GUIDE FOR THE INSTALLATION OF BARE OVERHEAD CONDUCTORS

Southwire recommends that conductor installations be performed in accordance with IEEE 524 "Guide to the Installation of Overhead Transmission Line Conductors". This guide is intended to summarize best practices for installing standard conductors.

Reel Handling and Storage

Special care should be taken to ensure the conductor and reels are not damaged. Unloading equipment must never come in contact with the conductor. Lifting must be performed using a fork lift or crane as described below.

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

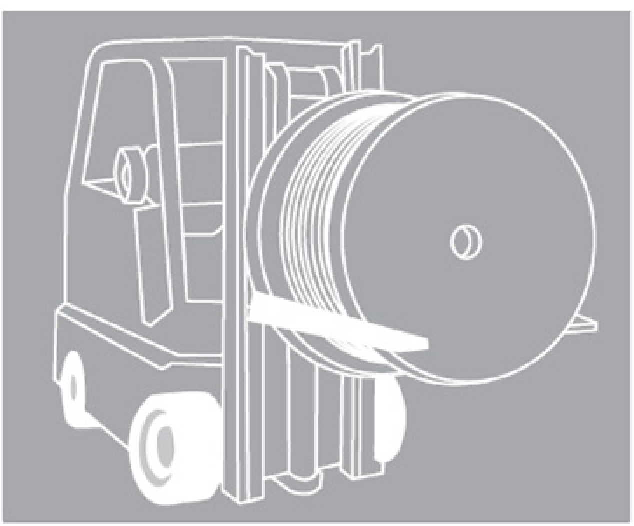

Figure 1. Forklift handling of reels.

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 conductor. “J” hooks should be placed in the arbor holes. Axles should be inserted through the arbor holes and lifted with straps.

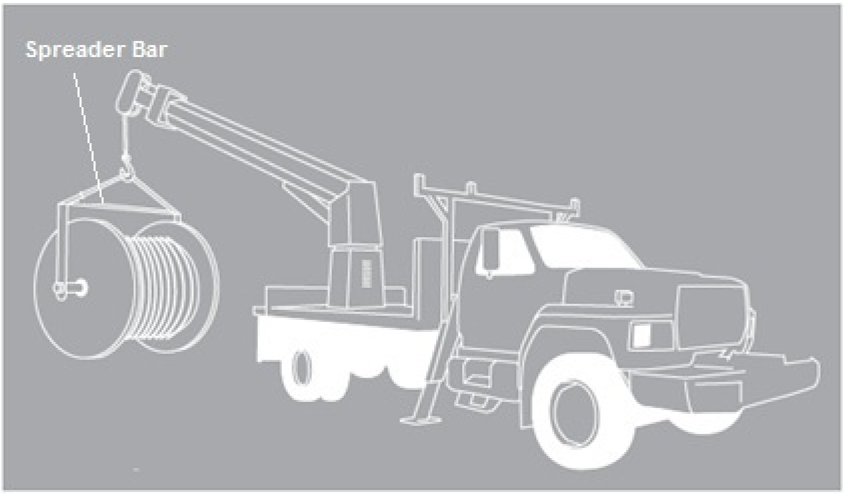

Figure 2. Crane handling of reels.

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

Conductor Oxidation

Exposure of conductor to air will cause oxidation to form on the conductor. Oxidation results from a chemical reaction between oxygen and aluminum, yielding an oxide layer on the conductor. While it is normal for oxidation to form, necessary steps should be taken to clean the conductor of oxidation at hardware application areas. The conductor must be brushed in these areas prior to installing hardware to ensure adequate metal-to-metal contact.

Figure 3. Oxidation on a conductor.

Conductor Staining

When conductor reels are stored outdoors, moisture can accumulate on the conductor on the underside of the reel. If the moisture contains chemicals from the surrounding atmosphere, a black stain can appear on the conductor. This has been found to be more prevalent in non-specular conductor because the drawing oils have been removed. Figure 4 shows the appearance of a water stain.

Figure 4. Water stain on conductor.

Water stains are a cosmetic issue; they have no adverse effect on the performance or service life of the conductor. In most environments, the conductor will darken in the first few months after the line is energized, and the stain will no longer be noticeable. Aluminum Association Technical Bulleting TR3, "Guidelines for Minimizing Water Staining of Aluminum" discusses this issue in detail and contains advice for avoiding water staining.

Conductor Handling

If conductor must contact the ground due to unavoidable circumstances, a smooth, rigid material may be laid in its path to prevent damage. Minor abrasions should not be a cause of concern; most can be sanded or buffed out. In an EHV application, the abrasion should be evaluated for possible corona concerns.

Spooling and Training

The minimum diameter for spooling is 30 times the conductor diameter. The minimum bending radius, or training radius, before permanent deformation occurs is 12 times the conductor diameter.

INSTALLATION

Payoff

The conductor reel should be set up on a reel payoff stationed 40-50 feet (12-15 meters) behind and in line with the bullwheel tensioner. This will ensure that the conductor does not scrub the flanges as it is being unwound[1].

Figure 5. Payoff and bullwheel setup.

Proper adjustment of the fairlead roller guides is necessary to prevent scuffing of the conductor as it reeves through the bullwheel. Only enough braking tension should be applied to the reel to prevent the reel from over-rotating (free-spooling) when the pulling operation stops. A slight droop between the payoff and bullwheel is desirable, as this indicates low tension between the bullwheel and payoff. Back tension should be kept at a minimum. This is especially important for smaller conductor diameters and wooden reels[2]. If too much back tension is applied, the conductor on the outer layer can "pull down" into the underlying layers, as in Figure 6.

[1]IEEE Standard 524-2016 pg. 62, [2]IEEE Standard 524-2016 pg. 69

Figure 6. Conductor pulldown.

Bullwheel

Only dual drum multi-groove bullwheel tensioners are recommended for multilayered conductor[3]. The bullwheel drums may be tilted or offset so that the offset will be approximately one-half the groove spacing[4].

Figure 7. Dual drum bullwheel, courtesy of Oncor.

[3]IEEE Standard 524-2016 pg. 52, [4]IEEE Standard 524-2016 pg. 82

Semicircular grooves with depths of 0.5 or more times the conductor diameter and flare angles of 5-15° from vertical generally are recommended. For multilayer conductors, the number of grooves in the bullwheel must be sufficient to prevent the outer layer of wires from slipping through underlying layers. The minimum bottom groove diameter of the bullwheel should be 39 times the conductor diameter minus 4 inches (10 centimeters). Additional sizing charts and diagrams can be found in IEEE Standard 524[5]. Bullwheels must be properly sized and lined to prevent scuffing and damaging of the conductor.

The conductor should be reeved through the bullwheels such that, when facing in the direction of pull, the conductor will enter the bullwheel on the left side and exit from the right. This orientation is necessary to avoid any tendency to loosen the outer layer of strands[5].

If lined, durable polymer-lined grooves are recommended to avoid permanent scuffing of the surface of the conductor. Semiconducting linings should not be relied on for grounding purposes[5].

It is important never to break the conductor over a small roller under high tension, as this can permanently damage the conductor. Figure 8 shows an example of the conductor traveling over a small roller (not recommended); Figure 9 shows a suitable roller diversion technique.

Figure 8. Adverse interaction of conductor with roller, courtesy of Transpower New Zealand.

[5]IEEE Standard 524-2016 pg. 52-53


Figure 9. Suitable technique for roller diversion, courtesy of Transpower New Zealand.

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 distance from the base of the structure to the height of the entrance block at the first structure[6]. This is important to ensure the conductor is not pulled over the entrance block at a large angle.

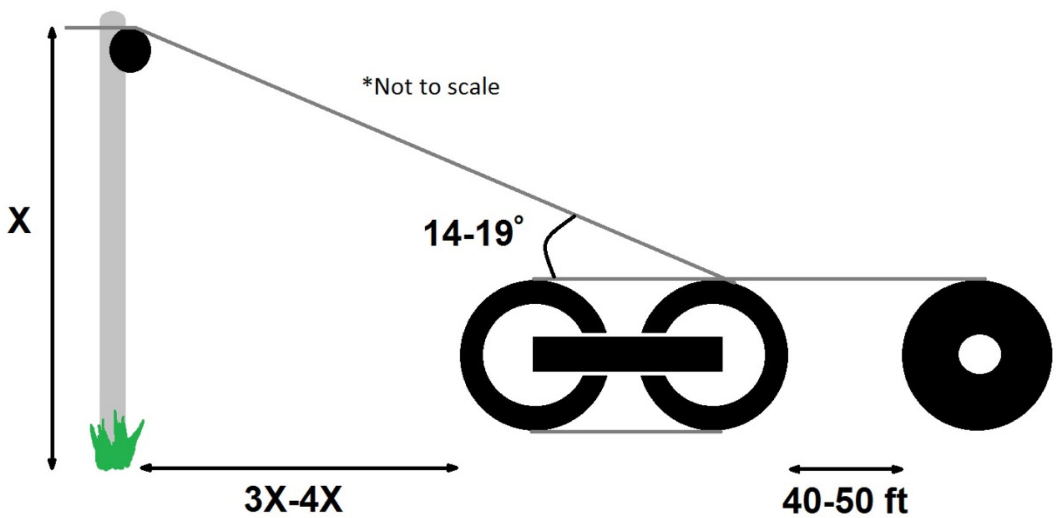

Figure 10. Orientation for bullwheel/payoff setup.

Stringing Sheaves[7]

Sizing recommendations for sheaves should be made by the sheave manufacturer, but typical sizing criteria are discussed below.

[6]IEEE Standard 524-2016 pg. 61, [7]IEEE Standard 524-2016 pg. 55-57

A minimum bottom groove diameter of 20 times the conductor diameter minus 8 inches (20 centimeters) is generally used for typical pulls [i.e. pulls less than 2 miles (3 kilometers) with level spans and minimal angles]. For pulls over 2 miles (3 kilometers) or with substantially uneven terrain, the bottom groove diameter should be increased by 4 inches (10 centimeters). **Bottom groove diameter should never be less than 12 times the conductor diameter.** Entrance sheaves are typically sized at 20 times the conductor diameter. Higher tension pulls or structures with a turning angle greater than 20° may also warrant larger sheaves. For angles between 20-45º, a bottom groove diameter of 25 times the conductor diameter is typically recommended. For angles up to 90º, two sheaves with bottom groove diameters of 25 times the conductor diameter are typically recommended. Sheaves on structures with a turning angle should be supported so that the conductor acts through the center line of the sheave. Measurement A in Figure 11 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 conductor. The location of this measurement is shown as Measurement B. Sheaves with a groove radius as above may, in general, be used with smaller conductors. However, the more layers of aluminum that exist, the more important it is to have a well-fitting groove.

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

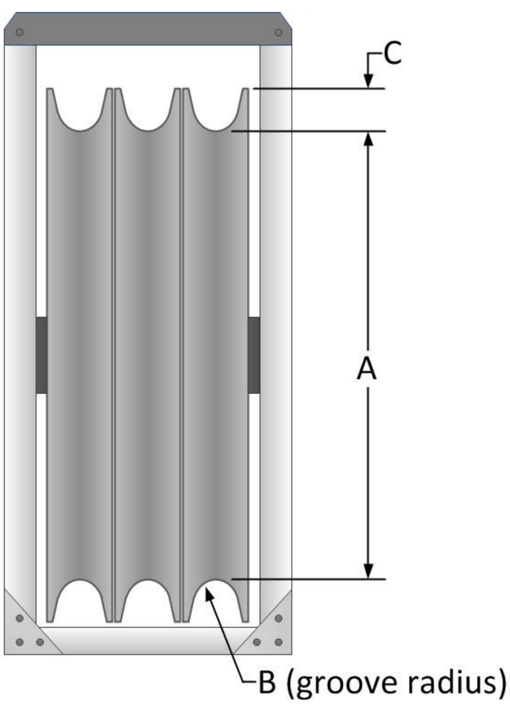

Figure 11. Measurements for stringing sheave.

If lined, sheaves should be lined with a durable polymer to protect against scratching of the conductor. Sheave bearings must be in good working condition and free-wheeling. Make sure all sheaves are in proper working order before use.


Figure 12. Stringing sheave.

Running Grounds[8]

Running grounds should be installed along two points in the pull—one between the reel stand or tensioner and first structure, and the other between the puller and last structure. Running grounds should be bonded to the established ground and free-wheeling. They should not be over tightened, as this could cause surface abrasion or birdcaging.

Conductor Stringing and Sagging

To avoid damaging the conductor, 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 (RBS) of the conductor and should not exceed 50% of sagging tensions. In circumstances where the tension must exceed 50% of sagging tensions, contact Southwire for a recommendation on creep correction. Typical pulling speeds are between 3-5 miles per hour (5-8 kilometers per hour)[9].

[8]IEEE Standard 524-2016 pg. 66, [9]IEEE Standard 524-2016 pg. 68

Southwire recommends that any conductor be pulled up to sag and clipped in as soon as possible. The conductor should not be left in the sheaves for more than 24 hours before being pulled up to sag. If tension must be reduced after sagging (due to vibration concerns, equipment availability, etc.), the attachment points should be marked immediately after sagging. The conductor should be clipped in within 72 hours of stringing[10]. If a conductor 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). If this tension is exceeded, contact Southwire for a recommendation on creep correction.

Sagging Methods[11]

Conductor sagging involves the use of stringing tables to determine the required sag or tension at a specific conductor temperature. Conductor temperature should be measured at the time of sagging using a conductor thermometer placed at or near the conductor. The conductor thermometer should be installed prior to sagging to allow for temperature stabilization. Conductor is often tensioned to the correct sag/tension using one of the following three methods: (1) stopwatch method, (2) transit method, or (3) dynamometer method.

Stopwatch Method
The stopwatch method involves jerking a rope connected to the conductor and measuring the time it takes the vibration wave to reflect a certain number of times. Three or five return waves usually provide an accurate measurement of sag. The governing equation for the stopwatch method can be seen below.

$$D = 48.3\left(\frac{t}{2n}\right)^2$$

D = conductor sag, inches
t = time, seconds
n = number of return waves

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.

Dynamometer Method
In the dynamometer method, a dynamometer is inserted in-line with the sagging equipment to get a direct measurement of line tension.

[10]IEEE Standard 524-2016 pg. 78, [11]IEEE Standard 524-2016 pg. 73-74

To ensure accurate sagging, there should be minimal sheaves in the line section. This method works best on smaller conductors, shorter spans, and ruling spans containing one or two spans.

Conductor Repair

Repair methods may include use of armor rods or a repair sleeve to reestablish the full current carrying capacity. Please consult the hardware manufacturer for their recommendation on use of armor rods or a repair sleeve.

Disclaimer: All conductor hardware must be approved by the hardware manufacturer for use with the conductor prior to installation. Please consult the hardware manufacturer for more information on proper application.

Miscellaneous

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References

IEEE Standard 524-2016, "Guide to the Installation of Overhead Transmission Line Conductors."

Thrash, Ridley, Kim Nuckles, Amy Murrah, and Mark Lancaster. *Overhead Conductor Manual 2nd Edition*. N.p.: Southwire, 2007. Print.