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**Amokabel –
a new generation covered conductor system
with a difference**

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Background

Bare conductors on distribution lines have served the electricity industry well for more than a century as a simple, relatively inexpensive solution. However, they are increasingly an impediment to OHL modernisation and to emerging technologies that meet sustainability needs and improve resilience to climate change.

- They cannot keep up with the impact of climate change, such as storms that cause power outages. The risk of bushfires is increasing due to bare conductors exposed to high winds, tree branches touching or breaking conductors, and other factors. Many feeders in rural bushy areas experience frequent outages and reliability issues.
- They also pose direct and indirect safety hazards. In urban areas, many overhead lines run through trees, which must be cut, resulting in unsightly scars. Furthermore, such trees become increasingly susceptible to structural failure as they grow; for example, a limb may break during storms, resulting in a fall to the ground and damage to property or injury to people.

- Wildlife is another big challenge. Electrocution of birds and other species has a detrimental environmental impact, while causing frequent power outages that affect SAIDI and SAIFI.



Traditional CCT (Covered Conductor Thick)

To mitigate these problems, some utilities introduced Covered Conductors Thick (CCT), with insulation up to 3.2 mm, to enhance abrasion and scratch resistance. However, most of them had significant design flaws and drawbacks and failed to fulfil their intended purpose, as follows:

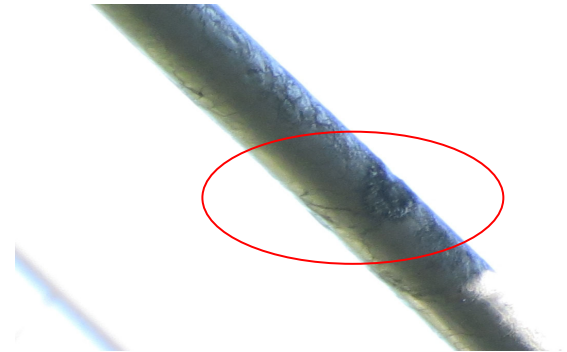
- Many of them do not have a semiconductive layer to spread the electrical field along the conductor and to control stress
- Very difficult to peel off the insulation without damaging the conductor, even with some dedicated tools
- In most installations, the integrity of the insulation coordination is compromised at joints, terminations, and T-offs (tap connectors) for connections to lightning arresters and temporary earths. The single layer of insulation, typically polyethylene (PE) or cross-linked polyethylene (XLPE), is designed to be weather- and UV-resistant, but is still susceptible to physical forces, environmental and electrical degradation
- Also, inconsistent insulation coordination makes CCT very susceptible to lightning strikes because it is difficult to design proper protection
- They are not resistant to tracking, as they do not maintain the insulation integrity and insulation coordination along a circuit
- An example of dielectric incompatibility among various components of the CCT systems, resulting in tracking, treeing, and failure



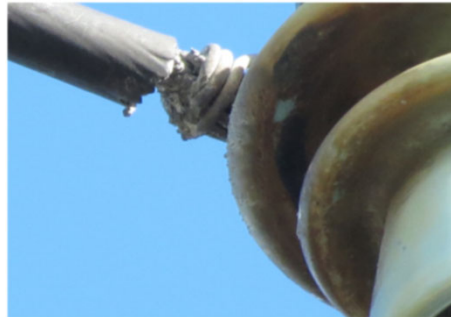
More failure modes of traditional CC and CCT

In essence, CCT is a CC with thicker insulation. They share a similar, non-shielded design and are subject to the same degradation and failure mechanisms; however, CCT introduces a **time delay and lasts slightly longer.**

- The insulation wears down if the conductor constantly rubs against tree branches or supporting structures due to wind or vibration, while at the same time, it is continuously exposed to electrical stresses, resulting in PD and degradation.



- Problem of dielectric incompatibility among various components of the CC and CCT systems, resulting in tracking, treeing, punctures, and failure



New Generation Covered Conductor System (NGCC)

A new-generation covered-conductor system (NGCC), designed and manufactured in Sweden, is different.

- This novel concept delivers a fully engineered, **complete solution** with a design life of more than 40 years at approximately 10% of the cost of undergrounding, or just 20% more than bare conductors
- It comprises covered conductors and associated accessories.
- The **purpose-designed IPC** (Insulation Piercing Connectors) eliminates the need to peel off and remove insulation.
- It can **significantly reduce bushfires** and **faults** caused by clashing lines while improving safety and reliability.
- This system has been **proven globally** and tested against all relevant international standards.

This covered conductor has three layers of covering:

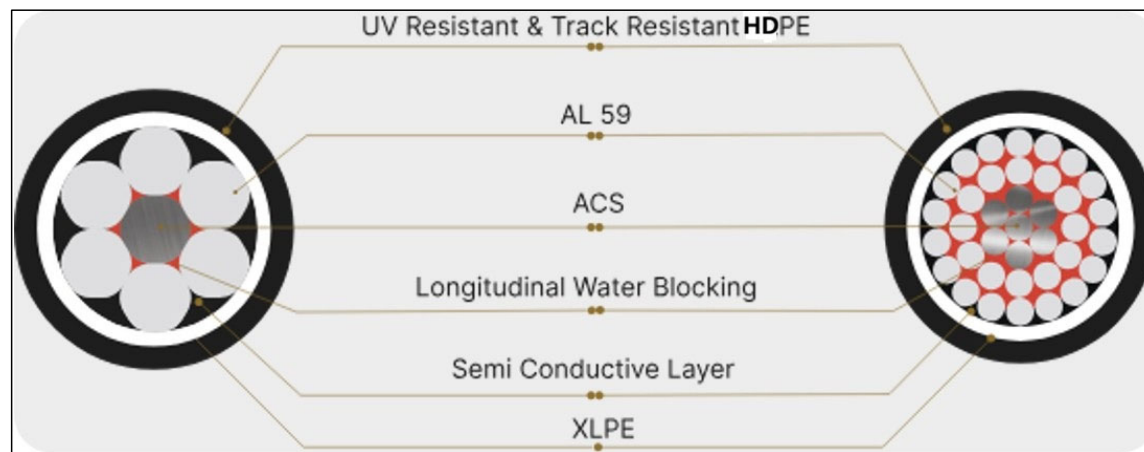
1. **Semi-conductive inner layer** provides stress control
 2. **High-grade XLPE layer** in the middle provides electrical insulation
 3. **Tough HDPE outer polymer jacket** provides further insulation and mechanical protection against abrasion, as well as intense UV light.
- It also has a longitudinal **water blocking**



The entire system, the covered conductor and its accessories, is effectively a **fully sealed cable system** that prevents water ingress and meets the EN 50397-1-2006 international standard. (Note: It is still considered not fully insulated like a cable (not touch safe), even though the insulation is much better than with standard CCTs)

- **Advanced, lightweight insulation materials** enable NGCC to be restrung on existing poles.
- According to **CSIRO** (Commonwealth Scientific and Industrial Research Organisation) this type of covered conductor **reduces bushfire risk by 98%**.

Cross-sectional area of a typical NGCC with ACS - Aluminium Clad Steel Core (other options are ACSR and AAAC)



Engineering considerations: Stress control

The NGCC has a superior semi-conductive layer that serves the following two purposes:

Stress Control:

- This smooth, uniform **semiconductive boundary layer** fills air gaps and smooths the irregular surface of the stranded conductor, **preventing the electric field from concentrating** at sharp points.
- In other words, it effectively **contains and homogenises the electric field** within the insulation, and eliminates hot spots (electrical stress concentrations) that could otherwise cause premature conductor deterioration and failure.
- For example, it **prevents or minimises partial discharge** at points where a tree branch touches the conductor, which would otherwise degrade the insulation over time. Proximity to a supporting structure or contact with a tree creates a region of high-voltage stress on the conductor, unless a semiconductive layer mitigates it.

Insulation Integrity:

- This layer ensures a **contaminant-free interface with the insulating material (XLPE)**, which is critical to maintaining the insulation's long-term integrity and reliability.

Engineering considerations: Insulation coordination

In earlier CCT installations and upgrades, most fittings were of mixed standards, e.g. with varying Basic Insulation Levels (BIL) or creepage distances, without accounting for their interactions. It compromised the integrity of the insulation coordination.

- With NGCC, its dedicated **insulation piercing connectors (IPCs)** and **other accessories** are designed and made to the same standard. They improve and maintain insulation coordination on medium-voltage (MV) systems, thereby preserving the network's insulation integrity.
- IPCs have a **sealed, waterproof design in a UV-resistant polymer housing** that prevents moisture ingress, a primary cause of insulation failure in outdoor or underground applications.
- IPCs use **shear-head bolts** that ensure the correct tightening force is applied during installation, **guaranteeing optimal contact pressure** and preventing damage to the conductor strands or over-compression of the insulation.
- A correctly installed IPC acts as a fully insulated, sealed component of the system, meeting the exact insulation coordination requirements of the rest of the insulated network.



Importance of Insulation Coordination for the proper design of protection against transient events and lightning strikes

All electrical equipment is susceptible to transient events and lightning strikes. The same applies to covered conductors; e.g., there is no 100% protection. There are methods to mitigate these risks using protective devices such as lightning arresters and arc protection devices.

The **key prerequisite** is to **achieve and maintain proper insulation coordination** along the protected line, because:

- The **arrester's protective voltage level must** be set **below the equipment's insulation level**, creating a safety margin
- In other words, the arrester should be selected for the "**Weakest Link**", e.g. its clamping voltage must be lower than the equipment's flashover voltage, ensuring the arrester takes the hit, not the transformer or covered conductor.
- So, **the "weakest link"** in the insulation chain then becomes **the arrester itself**, allowing it to operate, protect more expensive equipment, and maintain system reliability, rather than having the main equipment fail.

Without knowing the equipment's true basic insulation level (BIL) and without full integrity of the insulation coordination, it is difficult to design an appropriate level of lightning protection (e.g. to select the right arresters) because the "weakest point" can be anywhere along the line (as in previous CCT designs, which frequently failed due to transients and lightning strikes).

The **NGCC** and **associated accessories provide continuous insulation coordination** along the entire circuit. It enables the selection of appropriate protective devices that can operate under temporary and transient overvoltages (lightning and switching surges), while minimising failures and ensuring cost-effectiveness. It is now up to the power company to properly design the lightning protection for its covered conductors.

Engineering considerations: Tracking

Most early CCT designs had tracking problems, particularly under harsh conditions (pollution, moisture, UV), resulting in insulation degradation, carbonisation, and failure.

Tracking is mainly caused by:

- Degradation of the insulation material due to rain, dust, sea spray, industrial pollution, and UV
- High voltage in combination with contaminants or moisture causes surface discharges, leading to electrical tracking
- Over time, the insulation becomes brittle, cracks, or carbonises, forming conductive paths (tracks).



The NGCC system has:

- Tough, UV-protected HDPE outer layer with good track resistance.
- **The tracking on NGCC is less than 1mA**
- The connectors and clamps used with the system are also designed and tested to be compatible with this track-resistant conductor system.
- All accessories work effectively with the non-tracking properties of the conductor's outer sheath, ensuring the entire assembly remains highly reliable and safe.

Key advantages of the new covered conductor system

- **Compact design; Corrosion resistant;** made of new **Advanced materials**
- **The extrusion** of the entire conductor, including the semiconductive layer, the XLPE insulation and the outer HDPE protective layer (jacket), is done simultaneously and continuously **in one go**
- NGCC is **stronger and lighter** than old-fashioned CCT designs, e.g. the total thickness of all layers is between 2.4 and 3.4 mm, depending on the NGCC type.

NGCC (CCSX) vs traditional CCT (120mm² at 22kV)

Characteristic	CCSX	CCT
Weight/km	506kg	720kg
Diameter	20.3mm	26.1mm
Minimum Breaking Load	34.9kN	27.1kN

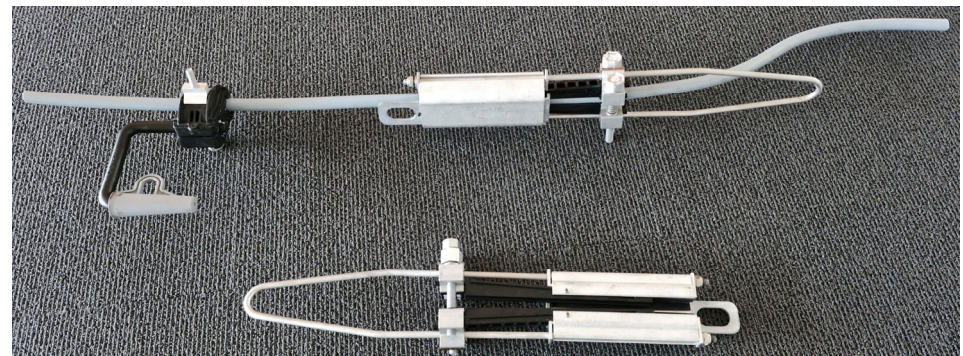


- NGCC is **much easier to install** than traditional CCT
- **No Stripping:** No need to remove insulation, which simplifies installation and increases reliability
- Excellent tolerance of conductors clashing and trees leaning, thus **reducing fire risks**
- Good tolerance to **withstand extreme weather** conditions
- It allows **retrofitting** in most existing networks, without inter-polling
- Option of **upgrading** an old bare conductor, **keeping the old structure**

Conductor	Bare Equivalent	Max Span Length
CCSX25	3/2.75	275m
CCSX62	7/3.0	170m
CCSX159	19/3.25	160m

Key benefits of the new covered conductor system

- Maintains the **integrity of the insulation coordination**
- **Much safer** - protects line workers during installation and maintenance, and the general public from accidental, momentary contact hazards
- **Provides much better wildlife protection**
- **98% effective in preventing bushfires**
- **Increases reliability dramatically** by preventing faults and power outages caused by vegetation or wildlife
- **Improved supply quality and network resilience**
- **No stripping required**, which eliminates the main failure cause of traditional CCT
- **Up to 10 times cheaper than undergrounding while achieving the same resilience**
- **Reduced asset lifecycle operating costs** due to fewer faults (up to 4 times lower than CCT)
- Extended life and higher reliability in **high corrosion zones**



Note: Stripping is required only for the installation of straight joints, and for CCSX25 (25 mm²), which is used as a direct replacement for SWER steel conductors. However, NGCC insulation is much easier to strip than CCT insulation.

Performance and cost

NGCCs are used in Europe, Africa, Australia, South America and Asia. In Australia, more than 1,000 km has been installed over 9 years. Feedback from one of the Australian distribution companies is as follows:

Cost:

- “Overall, the cost increase was estimated at around 20% compared with bare wires.
- This provides an excellent return on investment (ROI) in terms of improved network resilience and security of customer supply and reduction in risk to wildlife and fire start incidents.
- It is well on the way to recovering the additional cost of NGCC over bare wire.”

Performance:

- “The experience from the full-scale trials shows that the NGCC covered conductor is easy to install and work with.
- It will allow (the Company) to mitigate many of the potential risks that traditional open wire networks pose, at a reasonable cost, making it a viable standard replacement alternative.
- Reasons to install NGCC covered conductor include reducing customer outages and their duration (reliability), and the incidence of fire starts.”

Questions and Answers



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