

Chapter 8 – Sagging, Terminations, and Suspensions– Table of Contents

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1. PURPOSE

1.1. This is Chapter 8 of the ACCC® Conductor Installation Guidelines, covering ACCC sagging, suspensions, terminations, and ancillary hardware. The chapter also covers bundling. The Guidelines consist of nine chapters, each written to stand alone to address specific installation subjects. Taken together, the chapters comprise the entire Installation Guidelines:

- 1.1.1. Chapter 1 — General Installation Guidelines
- 1.1.2. Chapter 2 — Safety
- 1.1.3. Chapter 3 — Training
- 1.1.4. Chapter 4 — Reel Handling and Storage
- 1.1.5. Chapter 5 — Site Considerations and Set-ups
- 1.1.6. Chapter 6 — Tools and Equipment
- 1.1.7. Chapter 7 — Stringing / Pulling
- 1.1.8. Chapter 8 — Terminations, Sagging, and Suspending
- 1.1.9. Chapter 9 — Maintenance and Repair

1.2. The purpose of the Guidelines is to provide experienced transmission engineers, project

managers and planners, field inspectors, utility personnel and linemen with guidelines, recommendations and requirements necessary to safely and successfully install the ACCC composite-core bare overhead conductor and 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 personnel skill sets, or industry experience.

2. SCOPE

- 2.1. These guidelines apply to equipment and techniques required to successfully install all sizes of ACCC conductor.
- 2.2. These guidelines include additional equipment and techniques that are required for Ultra-Low Sag (ULS) ACCC conductor sizes.

3. DEFINITIONS

- 3.1. ACCC is a registered trademark of CTC Global, and is defined as Aluminum Conductor Composite Core, stranded with Aluminum 1350-0 (where 0 stands for fully annealed) or Aluminum 1350-0 Z-wire trapezoidal wire.
- 3.2. Initial Sag occurs when new conductor is pulled and terminated.
- 3.3. Initial Sag Tension is the target tension from the design sag charts.
- 3.4. Final Sag occurs when the conductor has been energized.
- 3.5. Ruling Span is the calculated span length that will have the same changes in conductor tension due to changes of temperature and conductor loading as will be found in a series of spans of varying lengths between deadends.

4. ASSOCIATED DOCUMENTS

- 4.1. IEEE Standard 524™ Guide to the Installation of Overhead Transmission Line Conductors.
- 4.2. OSHA Electric Power Generation, Transmission, and Distribution Standards 1910.269 and 1926.950 or ISO 29.240.20 or local country equivalents.
- 4.3. IEEE Standard 516™ Guide for Maintenance Methods on Energized Power Lines
- 4.4. The remaining Chapters of the Installation Guidelines

5. SAGGING

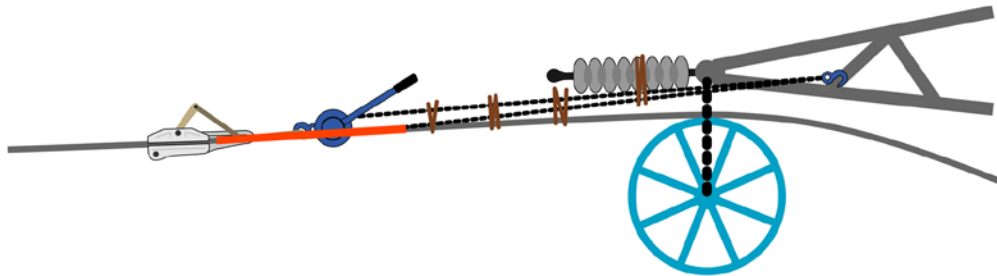
- 5.1. This guideline assumes that the user is familiar with industry standard sagging techniques.
- 5.2. There is nothing unique about sagging procedures for ACCC versus any other bare conductor, however the annealed aluminum causes ACCC to be more sensitive to over-tension and creep time with respect to sag. Follow the recommendations below to achieve expected sag performance.
- 5.3. Any of the four common methods of sagging may be used: line of sight, transit, stopwatch,

or dynamometer.

- 5.4. Conductors should NOT be allowed to remain in the stringing blocks more than 72 hours. If this time is exceeded, damage may occur to the conductors and/or sheaves.
- 5.5. Sagging Procedure:
 - 5.5.1. Assemble and connect the soft-side deadend.
 - 5.5.2. Apply tension, at least 90% of initial sag tension, but DO NOT EXCEED initial sag tension.
 - 5.5.3. Allow the conductor to remain at this tension for at least 10 hours or overnight. If sagging must be done same day, subtract 5° C (9° F) from the ambient temperature in the sagging calculations.
 - 5.5.4. Apply sag chart tension and mark the conductor for deadending
 - 5.5.5. Assemble hard-side deadend and connect to insulator linkage. It is recommended that hard siding be done in the air and not lowered to the ground.

6. INSTALL GRIPS

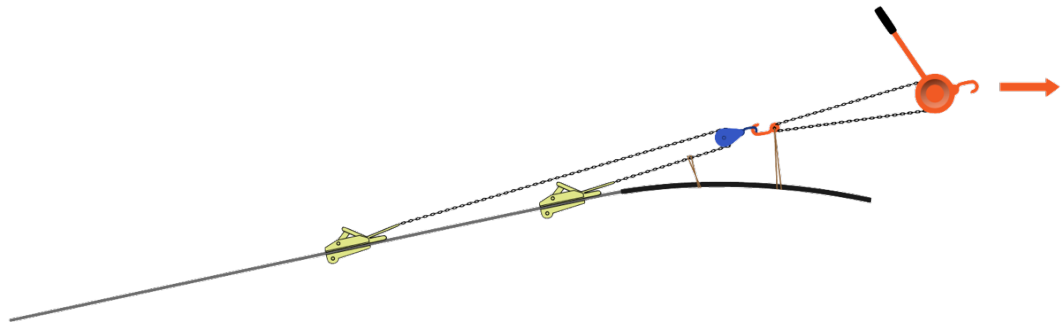
- 6.1. Never use wire mesh or “sock” grips for sagging.
- 6.2. The free end of the conductor MUST be supported during installation of grip and deadend hardware. This may be done with small ropes.



- 6.3. Grips are heavy and awkward, especially for larger size conductors. The free end of the conductor MUST be controlled to prevent over-bending and possible damage of the core. Good working platforms (hook ladders, bucket trucks, baker boards) should be provided for personnel for these operations.
- 6.4. The grip should be attached 4-5 meters from the end of the insulator to provide working room to install the deadend hardware. Install a split rubber hose over the conductor to protect the aluminum from the rigging. Use small ropes to fasten the free end of the conductor to the rigging.
- 6.5. Set the grip. It is always good practice to “set” a grip after placement on the conductor and after taking a small amount of tension on the grip, by sharply striking it’s lever arm with a hammer once or twice.

6.6. Double Grips

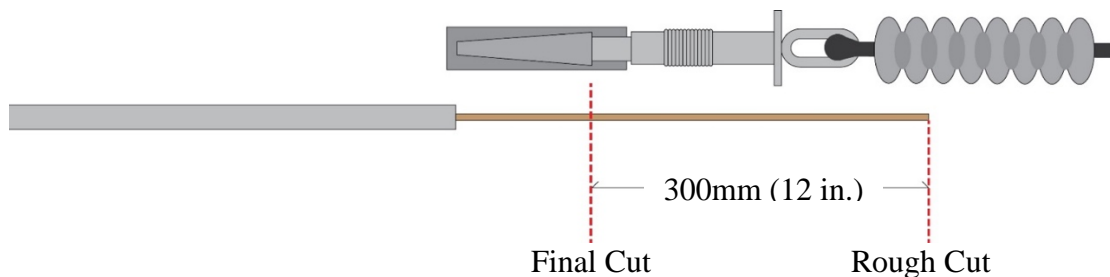
- 6.6.1. For higher higher tension loads; long pulls or crossings (if the load is expected to exceed the lesser of 42 kN (4300 kg; 9,500 lbs.) or 30% of RTS) or special conditions such as residual stranding oil or other contamination, or for additional safety redundancy it may be necessary to double grip the conductor.
- 6.6.2. In these cases, use a short sling (approximately 6 feet or 2 meters) to equalize the pull tension between the two grips.
- 6.6.3. Always use a pulley or snatch block to connect the hoist to the sling to assure that the grips share the load equally. Protect the exposed portions of the conductor between the grips and next to the snatch block with split rubber hose.
- 6.6.4. The grips **MUST NOT** touch when under full load, and they **MUST NOT** be too far apart or a bird-cage will be created between them.
- 6.6.5. Take some tension, tap the grip lever arms, mark the conductor at the grips, take more tension, and verify that there is no slippage in relation to your marks before taking full tension.



7. CUTTING THE CONDUCTOR

- 7.1. Rough cuts of the conductor may be made by any conventional tools or methods such as ratchet cutters or cable cutters. Note that any method other than hacksaw **WILL** damage the ACCC core locally to the cut. When a rough cut of the conductor is made, ensure that the tail tension is relaxed so that a bird cage doesn't occur as the aluminum will contract toward the grip which is still under tension.
- 7.2. The final cut of ACCC core must be done with a fine-tooth (32 tooth-per-inch TPI) hacksaw only. Any other cutting method is unacceptable.
- 7.3. Cutting of the aluminum strands of ACCC may be accomplished by either a fine tooth hacksaw or approved conductor stripper with the correct bushing. However, the method used must **NEVER** nick or scratch the core. To avoid core surface damage, the final separation of the aluminum strands on the bottom layer must be by gentle, repetitive bending fatigue only.

- 7.4. To ensure proper sagging dimensions, measure all of the linkage attached to the structure including insulators and any linkage required to attach the dead end eye for the ACCC conductor plus the dead end eye. Mark the conductor with this measurement. After marking the conductor at the appropriate location, cut the conductor towards the structure adding at least 12 inches (305 mm) of extra conductor in addition to the amount marked on the conductor. The initial cut can be made with cable cutters or ratchet cutters. Make the final cut according to the directions in the deadending kit.

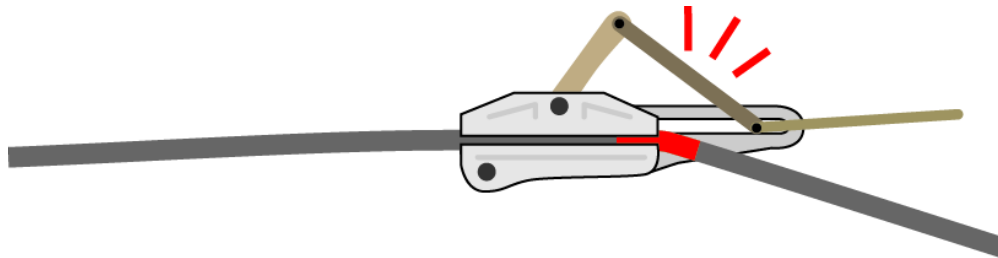


8. TERMINATIONS

8.1. Dead-Ends

Installing ACCC deadends is very similar to installing deadends for any common bare overhead conductor with two exceptions:

- 8.1.1. Conductor, Grip, and Deadend Handling. The weight of the deadend and/or conductor is sufficient to damage the ACCC core at the point where it exits the grip. The deadend must be supported in line with the conductor during installation and subsequent handling.



Similarly, it is possible to damage the ACCC core at the point where it enters or exits the deadend if too much bending force or weight is allowed there.

- 8.1.2. Back Pressing. ACCC terminations are pressed from the conductor end toward the eye end. The usual method of pressing from the eye toward the conductor can displace the trapezoidal aluminum strands of ACCC and cause a bird-cage.
- 8.1.3. Step-by-step instructions for correct installation of ACCC deadends are covered in ACCC® Installation TrainingSM, are available for free download on the CTC Global website, and are packaged with each dead-end hardware kit.

8.2. Mid-Span Splices

- 8.2.1. Installing an ACCC mid-span splice is very similar to installing a mid-span splice

for any common bare overhead conductor with two exceptions: a) Conductor, Grip, and Splice Handling – same issues as with deadends above, and b) Pressing Direction. Splices must be pressed from the short side of the conductor span toward the long side of the conductor span.

- 8.2.2. Step by step instructions for correct installation of ACCC splices are covered in ACCC® Installation TrainingSM, are available for free download on the CTC Global website, and are packaged with each splice hardware kit.

8.3. Bowing of Fittings

- 8.3.1. During compressions, care must be taken to keep both ends of the termination (deadend or splice) in line with the center line of the press dies. The aluminum becomes quite pliable as it nears maximum compression and as little as one (1) kilogram (2.2 pounds) of force on the free end can cause a slight bend at the compression. Several bends in a row result in a bowing or “banana” shape of the ideally straight assembly. Rotate the assembly 180° in the dies every two compressions to help keep the assembly straight as compressions proceed.
- 8.3.2. Slight bowing may be corrected during subsequent original compressions. During the compression cycle, and ONLY during this period, it is possible to exert light pressure to correct bowing from prior compressions. Again, one to two (1 - 2) kilograms is sufficient, for 2 to 5 compressions. Check often with a straight edge if needed. Do not stand or sit on the end - too much pressure can cause hairline fractures inside the compressed areas.
- 8.3.3. An alternative method to prevent bowing may be used with collet and housing style deadends: Assemble the collet, housing, and eyebolt per the instructions, and then connect the eyebolt to the insulator bells. Measure the distance between the housing and the aluminum strands (should be 50mm or two (2) inches). Then slowly release tension on the grip. The measurement may grow; up to total of 100mm or four (4) inches is permissible. If the grip is fully released at this point, it may be removed, but the deadend compressions must be completed within an hour of releasing the grip tension. If the 100mm limit is reached, then leave the remaining tension on the grip until the deadend is completed. Finally, slide the outer and inner housings into place and compress per the instructions.
- 8.3.4. Maximum allowable bowing is one-half (1/2) conductor diameter for deadends and one (1) conductor diameter for splices. Measure by placing a straight edge from end to end of the fitting and measure at the point of maximum bow.
- 8.3.5. Never attempt to straighten a bowed fitting after it has been compressed. This can cause micro cracks in the work-hardened aluminum which can lead to eventual mechanical failure of the fitting.

8.4. Terminal Pads

- 8.4.1. Installing ACCC terminal pads is identical to installing terminal pads for any common bare overhead conductor with one exception: ACCC terminal pads are back-pressed for the same reason as deadends.

8.5. T-Taps

- 8.5.1. Installing ACCC T-Taps is identical to installing T-Taps for any common bare overhead conductor with one exception: ACCC T-Taps must be pressed AWAY from the deadend, for the same reason that deadends are back-pressed.
- 8.5.2. Avoid placing T-Taps closer than 1 meter from a deadend.

8.6. Compression Dies

- 8.6.1. A chart showing correct part numbers for compression dies for all ACCC hardware is CTC Global document number F-750-069. The latest revision is available for free download on the CTC Global website.

9. CLIPPING IN – SUSPENSIONS and ANCILLARY HARDWARE

- 9.1. After sagging, ACCC should be transferred from stringing sheaves to permanent suspensions with 72 hours to avoid flattening of the conductor and risk of damage from wind.
- 9.2. ACCC is a high temperature, low sag (HTLS) conductor. It operates at much higher temperatures than conventional conductors, up to 180° C (350° F). Appropriate high temperature suspension hardware and ancillary hardware is REQUIRED.
- 9.3. Armor rods or protector rods are always required for all suspension and ancillary hardware and must be capable and rated for the higher operating temperatures for which ACCC is rated.
- 9.4. Tandem suspensions and yoke plates must be used where change of direction angles exceed 30 degrees.

9.5. Mountainous Terrain

This section taken from IEEE-524 2004:

- 9.5.1. In a series of suspension spans located in hilly terrain, wire in the sheaves will tend to run downhill. Gravity acting on the wire in the sheaves will cause excessive sag in the lower spans of the section and too little sag in the upper spans. The unbalanced horizontal tensions will result in the insulators being pulled off from plumb in an uphill direction. To equalize the horizontal tensions, it is necessary to redistribute the wire between the spans. This process of pulling the wire uphill is known as “clipping offsets.” The theory of clipping offsets is based upon the fact that, between snub structures, the total length of conductor at sag in the travelers is equal to the total length of conductor at sag in the suspension clamps. The distance that the clamp should be offset from the plumb position is calculated in order to pull slack from the lower spans and move it to the overly tight uphill spans.

- 9.5.2. There are several conditions that should be understood regarding the application of clipping offsets.
- Offsets must be calculated for the exact section being sagged. Insertion of a temporary snubbing position will change the offsets; therefore, offsets cannot be calculated until the sagging operation is determined.
 - All offsets must be marked prior to any clipping-in of the wire.
 - Offsets can be minimized by the judicious use of snubbing positions to separate line sections at different elevations.
- 9.5.3. Sags and clipping offsets are interrelated because sag corrections required for computing sags are dependent upon clipping offset computations. The application of sags and clipping offsets computed in this manner will produce balanced horizontal forces that will be the same for each structure within the sag section.

See IEEE-524 2004, Annex E for calculations and further detailed information.

Consider CTC's ACCC® Stringing Plan Review ServiceSM for technical installation assistance. Contact us at fieldservices@ctcglobal.com.

10.SAGGING BUNDLED CONDUCTORS

- See Chapter 7, Section 20 for guidelines for stringing bundled conductor configurations.
- ACCC is more sensitive to variance in sagging than conventional conductor types. Sagging bundled conductors is therefore critical to achieve expected bundle sag performance.
- Never apply tension above the initial (sag chart) tension. Over-tension or over-sag will cause the conductors' sag behavior to differ which will result in uneven bundle sagging.
- Ancillary hardware must be rated for the high temperature capability of ACCC.
- Sagging Procedure – this is essentially the same procedure used for single conductors as in Section 5 above. The critical differences are in bold.
 - Assemble and connect the soft-side deadends.
 - Apply tension, at least 90% of initial sag tension, but **DO NOT EXCEED** initial sag tension. All conductors in a phase bundle must be brought up to this tension within a few minutes of one another.
 - Allow the conductor to remain at this tension for at least 10 hours or overnight. If sagging must be done same day, subtract 5° C (9° F) from the ambient temperature in the sagging calculations.
 - Apply sag chart tension and mark the conductor for deadending. All conductors in a phase bundle must be brought to the target tension and marked as closely as possible at the same time...all within maximum 15 minutes of each other.

- 10.5.5. Turnbuckles or sagging links are recommended.
- 10.5.6. When stringing multiple conductors around line angles **in excess of 5°**, **bundle conductor travelers are required** until the running board passes through the traveler, **but should be replaced prior to sagging with single-type travelers** to provide proper wire length in the clipped-in position. It is desirable during sagging for the horizontal spacing of the sheaves to match the final sub conductor spacing to aid in preventing sub-conductor sag mismatch.
Some bundle conductor travelers may be converted to single conductor type travelers.
When multiple conductors are strung in bundled conductor type travelers, reduced horizontal spacing between grooves can result in conductor oscillation, even in a very light crosswind, too severe to permit satisfactory sagging. (For example, groove spacing of 5.4 conductor diameters permitted sagging of conductors in a crosswind condition that repeatedly prevented sagging with a groove spacing of 2.7 conductor diameters because of very active conductor oscillation.)
- 10.5.7. Suspension (clipping) of bundled conductors must be done together for all the conductors in the bundle.

11.TEN INSTALLATION DON'TS**11.1.DON'T OVER-BEND!**

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

11.2.TWO Tensioner DON'TS

- 11.2.1. Don't use a conventional tensioner fairlead for ACCC conductor. A multiple-roller fairlead with large effective radius **MUST** be used.
- 11.2.2. Don't let ACCC run hard on the end roller of the fairlead. Use an interim sheave to raise the conductor if needed.

11.3.TWO Payout Reel DON'TS

- 11.3.1. Don't allow the conductor to bounce or jump up and down between the payout reel and the tensioner. When the conductor is jumping or bouncing, the core can be damaged.
- 11.3.2. Don't use a payout reel with insufficient brakes. Poorly maintained or undersized brakes will cause jumping and bouncing of the conductor between the payout reel and the tensioner. The payout reel brakes should allow the tensioner to draw new conductor from the reel smoothly and evenly.

11.4.THREE Handling and Equipment DON'TS

- 11.4.1. Don't use grips that aren't designed for installing ACCC. Use Klein "Chicago" long jaw grips or equal, designed for the size conductor being installed. Never use pocketbook grips!
- 11.4.2. Don't allow the conductor tail or the deadend 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.
- 11.4.3. Don't hoist the conductor in any manner which causes a sharp bend in the conductor.

11.5.TWO Pulling / Stringing DON'TS

- 11.5.1. Don't install any ACCC with under-diameter sheaves on the first and last structure or any angles that are over 30 degrees.
- 11.5.2. Don't pull in conductor using old conductor if it is rusty. Don't use old conductor with splices or broken strands for pulling. Instead, pull in a pilot line using the old conductor and pull in ACCC using the pilot line. Always use a pilot line for long spans and river crossing.

REVISION HISTORY

REV.	CHANGE REQUEST #	DATE
A	121515-1	
B	Added paragraph 10.2 Added Section 10.5, "Sagging Bundles"	3/1/2016
C	Revised paragraph 5.2 Expanded Section 5.5, "Sagging Procedure" Revised section 6.6, added pulley block and graphic Inserted Section 8.4 "Bowing of Fittings" Inserted Section 9.5 "Mountainous Terrain" Expanded Section 10 "Sagging Bundled Conductors"	April, 2017