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"REVIEW & STUDY PAPER OF UNDERGROUND CABLES FOR 11KV TRANSMISSION LINE"

MAURYA RAJKUMAR R[1] , BHATT MAYUR V [2] ,SHARMA VIKAS K [3], DAVE DHAVAL B [4]

1. B.E.(Ele-6th) Leads Institute Of Technology & Engineering , Matar
2. M.E Electrical Engineering, Parul Institute of Technology, Baroda

rajkumarmaurya382@gmail.com , bhattmayur4@gmail.com , vik_sh66@yahoo.com, myself_dhaval@yahoo.com,

Abstract: **- Electrical energy is one of the most important factors for the developments of any country. But the generation of electrical energy is not possible at any place. So, to provide electricity from source to load transmission line is needed. Generally two types of transmission line are available. I) Overhead transmission line & II) Undergrond transmission line. This paper shows the benefits of underground line over overhead line. Overhead transmission line has some drawbacks and increases the efficiency & reliability of transmission line underground transmission line is takes place. There are different types of underground cables are available for transmission of electrical power. Here three types of underground cables are given.**

So, this paper shows the details of different kind of cables and one is suitable for the long transmission line and

Keywords: - **Underground cable, Construction, Different types of underground cables, Comparison**

I. INTRODUCTION

This overview contains information about electric transmission lines which are installed underground, rather than overhead on poles or towers. Underground cables have different technical requirements than overhead lines and have different environmental impacts.

"An underground cable essentially consists of one or more core/conductor covered with suitable insulation and surrounded by a protective covers."

The underground cables has several advantages over overhead line like less effect or damage though lighting, less maintenance cost, less chance of fault, smaller voltage drop, better general appearance & most reliable. In a modern power system for power distribution, generally used underground cables. However recent improvement in the design & manufacturing has leaded the development of the cable suitable for used at high voltages. This has made it possible to employ underground cables for transmission of electric power for short or moderate distance. This review paper focuses on the various types of cables which are used for the 11kv power transmission. The design and construction of underground transmission lines differ from overhead lines because of two significant technical challenges that need to be overcome. These are: 1) providing sufficient insulation so that cables can be within inches of grounded material; and 2) dissipating the heat produced during the operation of the electrical cables. **[1]**

Fig.1.1 Diagram Underground Cables [2]

Properties	Unit	Copper	Aluminium
Density	g/cm^3	8.89	2.703
Resistivity	Oh. Mm^2/Km	17.241	28.264
Constant mass temperature coefficient	1/ ℃	0.00393	0.00403
Conductivity	Siemens m/mm^2	58	36
Temperature coefficient at ℃	℃	234.5	228
Specific heat per unit weight	w/g/ ℃	0.389	0.8870
Coefficient of linear expansion	1/ ℃	$17x10^6$	$23x10^{-6}$

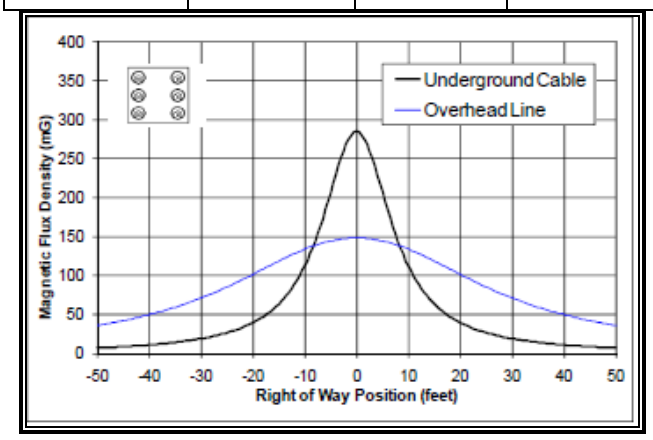

Fig.1.2 Simulation of underground cable & Overhead line [2]

II. GENERAL CONSTRUCTION OF CABLE

Table 2: Comparison of Cable properties [3]

In general construction of cable following contains is included:

- Core/conductor
- Insulation
- Metallic Sheath
- Bedding
- Armouring
- Serving

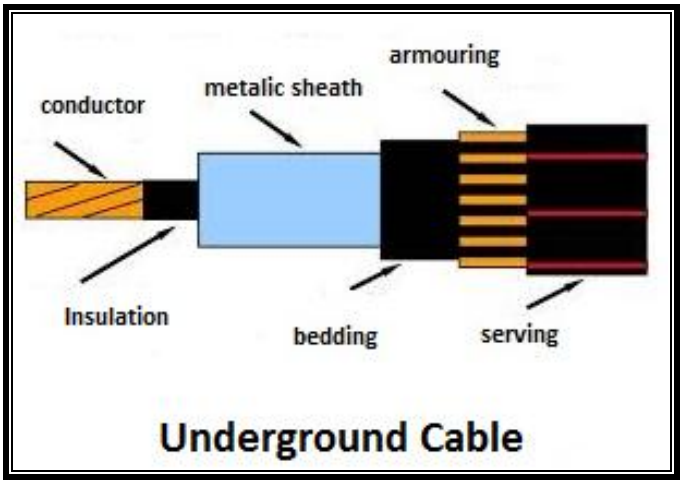

Fig.2.1 Details of Underground Cable [3]

A) Conductor:-

Generally conductor are made up of copper/aluminium with a circular, compacted & stranded. Copper and aluminium are used to provide sufficient flexibility in stranded form. Cable mainly consists of one, two, three or four conductor depending upon service required.

B) Insulation:-

In a laid underground conductor, it is used to provide a sufficient thickness of insulation and it depends upon the voltage level.

Insulation provides following properties: - High insulation resistance to avoid leakage current, High dielectric strength to avoid electrical breakdown of the cable, high mechanical strength.

Different material used for cable insulation: - Rubber, V.I.R (Vulcanized India Rubber), Impregnated paper, P.V.C (Polyvinyl chloride).

C) Metallic sheath:-

This layer of underground cable insulates with the presence of soil, moisture, gases, and some other liquids, in order to protect the cable metallic sheath made up of lead or aluminium to provide over the insulation.

D) Bedding:-

Bedding is provided to cable the cable from corrosion and some mechanical injuries. It is made up of jute or hessian tape.

E) Armouring:-

It consists of one or two layers i.e. galvanised steel wire or steel tape, to protect the cable from mechanical injuries while handling.

F) Serving:-

It is the outermost part of the cable, wiz made of some fibrous material like jute in order to protect the armouring from atmospheric condition.

III. Types of underground cables for 11kv that can list are as follows:-

1. Cross-linked polyethylene(XLPE)
2. Self-contained fluid-filled(SCFF)
3. High-pressure Gas-filled (HPGF)
4. Polyvinyl chloride (PVC)

1) Cross-linked polyethylene (XLPE) Cable:-

XLPE is an abbreviated designation of "cross-linked polyethylene". Cross linked polyethylene is produced from polyethylene under high pressure with organic peroxides as additives. The application of heat and pressure is used to effect the cross linking. This causes the individual molecular chains to link with one another which in turn causes the material to change from a thermoplastic to an elastic material.

An important advantage of XLPE as insulation for medium and high voltage cables is their low dielectric loss. The dielectric loss factor is about one decimal power lower than that of paper insulated cables and about two decimal powers lower than that of PVC- insulated cables. Since the dielectric constant is also more favorable, the mutual capacitance of XLPE cables is also lower, thus reducing the charging currents and earth-leakage currents in networks without the rigid star- point earthing. Its characteristic differs its property from other cables, which can be given as:

-- Its excellent electrical and physical properties.

--Capability of Carrying Large Currents The excellent resistance to thermal deformation and the excellent aging property of XLPE cable permit it to carry large currents under normal (90ºC), emergency (130ºC) or short circuit (250ºC) conditions

-- Ease of Installation XLPE cable withstands smaller radius bending and is lighter in weight, allowing for easy and reliable installation. Furthermore, the splicing and terminating methods for XLPE cable are simpler in comparison with other kinds of cables.

--Free from Height Limitation and Maintenance XLPE cables can be installed anywhere without special consideration of the route profile (height limitations) since it does not contain oil and thus is free from failures due to oil migration in oil-filled cables.

--No Metallic Sheath Required XLPE cable does not generally demand a metallic sheath. Thus it is free from the failures peculiar to metallic-sheathed cables, such as corrosion and fatigue.

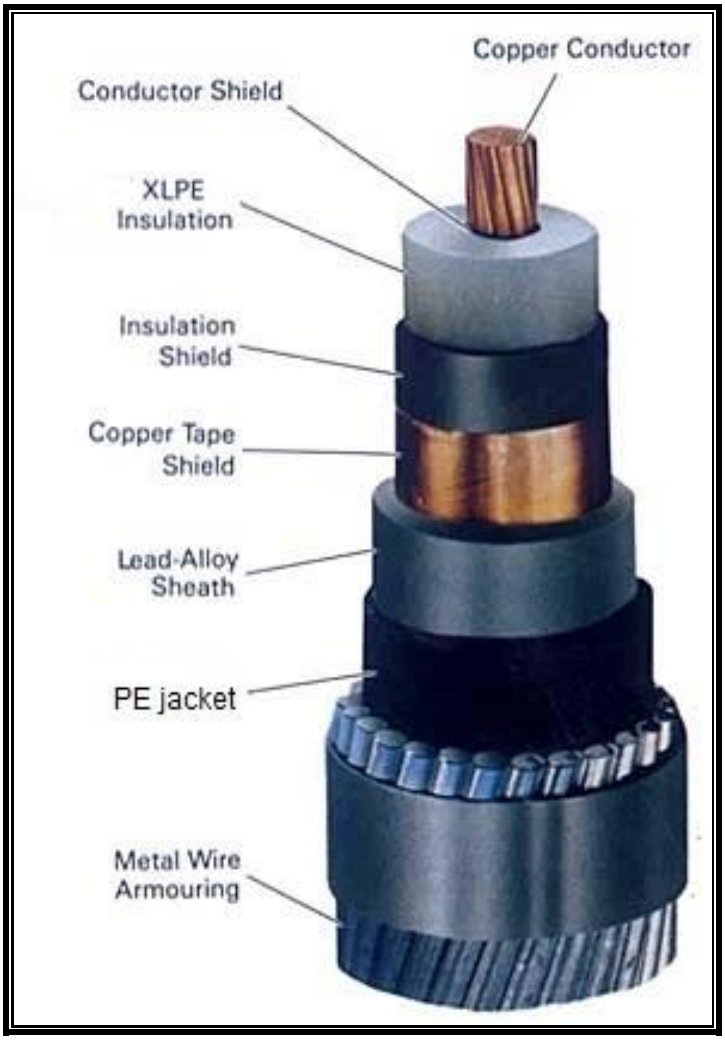

Fig: 3.1 [XLPE CABLE] [6]

- On the XLPE cables, high voltage test at room temperature is performed by testing the cables to withstand a voltage of 3kv ac at a frequency of 40 to 60 Hz or an ac voltage of 7.2 KV. It is kept under temperature of 82 ±2°C for 14 days and the maximum water absorbed value is 1 mg/cm2.[6]

2) Self-contained Fluid-filled (SCFF) Cable:-

SCFF cables are laminar paper or LPP insulation. These cables can be manufactured in very long splice free length which makes them useful for submarine projects, through use is diminishing worldwide. A fluid channel in the middle of the conductor (between the cores of three-conductor cable) permits the dielectric oil expansion and the contraction under pressure, inhibiting insulation voids from forming. It contains the positive internal pressure (15- 75psig, 0.1-0.5MPa) and an insulating jacket is put over the sheath.

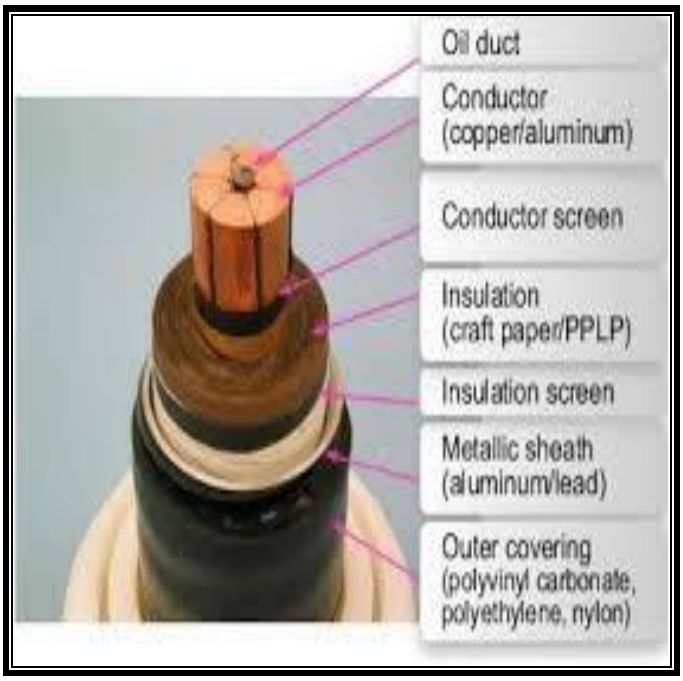

Fig: 3.2[SCFF CABLE] [2]

3) High-pressure Gas-filled (HPGF) Cable:-

HPGF cable is the modified version of HPFF cable, this system utilized a pressurized gas (Nitrogen) filled pipe instead of the fluid-filled pipe. It is highly reliable, not complex, trouble free-system with a proven long term track record for new bulk power transmission circuit in the 69kv to 500kv range, as an alternative to solid dielectric cables, It is more preferable in underground high voltage transmission cable because of its multiple layer of insulating tapes produce a uniform laminated insulation wall, minimizing effect of any abnormalities in the insulation wall, as compared to an extruded insulation solid dielectric cable and its longer length of 4000 feet minimizes the number of manholes, splices and cost.

These cables can be over insulated to allow future operation at a higher system voltage. A number of circuit have been installed in this fashion and operated at a lower voltage initially for years and then later switched to the higher operating voltage when greater MVA system capacity was required of the feeder.

HPGF cables are very similar in design to HPFF cables except:

a) The insulation thickness are greater as shown in table below due to the lower electrical strength of gas as compared to fluid;

Paper Insulation Thickness [4]

Voltage	HPGF	HPFF
69KV	0.300"	0.270"
115KV	0.485"	0.375"
138KV	0.585"	0.440"

b) The cable impregnate used in HPGF cables is a far more viscous fluid to minimize the drainage of the impregnate from the insulating tapes.

It provides the high reliability, ruggedness without a liquid in a pipe, which eliminates the environment concern. It also extremely low magnetic field (1 to 2 milligausses) as confirmed by industry tests and data. This is about 50 times lower than 1/C solid dielectric cables installed in duct banks or direct buried. The Nitrogen gas used in this cable is pressurize of 200 psig prevents ionization in service under normal and emergency operating condition with a low cost, thus this unit contains only three pressure switches for hi-low—Emergency alarms, one nitrogen pressure regulator and two nitrogen cylinders.

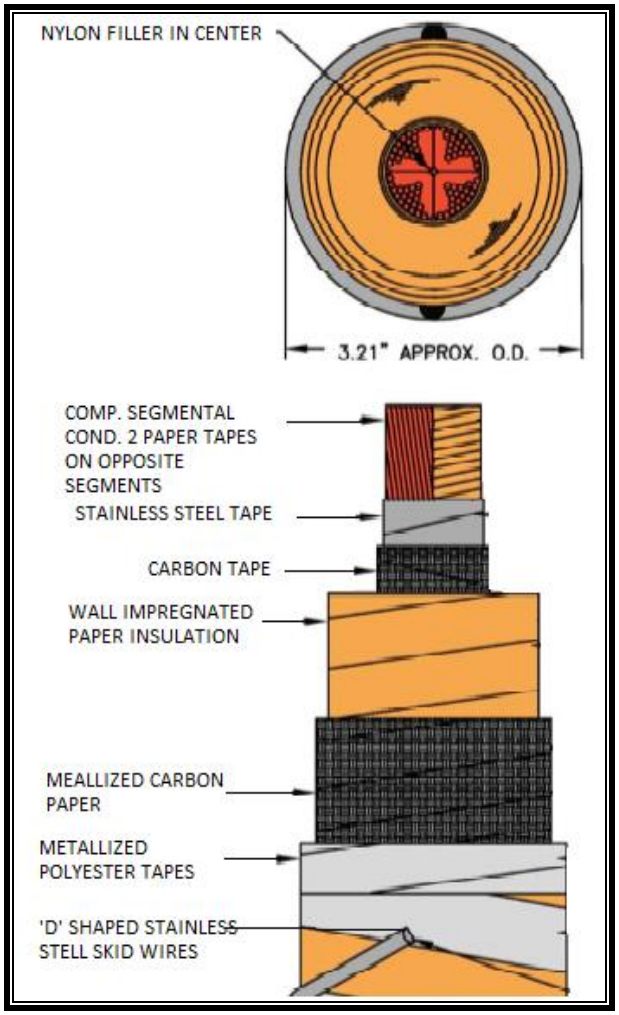

Fig: 3.3[HPGF CABLE][4]

4) Polyvinyl chloride (PVC) insulated cable:-

They are commonly abbreviated as PVC's, widely used in various fields. It is relatively at low cost, biological and chemical resistance which being used in various applications. Low voltage copper conductor PVC cables are extremely used for domestics home appliances wiring, house wiring and internal wiring for lighting circuits in factories, in control, instrumentation, submarine, etc. Due to its high tensile strength, superior conductivity, better flexibility & ease joining.

PVC CABLES

I. Railway signaling & auto cables

II. Power cables Upto 61 cores

III. Flat cables for submersible pumps

IV. FRLS/FR/HR/Fire survival cables

This type of cable is mainly thin insulated and used in LT side cables. It's have a tensile strength from 20-30 N/mm2 & elongation is of 300-400 %. The permanent elongation can be in negative value with maximum limit of 12%, its insulation thickness is 7.11mm and wire thickness 1.88mm. The treatment given to PVC cables constitute of keeping cables under temperature of 80±2˚C, 100±2˚C, 135±2˚C for Type A, Type B & Type C insulation respectively for 7 days. Mainly PVC cables are used under these cold conditions, the insulation resistance constant is around 36.7MΩ Km at 27˚C and 0.036 MΩ Km at maximum rated temperature.

Fig: 3.4[PVC CABLE][5]

IV. Comparison of Cables:-

FACTORS	SAMPLE 1 XLPE CABLE	SAMPLE 2 HPGF CABLE	SAMPLE 3 PVC CABLE	SAMPLE 4 SCFF CABLE
INSULATION	XLPE	PAPER	PVC	CRAFT PAPER
NO. OF CORE	Multi	3 core	Multi	3 core
OPERATING VOLTAGE RATING	Upto 500kv	Upto 345kv	Upto 33kv	Upto 138kv
VOLTAGE DROP	4-5% more than pvc	5-6% on normal Op. Temp	3-5% on normal Op. Temp	on normal Op. Temp
SHORT CKT TEMP.RATING	250 ˚C	250 ˚C	160 ˚C	160 ˚C
OPERATING TEMPERATURE	Upto 110 ˚C	Upto 105 ˚C	Upto 75 ˚C	Upto 85 ˚C
ARMOURING	Metal wire armoring	Unarmoured	PVC Armoring	PVC/Nylon Armored
COST	LESS	HIGH	VERY LESS	LESS
SERVICE LIFE	Long	Very Long	Long	Medium

V. CONCLUSION

This review and study paper concludes that from the above cables XLPE cable is most suitable than HPGF, PVC & SCFF for the long transmission line because it is available on very high voltage rating Upto 500kv and its service life is also long. The operating temperature of XLPE cable is high (Upto 110°C) and short circuit temperature rating is also high (Upto 250°C) and cost of XLPE Cable is also less as compared to HPGF Cable. So, on the basis of these features XLPE Cable is more suitable for long underground transmission line.

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