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A Case Study of 110 kV Covered Conductor Solutions in Power Line Upgrades

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Abstract

This paper addresses the challenges the power utility faces in upgrading a 110 kV Single Circuit (SC) power line to a 110/220 kV Multi Voltage Multi Circuit (MVMC) Line. With a mandate for uninterrupted power supply and limited Right of Way (ROW). As a solution, a 110 kV Covered Conductor approach has been utilized. This innovative approach significantly reduces installation space requirements, aligning with the project's limited ROW. The paper highlights the adaptability and reliability of Covered Conductor Solutions, showcasing their efficacy in meeting specific customer needs.

Keywords: Covered Conductor, Multi-Voltage Multi-Circuit, Right of Way

1. Introduction of Covered Conductor Solutions

The increasing demand for heightened reliability minimized tree clearing, and wildlife protection has compelled electricity distribution authorities to explore more efficient methods for medium voltage distribution. In light of financial constraints and the formidable challenges of trenching in densely populated areas, the options have narrowed down to utilizing Medium Voltage Aerial Bundled Conductors (MVABC) or converting existing overhead bare circuits to Medium Voltage Covered Conductors (MVCC).

While MVABC is still regarded by many as the optimal solution, owing to its fully screened design providing a "safe to touch" attribute, certain drawbacks have curtailed its widespread adoption. The associated costs of the cable, substantial additional weight necessitating pole replacements, the need for highly skilled installers, and challenges in establishing connections have limited its deployment to specific areas where it remains the sole viable solution. In contrast, the simpler connection and jointing processes of MVCC are making it the preferred choice in numerous countries, including India. The Covered Conductor Solution (CC) offers significant space savings, with approximately 40% narrower clearances required for line corridors passing through forested areas compared to standard bare lines. This space efficiency is further amplified in parallel line structures. Covered Conductor Solutions undergo rigorous testing by the EN 50397 standard. This standard, known for its heightened demands compared to previous national standards, thoroughly encompasses accessories tailored for such solutions. As a result, adherence to this stringent standard ensures a considerable enhancement in reliability for the Covered Conductor Solution.

A covered conductor consists of either aluminium or copper wire enveloped by layers of insulating material. The covering is specifically engineered to withstand phase-to-phase and phase-to-ground contact temporarily. It is essential to note that while the covering provides protection, its properties are reduced compared to those of insulated cable. The primary purpose of covered conductors is to prevent phase-to-phase and phase-to-ground faults, consequently lowering the likelihood of ignition. Figure 1 demonstrates all layers of the MVCC1[1].

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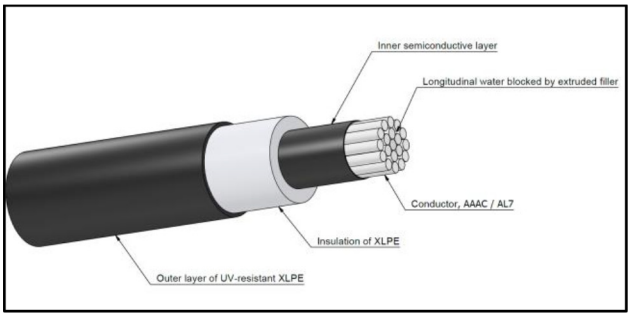


Figure 1. Aluminum-covered conductor.

2. Comparison of the Standard Bare Conductor and Covered Conductor

The utilization of medium voltage overhead-covered conductors is not a novel concept; rather, it has been employed with varying degrees of success in different parts of the world. There are different driving factors to opt for the covered conductor solution. In the domain of medium voltage power distribution systems, the decision between standard bare conductors and covered conductors carries significant implications for the overall effectiveness, longevity, and efficiency of the electrical infrastructure. This section aims to present a thorough comparison between these two types of conductors, shedding light on their respective merits, drawbacks, and specific applications.

2.1 Safety Reinforcement

Covered conductors play a crucial role in advancing safety within medium-voltage power distribution systems. The insulating layer serves as a protective shield, reducing the likelihood of electrical faults and enhancing overall system safety. By minimizing exposure to live parts, covered conductors contribute significantly to preventing accidental contact, thereby reducing potential hazards for both personnel and the general public.

2.2 Reliability Enhancement

Reliability holds paramount importance in power distribution systems, and covered conductors excel in this aspect. The additional insulation layer protects the conductor from environmental factors, ensuring consistent electrical performance. This reliability translates to a more stable and predictable power supply, lowering the chances of unplanned outages and bolstering the overall dependability of the distribution network.

2.3 Cost

While covered conductors may entail higher initial costs compared to standard bare conductors, their long-term cost-effectiveness becomes evident when considering factors such as reduced maintenance, extended lifespan, and enhanced reliability. The investment in covered conductors proves economical over the lifecycle of the system, presenting a compelling cost-benefit proposition for power distribution projects.

2.4 Right of Way (ROW)

Covered conductors contribute to the efficient utilization of the ROW in power distribution projects. Reduced clearance requirements and improved safety features enable a more compact design, optimizing space utilization within the ROW. This proves advantageous, particularly in urban or congested areas where space is at a premium, allowing for a more flexible and streamlined deployment of the distribution infrastructure.

2.5 Phase to Phase Distances (Clearances)

The design of covered conductors permits more favourable phase-to-phase distances, ensuring compliance with clearance regulations. Enhanced insulation properties enable a reduction in required clearances, contributing to a more efficient use of space within the distribution network. This aids in meeting regulatory standards and facilitates a more compact and aesthetically pleasing installation.

2.6 Theft-Proof

The covered conductor design inherently provides a theft-proof feature. The insulation layer acts as a deterrent, making it more challenging for unauthorized individuals to tamper with or steal the conductor. This security feature adds an extra layer of protection to the distribution infrastructure, safeguarding against potential theft and vandalism.

2.7 Reduction of Distribution Losses

Covered conductors contribute to the reduction of distribution losses through improved insulation. The insulation layer minimizes leakage currents and energy

losses, enhancing the overall efficiency of the power distribution system. This reduction in distribution losses not only improves the system's energy efficiency but also leads to cost savings over time. In summary, covered conductors offer a comprehensive set of advantages over the standard bare conductor. These benefits position covered conductors as a superior choice for medium voltage power distribution, providing a holistic solution that addresses various critical aspects of system performance and operation.

3. KSEB Project

The northernmost district of Kerala State, Kasaragod, receives power supply from the 110kV substation, Vidyanagar. Vidyanagar, in turn, is supplied power from the 220kV substation, Mylatty, through a 110kV single circuit line equipped with Tiger conductors with a current capacity of 290 Amps. Over time, the power requirements of Kasaragod have increased, necessitating an upgrade of the single circuit line to a double circuit line with a higher capacity conductor as can be seen in Figure 2.



Figure 2. 110 kV covered conductor parallel with bare conductor.

However, as the Vidyanagar substation receives power from a radial feeder, it became essential to establish an emergency parallel power restoration system. To address this, the KSEBL decided to implement a bypass arrangement using 110kV covered conductors. The proposed line would run parallel to the existing 110kV line within the available ROW. The total length of the line is approximately 11 km, and the plan was to complete it in four stretches, each with a length of 3 km.

For this specific requirement, a covered conductor solution has been proposed for a 110kV SC transmission line, featuring poles with a length of 14 m and spans approximately 40 meters. This 110kV covered conductor will require less space for installation and it will allow to installation new line with minimum clearance. The covered conductor solution meets the requirement of installation of MVMC line in limited ROW and public safety as can be seen in Figure 3[2].



Figure 3. 110 kV covered conductor sag view.

In Kasaragod district, a 50 MW solar park situated at Paivalige posed a challenge in power evacuation to the nearby 110kV substation. To address this, a 429 sq mm, 33kV covered conductor was employed. The performance of this solution has satisfactorily met the requirements of the state electricity board[3].

4. Type Test

The 110kV covered conductor underwent validation for its material, mechanical, and electrical properties at a third-party laboratory. All type tests were conducted in accordance with the EN 50397-1:2022 standard.

Table 1. Test Sequence of MVCC

S. No	Test description
1	Tracking resistance test
2	DC resistance test
3	Thickness of insulation and covering
4	Tensile strength
5	Mechanical properties and test of compatibility
6	Shrinkage test on insulation
7	Hot set test on insulation
8	Water absorption test on insulation
9	Test for longitudinal water tightness
10	Leakage current measurement

Along with the material and constructional verification, the 110kV Covered conductor also successfully went through critical Dielectric type test verification which is simulated as per site conditions.

Table 2. Additional test performed on MVCC

Test description	Test Method
Dry power frequency voltage withstand test at 110kV AC	Two numbers of 110kV covered conductors were tied together in a span of 200mm, which simulated the Tree falling condition. There is no flashover/puncture was observed on the covered conductor.
Dry power frequency voltage withstand test at 230kV AC	Two numbers of 110kV covered conductors were placed at an air gap distance of 500mm, which simulated the actual site condition. There is no flashover/ puncture was observed on the covered conductor.
Dry lightning impulse voltage withstand Test at 550kVp	Two numbers of 110kV covered conductors were placed at an air gap distance of 750mm and 550kVp was applied with 10+Ve and 10-Ve shots which simulated the actual site condition. There is no flashover/ puncture was observed on the covered conductor.

5. Project Challenges

A unique design was developed featuring 14-meter poles designed to carry three conductors using 110kV polymer insulators while maintaining the statutory vertical ground clearance for bare conductors. This design received approval from KSEBL. The poles were installed in 2-meter-deep pits, and no concrete foundation was provided, considering it as a temporary arrangement. During the construction of the bypass arrangement, a challenge arose regarding how to connect the covered conductor with the existing bare conductor. To address this, two Double Pole structures were erected at the ends of the bypass line, and the covered conductors were terminated in these structures. Jumpers were utilized to connect the bare conductors to the covered conductors, ensuring a seamless integration of the new arrangement with the existing infrastructure. As we are aware, the covered conductor cannot be dragged on the ground and pulled along as damage to the outer sheath could occur which will be detrimental to the technical functioning of these covered conductors. To overcome this, the pulling of the conductors for the entire length was carried out using single-sided pulleys. Another challenge was to cross a valley within the line route. There also two DP's were provided on both sides of the valley where the covered conductor was tensioned.



Figure 4. Tension clamps connection for the covered conductor.

Proper sag was maintained with applicable tension on the conductor as can be seen in Figure 4. The length of covered conductors was limited to 750 m on each drum to facilitate easy movement of these drums on the hilly terrain. One of the primary challenges involved ensuring appropriate clearances were maintained with adjacent buildings and existing trees in the narrow corridor where the covered conductors were being installed. Following the completion of the project and the parallel charging of the line with covered conductors

bearing the full load, measurements of Electric and Magnetic field levels were conducted for both covered conductor lines. The results confirmed that these levels were well within safe limits, and certification affirmed that there were no adverse effects on nearby buildings. Additionally, rigorous monitoring protocols were implemented throughout the installation process to uphold safety standards and minimize potential risks. This meticulous approach ensures the reliability and integrity of the power transmission infrastructure. Furthermore, continuous coordination with local authorities and stakeholders helped navigate potential challenges and ensure seamless project execution.



Figure 5. 110 kV covered conductor parallel with bare conductor at valley crossing.

5. Conclusion

In summary, this paper delves into the challenges faced by power utilities during the upgrade of a 110 kV Single Circuit power line to an advanced 110/220 kV Multi Voltage Multi Circuit Line. The need for an uninterrupted power supply, combined with limited Right of Way (ROW), prompts the search for innovative solutions. The utilization of a 110 kV Covered Conductor approach emerges as a promising remedy, effectively reducing space requirements during installation and aligning with the project's ROW constraints as seen in Figure 5, the bare conductor is compared to the covered conductor line. The study highlights the flexibility and reliability of Covered Conductor Solutions, showcasing their effectiveness in addressing the specific requirements of customers. The successful implementation of this inventive approach enables power utilities to navigate the complexities of power line upgrades, ensuring a smooth transition to higher voltage configurations. This paper provides valuable insights into the practical application of Covered Conductor Solutions, emphasizing their capacity to tackle challenges in power infrastructure upgrades and improve overall system performance. As power grids evolve, the findings advocate for considering and adopting Covered Conductor Solutions as a viable strategy to optimize power transmission systems.

6. Acknowledgement

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