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I. Introduction

The purpose of the ACCC® Conductor Maintenance and Repair Manual is to provide experienced personnel with guidelines, recommendations, and the requirements necessary to successfully Maintain and Repair ACCC composite-core bare overhead line conductor and associated accessories.

This document is an overview and guideline covering what to do but not necessarily how to do it. It is not intended to serve as a more intensive training manual or act as a substitute for proper training required, personal skill sets, or industry experience.

These Guidelines should be used in conjunction with the ACCC® Installation Guidelines, where advice on the correct tools and equipment and installation methods can be found. A copy of the installation Guidelines can be downloaded via CTC Global Website.

ACCC installations uses the same safety practices as to other conductors.

ACCC Conductor is maintained and repaired using industry standards, installation equipment, methods, and standards such as IEEE-524, National Grid Linesmens Manual M1 (UK), and others. Many standards exist world-wide and applicable standards must be observed.

II. Scope

These guidelines apply to all sizes and types of ACCC® Conductor and associated hardware, including Ultra-Low Sag (ULS), Ultra-High Strength (AZR™) (Ice Load), and ACCC® InfoCore™.

III. Supporting Documentation

- ACCC® Installation Guidelines.
- IEEE Std. 524-2016

IV. Inspection

Once installed, maintenance of ACCC® conductor consists simply of periodic inspection for environmental damage, structure degradation, broken insulators, hardware failure, phase to phase and phase to ground clearances, vegetation encroachment, or other issues, and then the repair of such damage, exactly as for any other bare metal overhead line conductor and in accordance with this manual.

A. Conductor Trolleys

There are no special requirements for the use of conductor trolleys on undamaged conductor. However, if aluminum strand damage is observed and the condition of the core is suspected to have been compromised, then a conductor trolley MUST NOT be used for access. An alternative source of access should be used to allow further inspection.

B. Conductor Inspection.

Visual patrols from a helicopter, fixed winged aircraft, drone, ground vehicle, or foot patrol can detect damage that might have occurred on insulators, broken or damaged conductor strands, leaning structures and vegetation. Thermal imaging cameras can quickly and reliably find "hot spots" in conductors and hardware, indicating a problem.

C. Discoloration

The surface of new ACCC Conductor will normally appear shiny, bright, and reflective. ACCC Conductor may be ordered with a non-specular finish to reduce reflectivity and the appearance is then silver or light grey.

When conductor reels are stored outdoors, moisture can be trapped in wrapping material next to the conductor, this is often found at the bottom of the reel where water has pooled. The moisture can combine with chemicals from the surrounding atmosphere, and a black stain can appear on the conductor. This has been found to be more prevalent in non-specular conductor as the drawing oils have been removed.

The photograph on the right is a typical example of this type of staining.

Water stains are a cosmetic issue; they have no adverse effect on the performance or service life of the conductor. In most environments, the conductor will darken in the first few months the line is energized, and water stains will no longer be noticeable.

New conductor may darken in service, sometimes rapidly and dramatically, due to contaminants in the atmosphere – e.g. near fertilized agricultural fields or heavily polluted areas.

D. Abrasion damage

Abrasion damage is a chafing, impact wear that accompanies relative movement between conductor hardware and the conductor or armor rods. Abrasion damage can be identified by black deposits on the conductor. Abrasion eventually results in the failure of the conductor strands. If the damage is detected early, it can be repaired. Always ensure the cause of the abrasion is identified and corrected.

E. Line Hardware

When inspecting the many aspects that make up line hardware, look for:

- Missing cotter pins, bolts, or nuts.
- Rust, as this is a telltale sign the hardware is in a weakened state and could ultimately cause the line to fall.

F. Strand Loosening / Birdcaging

It is more likely that any strand loosening or birdcaging observed would have been caused and not rectified correctly during the installation, as this would not normally occur post installation. However, anomalies in the conductor strands can also be a telltale sign of a broken core and therefore further examination must be undertaken.

Figure 1 - Example of Strand Deformation due to Broken Core

If the loosening is not too severe and the cross-sectional area of aluminum remains intact, then the electrical performance will not be affected. Where strand loosening is observed there is a possibility a small amount of debris could build up between the open strands. This has the potential to cause corona or noise.

Where bird caging has occurred, it is important to ensure the core is not visible as exposure to UV light will affect the life of the conductor. Where the core is visible the aluminum must be repaired, or the section replaced.

Where strand loosening is observed always carry out further checks to ensure the core has not been damaged or exposed to UV Light.

G. Conductor Damage Mid Span

If there is damage to the conductor mid-span due to contact with trees or from some other incident, it is important to look at the structures on both sides of the damaged conductor. Check both ends of the armor rod at each adjacent structure and ensure that there are no sharp bends in the conductor or strand opening as this could signify a possible broken core.

V. Types and Causes of Conductor Damage

A. Aeolian Vibration

Aeolian Vibration is a high frequency motion (10 to 50 Hz) which occurs under smooth conditions (8 to 24 km/h or 5 to 15 mph) across the conductor surface, resulting in cyclic bending at the supporting hardware (i.e. dead-ends, splices, suspension clamps,) and causes damaging stress fatigue and strand breakage.

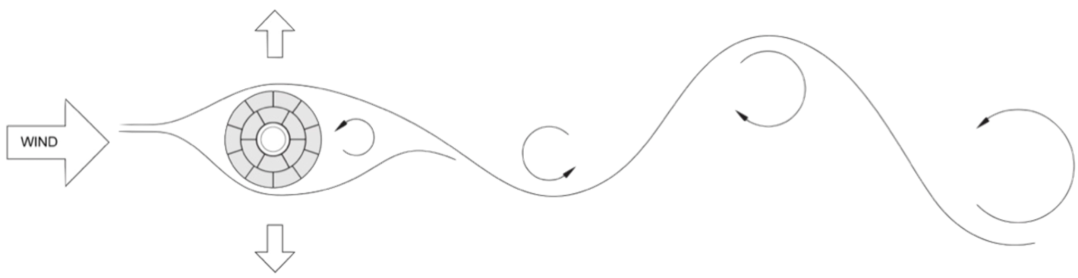


Figure 2 - Aeolean Vibration

B. Galloping

Galloping is a low frequency, high amplitude oscillation due to high winds (24 to 65 km/h or 15 to) blowing over the ice-covered conductor. Ice accretion takes place on the conductor, changing the shape leading to aerodynamic lift and rotational moment which results in negative aerodynamic damping and leads to galloping. Conductors can move up to 10 meters (30 feet) resulting in cyclic bending at the supporting hardware (i.e. dead-ends, splices, suspension clamps) and causes damaging stress fatigue and strand breakage.

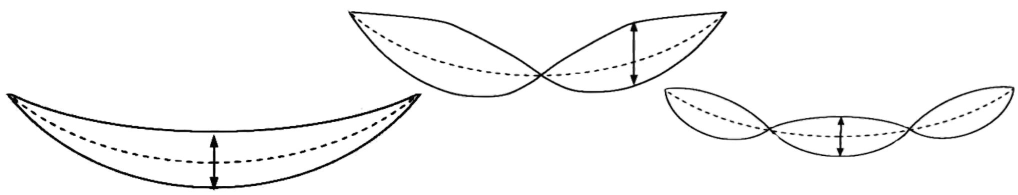
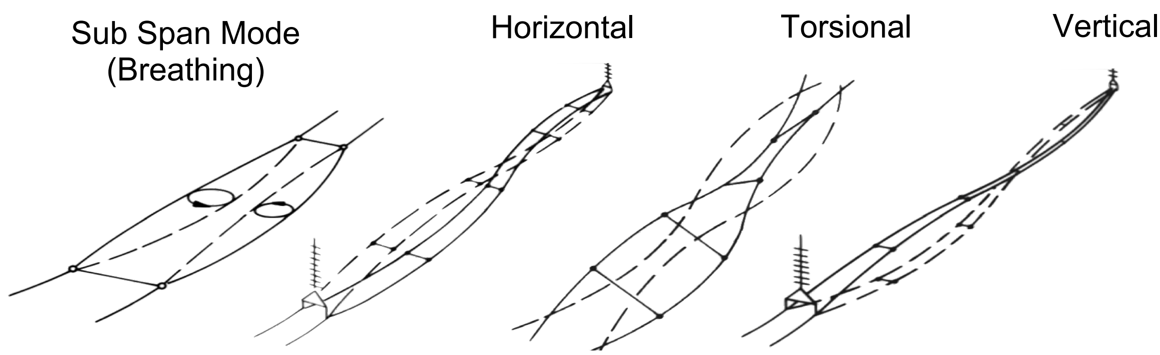


Figure 3 - One, Two, and Three-Loop Galloping

C. Wake-Induced Oscillation

Wake-induced oscillations, (winds of 10 to 40 mph) appear only in bundle conductors. They are due to the shielded conductor lying in the wake of the windward conductor. The oscillations may be vertical, horizontal, or torsional in motion. Cyclic stress fatigue can break strands at spacers, dead-ends, etc.



D. Other Damage Considerations.

To avoid a possible recurrence, it is important that the cause of the damage is established and repaired prior to the line being put back in service. Other possible causes of damage that should be considered but not limited to when inspecting conductors include:

1) Lightning Strike
2) Gun Shot
3) Short Circuit
4) Impact from Debris
5) Incorrect Fittings or Badly Installed Fittings
6) Poor Installation

VI. Repair Criteria

A. No Core Damage.

The following table must ONLY be used when you are <u>sure</u> that there is **no core damage**.

Number of Broken Strands	Preform Helical Repair Sleeve 2.4m (96”)	Compression Repair Sleeve	Mid Span Joint	ACCC Helical Conductor Splice (PLP)
1 Outer Layer Strand	✓	✓		✓
2 Outer Layer Strands		✓		✓
+3 Outer layer Strands			✓	✓
Any Inner Layer Strand			✓	✓

B. Compression Repair Sleeves.

ACCC® Aluminum compression sleeves may be used to repair and restore conductivity of aluminum stranding when one (1) or (2) outer layer aluminum strands are damaged. The two-piece sleeves are fitted over a damaged area, and then compressed in a similar way to dead-ends or splices. They are 350-600mm (14-24”) long, depending on manufacturer and conductor size.

C. Damaged Core.

Any amount of core damage must be repaired using a mid-span splice!

D. Mid-Span Splice

If the core is damaged or core damage is suspected in a single location, and that location is at least 15 m (50’) from a structure, then a single mid-span splice may be used for repair.

A splice replaces approximately 230mm - 280mm (9” - 11”) of core. Compression Dead ends and Splices represent the only way to restore the line to 95% of its original rated tensile strength (RTS). This is the best technical solution for repairing damaged transmission lines for the following reasons:

1) The compression dead end assembly or splice has a guaranteed ultimate breaking strength that’s equivalent to 95% of the rated breaking strength of the conductor.
2) The electrical resistance of the assembly when properly compressed on conductor is less than 75% of the resistance of the equivalent length of conductor.

VII. Repair Guidelines

When planning to make repairs the following must be taken into consideration;

1) Never install a splice any closer than 50’ (15 m) from a structure.
2) Repairs must always be made with materials and components which are rated for ACCC operating temperatures (200° C).
3) The minimum distance from a repair sleeve to another fitting on the conductor shall be 1.2m, this includes other repair sleeves. (If the repair sleeve is moved closer to the dead-end, the conductor strands may loosen and open and remain open).
4) A spacer damper of the appropriate size should be fitted
2 - 8 meters from the repair sleeve to prevent sub-conductor clashing in the vicinity of the repair.
5) When replacing conductors or a section of sub-conductor the creep of the existing conductors must be taken into consideration. For further advice contact fieldservice@ctcglobal.com.

VIII. Repair Examples

A. Aluminum Strand Damage Only

Use appropriate repair method from the earlier table.

B. Conductor and Core Damage, Small Area

Remove damaged core area and install a mid-span splice.

C. Conductor and Core Damage, Larger Area

If core damage extends greater than 230mm - 280mm (9” - 11”), or exists in multiple places, use multiple splices. When using splices replace 15 to 30 m (50’ to 100’) of conductor per each phase that is damaged. Keep splices at least 15 m (50’) away from any structure. Ensure the accumulated creep of the existing sub-conductors is considered when re-sagging.

D. Conductor Damage Mid-span and One Structure

If mid-span core damage is accompanied by damage at suspension clamp armour rod, use splices, replace all damaged conductor, keeping splices at least 15 m (50’) from any structure. Ensure the accumulated creep of the existing sub-conductors is considered when re-sagging.

E. Conductor and Core Damage, Dead-end Span:

Add a section of conductor with a splice and add a new dead-end. Ensure the accumulated creep of the existing sub-conductors is considered when re-sagging.

F. Conductor Strands Open, Core Exposed:

Cover the affected area using a suitable repair sleeve, where the area is too large to cover with a single repair sleeve the section must be replaced.

IX. Live Line Working

Live line maintenance can be utilized to work on ACCC Conductor, however it is important that the following points are considered prior to starting work:

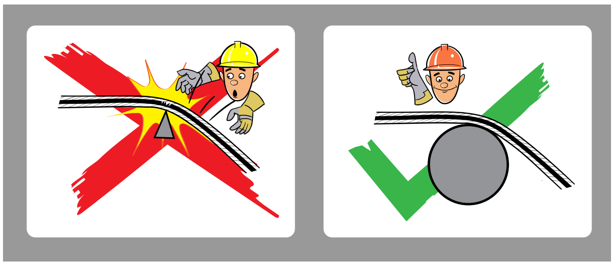
Hotsticks, gloves, Faraday suits, etc. are temperature rated, but always lower than 180°C ACCC rating. Thus, the maximum conductor temperature that can be worked will be determined by your equipment.

ACCC splices or dead-ends cannot be installed via live line maintenance because of the mechanical way that the splice or dead-end hold the core.

X. Dos & Don'ts

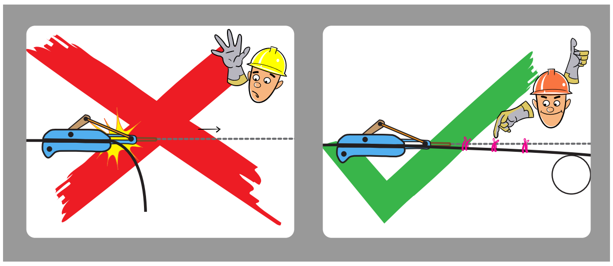
A. DON'T OVER-BEND!

Don't allow the conductor to contact surfaces that present sharp angles or small diameters.

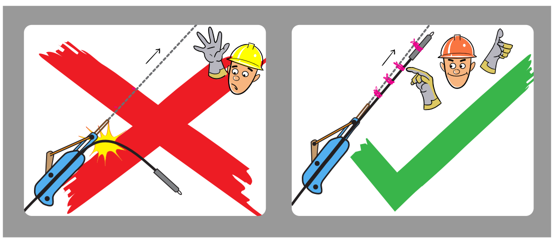


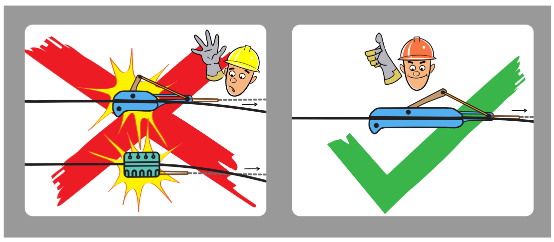
B. Tension Grip DON'Ts:

Don't allow the conductor tail or the dead-end to fall or droop unsupported while handling the conductor. If the tail is not controlled, it will damage the core at the back of the grip.



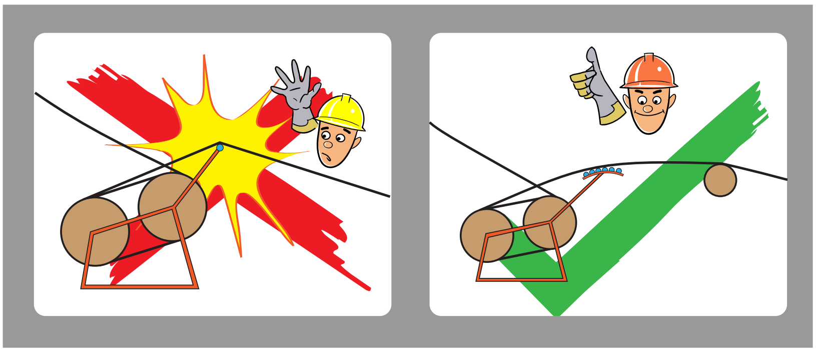
Don't allow the conductor tail or the dead-end to fall or droop unsupported while handling the conductor. If the tail is not controlled, it will damage the core at the back of the grip. Don't use pocketbook grips or short-jaw parallel jaw grips.





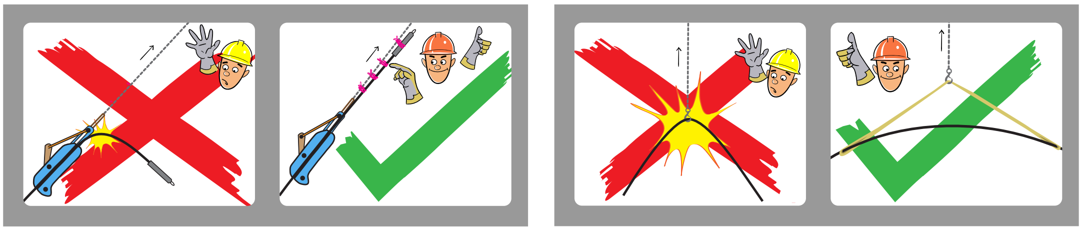
C. Fairlead DON'T:

Don’t let ACCC Conductor run hard against any roller of the fairlead. Always use a tensioner feed sheave (meeting minimum sheave diameter requirements) between the payout reel and tensioner to guide the conductor into the middle of the tensioner fairlead opening.



D. Handling DON'T:

Don’t hoist or handle the conductor in any manner which causes a sharp bend in the conductor.



E. Termination DON’T:

Don’t allow a sharp bend where the conductor exits the termination hardware. Hoisting conductor or dead-end without paying attention to this area can damage the core at that point.