Guide for Installation and Use of Southwire C^7® Tree Wire

Introduction

Tree wire is self-supporting covered conductor that is used in place of bare conductor in overhead primary distribution. Tree wire is used to reduce outages in areas where there is potential for incidental contact with tree limbs. Tree wire can also have a significant effect in the prevention of wildfires caused by sparks from primary conductors slapping together or contacting tree limbs. Tree wire cables can be an effective solution to solve problems with existing bare conductor circuits without the need for more expensive alternatives such as aerial bundled or underground cables. Although regular maintenance (e.g., tree trimming) is still required, Tree wire can help to reduce regular maintenance costs. While Tree Wire can lessen the concern around electrical arcs sparking and igniting nearby trees, the added weight of the covering causes another problem… additional sag. However, by modifying the cable to replace the steel core with a C^7® carbon fiber composite core, the additional sag caused by the conductor covering can be fully offset in the majority of cases, increasing the clearance to vegetation and eliminating the need to rebuild distribution circuits.

Southwire's C^7® Tree Wire is constructed with a single-strand or 7-strand carbon fiber composite (thermoset matrix) core surrounded by aluminum-zirconium strands and a three-layer TRXLPE insulation system, which is identical to Southwire's existing tree wire constructions. The system utilizes an inner low-density polyethylene (LDPE) layer for easier removal.

For C^7® Tree Wire benefits to be properly realized, the system must be designed, installed, maintained, and operated properly. C^7® Tree Wire is not suitable for long-term contact with grounded objects, such as trees. A regular tree trimming schedule should still be maintained for tree wire lines.

Differences compared to the equivalent bare conductor must be recognized. C^7® Tree Wire's ampacity rating is similar to its bare equivalent. Additional weight yields higher line tension that must be accounted for in the system design, notably pole selection and guying.

C^{7}® Tree Wire was designed with the crew in mind. Familiar tools, fittings, and procedures ensure that crews can be confident in the safety and reliability of the C^{7}® family. C^{7}® core is stronger than any steel core and only 20% of the weight.

It is, however, necessary to recognize that carbon fiber polymer composites are different from metals and may require different handling. The following section contains handling requirements to ensure a trouble-free installation. Proper installation will ensure a long service life for the cable.

Special Handling Precautions

C^{7}® Tree Wire is covered conductor and should ALWAYS be treated as bare conductor. Surface potential can approach phase voltage so workers should NOT rely on conductor coverings for any insulating value when handling. Since C^{7}® Tree Wire is non-shielded, if the covering becomes cracked or damaged, full line voltage could be present on the surface. New tree wire is designed to limit voltage stress at the covering surface to 50 volts per mil for 15 kV systems. Charging current is present on the covering surface and is approximately 350 micro-amperes per foot.

The C^{7}® carbon fiber composite core is stronger than even Southwire's ultra-high-strength steel core, HS285®. Linear composites like the C^{7}® core achieve their superior properties by orienting the strength members, in this case carbon fiber strands, in the same direction as the mechanical load. A steel core strand is strong when loaded in any direction; therefore, it can resist incidental compression and crushing loads during handling and installation. In tension, the C^{7}® core is almost 50% stronger than standard steel core. It is also one-fifth of the weight of steel.

Polymer composites do not match the hardness and abuse tolerance associated with steel. A steel core will bend, whereas a composite will resist bending up to the breaking point. Steel is hard and resists crushing forces much better than a polymer composite. Fortunately, the aluminum-zirconium outer strands protect the core strands during normal bending and crushing. Common-sense precautions are needed to prevent damage. If severe damage occurs to the core, a noticeable bend may be visible in the cable. Two failure modes and the associated countermeasures are discussed below:

1) <u>Excessive Bending:</u> A steel strand will kink if it is bent, but it can be straightened with only moderate loss of strength. Each C^{7}® core is tested at the factory to ensure it can tolerate reasonable bending stresses during installation. Unlike steel strands, C^{7}® core strands do not yield or kink when bent past a safe diameter. They reach a limit, and then break. The goal during all handling and installation is to keep a safe margin to the breaking point. The most important safety measure is to detect and report any event where the bending limit could have been exceeded.

   To ensure a safe margin to any damage threshold, contact Southwire before respooling or rewinding the cable onto a different reel. The entrance block and any running angles should use a block with a bottom groove diameter of at least 20 times the cable diameter. For tangent structures and turning angles less than 20°, the sheave bottom groove diameter must be at least 10 times the cable diameter.

Below are some rules-of-thumb regarding cable bending.

- A full-size block should be used to avoid excessive bending around small guide rollers.

- It is OK to drape slack cable across a small roller. This would not be acceptable if the cable were under tension or if the crew were pulling the tail to install a fitting.

- Care should be taken to ensure grips do not bend the cable. Make sure the tail from the grip is trained at a gentle angle, and tension on the slack side is low to prevent excessive bending.

- If the cable has taken a "set" from bending, the bent section should be cut out and a splice installed.

2) Crushing: Steel strands are hard and can resist crushing loads. The resins used in $C^{7®}$ Tree Wire are among the toughest available. They can tolerate some abuse, but the resin is softer than aluminum-zirconium strands, and if the cable is crushed, the core can sustain damage. Driving a vehicle across a cable is an example of abuse that a steel core cable might survive but will damage a composite core. Damaged sections should be cut out and a splice installed. Consider sending potentially damaged sections to Southwire for evaluation.

Prior to sagging, the full length of the line should be inspected for any signs of localized bending. Any kink must be evaluated. If in doubt, take a photograph and email it to Southwire for evaluation. Handling accidents during line construction are almost unavoidable. What is critical is that damage get reported and repaired before the line is pulled up to sag.

$C^{7®}$ Tree Wire can be installed using conventional techniques developed over the past 100 years of cable installation. IEEE 524, *Guide to the Installation of Overhead Transmission Line Conductors,* is an excellent guide and is endorsed by Southwire for both conventional tree wire and $C^{7®}$ Tree Wire installation practices. Southwire's installation guides are reviewed to ensure they are compatible with the guidelines in IEEE 524.

Reel Handling and Storage

Unloading equipment must never come in contact with the cable. Lifting must be performed using a forklift or crane as described below.

When using a forklift, the forks shall be placed under both flanges, with the flange facing the operator.

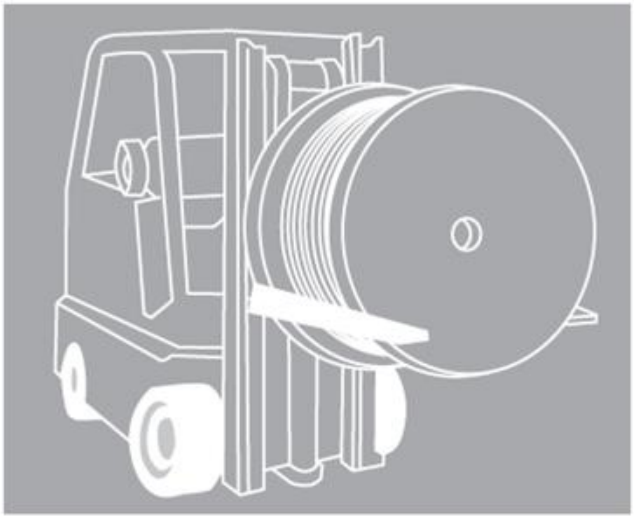

Figure 1: Forklift handling of reels.

When using a crane, a spreader bar must be used in conjunction with either “J” hooks or an axle to prevent damage to the reel flange and cable. “J” hooks should be placed in the arbor holes. Axles should be inserted through the arbor holes and lifted with straps.

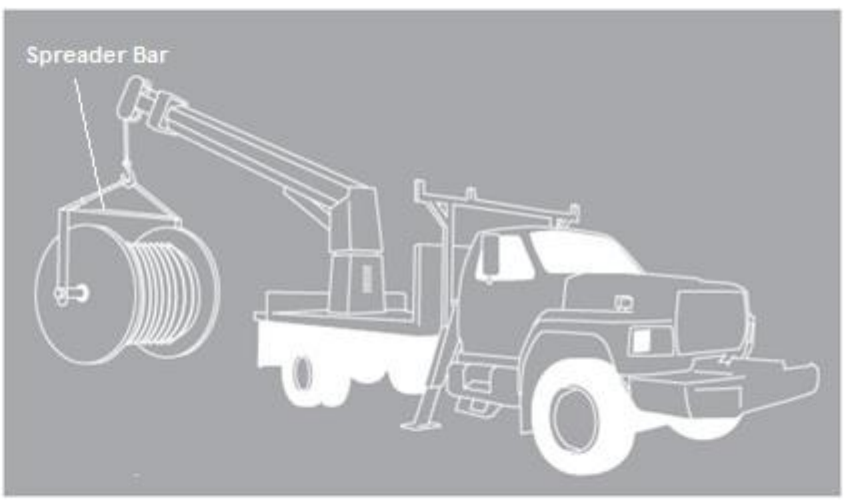

Figure 2: Crane handling of reels.

Reels should be stored away from physical and environmental hazards, such as chemicals. Reels must be stored standing on their flanges in a flat, well-drained area. The cable must not be allowed to touch the ground.

Caution should be taken with reels stored at locations near HV and EHV lines since the conductor is isolated on the reel and can pick up charge from adjacent circuits. Care should be taken when removing end caps or coming into contact with the conductor. These precautions are similar to those taken when storing underground MV cable or 600V cable.

Cable Handling

C^{7}® Tree Wire should not be dragged across any surface. Doing so will reduce the effectiveness of the conductor covering.

Payoff

The cable reel should be set up on a reel payoff stationed a minimum of 40-50 feet behind and in line with the bullwheel tensioner. This will ensure that the cable does not scrub the flanges as it is being unwound.

Paying off straight from the reel will help to avoid scuffing of the cable against the reel flange. Proper adjustment of the fairlead roller guides is necessary to prevent scuffing of the cable as it reeves through the bullwheel. Reels are designed only to transport the cable; they are not designed for use as tensioning devices. Minimal braking tension should be applied to the payoff to prevent damage to the cable or reel. Only enough braking tension should be applied to the reel to keep the cable taut between the reel payoff and tensioner and to prevent the reel from over-rotating when the pulling operation stops. Back tension should not exceed 1000 lb (4.4 kN). If too much back tension is applied, the cable on the outer layer can "pull down" into the underlying layers.

Bullwheel

Only dual drum multi-groove bullwheel tensioners are recommended for C^{7}® Tree Wire. The bullwheel drums may be offset or tilted so that the offset will be approximately one-half the groove spacing.

Semicircular grooves with depths of 0.5 or more times the cable diameter and flare angles of 5-15° from vertical are recommended. The minimum bottom groove diameter of the bullwheel must be 35 times the cable diameter. Bullwheels must be properly sized and lined to prevent scuffing and damaging of the cable.

Elastomer- or thermoplastic polymer-lined grooves are recommended to avoid permanent scuffing of the surface of the cable. Semiconducting linings should not be relied on for grounding purposes.

The bullwheel should be set up in line with the pull and 3-4 times as far from the base of the structure as the height of the entrance block at the first structure. This orientation will provide between a 14-19° angle as the cable exits the bullwheel and as it enters the entrance or breakover sheave.

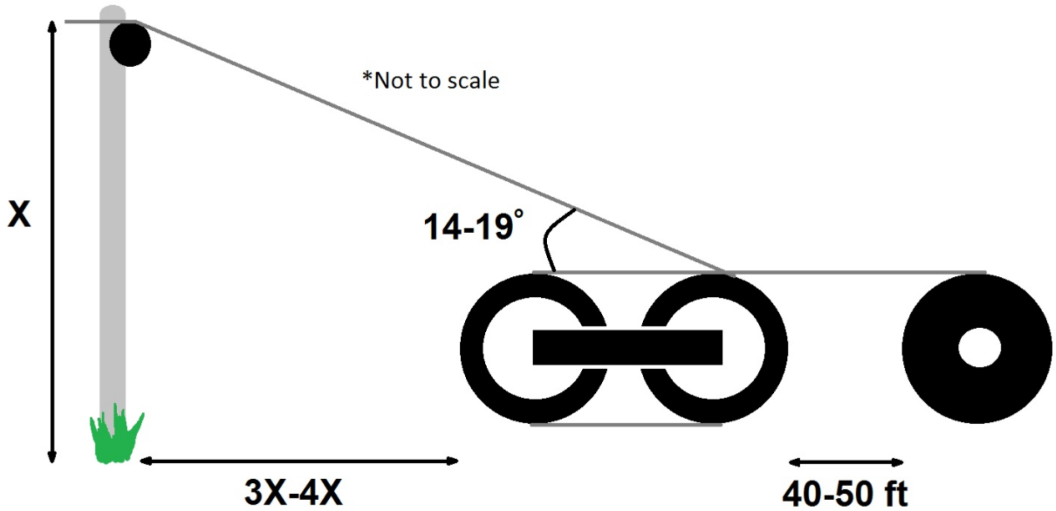

Figure 3: Orientation for bullwheel/payoff setup.

Stringing Sheaves/Blocks

Standard blocks used for bare conductor should be used for C^{7}® Tree Wire. A minimum bottom groove diameter of 10 times the cable diameter is recommended for tangent structures and partial turns (less than 20°). For entrance blocks and pulls with a structure offset greater than 20°, this diameter needs to be increased to 20 times the cable diameter. Measurement A in Figure 4 below shows where to measure the bottom groove diameter.

The minimum radius at the base of the groove is recommended to be 1.1 times the radius of the cable. The location of this measurement is shown as Measurement B in Figure 4. Sheaves with a groove radius as above may, in general, be used with smaller cables.

The minimum depth of the groove should be 1.25 times the cable diameter. This measurement is given as Measurement C in Figure 4. The flare of the grooves should be between 12-20° from vertical to facilitate the passage of swivels, grips, etc., and to contain the cable for angled pulls.

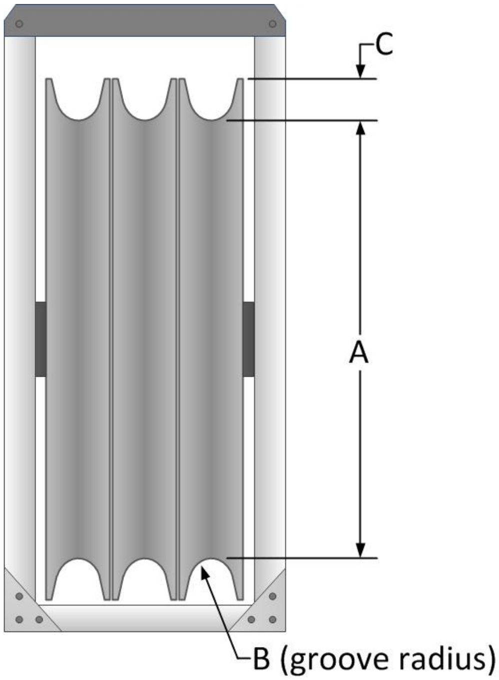

Figure 4: Measurements for stringing sheave.

Sheaves should be lined with neoprene or polypropylene to increase bearing area and prevent abrasion of the cable. Sheaves must be free-wheeling. Rough handling of sheaves can result in inadequate performance, so make sure all sheaves are in proper working order before use.

Temporary Grounds

To avoid any surface potential on the cable, a rotating ground should be installed on the payoff reel prior to installation.


Figure 5: Rotating ground.

Stringing and Sagging

To avoid damaging the cable, tension stringing is recommended. The maximum recommended pulling tension during the stringing operation should not exceed that necessary to maintain clearances above obstructions on the ground or safety structures. Recommended stringing tensions are between 5-10% of the rated breaking strength of the cable and must never exceed 50% of sagging tensions. Recommended pull speeds are between 2-5 mph (5-8 kilometers per hour).

Any cable that is to be left in the sheaves for an extended period of time can be damaged. Since it is not secured, weather and other factors can cause slack to move from sheltered span to more exposed spans during times of high wind. Temperature changes can also cause slack to travel across the blocks from the long spans to the short spans and vice-versa. Southwire recommends that any cable be pulled up to sag and clipped in as soon as possible. IEEE 524 recommends the cable remain in the stringing block no longer than 72 hours. The attachment points can be marked immediately after sagging if the cable must be left in the blocks for an extended period of time. If a cable must be left in the sheaves for an extended period of time, it should be left at a tension less than 50% of sagging tension, close to pulling tension, to prevent creep from affecting the sag values. Upon request, Southwire will recommend creep correction factors if a line was held above 50% of sagging tension for longer than several hours required for clipping in.

Cable Stripping

Conductor coverings and inner layers are stripped to expose the conductor for the purpose of installing grips, dead-ends, splices, taps, and personal protective grounding hardware. A stripping tool designed specifically for tree wire, in conjunction with a rubber strap wrench or similar counter torque tool, should be used to strip the covering and inner layers. The counter torque tool will help to prevent line rotation without damaging the covering. A recommended stripping tool is the Speed Systems Model 2900 Aerial Tree Wire/Spacer Cable Insulation Stripper. This stripping tool can be used for 5kV-35kV aerial cables for mid-span and end stripping. Its blade adjusts for insulation up to 300 mil thickness and is field replaceable.

Knives or heat torches are not recommended. The wrong tool, a dull blade, or a poorly maintained tool may result in difficulty removing the cover as well as conductor damage.

Before removal of the covering, clean the outer surface of the C^{7}® Tree Wire using an approved cleaning wipe at least 18” beyond the end of each section to be removed. Test the depth of the blade on the stripping tool on a scrap piece of wire before stripping the conductor to ensure clean cuts of the covering. It is crucial not to nick the conductor while stripping the covering. Proper tool operation depends on both the conductor diameter and the cable diameter. If the conductor is nicked, its mechanical strength and current carrying capability could be affected, and the blade of the stripping tool could be damaged. Once the blade is properly set, it should not require further adjustment. When skinning C^{7}® Tree Wire, keep the skinning tails short enough so as not to allow them to contact ground or another phase.

Figure 6: Speed Systems Model 2900 Aerial Tree Wire/Spacer Cable Insulation Stripper

Cable Grips

All grips used for C^7® Tree Wire must be properly sized for the cable type, diameter, and working installation tension. Prior to use, grips must be inspected to ensure they are in good operating condition and tested for holding strength on the cable to be installed. Southwire recommends taking a section of the cable to be installed and, using two line trucks as temporary anchors, testing the holding strength of the grips using a chain hoist and dynamometer to verify grip holding strength. During testing, grips should not slip when subjected to a minimum tension of 110% of the working installation tension. Refer to the grip manufacturer's instructions for installing grips on C^7® Tree Wire. The following grips may be used for C^7® Tree Wire:

For pulling:

- **Basket Grips:** Also referred to as a Kellems grip, a basket grip is the only acceptable grip for pulling C^7® Tree Wire. Basket grips must be double-banded on the end to prevent slipping. Friction tape should be used under the basket grip. Refer to the manufacturer instructions for proper applicable and use of a basket grip on tree wire.


Figure 7: Basket grips.

A swivel is required between the Basket grip and pull line or between grips if multiple reels are tied together (double-socked) for longer pulls. The swivel will allow the cable to rotate freely during the pulling process. The swivel should be periodically tested under load.

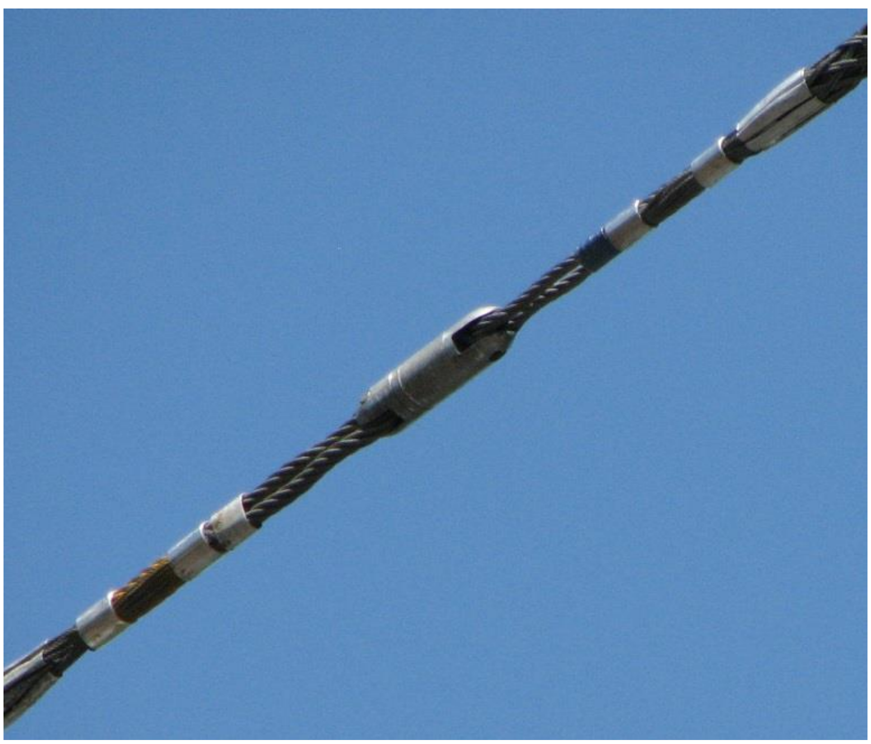
Figure 8: Swivel.

For sagging:

- **Klein "Chicago-style":** Klein grips are available for covered conductors and should be sized for the cable diameter.

- **Preformed** grips use pre-shaped wire to impart compression on the cable. These grips should be sized for the cable diameter.

Other grips may be determined to be applicable for use with $C^{7®}$ Tree Wire. Any grips should be qualified by the manufacturer for use with $C^{7®}$ Tree Wire and should be tested prior to use. Do not use grips that are not specifically authorized for $C^{7®}$ Tree Wire. Some designs, and especially range-taking grips, will transmit excessive crushing or bending force and could cause damage.

Splice, Dead-End, and Tap Connectors

Unless otherwise indicated by the hardware manufacturer, conductor coverings and inner layers must be stripped to expose the conductor before installing connection hardware. Hardware must be qualified by the hardware manufacturer for use on $C^{7®}$ Tree Wire prior to installation.

When installing dead-end hardware, cable stripping must extend 12-24 inches (305-610mm) past the dead-end clamp.

To protect from tree contact, splices must be covered with a splice covering. Additional measures may be taken to use split tube wildlife covers on dead-ends, terminations, equipment bushings, and jumper wires.

Splices for adjacent conductors should not be installed next to each other. Splices should be staggered by at least 18". Conductor splices should not be installed closer than five feet from a corner structure. Ensure that all tree limbs and branches are trimmed away from the area of the conductor splices. Contact of the splice covering with tree limbs should be avoided.

Approval of hardware is completed on a case-by-case basis and depends on the conductor size, construction, and customer requirements. Check with Southwire or your hardware manufacturer for a recommendation on usage of fittings on $C^{7®}$ Tree Wire.

To prevent phase-to-phase contact and flashover potential during lightning surges, taps should be staggered a minimum of 30 inches.

Splice Coverings

Splice coverings must be dielectrically matched to the PE conductor covering. Follow the steps below for installing the splice covering.

1. Before installing the splice, place the splice covering, which should be a cold shrink tube, onto one end of the C^{7}® Tree Wire and push it back far enough to be out of the way during splice installation.
2. Using marking tape, mark the conductor covering 11” back from the conductor end on each conductor end.
3. After installing and crimping the splice, install a mastic strip on each end of the splice between the end of the splice body and the cable covering. Stretch the mastic enough to fill the space without overlapping the splice body or conductor covering.
4. Beginning at one end, approximately one-half inch onto the cable covering, apply a half-lapped layer of semi-conducting tape all the way across the mastic, crimped splice, mastic, and one-half inch onto the conductor covering on the other side of the splice. Apply sufficient tension to the tape to achieve a good smooth surface. **DO NOT** extend the semi-conducting tape any further out on the conductor covering than the recommended one-half inch.
5. Beginning one-half inch from the inside of one of the marks on the conductor covering that was made in Step 2, apply a half-lapped layer of insulating tape. Extend the tape to within one-half inch of the inside of the mark on the cable covering on the other side of the splice. Both marks should still be visible.
6. Position the cold shrink tube over the splice area and align the end without the core ripcord directly over the cable marking. Start pulling the ripcord out and rotating around the conductor as the ripcord is pulled. The silicone tube will shrink around and securely seal the splice.

Spooling and Training

Contact Southwire before respooling or rewinding the cable onto a different reel. A limit of 35 times the cable diameter should always be maintained during temporary training and other handling situations. Damage to the core may self-identify. If a permanent “set” or kink is seen, it should be cut out and replaced with a splice.

Structure Guying

As with any overhead construction, all horizontal loads on non-self-supporting structures need to be properly and separately guyed. This includes all primary circuits, secondary circuits, and communication circuits. Strong consideration should be given to using separate anchor attachments for each guy attachment. In addition, all unequal tangent loads should be evaluated to ensure adequate support for the circuit and structure.

Full load calculated for the attached circuits must be considered when calculating the required strength of the guy wire strand. Loads include all ice, wind, and special loads used in designing the circuit(s). Guy wire strand shall be sized to adequately hold the design tensions along with the appropriate safety factors as spelled out in the NESC. Multiple guy wires may be used to hold loads more than the rating of one guy wire provided the pole attachments and anchors are also sized to handle the design loads. Anchor assembly sizing should consider soil conditions and the strength of the guy wire attachment.

The preferable pole attachment point for guy leads is the backside of the circuit support hardware. When this is not possible, guy attachments should be as close to the same level as the load they are counteracting. Guy leads, which are the distance from pole to anchor attachment point, should be designed such that, when the pole height is divided by the guy lead, the result is less than 2. This helps to ensure that the guy wire tension and pole column loading are within manageable limits. If the recommended guy lead is not possible, special care should be taken to ensure that the pole has adequate strength for the column forces that will be exerted from both the circuits attached to the pole and the resultant down force from the guy attachment.

Insulators

Pin-post polyethylene (PE) insulators and PVC plastic line ties are recommended to use with C^{7}® Tree Wire (conductor covering should not be removed). Post-type clamp-top insulators are not recommended for C^{7}® Tree Wire. For voltages up to 15kV, gray PVC ties (covered PE tie wire) should be used to secure C^{7}® Tree Wire at insulator locations. For voltages up to 35kV, black semi-conductive PVC ties should be used.

PE vice-top insulators with nylon inserts have also been successfully utilized by utilities. Nylon torque bolts with breakaway heads are recommended to avoid excessive compression force on the cable.

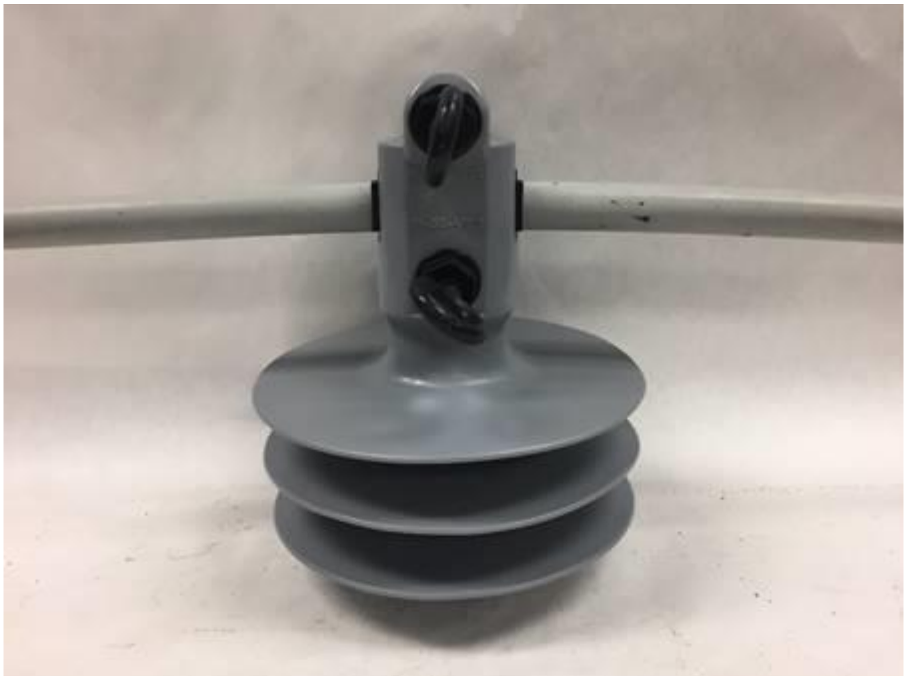

Figure 9: 33kV Vice-Top Insulator.

Follow these guidelines when utilizing insulators for C^{7}® Tree Wire:

1. Do not strip the conductor covering when installing on an insulator.
2. Do not use porcelain insulators, especially radio-free post-top. For purposes of dielectric matching, use only PE insulators.
3. Do not use bare tie wires.

Clearance Requirements

The National Electric Safety Code C2-2017 states, “Covered conductors shall be considered bare conductors for all clearance requirements except that clearance between conductors of the same or different circuits, including grounded conductors, may be reduced below the requirements for open conductors when the conductors are owned, operated and maintained by the same party and when the conductor covering provides sufficient dielectric strength to limit the likelihood of a short circuit in case of momentary contact between conductors or between conductors and the grounded conductor. Intermediate spacers may be used to maintain conductor clearance and to provide support.”

Sagging Methods

Cable sagging involves the use of stringing tables to determine the required sag or tension at a specific cable temperature. Cable is often tensioned to the correct sag/tension using one of the following three methods: the dynamometer method, stopwatch method, or transit method. It is important to keep in mind that over-tensioning the cable at initial installation will result in excessive load both on the cable and guy hardware during winter “storm-loaded” conditions, or during below 0°F temperatures. This could result in pole top splitting, pulled anchors, broken guy attachment hardware, and broken thru-bolts.

Dynamometer Method
In the dynamometer method, a dynamometer is inserted in-line with the sagging equipment to get a direct measurement of line tension in the line. There should be minimal sheaves between the dynamometer and span being measured. This method works best on smaller cables, shorter spans, and ruling spans containing one or two spans.

Transit Method
The transit method includes three types of sagging methods: calculated angle of sight, calculated target, and horizontal line of sight. Choice of the best transit sagging method to use is determined by the terrain of the span in the right-of-way and span length. Tall structures on flat terrain and short spans indicate the calculated target or horizontal line of sight method would be most applicable. Steep slopes, long spans, and large sags indicate the calculated angle of sight method would be best.

Surge Arresters

Overvoltage events can lead to conductor covering and inner damage if the overvoltage initiates an arc. Surge protection using properly located arresters will significantly reduce the changes of burndown. To mitigate potential damage to the covered conductor, surge arresters must be installed periodically along the line, especially at points where the bare conductor is exposed, to eliminate excessive overvoltage. Surge arresters must be installed at:

1. All locations where the covering has been stripped and bare conductor exposed, including where bare conductor is connected to C^{7}® Tree Wire
2. All dead-end locations
3. Pole closest to splices
4. All junctions with connecting circuits
5. Both sides of switching device locations
6. All transformer locations
7. Taps and all other connection points
8. Load side of fused cutouts, where practical

Some utilities have included internal guidelines to require 4-8 arresters per phase per mile. Surge arresters, when placed on a pole for the protection of apparatuses or transformers, shall be located on the same pole. In this case, a secondary neutral ground should be placed on an adjacent pole whenever possible. Any transitions from bare conductor to C^{7}® Tree Wire (or vice versa) using potheads shall have surge arresters installed close to the potheads. Arresters installed one or two spans from a junction are ineffective and render the C⁷® Tree Wire vulnerable to damage and burndown. Arresters should be located as close as practical to the covered conductor being protected.

An arc protection clamp can also be utilized in skinned areas.

C^7® Tree Wire Maintenance and Operation

Although regular maintenance (e.g., tree trimming) is still required, C^7® Tree Wire can help to reduce regular maintenance costs. Regular tree trimming must be continued, but tree limbs may be allowed to grow closer compared to bare conductor circuits. Constant contact with grounded objects such as tree limbs must be avoided.

Inspections should be performed on a regular basis, likely more often than bare circuits, to ensure the entire service life is preserved. Company practices for line inspection and maintenance vary according to the service environment. Some items to consider for any tree wire:

- Regular fly-by or drive-by patrols should look for ROW encroachments, covering puncture or erosion, and other issues that need follow-up repair or attention. Monthly is a common interval for cursory inspections.

- Review system operation and system protection to avoid long-term overloads. The three-layer insulation system is rated for 90°C continuously and 130°C for a maximum of 2000 hours during the life of the line. Cable temperature should never exceed 130°C.

- System grounding requirements should be followed. When installing temporary grounds, avoid removing any more covering than that necessary to install grounds. Use a previously stripped area when possible. Non-contact voltage indicators may be used for C^7® Tree Wire.

- Climbing inspections are sometimes needed to check the condition of the hardware and other small parts that are subject to wear. Drone technology and high-resolution imagery are becoming competitive with climbing inspection for detecting issues that are not visible during fly-by or drive-by inspections.

- Maintenance should be accomplished using the same rules as are used for bare conductor systems.

- Hot-line maintenance should also assume bare conductor. Further, realization of differences in construction should be considered. Cover-up practices should be extended to all phases.

C⁷® Tree Wire Repair

If the cable damage includes evidence of over-bending, kinking, or crushing, the suspect section should be cut out and a splice installed. If the damage is limited to conductor covering abrasion, repair the damaged section with a cold tube as referenced in the Splice Covering section of this guide.

Common Problems

Many of the problems concerning the use and operation of C⁷® Tree Wire come from assuming that the same parameters as those of bare conductor apply. Common problems are:

- Improper circuit design or operation
- Treatment of tree wire systems the same as bare
- Use of porcelain insulators instead of PE insulators
- Improper utilization of lightning arresters leading to covering punctures
- Damaged conductor at pin hole caused by surge flashover
- Conductor taps too close together
- Conductors installed too tight
- Inadequate guying
- Inadequate pole strength
- Improper dead-ending
- Corners installed using tangent brackets
- Irregular inspection
- Irregular or improper maintenance (e.g., tree trimming)
- Assuming the system is self-sustaining

References

IEEE Standard 524-2014, "Guide to the Installation of Overhead Transmission Line Conductors."

National Electric Safety Code C2-2017

ICEA S-121-733 "Tree Wire and Messenger Supported Spacer Cable"

ICEA S-70-547 "Weather-Resistant Polyethylene Covered Conductors"