

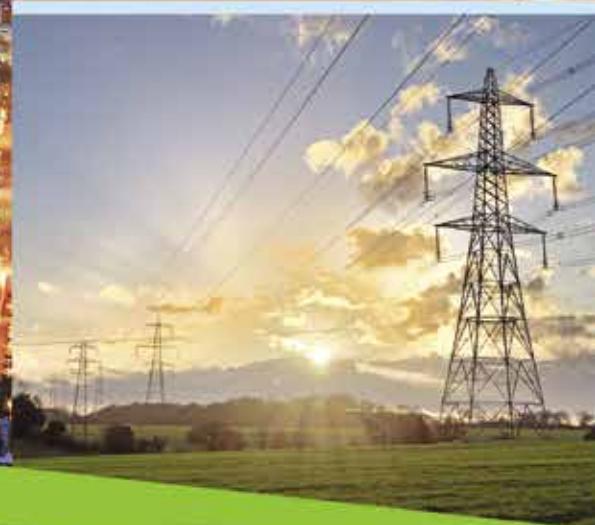


Trans Powr[®]

Overhead Conductor Installation Guide

Recommended Practices

First Edition



Reliability Matters

From household appliances to assembly lines, across the country, consumers and companies rely heavily upon their utilities. One storm-related event can affect the grid—and hundreds of thousands of homes and businesses. You need a partner that you can rely on to deliver consistent, quality products on time whenever the need arises.

General Cable has built its reputation on the cornerstone of reliability. Our engineering expertise and product innovation have resulted in product depth that can consistently provide solutions for our customers. Backed up by a culture of continuous improvement and safety, you can depend on General Cable to deliver what you require to keep your utility up and running.



When it's reliability you want, it's General Cable you need.





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USING THIS MANUAL

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1 INTRODUCTION

This guide provides suggestions for various methods, equipment and tools that have been found practical based on field experience during the installation of General Cable's **TransPowr**[®] bare overhead conductors on transmission lines. It is also applicable to many aspects of distribution line installations. The intent of this guide, along with IEEE Standard 524, *Guide to the Installation of Overhead Transmission Line Conductors*, is to provide guidance for an optimized installation of overhead conductors. The recommended dimensions for the stringing sheaves and bullwheel tensioner have been adapted from the IEEE publication. It is recognized that each and every installation set-up is different and there will be situations where customized techniques will be required that may be different from those found within this document.

This installation guide applies to the following conductor constructions: TransPowr[®] AAC, AAC/T-2[®], AAAC, AACSR, ACAR, ACSR, ACSR/TW, ACSR/T-2[®], ACSS, ACSS/TW, Covered Line Wire and Tree Wire.

As recommended by IEEE Standard 524, the conductor used in a given pull or sagging section shall be from a single manufacturer.

Special procedures for TransPowr[®] ACSS, ACSS/TW and T-2[®] are provided in the tabbed sections throughout the Installation Guide.

ACSS

TransPowr[®] ACSS and ACSS/TW products are high temperature bare overhead conductors manufactured with fully annealed 1350-O aluminum wires. The annealed aluminum wires are softer and much more ductile than the hard drawn wires in ACSR and ACSR/TW conductors. While these conductor types may be installed using techniques and equipment similar to that used to install conventional ACSR and ACSR/TW conductors, there are some special procedures that are recommended.

ACSS

T-2

TransPowr[®] AAC/T-2[®] and ACSR/T-2[®] products are bare overhead conductors manufactured with two tension-balanced conventional component conductors twisted around each other. While this conductor type may be installed using techniques and equipment similar to that used to install standard round overhead conductors, there are some special procedures that are recommended. Also discussed in this guide are problems that can be encountered during installation and suggested troubleshooting steps that may be of further assistance during the installation of TransPowr[®] T-2[®].

T-2

2 OVERHEAD CONDUCTOR HANDLING

The emphasis in any bare conductor installation should be placed on avoiding damage to the conductor surface. The conductor should not be dragged across the bare ground, over rocks, fences or guard structures. Overhead conductor should never be rewound from the original shipping reel to another reel in the field. Reels should be stored with the flanges upright on paved or compacted surfaces. For long-term storage, the flanges of the reel should be supported using wood or similar cribbing to keep the reel flange off of the ground. Never lay or transport a reel on its side.

3 OVERHEAD CONDUCTOR STRINGING METHODS

Most methods of installation have been used satisfactorily to install overhead conductors. These conductor stringing methods include Tension, Semi-Tension, Layout and Slack. All of these methods are adequate for distribution line erection. General Cable and IEEE Standard 524 only recommend the tension method (Section 3.1) for the installation of ACSS and ACSS/TW as well as for any other multilayer transmission conductor construction, defined as having more than one layer of aluminum over the core or central wire. The following is a brief description of each of these methods.

3.1 Tension Method

The tension method means that the conductor is pulled into position under tension. A puller (winch) is set up at one end of the line section, and a bullwheel tensioner at the other end. The reel of conductor is staged behind the bullwheel tensioner. A steel cable or synthetic rope, called a pulling line, is strung from the puller through each stringing block between the puller and bullwheel tensioner. The end of the pulling line is then attached to the conductor end after it has been threaded through the bullwheel tensioner. During the stringing process, the conductor is pulled through the stringing sheaves until the end reaches the puller. The tension maintained between the bullwheel tensioner and the puller keeps the conductor clear of the ground and other obstructions that could cause damage. It is important to note that the back-tension is created and controlled by the bullwheel tensioner and not the pay-off reel.

3.2 Semi-Tension Method

This method is similar to tension stringing except in this method the conductor is pulled directly off the pay-off reel and into the spans. Minimal ground clearance is maintained by applying gentle braking force to the let-off reel. It is important to recognize that the amount of braking force must be kept to an absolute minimum level. Excessive braking force cannot only damage the remaining conductor on the reel, but it can also damage or collapse the reel itself.

ACSS This method **must not** be used for the installation of **TransPowr**[®] **ACSS, ACSS/TW** or multilayer transmission size conductors.

ACSS

3.3 Layout Method

This method is similar to the slack method except the lead end of the conductor is tied off and the reel is mounted onto a vehicle or trailer which travels down the line section, paying out the conductor as it goes. The conductor is then lifted and placed into a stringing sheave at each structure.

ACSS This method **must not** be used for the installation of **TransPowr**[®] **ACSS, ACSS/TW** or multilayer transmission size conductors.

ACSS

3.4 Slack Method

This method consists of mounting the conductor reel on stands or jacks, leaving it free to rotate with just enough braking force on the reel to prevent over-run, backlash or loops. A vehicle, to which the conductor is attached, is driven past each structure while pulling out the conductor. At each structure, the conductor is lifted and placed into a stringing sheave. A stringing sheave may also be referred to as a traveler, block, dolly, sheave, stringing block, or stringing traveler. The vehicle continues to the end of the line section being installed.

ACSS This method **must not** be used for the installation of **TransPowr**[®] **ACSS, ACSS/TW** or multilayer transmission size conductors.

ACSS

4 TENSIONER TYPES

Bullwheel tensioners rely on friction between the bullwheel and the conductor to create tension in the conductor. To increase the area in contact between the two, multi-groove bullwheel tensioners are used. In order to wrap the conductor into the grooves, two wheels in tandem are used. Two different bullwheel tensioner types—offset and tilted—are used to transition the conductor from the back wheel to the front wheel. Bare aluminum conductors are built with a right-hand lay on the outside layer, so the bullwheel tensioner, regardless of the type, must be a right-hand lay design. As recommended by IEEE Standard 524, the conductor enters the tensioner from the top left-most groove of the front bullwheel and exits from the top right-most groove of the back bullwheel. All grooves of the bullwheels must be used.

Combination Bullwheel Tensioner/Pay-off Trailers and V-Groove Tensioners are also suitable for the installation of small conductor sizes. These tensioner types are discussed in more detail in Sections 4.4 and 4.5.

4.1 Offset Multi-Groove Bullwheel Tensioner

Figure 1 illustrates an offset multi-groove bullwheel tensioner. The front and back bullwheels stand vertical but are offset by half a groove's width. It is important that the radius of the grooves, and the bullwheel diameter at the bottom of the grooves, be sized correctly. The offset multi-groove bullwheel tensioner has been used successfully for many years.



Figure 1 – Offset Multi-Groove Bullwheel Tensioner

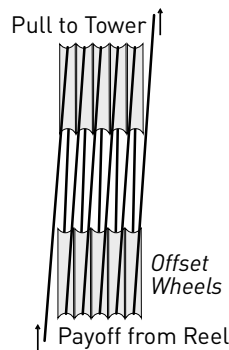
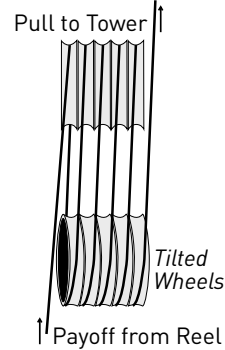


Figure 2 – Tilted Multi-Groove Bullwheel Tensioner



4.2 Tilted Multi-Groove Bullwheel Tensioner

Figure 2 illustrates another common tensioner where the grooves at the top of the two wheels are in line, but one wheel is slightly tilted. This type of tensioner allows the conductor to enter and exit each groove in a straight line, reducing the potential of the conductor to rub against the side of the groove which can loosen the strands in the outer layer. It is important that the radius of the grooves, and the bullwheel diameter at the bottom of the grooves, be sized correctly.

T-2

*The tilted multi-groove bullwheel tensioner has also been used successfully for many years and is the preferred tensioner recommended by IEEE Standard 524 for large sizes of **TransPowr® T-2®** conductor.*

T-2

4.3 Motorized Bullwheel Tensioner

Equipment used for the bullwheel tensioner can be motorized using a hydraulic system to work as the braking mechanism and apply the back tension for the pull. The same hydraulic system can be used to inadvertently push the conductor into the string instead of acting as a back brake.

T-2

*A motorized bullwheel tensioner is not recommended for **TransPowr® T-2®** conductors, as it has been found that if the speed of the motorized bullwheel tensioner is not regulated to keep the conductors tight against the bottom of the bullwheels, the conductors may open up as the twisted pair passes through the tensioner. Speed and tension mismatch between the tensioner and the puller can result in the twists of the **T-2®** conductor spreading and jumping over the bullwheel.*

T-2

4.4 Combination Bullwheel Tensioner/Pay-off Trailers

Combination bullwheel/pay-off trailer tensioning units can be used for small conductor sizes. For larger conductors, this type of tensioning unit does not allow for sufficient distance between the reel and the bullwheel device. Caution is advised when using this type of equipment for multilayer conductor sizes.

ACSS

T-2

*This type of equipment **must not** be used for the installation of **TransPowr® ACSS, ACSS/TW or T-2®** conductors.*

ACSS

T-2

4.5 V-Groove Tensioner

V-Groove tensioners are adequate for small 7-wire (or 8-wire) AWG size conductors. General Cable does not support the use of a V-Groove tensioner with any type of multilayer conductor, as recommended by IEEE Standard 524.

ACSS

T-2

*V-Groove tensioners **must not** be used for the installation of **TransPowr® ACSS, ACSS/TW or T-2®** conductors.*

ACSS

T-2

5 BULLWHEEL TENSIONER AND STRINGING SHEAVE DIMENSIONS

The two most important dimensions to check when selecting the correct size of a bullwheel tensioner and stringing sheave are the groove radius and the diameter at the bottom of the groove. Note that the overall diameter (at the top of the groove) of the stringing sheave or bullwheel tensioner is not a critical dimension.

5.1 Bullwheel Tensioner Dimensions - Diameter, Groove Radius and Depth Calculations

The dimensions recommended by IEEE Standard 524 shall be in accordance with Table 1.

Table 1 – Recommended Bullwheel Tensioner Dimensions

D_c is defined as the conductor outside diameter, except for T-2®, where $D_c = 2 \times$ diameter of one of the component conductors.

| Component | ACSR, ACSR/TW, ACSS, ACSS/TW | T-2® |
|--|---|---|
| Minimum Bullwheel Diameter at Bottom of Groove: D_b | $D_b = 39 D_c - 4$ (in) $D_b = 39 D_c - 100$ (mm) | $D_b = 28 D_c$ |
| Radius of Groove: R_g | Minimum Maximum | Minimum |
| Layer(s) of Aluminum: 1-2 layers 3 layers > 3 layers | $R_g = 0.525 D_c$ $R_g = 0.525 D_c$ $R_g = 0.525 D_c$ | $R_g = 1.10 D_c$ $R_g = 0.75 D_c$ $R_g = 0.625 D_c$ |
| Minimum Groove Depth: D_g | $D_g = 0.5 D_c$ | $D_g = 1.25 D_c$ |

5.2 Bullwheel Tensioner Lining Material

To avoid scratching or marking the surface of the conductor, bullwheels must be lined. The lining material can be urethane or molded nylon segments.

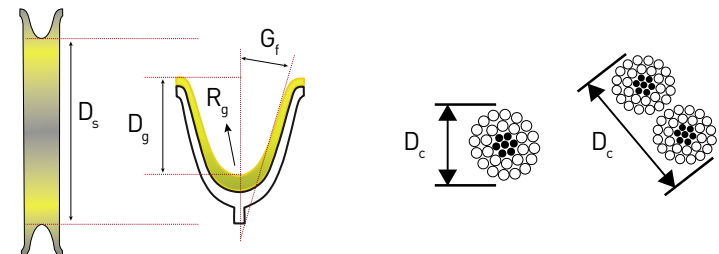
5.3 Stringing Sheave Dimensions - Diameter, Groove Radius, Depth and Flare Angle Calculations

For small distribution conductor sizes (less than 477 kcmil) and small AWG sizes of *TransPowr® T-2®*, and for slack and layout installation methods, the small Universal Stringing Block has been successfully used. Universal Stringing Blocks are not recommended for any type of transmission line conductor installation.

For the stringing sheave dimensions applicable to multilayer conductors in accordance with IEEE Standard 524, see Table 2 on page 9.



Table 2 – Recommended Stringing Sheave Dimensions



D_c is defined as the conductor outside diameter, except for T-2®, where $D_c = 2 \times$ diameter of one of the component conductors.

| Component | AAC, AAAC, AACSR, ACAR, ACSR, ACSR/TW | ACSS, ACSS/TW | T-2® | |
|---|---|--|--|--------------------------------------|
| | | | Range | D_s |
| Minimum Diameter at Bottom of Groove: D_s (see notes below) | For typical pulls: $D_s = 20 D_c - 8$ (in) $D_s = 20 D_c - 200$ (mm) For pulls greater than approx. 10,000 ft (3,000 m): $D_s = 20 D_c - 4$ (in) $D_s = 20 D_c - 100$ (mm) For pulls over substantially uneven terrain or at large angles or elevation changes: $D_s = 20 D_c$ | $D_s = 20 D_c$ | For component conductors: < 795 kcmil ≥ 795 kcmil At angles or elevation changes | $14 D_c$ $15 D_c$ $16 D_c$ |
| Radius of Groove: R_g Layer(s) of Aluminum: 1-2 layers 3 layers > 3 layers | Minimum $R_g = 0.55 D_c$ $R_g = 0.55 D_c$ $R_g = 0.55 D_c$ | Maximum $R_g = 1.10 D_c$ $R_g = 0.75 D_c$ $R_g = 0.625 D_c$ | Minimum $R_g = 0.55 D_c$ $R_g = 0.55 D_c$ $R_g = 0.55 D_c$ | Maximum See Fig. 3 |
| Minimum Groove Depth: D_g | $D_g = 1.25 D_c$ | | | |
| Groove Flare Angle: G_f | $15^\circ < G_f < 20^\circ$ | | $G_f > 20^\circ$ | |

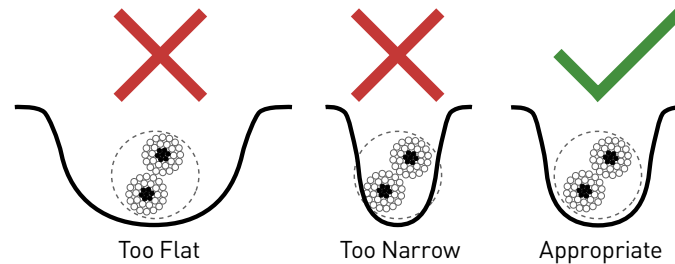
Notes:

- For the installation of multilayer transmission conductors, D_s must never be less than $16 \times D_c$.
- For angles or elevation changes, a tandem sheave arrangement may be used in place of a larger sheave.

T-2

For **TransPowr® T-2®** conductors, field experience indicates that the bottom of the groove and flare profile is important. The bottom of the groove profile must not restrict the conveyance of the normal twist in the conductor pair in passing over and through the stringing sheave. If the profile is too flat, it may cause the twist to be pushed back, and this action can be observed as violent rocking motion of the stringing sheave. If the profile is too narrow, it may cause pinching of the individual conductors and result in the pair of conductors having to rise up and fall down as they pass through the sheave. An inappropriate sheave groove profile will result in excessive scratching and displacement of the outer aluminum wires in one or both conductors. See Figure 3.

Figure 3 - T-2® Stringing Sheave Profile



When smaller than recommended bottom of the groove diameter sheaves are necessary, consideration should be given to shortening the pull length and reducing the total number of stringing sheaves utilized in the pull to avoid conductor damage.

T-2

5.4 Stringing Sheave Lining Material

It is very important to inspect the stringing sheave lining condition, as worn or torn linings should not be used. A worn out lining at the bottom of the groove means that the conductor will not track true and will have uneven pressure applied to it as it passes through the sheave. Stringing sheaves should roll smoothly when the conductor is being pulled through. A stringing sheave that bounces or does not spin at a constant speed indicates bad bearings. When this occurs, the conductor pull should be stopped, and the defective stringing sheave shall be replaced.

Urethane or neoprene-lined stringing sheaves have been successfully used in the installation of bare overhead conductors. For multilayer conductors, bare aluminum stringing sheaves should not be used, as they may scratch the conductor.

ACSS

For TransPowr® ACSS and ACSS/TW conductors, in accordance with IEEE Standard 524, unlined sheaves of any kind should never be used.

ACSS

T-2

For TransPowr® T-2® conductors, it is recommended to use urethane-lined stringing sheaves at angles. Neoprene-lined stringing sheaves have caused problems where the twisted pair climbs up the side of the sheave.

T-2

6 CONDUCTOR STRINGING OPERATION

6.1 Conductor Grips

There is a wide variety of conductor grip styles and tie-down products available in the industry. Always consult with the grip manufacturer for the correct selection so that the grip type and configuration is sized for the diameter and type of conductor being installed and is capable of holding the conductor to the highest tension that is anticipated during the sagging operation.

There are two basic types of mechanical grips that are used to secure the conductor during the pulling, sagging or dead-ending operation. The Klein (Chicago) and Crescent types of grip are open-sided rigid body with opposing jaws and swing latch that pinch the conductor between the jaws. The pocketbook type of grip, often referred to as come-along, suitcase, or four bolt, incorporates a bail attached to the body of a clamp that folds to completely surround and envelop the conductor. Bolts are then used to close the clamp and obtain a grip.

A woven wire grip (often referred to as a basket, wire mesh, Kellem®, or sock) sized to fit over the conductor and a suitably sized swivel link should be used for tension stringing. To prevent the grip from accidentally coming off the conductor, two punch-lock steel bands should be applied at the open end of the grip over the woven wire grip and conductor. Tape applied over the bands will protect the bullwheel tensioners and stringing sheave lining from the steel bands.

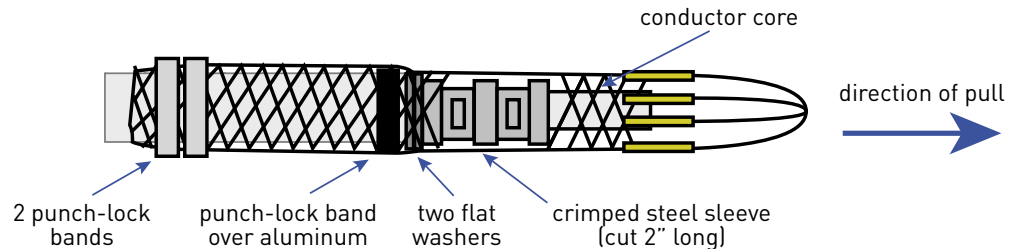


ACSS

For **TransPowr® ACSS and ACSS/TW** conductors during the sagging operations or tying down the conductor ends, double-jawed pulling grips and pocketbook (come-along) grips are recommended in accordance with IEEE Standard 524. Two grips can be used to increase the holding strength and reduce the possibility of damaging the conductor when sagging. Note that when utilizing two pulling grips in tandem, they do not equal twice the individual grip rated holding strength. Field tests can be utilized to determine the tension capability of the tandem grip arrangement.

For **ACSS and ACSS/TW**, if there is a need for a high pulling tension (such as for a long span, or with multiple reels pulled in tandem), special end preparation steps may be utilized to ensure the lead end pulling grip does not pull off the end of the conductor. See Figure 4. If this method is used, care must be taken during the pull, as the conductor could potentially bunch up inside the woven wire grip. Bunching can form a knot just behind the washers that could jam and/or damage the stringing sheaves.

Figure 4 – Special End Preparation for Woven Wire Grip Assembly on ACSS and ACSS/TW



To apply the woven wire grip,

- i. Cut back six inches of the aluminum strands to expose the steel core.
- ii. Slide on flat washers over steel core. Washer OD must be slightly less than the conductor OD.
- iii. Crimp on a short piece of steel core compression sleeve.
- iv. Apply a punch-lock band over aluminum strands just behind washers.
- v. Slide the woven wire grip over the conductor and apply the two punch-lock steel bands.
- vi. Apply tape over top of the steel bands to protect the stringing sheaves as the woven wire grip passes through them.

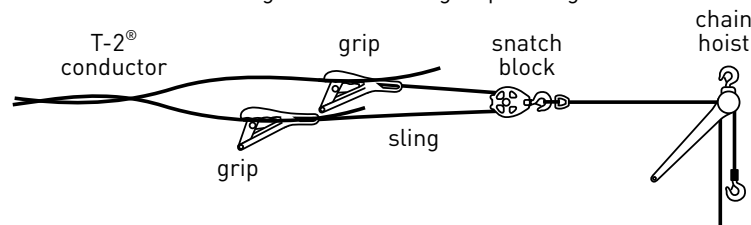
ACSS

T-2

For **TransPowr® T-2®**, a single woven wire grip sized to fit over both component conductors and a swivel link should be used for tension stringing. Each shipping length of T-2® conductor has metal bands applied at the factory around both component conductors. It is recommended by IEEE Standard 524 that these bands not be removed for the stringing procedure and that the woven wire grip be slid over them. These bands maintain the component conductor tension balance relationship during installation, splicing, or dead ending the conductor. Please note that if the T-2® conductor is to be cut before the entire reel of conductor is consumed, it is important that the conductor pair is re-banded while still under tension. Failure to do this may result in problems while stringing the remaining length of conductor on the reel.

For **TransPowr® T-2®** conductors, it is important for both conductors to be simultaneously tensioned, as recommended by IEEE Standard 524. This is accomplished by utilizing a special tensioning grip assembly that attaches to each component conductor. The two grips are connected through a snatch block with a sling. Tension is applied to the snatch block with a hoist or other appropriate tensioning device. This arrangement will apply even tension to the component conductors. See Figure 5.

Figure 5 – T-2® Sling Grip Arrangement



T-2

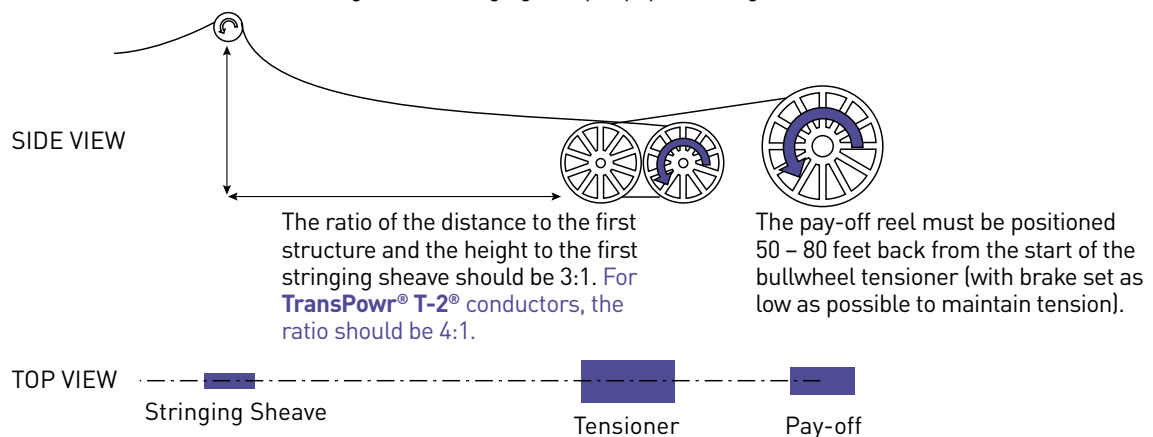
6.2 Bottom-End Conductor Attachment to Reel

The bottom end of the conductor on the reel must be secured to the reel to provide a stationary attachment point during manufacture and payout of the conductor. The end attachment must never be relied upon as an anchor point for the conductor. When paying out the conductor, the stringing operation must be stopped before the reel completely empties, and any required back tension must be transferred from the conductor on the reel to some other anchor point. The conductor end that is attached to the reel must never be considered as a brake or end-stop, as it is not capable of withstanding a conductor “run out” situation.

6.3 Stringing Setup

Figure 6 shows a typical conductor stringing operation set-up. Ideally, the pay-off reel, tensioner, first stringing sheave, and the first span past the break-over structure should be lined up as straight as possible. The ratio of the distance to the first structure and the height to the first stringing sheave should be three to one (3:1) as recommended by IEEE Standard 524, which corresponds to an upwards conductor angle of about 20 degrees. This practice will limit the vertical load on the structure and also the conductor pressure on the first sheave. The pay-off reel must be positioned 50-80 feet back from the start of the bullwheel tensioner.

Figure 6 – Stringing Setup Equipment Alignment



T-2

For **TransPowr® T-2®** conductors, the ratio of the distance to the first structure and the height to the first stringing sheave should be four to one (4:1), as recommended by IEEE Standard 524, which corresponds to an upwards conductor angle of about 15 degrees.

With T-2® conductors, wherever possible, the use of rollers on or between the reel trailer and the bullwheel tensioner should be avoided. A roller can cause distortion in the conductor twist. If a roller must be utilized, it should be as large as possible and constructed of a material that will not scratch the conductor.

T-2

6.4 Pay-off Brake Tension

As recommended by IEEE Standard 524, the brake tension on the pay-off reel should only be set high enough to prevent over-run when pulled into the tensioner.

Pay-off brake tension needs to be monitored throughout the conductor pull. As the reel empties down, it is important to lower the brake tension to reduce the tension force being applied to the conductor as it is pulled off the reel. Excessive brake tension can cause distortion of the reel flanges and lead to permanent reel damage. It can also pull the conductor down between the underlying wraps of conductor, where it could get wedged and damaged.



T-2

For **TransPowr**[®] **T-2**[®] conductors, higher pay-off tension can mark the surface of the conductor as the conductor enters the tensioner. Excessive brake tension can also cause the top layer of the conductor to crush down the layer of conductor below and damage or distort the surface of the underlying conductor, i.e., splay open strands. See Figure 7.

Figure 7 – T-2[®] Damage due to Excessive Brake Tension on Pay-off Reel



T-2

6.5 Rolling (or Running) Ground

Either a rolling or running ground is typically used during conductor installation. Please consult equipment manufacturers for the properly sized device to use. For installation of covered conductors, a rotating ground on the reel pay-off can be used.

T-2

For **TransPowr**[®] **T-2**[®] conductors, rolling grounds can be used. It is advised to consult the equipment ground manufacturer to make sure the rolling ground design selected will work with the T-2[®] conductors and accommodate the twisted conductor configuration.

T-2

6.6 Angle Changes (Breakover Sheave and Sheave Diameter)

An angle is defined as any directional change in line elevation and/or line direction. For pulls with multiple angles and/or elevation changes that could potentially cause problems during the pull, the installation should be broken up into separate pulls. If however the equipment cannot be relocated to reduce the total angle change, special measures must be taken to reduce the stresses on the conductor in order to eliminate the potential for damage.

Precaution must be taken to support the stringing sheaves as recommended in Section 6.7 *Support of Stringing Sheaves at Angles*.

If an angle is suspected of being a potential problem, it is common practice to have construction crew personnel at the angle structure during the stringing process to watch as the conductor passes through the stringing block. Conductor damage can be spotted quickly and remedial action taken immediately.

ACSS

For **TransPowr**[®] **ACSS** and **ACSS/TW** conductors, it is recommended for significant accumulated angle changes that the pull is broken up in separate pulls. Larger stringing blocks or tandem configurations should always be used at angles.

ACSS

T-2

For **TransPowr**[®] **T-2**[®] conductors, it is recommended for significant accumulated angle changes that the pull is broken up in separate pulls. Larger stringing blocks or tandem configurations should always be used at angles.

T-2

6.7 Support of Stringing Sheaves at Angles

For significant angle changes, the stringing sheave should be supported by means of a sling to allow the conductor to roll along in the bottom of the groove.

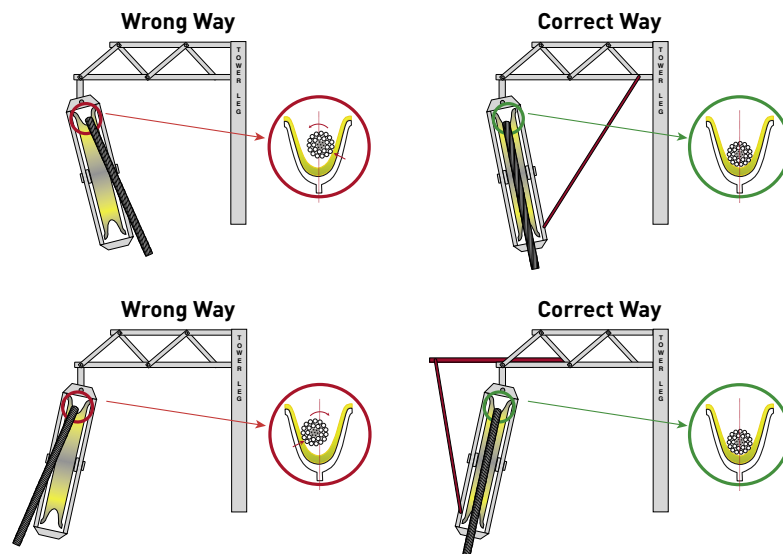
The stringing sheave in a static condition will hang plumb (vertical). When tension is applied to the pulling line/conductor, the angle in the line will cause the sheave to swing left or right of plumb, depending on the direction of the line change.

Figure 8 includes depictions of conductor tracking through a stringing sheave being pulled through an angle. When the line tension is pulling the sheave to one side or the other, as pictured in the images on the left hand side of Figure 8, it causes the conductor to ride up on the side of the sheave. The displacement from center produces a torsional moment that causes the conductor to rotate clockwise or counter-clockwise, depending on which side of the sheave the conductor is on.

To ensure that the conductor tracks in the middle of the sheave's groove during stringing, General Cable recommends supporting the sheaves at angles, as depicted in the images on the right hand side of Figure 8. This can be done with a simple rope or a chain and hoist if the blocks are heavy. Pulling the sheave to the appropriate angle minimizes the torsional forces placed on the conductor and the potential for damage.

If tandem sheaves are used, they must be properly secured together and supported in the same manner as single sheaves.

Figure 8 – Supporting of Stringing Sheaves at Angles



6.8 Recommended Maximum Pulling Tension

The maximum pulling tension applied to the conductor should not exceed ten percent (10%) of the rated strength of the conductor, as recommended by IEEE Standard 524. For example, Drake ACSR has a rated strength of 31,500 lb. (140 kN), therefore the pulling tension should not exceed 3,150 lb. (14 kN) during the installation of the conductor.

To calculate the recommended pulling tension, the following formula includes the “rolling efficiency” of the stringing sheaves:

$$T_{max} = \left(\frac{W \times L^2}{8 \times D} \right) \times \left(\frac{1}{E^n} \right)$$

Where:

T_{max} = pulling tension (assume level pull)

W = weight of the conductor (lb/ft)

L = average span length (ft)

D = average pulling sag during stringing (ft)

E = % of sheave resistance efficiency, expressed as a decimal (typically 0.98)

n = number of sheaves



Example: Pulling in 14,000 ft of Drake ACSR/GA2:

$$T_{\max} = \left(\frac{1.093 \times 900^2}{8 \times 90} \right) \times \left(\frac{1}{0.98^{17}} \right) = 1734 \text{ lbs}$$

Where:

$$W = 1.093 \text{ lb/ft}$$

$$L = 900 \text{ ft}$$

$$D = 90 \text{ ft}$$

$$E = 0.98$$

$$n = 17 \text{ sheaves}$$

Pulls which include angles and elevation changes will increase the pulling force. Tighter sag values will also increase the pulling force.

Pulling at 1734 lb (7.7 kN) would be within the ten percent (10%) rule, since the rated strength of Drake ACSR/GA2 is 31,500 lb. (140 kN).

Pulling at higher tension is sometimes necessary to clear high obstacles along the right of way. Before resorting to this solution, other methods such as temporary structures or crane-mounted sheaves should be investigated.

6.9 Conductor Side Wall Bearing Pressure

Another factor that should be considered when installing overhead conductors is the pressure between the conductor itself and the stringing block lining material. Excessive pressure can damage the conductor by deforming and/or loosening the aluminum strands. Excessive pressure will also accelerate the wearing away of the stringing sheave groove lining material. This force is referred to as the side wall bearing pressure or the conductor “bearing pressure”. This pressure per unit length between the conductor and the stringing sheave groove is a function of the pulling tension (T) applied to the conductor, the diameter of the stringing sheave at the bottom of the groove (D_s), and the diameter of the conductor itself (D_c). The pressure is independent of the length of radial contact around the sheave. For overhead conductors, the side wall bearing pressure can be expressed by the following equation:

$$P = \frac{3T}{D_s \times D_c}$$

Where:

$$P = \text{side wall bearing pressure (psi) (MPa)}$$

$$T = \text{conductor tension (lb force) (N)}$$

$$D_s = \text{diameter of sheave to bottom of groove (inches) (mm)}$$

$$D_c = \text{diameter of conductor or pulling line (inches) (mm)}$$

For stringing blocks, IEEE 524 suggests a limitation of 500-700 psi (3.4 – 4.8 MPa) maximum side wall pressure between the conductor and the sheave to minimize the potential for damaging the conductor.

ACSS

For **TransPowr® ACSS and ACSS/TW** conductors, it is recommended the maximum conductor side wall force against the stringing sheave always be less than 350 psi (2.4 MPa).

ACSS

Example: Pulling Drake ACSR/GA2 over a stringing sheave with a 24" bottom of the groove diameter:

$$P = \frac{3 \times T}{D_s \times D_c} = \left(\frac{3 \times 1734 \text{ lb}}{24" \times 1.108"} \right) = 196 \text{ psi}$$

Where:

- T = conductor tension of 1734 lb as calculated in Section 6.8 example
- D_s = 24" corresponding to the bottom of the groove diameter of the stringing sheave
- D_c = 1.108" for the nominal diameter of Drake ACSR

The calculated conductor side wall pressure force of 196 psi against the groove lining of the stringing sheave indicates a pulling tension of 1734 lb should not harm the conductor. The calculated value is below the suggested limitation of 500 – 700 psi maximum for an ACSR conductor.

6.10 Time in Stringing Sheaves

Conductors should never be left hanging in sheaves for long periods of time. IEEE Standard 524 suggests that the conductors be "sagged" within 24 hours of installation. Leaving the conductors sitting in the sheaves can cause damage, as the conductor is not secured and can come out of the sheave during high wind. Excessive sag at low tensions can have conductors clashing together. Tension should be kept as low as possible when temporarily tied down (snubbed-off conductor). The tension should never approach that of the sagging tension value. Keeping the holding tension low and working within the 24-hour window avoids having to rely on short-term creep correction curves for subsequent sagging. This is because these curves use assumptions as to tension, temperature and time, and as such are less accurate as time increases.

6.11 Pre-Tensioning

Although it is not a common practice, in some applications the conductor is pre-stretched prior to sagging. Pre-tensioning is carried out when it is desirable to sag the conductor according to its final condition. Usually the conductor is pulled to 50-60% of the rated strength and held for at least one hour. The pre-tension value is specifically calculated for each installation and temperature. Afterwards, the tension is backed off to the final sagging tension. Typically pre-tensioning is only done on a few spans. Sheaves and support hardware must be capable of withholding the applied tension.

6.12 Sagging

The sagging of ACSR conductors can be done using any of the existing methods. Line tension or sag may be set using:

- Transit method
- Dynamometer (measures tension)
- The "Stop-Watch" method, which is sometimes used to verify tension at multiple locations. The "Stop-Watch" equation is:

$$t = \sqrt{\frac{\text{Sag} \times N^2}{12.075}}$$

Where:

- t = time for Nth return wave (s)
- Sag = sag (in)
- N = number of return waves



6.13 Sag Adjustments

When sagging the conductor, the tension adjustments should be completed within one hour. It is good practice to check the sag at more than one location along the line, selecting level sections with similar span lengths. Bundle conductors should all be sagged at the same time. Once the sagging tension is set, it should not be adjusted again.

To compensate for conductor creep in situations where the installed conductor has sat in the stringing sheaves and has not been sagged within 24 hours, estimated creep correction curves should be considered.

6.14 Clipping

Ideally, conductors should be clipped in within 24 hours after the line is brought into sag. The line tension should never be adjusted again, as creep will have started to take place. IEEE Standard 524 states that the total time for conductors sitting in the sheaves, from initial installation until clipping, should never be more than 72 hours. If this time is exceeded, damage may occur to the conductor and/or sheaves. The installation of dampers, spacers and spacer-dampers should be completed as soon as possible after sagging to prevent damage to the conductors.

7 HARDWARE

It is important to ensure that the fittings and hardware be suitable for the conductor (type and temperature rating) being installed. There are numerous overhead conductor splice and dead-end accessories for installations. Always consult with the accessory manufacturer for the correct selection and installation procedure for its product.

In general, compression accessories are used on large conductors for transmission lines. These fittings have been used for many years and have proven to be very efficient in being capable of carrying the full mechanical load of any conductors. Compression accessories come as dead-ends, splices, tap-off, jumper terminals, etc. Bolted and preformed products are more commonly used on smaller conductors for distribution lines.

ACSS

For TransPowr[®] ACSS and ACSS/TW conductors in tension span applications, bolted dead-end fittings must not be used.

ACSS

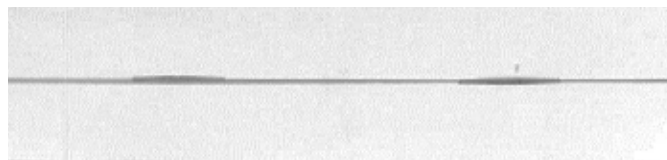
T-2

For TransPowr[®] T-2[®] conductors, it is important that the line hardware maintains an even conductor tension balance with the two individual conductors.

For splices in T-2[®], the conductors are joined by separately splicing each component conductor together. Compression-style splices are preferred; however, for small AWG sizes, provided the utility will allow their use, "automatic" type splices have been used. The splices in the individual component conductors are spaced apart so the adjacent splice bodies do not stack together, as recommended by IEEE Standard 524.

Special steps must be followed to ensure the tension balance in the component conductors is maintained. Just beyond the region where the factory-installed conductor bands are located, overlap the two lengths of T-2[®] conductor by approximately five feet. With the two conductors held side by side, mark the corresponding component conductors where they will be cut. Cut one set of corresponding conductors on their marks and splice together. Once this splice is completed, repeat the same with the other corresponding component conductors. An additional twist may be needed before the second splice is made to remove any looseness between the component conductors. See Figure 9 for an example of a spliced T-2[®] conductor.

Figure 9 - Example of a T-2[®] Conductor Splice



T-2

T-2

Line taps are also used with the **TransPowr**[®] T-2[®] conductor. Most accessory manufacturers have either hot line taps or parallel groove connectors that can be used for electrical connections. Depending on the magnitude of the tap current, the line tap may be made either off of just a single T-2[®] component conductor or be required to bridge across both conductors. Always make sure to consult with the accessory manufacturer for the correct selection and installation procedure for the product. **WARNING** - Line taps should never be installed on a twisted pair conductor product where the product has a very short twist length. With the shorter twist length, the rotational oscillation movement of the conductor is more pronounced. The oscillation movement transfers into the line tap, causing it to move, and may lead to mechanical fatigue and failure of the associated copper jumper wire.

T-2

8 INSTALLATION PULL RECORD

General Cable has prepared an Overhead Conductor Installation Pull Record document that utilities are encouraged to use. This document is important as it provides a record of the installation equipment and pull parameters for each set-up. While the document is mainly designed around the tension stringing method, it is adaptable for other installation methods. It is encouraged to have the record completed and a copy retained for future reference. A copy of the document may be sent to General Cable for the purpose of continuous improvement of this Installation Guide.

Contact a General Cable sales representative today and ask for a copy of the Overhead Conductor Installation Pull Record document.

Information may be e-mailed to utilityspecengineers@generalcable.com or mailed to:

General Cable
Electric Utility Engineering
4 Tesseneer Drive
Highland Heights, KY 41076

Please be sure to include a name and telephone number that we can contact for further discussion concerning the installation information.

9 TECHNICAL ASSISTANCE

The purpose of this installation guide is to provide suggestions for various methods, equipment and tools that have been found practical based on reported field experience during the installation of General Cable's **TransPowr**[®] bare overhead conductors. At this time, it is not intended to address the special installation details for composite-reinforced conductors, expanded core conductors, or self-damping conductors (SDC). For additional assistance, please contact your General Cable sales representative.



Cable Solutions for the Energy Market

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TransPowr® Overhead Conductors

AAC; AAC/TW; AAAC; ACAR; ACSR; ACSR/AW; ACSR/TW; ACSS; ACSS/AW; ACSS/TW; AAC/T-2®; ACSR/T-2®; ACSR/SD; Overhead Line Wire; Grounding Conductor; Aluminum Tie Wire; Tree Wire



Sitec® Brand Underground High- and Extra-High-Voltage Solutions

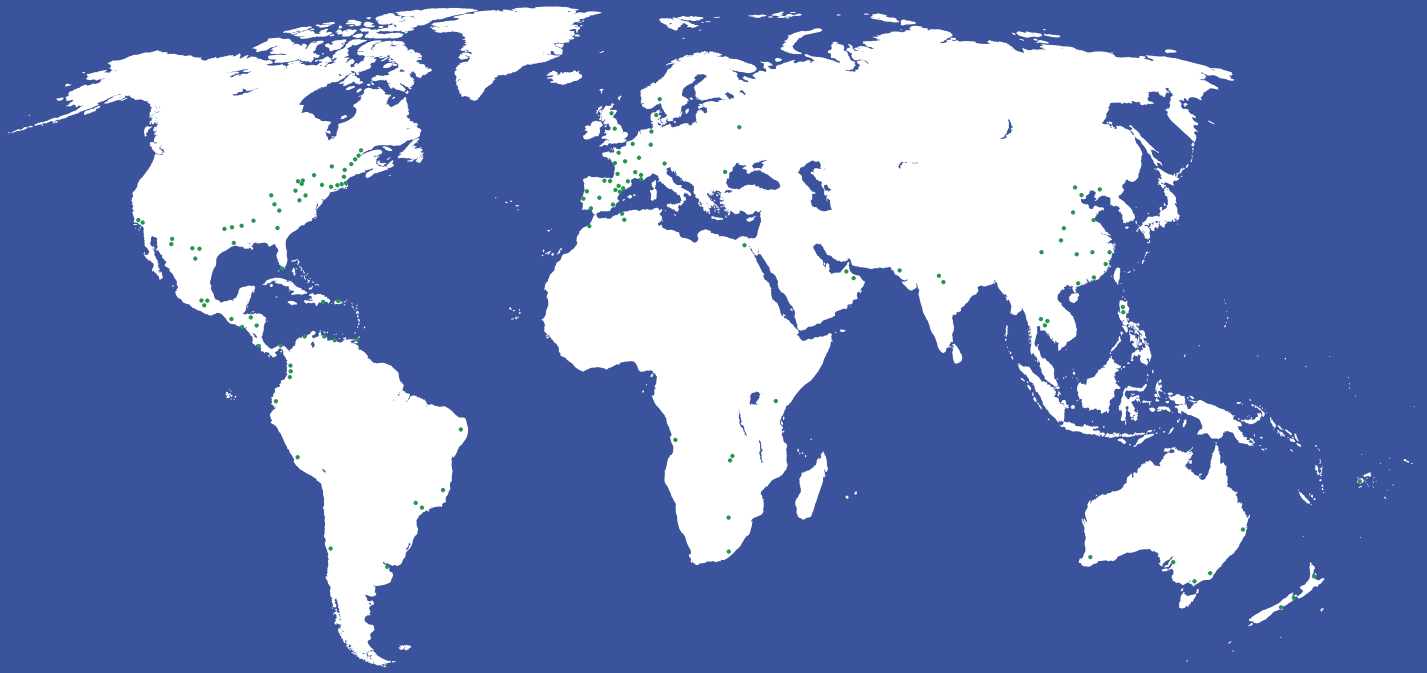
Underground Transmission Cables up to 5000 kcmil
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Global Reach



General Cable, a leading wire and cable innovator for over 170 years, serves customers through a global network of 57 manufacturing facilities in 26 countries and has worldwide sales representation and distribution. The Company is dedicated to the production of high-quality aluminum, copper and fiber optic wire and cable and systems solutions for the energy, construction, industrial, specialty and communications sectors. In addition to our strong brand recognition and strengths in technology and manufacturing, General Cable is also competitive in such areas as distribution and logistics, marketing, sales and customer service. This combination enables General Cable to better serve its customers as they expand into new geographic markets.

General Cable

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