



Aluminum Conductor Composite Reinforced Installation Guidelines and Maintenance



Installation Guidelines and Maintenance for ACCR

Aluminum Conductor Composite Reinforced

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1. Introduction

This document is intended to highlight the installation aspects and maintenance of the 3M composite conductor. Installation equipment, procedures and hardware that have been qualified for use are described. It is meant as a supplement to the IEEE-524. The contents are based upon the various installations that have occurred to date.

Installation Equipment	ACSR	ACCR
Stringing Blocks for Suspension Towers	Yes	Consult 3M Co. (Typically 28" [71cm] Min Ø)
Stringing Blocks for Break-over Towers	Yes	3M Roller Array Stringing Block Required
Bull Wheel	Yes	Consult 3M Co. (Typically 60" [1.5m] Min Ø)
Drum Puller	Yes	Yes
Sock Splice	Yes	Yes
Conductor Grips	Any	TG-Grips
Cable Spools	Yes	Yes (40" (101cm) Drum)
Cable Cutter	Yes	Yes
Reel Stands	Yes	Yes
Grounding Clamps	Yes	Yes
Running Ground	Yes	Yes

The hardware used during the installation of the 3M Aluminum Composite Conductor Reinforced, or "ACCR" is like that of any typical ACSR installation. The table above shows the comparison of hardware that can be used when installing ACCR.

2. Conductor Information

Material Properties

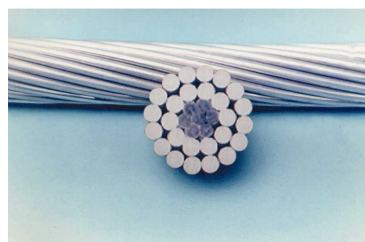
The 3M Composite Conductor is a non-homogeneous conductor consisting of high-temperature aluminum-zirconium strands covering a stranded core of fiber-reinforced composite wires. Both the composite core and the outer aluminum-zirconium (Al-Zr) strands contribute to the overall conductor strength.

Composite Core

The composite core contains 3M metal matrix composite wires with diameters ranging from 0.074" (1.87 mm) to 0.116" (2.94 mm). The core wires have the strength and stiffness of steel, but with much lower weight and higher conductivity. Each core wire contains many thousand, ultra-high-strength, micrometer-sized fibers. The fibers are continuous, oriented in the direction of the wire, and fully embedded within high-purity aluminum. Visually, the composite wires appear as traditional aluminum wires, but exhibit mechanical and physical properties far superior to those of aluminum and steel. For example, the composite wire provides nearly 8 times the strength of aluminum and 3 times the stiffness. It weighs less than half of an equivalent segment of steel, with greater conductivity and less than half the thermal expansion of steel, as shown in Table 2.

Outer Strands

The outer strands are composed of a temperature-resistant aluminum-zirconium alloy which permits operation at high temperatures (210°C continuous, 240°C emergency). The Al-Zr alloy is a hard aluminum alloy with properties and hardness similar to those of standard 1350-H19 aluminum but a microstructure designed to maintain strength after operating at high temperatures; that is, it resists annealing. In contrast, 1350-H19 wire rapidly anneals and loses strength with excursions above 120–150°C. The temperature-resistant Al-Zr alloy



The outer strands maintain strength after operating at high temperatures.

wire has equivalent tensile strengths and stress-strain behavior to standard 1350-H19 aluminum wire, as shown in Table 3.

Table 2: Properties of Composite Core

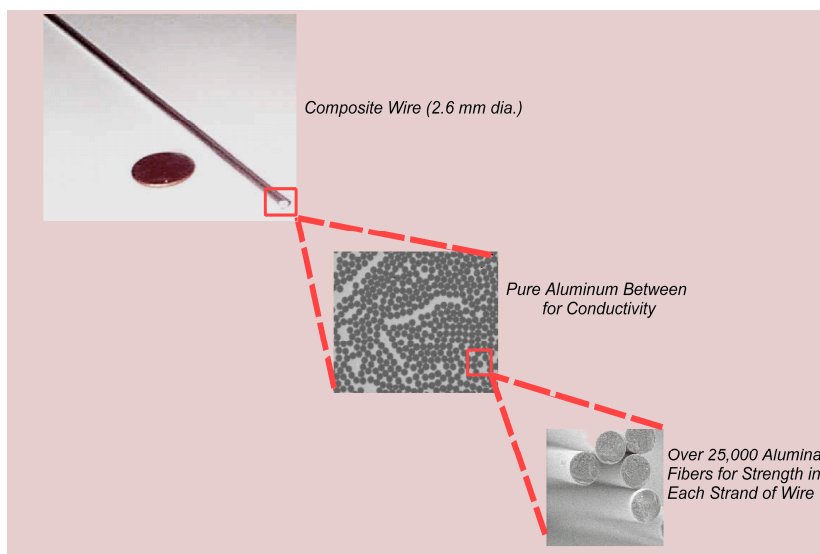
Property	Value
Tensile Strength	200 ksi (1380 MPa)
Density	0.12 lbs/in ³ (3.33 g/cc)
Stiffness	31 Msi (215 GPa)
Conductivity	27% IACS
Thermal Expansion	3.3 x 10 ⁻⁶ / °F (6 x 10 ⁻⁶ / °C)
Fatigue Resistance (Endurance)	> 10 million cycles at 100 ksi (690 MPa)
Emergency Use Temperature	> 570°F (300°C)

Table 3: Properties of Aluminum – Zirconium Wire

Property	Value
Tensile Strength (<0.153" diameter) #	>23.5 ksi (162 MPa)
Tensile Strength (>0.153" diameter) #	>23.0 ksi (159 MPa)
% Tensile Elongation ¹	> 2%
Tensile Strength Retention after 280°C/1hr #	> 90%
Density	0.097 lbs/in ³ (2.7 g/cm ³)
Conductivity / Resistivity at 20°C	>60% IACS <28.73 x 10 ⁻⁹ Ohm.m
Continuous use temperature	210°C
Emergency use temperature	240°C

10 in. (250 mm) gauge length

Source: *Properties of Heat-Resistant Aluminum-Alloy Conductors For Overhead Power-Transmission Lines*, K. Kawakami, M. Okuno, K. Ogawa, M. Miyauchi, and K. Yoshida, Furukawa Rev. (1991), (9), 81-85.



The composite wire provides high strength and conductivity at low weight.

3. Installation Equipment

Drum pullers like the one shown have been used successfully in the stringing procedures of ACCR conductors. In conjunction with a back tensioning device such as a bullwheel tensioner this device can be used with any installation of ACCR conductors.

Drum Puller



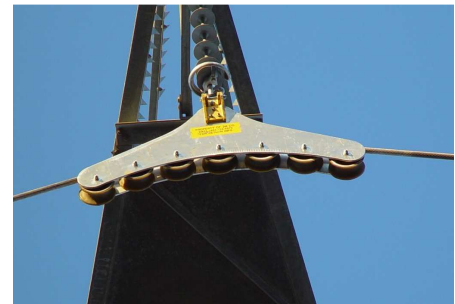
Bullwheel Tensioner

Bull wheel tensioners have been used during the installation of ACCR conductors. It is very important to use a larger sized bull wheel diameter when stringing this type of conductor. Consult 3M Co. on the recommended size Bullwheel to use pertaining to the particular installation needs. The picture below shows a 54-inch (1.37m) diameter combination tensioner with a reel stand. This bullwheel was used during the

54" Bullwheel Tensioner



installation of a 795 Kcmil ACCR. The use of a "V-Groove" type tensioner should be avoided and not be used to install any size ACCR in any case.



Roller Array Block

Stringing Blocks

A combination of high stringing tension with a small bend radius can damage the inner core wires of the ACCR conductor. Therefore the need for larger diameter stringing blocks is essential when installing ACCR. A roller array block is required at all break-over towers and high running angles. 28" (71cm) min stringing blocks are required at all suspension towers. Consult 3M Co. on the recommendations of stringing blocks pertaining to the particular installation needs.



28" (71cm) Stringing Block

Sock Splices

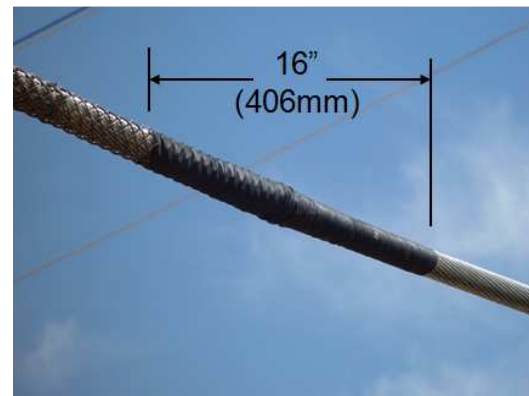
A sock splice, also known as a basket grip, wire mesh or Kellem grip can be used to string ACCR conductor. It is required that a swivel connection be utilized with the sock splice to reduce any twisting of the conductor during the tension stringing operation. The conductor should not be used that is under the sock splice and should be cut out. No bands should be used on the end to hold the sock splice. Pulling socks splices through stringing blocks with bands can cause damage to the composite core wires. Friction tape (3M #1755, typical) is to be applied over the end of the sock splice and the conductor a distance of 16 inches (406mm).



Sock Splices with Swivel

Chain Hoists

Any type of chain hoist may be used to tension hold the ACCR conductor. To grip the ACCR conductor when using a chain hoist, a special conductor grip must be used. This grip is detailed on page 8.

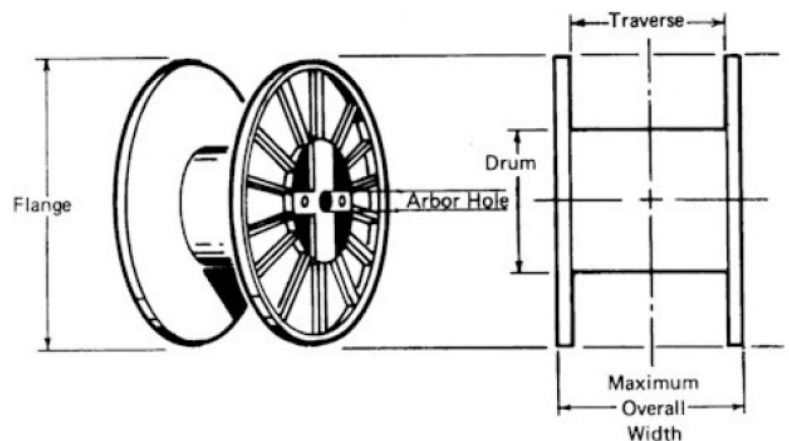


Friction Tape Applied to Sock Splice

or

Reel Stands/NEMA Reels

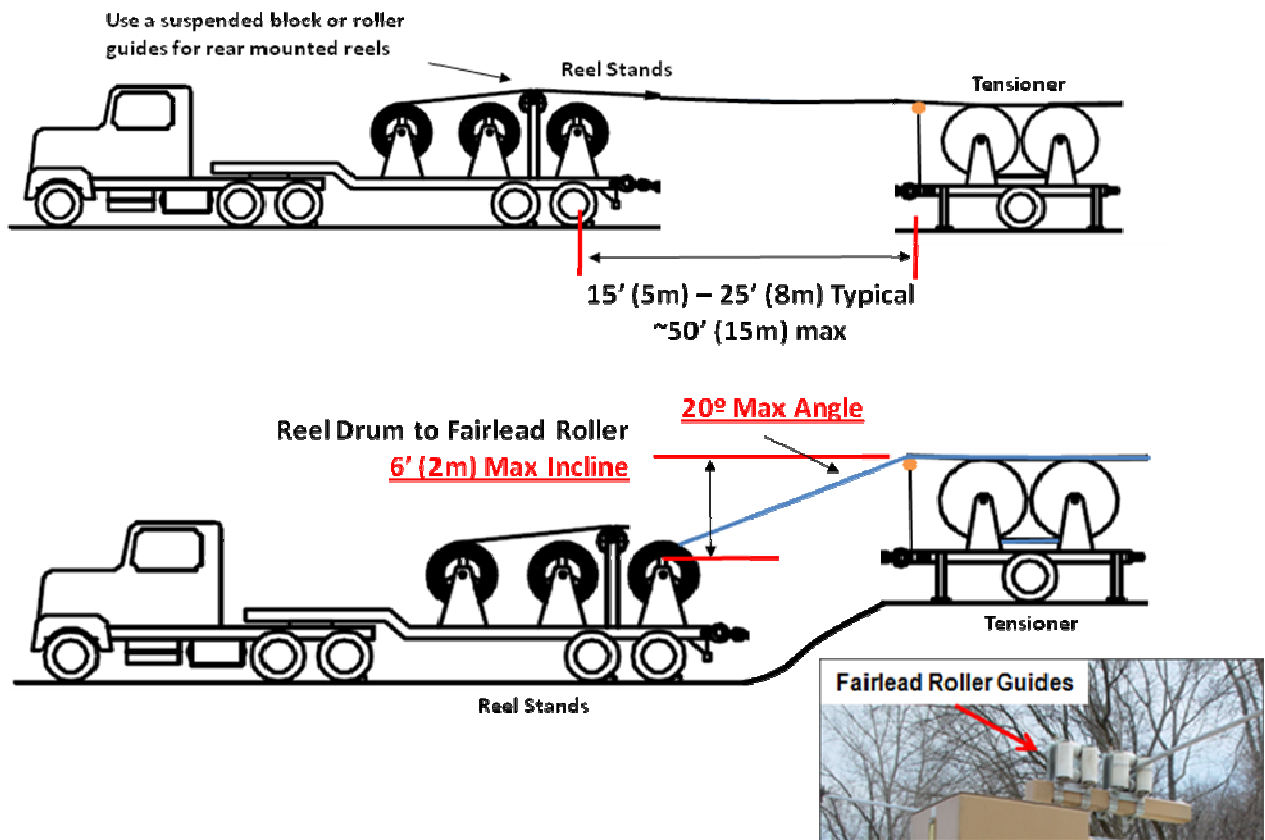
Standard reel stands may be used to hold the reel of ACCR conductor during the stringing operation. Reel stands combined with bullwheel tensioners are used to ensure proper back tensions on the ACCR conductor during the stringing operation. It is required that a bullwheel tensioner along with a reel stand be utilized to maintain proper stringing tensions. ACCR is delivered primarily on NEMA standard steel returnable reels:



NEMA Reel Design	Flange	Traverse	Arbor Hole (Hub) ID	Empty Reel Weight
RMT 84.36	84" [213.3cm]	36" [91.4cm]	5.25" [13.3cm]	895 Lbs [406 Kg]
RMT 84.45	84" [213.3cm]	45" [114.3cm]	5.25" [13.3cm]	930 Lbs [422 Kg]
RMT 90.45	90" [228.6cm]	45" [114.3cm]	5.25" [13.3cm]	1030 Lbs [467 Kg]
RMT 96.60	96" [243.8cm]	60" [152.4cm]	5.25" [13.3cm]	1268 Lbs [575 Kg]

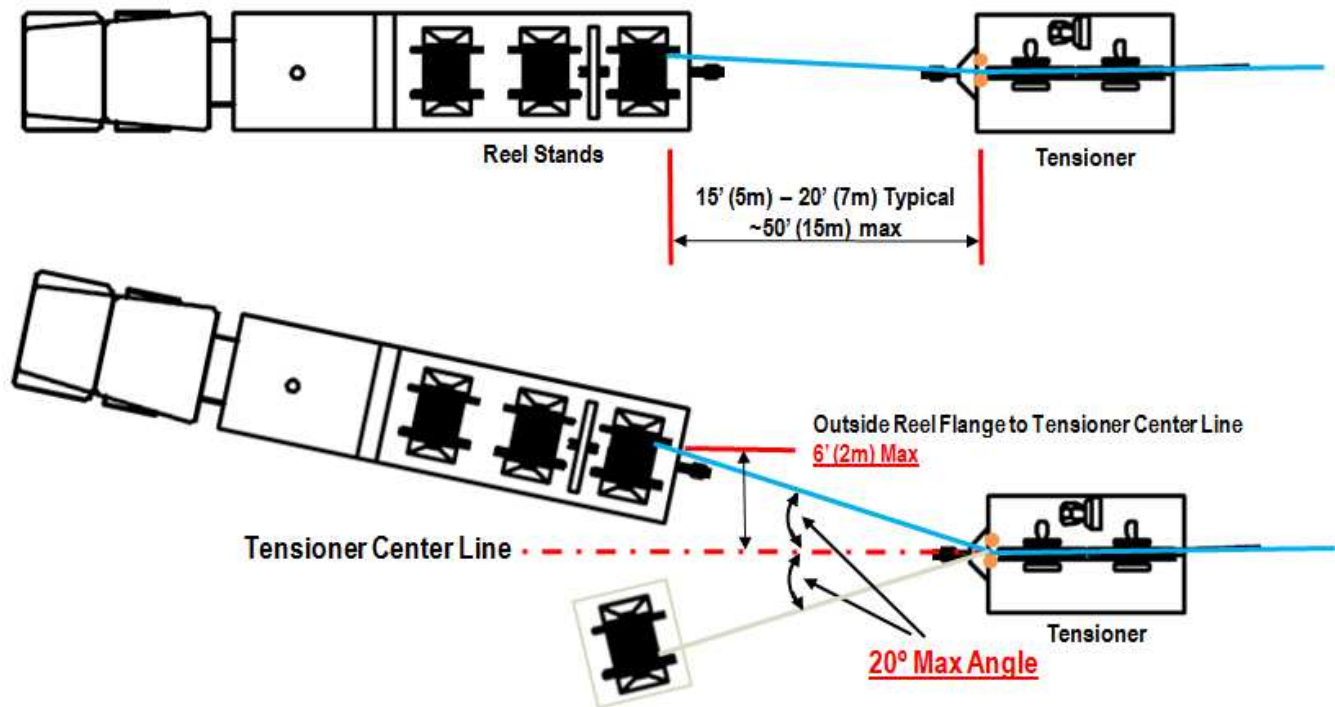
Reel Stand Set-Up with Tensioner

As described in the diagram below, the orientation of the reel stands in relation to the tensioner should be that the ACCR does not exceed a 20 deg incline angle over the fairlead roller guides mounted on the tensioner. The set-back distance from the tensioner to the reel stands is typically 15' (5m) – 25' (8m) and should never exceed 50' (15m). Proper tension control on both the tensioner and the reel stand is important as to not cause any sudden jerking or bouncing of the ACCR as it is payed off the reel.



A 28" (700mm) min stringing block should be used between the reel stand and the tensioner if the incline angle over the fairlead roller is greater than 20 deg. An example of this procedure is shown in the picture here. The stringing block suspended by a crane reduces the angle over the fairlead roller mounted on the tensioner.

The reel stands should also be orientated so that they are in-line as best as possible with the tensioner centerline. In the case of a bundled conductor pull, the reel stands should be orientated so the off-set angle through the fairlead roller does not exceed 20 deg. This is also the case if multiple reel stands are used during single conductor installations in order to change our conductor reels quickly.



Conductor Grips

Important Note: Chicago grips shall NOT be used in any way to hold, grip or tension ACCR conductors. Tests done with the Chicago grip has shown that due to the offset gripping action, it induces a sharp bend to the conductor and causes damage and destruction to the composite wires at even low tensions.

A Tensioning Grip (TG Grip) or temporary THERMOLIGN™ dead end assemblies are the only 3M approved conductor grips to be used on the ACCR. PREFORMED Tensioning Grips may be applied up to 3 times for the tensioning of the conductor during a new pulling or sagging operation. The reapplication is acceptable for the purpose of re-positioning or adjusting the sag during that individual operation. PREFORMED Tensioning grips are not to be re-used after the final application of the individual operation. A tensioning grip is shown below.



Tensioning Grip

Another type of conductor grip that can be used on the ACCR conductor is a temporary THERMOLIGN™ Dead End. This two-piece assembly can be used 3 times as a conductor grip or 1 time as a conductor grip and then be used as a permanent dead end assembly. A preformed dead end used as a conductor grip is shown below as well.



THERMOLIGN™ Dead End

Both of these conductor grips have been used successfully to grip the ACCR conductor during the sagging procedures before the permanent dead end is installed.

The pictures above show that each of the conductor grips is not fully installed. The “tails” of each assembly are not snapped down and locked on to the conductor. This allows the grip to be un-installed and removed more easily. The maximum allowed “tail” to not be snapped down for removal of the grip is 4” (10.16 cm). These types of grips should be used at any time the ACCR needs to be gripped, this includes if insulators need to be changed or serviced to release tension in the line.

The use of a thimble clevis with the TG-Grip is required at all times:

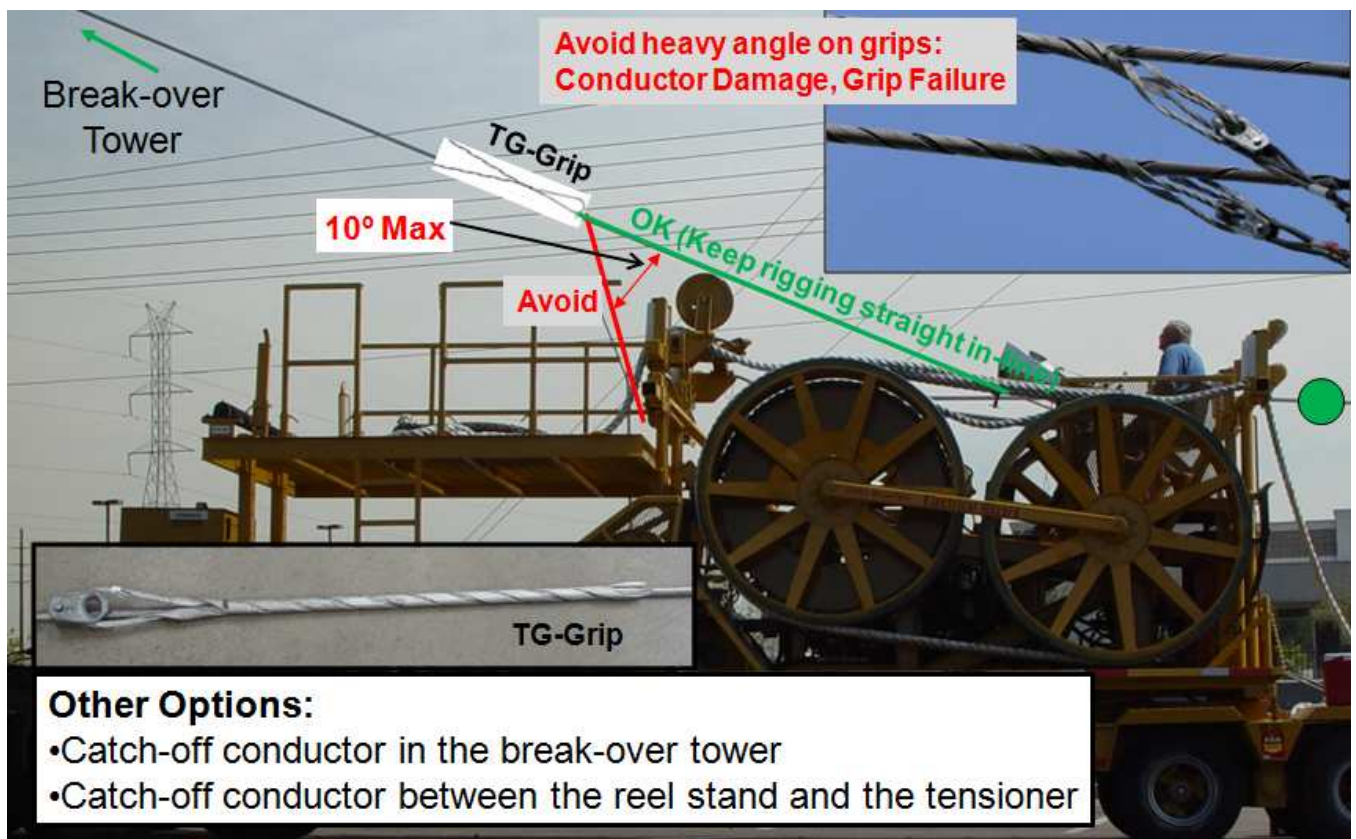


Thimble Clevis installed on TG-Grip

The picture below shows a TG-Grip installed on the ACCR with a chain hoist:



Caution When Using TG-Grips: Avoid placing heavy angles on the TG-Grip assembly when gripping the ACCR. Heavy angles can possibly cause conductor damage or TG-Grip failure (commonly known as “peel-out”). During gripping the ACCR, make sure to keep the rigging as much in-line as possible to avoid heavy angles on the TG-Grip. The maximum angle placed on the TG-Grip should not exceed 10°.



Cable Cutters

Any type of cable cutter that is meant to cut ACSR or AAAC may be used to cut the ACCR conductor. Tape the outer conductor strands down before cutting the cable to prevent the aluminum strands from un-stranding or bird caging.

Conductor Grounding Clamps

Grounding clamps that are typically used on other conductors are compatible with use on the ACCR conductor. Grounding clamps should be sized appropriately to fit the size conductor being installed. This picture shows a typical grounding clamp used on a 795 Kcmil ACCR.



Conductor Grounding Clamp

Running Grounds

The use of running grounds or traveling grounds can be used when installing ACCR conductors. The proper sized running ground should be used when installing the ACCR conductor. The picture below shows a running ground that was used during an ACCR installation.



Running Ground

4. Installation Procedures and Hardware

Tension Stringing

The required stringing procedure used to install ACCR conductor is the tension stringing method. This method involves pulling or stringing the ACCR conductor under tension and not allowing the conductor to drag on the ground.

The “slack” stringing procedure involves that the conductor would be pulled out on the ground by means of a pulling truck or placed out on the ground by dispensing the cable from a moving vehicle holding the reel stand. This method is not recommended by 3M as it may cause unknown damage to the ACCR.

It is required that the contractor or utility installing the ACCR chooses the correct equipment to maintain sufficient back tension and pulling tension when installing the ACCR conductor. The ACCR shall not be allowed to drag onto the ground, trees, buildings, guard structures, etc during the stringing procedure. On the other hand too much back tension combined with small bend radiuses such as small diameter stringing blocks can cause damage to the inner composite core wires. Consult 3M Co. on the recommendations of stringing blocks pertaining to the particular installation needs. Tensioning equipment shall be located at 3X the height of the break-over block on the first tower with minimum running angle as well. Every attempt should be made to obtain this set-up distance to reduce the pulling angle over the break-over point.

Experience has shown that pulling speed is an important factor in achieving a smooth stringing operation. ACCR should be pulled within speeds of 3-5 mph (5-8 km/h). This speed usually provides a smooth passage of connecting hardware over the stringing blocks; whereas slower speeds may cause significant swinging of the stringing blocks and insulator hardware assemblies. Higher pulling speeds create a potential hazard of greater damage in case of a malfunction.

Sagging Procedures

Methods of sagging that have been used on the ACCR include line-of-sight measurements and rope or wave reflection sagging. Sagging procedures of ACCR conductor are very similar to that of any other conductor. Whether or not a compression type or THERMOLIGN™ dead end is to be used on the conductor, the conductor grip must be placed on the conductor at least 15 to 20 feet (5m to 6m) from the connection point to the insulator string. After the final sag tension is set, the dead ends can be installed onto the ACCR. With the initial placement of the conductor grip at 15 to 20 feet (5m to 6m), this should allow enough slack in the conductor to maneuver it and apply the dead end assembly. This will be detailed in the next few sections.

The time limit allowed from when the ACCR is pulled or strung into position and hanging in stringing blocks to when the cable is tensioned to the specified sag is **72 hours**.

Dead ending Procedures

Compression Dead Ends

Compression type dead ends manufactured by AFL have successfully been utilized in the installations of ACCR conductor. These types of compression dead ends are specifically designed by AFL to grip not only the outside aluminum strands but also to grip the core wires separately of the ACCR. Therefore the installation steps of the dead end consist of a two-step compression procedure.

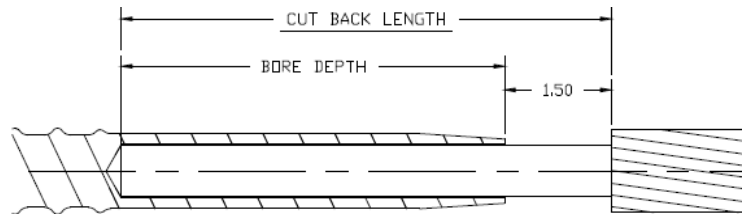


AFL Brand Compression Dead End

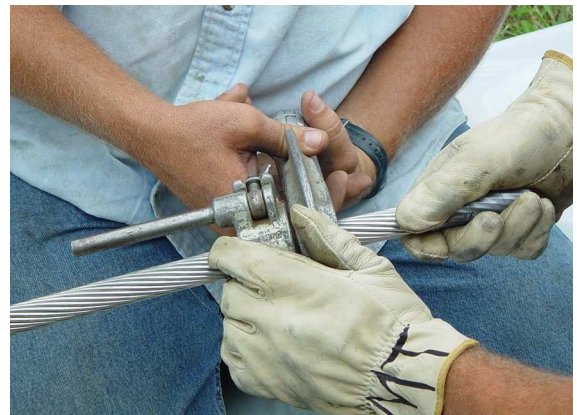
After the final sag tension of the conductor is established, a measurement is made to determine where the dead ends will be connected to the insulator string. The cable is then cut at this point. The first step to install the AFL dead end is to slide, or “park” the large outer aluminum body of the dead end over the conductor making sure that the jumper pad on the body is facing the end of the cable that was just cut. Park the large aluminum body on the conductor about 3 feet (1m) down from the end of the cable.

By using a cable strand-trimming device, also known as a cable circumciser, the outer layers of aluminum are removed. It is very important to not nick the composite wires while trimming the aluminum layers. Prior to cutting back the aluminum strands, the depth of the bore must be

determined in the steel forging. Insert a clean object or length of core until it bottoms out in the forging. Measure the bore depth and add 1.50 inches (40mm). This will be the length to cut back the aluminum strands:

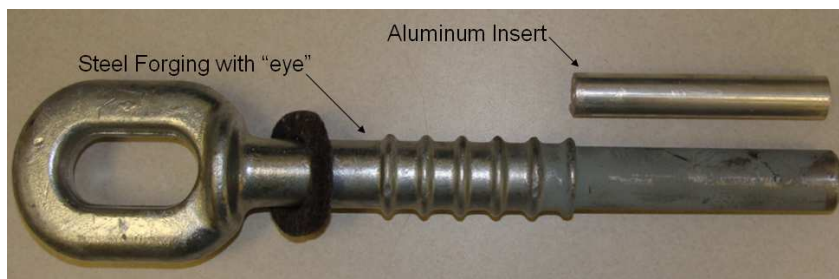


There is an aluminum tape that is wrapped over the composite wires on the ACCR. Normally this tape is not removed from the core wires when pressing a dead end forging except for a few ACCR conductor sizes. This is explained in more detail on the requirement to remove the core tape on page 14 (slotted inserts).



Trimming the Aluminum layers

Located inside of the end fitting (steel forging) is an aluminum tube insert. The main purpose of this aluminum insert is to obtain a strong bond between the ACCR core wires and the steel sleeve that is connected to the “eye” of the forging. This “eye”, in turn is then connected to the insulator string on the dead end tower or at a substation connection.





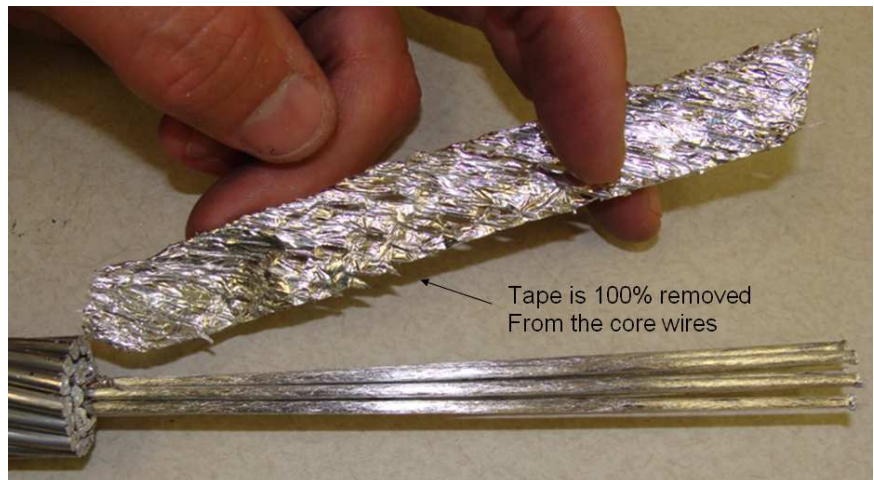
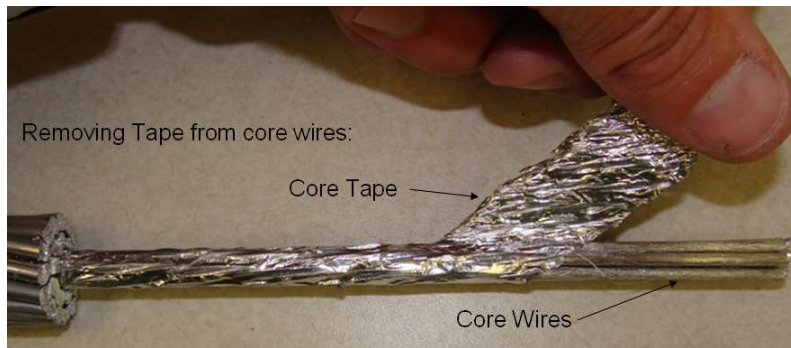
Details on Slotted Aluminum Inserts

On some ACCR conductor sizes, the aluminum insert for the AFL dead end will have slots or grooves manufactured into it. This allows for even greater gripping force on some core sizes used for a given ACCR size. As mentioned in the beginning of this section there is an aluminum tape wrapped over the core wires. Normally this tape is left on the core wires and the core is inserted into the aluminum sleeve/steel forging and then compressed. However: **If an aluminum sleeve is found to have any number of slots or grooves cut into the length of the sleeve, then ALL (100%) of the tape must be removed from the length of the core that would be inserted into this sleeve. If the aluminum insert is found to have no slots or grooves, then the tape is NOT to be removed from the core wires.**



← Non-slotted Aluminum Insert
(Leave all tape on core wires)

← Slotted Aluminum Insert
(Remove 100% of the core wire tape)



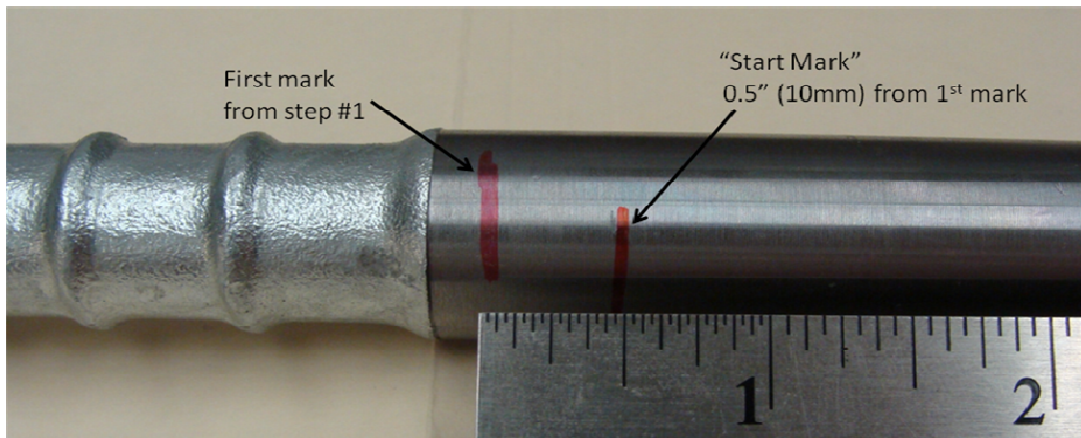
Marking the “Start Mark” on the Steel Forging

The first compression “start mark” must be made on the outside of the steel forging prior to compressing the steel forging over the core wires. Failure to do this may result in a severely bent or damaged steel core forging during the compression. Use the following procedure to produce the “start mark” prior to compressing the steel forging:

Step #1: Remove the aluminum insert and hold it over the outside of the steel forging lining up the ends so they are flush with each other. Mark the outside of the steel forging at the end of the aluminum insert to reference the actual depth of the insert:



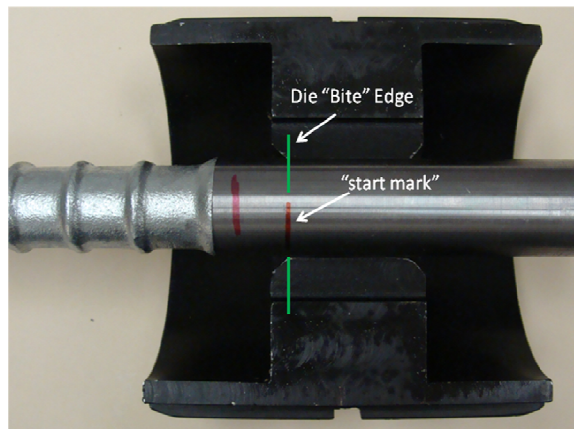
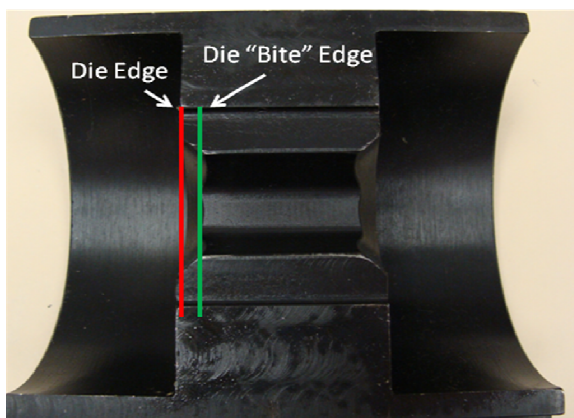
Step #2: Mark the “start mark” 0.5” (10mm) from the first mark towards the end of the forging (not towards the “eye” end):



Step #3: Re-Insert the aluminum insert sleeve:



Step #4: Align die “bite” edge (green line in picture) with the start mark produced on the steel forging:



Next, the steel forging with the aluminum insert installed in it is placed over the core wires until the core wires bottom out. Make sure that the aluminum insert is pushed into the steel forging and that it is flush with the end of the steel bore. There are two sized dies used to compress the AFL dead end: One die for the steel forging and another die for the larger outer aluminum body of the dead end. Install the correct steel compression die used for the steel forging into the 100-ton (90.8 metric tons) press head. While holding the core wires tight inside the steel forging, make the first compression on the steel forging at the “start mark”. Make sure that the two die halves come together and the pump pressure reaches 10,000 PSI for each compression bite. Continue to press the entire length of the steel forging to the end, overlapping each die bite by 0.5 inches (10mm). After the steel forging is compressed, care should be taken to secure the forging assembly to the rigging to not allow the conductor to be dropped. This can cause stress on the ACCR core wires.

Compressing the Steel Forging



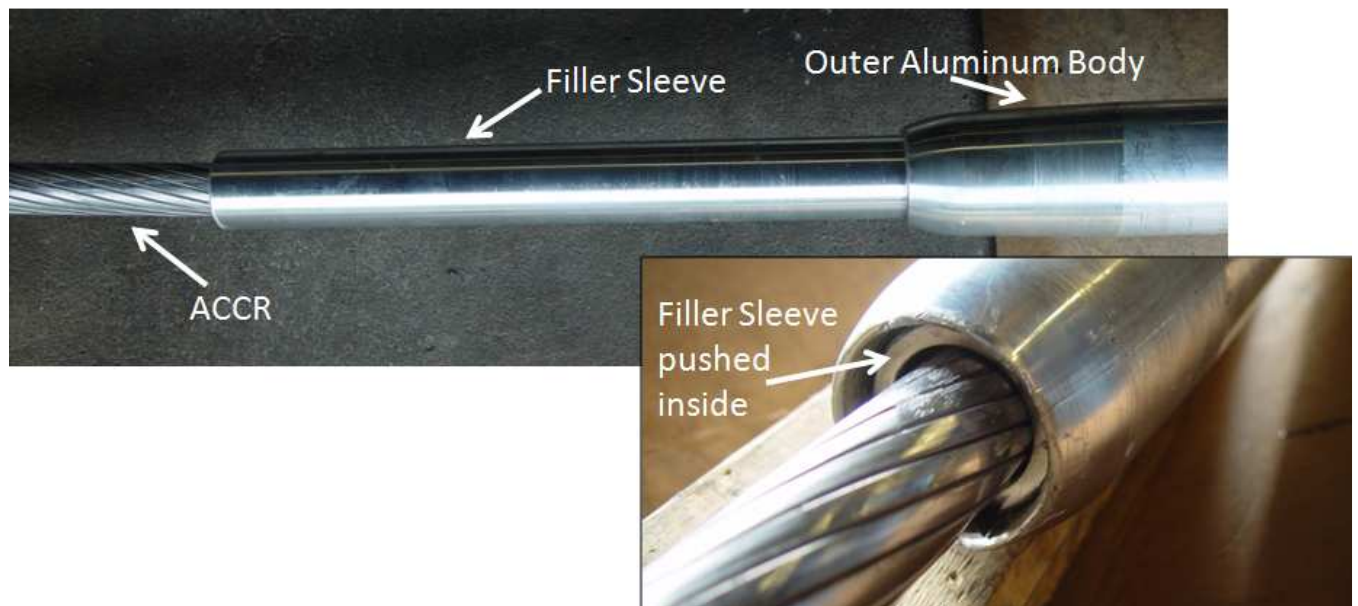
It is mandatory that the cable is brushed with a wire brush to remove oxides from the cable surface. To do this, apply a bead of HiTemp® AFL Filler Compound (AFCHT™) on to the conductor surface over which the large aluminum body will be pressed. Vigorously brush the compound into the conductor aluminum strands with a wire brush covering the entire area of the cable.

The outer sleeve is then slid over the compressed steel forging and filled with the proper amount of HiTemp® AFL Filler Compound (AFCHT™). The grease port is then plugged with the provided plug or “pill”.

Larger Outer Aluminum Sleeve:



On some ACCR sizes the dead end assembly also contains an aluminum filler sleeve that must be fitted inside of the larger outer aluminum body. This filler sleeve must be pushed into the outer aluminum body so it is recessed inside of it.



Application of a solid lubricant, such as a 3M approved bar soap, is required on the outer aluminum sleeve on the areas that will be pressed. Do not use any other lubricant other than bar soap.

Applying solid lubricant (bar soap):



Change the dies used to press the steel forging in the 100 ton press head to the dies used to press the large outer aluminum sleeve. Making sure that the large outer sleeve is held tight against the felt washer installed on the steel forging, press the large outer aluminum sleeve with the 100-ton (90.8 metric tons) press. There are 2 areas to be pressed on the dead end body. These areas are stamped

with “**Start**” and “**Press to End**” knurl markings on the aluminum body. The area over the compressed section of the steel forging is not compressed. This area is stamped “**Do Not Press**”.

Make sure that the two die halves come together for each compression bite and the pump pressure reaches 10,000 PSI. Continue to press the 2 areas of the aluminum body overlapping each die bite by 0.5 inches (10mm).

IMPORTANT:

Under no circumstances can the tension on the conductor be “let off” and tension placed through the ACCR to the dead end prior to completely compressing the **entire** dead end body.

Pressing the outer aluminum sleeve:



After the entire dead end body is completely pressed on to the ACCR, care should be taken to secure the dead end assembly to the rigging to not allow the dead end to be dropped. This can cause stress on the ACCR. The compression dead end can now be connected to the insulator string and appropriate jumper connectors can then be installed. Brushing of the terminal pads of the dead end and jumper terminal with a wire brush is required. The use of AFL’s Alnox® Electrical Joint Compound (EJC) or any other EJC approved by 3M for this application is required between the terminal pad and the dead end pad for a good electrical connection.

THERMOLIGN™ Dead End

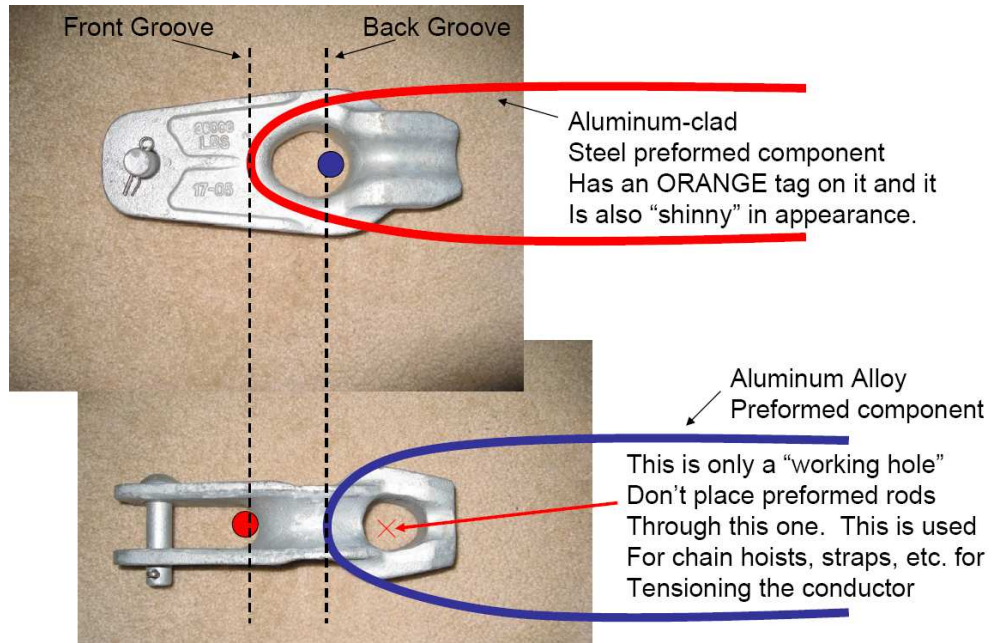
THERMOLIGN™ dead ends produced by Preformed Line Products have been used successfully in the installation of ACCR conductors. The dead end designed for the ACCR is a two-layer construction consisting of a reinforcement rod layer and two preformed dead end layers, which are used as the connection point to the insulator string.



PLP Dead End

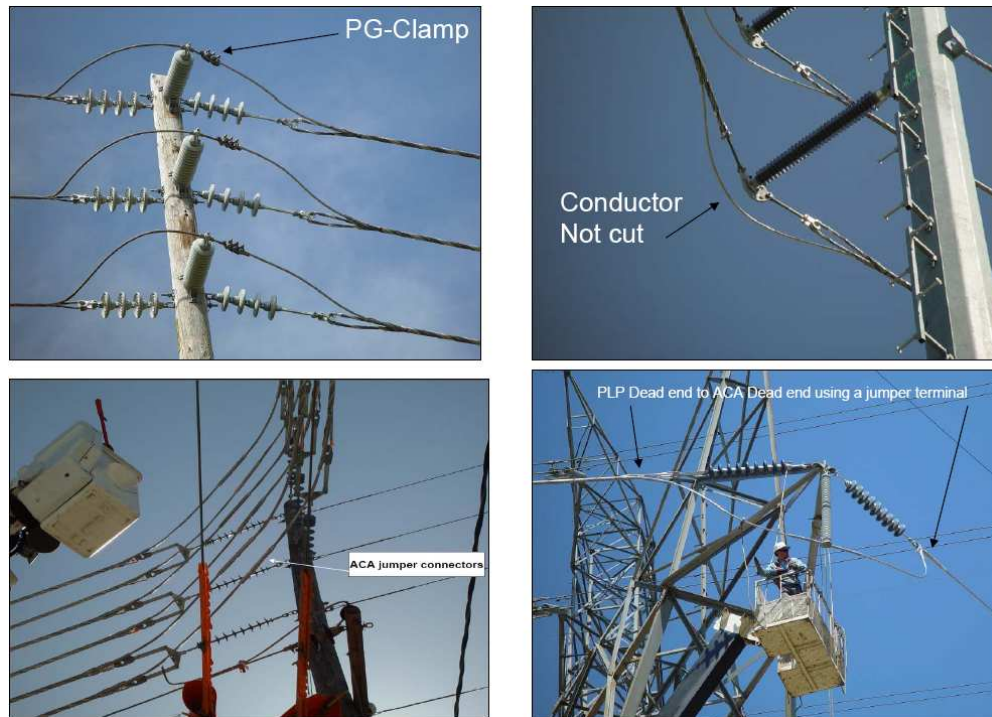
After the final sag tension of the conductor is established, a measurement is made on the conductor to determine where the dead end assembly will connect to the insulator string. There are two layers that make up the construction of the preformed dead end assembly. Each layer has match markings on them. These match markings will determine where the first layer of reinforcement rods will be placed onto the conductor. After the rods are installed onto the conductor the preformed wire dead-end layers are placed over the rods matching up the markings over each other.

There are two separate types of preformed wire dead end components: **Aluminum-Clad Steel** and **Aluminum-Alloy**. A thimble clevis is used to attach the preformed wire dead end components to the insulator string. The location of each type of dead end component into the thimble clevis is described below.



Locations of preformed wire dead end components in The thimble clevis for the PLP dead end

The chain hoist can now be removed along with the conductor grip. These assemblies allow the conductor to pass through the dead end and create a "tail". This "tail" of the conductor will not be under any tension and can be cut to any length and allow it to be used as a connector or jumper to the existing line. The pictures below show multiple ways to connect this jumper tail.



Full Tension Splices

Compression Splices

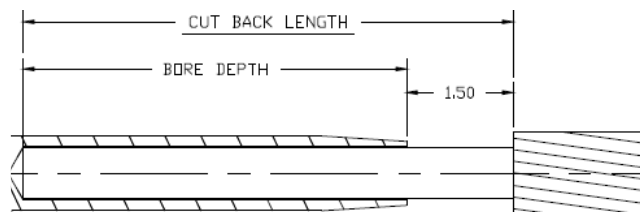
Compression type conductor splices manufactured by AFL have successfully been utilized in the installations of ACCR conductor. These types of compression splices are specifically designed by AFL to grip not only the outside aluminum strands but also to grip the core wires separately of the ACCR. Therefore, like the compression type dead end assembly, the installation steps of the full tension splice consist of a two-step compression procedure.

Full Tension Compression Splice



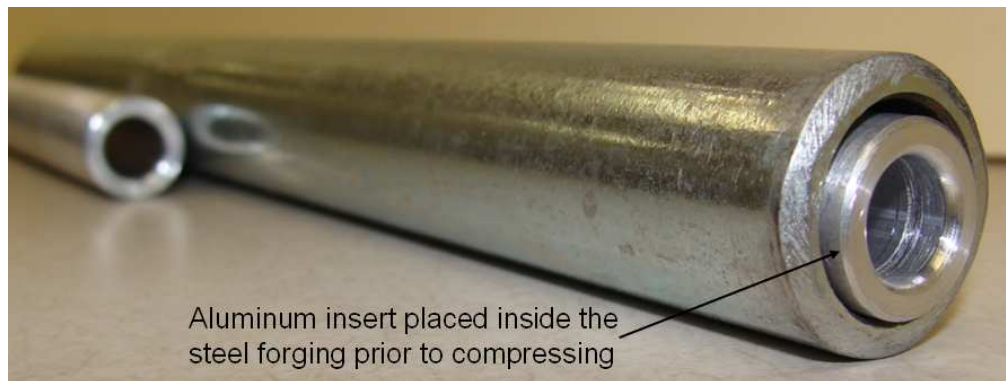
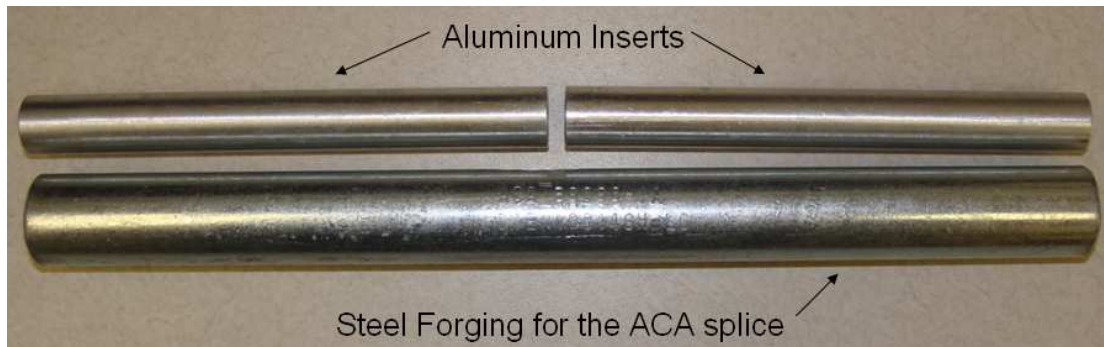
3M recommends that the minimum distance from a final installed splice location to a dead end or suspension tower should be 50 feet (15m). The two ends of the conductor that are going to be spliced are brought together and held by the use of a chain hoist and two approved conductor grips. (See section 3 on information regarding the proper selection and use of conductor grips) Conductor grips must be spaced out so that the installation of the splice does not interfere with the conductor grips themselves. This distance should be approx 20 feet (7m) between the thimble end of the conductor grips.

The first step to install the splice is to slide the large outer aluminum body of the splice over one end of conductor and “park” it about 3 feet (1m) away from the end of the cut cable. The next step consists of trimming back the top aluminum layers of the two conductor ends to be spliced. This procedure involves the use of a cable-trimming device. Care must be taken to not nick the composite wires when trimming the aluminum layers off of the conductor. Prior to cutting back the aluminum strands, the depth of the bore must be determined in the steel forging. Insert a clean object or length of core until it bottoms out in the forging. Measure the bore depth and add 1.50 inches (40mm). This will be the length to cut back the aluminum strands.



There is an aluminum tape that is wrapped over the composite core wires on the ACCR. Normally this tape is not removed from the core wires when pressing a splice forging except for a few ACCR conductor sizes. This is explained in more detail below on the requirement to remove the core tape (slotted inserts).

Located inside each end of the steel forging for the splice is an aluminum tube insert. The main purpose of this aluminum insert is to obtain a strong bond between the ACCR core wires and the steel sleeve.



Details on Slotted Aluminum Inserts

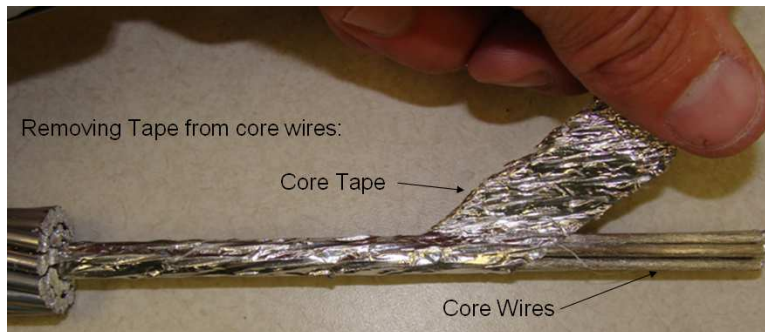
On some ACCR conductor sizes, the aluminum insert for the AFL splices will have slots or grooves manufactured into it. This allows for even greater gripping force on some core sizes used for a given ACCR size. As mentioned in the beginning of this section, there is an aluminum tape wrapped over the core wires. Normally this tape is left on the core wires and the core is inserted into the aluminum sleeve/steel forging and then compressed. **However: If an aluminum sleeve is found to have any number of slots or grooves cut into the length of the sleeve, then ALL (100%) of the tape must**

be removed from the length of the core that would be inserted into this sleeve. If the aluminum insert is found to have no slots or grooves, then the tape is NOT to be removed from the core wires.



← Non-slotted Aluminum Insert
(Leave all tape on core wires)

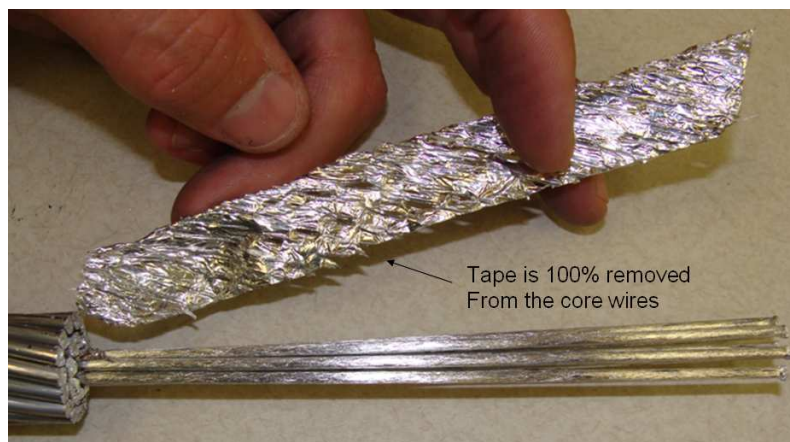
← Slotted Aluminum Insert
(Remove 100% of the core wire tape)



Removing Tape from core wires:

Core Tape

Core Wires



Tape is 100% removed
From the core wires

After the aluminum strands have been removed, the two exposed composite wire cores can be spliced together. The steel forging with the aluminum insert installed in it is placed over the core wires until the core wires bottom out. Make sure that the aluminum inserts are pushed into the steel

forging on both sides and that they are flush with the ends of the steel bore. There are two sized dies used to compress the AFL splice: One die for the steel forging and another die for the larger outer aluminum body. Install the correct steel compression die used for the steel forging into the 100-ton (90.8 metric tons) press head. While holding the core wires tight inside the steel forging, make the first compression on the steel forging at the very center of the steel forging. Make sure that the two die halves come together and the pump pressure reaches 10,000 PSI for each compression bite.



Continue to press the entire length of the steel forging from the first compression bite at the center towards each end of the steel forging, overlapping each die bite by 0.5 inches (10mm).

Pressing the steel forging of the AFL splice:



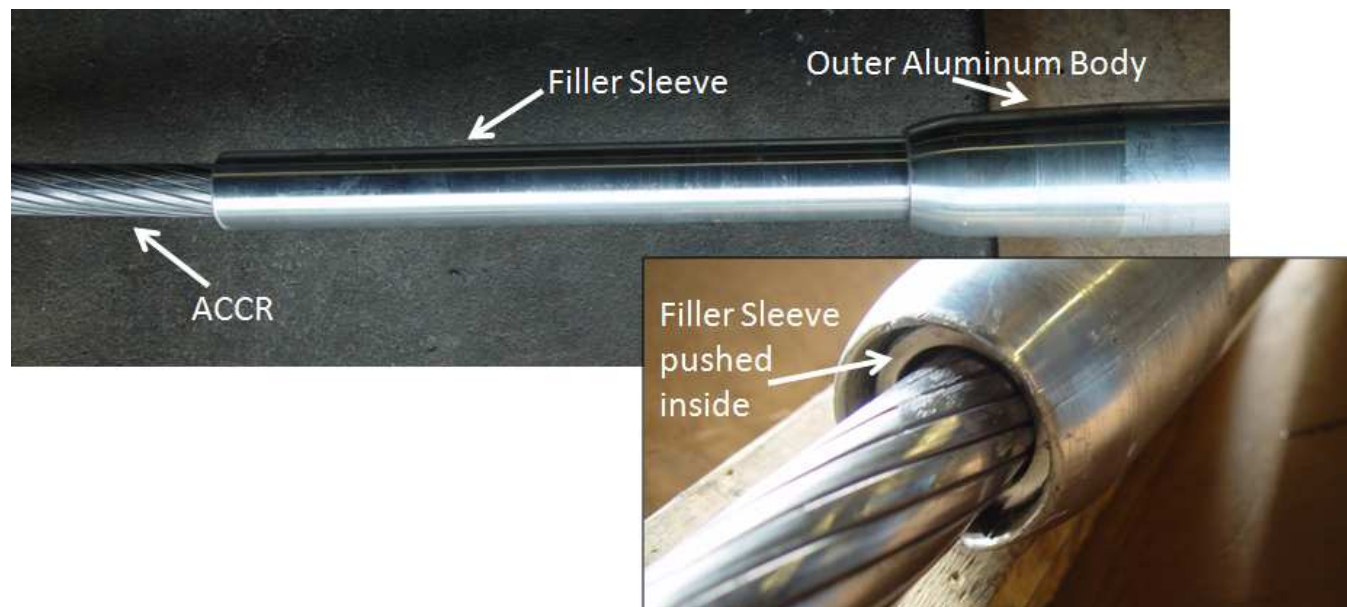
Care should be taken to secure the forging assembly to the rigging to not allow the conductor to be dropped. This can put stress on the ACCR core wires.

It is mandatory that the cable is brushed with a wire brush to remove oxides from the cable surface. To do this, apply a bead of HiTemp® AFL Filler Compound (AFCHT™) on to the conductor surface on each side of the steel forging that the large aluminum body will be pressed over. Vigorously brush the compound into the conductor aluminum strands with a wire brush covering the entire area of the cable. The outer sleeve is then slid over the compressed steel forging and filled with the proper amount of HiTemp® AFL Filler Compound (AFCHT™). The grease port is then plugged with the provided plug or “pill”.

Application of a solid lubricant, such as a 3M approved bar soap, is required on the outer aluminum sleeve on the areas that will be pressed. Do not use any other lubricant other than bar soap.

Change the dies used to press the steel forging in the 100 ton press head to the dies used to press the large outer aluminum sleeve. Slide the large outer aluminum body over the compressed forging making sure it is centered over the steel forging.

On some ACCR sizes the splice assembly also contains an aluminum filler sleeve that must be fitted inside of the larger outer aluminum body. This filler sleeve must be pushed into the outer aluminum body so it is recessed inside of it.



Press the large outer aluminum sleeve with the 100-ton (90.8 metric tons) press.

There are 2 areas to be pressed on the outer body of the splice. These areas are stamped with “**start**” and “**press to end**” knurl markings on the aluminum body. The area over the compressed section of the steel forging is not compressed. This area is stamped “**do not press**”. Make sure that the two die halves come together for each compression bite and the pump pressure reaches 10,000

PSI. Continue to press the 2 areas of the aluminum body overlapping each die bite by 0.5 inches (10mm).

IMPORTANT:

Under no circumstances can the tension on the conductor be “let off” and tension placed through the ACCR to the splice prior to completely compressing the **entire** splice body.

Pressing the outer aluminum sleeve of the AFL Splice:



THERMOLIGN™ Full Tension Splice

Preformed type full tension splices produced by Preformed Line Products have been used successfully in the installation of ACCR conductors. The splice designed for the ACCR is a two-layer construction consisting of a reinforcement inner rod layer and an outer rod layer.

PLP THERMOLIGN Full Tension Splice:



It is mandatory that the cable is brushed with a wire brush to remove oxides from the cable surface. AFL's Alnox® Electrical Joint Compound (EJC) is to be placed on the conductor in the areas where the splice rods are to be installed over. The two ends of the conductor that are going to be spliced are brought together and held by the use of a chain hoist and two approved conductor grips. (See section 3 on information regarding the proper selection and use of conductor grips) Conductor grips must be spaced out so that the installation of the splice does not interfere with the conductor grips themselves. This distance should be approx 20 feet (7m) between the thimble end of the conductor grips. 3M recommends that the minimum distance from a splice location to a dead end or suspension tower should be 50 feet (15M).

The first layer of rods is applied to the conductor making sure that the center markings on the rods are at the splice point of the two conductor ends. After the first layer of rods is applied the second layer can now be installed over the first. There are also center marks on the second layer of rods that match up with markings on the first layer. The installation of the preformed full tension splice is then complete.

Conductor Jumpers / Electrical Connectors

Compression

Compression type jumper connectors and jumper terminals have been utilized in the installation of ACCR conductors. These types of compression terminals, made by AFL, can be compressed directly over the outside layer of the ACCR. Since these types of terminals are generally used on the conductor where there are no tensions involved, there is no need to trim back the outside layers of the conductor and compress a second steel sleeve onto the composite wires. An example of a compression type terminal connector is shown below. It is mandatory that the cable is brushed with a wire brush to remove oxides from the cable surface. To do this, apply a bead of HiTemp® AFL Filler Compound (AFCHT™) on to the conductor surface that the aluminum body of the terminal will be pressed over. Vigorously brush the compound into the conductor aluminum strands with a wire brush covering the entire area of the cable.

Application of a solid lubricant, such as a 3M approved bar soap, is required on the aluminum sleeve of the jumper connector or terminal on the areas that will be pressed. Do not use any other lubricant other than bar soap.

Brushing of the terminal pads of the dead end and jumper terminal with a wire brush is required. The use of AFL's Alnox® Electrical Joint Compound (EJC) or any other EJC approved by 3M for this application is required between the terminal pad and the dead end pad for a good electrical connection.

AFL Jumper Terminal Connectors:



Parallel Grove Clamp (PG Clamp)

Parallel Grove Clamps, or PG clamps, have been utilized in the installation of ACCR conductors. These types of connectors, made by AFL, can be installed directly over the outside layer of the ACCR. An example of a PG Clamp is shown below. It is mandatory that the cable is brushed with a wire brush to remove oxides from the cable surface. To do this, apply a bead of AFL's Alnox® Electrical Joint Compound (EJC) on to the conductor surface where the PG-Clamp will be attached. Vigorously brush the compound into the conductor aluminum strands with a wire brush covering the entire area of the cable. The voltage limit of the PG Clamp is 230Kv.

Parallel Grove (PG) Clamp:



Installing a PG Clamp on ACCR:



T-Tap Connectors

Compression and bolted type T-Tap connectors have been utilized in the installation of ACCR conductors. These types of connectors, made by AFL, can be installed directly over the outside layer of the ACCR.



Bolted T-Tap Connector

Bolt Diameter	Torque
Inch	lbft (N.m)
7/16	20 (27)
1/2	25 (34)
5/8	40 (54)
3/4	60 (81)

Recommended Bolt Torque

Bolted T-Taps from AFL must be the type approved for use on ACCR conductors. It is mandatory that the cable is brushed with a wire brush to remove oxides from the cable surface. To do this for a bolted type T-tap connector, apply a bead of AFL's Alnox® Electrical Joint Compound (EJC) on to the conductor surface. Vigorously brush the compound into the conductor aluminum strands with a wire brush covering the entire area of the cable. The voltage limit of the bolted T-Tap is 230Kv and is only allowed on ACCR 954-T13 and smaller sizes.

Compression T-Taps from AFL must be the type approved for use on ACCR conductors as well as the proper die sized used for that T-Tap. It is mandatory that the cable is brushed with a wire brush to remove oxides from the cable surface. To do this for a compression type T-tap connector, apply a bead of HiTemp® AFL Filler Compound (AFCHT™) on to the conductor surface and vigorously brush the compound into the conductor. Compression T-Taps can be used for EHV applications.

Application of a solid lubricant, such as an approved 3M bar soap, is required on the aluminum sleeve of the compression T-Tap on the areas that will be pressed. Do not use any other lubricant other than bar soap. Compression T-Taps are allowed for usage on all ACCR sizes.

Brushing of the terminal pad of the T-Tap connectors with a wire brush is required. The use of AFL's Alnox® Electrical Joint Compound (EJC) is required between the T-Tap terminal pad and the accessory connecting to it for a good electrical connection.

Compression T-Tap



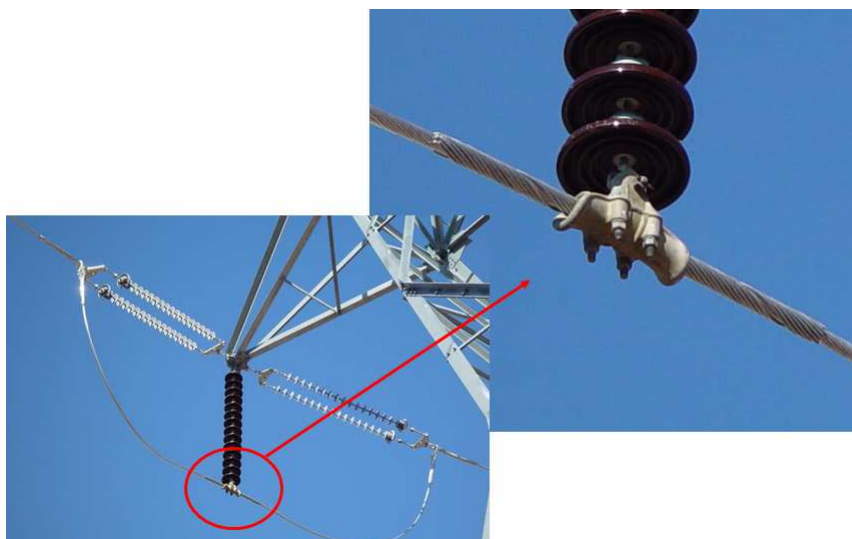
Recommended Bolt Torque

Bolt Diameter	Torque
Inch	lbft (N.m)
7/16	20 (27)
1/2	25 (34)
5/8	40 (54)
3/4	60 (81)

Jumper Support Insulator

When there is a need to use a jumper support insulator, the installation of Line Guard is required to support the ACCR conductor. Line Guard manufactured by Preformed Line Products must be used in the installation of ACCR conductors where it is needed to connect to a jumper support insulator. The Line Guard is installed over the ACCR and then the connector or "shoe" is installed over the Line Guard.

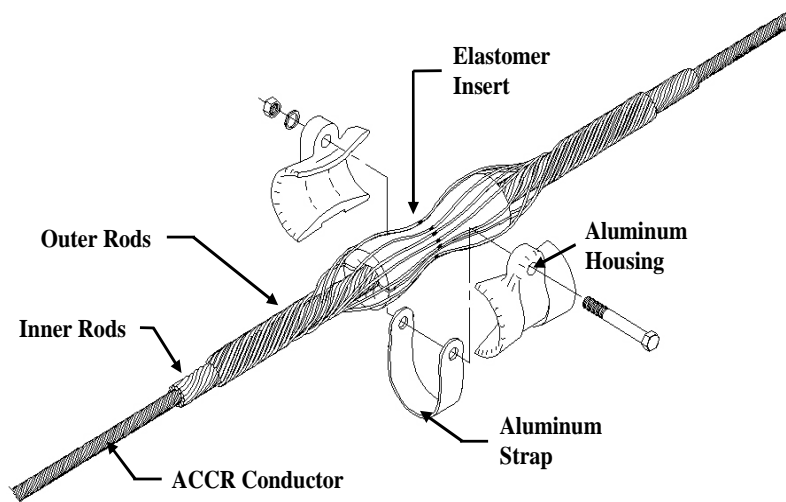
The shoe is then connected to the insulator string. The Line Guard gives the ACCR conductor more rigidity and also dissipates and high temperatures away from the insulator string. It is important to note that the shoe size will have to be increased to go over the outside dimensions of the Line Guard plus the ACCR conductor. Please note that 3M does not provide the support shoe.



Clipping-in Procedures / Suspension Assemblies

Preformed Line Products - Thermolign™

Preformed Thermolign suspension assemblies are the required choice for use on the ACCR conductor. This suspension assembly, manufactured by Preformed Line Products, is a 2-layer helical-rod construction consisting of a reinforcement inner rod layer, a neoprene elastomer insert and a second outer layer of rods installed over the neoprene insert. For line angles 30° or more, a double suspension is required. Please consult 3M on the required suspension assembly pertaining to the particular installation needs.



Helical-Rod Suspension Assembly from PLP.

The clipping portion of the conductor stringing operations involves the work following the sagging and dead-ending of the conductors. The first step of installing the suspension assemblies is to mark the conductor's center point referenced to the final connection to the insulator string. This is done while the conductor is still in the stringing block.

The next step is to install the first layer of the inner reinforcement rods to the conductor. It is required that the first layer of rods be installed on the conductor while the conductor is still in the stringing block. The first layer of rods is installed this way because in the next step of removing the block, the conductor must be held up in place by the use of a conductor hook or picking strap along with a chain hoist. By having the reinforcement rods in place before the conductor hook or picking strap is used, this gives the conductor more rigidity. The conductor hook or picking strap can cause damage to the inner composite wires of the ACCR if this first layer of rods is not installed before the conductor is removed from the stringing block. There are center marks on each of the inner rods that must be lined up with the center mark on the conductor.



1st Layer of Rods

Stringing Block

Inner rods installed through stringing block

After the first layer of rods is installed onto the conductor, the conductor can now be removed from the stringing block with the use of a picking strap along with a chain hoist. The picking strap must be positioned on the conductor giving clearance to install the neoprene insert and also be able to install the outer rods over the insert. Please note that the picking strap must be rated high enough in strength to lift the conductor safely out of the stringing block.



Picking Strap with chain hoist

Stringing block is removed

The neoprene insert is now placed over the inner rods lining up the center of the insert with the center marks on the inner rods. The two halves of the neoprene insert may be temporarily taped together to hold it on to the conductor before the outer rods are installed over it.

The outer layer or rods are now installed over the neoprene insert. These rods also have center marks on them that must match up with the center of the neoprene insert. The provided aluminum housing with the aluminum strap is then placed over the outer rods of the assembly. The suspension assembly is brought up to the insulator string and attached to it using the hardware provided with the aluminum housing.

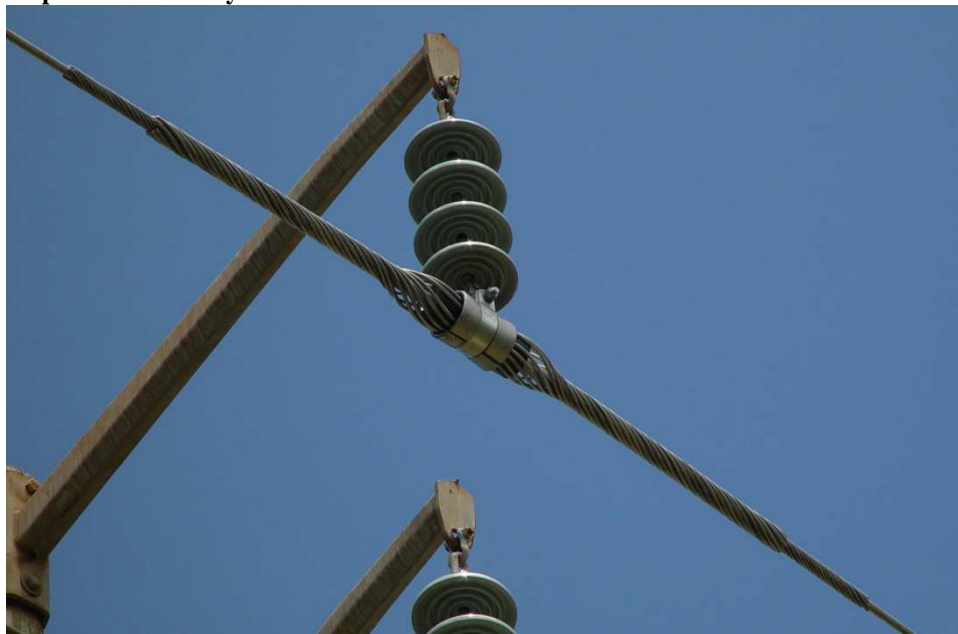
The chain hoist and picking strap are then removed. The strap is pulled out of the open slots in the outer rods created when they were installed.



Second layer of rods on suspension

Open slots in
outer rods

Completed PLP Suspension assembly:

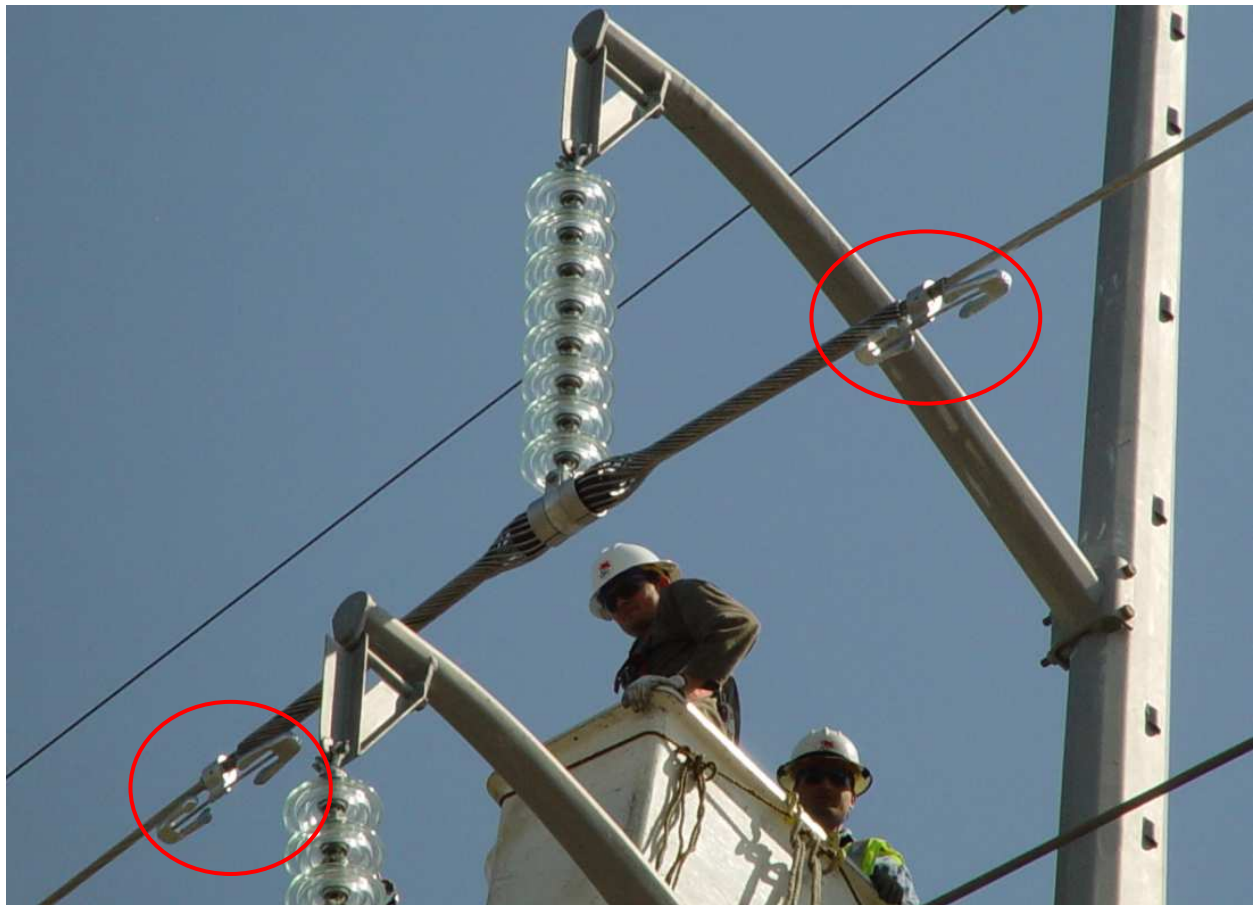


Vibration Dampers

Vibration dampers, manufactured by PLP have been successfully used in the installations of ACCR conductors. PLP vibration dampers have a breakaway torque bolt that insures the proper torque setting when installed on the conductor. Vortex damper analysis reports for PLP dampers are utilized for each ACCR project to determine damper type, quantity and placement information on the conductor. Due to the high operating temperature of the ACCR conductor, the PLP dampers must be installed over protector rods, the rods of the PLP THERMOLIGN suspension assembly or rods of the PLP THERMOLIGN dead end assembly.

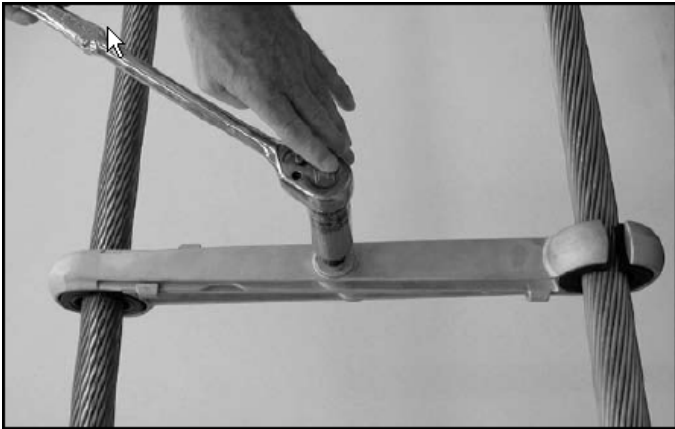
NOTE: Dampers must be installed on the ACCR within 72 hours *after* the conductor is tensioned to the specified sag and the dead ends are installed.

PLP Dampers installed on ACCR:



Spacers/Spacer-Dampers

PLP THERMOLIGN spacers are qualified for use on ACCR conductor on bundled installations. The two spacer halves are connected together at the proper location of the bundle conductor for each span. The two halves are connected using a single break-away bolt to ensure that the two halves are connected and tightened to the correct torque. The final step of the spacer installation involves applying a single layer of protector rods over the conductor and centered over each side of the connection points of the spacer on the conductor. The figures below show the details of the installation steps to complete the assembly. Tri-Bundle spacer/dampers are also available from PLP for use on ACCR installations.



**Connecting the spacer halves
Using the break-away bolt**



Protector rods applied over the spacer connection point



Completed PLP spacer assembly

5. Maintenance of ACCR

Recommendation for Usage of Repair Rods and Full-Tension Splices

Damage of conductor strands can reduce the strength and electrical conductivity. Restoration of these properties may be achieved by the use of various repair options as presented below. These are recommendations provided by the accessory suppliers.

Specific strand counts are provided with reference to a 300 ACCR conductor with a 26/7 construction.

Supplier	Repair Product	Max. % of Broken Aluminum Strands	Example: Max Number of Broken Aluminum Strands for 300 ACCR	Max. Number of Broken Core Strands
PLP	Line guard	11%	3	0
PLP	Repair Rods	22%	5	0
PLP	Full-Tension ACCR Splice	>22%	26	1 or More
AFL	Compression Repair Sleeve for ACCR	33%	8	0
AFL	Compression Full-Tension ACCR Joint	>33%	26	1 or More

PLP – Preformed Line Products – www.preformed.com

AFL – AFL Conductor Accessories (formerly Alcoa) – www.aflglobal.com

Please note that only accessories used for Hi-Temperature ACCR may be used with the 3M conductor. All other maintenance procedures having to do with the ACCR conductor should follow the requirements in this booklet for safe handling of and installation of any and all accessories.

Hot Line / Hot Stick Work

Case studies have shown while the ACCR conductor is running in a high load condition, the actual surface temperature of the ACCR is only a few degrees above ambient temperature. This actual increase in surface temperature is affected by conditions including: actual ambient temperature, wind speed, size of the conductor, line loading, etc. Therefore the working temperature of the conductor is well under the heat rating of hot sticks. It is 3M's recommendation however to verify the surface of the ACCR under load prior to hot stick work with a noncontact (IR) thermometer and comparing this temperature to the manufacture's recommended temperature limit on the hot stick to be used.

General ACCR Maintenance Information

It is important and required that the only accessories to be installed on ACCR must be qualified for usage by AFL, PLP or 3M. In no case shall another type of accessory used for ACSR, ACSS or other conductor type be used on ACCR conductor. It is 3M's recommendation that all spare accessories used on the ACCR be kept in a separate location and well labeled as to not be confused or mixed in with non-ACCR accessories. A typical list of spare or maintenance type accessories should include:

AFL

Full Tension Compression Splices
Full Tension Compression Dead Ends
Compression Terminals
HiTemp® AFL Filler Compound (AFCHT™)
AFL's Alnox® Electrical Joint Compound (EJC)
Correct Sized Compression Dies (both steel and aluminum sizes) for Compression Hardware

PLP

TG Grips to be used as ACCR Conductor Grips
Thimble Clevis for TG-Grips
Armor (Repair) Rod
Full Tension Preformed Splice if Applicable
Full Tension Preformed Dead End if Applicable
THERMOLIGN Suspension (or Trunion type) Assemblies

Installation Tools and Equipment

Bullwheel Tensioner (Diameter size approved by 3M)
Sherman and Reilly Roller Arrays
28" (71cm) sheaves for suspension towers
100 Ton Press (90.8 metric tons) and a 10,000 psi (70,000 kPa (700 bar)) hydraulic pump system
Picking strap (load approved) for installation of suspensions
Steel Wire Conductor Brush
Heavy Duty Friction Tape for Sock Splices

6. 3M On-site Support

The 3M installation representatives are only present for providing on-site training for the installation of the ACCR conductor and associated accessories. The typical duration for training and associated technical support is 2-5 days.

The utility and/or installation contractor are responsible for, among other things, the following:

- 1) Supervising the installation and the crews
- 2) Procuring, maintaining and operating equipment including bullwheel, puller, hoist, reel stand, bucket truck, sock splices, swivels, etc.
- 3) Following all applicable safety procedures.
- 4) Obtaining applicable permitting, outage, etc.
- 5) Procuring all the installation equipment necessary that is not included in the bill of materials provided by 3M.
- 6) Establishing pulling sites to follow 3M recommendation on maximum angles and tension.
- 7) Stringing the conductor and installing all the accessories according to installation instructions.
- 8) Providing the appropriate sag table.
- 9) Measuring sag.
- 10) On site inspection and final inspection.

7. Disclaimer and Limitation of Liability

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