# AB cable – Design – ISSUES- standards

- Design and construction
- Stringing
- Materials used for stringing
- IS standards
- Testing of ABC
- Field Testing of ABC
- Earthing of ABC
- Various issues faced in FIELD
- QUESTIONS

# Design and construction

- Messenger:

a) Conductor : Aluminum Alloy, Aluminum Conductor, Aluminum Conductor Steel Reinforced

b) Insulation: PVC

- 11KV ABC Cable:

a) Conductor: Hard Drawn Aluminum

b) Conductor Screen: Semi-Conductive Compound

c) Insulation: Cross-Linked Polyethylene

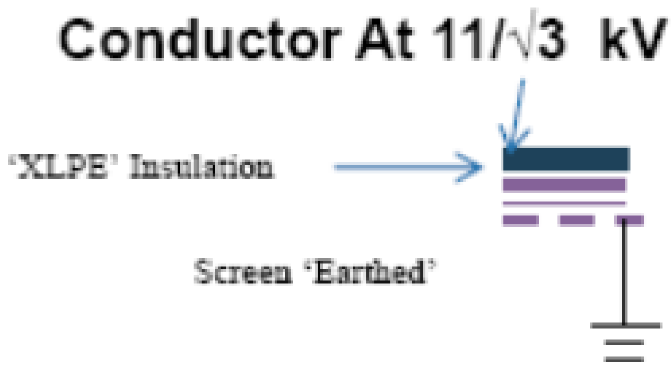
d) Insulation Screen: Sem-conductive Compound

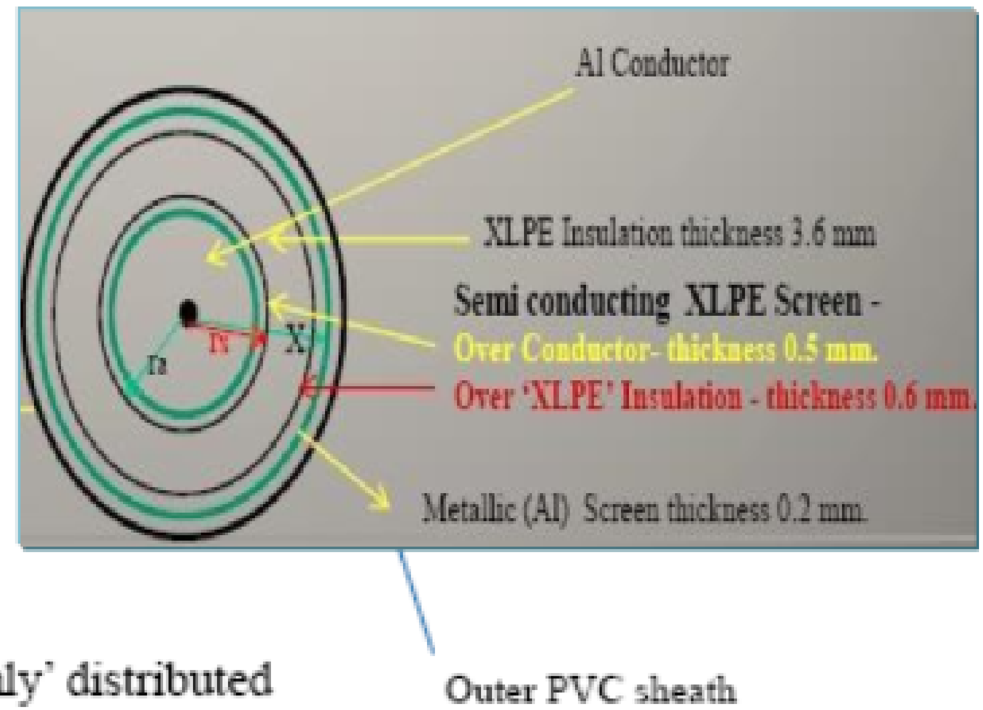
e) Metallic Screen: Copper Tape

f) Outer Sheath: Black PVC + Ultra Violet Resistant

# CROSS SECTION

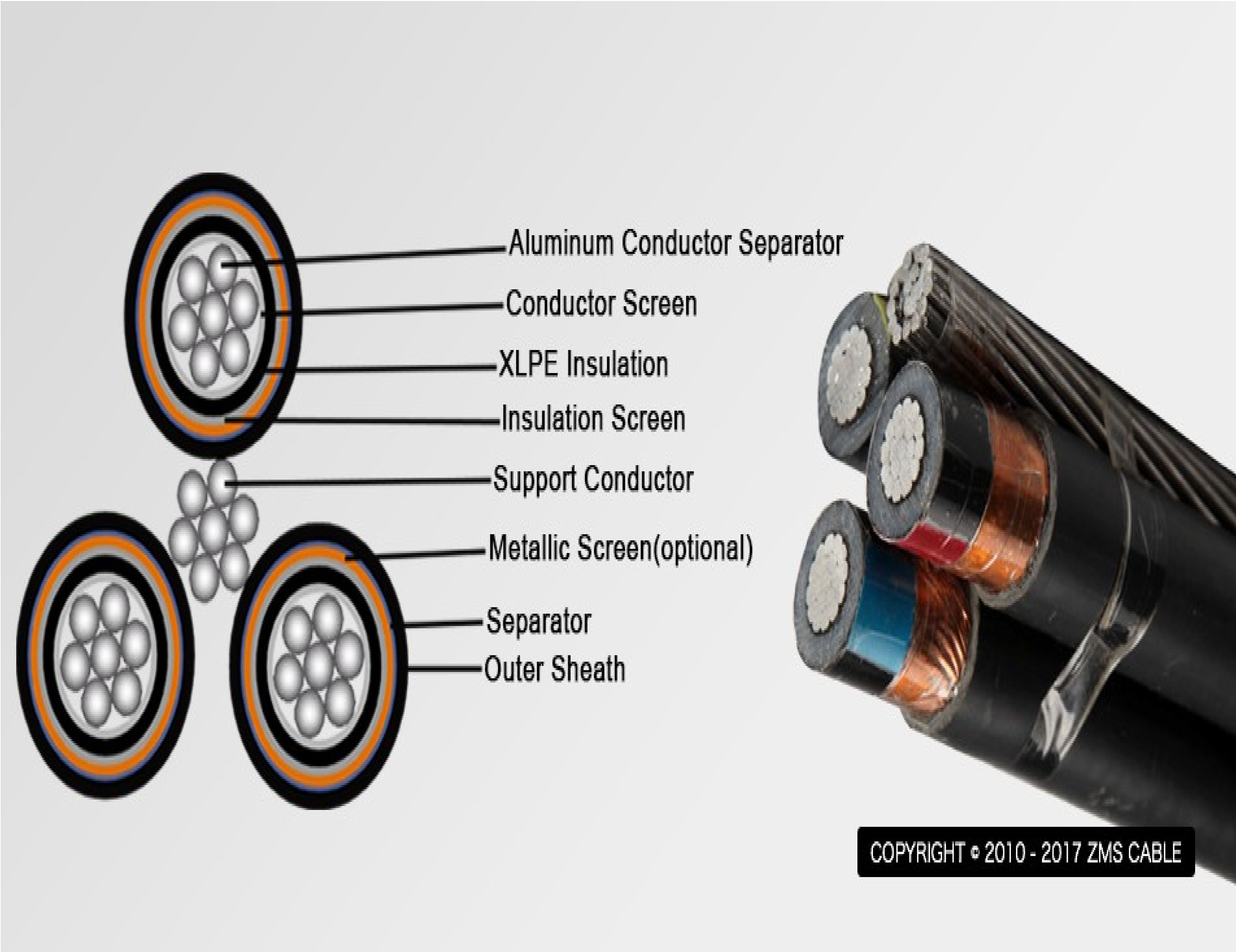
## SECTIONAL DIAGRAM




1. The AB Cable is a 'Capacitor' with two metal Electrodes (**Conductor** and **Metallic Screen**) separated by dielectric material(XLPE).
2. There is Voltage gradient from 'HV' to 'Earth'.
3. The Voltage gradient is required to be 'Uniformly' distributed to prevent 'stress' and insulation break-down.
4. The electro-static charge distribution on each of the surface/ layer is dependent on material property/quality.
5. The metallic screen 'Earthing' prevents the magnetic field/induction reaching external surface and conducting material.

***Note: Diagram not to Scale***


Aluminum Conductor Separator
Conductor Screen
XLPE Insulation
Insulation Screen
Support Conductor
Metallic Screen(optional)
Separator
Outer Sheath
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# Semi conducting layer

The material is a polymer base mixed with a conductivity imparting agents such as carbon black.

- Semi-conducting compounds also have the effect of fillings in the **interstices of the conductor** giving a smooth surface for insulation.
- **semiconductor behaves as conductors when temperature rises** so when the HT cables is on load , Its conductor temperature rises due to this the semicon layer which is on conductor behaves like **conductor as a result overall cross-section area is increased**
- The second silicon layer which is over XLPE on temperature rise behaves a conductor and used for **dissipating heat out of conductor** as the cable heat due to load. The semi-conductive layer also serves to even out the stresses associated with partial discharge which would otherwise attack the insulation at specific points.
- It acts a smooth transition between each layers
- It protects XLPE insulation from moisture abosrption.

# Components of HV ABC

- Stranded Aluminium round Phase conductor - IS: 398
- Conductor screen of semiconducting compound (0.5 mm thick)
- Polyethylene (XLPE) Insulation - IS:7098 (Pt-II) (3.14 Min/3.6 Nom mm thickness)
- Insulation screen (0.6 mm thick)
- Conductors for insulated electric cables and flexible cords - IS:8130 and IS:398
- Copper tape (Min. 0.1 mm thick)( **very important- at chimmony the size is .045mm)**
- Outer PVC sheath Type ST-7(1.4 Min/2.0 Nom mm thick)-IS: 5831
- Process for both conductor screen and insulation screen which is semi-conducting compound are extruded and are applied along with XLPE insulation in a single operation by ‘triple extrusion’ process. Method of curing is dry curing.

# MESSENGER

- Messenger wire made of Aluminium alloy- IS: 398 (Part-IV)
- Messenger wire shall be of size 150 ,

generally conforming to IS: 398 (Part-IV)-1979.

- Comprising of 7 strands, suitably compacted, have smooth round

surface to avoid damage to the outer insulating sheath of single-core

‘Phase cable’ twisted around the messenger.

- **The messenger wire is ‘Earthed’ at multiple points during its normal service**

# Components of HV ABC

There is risk to personal and apparatus (clamp/suspension hook)

when **messenger wire is not ‘Earthed’ properly or due to increased ‘Earth’ resistivity due to:**

ༀ Direct lightning stroke on Line

ༀ Over Voltage in phase and resulting rise in Voltage/potential of messenger

wire

ༀ The messenger wire may break at weak ‘spot’ or dent, caused during

installation mishandling

ༀ Heating of termination/suspension hook due to induction, in case of

selection of magnetic material

• **Provide a return path for fault current to flow to ‘Earth’ and ‘Neutral’ in case of AB Cable insulation failure. Messenger wire is the second line of defense, in case of Cable failure and ‘flash over’**

# XLPE cable

## Single-core XLPE High Voltage Cable with Aluminium laminated sheath

### Cable layout

- *Copper* conductor, stranded, cross-sections of 1000 sqmm and above segmented, optionally with longitudinal water barrier
- Inner semiconductive layer, firmly bonded to the XLPE insulation
- XLPE main insulation, cross-linked
- Outer semiconductive layer, firmly bonded to the XLPE insulation
- *Copper* wire screen with semi-conductive swelling tapes as longitudinal water barrier
- *Aluminium* lamninated sheath
- HDPE oversheath, halogen-free, as mechanical protection, optionally: with semi-conductive and/or flame-retardant layer

### Production process

The inner semiconductive layer, the XLPE main insulation and the outer semiconductive layer are extruded in a single operation.

### Special features of metallic sheath

- *Copper* wire screen as short-circuit current carrying component
- *Aluminium* foil, overlapped, 0,25 mm thick, as radial diffusion barrier
- Low weight, low cost, internationally proven design

### Applicable standards

IEC 60840 (2004-04)
AEIC CS7-93
ANSI / ICEA S-108-720-2004

**XDRCU-ALT**
**132/76 kV**

### Technical data

| Copper conductor | Outer | Cable weight | Capacitance | Impedance | Surge | Min. bending | Max. pulling |
|---|---|---|---|---|---|---|---|

# WATER TREE and Semi con JOINTING issues

**Water trees** grow relatively slowly over a period of months or years.

Semiconducting screens or semiconducting shields are extruded over the conductor and the insulation outer surface to maintain a uniformly divergent electric field with in the cable core.

As water tree grow the electrical stress can increase at the tip of water tree.

Once initiated electrical trees grow rapidly until the insulation is weakened to the point that it no longer with stand the applied voltage and an electrical Faults occurs.

**The oval shape of the core max value – min value in the same level may not exceed 0.5 mm whereby the core is to be investigated in circular.**

The support plates of the peeling device will cause shallow grooves on the surface of the extruded insulation screen

# Stringing

Stringing is very important.

1, Use winch for stringing.

2, USE NYLON pulley with a groove size of more than 1.5 D with flexible fixtures

3, use messenger for stringing, load on 11 KV cable shall be restricted. If using chineese puller, use adequate measures to protect cable.

4. Dont use vehicles as far as possible

# Materials used for stringing

1, its same as 11 KV OH line

2, use suspension clamp whereever we use PIN insulator

3, use dead end clamp at cut points(6nos disc=2 nos dead end

4, Tee-joint at every .5 KM

5, USE A POLE –

- can load more than two cables
- can have enough spacing between LT and ABC 11 KV line
- Cut end poles needs to be APOLE
- Wont get damaged in vehicle dashing.

PSC pole-

- use it only at places where not more than one cable is strung
- Only for suspension clamps or DP for T joint

# IS standards

We all know there is no IS standard for HT ABC. But we are still using the spec applicable of XLPE cables(7098).

CROSSLINKED POLYETHYLENE INSULATED

THERMOPLASTIC SHEATHED CABLES —

SPECIFICATION

PART 2 FOR WORKING VOLTAGES FROM 3.3

kVUP TO AND INCLUDING 33 kV

# Routine TESTs

- Conductor resistance test
- Partial discharge test (for screened cables

Only)

- High voltage test

I. We need to measure the copper shield resistance before and after stringing.

II. IR can be taken with 500 v meggar to avoid DC stress

III. Tan delta measurement will assure the cable performance

IV. DC cable fault locators are used for fault finding

# Earthing of ABC

Earthing Messanger

1, use adequate size of aluminium conductor for earthing- at least the size of messanger

2, use pipe earthing or better earthing at every 250 meters

3, messanger shall be earthed on all posts solidly using coil earth of post

4, use PG clamp for earthing

# Earthing of shield

This is also very important.

- Earthing at both ends are preffered as the cable is 120 degree spaced.
- Earthing at one end may increase the voltage of unearthed end linearly
- Using LA at the unearthed end is also used in EHV cables
- Use adequate size of earthing mechanism preferably of copper with supporting insulators to the earthing pipe/rod.
- Make sure the sheild is not cut or opend by measuring the continuity
- LA has to be earthed using appropriate size

# Earthing of shield

## 2.5 Earthing methods, induced voltage

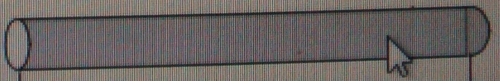
High voltage cables have a metallic sheath, along which a voltage is induced as a function of the operating current. In order to handle this induced voltage, both cable ends have to be bonded sufficiently to the earthing system. The following table gives an overview of the possible methods and their characteristics:

| Earthing method | Standing voltage at cable ends | Sheath voltage limiters required | Typical application |
|---|---|---|---|
| Both-end bonding | No | No | Substations, short connections, hardly applied for HV cables, rahter for MV and LV cables |
| Single-end bonding | Yes | Yes | Usually only for circuit lengths up to 1 km |
| Cross-bonding | Only at cross-bonding points | Yes | Long distance connections where joints are required |

Overview of earthing methods and their characteristics

*Both-end bonding*

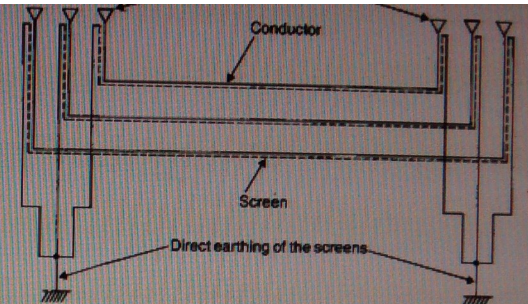
Both ends of the cable sheath are connected to the system earth. With this method no standing



# Shield earthing – one end LA

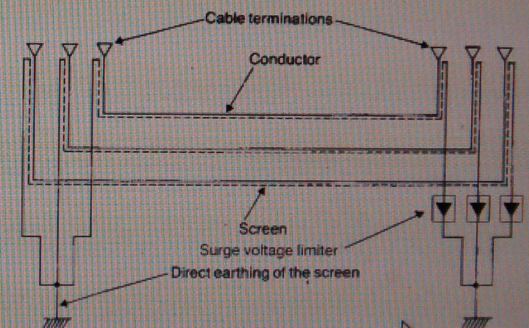
## Bonding of the metallic screens

The electric power losses in a cable circuit are dependent on the currents flowing in the metallic sheaths of the cables. Therefore, by reducing or eliminating the metallic sheath currents through different methods of bonding, it is possible to incresase the load current carrying capacity (ampacity) of the cable circuit. The usual bonding methods are described below:



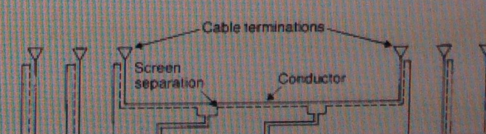

**Both-ends bonding**

A system is both ends bonded if the arrangements are such that the cable sheaths provide path for circulating currents at normal conditions. This will cause losses in the screen, which reduce the cable current carrying capacity. These losses are smaller for cables in trefoil formation than in flat formation with separation.




**Single-point bonding**

A system is single point bonded if the arrangements are such that the cable sheaths provide no path for the flow of circulating currents or external fault currents. In such case, a voltage will be induced between screens of adjacent phases of the cable circuit and between screen and earth, but no current will flow. This induced voltage is proportional to the cable length and current. Single-point bonding can only be used for

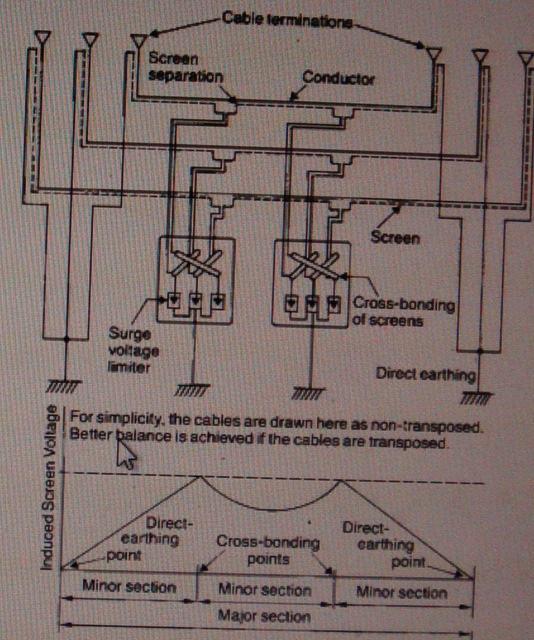


# Sheild earthing using cross bonding

will be induced between screens of adjacent phases of the cable circuit and between screen and earth, but no current will flow. This induced voltage is proportional to the cable length and current. Single-point bonding can only be used for limited route lengths, but in general the accepted screen voltage potential limits the length.

**Cross-bonding**

A system is cross-bonded if the arrangements are such that the circuit provides electrically continuous sheath runs from earthed termination to earthed termination but with the sheaths so sectionalized and cross-connected in order to eliminate the sheath circulating currents. In such case, a voltage will be induced between screen and earth, but no significant current will flow. The maximum induced voltage will appear at the link boxes for cross-bonding. This method permits a cable current-carrying capacity as high as with single-point bonding but longer route lengths than the latter. It requires screen separation and additional link boxes.



# Issues faced at chimmony

# ECCENTRICITY will damage cable

# ECCENTRICITY(Insulation) and OVALITY(conductor)

**1)The oval shape of the core max value – min value in the same level may not exceed 0.5 mm whereby the core is to be investigated in circular.**

**Tolerance on Thickness of Insulation**

**The smallest of measured values of thickness of**

**insulation shall not fall below the nominal value (t i )specified in IS-3.6mm by more than 0.1 mm + 0.1 t i=.46mm**

**<u>2)Eccentricity and Ovality</u>**

**Eccentricity of insulation shall not exceed 15 percent**

**when tested as per Annex A**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# Semicon voids and damaged sheath

We can see that semicon is having voids

Metallic shield is damaged( ingress of water )

Water tree formation

# Inappropriate Relay configuration

We need to have proper relay co-ordination. If there is any fault in cable, the same has to be cleared in milli seconds. This normally doesnt happen and earth fault may leads to 3 phase fault

# Earth fault developed to 3phase fault

# 3 phase fault

# Issues/reason

1, improper shield earthing( used DO fuse wire for sheild earthing and broken during fault- cable became unearthed)

2, messanger cut- due to improper earthing

# Cable jointing

If cable is not properly jointed it may invite more issues.

1, joint has to be made in the clean environment

2, need to measure the IR value of cable and resistance of shield before and after the joint making process

3, make up process need better skills for longer operation of cable.

4, Cable is also like a transformer. It can also breath and absorb moisture. If there is any water tree it can damage the entire cable

# sheath thickness

Shield thickness is very critical for fault current carrying.

The thickness of metalic sheath decides the amount of fault current.

The semicon layer gives a smooth transition of voltage between layers. If there is any insulating media like “ cable identifiers” it may resist the smooth transition of stray voltages to the earth.

# Circulating current from another system

We have to make sure LT neutral voltage does not effect the working of ABC. At chimmony we had faced an issue where LT neutral voltage circulated along the ABC earthing loop. We had to add one pin in LT to avoid this issue.

Similary- HT OH fault may damage your system. Its good to use either ABC or OH. Both wont work together.

# Significance of Multiple Sheath

**First layer** of semiconducting screen on outer surface of Conductor is semiconducting ‘XLPE’ compound of 0.5 mm thickness, gives smooth and uniform surface . This

- Distribute the electric field uniformly around the conductor
- Prevents the formation of ionized voids in the conductor.
- Dampens impulse currents travelling over the conductor surface

• Extruded cross linked polyethylene (XLPE) of 3.6 mm thickness, forms the Primary Insulation of the overall A B Cable

• Again, **2nd layer** of extruded semi-conducting compound of 0.6 mm thickness is a Voltage stress grader. This is

- To reduce the surface voltage to zero
- To confine the electric field within the insulation, eliminating tangential stresses

# Significance of Multiple Sheath

Metallic screen of Aluminium or Copper tape or sheath limits the radial electrostatic field and shielding of the electromagnetic induction; this screen is to be compulsorily ‘Earthed'.

The metallic Screen, while in service, generally fulfills the following electrical

requirements:

- Conducting the earth fault current
- Returning the capacitive charging current
- Limit the radial electrostatic field
- Shielding of the electromagnetic field

# Significance of Multiple Sheath

'Metallic' screen, when not Earthed properly or loose connection

- Causes rise in **Cable surface Voltage** gradient and un-equal Voltage stress causing fault at the spot/failure of Cable
- During passage of through (external) fault current on the feeder, high magnetic field is produced around the Cable outer surface and lead to rise in potential of nearby metallic structures and increase **the touch potential above safe limits.**

• Outer 'PVC' ST7 sheath of light grey colour of 2.0 mm Nom

thickness is to protect 'XLPE' insulation from **direct solar rays and act as outer guard**

# ADVANTAGES

- Easy to Install and maintain.
- Installed where we have ROW issues and safety issues
- This can reduce the issues of induction as the shield is earthed.
- Can be used where we have multiple feeders drawn on same ROW
- Can be used where there are chances of THEFT
- Can be used where there are solid vegitation or forest( frequent tree failling areas may be omitted- Rubber plantation)
- Interlinking of feeders under EHV feeders
- Paralleling issues of feeders can be avoided
- Asthetic sense

# Issues

NO BIS standards available for HT

Phase to phase and phase to earth clearance distance aspects of HVAB cable installation has not addressed in the regulation

* some places they use HT ABC with 1Cx95+35sqmm. Just like a covered conductor.

# THANK YOU

Shine Sebastian AE