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Research Article

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Impact of covered conductors on Ghana's distribution network

Abstract

Electrical power outages experienced in the vegetation areas in Ghana are as a result of bare conductors coming in contact with grounded objects such as trees and tree branches. To curb this problem, the electricity company of Ghana has introduced into its overhead distribution networks the use of CC, covered conductors. These covered conductors unlike the traditional bare wire conductors are able to temporarily withstand phase-to-phase earth voltages. XLPE, Cross-Linked Polyethylene, HDPE, High Density Polyethylene covered conductors together with ABC, Aerial Bundled Conductors are considered. Limitations associated with these covered conductors, greatly relating to cost, reliability, supply quality and safety have been discussed in this paper.

Keywords: aerial bundled conductors, bare conductors, covered conductors, distribution networks, cross-linked polyethylene, high density polyethylene

Volume 3 Issue 5 - 2019

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Received: September 24, 2019 | **Published:** October 22, 2019

Abbreviations: ECES, European committee for electro technical standardization; CCs, covered conductors

Introduction

Electric energy consumers expect uninterrupted supply of electricity. However, there are numerous electrical power outages experienced in certain areas in Ghana. Among the causes of these numerous outages is the choice of conductors. PDS, Power Distribution Services as the main distributor of electricity in Ghana has introduced the use of CCs, covered conductors in its overhead distribution networks so as to improve on the quality of supply. In Ghana, covered conductors have been introduced to replace bare conductors in some vegetation areas. This move is necessary due to the numerous outages reported in the vegetation areas where bare conductors were installed. The replacement will also go a long way to minimize the possibility of bush fires in these areas. Covered conductors, though have great advantages, are confronted with certain limitations. These limitations are related to safety, quality of supply, Cost and Reliability. Covered conductors refer to conductors encased in insulating materials whose thickness or composition is not recognized by the national electrical code as electrical insulation. The current European CENELEC (European Committee for Electro technical Standardization) draft standard defines covered conductors as conductors surrounded by a covering made of insulating material as protection against accidental contacts with other covered conductors and with grounded parts such as tree branches.[1] In comparison with insulated conductors, this covering has reduced properties, but it is sufficient to withstand the phase-to-earth voltage temporarily. The most commonly used types of covered conductors are XLPE/HDPE type, spacer cables type and aerial bundled type.

Methods

Three covered conductors currently being used in the power distribution network in Ghana are reviewed in this paper. The limitations associated with each as well as safety and reliable issues associated with them are discussed.

XLPE/HDPE covered conductors

XLPE, Gross-linked polyethylene as opposed to PVC has improved electrical properties. These properties include higher resistance to distortion at elevated temperatures. Also, XLPE can be implemented safely with a conductor temperature of 90 °C, hence increasing the useful current rating.[2] HDPE, High Density Polyethylene is prepared the catalytic process from ethylene. This means that there is no branching, thus its structure is more closely packed. This results in it having higher density and chemical resistance. It is opaque and harder so can withstand higher temperatures.[3] The XLPE is currently being used widely for the production of electrical conductors because of its lower cost and agreeable electrical properties. Covered conductors (CCs) are of two types, single sheath CCs and multiple sheath CCs.

Single Sheath CC

Aluminium conductors with XLPE or HDPE covering of 2.3 mm-2.3 mm thickness is mostly employed for Single sheath CC. Wind resistance leading to lower vibration levels are achieved with the use of this CC because the thinner sheaths reduce the overall diameter and so the. Copper is used in highly salt-polluted environments. However, sheath thicknesses of up to 3.3 mm can be used to improve long-term phase-to-phase contact performance at higher voltages.[1] Single sheath CC has lower impulse strength than multiple layer designs and offers a level of resistance to outages caused by trees and wildlife contact. The insulators used on CC lines are normally porcelain pin or post insulators. Epoxy resin insulators are also used. The phase-to-phase distances at poles are usually one-third the phase-to-phase distances of bare conductor lines. The pictorial view of a CC is shown in Figure 1.

Multiple sheaths CC

At medium voltage CC can have one, two or three sheath layers (6.6-33kV) whilst at 66-132 kV the conductor may have up to 5 layers. To reduce tracking problems, they are available in low (0.5%) or zero carbon content sheath material. The uncompact, designs have a larger overall diameter than the corresponding compacted versions.

Partially compacted forms are also available. Figure 2 shoes a three sheath CC.[1]

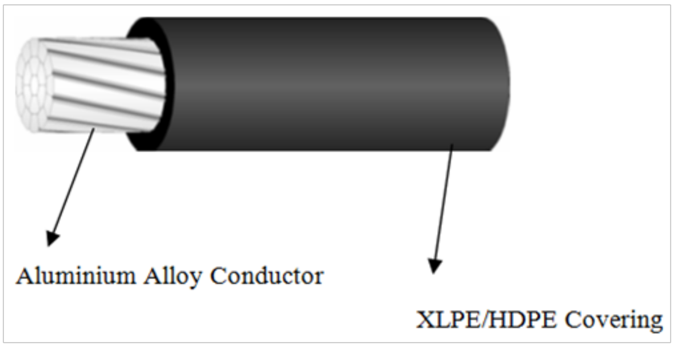

Figure 1 Pictorial View of Single Sheath CC.

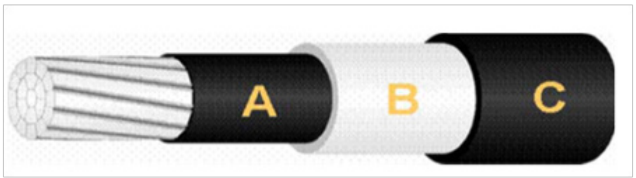

Figure 2 Basic Triple-Sheath CC Design.

Universal cable

Universal cable also referred to as Aerial cable, is fundamentally a cable that can be looped overhead and routed through underground and underwater. It removes the requirement for OHL/cable junctions and also has a very low susceptibility to lightning. Voltage drop across this type of CC is lower since it has much lower impedance. Using aerial cable, the network length between substations may be increase by 40-50%.[5] In case of insulation failure, the different layers of insulation, voltage stress relief, anti-tracking and metallic shield provide a designated path for fault and charging current to flow.[6] Table 1 indicates some rated values for aerial cable and CCs (Figure 4).

Spacer cable

These are essentially three CC phases in a polymeric support cradle reinforced by a 'messenger' cable.[4] Figure 3 shows the support system at a pole. The spacer cable is mostly used because the system has messenger-supported three layer cable construction in a close triangular configuration, the electrical strength to prevent faults due to line to line or line to ground contact, tree or animal contact, a complete coordinated system including cable, messenger, spacers, insulators and hardware and the mechanical strength to operate under severe weather conditions.

Figure 3 Typical Mounting of Triple Sheathed Spacer Cable.

Table 1 Voltage Drops/Km for Axces Aerial Cable and Standard Covered Conductors

Conductor	Size	Resistance Ω/km	Impedance Ω/km	ΔV/per km (10 kV ph-ph 100 A)	ΔV/V per km (20 kV ph-ph 100 A)
Aerial cable	Axces 3×95 mm^2	0.32	0.33	0.59%	0.29%
Covered conductor	Covered conductor 99 mm^2	0.35	0.53	0.95%	0.47%
Covered conductor	Covered conductor 157 mm^2	0.22	0.46	0.83%	0.42%
Covered conductor	Covered conductor 241 mm^2	0.14	0.42	0.76%	0.38%

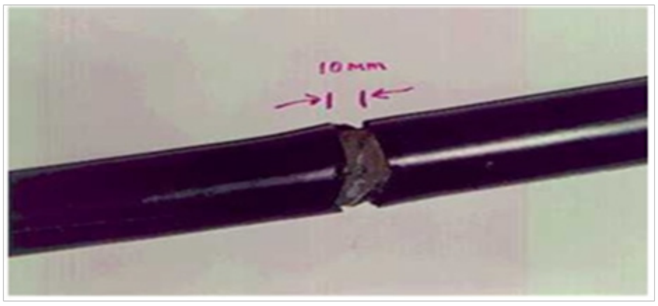

Figure 4 Stress Crack on HDPE ABC.

Limitation associated with covered conductors

Covered conductors are wrought with some implantation challenges.

Limitations Associated with ABC, Aerial Bundled Conductors

Difficulties associated with mounting these lines are as a result of:

I. Attempting terminations at discontinuities
II. Accessing conductors for testing and earthing maintenance
III. Operations, Switching, Earthing practices being very different

from the ones followed for bare conductor mains and rather closer to the ones followed by underground system hence needing extensive training for installation and maintenance personnel.

Failure modes of the MV ABC:

I. Cracks resulting from stress on the outside covering of the cable
II. Damaged copper screen
III. Singed outer covering
IV. Damaged outer covering from animal bites
V. Dislodged straight-through connection.

HDPE emits a fruity-like odor that attract rodents or squirrel.[6] This makes the cable susceptible to rodents who chew on the outer covering resulting in further exposure of the copper screen to the environment. This culminates in the screen being oxidized as shown in Figure 5. This then creates a high resistance path within the copper screen. Upon the occurrence of a fault on an ABC feeder, the fault current flows to the source through the damaged or cracked copper screen. Thus, the copper screen becomes highly resistant, the fault current would then overheat the XLPE and the outer sheath resulting in further damage of the ABC as pictured in Figure 6. A layer of copper screen is used in the ABC design. A cracked or damaged copper screen of an ABC (Figure 7), would expose it to local overheating and further damage. Moreover, ABC failures are contributed to by gnawing on the outer sheath by rodents, in the process, exposing the conductor screen to the mercy of the environment as illustrated in Figure 8. Another implementation drawback associated with ABC is the failure of its straight through joints and terminations.[7] the straight through joints or terminations are dislodged due to the shrinkage of the poly ethylene jacket. Figure 9 shows contraction of a poly ethylene jacket.

Figure 5 Exposed Copper Screens.

Figure 6 Burnt Outer Sheath.

Figure 7 Damaged or Cracked Copper Screen.

Figure 8 Damaged Outer Sheath by Squirrel Bite.

Figure 9 Contraction of ABC Joint.

Limitations Associated with XLPE/HDPE Covered Conductors

Limitations associated with XLPE/HDPE covered conductors are greatly related to cost, reliability, supply quality and safety.

Cost

Full installation cost of covered conductors according to,[1] is about 10 % to 20 % more than that of bare conductors (Figure 10).

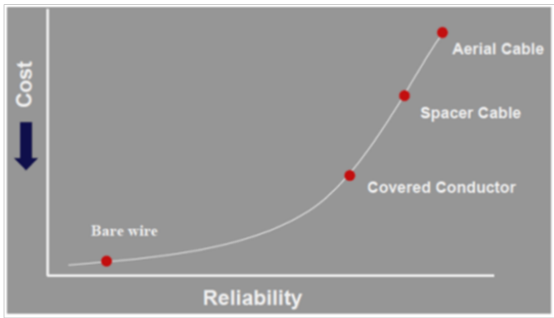

Figure 10 Cost versus Reliability Graph for Various Covered Conductors.

Reliability issues

The following factors affect the reliability of covered conductors:

I. Lightning strikes
II. Corrosion problems due to compromised insulation integrity
III. Leakage currents at pin insulators can causing insulation damage in contaminated environments
IV. premature failure due to aeolian vibration
V. Radio interference can occur due to discharges between the helically preformed tie and the arc protection device wire and poor connection of the device.

Electricity supply quality

Quality of electricity supply denotes a minimal number of power supply interruptions and their period kept to a minimal tim.[8] Thus;

I. Advanced lightning protection system would be needed.

II. Frequent use of arc gaps in the lightning protection of covered conductor need to be avoided

Safety

Covered conductors are confronted with certain safety challenges that could pose great danger to both animals and human. For instance, there could be the possibility of birds and small animals being electrocuted at arc gaps on pole tops. Humans on the other hand encounter difficulties in detecting minor breaks or faults in both the conductor and its covering.

Conclusion

I. Covered conductors are more expensive than the traditional bare wire conductors.

II. Covered conductors though having agreeable electrical properties are affected negatively by bad installation practices.

III. Covered conductors are also affected negatively by age.

Acknowledgements

None.

Funding details

None.

Conflicts of interest

The author declares there is no conflict of interest.

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