, the trench shall not be filled up until the Railway representative authorizes filling of the trench after examining the same.

t. **Cable Reserve**: For the following locations, it will be necessary to provide reserve cable for future possible use.

u. Where a change in route to cable like is expected, the reserve to be allowed depends on circumstances.

v. In freshly banked soil, to allow for slipping of the bank an allowance of 30 CMs should be provided for every 10 meters of trench (3%). The cable should be laid in a sinuous form.

w. Near roadways, buildings and culverts, reserve of 5 meter should be allowed at the drum end.

x. On each side of major girder bridge a reserve of 10 meter, for minor bridges a reserve of 5 meter and at every joint a loop of 3 meter on either side shall be provided /left.

y. At the time of commissioning of the cables, the insulation values of the cable should again be checked and the value obtained shall not be below 100 Mega Ohms per KM with 100V Megger. If there is wide disparity between insulation of different conductors, the conditions of the cable should be thoroughly checked before permitting its use. The readings shall be recorded in the register for all cables.
z. Furnish the final cable route plan showing the distance of cable from the nearest track centre at every 30 M and location of EC posts and joint locations.

6.11.8. Cable Markers

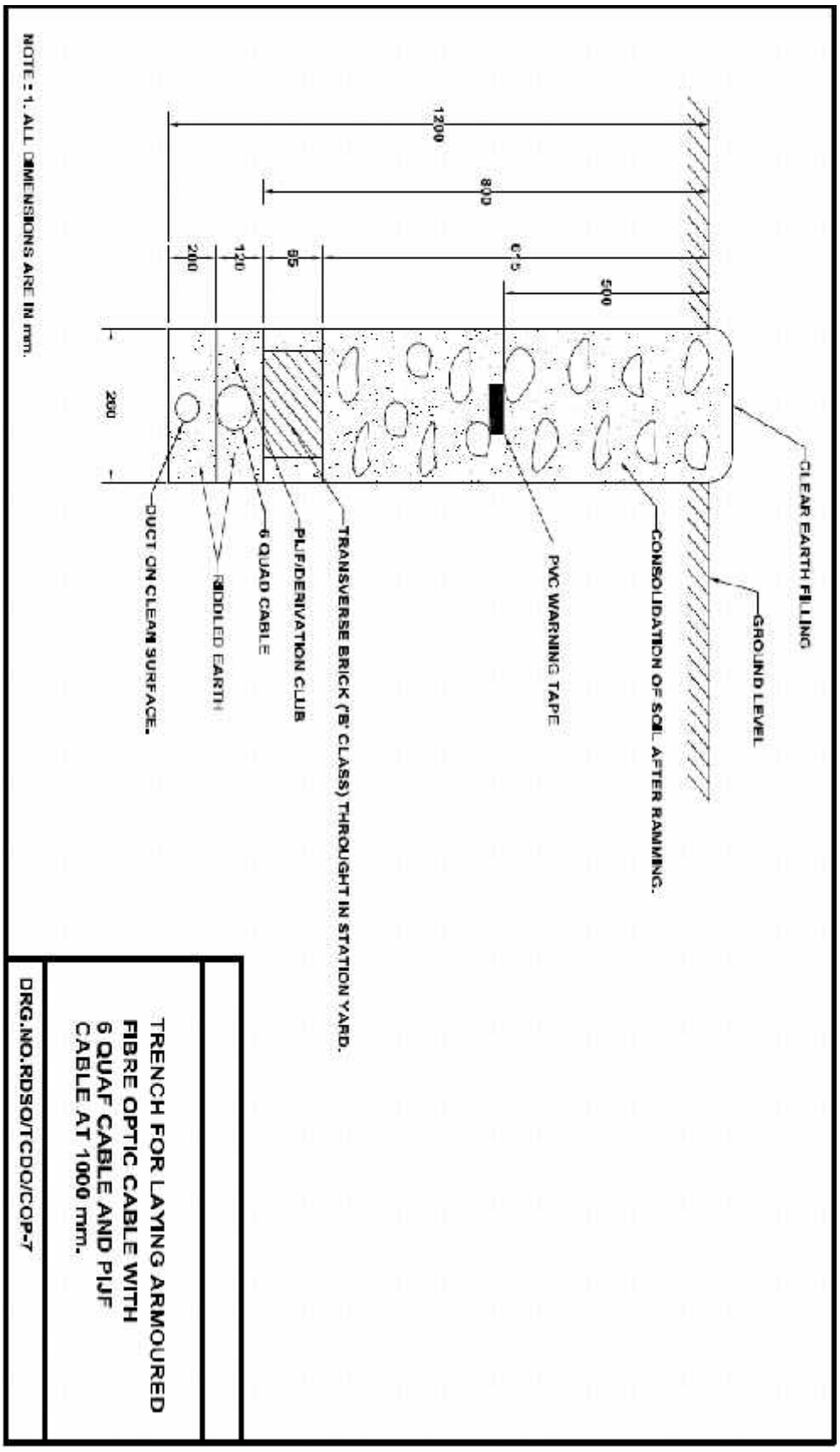
RCC cable markers shall normally be provided at a distance of every 50 meters on the cable route, at derivations and also to be provided at all types of cable joints. They should be of standard RCC with letters " **IR / 6 QUAD CABLE** " and logo engraved and painted. They shall be painted with **green** when placed at joint locations and painted with **red** for normal indication.

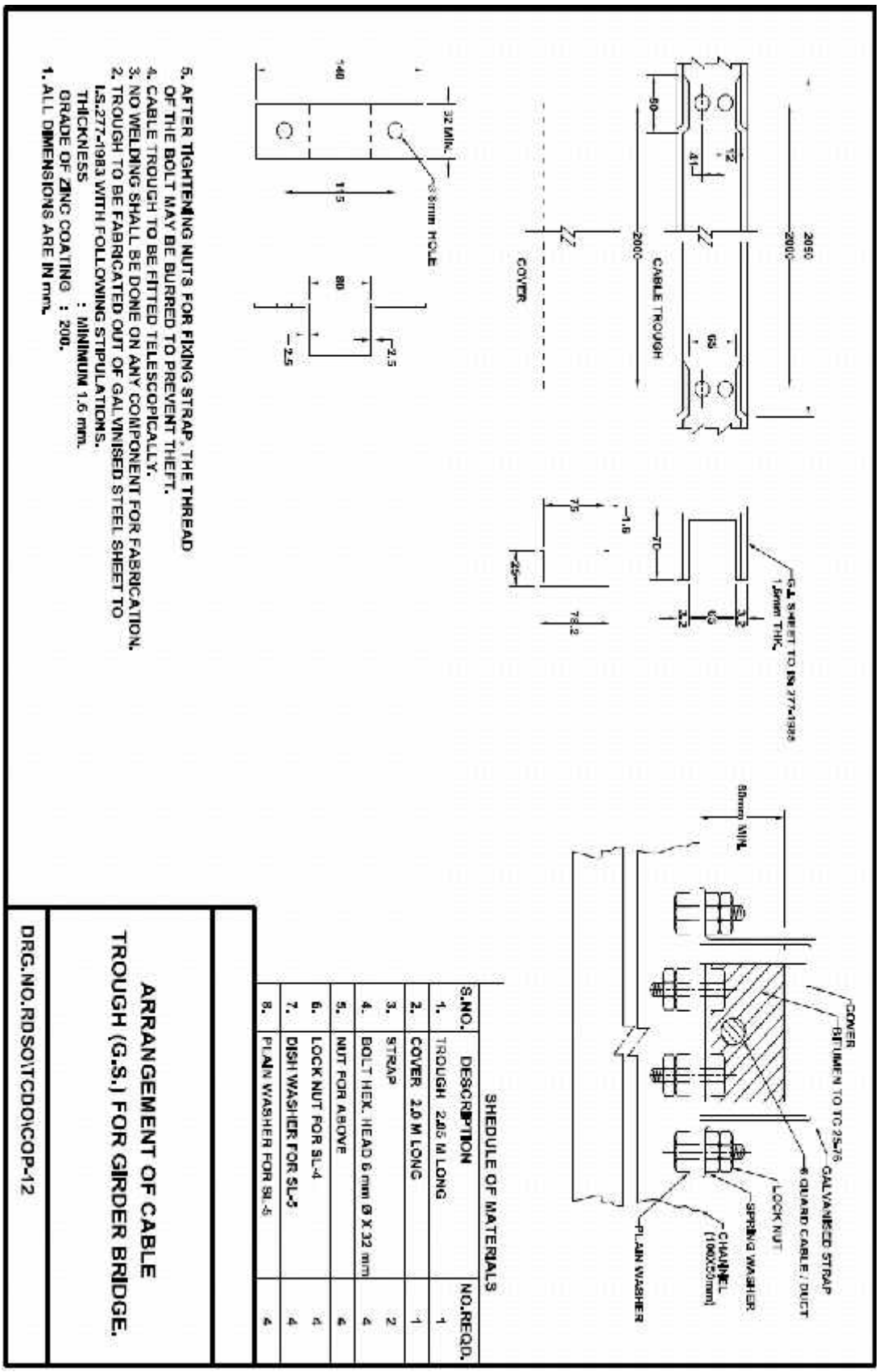
Joint Inspection shall be carried out by SSE/JEs of Open Line and SSE/JEs of Concerned Organisation (Ex: Projects/Con.) after completion of cable laying works.

6.12 Power Crossing 11KV and above

Whenever laying of new telecom cables across or parallel to the existing 11KV and above power crossing within vicinity of 8 Kms, PTTC (Power Telecom Co-ordination Committee) approval is mandatory to protect Railway Telecom network from induced voltage effects from power lines and vie versa. As per the PTTC guideline the protection devices such as surge protection devices shall be provided.

As per PTTC , it is advisable to take the telecom cable with maximum horizontal clearance as far as practicable but not less than 0.6 meters, so that the intensity of inductive interference can be minimized. Absence of sheath continuity and armour continuity in Telecom cable and it's improper earthing in the vicinity of power cable will result in AC induction and consequent impairment of the telecom circuits. When the power parallelism is more than 0.8 kms the cable route should be referred to PTCC for recommendation of protection measures. In case of crossings, care should be taken see that telecom cable crosses at right angles and at a vertical clearance preferably of 0.6 meters but not less than 0.3 meters at any point. When the specified clearances cannot be maintained, it is preferable to lay the telecom cable through cement concrete pipes for a length of 1 meter on either side of power cable to the crossing and seal the mouths at both ends.


CLEAR EARTH FILLING
GROUND LEVEL
CONSOLIDATION OF SOIL AFTER RAMMING.
PVC WARNING TAPE
TRANSVERSE BRICK ('B' CLASS) THROUGHT IN STATION YARD.
PIJF/DERIVATION CLUB
6 QUAD CABLE
DUCT ON CLEAN SURFACE.
1200
800
600
500
200
120
85
250
NOTE : 1. ALL DIMENSIONS ARE IN mm.
TRENCH FOR LAYING ARMOURED
FIBRE OPTIC CABLE WITH
6 QUAF CABLE AND PIJF
CABLE AT 1000 mm.
DRG.NO.RDSO/TCDO/COP-7



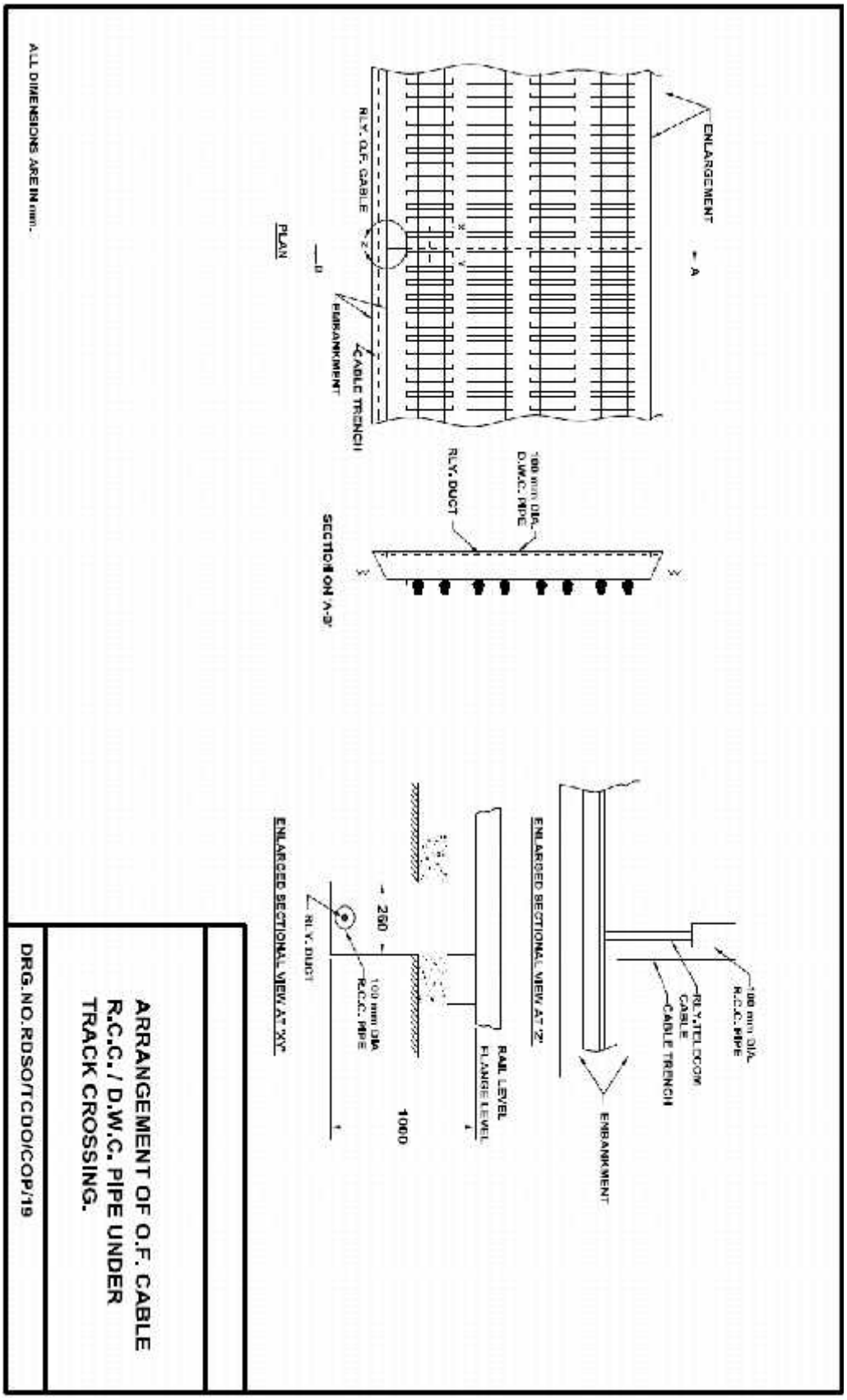
SHEDULE OF MATERIALS

S.NO.	DESCRIPTION	NO.REQD.
1.	TROUGH 2.65 M LONG	1
2.	COVER 2.0 M LONG	1
3.	STRAP	2
4.	BOLT HEX. HEAD 6 mm Ø X 32 mm	4
5.	NUT FOR ABOVE	4
6.	LOCK NUT FOR SL-4	4
7.	DISH WASHER FOR SL-5	4
8.	PLAIN WASHER FOR SL-6	4

5. AFTER TIGHTENING NUTS FOR FIXING STRAP, THE THREAD OF THE BOLT MAY BE BURRED TO PREVENT THEFT.
4. CABLE TROUGH TO BE FITTED TELESCOPICALLY.
3. NO WELDING SHALL BE DONE ON ANY COMPONENT FOR FABRICATION.
2. TROUGH TO BE FABRICATED OUT OF GALVINISED STEEL SHEET TO I.S.277-1983 WITH FOLLOWING STIPULATIONS.
   THICKNESS : MINIMUM 1.6 mm.
   GRADE OF ZINC COATING : 200.
1. ALL DIMENSIONS ARE IN mm.

ARRANGEMENT OF CABLE TROUGH (G.S.) FOR GIRDER BRIDGE.

DRG.NO.RDSO\TCDO\COP-12


ENLARGEMENT - A
RLY. OF. CABLE
EMBANKMENT
CABLE TRENCH
PLAN
RLY. DUCT
100 mm DIA. R.C.C. PIPE
SECTION ON 'A-B'
100 mm DIA R.C.C. PIPE
RLY.TELECOM CABLE
CABLE TRENCH
EMBANKMENT
ENLARGED SECTIONAL VIEW AT '2'
RAIL LEVEL
FLANGE LEVEL
1000
260
100 mm DIA R.C.C. PIPE
RLY. DUCT
ENLARGED SECTIONAL VIEW AT 'XY'
ALL DIMENSIONS ARE IN mm.
ARRANGEMENT OF O.F. CABLE
R.C.C. / D.W.C. PIPE UNDER
TRACK CROSSING.
DRG.NO.RDSO/TCDO/COP/19

CHAPTER-7

JOINTING OF UNDER GROUND CABLES

7.1 Introduction

Underground Telecommunication cables are manufactured in the lengths of 1000 Metres or 500 Metres. To increase the length of the communication media to the required length, the available cable lengths are to be jointed compulsorily. Therefore cable jointing is unavoidable to meet the need. But cable jointing is a highly skilled job and should be done with all precautions. Any defect in the joint may leads to the total failure of all the circuits. Joints are very vulnerable points in a cable network, so efforts should be made to do the perfect joint strictly as per the specifications.

7.2 Preparation of Cable for Jointing

a) During the installation, a minimum of 10 meter of cable of each end is coiled in the jointing pit to provide for jointing to be carried out at convenient location as well as spare length to be available for future use in case of failures.
b) The pit size must be chosen carefully to ensure that length of the wall on which joint is mounted is greater than closure length plus twice the minimum bending radius of the cable. A pit length of 1 meter is sufficient for most of the cable and joint closures.
c) The cable is then coiled on to the pit wall in the same position as required after the joint is complete. The marking is done on all the loops so that it will be easier to install it later.
d) The distance from the latest center to the end of the cable must be atleast 1.8meter. This is being the minimum to be stripped for preparation of the joint.
e) Sufficient cable at each end upto the jointing vehicle/enclosure is then uncoiled from the pit for jointing.

7.3 Jointing procedure of Quad Cable conductors

The method of conductor joints are:

The conductors are twisted and soldered. The twisted portion is covered with PVC sleeve so that the entire twisted portion up to the PET insulation is well covered by the sleeve.

7.4 Important Stages of making a Cable Joint

1. Testing of Cable ends
2. Arrange pairs/quads
3. Twisting of conductors
4. Soldering Conductors
5. Sheath Continuity (Poly Al , Al Screen and GI armour)
6. Filling the splice filling compound
7. Provision of Al Cannistor
8. Shrinking of RTSF sleeve

7.5 Various Types of Joints in Quad Cables

The 6 Quad Telecommunication cable is received in lengths of 500/1000 metres. So there will be a main cable joint at regular intervals. These joints are systematically arranged as

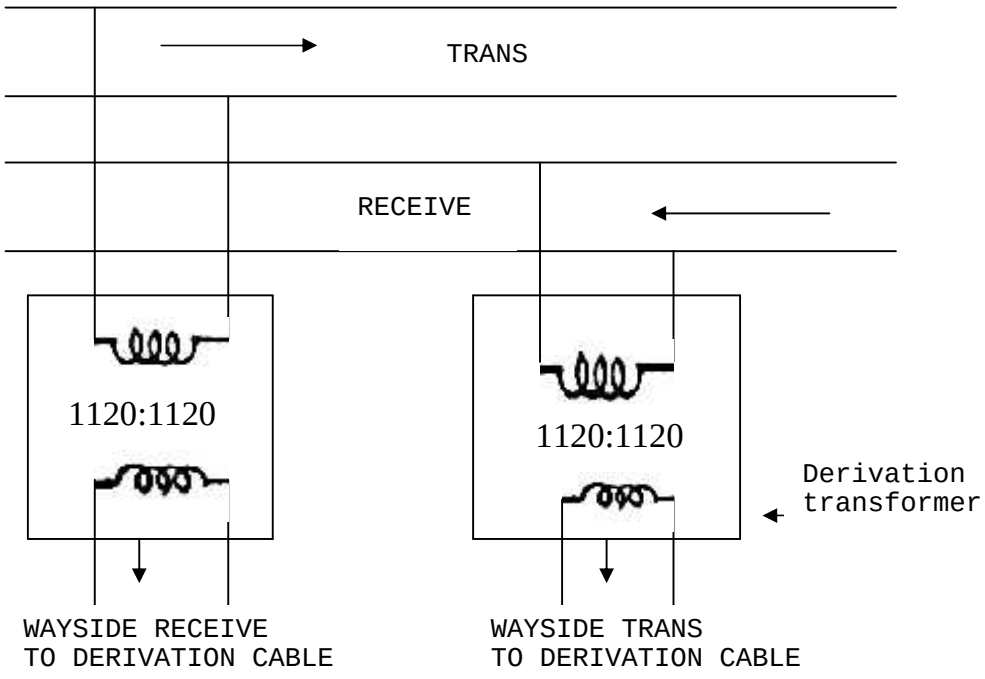
(i) Straight joints
(ii) Condenser joint
(iii) Loading coil joint.
(iv) In addition to main cable joints there will be a number of derivation joints for giving connection to the wayside stations.
i) Normal Joints

Normal joints are straight through joints connecting two ends of a cable.

i) **Condenser Joints:** The condenser joints are provided in the middle of a loading section. The purpose of connection of condensers in parallel to the conductors is for balancing in order to reduce the cross talk and noise.

ii) Loading Coil Joints: The loading coils with the value of 118 mH are connected in series with each pair to reduce the transmission loss of speech from 0.63 dB to 0.25 dB. It also works as low pass filter. The distance between two consecutive loading coils is called loading section and it is 2000 mtrs.

iii) Derivation Joints: These are transformer joints for tapping various railway control circuits, to the various utilisation points. According to the requirements of the tapping points the requisite amount of transformers are wired inside a brass casing. The derivation side of the transformer windings are connected to the derivation cable and the main side of the transformer windings are connected to the main cable. A typical transformer joint connection is shown in following figure.

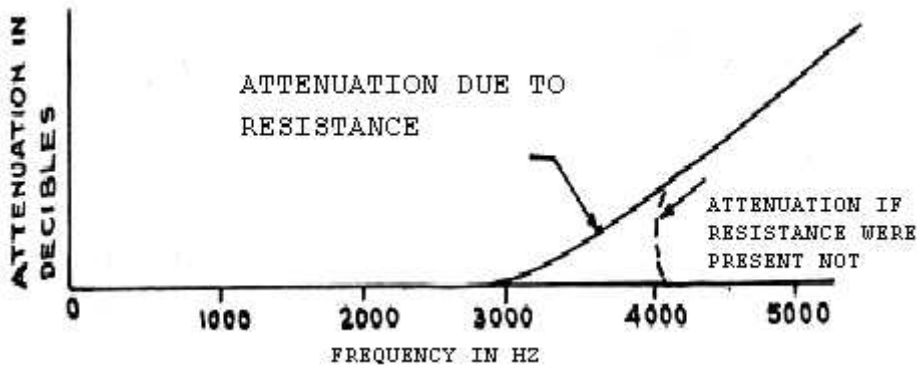


The type of transformer used will depend upon the type of circuit. The following table shows the transformers of different ratios.

The impedance ratio of matching transformer		Name of the circuit where it is used
When 6 quad cable is loaded	**When 6 quad cable is not loaded**	
1120: 1120	470:1120	For V.F. circuits (Control etc)
1: 2	1:2	For Signalling (Ringing Voltage)
1120: 600	470:600	For terminations of 2 wire circuits(LC)
470 :1120	470:1120	For Block circuits.
Insertion loss of VF Transformer		As per IRS-TC 60-93 0.6dB maximum

7.6 Effect of using 118 mH loading coil in 6 Quad Cable

The object of loading cables for voice frequencies is almost solely for the purpose of reducing the attenuation constant per Km. For long distance cables and for trunk cables 118 mH coils are used and spaced at regular intervalls of 2000 mtrs. Each (2000 mtrs) of such a cable then appears as one section of a low pass filter in which **L = 118 mH(59 mH in each limb of a pair)** and the shunt capacitance is C x S (C = Capacity per Km and S = spacing in Km)



Attenuation Vs Frequency of one Loading section

A cable has an appreciable amount of resistance, so that the attenuation characteristic of any one loaded section, would be as shown in above figure.

Note*:* Unloaded cable has an attenuation of approx. 0.65 dB/ Km. This system of loading, increases the Z_o from 470 ohms to approximately 1,100 ohms and reduces attenuation to 1/3 of its unloaded value i.e. 0.25dB/Km and this is the practice being followed in 6 Quad Cables.

Requirement of a Loading Coil:

The general requirements of loading coils are

i) High insulation resistance in order of 1000 mega ohms. between windings.
ii) Low capacitance between windings in order of .003 mfd.
iii) Magnetic stability with time and current.
iv) Non-interference between coils of neighbouring circuits.
v) Accurate inductive and resistance balance between windings.
vi) Economy of space.

7.7 The capacitance Unbalance Measuring SET [CUM SET]: -

The device is used to know the value of capacitance unbalances between the cables Pairs.

Procedure of balancing the cable

Balancing is to be done for required quads only. Before commencement of cable balancing of a loading section of 2000 mtrs. (half loading section of 1000 mtrs) all the transformer joints should be completed and the derivation cable ends should preferably be terminated on their respective cable termination points. A loading section includes the following joint positions.

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L1 ---------- SJ1 ---------- CJ ---------- SJ2 -----TJ---------L2
(a) (c) (b) (c) (d) (a)

Typical arrangement of joints in LOADING section

a) Loading coil joint
b) Condenser joint
c) Straight through joint
d) Transformer Joint (Derivation Joint)

The cable is to be balanced in loading section by loading section. The balancing comprises the following distinct operations:(Refer chapter 1.7.6 to 1.7.8)

i) Measurement of earth couplings el and e2 and poling operation for reduction of the earth couplings.
ii) Measurement and Balancing of cross-talk couplings K9 to K12 between adjacent quads.
iii) Measurement and balancing of cross-talk coupling K1 within a quad and reduction of K2 & K3 to the extent possible while connecting the balancing condensers for K1.
iv) Measurement of residual capacitance unbalances.

The earth couplings are reduced by means of “poling” i.e., either straight connecting or cross connection of the two conductors of a pair in adjacent cable lengths. The cross-talk couplings are balanced mainly by adding balancing condensers to the cable conductors.

4 Wire Condensers

The 4-wire condenser has the flexibility to provide capacitance value other than the rated values by varying the combination of its terminals as shown below.

The capacitance values with different lead combinations are as below:

Sl.No.	Between Leads	Capacitance Value
1	1,2 (together) **and** 3,4 (together)	Full value – 4C
2	1,3 (together) **and** 2,4 (together)	Half Value - 2C
3	1 and 2 **or** 3 and 4	Quarter Value -C
4	1 and 4 **or** 1 and 3 **or** 2 and 3 **or** 2 and 4	4/3 C
5	1,3 (together) and 2 **or** 1,3 (together) & 4	3C/2

It would be seen that a 4-wire condenser could be used as a 2-wire condenser also giving a range of values depending upon the connections of its leads.

7.8 Jointing Procedure of PIJF Underground Cables

7.8.1 Jointing of polythene insulated jelly filled paired cables

The Underground PIJF telephone cables are as per RDSO's Specs IRS/TC/41/97.

To make cable joints for PIJF Underground telephone cable, universal TSF kit under RDSO Specification IRS-TC-57/2006 is used.

The cable drum length, of 10, 20, 50 and 100 pairs, is generally of 500/1000 mtrs. When two cable lengths are joined together with the Thermo shrink filled closure type jointing kit, the following sizes of jointing kits are selected. The jointing procedure of polythene insulated paired cables is same as the polythene insulated quad cables.

Straight through jointing kits selection Table

Type of kit	Dia of the conductor in mm				Heat shrink sleeve size (mm)	Size of Aluminium canister length/ dia (mm)	Maximum sheath opening length L (mm)
	0.4	0.5	0.63	0.9			
TSF-1	10P 20 P	10 P 20 P	5 P 10 P 20 P	5p 10 P 20 P	525 +/-15 42/8	155/42	225
TSF-2	50P	50P	50P	20P	700 +/ –15 42/15	305/42	350
TSF-3	100P	100P	100P	50P	700+/-15 62/22	305/62	350
TSF-4	200P 400P	200P 400P	200P	200P	910+/-15 92/30	405/92	500

7.8.2 Jointing of 6 Quad underground Telecom Cables.

This chapter deals with the requirements of various types of joints on 6- Quad cable, jointing procedure and V.F. transformers etc.

Thermo shrink joint closure for various types of joints in 6-quad Telecom cables is used as per Specification No. IRS.TC.77-2012 . For L.C. gate, Pump Houses etc., the straight through joints with branching kits shall be provided for deriving the circuits using 10 pair PIJF cable. The 2T (for 1 quad) Transformer assembly is as per IRS TC-76/2000.

Transformer joints shall be used for deriving Emergency Sockets approximately at one Km distance. This joint shall generally be combined with normal joint. The tapping shall be derived through VF transformer using 10 pair PIJF cable. If the phantom circuit is not required in the 2T transformer of 1120: 1120 Ohms / 470:1120 Ohms, the centre tap wires of Transformer shall be cut permanently and insulate and not to be derived. Where block instruments are provided in the end cabins, the block part shall be derived near the cabin through derivation on 6 Quad cable using 10 pair PIJF cable. The spare conductors of the Block quad between the cabin and cable hut shall also be derived on the either side for extending block spare or Telephone between Cabin and Cable Hut/ASM.

7.8.2.1 Jointing Kit

Thermoshrink Jointing Kits, specification no: IRS-TC: 77/2012, for Underground 4/6 Quad Jelly Filled Cables and underground 4 quad dry core cable of conductor dia 0.9 mm and for Underground 4/6 Quad Jelly Filled Cables of conductor dia 1.4 mm .

This Jointing Kit is meant for Straight through/normal, condenser, Y/derivation, Loading Coil & Transformer Joints

7.8.2.2 General Jointing Procedure

a. For jointing of cables pit of 1Mx1Mx1.5M shall be made. The pit surface is to be levelled by ramming the earth. In case of loose soil or mud, bricks or ballast may be used if necessary. A tent may be placed over the pit to protect adverse weather/ dust.
b. Bend the two cable ends slowly into an 'S' shape taking care that the cables are not strained excessively and minimum over lap of 350 mm is available.
c. Prepare the cable ends as per the detailed installation instructions for making heat shrinkable joints for 6 quad cables.
d. Preliminary checks may be carried out using Multimeter for continuity of conductors and breaks/crosses etc., if any. The insulation is measured between all conductors bunched together and screen/armour by 500 V megger. The equivalent average insulation resistance/conductance/Km is obtained by multiplying the megger reading with the number of conductors and the length of the cable in Kilometres.
e. Slip the quad rings on a PE insulated quad of the cable end. Similarly slip another quad ring on the corresponding PE insulated quad of other cable ends. Select a conductor and slip a PE sleeve over it. Take this corresponding conductor of the corresponding PE quad of the other cable end. Peal off the PE insulation from these conductors for a length of 50mm.
f. Bring the two conductors together perpendicular to the cable. Twist the two conductors by rotating, giving approximately 10 turns for a length of 25mm. Cut off the surplus wire. Solder half the length of twisted conductors using solder resin core. Solder bit flat and blowlamp. Fold the twisted conductors along the main cable conductors and allow it to cool. Draw a PE sleeve over twisted joint in such a way that former projects equally on the two sides of the latter and equally covers the polythene insulation of the two conductors. It should be ensured that the PVC sleeve fits properly over the twisted joint and does not move easily over it.
g. For tapping joint, select the quad from which the circuit is to be tapped. Cut the quad, slip numbered group ring over both ends as also on the lead wire bunch of required transformer. Select a conductor in one quad and slip a P.E. sleeve over it and its other end. Select a conductor, a short lead wire and transformer lead wire and make twisted joint. With the other end of the short lead and other cut end of same conductor, make another twisted joint.
h. The conductors of the remaining PE quads should also be jointed accordingly.
i. Complete the joint as per the detailed installation instructions given in the jointing kit for making heat shrinkable joints for 6- Quad telecom Cable
j. Thermo shrink joints of appropriate size for straight through or branch off joints, as RDSO specification shall be provided.

7.8.2.3 Quad Cable Jointing Procedure

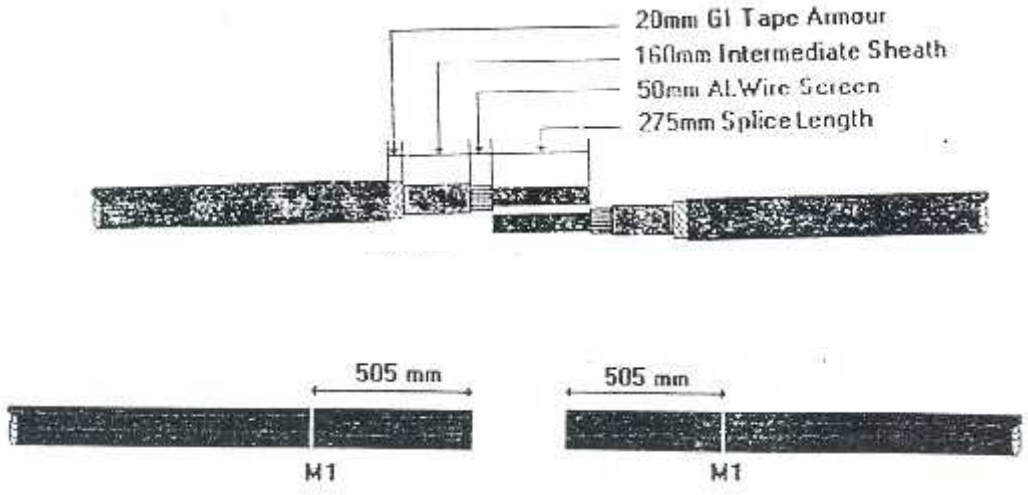
For Normal or Straight through / Derivation / Transformer / Condenser or Loading Coil Jointing of 4/6 quad jelly filled cable.

(As per Installation Instructions of RTSF kit manufacturers)

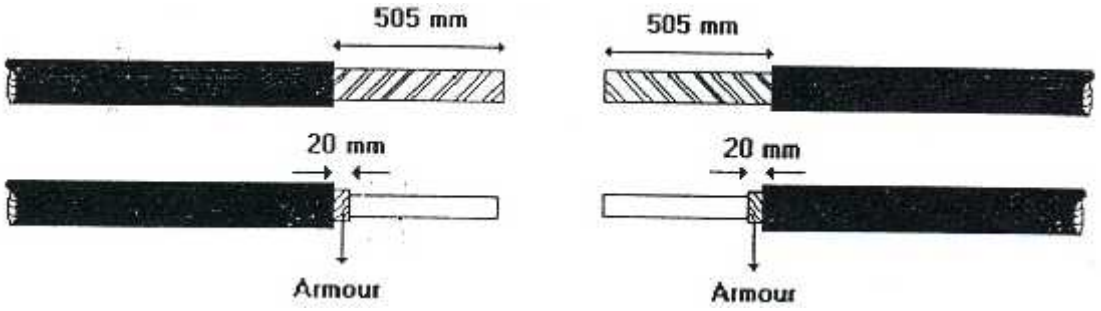
Cable Preparation

A. Lay cables with overlap of 505mm for Straight through joint, Condenser joint, Loading coil joint, Transformer joint (Derivation).
B. Expose various sheaths/armour as per details given below:
   - Outer Sheath : 505 mm
   - GI double tape armour : 20 mm
   - Intermediate sheath : 160 mm
   - Aluminium Wine Screen : 50 mm
   - Inner sheath + poly al (splice length) : 275 mm

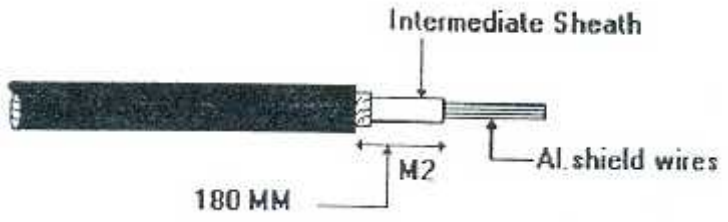
C. Cut section of 40D/4QJ/6QJ cable for Thermoshrink joint.



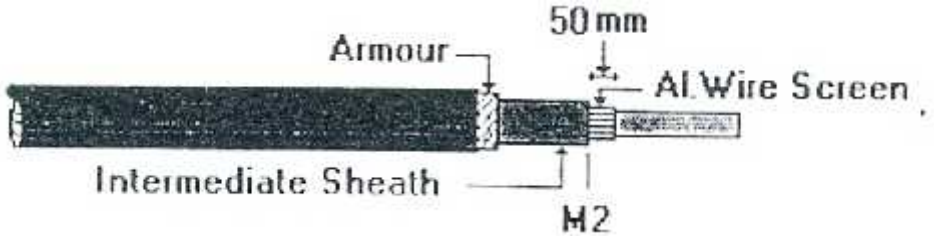
1. Mark M1 on both the cables at a distance of 505mm from the end. Cut and remove the outer most sheath up to M1.



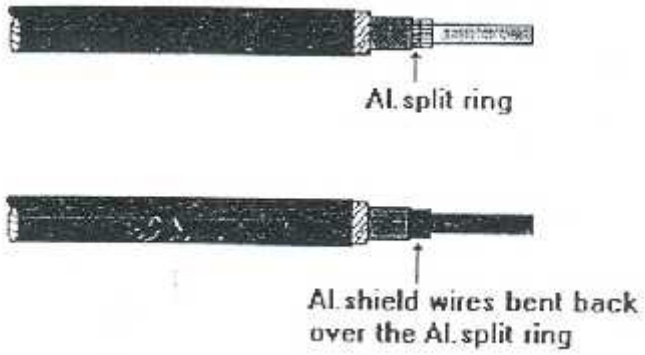
2. Cut and remove the armour up to a distance of 20 mm less than M1.



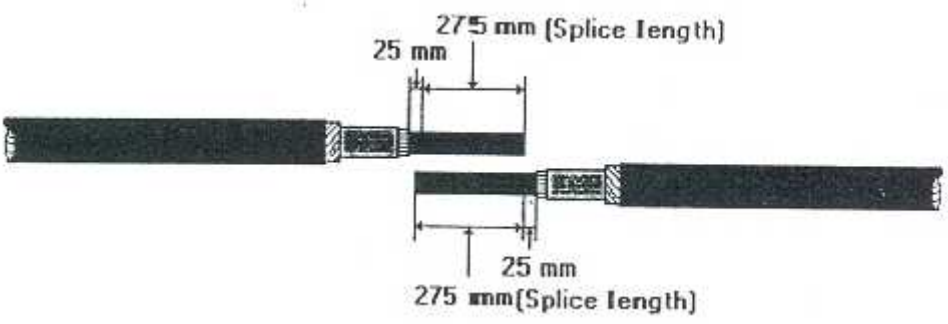
3. Mark M2 at a distance of 180 mm from M1, towards the cable end, on the middle sheath. Cut and remove the middle sheath up to M2.



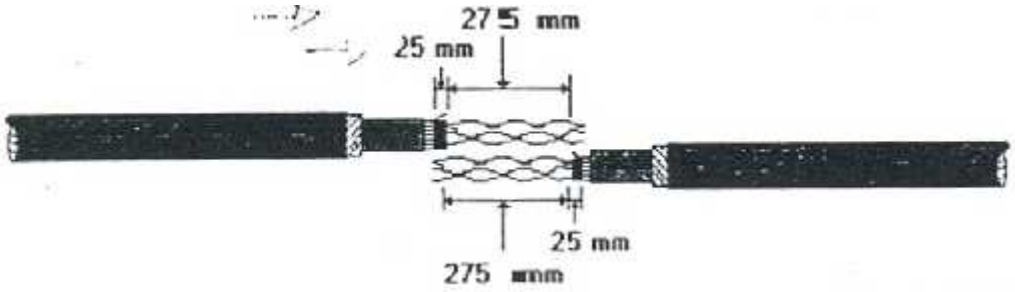
4. Mark 50 mm from M2 towards the cable end, on the Aluminium shield wires. Cut and remove Aluminium shield wires up to this mark.



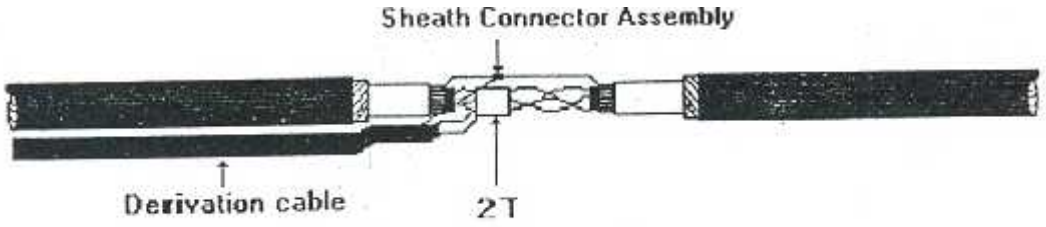
5. Slide the split Al. ring over the A1. Shield wires and bend back the wires over the ring. Repeat steps 2 to 5 on the other cable also.



6. Lay cables with an overlap equal to exposed inner sheath (275mm). This will be the splice length.



7. Mark 275mm on the inner sheath from the cable end. Cut and remove inner sheath up to this mark. In case of Jelly filled cable, clean the jelly using the cleaning liquid. This will expose 25mm of inner sheath of the cable. By making two 10mm wide parallel cuts on the inner sheath, lift this portion by 45º (inner sheath together with polyal sheath) for crimping sheath connector assembly.



8. In case of Derivation / Transformer Joints, Connect Sheath Connector Assembly to the inner sheath of quad cable and Jelly filled cable. For Straight Through, Condenser and Loading Coil Joints connect the sheath connector assembly between inner sheath of Quad Cables. Insert PVC Sleeve over all the wires to be connected, twist the conductors, solder them. After soldering, pull back the PVC sleeves over the soldered conductors. The conductor joints should be staggered to ensure even splice bundle.

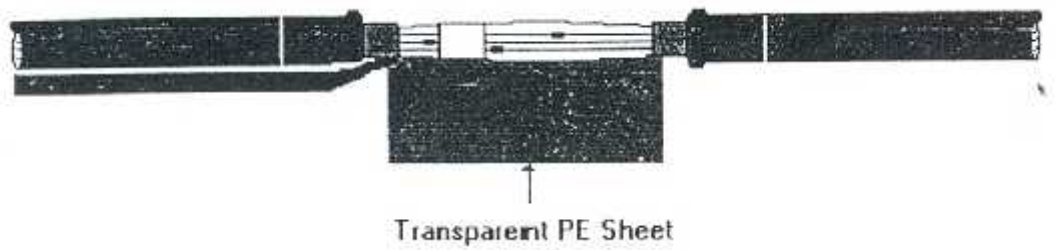
   (i) In case of Transformer Joints, the lead wires of transformer and derivation cable also need to be twisted along with the quad cable conductors and soldered.

   (ii) For loading Coil Joints, the lead wires of loading coil should be twisted along with the quad cable conductors and soldered.

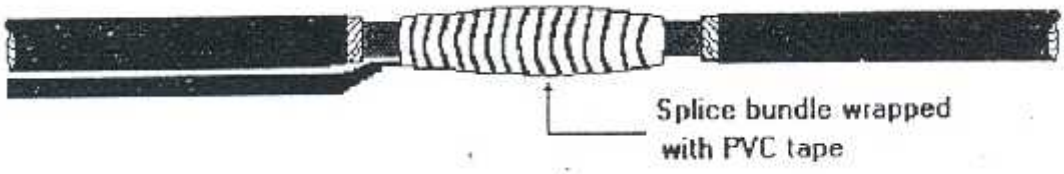
   (iii) For condenser Joints, the condenser wires should be twisted along with the quad cable conductors and soldered.

   (iv) For derivation joints, the wires of derivation cable should be twisted along with the required wires of quad cables.

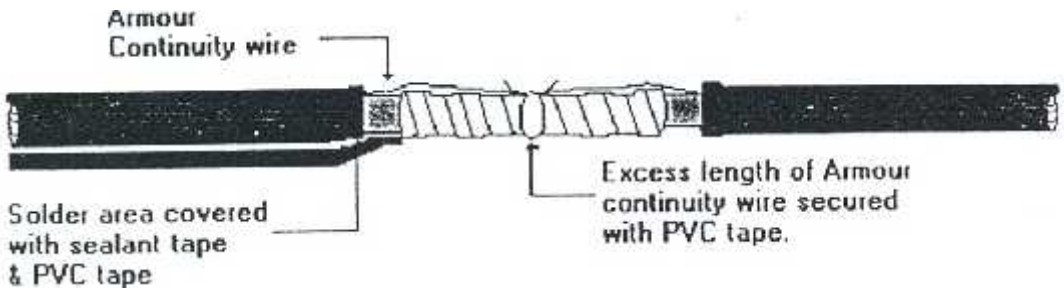
9. Slip the heat shrink tube centrally over the tinned copper braid and shrink the tube on the braid. Ends will be exposed. Fix the bare end of copper braid to shield wire and apply one turn of spring roll, bend the copper braid end towards inner sheath and complete full turns of spring roll.



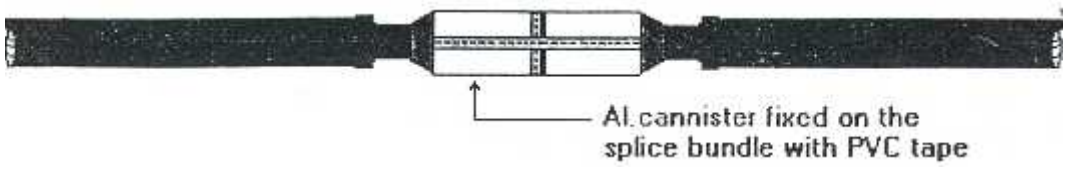
10. Affix Transparent PE Sheet on to the sealant tape and secure the ends of the pouch after filling the splice filling compound. Filling Compound should be used in all quad cables including dry core cables.



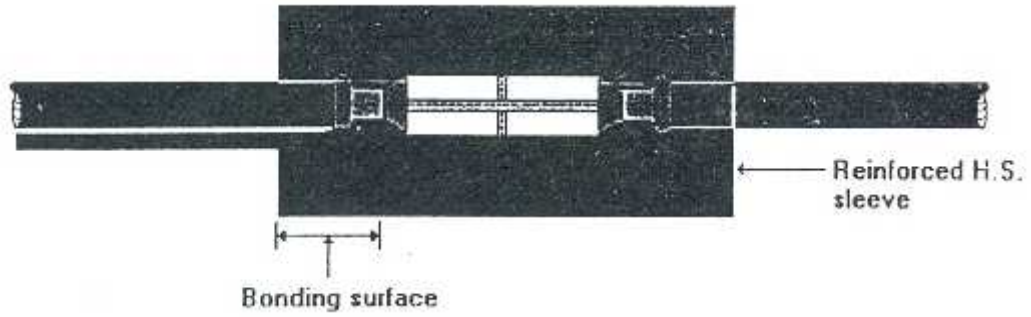
11. Wrap the PVC tape over the splice bundle with a 50% overlap. Start from one end and proceed to the other.



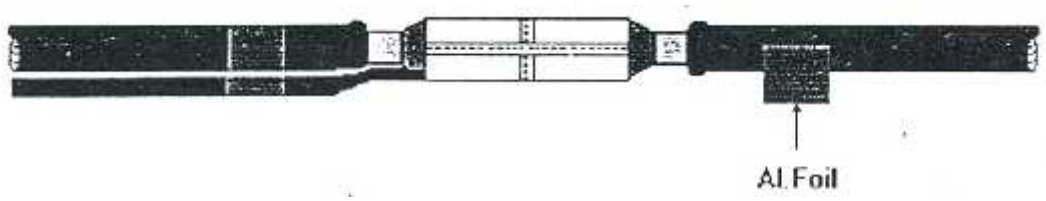
12. Remove the insulation of the armour continuity wire to the required length and wrap three rounds of the bare wire over the armour. Solder the wire to the armour and cover the soldered area with sealant tape followed by PVC tape. The excess length of the wire can be secured to the middle of the splice bundle, with PVC tape.



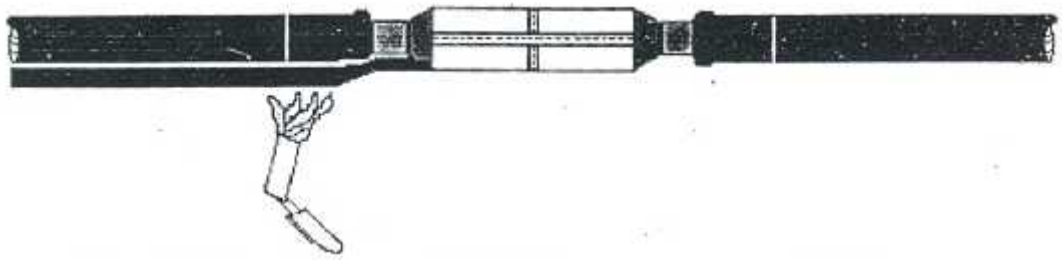
13. Install the Aluminium Cannister centrally over the splice bundle. Apply one round of PVC tape in the center to hold the half-shells. Cover the parting lines with PVC tape. Wrap two layers of PVC tape tightly, with 50% overlap, on the canister fingers to form the transition. Start from the crown end and proceed to the finger end.



14. Place the reinforced H.S.Sleeve centrally on the splice and mark the sleeve ends on the cable. The area between this mark and the end of the canister is the Bonding Surface. Clean the bonding surface of grease and dirt with the cleaning tissue and abrade the surface circumferentially with emery strip. DO NOT TOUCH THE BONDING SURFACE AFTER CLEANING OR ABRADING.

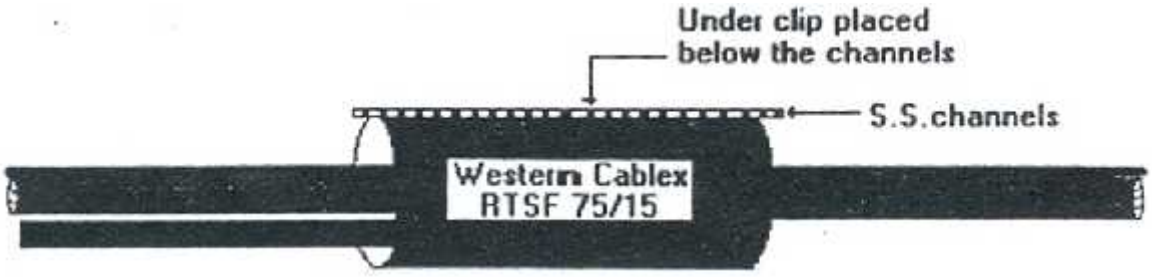


15. Wrap the Adhesive Aluminium Foil around the Outer Cable Sheath by keeping 25mm of foil inside the bonding surface.



16. Flame brush the bonding surface TILL IT BECOMES GLOSSY. DO NOT OVER HEAT AS IT COULD DAMAGE THE CABLE SHEATH.

17. Remove the protective film from the Heat shrink Sleeve.



18. Wrap around the reinforced H.S. Sleeve and position the under clip on the rails at the center. Slide the S.S. Channels over the rails in such a way that they meet at the center of the sleeve and are held by the under clip. The S.S. Channel and the canister parting lines should not come over one another.

19. Insert branch off clip between the cables on to the thermoshrink sleeve. The thermoshrink sleeve shall be evenly distributed over all the cables. Use cable tie provided in the kit for securing derivation cable and main cable together.

20. Pre-heat the channel for about 30 seconds to a minute and then start shrinking the sleeve. Begin from the center and proceed circumferentially to either ends. Tap the channel portion gently at the transition points adjacent to the canister crown. The shrinking is complete when the Thermochromic paint changes colour and white lines appear below the channels.

21. Concentrate the flame on the metal part of the BOC till the adhesive on the clip melts and oozes out. Post heat the channels with a moving flame for 15 seconds. Press the channel with a blunt tool to follow the form of canister at the transition area and post heat the transition area.

22. After shrinking, allow the joint to cool for at least 30 minutes, before handling.

Note: After making Straight through joint, Loading coil joint and Condenser joint, the following components will be in excess:
(i) Bridge connector and Aux. wire of sheath connector assembly (ii) Cable tie

7.8.2.4 Description of contents in a jointing kit of Western Cablex

(Spec. IRS:TC-77/2012 Rev.3 w.e.f: 01.11.2012)

The material (Kit Contents) for Universal Jointing Kit to be used for straight through joint, condenser joints, Y-(Derivation) joint , Loading Coil Joint, Transformer Joint.

Sl. No.	Description of Materials	0.9 mm cond. dia of 4/6 Quad cable		1.4 mm cond. dia of 4/6 Quad cable	
		Size	Qty	Size	Qty
1	Heat Shrink Sleeve(Reinforced)	Size: 75/15mm Length: 850m	11	Size: 92/25mm Length:910mm	11
2	Stainless Steel Channels x 2	Length – 450mm Thickness 0.7mm & Under clip (Length = 35mm) & Thickness 0.2mm	1	Length – 470mm Thickness 0.7mm & Under clip Length = 35mm) & Thickness 0.2mm	11
3	Aluminium Canister Finger Coated	Size = 75mm x length 507mm	1	Size = 92mm x length 507mm	1
4	Adhesive P.V.C.Tape	Width (25mm ±1mm)x length (10 meter/roll Minimum) x Thickness (0.1 to 0.13mm)	2	Width (25mm±1mm)x length (10meter/roll Minimum) x Thickness (0.1 to 0.13mm)	2
5	Adhesive Aluminium Foil	Length(400mm±4mm) xwidth (100mm±2mm) x thickness (0.06 ±0.01mm)	1	Length(400mm±4mm) x width (100mm±2mm) x thickness (0.06 ±0.01mm)	1
6	Cleaning Tissue (Soaked with5ml min Iso Propyl Alcohal)	Tissue paper size- Length (190mm min.) Width- (140mm min.)	3	Tissue paper size-Length (190mm min.) Width- (140mm min.)	3
7	Emery Strip	Length (600mm±5mm) x width(25mm± 1mm)x 60 mesh)	2	Length (600mm± 5mm) x width(25mm± 1mm)x 60 mesh)	2
8	Tinned Copper braid	length (500mm±5mm) x width (7mm±1mm) with heat shrink tubing size 12/4mm (length 450mm).	1	length (500mm±5mm) x width (7mm±1mm) with heat shrink tubing size 12/4mm (length 450mm).	1

9	Sealant Tape	Length 400mm ±10,width 35mm ±3 x thickness 3mm ±0.5	2	Length 400mm ±10,width 35mm ±3 x thickness 3mm ±0.5	2
10	Protective split Aluminium Ring	Size :– Dia 22mm x width 20mm x thickness 0.9mm	2	Size :– Dia 22mm x width 20mm x thickness 0.9mm	2
11	Spring Steel Roll	OD-21mm ±1mmWidth – 16mm ±1mm, No of rolls Minimum 8,thickness of the steel sheet 0.2mm±0.02mm	4	OD-21mm ±1mmWidth – 16mm ±1mm, No of rolls Minimum 8,thickness of the steel sheet 0.2mm±0.02mm	4
12	PVC Sleeves	dia –(5mm±0.5mm) x length (50mm±3mm)	30	i) dia –(7mm±0.5mm) x length (50mm±3mm) ii) dia – (10mm±0.5mm) x length (65mm±3mm)	30 10
13	Cleaning Cloth	Length 1 Meter min. x Width 0.75 meter min.	1	Length 1 Meter min. X Width 0.75 meter min.	1
14	Cotton Waste	50 gram (min.)	bbags	50 gram (min.)	bbags
15	Multi strand tinned copper conductors insulated cable (single core)	Length 2000 mm±10 mm, Nominal Cross sectional area4 sq. mm, for armour continuity	1	Length 2000 mm±10 mm, Nominal Cross sectional area 4 sq. mm, for armour continuity	1
16	Transparent polythene sheet:	length (500mm Min)x width (300mmMin), thickness (0.07 to 0.1mm	1	length (500mm Min)x width (300mmMin), thickness (0.07 to 0.1mm	1
17	Jelly filling Compound	(300 gm. min.)	ppack	(300 gm. min.)	Ppack
18	Installation Instructions		11		1
19	Kit Packing Box	size length 900mm x 140mm height x 120mm width (Tolerance + 10mm, -5mm)	1	size length 950mm x 140mm height x140mm width(Tolerance + 10mm, -5mm)	1
20	Packing Slip		1		1
21	Cleaning Liquid	200 gm. (min.)	ppack	200 gm. (min.)	Ppack
22	Sheath Connector (1+1+1) Assembly	(1+1+1) indicates a) 2 Clips Sheath Connector**,** length 700mm ± 7mm b) 1 Clip Sheath Connector, length 300mm ± 3mm c) Bridge connector	1 1 1	(1+1+1) indicates a) 2 Clips Sheath Connector, length 700mm ± 7mm b) 1 Clip Sheath Connector, length 300mm ± 3mm c) Bridge connector	1 1 1

23	Branch Off Clip (Medium)	For Y (Derivation) Joint & Transformer Joint	1	For Y (Derivation) Joint & Transformer Joint	1
24	Cable tie	Length (254mm±3mm), Width (4.75mm±0.5mm),Thickness(1.43mm±0.1mm)	1	Length (315mm±3mm), Width 4.75mm±0.5mm), thickness (1.56mm±0.1mm)	1
25	IDC type Jelly filled discreet wire connectors	IDC type jelly filled butt connector modules made of polypropylene for 3 wires (0.4mm to 0.9mm dia. conductors)	30 Nos.	Not applicable	-
26	IDC type Jelly filled discreet wire Connector	IDC type jelly filled connector modules made of polypropylene for 2 wires bridging type(0.4mm to 0.9 mm dia. conductors)	6 Nos.	Not applicable	-
27	Parallel jaw plier	Parallel jaw plier for crimping the discrete wire connectors. The dimension of the plier shall be compatible with the crimping tool and shall be supplied by the manufacturer of the discrete wire onnectors.		Not applicable	-

Note:- Supply of either item at SN.12 or items under SN 25, 26 and 27 shall be specific to purchaser's requirement as per clause 12 of the specification. Item No. 25, 26 and 27 shall only be supplied if IDC type discreet wire connectors are required by purchaser and in that case item number 12 shall not be supplied.

7.8.2.5 Precautions for Thermoshrink Joints of Quad Cables

RDSO guidelines issued vide lr no: STT/RE/CJ/368 dated 06.03.2013

It has been noted that the failure of the joint is often caused due to incorrect jointing method. The detailed method of jointing is explained in the installation instructions which are supplied along with every jointing kit. The performance of Thermo Shrink Joints depends to a large extent, on the correct of jointing method. Thus the jointing must be carried out by trained jointers only.

Certain important points are highlighted in Annexure -1 which if taken care shall ensure correct joint in the field.

Precautions to be taken while jointing the cables

1. The mud around the tent should protect the pit from entry of water.
2. The joint should be kept at the same horizontal level.
3. A heap of mud is to be placed over the buried joint so that the water flows away from the joint.

7.8.2.6 6 Quad Cable joint located in half location box.

Instead of putting the joints into the jointing pits, the joints are kept into a half location box in the middle of the sections.

7.9 Termination of 6 QUAD CABLE at Stations/SSP/SP/IB Hut.

The 6 Quad cable will be terminated in 20 pair cast iron termination box called as 20 pair CTB. The CT box after termination of quads shall be sealed by pouring paraffin wax.These 20 pair CTB will be used at ASM rooms, LC gate lodges, IBS huts etc.

The 6 quad cables will have to be lead inside the masonry building in the ASM's room / SSP/IB Hut at a depth of 0.75 meter by cutting the masonry structure of the wall. After the cable has been lead inside the masonry wall, the floor inside shall be duly repaired and plastered. The 6 Quad cables shall be taken through GI pipe and dressed upon teak wood plank mounted at one-meter height from the floor level and terminal box duly fixing on the wall with suitable bolts and nuts.

The Six quad cables shall be terminated in the following order in a CTB.

Quad 1:	I Pair	a) White	b) Orange
	II Pair	c) Red	d) Grey
Quad 2:	I Pair	a) White	b) Blue
	II Pair	c) Red	d) Grey
Quad 3:	I Pair	a) White	b) Brown
	II Pair	c) Red	d) Grey
Quad 4:	I Pair	a) White	b) Green
	II Pair	c) Red	d) Grey
Quad 5:	I Pair	a) White	b) Yellow
	II Pair	c) Red	d) Grey
Quad 6:	I Pair	a) White	b) Black
	II Pair	c) Red	d) Grey

The cable termination box shall consist of the following components.

1. Case
   a. Front cover
   b. Back plate
   c. Terminal plate
   d. Terminal stud
   e. Sleeve
   f. Hinge pin.

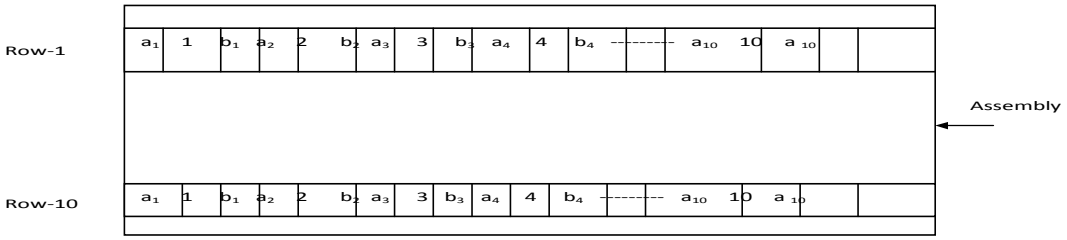
The case front cover and back plate shall be made from alloy aluminium casting. Brass used for terminals. The terminals block shall form one face of the C.T.Box. It shall have requisite pairs of brass terminals so that the connections of the underground cable can be soldered on the inner side of the block and external wires can be connected with nuts on the outer side. For outdoor cable termination the Cast Iron C.T. Box or Alloy aluminium casting C.T. Box is used for R.E or non-R. E area.

7.10 Termination of 10p/20p/50p/100P PIJF Telephone Cables

Termination Box (CTB) with Krone / Wago type modules are in use for terminating PIJF telephone cables . Cable terminal boxes are supplied in different variants viz: 20 pairs, 50 pairs and 100 pairs. They are used for terminating the switch board cables or jelly filled cables entering the CTB.

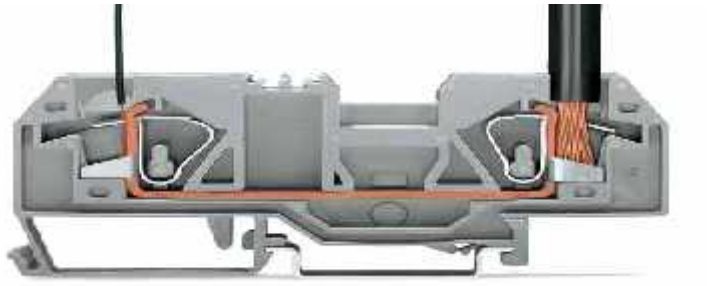
KRONE LSA-PLUS® Connection Module

KRONE LSA-PLUS® Connection Module, for 10 pairs with parallel test facility or provision for over voltage protection using 10 pair protection magazine. Conductor diameters of connectable wires are 0.40 to 0.63 mm



100 Pair Krone modules assembly

At present the pairs of polythene-insulated jelly filled cables are terminated in Krone. Generally one block of Krone can be used for termination of 10 pairs of cable. Such type of crone can be used in CTB / Location Box for termination of primary, secondary or distribution cable. Each block of Krone is assembled in a frame, which may hold 10 such blocks (100 pairs termination).



Wago terminal block

A 0.2mm2 conductor (left) and nominal diameter 16mm2 (right) in one 16mm2 terminal block. CAGE CLAMPR and CAGE CLAMPRS connections clamp CU conductors from 0.08mm2 to 35mm2 (95mm2), or from 0.25mm2 to 25mm2, respectively. Splice protection is not required– but can be used. The conductor is pressed against the current bar in the predefined contact area, without damaging it. The clamping force automatically adjusts to the wire size. Possible conductor deformation is balanced, an accidental loosening is safely prevented.

CHAPTER-8

TESTING OF CABLES

8.1 Types of tests : Cable testing can be classified into,

1. Testing before laying of cable.
2. Testing after laying of cable.
3. Fault localization tests.
4. Testing of cable before commissioning of BPAC.
5. Routine Testing (as per Telecomm Manual)

8.1.1 Tests before cable laying

a) Test the cable for proper end sealing.
b) Check for any physical / Mechanical damages during transportation, and during manufacturing,. etc.,
c) Continuity and Insulation Test

8.1.2 Tests after completion of cable laying

a) Continuity test – Ohm-meter
b) Insulation test – Insulation Megger.

8.1.3 Fault localisation tests

a) Conventional methods
b) By using Cable fault locator

8.1.4 Testing of cable before commissioning of BPAC application

Mandatory Check &Tests to be done before commissioning of BPAC/SSDAC/MSDAC applications on Quad/PIJF cables as per RDSO letter No. STS/E/SSDAC/ SPN/177 dt. 28/30-08-2006. (refer Para 8.4)

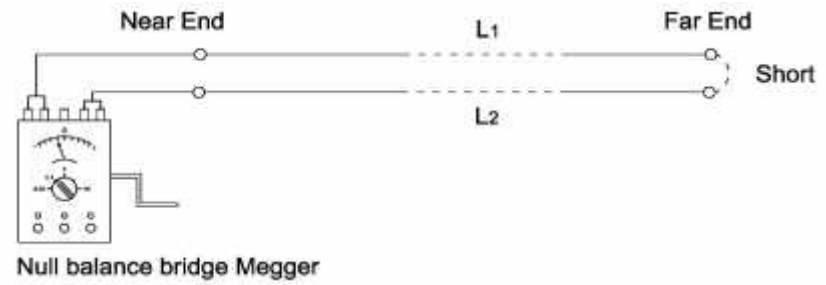
8.1.5 Routine tests

a) Conduction test.- Monthly
b) Transmission loss test.- Monthly
c) Crosstalk (near end and far end) test - Quarterly
d) Psophpmetric Noise test - Quarterly
e) Insulation test – Yearly.

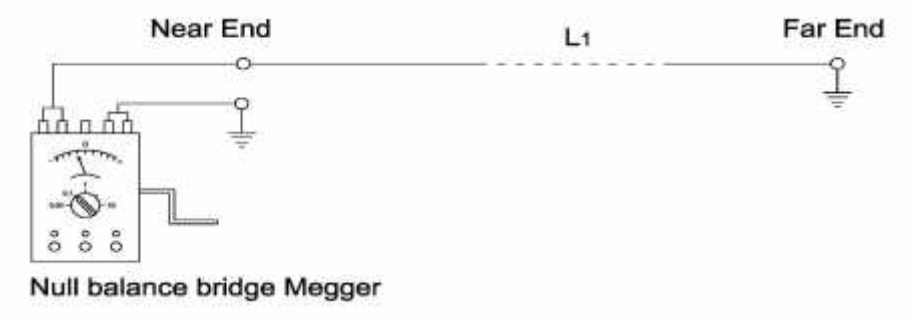
8.2 Acceptance tests for 6 Quad PIJF cables

8.2.1 Conduction Test (loop resistance and continuity)

To measure the loop resistance of pair and resistance of each conductor. Measuring instrument used is Multi meter or Ohm meter or Null balance Bridge Megger

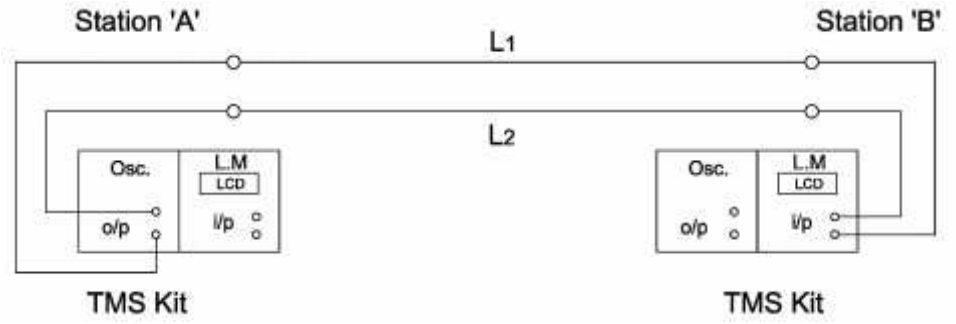


Null balance bridge Megger



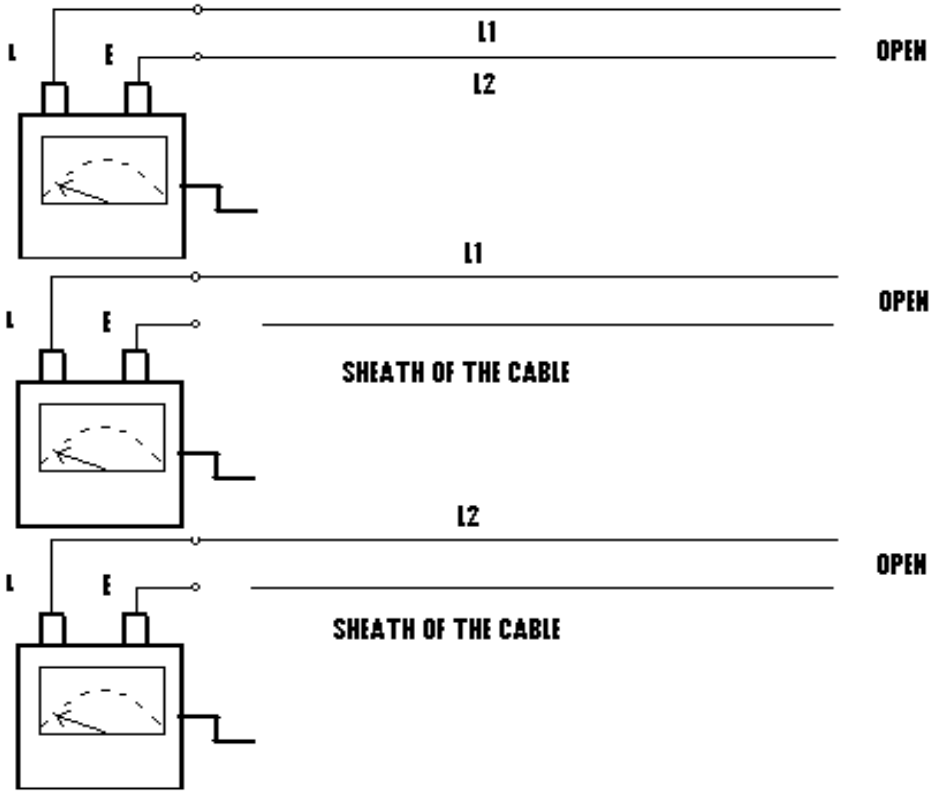
8.2.2 Transmission loss test (Frequency attenuation measurement)

To measure the Transmission loss of the system (cable). It also indicates the insertion loss of way station equipments. Instruments used are Transmission measuring sets



8.2.3 Insulation Resistance test

To measure the Insulation Resistance of a transmission line (conductors) Instrument used for measurement of insulation resistance is Insulation Tester (Megger)



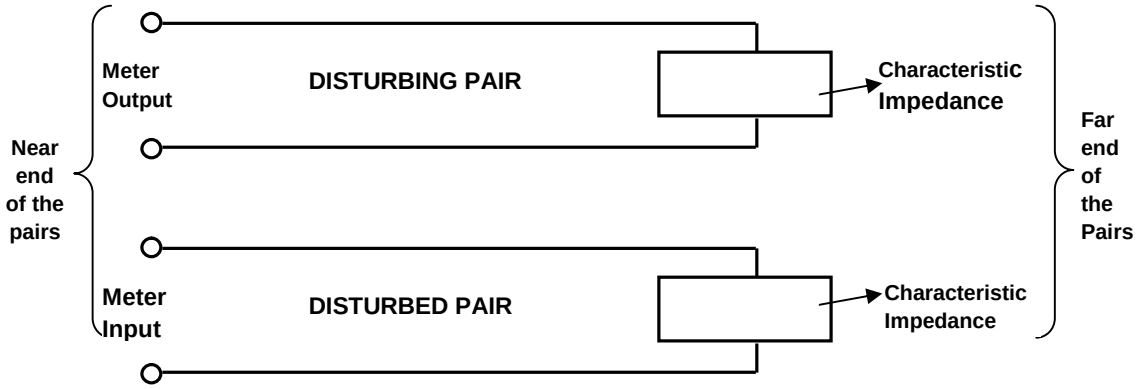
8.2.4 Cross Talk Test:

The signals of one pair of the cable produce unwanted signals in other pairs due to electrostatic and electromagnetic induction effects. These unwanted signals are called as 'Cross Talk'. The first pair is called the DISTURBING PAIR and the other pair is called the DISTURBED PAIR.

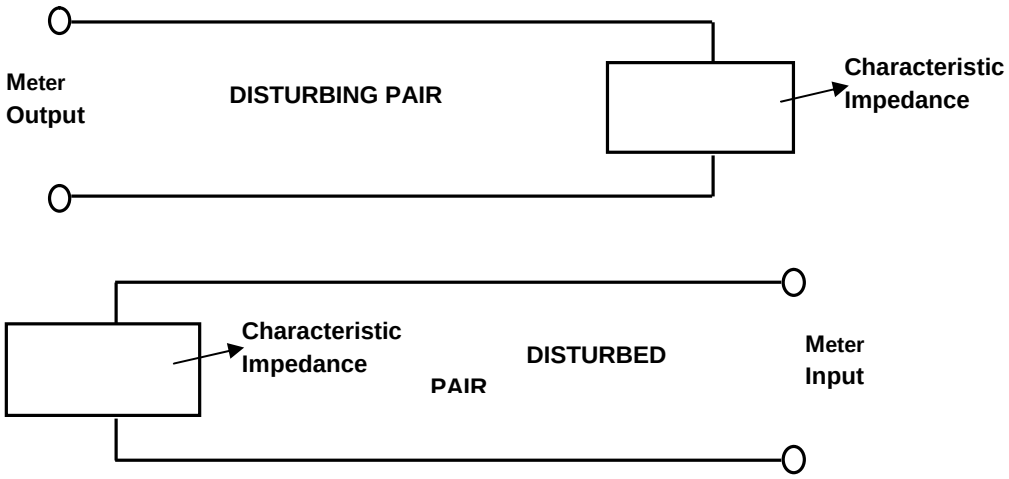
The instrument used is Cross Talk measuring sets. The cross talk is of two types:

1. Near end cross talk (NEXT) 2. Far end cross talk (FEXT)

1. Measurement of Near End Cross Talk (NEXT):

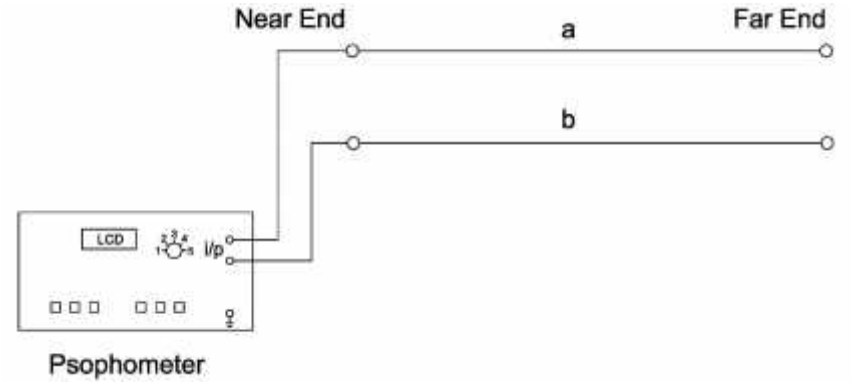


2. Measurement of Far End Cross Talk (FEXT):



8.2.5 Psophometric noise level test

Psophometer is basically used to measure the interfering effect of noise in telephone equipment caused by amplifier noise, fundamental and harmonic frequencies of AC line supply as well as by intelligible or unintelligible cross-talk from neighbouring lines. Instrument used for measuring this noise is Psophometer.



8.3 Standard values of various tests

Sl No	Description	Value
1	Loop Resistance in Ω Cable conductor of dia 0.51 mm Cable conductor of dia 0.63 mm Cable conductor of dia 0.9 mm	 182 Ω / L.Km 114 Ω / L.Km 56 Ω / L.Km
2	Psophometric Noise	≤ 2 milli Volts
3	Insulation Resistance in MΩ a) With 100V Megger b) With 500V Megger	 >100 MΩ / Km >5000 MΩ / KM
4	Transmission loss in dB a) Cable conductor of dia 0.51 mm b) Cable conductor of dia 0.63 mm c) Cable conductor of dia 0.9 mm	 1.379 1.107 0.65 (unloaded) 0.25 (when loaded}

8.4 Mandatory Check &Tests to be done before commissioning of BPAC/SSDAC/MSDAC applications on 4/6 Quad/ PIJF cables.

a) Conduction test : 56 ohms/loop km
b) Insulation Resistance : > 10 M Ohms.
c) Transmission loss test. : At 2 KHz/600ohms Transmission loss will be 1.2 dB/Km and it shall not be more than 30 db for full length Block section.
d) Near end Crosstalk at 155 KHz : Should be better than -55 dB
e) Far End Crosstalk at 155 KHz : Should be better than -55 dB
f) Psophometric Noise : Should not be more than 2 mV.
g) Continuity of Armour : Should be Ensured
h) Earth Resistance at Armour : Less than 1 Ohm
i) Position of one quad in quad cable x(A)
x (C) x (D) 1st pair - AB
x (B) 2 nd pair-CD
j) Each Quad is bounded by respective quad colour binder

Precautions to be taken while using quad cable:

- Designated pair of wire of same quad should be used.
- Do not use one wire of one quad and another wire from other quad.
- If any wire of a pair of the quad is broken then fresh pair of wire should be used.
- No wire should be paralleled for reducing the conductor resistance**.**

8.5 Causes for cable failures & precautions

- Manufacturing defects – Test the cable before laying.
- Laying of cable at lower depth – Check the depth of trench before closing the cable trench.
- Joint failure due to use of substandard / expired jointing kit or jointing done by un skilled jointer- use RDSO approved jointing kit and ensure skilled person (jointer) for jointing.
- Cable joint burnt due to lightning- Ensure the proper continuity of amour before closing the joint and armour shall be connected to an earth at cable terminations. Earth Resistance shall be less than 1 ohm at both ends of cable termination.
- Using of Quad cable without jelly – Water enters into the joint along with cable core when there is any cable damage (crow bar hit) in between two joints- Use the PIJF 6 quad cable as per RDSO spec no. IRS: TC30-2005.
- Exposing of cables on Bridges/ Culverts/Rocky areas- Regular Cable route inspection shall be done by section Technician (TCM)/JE and strengthening of cable route shall be carried out as per Railway Board Telecom Action plan.
- Cable cuts and thefts- Ensure the cable laid with in Railway boundary, avoid the exposing of cable, implement the Railway Board JPO for Earth digging works by Engg. Dept., update the cable route diagrams and upload to web page for easy access to concerned dept.
- Codal life of Cable- Plan for replacement of cable within its codal life (20 / 25 years).

8.6 Fault localisation Tests

8.6.1 Conventional methods

Inspection of cable route to identify the spots of recent digging:

Foot inspect the entire cable path in the section. If there is any sign indicating any recent digging the same can be suspected to contain the fault. Excavate the trench and expose the cable. Extend the trench for about 10 ft. length or up to the length covered by the recent digging. Expose the cable. Inspect for any damage on the cable. If there is any damage, operate the cable.

Operating the joint nearest to the point of localization

a) Find out from the cable diagram the joint nearest to the point of localisation. Locate it (Joint J1 in figure). Expose the joint. Inspect for any damage. If the joint is damaged, verify if this was the fault. If so, repair and close the case.
b) If the fault is not found in this joint, expose the joint on the other side of point of localisation. Call it joint J2 and repeat the above operation of testing.

Spot localizations

1. Test from joint J1 to determine if the fault is towards the point of localisation or on the other side i.e., towards joint J3.

Jl ------L------ J2 -----L-------J3-----L-----J4

2. If the fault is towards joint J2 take the test from J2 If the fault is towards J1 from here, proceed for spot localisation and determine the length of the overlap between joints J1 and J2.
3. If fault is towards J3, tested from J2, operate J3 and repeat the spot localisation and determine the length of overlap between J2 and J3.
4. If you find fault on either side of a joint, it indicates multiple faults. Clear faults one by one.

8.6.2 By using Cable fault locator

Fault localizations by using Digital Cable Fault locator

Cable repair work, localisation of faults must be simple and accurate. In most of the techniques adopted for cable fault localisation, the procedure adopted is very much laborious. A loop test for example, is time consuming. It is essentially a D.C. test whose accuracy can be altered with the presence of a foreign potential in the cable pair under test.

All the types of faults in the cable as mentioned below can be identified

1. Break/Open Circuit and Short Circuit fault.
2. Low Insulation faults.
3. Induced Voltage

For accurate and speedy fault localisation, the techniques using pulse reflection method is found to be quite useful. It is essentially a high frequency AC test signal generator and useful for localizing those faults that do not upset any DC condition but affect the propagation of the A.C. high frequency energy. The nature of faults that include open circuits, open sheaths, high resistance joints, and water logged cable section etc.

Testing Procedure

There is no need for a good pair or limb for conducting the tests of break, open, insulation and induced voltage. However if a good pair is required as a reference pair to identify low insulation faults. It is advisable that the cable pair to be tested is free from voltage. The reflection of pulse will depend on the impedance irregularity of the pair under test.

In the case of open or break fault the reflection pulse will be indicated by upward kink or positive reflection. For short or low resistance faults the reflection pulse will be indicated by downward kink or negative reflection. Whatever energy reaches the dead short is totally reflected back because the dead short appears as a mere impedance irregularity and we can see a big reflected pulse corresponding to the dead short. Poorer the insulation at the fault greater is the magnitude of the impedance irregularity and bigger the reflected pulse. The presence of moisture in a particular section alters transmission characteristics of that section. It is essential to connect the instrument to one end of the circuit under test and shift it to the other end and carryout the same test so as to find out the length of overlap.

The accuracy of distance to fault depends upon the accuracy of V/2 values.

D = V/2 X T where T is the time taken for the reflected pulse energy to arrive back at the instrument, V is the velocity of propagation in a circuit and D is the distance to fault.

For Knowing V/2 value, connect the cable pair to the instrument the reflected pulse should be aligned accurately with the incident pulse and the switch should be set such that the display on the digital readout corresponds to the V/2 value for that pair.

It should be remembered that alignment of incident and reflected pulses should be done with reference to the commencement of their leading edges (align the foot of the reflected pulse with the foot of incident pulse).

Types of Faults and their respective Reflection Pulses

1. Conductor break fault (one limb or both):A positive reflection will be shown at the point of break.
2. Contact Fault (Limb to Limb). A negative reflection will be shown at the point of contact.
3. Earth Fault (Limb to Sheath). It is a very low resistance fault. When pulse is applied between the conductor (limb) and sheath a negative reflection similar in the above case is observed.

CHAPTER-9

QUAD CABLE MAINTENANCE

9.1 Typical 6 Quad cable failures & their causes

1. Cable burnt at joint due to lightning and all circuits failed- armour connectivity in joint was given up.
2. Cable is noisy while train passing in the section and BPAC circuit is frequently failing- improper earthing of cable armour.
3. Abnormal delay (48 hrs) in restoring of 6 quad cable fault: Cable was not traceable because cable was laid outside Railway Boundary one year back and the colony people constructed culvert on the cable route at about 10mts. The drainage water was over flowing and spread over the area and got covered with thick bushes. Staff were not able to walk on the cable route with cable route locater and missed the fault. Cable was found damaged in the culvert.

Integrated Cable path diagram showing all S&T Cable path position shall be prepared and made available with all S&T staff to protect the under- ground S&T Cables.

9.2 Important tools to protect underground S&T Cables from damages

1. Integrated Cable Path diagram
2. Cable route tracer
3. Cable Fault Locator (Digital)

QUAD CABLE MANTENANCE REGISTER

General Instructions

Do's

1.	Quad cable testing of Block, BPAC and IB applictions should be done with disconnection and jointly with ESM/ JE-Sig.
2.	To avoid train detention ensure proper planning before work and test the circuit after the work is completed in consultation with signal staff.
3.	Before testing the cable, ensure suitable staff availability at both ends
4.	Before testing, check your meters for correct calibration.
5.	Isolate working circuit from the end point and test the cable end to end.
6.	Before insulation testing check earth resistance at test point. Test results will be misleading in absence of proper earth.
7.	Ensure the watering of earth pit in every visit.
8.	After testing and reconnecting the cable, ensure functioning of all circuits with SMR / Test room.

Don'ts

1	Don't disconnect Block, BPAC and IB circuits without issuing disconnection memo for testing of Quad cable

Measuring Instruments &Tools Required for Maintenance of Underground Telecom cables

(i)	Multimeter	1 No.
(ii)	T.M.S. Kit	2 Sets
(iii)	Psophometer	1 No.
(iv)	Cross Talk Measurement Set	1 (-70 dB range shall be available)
(v)	Capacitance Unbalance Measuring Set	1 No.
(vi)	Earth Tester	1 No.
(vii)	Megger (100 Volts)	1 No.
(viii)	Cable fault locator (Digital)	One in repeater
(ix)	Cable Route Locator	1 No. (with In charge Inspector)
(x)	Frequency counter for DTMF Signalling	1 in Headquarters
(xi)	Hydrometer	1 in each repeater and test room
(xii)	Emergency Control Telephone	1 with each Inspector
(xii)	Pick axe	2 Nos.
(xiii)	Crow Bars	2 Nos.
(xiii)	Shovels	2 Nos.
(Xiv)	Search Light	1 with each Inspector

Schedule of Testing & Measurements

1	Checking Attenuation	Monthly
2	Loop Resistance Test	Monthly
3	Checking Cross Talk Level	Quarterly
4	Checking Noise Level	Quarterly
5	Insulation Resistance Test	Yearly

Inspections

1	Monthly schedules	carried out by Telecom. Inspector
2	Quarterly & Yearly schedules	Telecom. Inspector Incharge
3	Annual inspection	ASTE/ DSTE/ Sr.DSTE

Mandatory Check & Tests before commissioning of
Quad /PIJF cable for BPAC/ SSDAC / MSDAC applications

As per RDSO letter No. STS/E/SSDAC/ SPN/177 dt. 28/30-08-2006)

1. Check for the cable parameters as below:

a) Insulation - shall be greater than 10 M Ω.

b) Loop resistance - shall be 56 Ω./ km (Loop)

c) Attenuation Losses - at 2 KHz/ 600 Ω impedance shall not be more than 30 dB for full length of Quad cable

d) Near end crosstalk - shall be better than - 55 dB at 155 KHz

e) Far end crosstalk - shall be better than - 55 dB at 155 KHz

f) Continuity of Armour - shall be ensured

g) Earth resistance at Armour - shall be less than 1 Ω.

2. Precautions to be taken care during the wiring/ connections are to be done

a) Position of One Quad in Quad cable:

White
X(A)
Red (C) X X (D) Grey
X (B)
Quad colour

1st pair = White & Quad colour i.e. A & B Wires

2nd pair = Red & Grey colour i.e. C & D wires if designated colour of quad

Each Quad is bound by the respective quad colour binder

b) Colour scheme of PE insulated Quads

Quad Colour	Quad No.	Pair No.	A-Wire	B-Wire	Pair No.	C-Wire	D-Wire
Orange	1	1A	White	Orange	1B	Red	Grey
Blue	2	2A	White	Blue	2B	Red	Grey
Brown	3	3A	White	Brown	3B	Red	Grey
green	4	4A	White	Green	4B	Red	Grey
Yellow	5	5A	White	Yellow	5B	Red	Grey
Black	6	6A	White	Black	6B	Red	Grey

c) Precautions to be taken for using QUAD Cable:

i) Designated pair of wire of the same Quad (mentioned in the above colour scheme) should be used.

ii) Do not use one wire from one Quad and another wire from some other Quad.

iii) If any wire of a pair of the Quad is broken/Non functional, then use fresh pair of wire.

iv) No wire should be paralleled for reducing the conductor resistance.

Quad Cable Allocation in the Section

Quad No.	Circuit working
Quad 1	
Quad 2	
Quad 3	
Quad 4 / 1	
Quad 4 / 2	
Quad 5	
Quad 6 / 1	
Quad 6 / 2	

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6 QUAD CABLE TEST REPORT (for 1st Quarter)

Control Section : _____

Section Under Testing : _____

Quad No	1 st Month _____ Date of Testing _____				2 nd Month _____ Date of Testing _____				3 rd Month _____ Date of Testing _____			
	Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)	
	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2
1												
2												
3												
4												
5												
6												
1) Earth Resistance at cable Armour (To ensure integrity of Earth)			_____ Ω.		_____ Ω.				_____ Ω.			
2) Armour continuity with respect to Earth (To ensure Armour continuity)			_____ Ω.		_____ Ω.				_____ Ω.			
Remarks :												
Signature												
Name												
Designation												

6 QUAD CABLE TEST REPORT (for 2nd Quarter)

Control Section : _____

Section Under Testing : _____

Quad No	1 st Month _____ Date of Testing _____				2 nd Month _____ Date of Testing _____				3 rd Month _____ Date of Testing _____			
	Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)	
	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2
1												
2												
3												
4												
5												
6												
1) Earth Resistance at cable Armour (To ensure integrity of Earth)			_____ Ω.		_____ Ω.				_____ Ω.			
2) Armour continuity with respect to Earth (To ensure Armour continuity)			_____ Ω.		_____ Ω.				_____ Ω.			
Remarks :												
Signature												
Name												
Designation												

6 QUAD CABLE TEST REPORT (for 3rd Quarter)

Control Section : _____

Section Under Testing : _____

Quad No	1 st Month _____ Date of Testing _____				2 nd Month _____ Date of Testing _____				3 rd Month _____ Date of Testing _____			
	Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)	
	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2
1												
2												
3												
4												
5												
6												
1) Earth Resistance at cable Armour (To ensure integrity of Earth)			_____ Ω.		_____ Ω.				_____ Ω.			
2) Armour continuity with respect to Earth (To ensure Armour continuity)			_____ Ω.		_____ Ω.				_____ Ω.			
Remarks :												
Signature												
Name												
Designation												

6 QUAD CABLE TEST REPORT (for 4th Quarter)

Control Section : _____

Section Under Testing : _____

Quad No	1 st Month _____ Date of Testing _____				2 nd Month _____ Date of Testing _____				3 rd Month _____ Date of Testing _____			
	Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)		Conduction Test (56 Ω /KM)		Transmission Loss @ 800HZ (0.28 db/KM for loaded 0.8db/Km unloaded)	
	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2
1												
2												
3												
4												
5												
6												
1) Earth Resistance at cable Armour (To ensure integrity of Earth)			_____ Ω.		_____ Ω.				_____ Ω.			
2) Armour continuity with respect to Earth (To ensure Armour continuity)			_____ Ω.		_____ Ω.				_____ Ω.			
Remarks :												
Signature												
Name												
Designation												

Length of the cable : _____ KMs

Test Location : _____

1st Quarter Date of Testing _____									
Near End Crosstalk @ 800 Hz (better than -61db)		Far End Crosstalk @ 800 Hz (better than -65db)		Psophometric Noise (< 2 m V)		Induced Voltage w.r.t earth (<5V)			
Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	a	b	c	d

Length of the cable : _____ KMs

Test Location : _____

2nd Quarter Date of Testing _____									
Near End Crosstalk @ 800 Hz (better than -61db)		Far End Crosstalk @ 800 Hz (better than -65db)		Psophometric Noise (< 2 m V)		Induced Voltage w.r.t earth (<5V)			
Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	a	b	c	d

Length of the cable : _____ KMs

Test Location : _____

3rd Quarter Date of Testing _____									
Near End Crosstalk @ 800 Hz (better than -61db)		Far End Crosstalk @ 800 Hz (better than -65db)		Psophometric Noise (< 2 m V)		Induced Voltage w.r.t earth (<5V)			
Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	a	b	c	d

Length of the cable : _____ KMs

Test Location : _____

4th Quarter Date of Testing _____									
Near End Crosstalk @ 800 Hz (better than -61db)		Far End Crosstalk @ 800 Hz (better than -65db)		Psophometric Noise (< 2 m V)		Induced Voltage w.r.t earth (<5V)			
Pair-1	Pair-2	Pair-1	Pair-2	Pair-1	Pair-2	a	b	c	d

6 QUAD CABLE INSULATION TEST REPORT (YEARLY)

Control Section : _____

Section Under Testing : _____

Quad No	Insulation test w.r.t Earth (10 M Ω/KM)				Insulation test with Adj. conductor in the quad (>20 M Ω)					
	a	b	c	d	ab	ac	ad	bc	bd	cd
1										
2										
3										
4										
5										
6										
Remarks :										
Signature										
Name										
Designation										

Length of the cable : _____ KMs

Test Location : _____

Insulation test with adjacent Quad (>20 M Ω.)														
Q1-Q2	Q1-Q3	Q1-Q4	Q1-Q5	Q1-Q6	Q2-Q3	Q2-Q4	Q2-Q5	Q2-Q6	Q3-Q4	Q3-Q5	Q3-Q6	Q4-Q5	Q4-Q6	Q5-Q6

Annexure-1

JPO issued by Railway Board to prevent cable cuts

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)
***

No.2003/Tele/RCIL/1 Pt.IX

New Delhi dated 24.06.2013

General Managers,
All Indian Railways.

Telecom Circular No. 17/ 2013

Sub: Procedure for undertaking digging work in the vicinity of Signaling, Electrical and Telecommunication Cable.

JPO No. 1/Sig/2004 dated 16.12.2004 issued by Board on the subject matter was reviewed in consultation with Signal, Electrical, Civil Engineering and Works Directorates of Board.

2. The same has now been finalized and a copy of the Revised Joint Procedure Order duly signed by ED/TD, EDCE/P, ED/SD, ED/W and EDEE/M is attached for compliance.

3. Please acknowledge receipt.

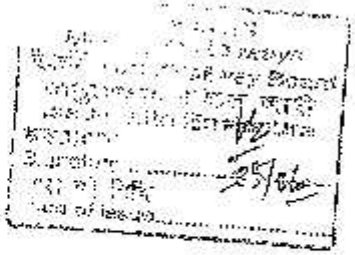
DA: 1 in 5 pages.

(Rakesh Ranjan)
Director(Telecom.

Copy to:-

i) ED/TD, EDCE/P, ED/SD, ED/W and EDEE/M
ii) CSTEs, All Indian Railways
iii) CSTEs/Construction, All Indian Railways
iv) ED/Tele, RDSO, Lucknow
v) MD/RCIL, 143, Institutional Area, Sector 44, Gurgaon – 122003.Haryana.

o/c



Annexure to Telecommunication Circular No. 17/2013

JOINT PROCEDURE ORDER FOR UNDERTAKING DIGGING WORK IN THE VICINITY OF UNDERGROUND SIGNALING, ELECTRICAL & TELECOMMUNICATION CABLES.

A. A number of Engineering works in connection with gauge conversion/doubling/third line are in progress on various Railways, which require extensive digging work near the running track, in close vicinity of the working S&T cables carrying vital safety circuits as well as electrical cables feeding the power supply to cabins, ASM room, RRI Cabin, Intermediate Block Huts (IBH) etc. Similarly, S&T organisation under open line or construction units under CAO/C, are executing various Signaling and Telecom works requiring digging of earth for laying of cables or casting of foundations for the erection of signal posts etc. RailTel is also executing the work of laying of quad cable and OFC on various Railways as a part of sanctioned works for exclusive use of Railways for carrying voice and data i.e. administrative and control communication, PRS, FOIS etc. or shared by RailTel Corporation of India Ltd. On certain sections digging is also required for laying of electrical cable and casting of foundation for the erection of OHE masts by Electrical Deptt. Generally, these works are executed by contractors employed by these organisations.

B. However, while carrying out these works in the vicinity of working signaling, telecommunication and electrical cables, at times, cable cuts take place due to JCB machines working along the track or during the digging work being done by contractors carrying out the Civil Engineering works. Similarly, such cable cuts are also resulting due to works undertaken by S&T or Electrical departments. Such cable faults results in the failure of vital signaling and telecommunication circuits & electrical installations.

C. Henceforth, the following joint procedure shall be followed by Engineering, Electrical and S&T (and RailTel organisation, wherever such works are being done by them) officers of the respective divisions and by the construction organisation, while carrying out any digging work near to existing signaling & telecommunication and electrical cables, so that the instances of cable cut due to execution of works, can be controlled and minimized.

1. S&T department (and RailTel, where they have laid the cables) and Electrical department shall provide a detailed cable route plan showing exact location of cable at an interval of 200 m or wherever there is change in alignment so that the same is locatec easily by the Engineering official/contractor. In addition, S&T department and Electrical department shall also provide cable markers along the alignment of the cable. These cable route plans shall be made available to the Sr.DEN/DEN or Dy.CE/C, as the case may be, by Sr. DSTE/DSTE or Sr.DEE/DEE of the divisions or Dy. CSTE/C or Dy. CEE/C within 15 days in

1 of 5

duplicate. Sr. DEN/DEN or Dy.CE/C will send copies to their field unit i.e. AEN/SE/P. Way & Works.

2. Before taking up any digging activity on a particular work by any agency, Sr. DSTE/DSTE or Sr.DEE/DEE of the section shall be approached in writing by the concerned Engg. or S&T or Electrical officer for permitting to undertake the work. Sr.DSTE/DSTE or Sr.DEE/DEE, after ensuring that the concerned executing agencies including the contractor have fully understood the S&T and Electrical cable route plan, shall permit the work in writing within 7 days of the request by concerned department.

3. After getting the permission from S&T or Electrical department as the case may be, the relevant portion of the cable route plan shall be attached to the letter through which permission is issued to the contractor by concerned Engg. official for commencement of work and ensuring that the contractors have fully understood the cable route plan and precautions to be taken to prevent damage to the underground cables. The contractor shall be asked to study the cable plan and follow it meticulously to ensure that the safety of the cable is not endangered. Such a provision, including any penalty for default, should form part of agreement also. It is advisable that a suitable post of SE/Sig or SE/Tele or SE/Electrical(TRD or G) shall be created chargeable to the estimates of doubling/gauge conversion, who can help Engg. agencies in the execution of the work. However basic responsibility will be of the department executing the work and the contractor. Creation of posts is not mandatory.

4. The SE/P.Way or SE/Works shall pass on the information to the concerned SE/Sig. or SE/Tele or SE/Electrical(TRD or G) about the works being taken up by the contractors in their sections at least 3 days in advance of the day of the work. In addition Engineering control shall also be informed by SE/P.Way or SE/Works, who in turn shall pass on the information to the test room/network operation center of RailTel/TPC/Electrical control.

5. On receiving the above information, SE/Sig or SE/Tele or SE/Electrical(TRD or G) shall visit the site on or before the date of taking up the work and issue permission to the contractor to commence the work after checking that adequate precautions have been taken to avoid the damage to the cables. The permission shall be granted within 3 days of submission of such requests.

6 The name of the contractor, his contact telephone number, the nature of the work shall be notified in the Engineering control as soon as the concerned Engineering officials issue the letter authorizing commencement of work to the contractor. Test room shall be given copies. Test room shall collect any further details from the Engineering control and shall pass it on to S&T/RailTel & Electrical officials regularly. In case the supervisors of concerned departments do not turn up on the day as advised in terms of para 4 and 5 above, the works of contractor should not be stopped on this account.

7. In case of works being taken up by the State Government, National Highway Authority etc., the details of the permission given i.e. the nature of work, kilometer etc. be given to the Engineering control including the contact person's number so that the work can be done in a planned manner. The permission letter shall indicate the contact numbers of Test room/Network Operating Centre of RailTel/IPC/Elect. Control.

8. Where the nature of the work taken up by the Engineering department is such that the OFC or other S&T cables or Electrical cables is to be shifted and relocated, notice of minimum one week shall be given so that the Division/RailTel/Construction can plan the works properly for shifting. Such shifting works shall in addition, for security and integrity of the cables, be supervised by S&T supervisors/RailTel supervisors/Electrical supervisors.

9. The concerned SE/P.Way/SE/Works/SE/Sig/SE/Tele/ SE/Electrical(TRD or G) or RailTel supervisors supervising the work of the contractor shall ensure that the existing emergency sockets are not damaged in view of their importance in providing communication during accident/emergency.

10. In case of minor nature of works where shifting of cable is not required, in order to prevent damage to the cable, the Engineering contractor shall take out the S&T or optical fibre cable or Electrical cable carefully from the trench and place it properly alongside at a safe location before starting the earthwork under the supervision of SE/Sig. or SE/Tele or SE/Electrical(TRD or G). The cable shall be reburied soon after completion of excavation with proper care including placement of the brick over the cable under the supervision of S&T or Electrical supervisors. However, the work will be charged to the concerned engineering works. The responsibility for ensuring availability of SE (Signal), SE (Electrical) as per para 4 and 5 above lies with the respective department. The contractor will go ahead with the shifting of cables as per the program decided and he will not be held responsible for any cable cut.

11. In all the sections where major project are to be taken up/going on RailTel/S&T department shall deploy their official to take preventive/corrective action at site of work. As regards Electrical Department, the official may be deputed on need basis.

12. No new OFC or quad cable shall be laid close to the existing track. It shall be laid close to the Railway boundary on one side of the Railway track to the extent possible to avoid any interference with the future works (doubling etc.). It shall be ensured in the new works of cable laying that the cable route is properly identified with electronic or concrete markers. Wherever multiple cables are laid in a trench, RFID markers may be provided for easy identification of the cable. Henceforth, wherever cable laying is planned, before undertaking the cable laying work, the cable route plan of the same shall be prepared by the Dy.CSTE/C or Dy.CEE/C

and shall be got approved from the concerned Sr. DSTE/DSTE or Sr. DEE/DEE and also from the concerned Dy. CE/C for new lines and from the concerned Sr.DEN for all other projects including doubling GC etc., to avoid possible damage in future. Such approval shall be granted within 15 days of the submission of the request.

13. The works of excavating the trench and laying of the cable should proceed in quick succession, leaving a minimum time between the two activities.

14. In case damage is caused to OFC/Quad cable [illegible] during execution of the work, the contractor is liable to pay a penalty for damaging the cable. Penalty shall not be levied in case of the following:-

(i) Detailed cable route plan as per clause C-1 not provided by concerned department or cable is not protected as per laid down procedures.
(ii) The alignment of the cable does not tally with the information provided to the contractor.
(iii) The cable depth is found to be less than 800 mm from normal ground level.
(iv) No representative of S&T department/RailTel was available at site guarding the cables on the fixed pre determined date and time.

15. Penalty to be imposed for damages to cable shall be as under:-

Cable damaged	Penalty per location
Only Quad cable or Signaling cable	₹ 1.0 Lakh
Only OFC	₹ 1.25 Lakh
Both OFC & Quad	₹ 1.5 Lakh
Electrical Cable	₹ 1.0 Lakh

Necessary debit in this regard shall be raised on the department undertaking the work who shall in turn levy the penalty on the defaulting contractor. S&T department shall raise the debits in case of damage to OFC or Quad or Signaling cable and Electrical department shall raise the debits in case of damage to Electrical cable.

16. Railways will not lodge FIR with RPF in cases of works being executed by authorized contractors of Railways who have been duly permitted to execute the works in accordance with this JPO. Joint note by the supervisors of the concerned department shall be prepared and the responsibility of the cable cut should be decided without involving RPF. The joint note deciding the fact whether the contractor should be penalized shall be completed in 4 day's time from the occurrence of cable cut.

In all other cases, when the cable is cut by an agency that was not permitted to execute any work, FIR should be lodged with RPF.

EDT(T) EDET/I 4 of 5 EDT/W EDOPT

17. While giving permission for taking up the works, concerned departments may note that earthwork by engineering contractors will normally be done by machines except in a few isolated locations where the quantity of earth work is very less.

18. Railways shall make necessary correction in their future contract so that this JPO can also be enforced contractually.

19. In case of damage to OFC, RailTel should be paid 5/6th of the penalty recovered. RailTel shall raise demands on the S&T department in this regard.

20. All types of signaling & OHE bonds i.e. rail bond, cross bond and structure bond shall be restored by the contractor with a view to keep the rail voltage low to ensure safety of personnel.

---

21. Above joint circular shall be applicable for construction as well as open line organisation of Engineering, S&T & Electrical.

22. S&T cable and electrical cable route plan should be prepared by the concerned S&T and Electrical officers respectively and got approved as stipulated in para C-12 before undertaking the work. The completion cable route plan should be finalized block section by block section as soon as the work is completed.

23. All cable laying works shall be executed as per laid down technical specifications, such as protection measures/protective cover, compaction of refilled material etc.

(Rajeev Sharma)	(S K Saxena)	(Shobhan Chaudhuri)	(V P Dudeja)	(Surinder Pal)
Exec. Dir.	Exec. Dir.	Exec. Dir.	Exec. Dir.	Exec. Dir.
Signal Devel.	Elect. Energy (M)	Telecom (Dev)	Works	Civil Engg.(P)

Annexure-2

Precautions for Thermoshrink Joints of Quad Cables issued by RDSO

भारत सरकार

रेल मंत्रालय

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

क्वाड केबिल के लिये थर्मोश्रिंक ज्वाइन्टिंग किट

Thermoshrink Jointing Kit for Quad cable

(क्वाड केबिल की थर्मोश्रिंक जोड़ हेतु सावधानियाँ)

(Precautions for Thermoshrink Joints of Quad Cables)

रिपोर्ट संख्या – एस टी टी /44

(मार्च 2013)

Report No. STT-44

(March 2013)

दूरसंचार निदेशालय

अनुसंधान, अभिकल्प एवं मानक संगठन

मानक नगर, लखनऊ –226011

TELECOMMUNICATION DIRECTORATE
RESEARCH DESIGN AND STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW - 226011

Precautions for Thermoshrink Joints of Quad Cables

It has been noted that the failure of the joint is often caused due to incorrect jointing method. The detailed method of jointing is explained in the installation instructions which are supplied along with every jointing kit. These guidelines shall be followed to ensure correct jointing method.

In this write up certain important points are highlighted which if taken care shall ensure correct joint in the field.

While making joint;

1. Ensure that the Heat Shrink sleeve is shrunk over the intermediate (grey) sheath of the cable also, in addition to its shrinking on the Outer sheath of the quad cable:

1.1 How to ensure:

The cable should be prepared with following exact measurement to ensure correct profile of the cable as shown below in figure 1:

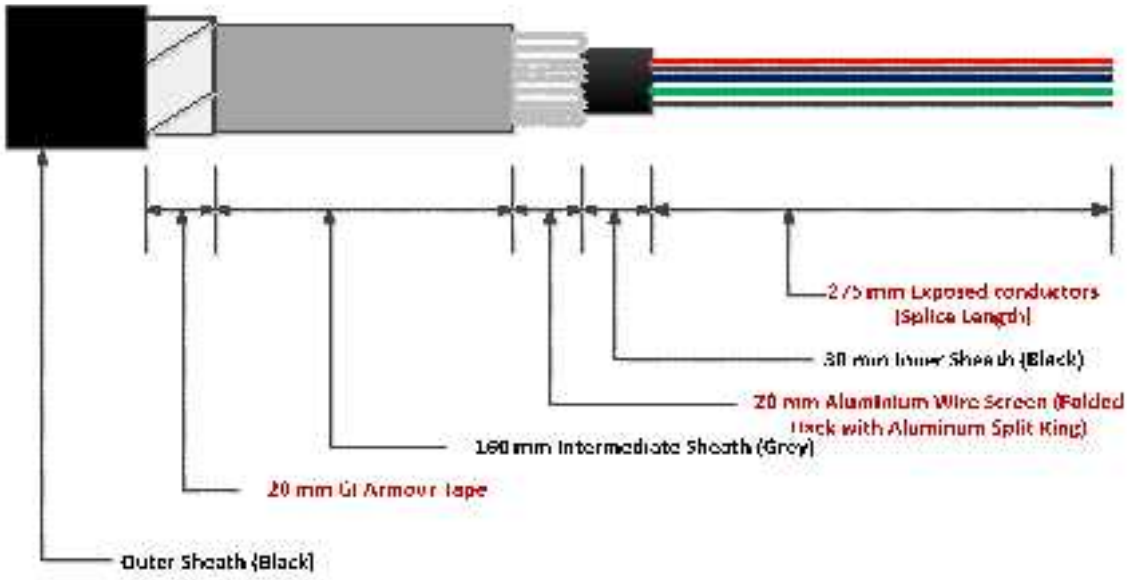


Figure 1

The relative position of two cables to be jointed is shown in figure 2 below. The same is also shown in figure 3 which shows photograph of two cables.

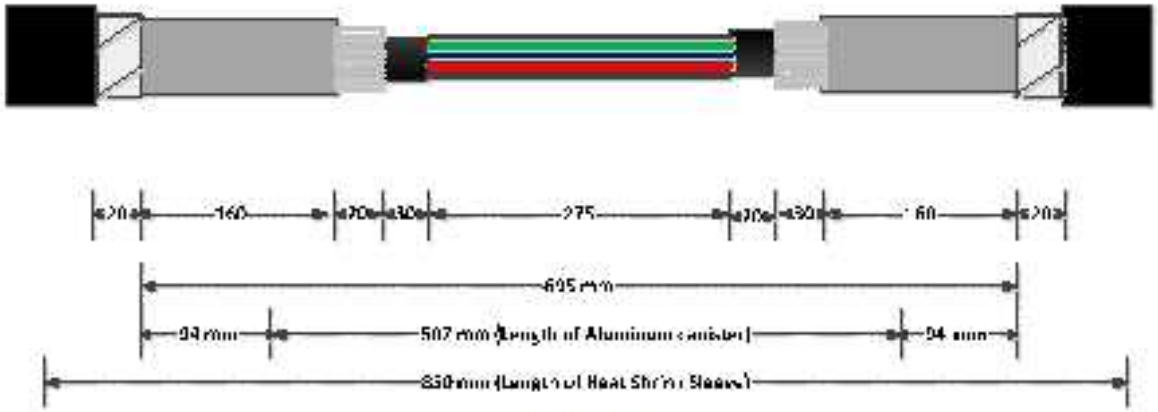


Figure 2

The figure 2 also shows the length of Aluminum canister and length of Heat shrink Sleeve with respect to cables positioned for jointing.

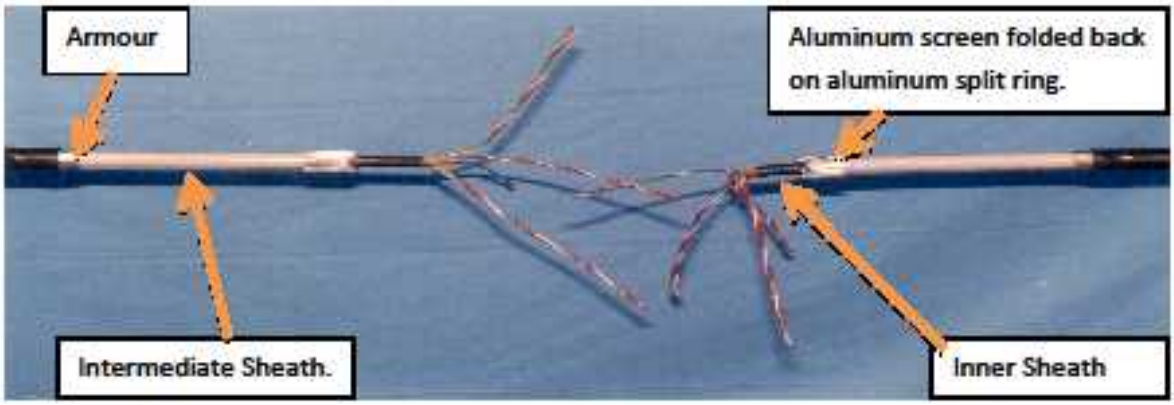


Figure 3: Photo graph showing two cables ready for splicing of conductors.

In the photograph shown in figure 3, various parts of cables like armour, intermediate sheath (grey), folded back aluminum screen, inner sheath (black) can be seen.

If above positioning is ensured, the Aluminum canister would rest on the Intermediate Sheath of the cables (at points A, B, C and D) as shown in the figure 4 below. The same can also be seen in figure 5 through photograph.

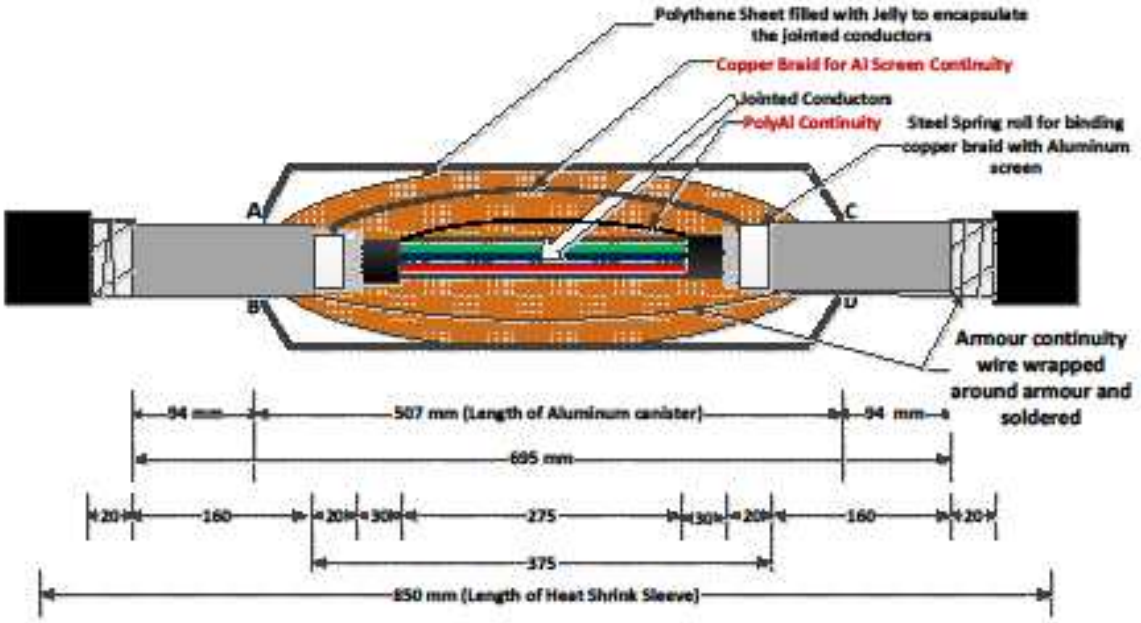


Figure 4

Figure 5: Photograph showing relative position of Aluminum canister and spliced conductor inside jelly filled polythene pouch along with transformer (being transformer derivation joint)

And with this profile, when heat shrink sleeve is shrunk over the Aluminum canister, **it will shrink at the intermediate sheath** in addition to outer sheath as shown in figure 6.

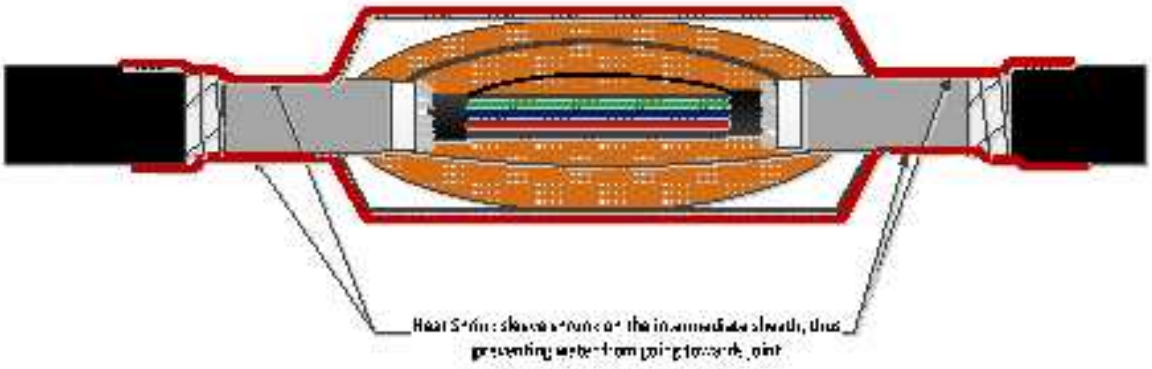


Figure 6

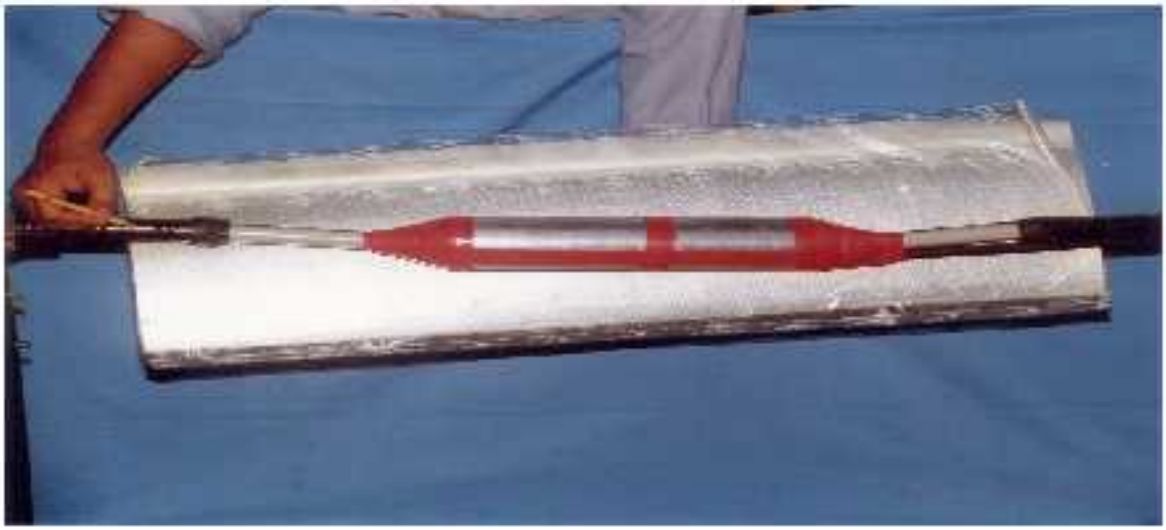


Figure 7: Photograph showing position of the Aluminium canister resting on intermediate sheath (grey) of the quad cable and length of the heat shrink sleeve. In this position heat shrink sleeve will shrink over aluminum canister, intermediate sheath and outer sheath of the quad cables.

1.2 Why it must shrink at Intermediate sheath:

In case of damage to outer sheath, the water entering from such damaged outer sheath can flow towards the joint through the space between Outer sheath and intermediate sheath. However when this water reaches the joint, its flow towards jointed conductor shall be prevented by the barrier created by the heat shrink sleeve which has shrunk on to the intermediate sleeve and holding it tightly, as shown in the figure 6.

However if the profile is not cut properly, thejoint shall be as shown in figure8.

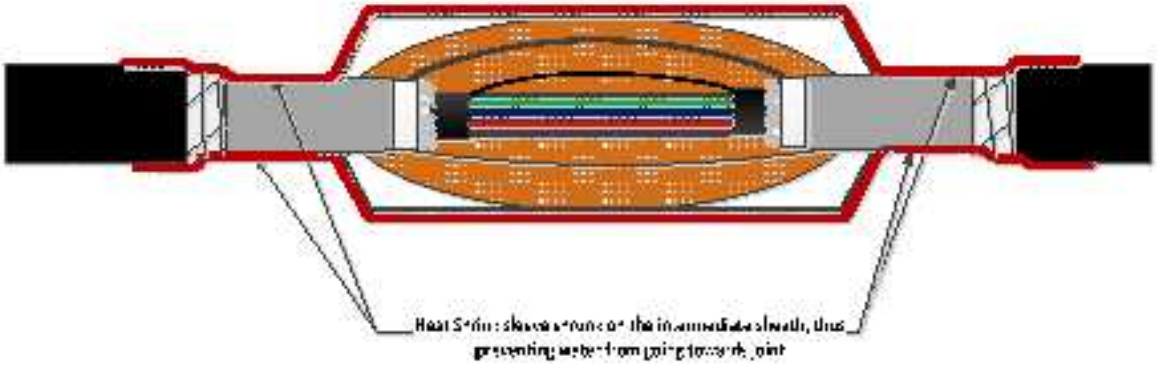


Figure 6

Figure 7: Photograph showing position of the Aluminium canister resting on intermediate sheath (grey) of the quad cable and length of the heat shrink sleeve. In this position heat shrink sleeve will shrink over aluminum canister, intermediate sheath and outer sheath of the quad cables.

1.2 Why it must shrink at Intermediate sheath:

In case of damage to outer sheath, the water entering from such damaged outer sheath can flow towards the joint through the space between Outer sheath and intermediate sheath. However when this water reaches the joint, its flow towards jointed conductor shall be prevented by the barrier created by the heat shrink sleeve which has shrunk on to the intermediate sleeve and holding it tightly, as shown in the figure 6.

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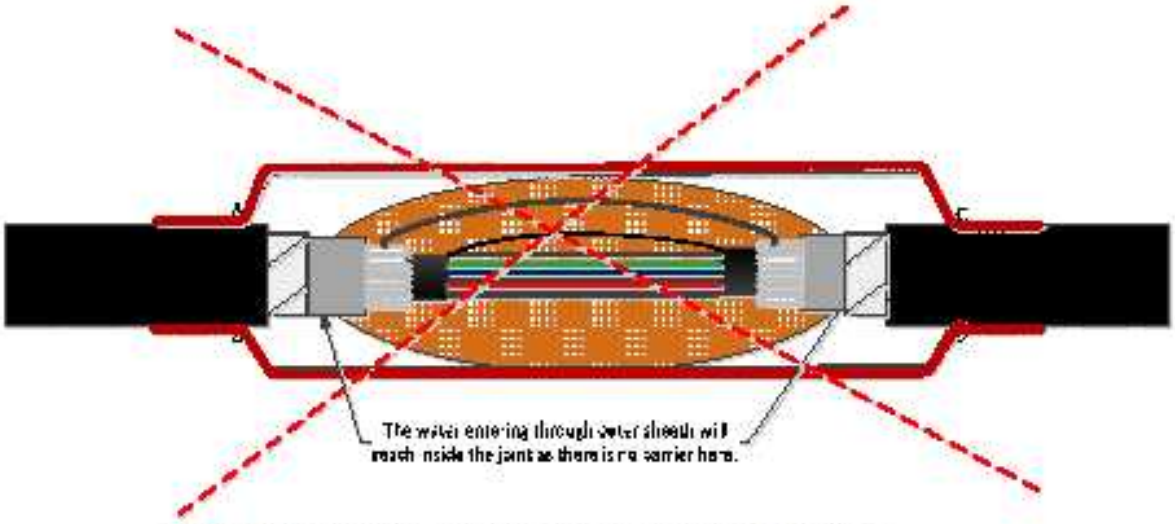

Figure 8: The wrong method of cable preparation and Jointing

The water in this situation will enter the joint and will reach the cable conductors if the protection by jelly is not effective.
Similar precautions to be taken for derivation joint while preparing cables specially if the derivation cable is also a quad cable.

2. Ensure that Aluminium wire screen continuity , steel tape armour continuity and Poly Al continuity is maintained.

It has been observed in some cases that Aluminum screen continuity is not ensured and only steel armour continuity is being done which affects screening performance and may result into noise in voice communication or increased rate of data error in case of data communication. The continuity of Aluminum screen has to be ensured using copper braid, split aluminum rings and steel spring rolls provided for this purpose in the jointing kit. Aluminum wire screen continuity and armour continuity are shown in figure 9 below.

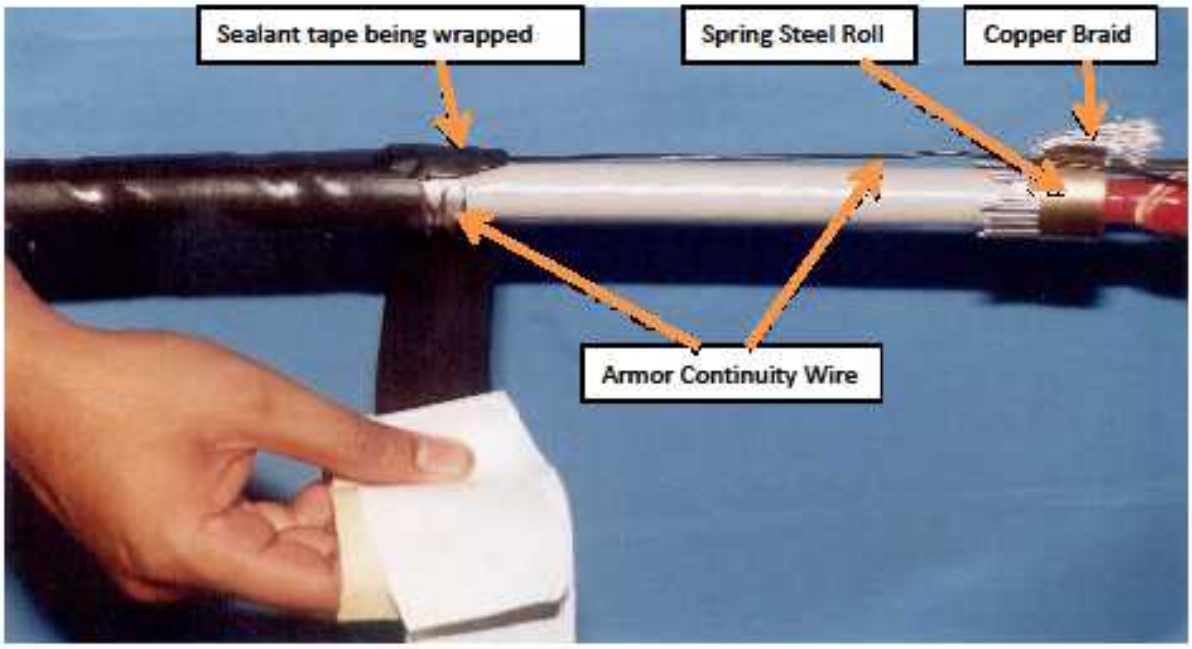

Figure 9

Figure 9shows one end of armour and screen continuity arrangement.
The armour continuity wire is wrapped around the armour and soldered. The point of contact has to be covered with sealant tape. The sealant tape cover sharp edges if any and protect the heat shrinkable sleeve from damage when it is shrunk on it.
The arrangement for connecting copper braid to the aluminum screen wires is shown. The photograph shows aluminum screen wires folded back on the aluminum split ring and copper braid sandwiched between layers of spring steel roll which wraps tightly around the aluminum screen wires. This is also required to be covered with sealant tape.
Poly Al is a very thin aluminum layer provided at the inside of the inner sheath. Its continuity is to be provided using sheath connector assembly supplied in jointing kit.

3. Other items which are to be kept in mind:

a. Ensure proper application of heat on heat shrink sleeve. The sleeve is provided with spots of temperature sensitive paint (see figure 10). If the proper heat is applied these spots would disappear.

b. After proper shrinking white line appear below the Stain less steel channel which holds two ends of the heat shrink sleeve.

c. Branch-of clip must be used in case of derivation joint between main and derivation cable (Figure 10).

d. In case of derivation joint thicker main cable has to be placed near to the stainless steel channel and the thinner derivation cable has to placed away from the stainless steel channel with branch-of clip in between the two cables. (Figure 10)

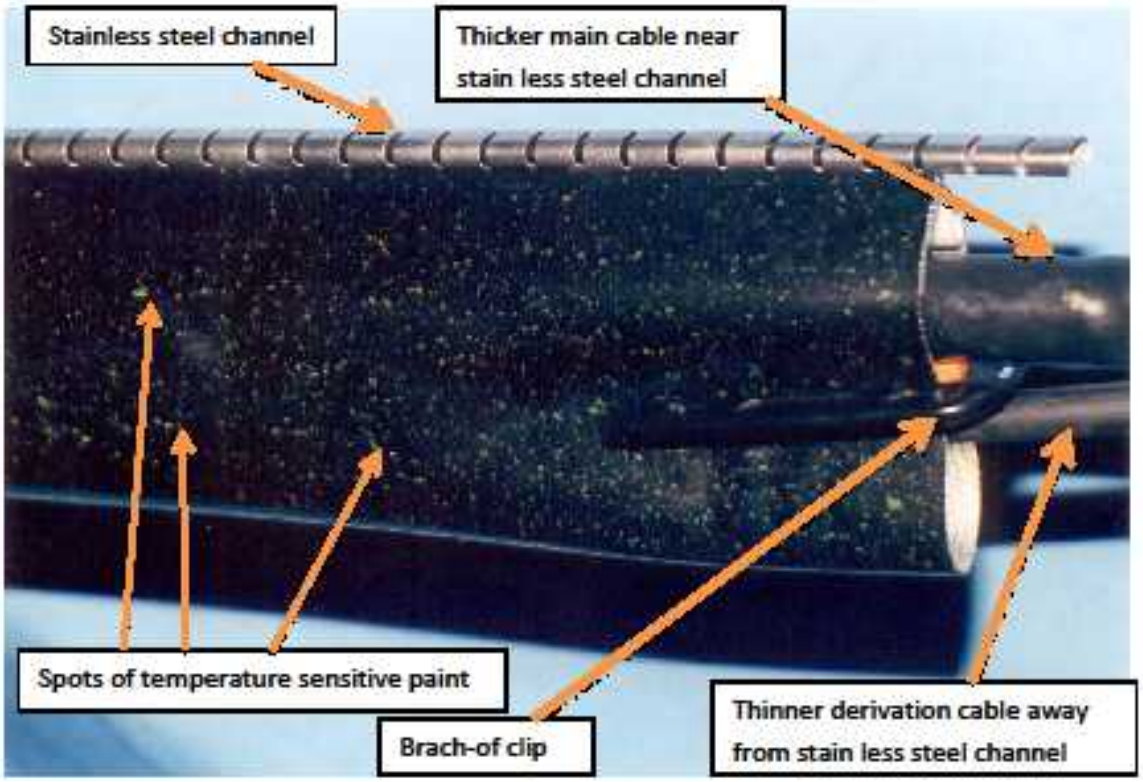

Figure 10: Photograph showing dots of heat sensitive paint and positioning of branch-of clip in case of derivation joint.

4. As per extant instructions, jointing kit must be procured from RDSO approved vendors and inspected by RDSO irrespective of the value of the purchase.

**********End**********

ANNEXURE-3

RDSO Specifications pertaining to Telecom Cables(Copper)

Sl. No.	Description of Telecommunication Item	Specification / Drawing No.
	Telecom Cables	
1	PIJF Telephone Cable (Polythene Insulated polythene sheathed Jelly Filled Telephone Cable with poly –Al moisture barrier)	IRS TC 41/97(Amd.2)
2	Underground Railway Jelly Filled Quad Cables for Signaling and Telecom Installations (0.9 mm dia conductor)	IRS TC 30/2005 (Ver.-1) Amd. 4
3	1.4 mm dia copper conductor 4/6 quad cable	RDSO/SPN/TC/72/2007, Rev.0, Amd.1
4	Composite Underground Armoured Cable Consisting of 6 Copper Quads And 8/24 Fibers	RDSO/SPN/TC/50/2007 (Rev 5)
5	Telecommunication Switch Board Cables	TEC Specification: GIR/WIR – 06/03 March 02
	Jointing Kits	
1	Thermo Shrink Jointing Kit For Jointing Underground PIJF Cable (TSF : 1-5)	RDSO/SPN/TC/57/2006 (Rev.0) Amd-1
2	Thermo Shrink Jointing Kit for Jointing Underground Quad Cable (RTSF for 0.9mm/1.4mm conductor dia 4/6 quad cable Derivation Joint/transformer Joint/Straight through Joint/Condenser Joint/Loading Coil Joint)	IRS TC 77/2010(Rev.2) or IRS TC 77/2012(Rev.3)
3	Joint Closure for Composite (Optical & Quad) Underground Armoured Cable.	RDSO/SPN/TC/56/2007(Rev.-2) (Amdt-1)
4	Silicone Gel based cable jointing kit	RDSO/SPN/TC/101/1012
	Termination boxes	
1	Cable Termination Boxes (indoor)	IRS TC 18/75
2	Telecom Cable Termination Box (non metallic) for indoor use	RDSO/SPN/TC/97-2012 Rev.2
4	KRONE LSA-PLUS Connection Module	TEC: CT Block spec. GR/CTN-03/03 March 04
5	KRONE LSA-PLUS Insertion Tool	TEC spec. GR/CTN-01/04 May 2005
	Passive Devices	
1	V.F. Tapping Transformer ; 1120: 1120 , 1120: 600 & 470 : 1120	IRS TC: 22/76
2	V.F. Transformers (2T/3T) Suitable for underground telecom. Cable circuits.	IRS TC: 76/2000 with Amd-1
3	Balancing Condensers.	IRS TC 11/73
4	Polystyrene Condenser for Balancing and Building out Network.	IRS TC 49/93
5	Loading Coil joints.	IRS TC 29/81

	Earthing System	
1	Conventional Earthing arrangement	RDSO drg no: TCA 565(ADV)
2	Code of practice for earthing and bonding system for signalling equipment (The acceptable Earth Resistance shall not be more than 1 ohm).	RDSO/SPN/197/2014 ver.1
	Control Communication	
1	4 Wire / 2 Wire Train Traffic Control Equipment with Dual Tone Multi Frequency (DTMF) Signalling	IRS TC: 60/2007
2	Repeater Station Equipment	IRS TC 50/90
3	Voice Frequency Communication System For Underground Quad cable	RDSO/SPN/TC/34/2002 (Ver. 4)
4	Junction Equipment and speech Conversion Equipment used in AC Electrified Area.	IRS TC 46-88
5	Desk Type 2 Wire, 12 Way DTMF Telephone	IRS TC 80/2000 (Amd. 1)
6	Universal Wayside DTMF Control Telephone	IRS TC 82/ 2005 (Amd.1)
7	Integrated Way Station Control Communication Equipment	RDSO/SPN/TC/70/2007 With Amendment- 1
8	Emergency Control Room Equipment	IRS TC:61/93 (Amd.1)
9	Light Weight Portable Control Telephone	IRS TC: 78/2000 (Amd.1)
10	4-Wire Way Station Control Telephone	IRS TC: 38/97 (Amd.1)
11	2 –Wire Way Station Control Telephone	IRS TC 37/97 (Amd.1)
12	4-Wire/2 Wire Combined Portable Control Telephone	IRS TC: 75/99 (Amd-2)
13	Magneto Telephone Desk Type	IRS TC: 36/97 (Amd.1)
14	Desk Type Electronic Magneto Telephone	IRS TC: 79/2000(Amd.2)
15	LC Gate Control Equipment Using Wired & Wireless Data Communication.	RDSO/SPN/TC/49/2003 Ver. 3
16	Electronic L.C Gate Telephone System	RDSO/SPN/TC/51/2004 (Ver.0) Amdt-2
17	Auto Dialing System From Emergency Socket in RE Area	IRS: S-83/2007 Amd-1
18	Six Pin Emergency Plug And Socket	IRS TC : 42/87 (Amd .1)
19	Emergency Socket Box of FRP Material	RDSO/SPN/TC/44/2002 Ver.2, Amd-2
20	Power Supply Unit For Telecom Installations At Way Side Stations In 25 KV Electrified Area	IRS TC: 72/97 (Amd.1)
	Measuring Instruments	
1	Digital Capacitance Unbalance Measuring set.	IRS TC 48/90
2	Transmission Measuring Sets.	IRS TC 43/87
3	Cross Talk Measuring Sets.	IRS TC 45-88
4	Digital Cable Fault Locator	TEC Spec: GR/TIE-05/03 July 2006
	OFC Cable	
1	24 Fiber Armoured Optic Fiber Cable	IRS TC: 55/2006 Rev-1 Amd. 1.1
2	Fibre Distribution Management System	RDSO/SPN/TC/037/2000 (Ver. 3) Amdt.-1
3	Fibre Distribution Management System for Composite (Optical and Quad) Underground Armoured Cable	RDSO/SPN/TC/071/2008 (Rev. 1.0) Amdt.-1

Review Questions

Chapter 1 : Introduction of Telecom Cables(copper)

Objective:

1) The maximum number of pairs on a pole route in Over Head Alignment is limited to __.
2) Distortion less condition in a cable can be achieved by satisfying the condition of_____.
3) Over Head lines are not fit for Tele communication circuits in RE area because of_____.

4) Loading of cable in underground cable is done to reduce _____.
5) Length of Loading section in 4/6 quad cable system is _____.
6) Phantom circuit is a _____ circuit derived from side circuits.
7) Cross-talk couplings causes_____ and Earth couplings cause_____ in VF circuits.
8) The purpose of twisted pairs in telecom cables is _____.

Subjective:

1) What are the different types of transmission media used in Indian Railways Telecommunication ?
2) Compare Under ground cables with O/H lines.
3) Give the Classification of Telecommunication cables.
4) What are the “Primary elements” in telecom cable? What is their effect? How they are taken care while manufacturing the cable?
5) Explain the relation between Impedance and Frequency.
6) What is the importance of V.F,Balancing and Loading in Telecom cable?
7) What are the different types of capitance unbalance couplings in Telecom quad cable? Explain them with a sketch?

Chapter 2 : Paired Telephone Cables

Objective:

1. The Characteristic impedance of pair in a switch board cable is _____.
2. Purpose of Rip Cord in SB cable is _____
3. Expand UTP_____..
4. In general, CAT cables will be terminated with _____ or _____ type connecters.
5. In STP cables, _____ is used as screen.
6. The co-axial cable usual impedance shall be _____ or _____ Ohms.
7. RG 8 cable can be used upto the length of _____.
8. The material used as conductor in telecom cables is high conductivity_____.
9. 0.5 mm dia copper conductor is denoted as_____SWG.
10. What is the colour code of 37^{th} pair in a 50 pair switch board cable_____.
11. Specification of Switch Board cable is_____.

Subjective:

1) What are different types of Switch Board Cables and its specifications?
2) What are the different types of schemes of colour codes of 20 pair SB cable?
3) Explain briefly about Twin Flat and FS cable.
4) Write short notes on UTP and STP cables.
5) Mention different types of cables and its applications in Railways.

Chapter 3 : Under Ground PIJF Cables

Objective:

1. Expand PIJF :_____
2. RDSO spec. for PIJF telephone Cable is _____
3. In 20 pair PIJF cable, colour code of pair number 16 is _____.
4. In 20 pair PIJF cable, conductor insulation main colours are_____ and mate colours are _____.I
5. The number of units in 20 pair cable are _____.
6 The number of units in 50 pair cable are _____.
7. The number of units in 200 pair cable are _____.
8 The different colours of the binding tape used for identifying each unit are _____.
9. 0.5 mm dia conductor pair may be used upto _____ mtrs for subscriber loop application.
10. Entry of moisture / water is prevented by _____in the core of PIJF cable.
11. Amour in UG cable gives_____.
12. PVC Jacket is the sheathing arrangement made over armoured cable to protect the armour against _____.
13. The purpose of Jelly in PIJF cable is_____.

Subjective:

1. Describe PIJF cable and its formation.
2. What are the advantages of Polythene Insulated Jelly filled cables.
3. Compare the specifications of 0.5 mm and 0.6 mm dia conductors of paired cables.

Chapter :4 Effects of Railway Electrification on Telecom Circuits

Objective:

1. The induction by A.C traction system in Telecom circuits is due to_____ couplings.
2. Sectionalisation of the Telecom circuits prevents cumulative build up of induced_____.
3. Psophometric voltage in the communication circuits should not exceed _____ mV.
4. The screening factor of Aluminium sheath/screen is always less than _____.
5. Isolation transformers are used to reduce the_____.
6. Under normal conditions of traction power system the longitudinally induced voltage in the telecommunication cable should not exceed _____V.
7. Electrostatic induction occurs due to _____ coupling between conductor and earth.
8. Cumulative build up of induced voltages in a circuit in RE are can be prevented by introducing isolation transformers at a regular intervals of _____Km.
9. Before cutting the armour or sheath/screen of cables an _____to be established between two ends of the cable through an external wire.

Subjective:

1. Explain the types of induction develops in Telecom circuits in RE area.
2. Define Screening factor and explain how screening of voltage is done in Telecom Cables.
3. What are the ITU-T recommendations, on permissible induced voltages?
4. Define Psophometric noise and how it degrades transmission quality in Telecom circuits?
5. What are remedial measures to be taken to minimise the effects of 25KV 50 Hz AC traction system in Telecom cables?
6. What are the Precautions to be taken for protection of staff and equipment in 25 KV 50 Hz AC traction territory ?

Chapter 5 : Telecom Quad Cables

Objective:

1. The Transmission loss in 4.5 mm dia ACSR line is_____ and 0.9 mm dia copper pair in quad cable is _____.
2. 4 Wire system in U/G cable is because of _____.
3 RDSO specification of 4/6 PIJF quad cable of 0.9 mm dia conductor is _____.
4. RDSO specification of 4/6 PIJF quad cable of 1.4 mm dia conductor is _____.
5. 1.4 mm dia conductor 4/6 quad cable is used at _____.
6. The insulation resistance between each conductor in a quad shall not be less than _____ ohms per kilometre.
7. Purpose of Poly Aluminium Moisture Barrier in a quad cable is_____.
8. The colour code of quad no 5 in 6 quad cable is_____.
9. Present Status of 6 Quad Cable System used in various Railways is _____, _____and _____.
10. The Colour of the 4^{th} quad whipping is_____.

Subjective:

1. Explain the importance of Quad Cable over ACSR over head lines in RE area.
2. What are different types of Quad Cables?
3. Explain about RE Main Cables.
4. Explain the construction of 6 quad cable with a neat figure.
5. Explain the importance of metallic protection system available in quad cable.
6. What is the colour code scheme of 6 quad cable?
7. What are the general specifications of 4/6 quad cable of 0.9 mm & 1.4 mm dia conductor?
8. Write the Specifications of 6 quad cable.
9. Write the quad allocation of 6 quad cable with OFC and without OFC.
10. What are the difference between PIJF underground Paired and Quad Cables

Chapter 6 : Cable laying practices

Objective:

1. The normal depth of trench for Telecom Cable is _____.
2. The standard drum length of 4/6 quad cable is_____.
3. Tapping diagram consists of _____.
4. The derivation cable used in 4/6 quad cable system is _____.
5. All new Telecom cables shall be laid close to _____.
6. Telecom cable shall be laid in _____pipes for a length of _____on either side of TSS.
7. The cable route indicators are to be placed at every_____ meters on normal path.
8. On each side of major girder bridge a reserve of ____ meters, for minor bridges a reserve of_____ meters and at every joint a loop of _____ meters on either side shall be provided..

Subjective:

1. What are the important objectives to be considered in preliminary cable route survey ?
2.. What are guidelines for finalizing the route and preparation of the cable route plans ?
3..What are the methods of laying underground cable? Explain each in detail.
4. What is the procedure of laying of U/G cable while crossing Roadways, Railway tracks?
5. How underground cables shall be protected on culverts and bridges?
6. What are precautions to be taken while laying underground cables at TSS/FP locations?
7. How underground telecom cables are protected in 11KV electric cables exists area ?

Chapter 7 : Jointing of Underground Cables

Objective:

1. The impedance ratio of matching transformer in unloaded quad cable is _____.
2. Value of loading coil used for 6Q cable is _____ mH.
3. "Branch off clip" is used for _____joint only.
4. Expand RTSF;_____.
5. RDSO specification for RTSF jointing kit is_____.
6. The meaning of 75/15-850 of RTSF is_____.
7. Aluminium foil in TSF kit is to prevent the damaging of _____ during shrinking process.
8. Aluminium canister is used in jointing for _____.
9. In 6 quad cable the splice to be filled with _____.
10. Codal life of U/G cable jointing kit is_____.
11. Length of loading section in 6Quad cable is _____Km.
12. In Quad cable jointing the aluminium screening is made through by using _____.
13. The basic advantage of Wago terminal is:_____& _____.

Subjective:

1. What are important stages of making cable joint?
2. What are the various types of joints in 4/6 quad cable and explain them briefly?
3. What are the requirements of a loading coil and explain the effect of using loading coil in quad cable?
4. Explain jointing of PIJF paired cables and PIJF quad cables.
5. Explain the procedure of Quad Cable Jointing by using RTSF kit.
6. What are the contents in a RTSF Jointing kit used for quad cable jointing.
7. What are the precautions followed for RTSF joints of quad cable?
8. Write short notes on the following:

   a) Termination of Quad Cables b) Termination of Paired Cables

Chapter 8 : Testing of Cables

Objective:

1. Insulation resistance of quad cable conductors shall be tested with _____ V Megger after completion of jointing of cables.
2. Transmission loss test shall be carried out with _____.
3. Cross Talk has to be measured with _____ frequency for BPAC Circuit.
4. Quad cable armour shall be connected to earth which is having resistance of _____.
5. Working principle of Digital Cable Fault locator is_____.
6. Periodicity of Psophpmetric Noise test in a quad cable is _____.

Subjective:

1. What are test to be carried out before laying the cable and after laying the cable?
2. What are mandatory check and tests to be carried out before commissioning of BPAC application in quad cable?
3. What are causes for cable failures and how to prevent them?
4. How to localize the cable faults and explain its procedure?
5. What are cable faults, can be identified by using Digital Cable fault locator ?

Chapter 9 : Quad Cable maintenance

Objective:

1. Before disconnecting Block, BPAC and IB circuits for testing of Quad cable _____ has to obtained from Station Master.
2. The purpose of Integrated Cable path diagram is _____.
3. The important tools, to protect S& T Cables from damages, are_____, _____ & _____.
4 BPAC circuit in quad cable shall be tested from _____ & _____.
5. Quad cable has to be tested periodically by JE/T_____ & SSE/T_____
6. Quad cable has to inspected by Officers once in_____.

Subjective:

1. What are typical 6 quad cable failures and their causes?
2. What are Dos and Don'ts while carrying out quad cable testing?
3. What are schedule of testing and measurements to be carried out in quad cables?
4. Practice how to fill up / maintain "Quad Cable Maintenance Register".

Chapter 10: Annexure

1. What is the role of JE/SSE (Tele) to prevent cable cuts ?
2, Note down the departments and officials who signed on JPO issued by Railway Board to prevent cable cuts.
3. Under which clause the penalty on cable damage shall not be levied on contractor who is executing the work ?

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