SIMPLIFIED STAKING MANUAL FOR OVERHEAD DISTRIBUTION LINES

Fifth Edition

PROJECT 07-03 | SEPTEMBER 2023

NRECA
America's Electric Cooperatives

Business & Technology Strategies

APPENDICES

- Appendix A: Assembly Numbering, RUS Bulletin 1728F-804, 12.47/7.2-kV Specs
- Appendix B: Sag and Tension Tables
- Appendix C: Horizontal Pull and Total Guy Load at Angles for 30- to 55-Foot Poles Using Grade C Construction

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The National Rural Electric Cooperative Association

The National Rural Electric Cooperative Association (NRECA), founded in 1942, is the national service organization supporting more than 900 electric cooperatives and public power districts in 48 states. Electric cooperatives serve 42 million people, including 92% of persistent poverty counties, and power more than 21 million businesses, homes, schools, and farms. NRECA harnesses research and development to benefit its electric co-op members in addressing the opportunities and challenges of our evolving industry, and maintaining economical and reliable electricity for their consumer-members. For more information on cooperatives, see the Electric Cooperative Fact Sheet and, for additional resources for members, visit **cooperative.com**.

Simplified Staking Manual for Overhead Distribution Lines—Fifth Edition

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acknowledgments

This simplified manual on the techniques of staking distribution lines is the culmination of countless hours of effort by many fine individuals. The manual is now in its fifth edition, which proves its value to our industry as a reference book and a learning tool.

The dedication of the lead author, W. Richard Lovelace of Hi-Line Engineering, LLC, to this project made this manual a reality. His diverse experiences as a lineman, staking engineer, and an instructor were invaluable to this project. Kevin Mara, P.E., provided input and direction to the original edition. He also managed the subsequent revisions with assistance from Mathew Pamperin, Braxton Underwood, and Linda Gray.

The original undertaking to create this manual was managed by Robert C. Dew, Jr., P.E., with valuable technical support provided by John A. Rodgers, P.E., Linda Gray, and Joe L. Thebeau.

The changes for the Fifth Edition were the responsibility of Kevin Mara.

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1 Introduction and Overview

In This Section: Purpose Overview

Purpose

The purpose of this manual is to simplify the staking of overhead distribution lines. The motivation for this manual is the continued loss, mostly through retirement, of experienced field engineers who are specialists in the staking of distribution lines. NRECA is helping to fill the gap caused by the loss of these staff members by creating a good reference document to train new staking technicians. In this manual, the term "staking" is all-encompassing and means the complete mechanical design and field layout of overhead distribution lines.

The objective of this manual is to provide a reference tool for staking technicians that will help acquire a basic working knowledge of the correct principles and practices of distribution line staking.

Overview

The staking of a distribution line consists of the selection of the various physical components—such as conductors, poles, pole-top assemblies, guys, and anchors—that compose distribution structures. It includes the proper location and positioning of stakes to mark the location of these structures to provide safe, reliable, and efficient construction of distribution lines. The target audience is novice staking technicians; therefore, many advanced applications in staking are not throughly covered, such as designing for extreme wind and extreme ice. Basic information is presented to expose those new to line design and provide a foundation for further learning.

The quality of the design depends on the staking technician's knowledge, experience, and degree of skill applied to the job.

Tables, illustrations, photographs, and rules of thumb are provided throughout the manual. All calculations have been simplified to their fundamental components for ease in understanding. After learning the fundamentals, more advanced applications of both formulas and principles are provided so that staking technicians can expand the realm of their learning. This manual contains information on a limited number of conductors. It is assumed that staking technicians will carry into the field similar tables for conductors used on their system.

It is recommended that the staking technician study the sections in this manual in the order presented after becoming familiar with the *National Electrical Safety Code (NESC);* current RUS specifications and drawings; and RUS Informational Publication 202-1, "List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers" (List of Materials), current updates of which are available on the RUS Web site.

Additionally, since the second edition of the *Staking Manual* was published in 2002, there have been a number of new RUS bulletins on distribution system design and construction. Foremost among them is the new Bulletin 1728F-804, "Specifications and Drawings for 12.47/7.2-kV Line Construction," dated October 2005. This new construction specification has many changes, including assembly number changes, upgraded construction and strength of certain assemblies, and new narrow profile assemblies. Additionally, the Appendix contains a number of tables and other design aids for the staking technician. Furthermore, the following bulletins contain valuable information, calculations, design guides, etc., for the staking technician. These bulletins are available on the RUS Web site, **https://www.rd.usda.gov/resources/regulations/bulletins**, and are listed here as valuable reference material:

- 1724E-150, Unguyed Distribution Poles—Strength Requirements (08/14/2014)
- 1724E-151, Mechanical Loading on Distribution Crossarms (02/23/2016)
- 1724E-152, The Mechanics of Overhead Distribution Line Conductors (7/30/2003)
- 1724E-153, Electric Distribution Line Guys and Anchors (4/25/2001)
- 1724E-154, Distribution Conductor Clearances and Span Limitations (7/30/2003)

RUS policy requires borrowers to construct their lines in compliance with the current *NESC*, except where local codes and RUS bulletins or directives are more restrictive. The cooperative must conform to the legal safety code of the administrative authority that has legal jurisdiction over the cooperative.

The first edition of this manual was based on the 1993 edition of the *NESC*. The second edition was based on the 2002 *NESC*. The third edition was based on the 2007 *NESC*. The fourth edition was based on the 2012 *NESC*. This fifth edition is based on the 2023 *NESC*. Applicable text, tables, and calculations have been revised to reflect the changes from previous codes to the current edition of the *NESC*.

It must be the responsibility of the staking technician to become well-versed in the *NESC* and other regulations that govern the construction of electric distribution lines so that later editions of the codes can be correctly applied.

The staking technician is encouraged to become familiar with the original text and interpretations of the current edition of the *NESC*. He/she should be alert to changes that may occur from one edition to another. This *Staking Manual* is not intended as a replacement for the *NESC*, but as a training aid based on *NESC* requirements.

The 1990 edition of the *NESC* was specifically revised to delete the use of the word "minimum" because the term was often misinterpreted as some kind of minimum number that should be exceeded in practice; such is not the case. The values in the *NESC* indicate the clearances that are required for safety purposes. In some cases construction tolerances or additional separation have been added to the tables to aid novice staking technicians who may need the extra margin of clearance until they are more confident in their designs. It should not be confused as overriding the basic clearances found in the *NESC*. Many of the tables included in this manual are adapted from the *NESC*.

Throughout this manual, there are references to the 2023 *NESC* rules, tables, figures, and footnotes. Where references are made, the staking technician must refer to the *entire* rule, table, or figure and not just the excerpt.

As a final review of Sections 1 through 10, which are designed as modular learning building blocks, Section 11 is provided to challenge the staking technician's expertise and to demonstrate the use of the newly acquired information. The staking technician is given two comprehensive staking situations:

1. A short single-phase line extension to a residential consumer
2. A moderate but challenging three-phase line extension to an industrial consumer

Extra-large conductor considerations and design parameters are introduced and explained in Section 12. Here the staking technician is exposed to the challenges of designing line using extra-large conductors while using standard RUS distribution materials.

Upon completion of this manual, the staking technician will be familiar with the necessary tools and information that make possible safe and reliable distribution line construction.

2 Field Staking Practices and Procedures

In This Section:

Staking is not simply placing wooden stakes in the ground to mark the location of a proposed pole line. Rather, staking is a complete engineering evaluation of all the conditions surrounding the choice of each structure and its location prior to driving the first stake, as well as the placement of those stakes. A properly staked line will result in adequate construction at minimum costs, while a poorly staked line will result in substandard construction, unnecessary delays, possible restaking, and invariably higher cost.

Technical terms used in this section can generally be found in the glossary and in subsequent sections of this manual.

Examination of Local Conditions

To fully evaluate the conditions affecting the choice and placement of a structure, the staking technician must consider the following local conditions:

- Terrain
- Existing facilities
- Right-of-way
- Problem consumers or landowners

TERRAIN

A cursory inspection of the overall topography along the proposed route will provide an idea of environmental conditions to be addressed.

EXISTING FACILITIES

An evaluation of the existing poles and assemblies should be made to determine the following:

- Can the existing structure be reused?
- Will replacement of the structure be required?
- Can the existing services be integrated into the new line?

RIGHT-OF-WAY

An examination of the right-of-way along the proposed route should be made to gain the following information:

- The quantity and type of trees and brush to be cleared or trimmed
- The easements that must be obtained from property owners
- The encroachment permits that must be obtained to locate structures on property owned by state or local agencies (highway rights-of-way), railroads, the gas company, and other utilities

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PROBLEM CONSUMERS OR LANDOWNERS

It is desirable that the staking technician determine the location of any potential problem consumers or landowners along the proposed route of construction prior to the placement of any stakes. Judgments should be made based on personal experience, knowledge gained from inquiries of other cooperative employees, or from personal contacts with neighboring landowners. Notes should be made to describe any special procedures necessary to deal effectively with these problem consumers or landowners.

Practical Structure Location

CONTROL POINTS

A control point is a point along the route that definitely fixes the location of a structure.

On any line, there will be certain points that will fix the location of structures. Such points may occur at stream crossings, transformer locations, branch tap locations, and angles in the line.

The first control points established are those where the route obviously changes direction. During both planning and staking, other points will be found that will control the lengths of the intermediate line segments. Some of these control points will affect the exact alignment of the pole centerline. They may be due to topographic features, man-made objects, or right-of-way limitations. Other control points may establish pole locations but not affect alignment.

Typical control points include:

- Points required for junction poles or transformers and service taps
- Abrupt changes in topography, such as gullies, hills, cliffs, and waterways
- Consumer or landowner requirements, such as a pole on the property line
- Special clearance problems, such as signs, grain bins, or buildings
- Crossings (roads, power lines, railroads, and waterways)
- Changes in direction of the line
- Joint-use structures

When actual staking begins, the first step is to determine, as accurately as possible, all the control points that fix structure locations. Span-by-span staking is then done in segments between these control points.

Some of these control points are definitely fixed, and others allow some leeway that the staking engineer may use to obtain desired span lengths. Field conditions often make it necessary to shift structure locations in a few spans or perhaps increase the height of an occasional pole to obtain the best average span length. Span selection will be discussed in **Section 4**, Conductor Characteristics.

The use of guyed angle structures increases the cost of line construction, as well as operation and maintenance. Generally, the fewer angles in a line, the more economical it is to build. In most cases, it is desirable to avoid a series of small angles. This can be achieved by extending the straight line segments as far as possible.

UPLIFT

In laying out a line over rough country, it is desirable to locate poles on the high points to take advantage of increased ground clearance. If it becomes necessary to locate a pole at a low point in the line, a check should be made to determine if the conductors will be subjected to *uplift*. During cold weather, conductors will contract and approach their minimum sag values. Often this contraction will cause the conductors to pull *up* on a pole that is on a lower elevation than adjoining poles. This upward pull is known as uplift and is shown in **Figure 2.1**; it must be considered in selecting the height of the structure. Uplift is one of the most frequently found staking errors.

Figure 2.2 shows uplift of conductors on an RUS distribution structure.

In staking lines over extremely rough sections of country, it may be necessary to prepare a profile of the route to determine uplift. This will require determining the elevation of the poles relative to each other and the preparation of sag templates. This may best be accomplished by the cooperative engineer or a consultant.

Where extra-tall poles are used at locations such as crossings (wide highway, lake, etc.), it may be necessary to increase the height of adjacent poles to prevent conductor uplift. The

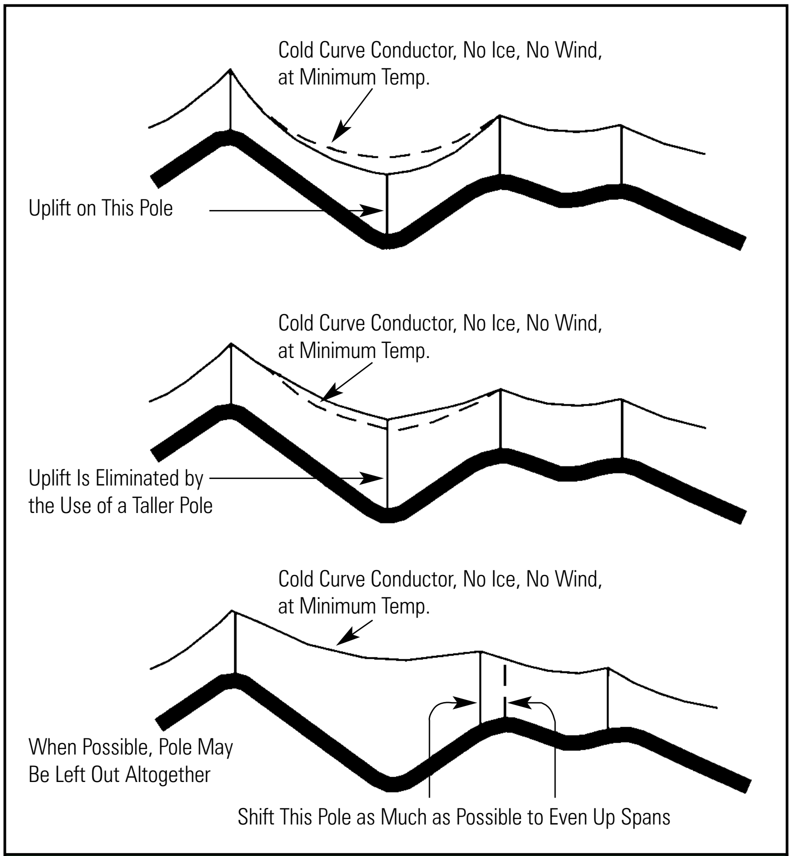


FIGURE 2.1: Uplift on Structure.

FIGURE 2.2: Conductor Uplift.

poles should increase in height (typically 5 feet taller for each adjacent span) to the maximum height required for the crossing pole and decrease in like manner, assuming that the ground beneath the affected spans is fairly level. Where sharp breaks occur in the topography, the pole heights should vary accordingly. This process is called "grading" the line.

ACCESSIBILITY

When selecting a structure location, the staking technician should consider accessibility to the site by line construction crews, vehicles, and equipment. Terrain such as swamps, watercourses, deep ditches, and severe slopes will limit accessibility. When possible, an alternative location should be selected to allow better access to the work site. Remember, a contractor may build the line, but the cooperative will have the responsibility of maintaining it.

Another factor affecting accessibility to the structure is landscaping. A site should be selected to avoid damage by vehicles and equipment to lawns, ornamental plants, fences, and residential driveways.

Structure locations should also be selected to avoid vehicle or equipment travel over or near septic tanks or associated septic lines.

OPERATIONAL RELIABILITY AND CONVENIENCE

When selecting a route for the rebuild of an existing line, the staking technician must determine whether to rebuild the line in place or move to a more desirable location.

Relocating the line may provide for increased reliability and efficiency in operating the circuit.

Factors affecting reliability and efficiency of operation include the following:

- Lines located in areas visible from roads allow for efficient and low-cost maintenance inspections and the ability to swiftly locate damaged structures and conductors.
- Lines located close to roads allow ease of maintenance and repair.
- Lines relocated from heavily wooded areas to along road rights-of-way or other open areas provide for reduced clearing and trimming costs as well as limiting danger to the conductors from limbs and trees.

2

It is the staking technician's responsibility to select a route and specify structures that will result in the construction of a safe and reliable distribution pole line for the lowest possible cost. Factors directly affecting the cost of a line include:

- Size and quantity of poles
- Types of assemblies
- Span lengths
- Quantity of guyed structures
- Construction methods (energized or dead work and/or accessibility)

Also, as seen above, the choice of structure location or line route adopted by the staking technician has a significant influence on operating and maintenance costs.

When staking any distribution line, the technician must be aware of the cost of larger poles and angled construction versus smaller poles and straight-line construction. Also, the technician should take into consideration if the cooperative's poles are sharing space with telecommunication, cable TV, and broadband fiber and possibly other utilities. When staking a new line or rebuilding an old line, joint use must be carefully evaluated.

Structure Selection

The final step in staking a distribution pole line is the selection of the appropriate structure to support the conductors.

Factors to be considered in determining the structure include:

- Conductor size and type
- Pole height and class
- Type of pole-top assembly
- Sizes and types of guys and anchors

The size of conductors should be determined from the cooperative's construction work plan or long-range plan, or by the cooperative engineer or a consultant. Once the size and type of conductor are established, it will control the selection of the design tension and ruling span of the pole line. (Design tension and ruling span are discussed in **Section 4**, Conductor Characteristics.)

These factors combined will then form the basis for the selection of poles, assemblies, guys, and anchors.

Poles must be chosen to provide adequate clearance and strength in supporting the conductors.

Pole-top assemblies are selected on the basis of conductor size and type and the configuration and voltage class of the circuit.

Sometimes right-of-way restrictions may dictate selection of the pole-top assembly, such as use of vertical-type construction. Similarly, the environment may dictate the need for raptor-friendly pole-top assemblies.

Guys and anchors are used to provide lateral support to prevent the structures from overturning. Selection of these guys and anchors depends on the amount of unbalanced pull on the structure, the length of the guy lead, the type of pole-top assembly, and the soil type in which the anchor is installed.

These factors regarding structure selection are discussed in the following sections of this manual. Each item is considered a building block in the total distribution pole line design package.

It is important that the staking technician understand each of these items in order to assemble these building blocks into a safe, reliable, and efficient distribution pole line.

Mechanics of Staking

Actual staking requires procedures such as running straight lines, measuring distances, and measuring line angles. The staking technician should have a working knowledge of these procedures and accurately apply them when laying out and setting stakes for a distribution pole line.

STAKING BETWEEN CONTROL POINTS

It is important to set stakes for the construction crew which results in a straight line between control points. If one of the stakes is not in line, a slight angle on the poles will result and weaken the design.

One very accurate method to align stakes uses an engineer's transit to run the line between control points. As shown in Figure 2.3, the transit may be set up and leveled over one of the control points (A), if the other point is visible. By taking a "foresight" on a range rod placed vertically at the other control point (B), the line is established. A rodman then proceeds from the transit position toward the other control point (B), and the transit operator lines the rodman in at points along the line where poles are to be placed. A stake marked with the pole number should be driven at each pole location.

If neither control point can be seen from the other, the transit may be set up at some intermediate point. This point may be on the top of a knoll midway along the centerline where range rods set at each control point are visible. The transit is set up on a point estimated to be on the centerline. A backsight is taken on one of the control points and then the telescope is reversed on its vertical axis and a foresight is taken on the point ahead. A check is then made to determine the extent to which the transit is left or right of the centerline. By repeating the above procedure one or more times, the transit is finally placed on line. This process is sometimes called "bustin' in." Once the transit location is established, intermediate stakes can then be set by the rodman proceeding along the centerline between the control points. The transit operator lines the rodman in at each pole location.

There may be some sections of line between control points where it is difficult to line in range rods because of brush, trees, crops, or other obstacles. In such instances, it may be necessary to run a parallel line along the edge of a traveled road or clear area where visibility is unobstructed. If so, a line may be run as previously described and the structure locations staked. As shown in Figure 2.4, the intermediate pole stakes are located by measuring back toward the span centerline at right angles to the temporary offset line a distance equal to the offset. If this method is used, care must be exercised to make certain that the offset control points (A' and B') are at equal distances measured at right angles to the original control points (A and B).

Another common method used for short distances and open terrain requires applying multiple range rods. The range rods can be used to establish a straight line between control points. As shown in Figure 2.5, a range rod is set at

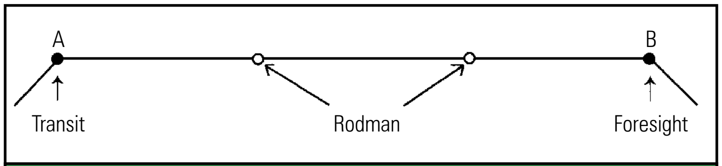


FIGURE 2.3: Running a Line Between Control Points Using a Transit.

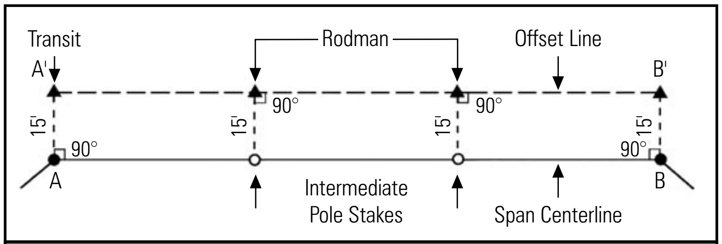


FIGURE 2.4: Location of Pole Stakes Using a Temporary Offset Line.

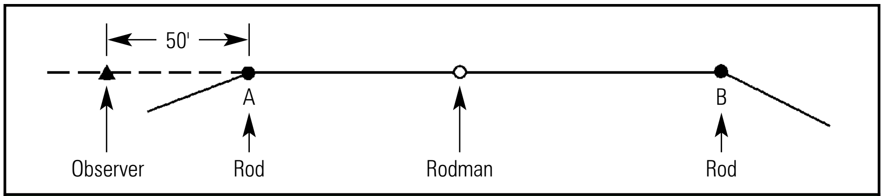


FIGURE 2.5: Use of Range Rods to Establish a Straight Line Between Control Points.

each of the two control points A and B. An observer is stationed approximately 25 to 50 feet behind point A. A rodman then proceeds toward point B and is visually lined in by the observer.

MEASURING DISTANCE USING ELECTRONIC DEVICES

The staking technician must accurately measure the span lengths for the line section he or she is staking. This has traditionally been done using a measuring wheel. Now, technology provides us with laser range-finders and GPS (the Global Positioning System). Laser rangefinders emit a harmless laser beam that reflects from a sighted object such as a pole and an extremely accurate clock measures the time for the reflected laser beam to return to the instrument.The distance is measured by determining the difference in the speed of light from its emission to its return. These devices are especially useful to the staking technician if he or she must work alone. Accurate measurements can be made even when dense brush prohibits using a measuring wheel.

Laser rangefinders are available in several configurations. The more elaborate ones look like pistol-type guns and have an internal compass. These instruments not only measure horizontal distances, but can also turn angles, measure heights, and calculate the distance between two points. Simpler devices made for hunting and shooting are also very useful in staking lines and are less expensive. These rangefinders usually measure distance in yards and in some cases in feet and are limited to 800 yards maximum or less, based on the reflective properties of the object sighted.

Many cooperatives are using staking packages which combine mapping, staking, storeroom, system modeling, facilities management, and work order management systems into an integrated solution. These systems often use GPS receivers to map the location of existing and proposed pole locations when staking a new or modified line. GPS is a satellite-based navigation system which uses 27 active satellites. The GPS satellites emit a coded radio signal that denotes the satellite's exact location. The handheld GPS receivers decode the signals and use them to calculate the distance from the receiver to each satellite in view. The GPS receiver typically needs to "see" four satellites to determine the location of the GPS receiver in terms of longitude and latitude.

The accuracy of the coordinates is based partly on the quality of the GPS receiver. There are recreational-grade devices with accuracies of 10 to 50 feet, mapping-grade devices with 3 to 10 feet (1 to 3 meters) accuracies, and survey-grade devices which can locate with accuracies within a centimeter. Further, the signal from the satellites is relatively low power and is adversely affected by materials with high water content, such as tree leaves. If the line of sight to the sky is limited by a house or building, few satellites can be seen by the GPS receiver.

Many of the GPS receivers use static data collection, which is a process of collecting multiple GPS positions while keeping the receiver stationary. The GPS receiver then "averages" its location from these multiple points. In addition, there are other methods available to improve the accuracy of the position using post processing and communication with other communication satellites.

However, to be clear, unless the GPS receiver is a survey-grade device, horizontal measurements between coordinates of poles will have an inherent error. Normally, this error is not an issue when measuring between poles for span lengths. But this error of 3 to 10 feet in the location of a pole adds uncertainty to the accuracy of the measured deflection angles of a line.

The elevation measurement collected by a GPS receiver can also have an error similar to the 3 to 10 feet horizontal accuracy. The vertical component (elevation) is dependent on satellites within the sight of the receiver and the spacing of the satellites. Field mapping GPS units are not normally used to determine elevations for road or lake crossing permits.

MEASURING AND BISECTING LINE ANGLES

When the distribution line changes direction, the angle of change must be accurately measured. The most precise method of measurement is accomplished by using an engineer's transit. The line angle measured is called the *deflection angle*. This is the angle produced by the change in the direction of the line relative to the continuance of the original centerline. See Figure 2.6.

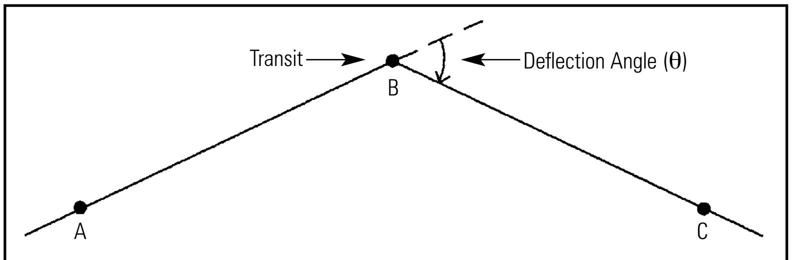


FIGURE 2.6: Measuring the Deflection Angle Using a Transit.

The following steps describe the measurement of a line (deflection) angle with a standard open-type engineer's transit:

STEP 1: Set transit up at point B.
STEP 2: Set the transit horizontal degree scales to zero and lock down the upper transit plate.
STEP 3: Invert the telescope and back sight on point A and lock down the lower transit plate.

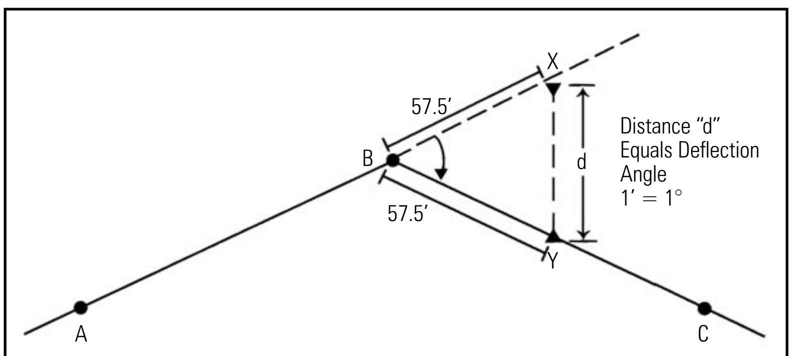


FIGURE 2.7: Use of a Measuring Tape for Measuring a Deflection Angle.

STEP 4: Plunge (flip) the telescope on the vertical axis to the normal position.
STEP 5: Loosen the upper transit plate and rotate the telescope on the horizontal axis until it aligns with point C.
STEP 6: Read the angle from the horizontal degree scale.

After the angle has been measured, it must be bisected to determine the position of the anchors.

The following steps describe the bisecting of a line angle with a standard open-type engineer's transit:

STEP 1: Divide the measured line angle by 2.
STEP 2: Subtract the answer from 90°.
STEP 3: Rotate the upper transit plate or telescope on the horizontal axis back through the previously turned deflection angle to the degrees calculated in Step 2.
STEP 4: Position a rodman at the desired guy lead distance and align the rod with the vertical cross hair.
STEP 5: Set the anchor stake.

Another method for measuring and bisecting a line angle is to use a measuring tape, as shown in Figure 2.7. This is a simpler method and reasonably accurate.

The following steps describe the measurement of a deflection angle using a measuring tape:

STEP 1: From point B (structure location), measure 57.5 feet ahead along the continuance of the original centerline and set a temporary point X in line with points A and B. To provide acceptable accuracy, the distance of 57.5 feet must be used for this method.
STEP 2: From point B, measure 57.5 feet ahead along the new line route toward the next structure and set a temporary point (Y) in line with points B and C.
STEP 3: Measure the distance d between the temporary points (X and Y) and read the line angle (1 foot = 1°).

The angle may be bisected by using a measuring tape as shown in Figure 2.8. The steps are:

STEP 1: From point B, measure an arbitrary distance L back along the original center-line toward the last pole A and set a temporary point X.

STEP 2: From point B, measure the same distance L ahead along the new line toward the next pole (point C) and set a temporary point Y.

STEP 3: Measure the distance between X and Y along the inside of the angle.

STEP 4: Divide the total distance by two and set a temporary point Z at the calculated midpoint between X and Y. Set a range rod at point Z.

STEP 5: Proceed to the approximate anchor location at a point on the outside angle back of the pole and equal to the desired guy lead distance (explained in **Section 7**, Guying Practices and Procedures).

STEP 6: Move laterally until alignment with the pole and the point Z range rod is obtained.

STEP 7: Set the anchor stake.

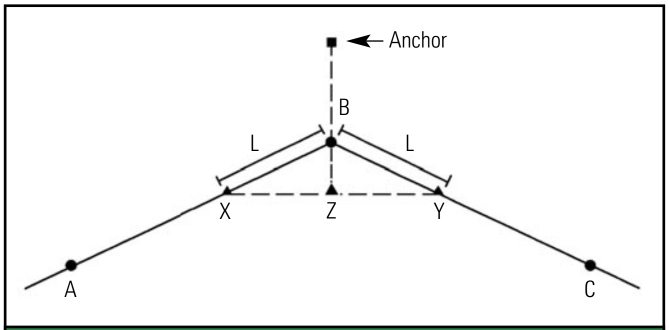


FIGURE 2.8: Use of a Measuring Tape for Bisecting a Deflection Angle.

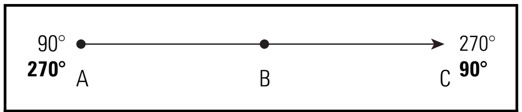


FIGURE 2.9: 180° Reverse Compass Scale.

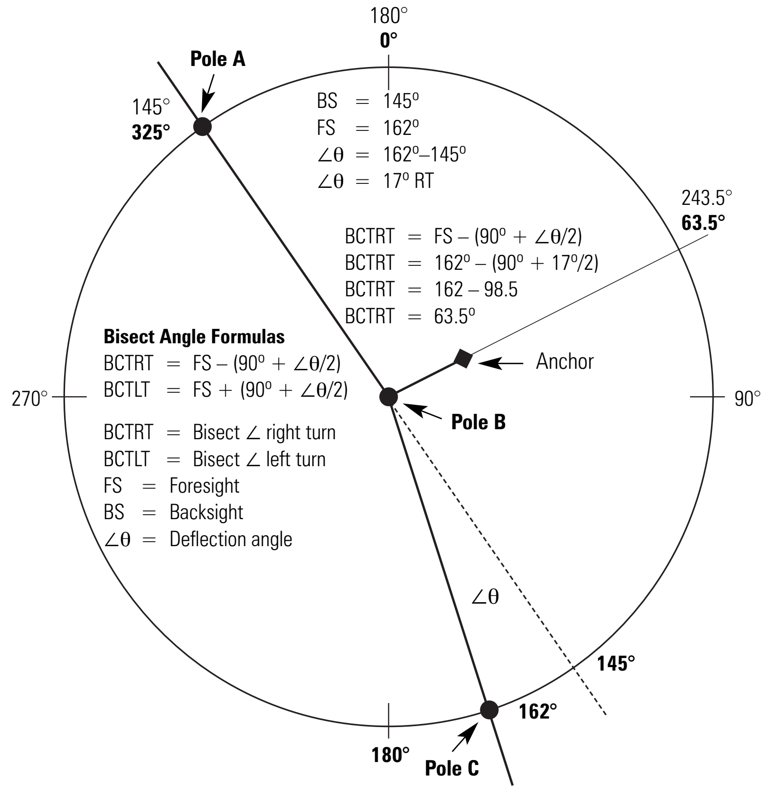
MEASURING AND BISECTING A DEFLECTION ANGLE USING A HAND COMPASS

The staking technician working alone must be able to correctly measure and bisect deflection angles. The hand compass is a useful tool to perform this task. Using this tool correctly and within its limitations can provide accurate angle measurements. Angles and bisect readings measured with a good-quality hand compass are usually within one degree of readings made using a transit.

Obtain a quality survey-grade hand compass. Less expensive outfitter or army-type compasses will not do the job as well or as easily as a survey-type compass. Select a compass that has the 180° reverse azimuth scale (Figure 2.9). This feature allows the viewer to read the direction ahead on the scale when making a backsight. This is readily seen when following the steps in **Figure 2.10**. If the compass does not have a 180° reverse, the viewer must subtract or add 180° to the backsight reading to get the bearing for the line ahead.

The viewer stands at point B and wants to extend the line from point A to B to point C. The backsight is taken on point A (270°). To get the bearing to point C, 180° must be subtracted from the backsight reading (270° – 180° = 90°). If the compass has the reverse reading on the scale, the computation is unnecessary. Usually, the direct reading is in bold print and the 180° reverse is in lighter print.

Figure 2.10 illustrates the procedure and provides steps for measuring and bisecting line angles with a 180° reverse-scale survey-grade hand compass. Formulas are provided to calculate the bisect angle from the compass readings.



STEP 1: Imagine that you are in the center of a large circle encompassing the poles.

STEP 2: Stand at the center (Pole B) and establish a line of sight between poles B and A.

STEP 3: Take the backsight (BS) on pole A (read the 180° reverse azimuth scale on the compass).

STEP 4: Remain at pole B, rotate your body 180°, and establish a line of sight between poles B and C.

STEP 5: Take the foresight (FS) on pole C (read the direct azimuth scale on the compass).

STEP 6: Calculate the line angle: Take the arithmetic difference between the backsight and the foresight (larger number minus the smaller number).

STEP 7: Calculate the bisect azimuth for the guy/anchor using the formulas at left.

STEP 8: Move to the specified guy lead length and line your body up with the 180° reverse azimuth scale bisect reading and pole B. Establish the anchor location.

FIGURE 2.10: Measuring and Bisecting a Deflection Angle with a Hand Compass.

MEASURING CHANGES IN GROUND ELEVATIONS

To properly select pole heights to prevent uplift and excessive downstrain, it may be necessary for the staking technician to measure the amount of change in elevation of the ground beneath the proposed distribution line. Some GIS mapping systems that can provide relative terrain changes include Google Earth. This can sometimes be done simply by observing the profile of the terrain and estimating the rise and fall in feet. However, topography can be deceiving, and the above "eyeball" method may not provide the degree of precision necessary for the proper grading of the line.

A reasonably accurate method acceptable for determining changes in grade elevation of projects not requiring a high degree of precision is the measurement by use of a hand level or clinometer. The observer first measures the H.I. (the height of the instrument, hand level, at the observer's eye above the ground) with a measuring tape. For leveling uphill, adjust the instrument to zero and take a sight in the direction of travel. The point at which a level line of sight strikes the ground will have the same elevation as the observer's H.I. For example, if the observer's H.I. is 5 feet, the observed point is 5 feet higher than the ground beneath the observer's feet. After identifying this point on the ground, the observer moves to that point and takes another sight. This procedure is repeated until the top of the rise is reached or the final measurement is determined for a designated point. More accurate measurements can be obtained by using a measured staff or range rod as a support for the hand level.

If the final level sight is observed to be some distance above the top of the rise, a range rod may be set and the final sight taken. Range rods are painted with alternate orange and white bands of 1 foot each. Record where the level sight strikes the range rod. Simply subtract the feet above the top of the rise from the H.I. to determine the change in elevation. See Figure 2.11.

For leveling downhill, reverse the above process. As can be seen, a range rod or other graduated device will be required to level downhill.

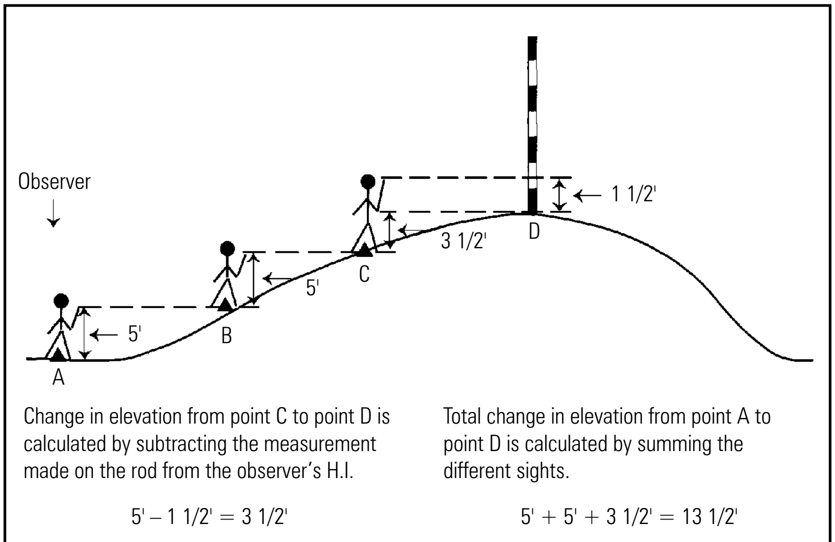


FIGURE 2.11: Determination of Change in Elevation.

USE OF STAKING TABLES

The staking table is a design aid used in the field staking of overhead distribution lines. It reduces the time and effort required to stake a line. It serves the same purpose as plotting a plan and profile of the span and then applying a sag template curve to determine the height of poles necessary to provide the required clearance.

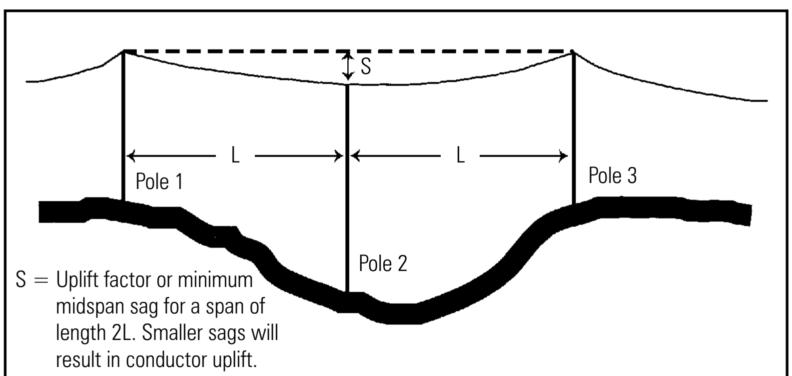


FIGURE 2.12: Uplift Factor.

The staking table gives a range of permissible maximum span lengths for the span between two identical pole structures. These span lengths are controlled by the change in ground elevation below the conductor. A typical staking table includes ground elevation values in feet for both rise and depression, and they are usually shown as positive or negative numbers.

Table 2.1 is an example of a typical distribution line staking table. The base structure is a 35-foot pole with an A1, B1, or C1 pole-top assembly. The controlling conductor is the 2 ACSR neutral. The midspan clearance is based on 18 feet plus a 1-foot staking and construction tolerance. The maximum operating temperature for the conductor is 120°F, and the design tension is 45.3% or 1292 lb. The ruling span is 325 feet. The table is based on conductor characteristics for the medium loading district.

Using 35-foot poles, it can be seen from **Table 2.1** that the span length for a level ground condition is 431 feet. The other spans range from 244 feet for a rise at midspan of 5 feet to 692 feet for a depression of 10 feet. The table also provides the value of rise or depression at the quarter span points that permits the same span length. Also shown are the midspan and quarter-span rise and depression values that permit the same span length when using the next longer pole length of 40 feet.

The last column in the staking table shows the uplift factor for the designated span length. It represents values that are minimum midspan sags for spans twice the length of the span with which the value is associated on the staking table, since the sag of a span equals twice its length. See Figure 2.12. If the center pole is not at midspan, the uplift factor must be interpolated. To do this, find the uplift factors for each of the spans and average the two values to produce the uplift factor for the center pole.

Many variables must be considered in the preparation of staking tables. Each cooperative should decide on the basic parameters that best suit its system and standard construction and request the staff engineer or consulting engineer to prepare staking tables accordingly.

TABLE 2.1: Typical Distribution Line Staking Table

	PHASE	NEUTRAL
Conductor Description	No. 2(6/1) ACSR	No. 2(6/1) ACSR
Max. Operating Temperature	120°F	120°F
Basic Ground Clearance	20 feet	18 feet
Design Tension	1292 lb (45.3%)	1292 lb (45.3%)

325-Foot Ruling Span — Medium Loading District

FOR USE WITH A1.1, B1.11, AND C1.11 TYPE ASSEMBLIES
(All distances are in feet)

35-foot Poles			40-foot Poles		
Quarter Point of Span	Center of Span	Span Length	Center of Span	Quarter Point of Span	Uplift Factor
5.4	5.0	244	10.0	10.4	2.0
5.0	4.5	268	9.5	10.0	2.7
4.7	4.0	289	9.0	9.7	3.3
4.4	3.5	309	8.5	9.4	3.9
4.1	3.0	328	8.0	9.1	4.5
3.7	2.5	347	7.5	8.7	5.2
3.4	2.0	365	7.0	8.4	5.8
3.1	1.5	382	6.5	8.1	6.5
2.7	1.0	399	6.0	7.7	7.1
2.4	0.5	415	5.5	7.4	7.8
2.1 LEVEL	0.0	431	5.0	7.1	8.5
1.7	–0.5	447	4.5	6.7	9.2
1.4	–1.0	462	4.0	6.4	9.9
1.1	–1.5	477	3.5	6.1	10.6
0.7	–2.0	492	3.0	5.7	11.4
0.4	–2.5	506	2.5	5.4	12.1
0.0	–3.0	520	2.0	5.0	12.8
–0.3	–3.5	533	1.5	4.7	13.5
–0.6	–4.0	547	1.0	4.4	14.3
–1.0	–4.5	560	0.5	4.0	15.0
–1.3	–5.0	573 LEVEL	0.0	3.7	15.8
–1.7	–5.5	586	–0.5	3.3	16.5
–2.0	–6.0	598	–1.0	3.0	17.3
–2.3	–6.5	611	–1.5	2.7	18.1
–2.7	–7.0	623	–2.0	2.3	18.8
–3.0	–7.5	635	–2.5	2.0	19.6
–3.4	–8.0	647	–3.0	1.6	20.4
–3.7	–8.5	658	–3.5	1.3	21.2
–4.1	–9.0	670	–4.0	0.9	21.9
–4.4	–9.5	681	–4.5	0.6	22.7
–4.8	–10.0	692	–5.0	0.2	23.5

- Table 2.1 includes a 1-foot staking and construction tolerance in addition to the basic clearances. It also includes a 1-foot uplift factor tolerance.
- This table may be used for any phase conductor whose maximum temperature is 120°F or less, and whose 60°F final sag in a 325-foot span is less than or equal to 2.7 feet.

MARKING THE ROUTE AND STRUCTURE LOCATION

Stakes should be set at each structure location along the route of the proposed construction. In addition, all guyed structures should have a stake set at each anchor location. Anchor stakes should be set in line with the conductors at deadends and in bisect on certain angle poles. The structure stakes should be identified with the number of the structure and the initials of the cooperative. On an extended vertical angle structure, such as a C3.2, the pole location stake should be offset from the centerline stake at a distance equal to the horizontal component of the angled position of the insulator string and associated hardware. See Figure 2.13. If this procedure is not followed and the C3.2 pole is set on the centerline stake, a line angle will occur on the assemblies of the adjoining straight-line poles behind and ahead. Over time, these poles will lean toward the strain produced by the angle. This phenomenon becomes more pronounced as conductor size increases. The centerline stake previously set on the initial running of the transit line should remain in the ground and be marked in the field as a centerline stake and *not* a structure stake.

The route of the proposed distribution line should be clearly identified by the use of brightly colored vinyl flagging and/or brightly colored paint. Wrap and tie flagging around all structure and anchor stakes. It also is helpful to tie flagging on the surrounding vegetation. Where there are existing structures to be replaced, structure numbers should be painted on the pole with brightly colored paint. As an alternative or where there is no existing structure, numbers can be painted on the edge of the pavement adjacent to the structure or stake. *Note:* Although this is a commonly used procedure, the state highway department's rules and regulations should be consulted and adhered to regarding painting numbers on roads.

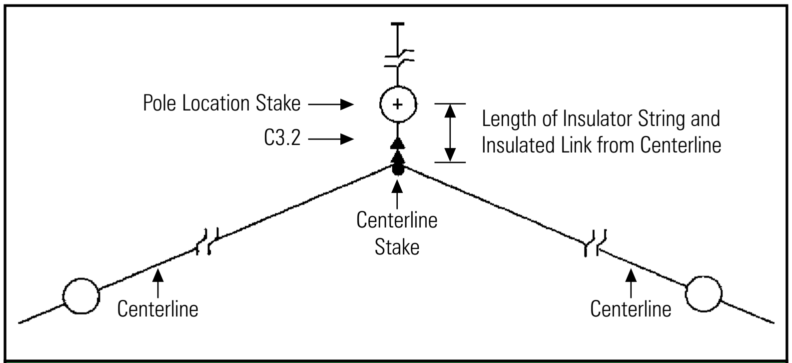


FIGURE 2.13: Staking of an Extended Vertical Angle Structure.

Preparation of Documents

A hard copy staking sheet or electronic staking sheet should be prepared to fully describe the construction for the proposed line. Typically, a staking sheet will include, as a minimum, the following data:

- Name of job
- Work order number
- Cooperative name
- RUS designation
- Name of staking technician
- Date when staked
- Sheet number
- Construction assemblies
- Span lengths
- Conductor size and type
- Ruling span
- Descriptive notes
- Line angle
- Date when released for construction
- Other data necessary for cooperative operations, such as substation name, map location, line section, account number, county, and consumer name

A sketch should be prepared along with the staking sheet. It should show the following:

- Route of the line to be built
- Poles
- Guys and anchors
- Transformers

- Taps
- Sectionalizing devices
- Secondaries/services
- Open points
- Phasing
- Two-way feeds
- Terrain features
- Roads
- Buildings
- Waterways
- North arrow
- Load arrow
- Special instructions

An example of a typical staking sheet is shown in **Figure 9.2**.

Both initial and final sag tables for all the ruling spans involved in the total job should be obtained from the consulting engineer or manufacturer.

Where applicable, prepare any Department of Transportation or other utility permit application forms and drawings required for the construction of the line.

Sometimes it is necessary for the staking technician to prepare other documents for the cooperative's operating and accounting functions. They may include the preparation of unit summaries, continuing plant records, and material pick lists (the detailed stock list of materials required to construct the project).

All documents relative to the construction should be clear, neat, and detailed. Keep in mind that these documents will be used for the construction of the line, the final accounting, and as verification of proper construction in the event of litigation.

Staking Equipment, Materials, and Design Aids

The planning for staking also includes ensuring in advance that the tools necessary for staking will be available. This includes not only equipment and materials, but also the necessary design aids for the staking. The following checklist provides a reasonably complete list for a major staking project.

DISTANCE MEASURING EQUIPMENT

- ❑ Measuring wheel (steel)
- ❑ Measuring tapes (reel type, 100-foot and 50-foot)
- ❑ Laser rangefinder (optional)
- ❑ GPS unit (optional)

ROUTE SURVEYING EQUIPMENT

- ❑ Range rods (minimum of 3)
- ❑ Level rod
- ❑ Transit
- ❑ Tripod
- ❑ Plumb bobs
- ❑ Hand compass (good quality)
- ❑ Clinometer or Abney hand level
- ❑ GPS receiver and collection device (optional)

BRUSH-CLEARING EQUIPMENT

- ❑ Bush axe
- ❑ Machete
- ❑ Sharpening tools

PERSONAL SAFETY EQUIPMENT

- ❑ Jug of water
- ❑ First aid kit
- ❑ Hard hat
- ❑ OSHA-approved, highly visible safety vest
- ❑ Safety and/or sunglasses
- ❑ Snake leggings
- ❑ Toilet paper
- ❑ Bug spray
- ❑ Tick spray

CONDUCTOR SAGGING EQUIPMENT

- ❑ Stopwatch
- ❑ Thermometer
- ❑ Insulated rope

MISCELLANEOUS EQUIPMENT

- ❑ Hammer
- ❑ Insulated clearance measuring stick
- ❑ Binoculars
- ❑ Calculator (scientific)
- ❑ Laptop computer

GROUND REFERENCE POINT MATERIALS

- ❑ Stakes
- ❑ Hubs
- ❑ Large nails (for establishing reference points in asphalt or pavement)

VISIBILITY MATERIALS

- ❑ Brightly colored vinyl flagging
- ❑ Brightly colored spray paint
- ❑ Marking pens (permanent ink)

DOCUMENTATION MATERIALS

- ❑ Field book
- ❑ Staking sheets
- ❑ Note pad
- ❑ Pencils
- ❑ Laptop computer (optional)
- ❑ Permanent markers

CODES AND SPECIFICATIONS

- ❑ Current *National Electrical Safety Code* (2023)
- ❑ RUS specifications and drawings
- ❑ This NRECA design manual
- ❑ Utility design standards

DESIGN GUIDES

- ❑ Tables (guying, sag, staking, etc.)
- ❑ Graphs (conductor, guying, etc.)

MAPS

- ❑ Circuit diagrams
- ❑ U.S. Geological Survey topographic map
- ❑ Tax maps showing property lines and landowners
- ❑ Distribution system detailed map

3 Applicable Codes and Specifications

In This Section:

To correctly specify the appropriate structure for a particular conductor and stake the distribution line, a staking technician must possess a working knowledge of the following:

- *National Electrical Safety Code (NESC)*
- RUS specifications and drawings
- RUS List of Materials Acceptable for Use on the Systems of RUS Electrification Borrowers

The *NESC* applies to electric distribution systems and equipment under the control of qualified persons and operated by utilities or similar establishments. In addition, RUS specifications and drawings and the List of Materials also apply to the electric distribution systems operated by electric cooperatives that are under the authority of the Rural Utilities Service.

Other governing agencies may have additional rules and regulations that apply to electric distribution systems in specific areas of the country or for particular rights-of-way. These may include local and state governments, departments of transportation, railroads, etc. Since the scope of this manual does not cover these additional governing agencies, the staking technician must ascertain which governing agencies have jurisdiction, become familiar with their rules and regulations, and comply with their requirements.

National Electrical Safety Code (NESC)

The *National Electrical Safety Code (NESC)* is a safety standard for electric power lines used throughout the United States. It must be emphasized that the *NESC* contains standards for the safe design of electric power lines. It is essential for those personnel responsible for the construction, design, safety, and operation of electric utility power lines to be knowledgeable of the requirements of this code. The *NESC* is written in what is commonly called "legalese," the language of lawyers, which is sometimes very hard for the lay person to read and interpret. The code is further complicated by covering rules for communication circuits and electric power lines of all voltages. The purpose of this manual is to assist in the understanding of the requirements of the *NESC;* however, this manual is not intended to replace the current, past, or future editions of the *NESC.*

Throughout this manual, there will be references to the *NESC* specifically, and references to specific rules such as (250). This notation means to see Rule 250 in its entirety as contained in the *NESC.* These numbers do not refer to page numbers of the *NESC.* The rule number can be quickly found in the upper right-hand corner of each page in the code.

The *NESC* is approved as American National Standard C2 by the American National Standards Institute (ANSI). The responsibility for the content of the *NESC* rests with the ANSI C2 Committee, which operates under the administrative secretariat of the Institute of Electrical and Electronics Engineers (IEEE). Neither IEEE nor ANSI has any legal authority to enforce the code; therefore, the code sets forth a voluntary safety standard. However, many federal, state, and local jurisdictions use the *NESC* in the development of their own legal safety codes. It may be adopted in part or in its entirety, unchanged, or modified as required to meet the needs of the administrative authority. Several states have never adopted a state safety code. In these states, the *NESC* essentially becomes a common law code under the judicial process.

RUS requires borrowers to construct their lines in compliance with the current *NESC*, except where local codes and RUS bulletins or directives are more restrictive.

This section of the manual mainly discusses loading districts, grades of construction, grounding, and clearances. Rules and regulations that pertain to a specific section, such as poles, guys, or anchors, are discussed within that particular section.

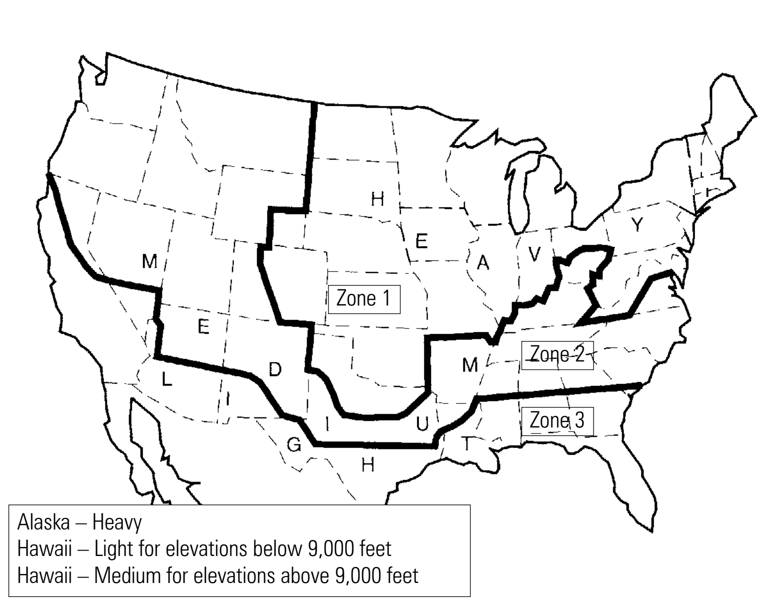


FIGURE 3.1: Loading District Map.

NESC LOADING DISTRICTS (250)

The strength that must be designed into an overhead line depends on the wind and ice loads that may be imposed on the conductor and supporting structure. This is related generally to the geographical location of the line.

The *NESC* divides the country into three weather or loading districts as shown in Figure 3.1. The usual practice is to design the line to withstand the ice and wind loads specified for the loading district in which the line is located. These design conditions are shown in **Table 3.1**.

The *NESC* defines ice and wind loading to be used for determining clearance from the conductors to roads, buildings, signs, etc., in Rule 230B. This rule defines clearance zones which are same geographic areas as the Loading Districts defined in Rule 250B and shown in Figure 3.1. Zone 1 has the same ice and wind as the Heavy Loading District, Zone 2 has the same ice and wind as the Medium Loading District, and Zone 3 has the same ice and wind as the Light Loading District as shown in Table 3.1.

In 2012, the *NESC* added a fourth loading zone to address the weather conditions on islands such as American Samoa, Guam, Hawaii, Puerto Rico, and the Virgin Islands. To apply the loading zone for the islands, it is recommended that the Light Loading (Zone 3) be used for facilities located between sea level and 9,000 feet. For facilities on islands with an elevation of more than 9,000 feet above sea level, use the Medium Loading District (Zone 2).

Extreme Wind Loading

The *NESC* requires that if any portion of a structure or its supported facilities (including conductors) exceeds 60 feet above ground or water level, it must meet Rule 250C for Extreme Wind Loading. The wind speed to be used for Extreme Wind Loading is determined in part by the Grade of Construction which is described in this manual in **Table 3.3**. Grade B construction will use wind speed maps in the NESC in Figure 250-2(a) and Grade C construction will use wind maps in the NESC in Figure 250-2(b). Portions of

TABLE 3.1: *NESC* Loading District Ice and Wind Loads					
	Ice and Wind Loads (For Use with Rule 250B)			Extreme Wind Loading (For Use with Rule 250C)	Extreme Ice Loading (Concurrent Wind Rule 250D)
	Heavy	Medium	Light		
Radial thickness of ice (inches)	0.5	0.25	0	0	See *NESC* Figures 250-3a & 3b
Horizontal wind pressure (lb per sq ft)	4	4	9	Figures 3.2(a) and 3.2(b)	See *NESC* Figures 250-3a & 3b
Temperature (°F)	0	+15	+30	+60	+15

Excerpted from *NESC* Table 250-1.

these wind speed maps are shown in **Figure 3.2(a): Wind Speed Map for Grade B** and **Figure 3.2(b): Wind Speed Map for Grade C**. Major modifications were made in the 2002 *NESC* regarding extreme wind loading. The old rule used a sustained wind loading; the current rule applies a 3-second wind gust. This change has complicated the calculations to determine the strength requirements of structures when subjected to extreme wind loading. Specifically, the wind pressures are modified by gust and response factors. The method for applying these factors is demonstrated in **Section 5**, Pole Strength. Designing systems for extreme wind can be very complex and require additional tension data for the conductors before the strength requirements for pole-top assemblies and guyed structures can be calculated. The staking technician is advised to seek assistance from the system engineer or a consultant when designing structures subject to extreme wind loading.

The majority of the distribution facilities will not be required to meet the extreme wind rule (250C). However, many water crossings and sections of line in the mountains will fall under this rule. If a line spans a gorge where the height of the conductor exceeds 60 feet above the ground, the line and its associated structures must comply with this rule.

The horizontal wind pressure table of Table 3.2 can be used in conjunction with the wind speed map shown in **Figures 3.2(a)** and **3.2(b)**.

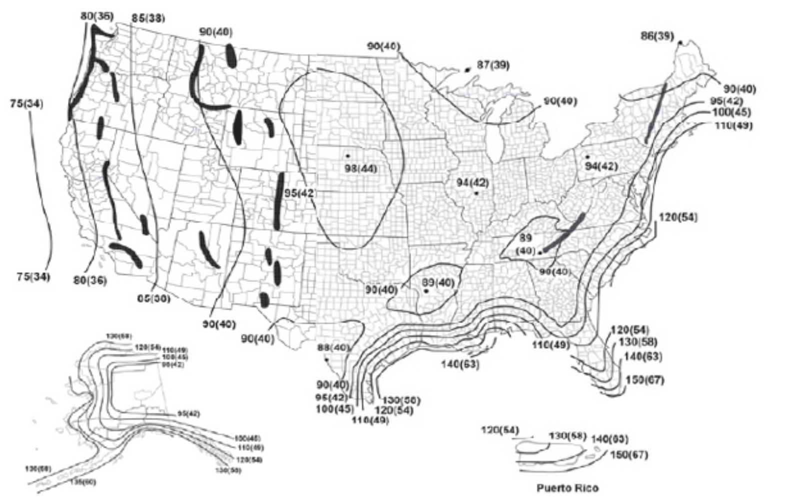
Extreme Ice with Concurrent Wind

In 2007, the NESC added a new loading requirement (250D) which requires structures and their supported facilities that are 60 feet or more above ground be designed for extreme ice loading. The amount of ice is based on historical ice loading patterns along with the amount of wind that is expected for the local area (either 40 mph or 30 mph). **Figure 3.3** shows these ice and wind loadings. Note, per the *NESC* (250D2), that the amount of ice shown in fig-

TABLE 3.2: Horizontal Wind Pressures on Cylindrical Surfaces*

Wind Speed (mph)	Wind Pressure (psf)
30	2.3
40	4
49	6
60	9
85	18
90	21
100	26
110	31
130	43
140	50

mph = miles per hour.
psf = pounds per square foot.
* Both poles and conductors are cylindrical surfaces.

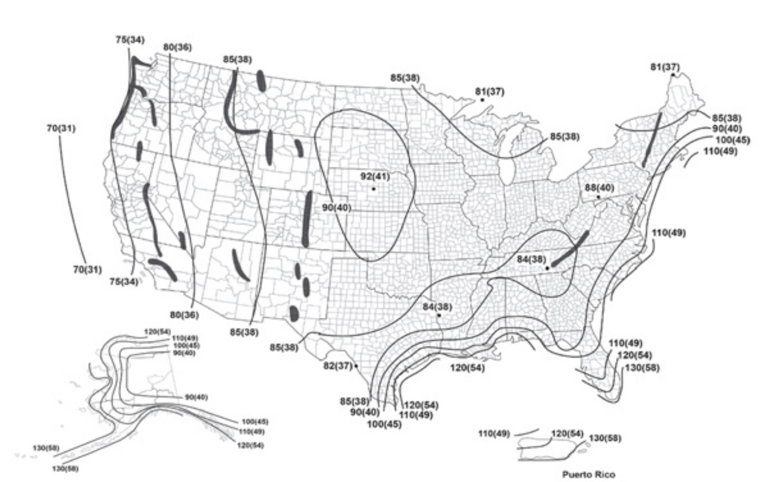


NOTES:
1. Values are nominal design 3-second gust wind speeds in miles per hour at 33 ft above ground for Exposure Category C.
2. Linear interpolation between wind contours is permitted.
3. Islands and costal areas outside the last contour shall use the last wind speed contours of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

Location	mph
Guam	163
Virgin Islands	143
American Samoa	134
Hawaii – Special Wind Region Statewide	86

Source: NESC Fig. 250-2(a), Grade B Wind Speed Map.

FIGURE 3.2(a): Wind Speed Map for Grade B.



NOTES:
1. Values are nominal design 3-second gust wind speeds in miles per hour at 33 ft above ground for Exposure Category C.
2. Linear interpolation between wind contours is permitted.
3. Islands and costal areas outside the last contour shall use the last wind speed contours of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

Location	mph
Guam	146
Virgin Islands	130
American Samoa	125
Hawaii – Special Wind Region Statewide	67

Source: NESC Fig. 250-2(a), Grade C Wind Speed Map.

FIGURE 3.2(b): Wind Speed Map for Grade C.

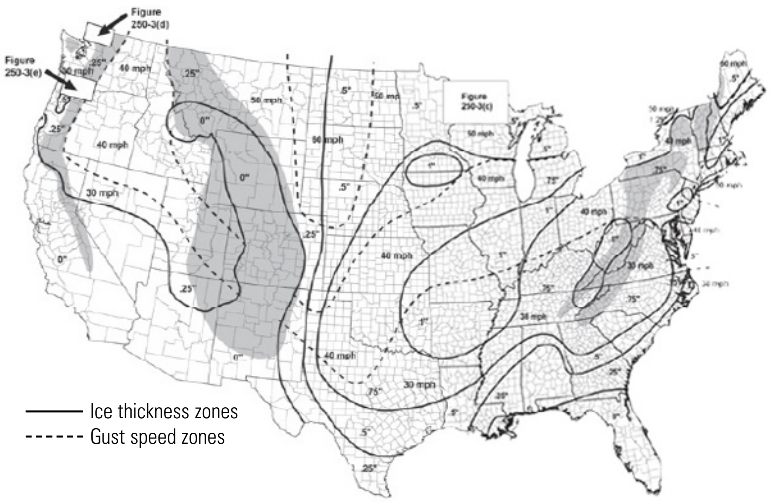
ures will be reduced by 80% if the line is to be built to Grade C. Extreme ice loading does not apply to warm islands, such as Hawaii and American Samoa.

An example application for extreme ice loading is contained in **Section 5**, Pole Strength. Note also that the strength of the cross arm for ice loading should be considered.

NESC GRADES OF CONSTRUCTION

A line must be built with sufficient strength to withstand the assumed district ice and wind loadings. The margins for safety of power lines are given in the *NESC* for three different grades of construction—Grades B, C, and N. Grade N is not permitted by RUS; therefore, it is not addressed in this manual. **Table 3.3** lists grades

50-Year Mean Recurrence Interval Uniform Ice Thickness Due to Freezing Rain with Concurrent 3-Second Gust Speeds: Contiguous 48 States.



NOTES:

1. Ice thickness on structures in exposed locations at elevations higher than the surrounding terrain and in valleys and gorges may exceed the mapped values.
2. In the mountain west, indicated by the shading, ice thickness may exceed the mapped values in the foothills and passes. However, at elevations above 5000 ft., freezing rain is unlikely.
3. In the Appalachian Mountains, indicated by the shading, ice thickness may vary significantly over short distances.

Source: NESC Fig. 250-3(a,b), Uniform Ice Thickness with Concurrent Wind.

FIGURE 3.3 Extreme Ice Loading Map.

of construction that apply to various distribution situations. This table has been adapted to conform to the RUS requirement to use Grades B and C only.

Grade B is the strongest and is generally used for transmission line construction and for distribution lines crossing railroad tracks, limited-access highways, and water crossings requiring a crossing permit, such as a permit from the Corps of Engineers. Under some conditions, it is also used for distribution lines that cross communication circuits.

Grade C is the next strongest and is required by RUS for rural distribution lines, except as previously noted in the Grade B requirements.

The term "at crossing" used in **Table 3.3**, as defined by the *NESC* (241C), means that wires, conductors, or other cables, of one line are considered to be at crossings when they cross over another line, whether or not on a common supporting structure, or when they cross over or overhang a railroad track or the traveled way of a limited access highway or when they cross navigable waterways requiring a waterway-crossing permit. Joint-use or collinear construction in itself is not considered to be at crossings.

When supply conductors and communication conductors are arranged in the same linear order, they are considered collinear. An example is a pole line with an underbuilt communication line. The communication line and power line are considered collinear.

Tables in the *NESC* and this manual refer to voltages measured from phase to ground for effectively grounded circuits. **Table 3.4** lists the most common voltages used on cooperative systems and their associated phase-to-ground voltages.

Open wire distribution lines operating over 750 volts that cross over communication lines require Grade B construction. However, where certain conditions exist, Grade C construction may be permitted. According to the *NESC* (242), Grade C construction may be used if the power and communication circuits are so constructed, operated, and maintained that both of the conditions set forth in Note 1 to **Table 3.3** exist.

RUS standard sectionalizing practices usually provide for prompt removal of a fault if a path exists to ground through the telephone system

TABLE 3.3: Grades of Construction for Supply Conductors Alone, at Crossing, or on the Same Structures with Other Conductors

The information provided in this table applies only to effectively grounded circuits and two-wire grounded circuits. Voltages shown are phase-to-ground values. The grade of construction for supply conductors, as indicated across the top of the table, must also meet the requirements for any lines at lower levels, except when otherwise noted.

Conductors, Tracks, and Rights-of-Way at Lower Levels	Constant-Potential Supply Conductors at Higher Levels		
	0 to 750 V	750 V to 22 kV	
	Open or Cable	Open	Cable
Common or public rights-of-way	C	C	C
Railroad tracks, limited access highways, and navigable waterways requiring waterway-crossing permits	B	B	B
Supply conductors 0 to 750 V Open or cable	C	C	C
750 V to 22 kV Open or cable	C	C	C
Exceeding 22 kV Open or cable	B	B	B
Communication conductor Open or cable	C	B[1,2]	C

1 Grade C construction may be used if the communications facilities are all-dielectric *or* both of the following conditions are met:
(a) The supply voltage will be promptly removed from conductive components of the communications facilities where such conductive components are present, by de-energization or other means, both initially and following subsequent circuit-breaker operations in the event of a contact with the communications facilities, and
(b) The voltage and current impressed on conductive communications facilities in the event of a contact with the supply conductors are not in excess of the safe operating limit of the communications-protective devices.

2 On systems of RUS borrowers, Grade C construction may be used over not more than one twisted pair of parallel-lay communication conductor or communication service drops.

For other exceptions, see *NESC* Table 242-1.

Adapted from *NESC* Table 242-1.

TABLE 3.4: Common Voltages of Cooperative Systems with Associated Phase-to-Ground Voltages

System Voltage	Phase-to-Ground Voltage
12.47/7.2 kV	7.2 kV
13.2/7.62 kV	7.62 kV
24.9/14.4 kV	14.4 kV
34.5/19.9 kV	19.9 kV

and the fault is within a few spans of the crossing. The communication system engineers should be consulted to determine if power contact protectors of the required time/current characteristics are installed near the crossing. Since most communication lines are bonded to the power line grounding conductor, they meet the required conditions and will permit the use of Grade C construction.

SYSTEM GROUNDING

System grounding must conform to the requirements of the *National Electrical Safety Code*, to any applicable local code, and to RUS construction specifications. Where a conflict exists, the more stringent code will apply.

A driven ground rod must be installed at each equipment location and individual service. The primary neutral should have a ground connection four times per mile [an easier way to consider this requirement is one ground every 1,320 feet (1/4 mile) or less], in addition to the ground connection at the individual services. More ground connections may be needed to limit the voltage rise on the system neutral. The number will depend upon the resistance to earth of the individual electrodes, earth resistivity, and magnitude of neutral and earth return current.

The resistance to earth of an individual grounding electrode depends on its depth in the earth, contact area, chemical makeup, and the moisture content of the surrounding soil. The ground rods should be driven at least 9 feet into the earth and deeper into the permanent moisture level, if conditions permit. Rods in the permanent moisture level will tend to minimize the variation of ground resistance because of the seasonal fluctuation of moisture content in the soil. At locations where one ground rod does not provide sufficiently low resistance, the resistance may be lowered by installing two or more ground rods in parallel or installing sectional ground rods. If two or more ground rods are used, they should be at least 6 feet apart for optimum benefit. Spacings of less than 6 feet will result in overlapping ground rod currents being dispersed into the earth and increase the resistance to earth of the parallel ground rods.

Grounding Conductor

RUS requires the grounding conductor to be not less than #6 copper or equivalent, and the *NESC* (093C2) specifies the grounding conductor must provide at least one-fifth the conductivity of the neutral to which it is attached. A #4 copper is required for neutrals larger than 336 ACSR.

Pole Protection Grounding

In the past, some cooperatives protected poles from lightning damage by grounding the pole and extending the ground wire to the very top of the pole. The use of a grounding conductor to provide pole protection is an *old* technology that is generally not as effective as lightning arresters. This practice is no longer shown in RUS construction standards. The new H1.1 (M2-11) grounding specification in RUS Bulletin 1728F-804 calls for the pole ground to stop at the neutral conductor. In the past, the ground wire extension above the neutral to within 4 inches of the pole-top pin has often resulted in pole-top damage and radio noise. With the use of modern surge arresters, this type of construction is no longer acceptable.

HORIZONTAL AND VERTICAL CLEARANCE FOR LINE CONDUCTORS ATTACHED TO THE SAME POLE (235)

The *NESC* specifies horizontal and vertical clearances between conductors carried on the same supporting structure. The maximum allowable span based on separation will be controlled by one of these clearances. Therefore, it is necessary to determine *both* clearances and decide which one will control. Clearances at the pole as well as in the span must be considered.

Horizontal Clearance between Conductors

The *NESC* establishes horizontal spacing for conductor supports (pins, insulators, etc.) based on both voltage and the amount of sag of the conductor.

Standard RUS assemblies have adequate spacing to meet the *NESC* voltage requirement (235B1a); however, the sag requirement (235B1b) must be met by controlling the length of the spans.

The maximum allowable span, based on the horizontal separation of the conductors at the pole-top assembly and the sag of the conductor in the span, must be calculated. The actual determination of the maximum allowable span based on the horizontal separation is shown in **Section 4**, Conductor Characteristics.

Vertical Clearance between Conductors

The *NESC* also sets vertical clearances between line conductors on the same supporting structure. These clearances are based on both voltage and the amount of sag of the conductor

TABLE 3.5: Basic Vertical Clearances at Supports between Line Conductors				
All voltages are phase-to-ground for effectively rounded circuits. When calculating clearances value within the table, all voltages are between the conductors involved.				
	Conductors and Cables Usually at Upper Levels			
	Insulated Secondary Cables, Multigrounded Neutrals, Communication Cables Located in Supply Space	Open Supply Line Conductors[1]		
			8.7 to 50 kV	
Conductors and Cables Usually at Lower Levels		**0 to 8.7 kV[2] (in.)**	**Same Utility (in.)**	**Different Utilities (in.)**
COMMUNICATION CONDUCTORS				
Located in the Communication Space[1]	40[3]	40[3]	40	40 inches plus 0.4 inches per kV[6] in excess of 8.7 kV
Located in the Supply Space[2]	16[3]	16[3]	40	40 inches plus 0.4 inches per kV[6] in excess of 8.7 kV
SUPPLY CONDUCTORS AND CABLES				
Insulated supply cables operating 0 to 750 volts and Multigrounded neutrals	16[5]	16[4]	16 inches plus 0.4 inches per kV[6] in excess of 8.7 kV	40 inches plus 0.4 inches per kV[6] in excess of 8.7 kV
0 to 8.7 kV[2]	16	16[4]	16 inches plus 0.4 inches per kV[6] in excess of 8.7 kV	40 inches plus 0.4 inches per kV[6] in excess of 8.7 kV
8.7 to 22 kV	40 inches plus 0.4 inches per kV[6] in excess of 8.7 kV	40 inches plus 0.4 inches per kV[6] in excess of 8.7 kV	16 inches plus 0.4 inches per kV[6] in excess of 8.7 kV	40 inches plus 0.4 inches per kV[6] in excess of 8.7 kV

[1] Communication Space is the space on structures where communication facilities are separated from the supply space by the communication worker safety zone.
[2] Supply Space is the space on structures where supply facilities are separated from the communication space by the communication worker safety zone. A worker must be qualified to work in the Supply Space (Reference *NESC* 224A).
[3] See *NESC* Table 235-5 for exceptions and notations.
[4] Where conductors are operated by different utilities, a vertical clearance of not less than 40 inches is recommended. Also see *NESC* Table 235-5 for exceptions and notations.
[5] No vertical separation at the structure is required between a neutral conductor and a multiconductor cable, such as duplex and triplex supported by an effectively grounded bare messenger or neutral.
[6] The greater of phasor difference or phase-to-ground voltage; see Rule 235A3 and example calculations in Rules 235Ca and 235C2b.

Adapted from *NESC* Table 235-5.

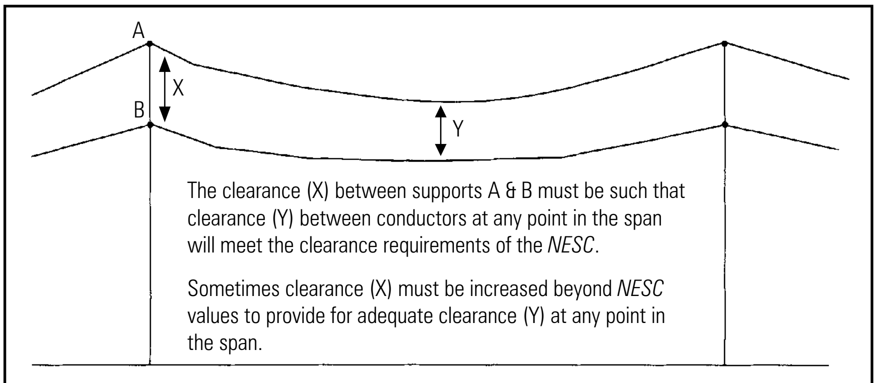


FIGURE 3.4: Required Vertical Clearance at Any Point in the Span.

(Figure 3.4). Table 3.5 lists recommended clearances for various combinations of conductors.

The required vertical clearances at any point along the span are shown in **Table 3.6**.

The maximum allowable span, based on the vertical separation of the conductors at the pole-top assembly and the sag of the conductor in the span, must be calculated. The actual determination of the maximum allowable span based on the vertical separation is shown in **Section 4**, Conductor Characteristics.

TABLE 3.6: Vertical Clearance at Any Point in the Span from Distribution Conductors to Underbuild Conductors[1,2]

Upper Level / Lower Level	Services[3] 0 to 750 V and MGN[4] (in.)	Nominal System Voltage in kV		
		12.47/7.2 kV (in.)	24.9/14.4 kV (in.)	34.5/19.9 kV (in.)
Communications	30[5]	30	32	34
Services 0 – 750 V[3] and MGN[4]	—	12	14	16
12.47/7.2 kV	—	12	16	18
24.9/14.4 kV	—	—	19	21
34.5/19.9 kV	—	—	—	22

[1] Where conductors are operated by different utilities, add 24 inches.
[2] See *NESC* Table 235-5 and Rule 235C2b for details and exceptions.
[3] Multiconductor wires or cables, and duplex, triplex, or paired conductors supported on insulators or messengers.
[4] MGN = multigrounded neutral.
[5] Clearance between MGN and communication can be reduced to 12 inches if the communication messenger is bonded to the MGN.

Conditions Under Which Clearances Apply. The clearances apply for the final sag conditions. The condition (a or b below) that yields the least vertical clearance in the span is the condition to be used when determining span clearance:
a. Upper conductor at a temperature of 32ºF, no wind, with the radial thickness of ice for the applicable loading zone. The lower conductor at a temperature of 32ºF, no ice, and no wind.
b. Upper conductor at a temperature of 120ºF or its maximum design conductor temperature, no wind. The lower conductor at a temperature of 60ºF, no wind.

Sometimes it is necessary to increase the vertical separation between the conductors at supports beyond the clearances shown in **Table 3.5.** This is done to compensate for the sag of the conductors at any point in the span (such as midspan) that may cause the required clearance at any point in the span shown in Table 3.6 to be violated. This requirement for midspan separation does not apply to conductors of the same utility when the conductors are the same size and type and are installed at the same sag and tension.

Standard RUS pole-top assemblies provide sufficient vertical separation to meet the requirement for vertical clearance between conductors at supports. However, the required vertical clearance, at any point in the span, must be met by controlling the length of the span. The maximum allowable span, based on vertical separation of the conductors, at any point in the span, must be calculated. The actual determination of this span is shown in **Section 4**, Conductor Characteristics.

Climbing Space (236)

When selecting pole-top assemblies, the staking technician should allow adequate clearance for climbing space. The *NESC* specifies clearances based on the voltage of the circuit.

For 12.47/7.2-kV structures, climbing space is defined as an unobstructed horizontal space 30 inches square that continues vertically 40 inches above and 40 inches below the limiting conductors or obstructions. For 24.9/14.4-kV poles, the climbing space is 36 inches square, and for 34.5/19.9-kV the climbing space is 40 inches square. Both 24.9/14.4-kV and 34.5/19.9-kV poles have the same vertical dimensions as given for the 12.47/7.2-kV structures. These clearances are shown in **Table 3.7**.

Climbing space may be provided on one side or corner of the pole. When the pole, or a portion of the pole, is located within the climbing space, either at a corner or on one side, it must not be considered as an obstruction to the climbing space.

TABLE 3.7: Clearance Between Conductors Bounding the Climbing Space

Voltage	Horizontal Dimension	Vertical Dimension[1]
12.47/7.2 kV	30 inches by 30 inches	40 inches
24.9/14.4 kV	36 inches by 36 inches	40 inches
34.5/19.9 kV	40 inches by 40 inches	40 inches

[1] The vertical clearance dimension is above and below the limiting conductor.

Adapted from *NESC* Rule 236E.

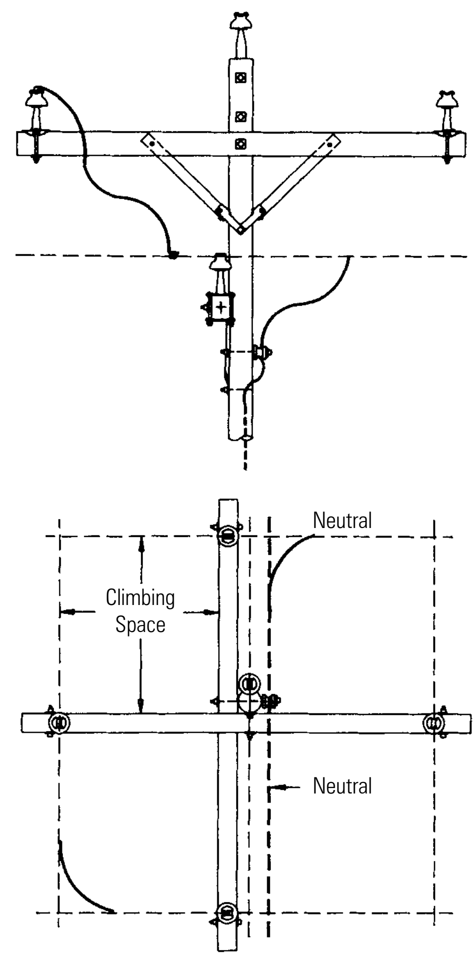


FIGURE 3.5: Unobstructed Climbing Space.

Vertical conductor runs must not be installed in the climbing space except when installed in conduit. Conduit runs must not interfere with the climbing of poles.

It is desirable that bolt ends not project into the climbing space. In any case, bolt ends must not project from any part of the pole more than 2.5 inches.

Foreign attachments must be made to conform with climbing space requirements.

Figure 3.5 illustrates unobstructed climbing space.

Working Space (237)

In addition to climbing space, the *NESC* requires that unobstructed working space must be provided on the climbing face of the pole at each side of the climbing space.

Working space is significant only on poles carrying conductors at two or more levels—double-circuit construction, for example.

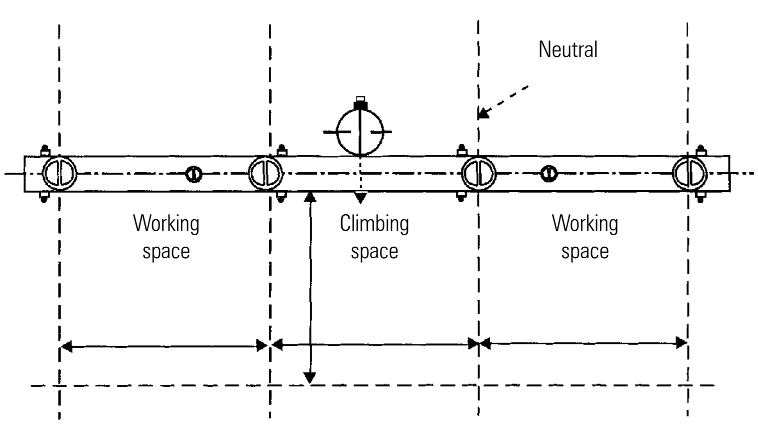


FIGURE 3.6: Unobstructed Working Space.

As shown in Figure 3.6, the working space must extend from the outer limit of the climbing space to the outmost pin positions on the crossarm. As measured from the face of the crossarm (in line with the conductors), the working space must not be less than the climbing space—30 inches for 12.47/72.-kV lines, 36 inches for 24.9/14.4-kV lines, and 40 inches for 34.5/19.9-kV lines.

The height of the working space must not be less than that required for vertical separation of line conductors and must not be obstructed by vertical or lateral conductors.

Figure 3.7 illustrates obstructed climbing and working space on a distribution structure.

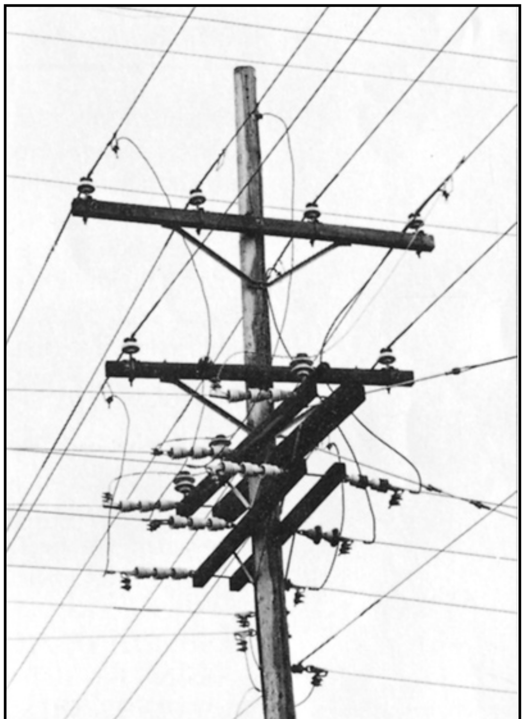


FIGURE 3.7: Obstructed Climbing and Working Space.

VERTICAL CLEARANCES OF WIRES, CONDUCTORS, CABLES, AND EQUIPMENT ABOVE GROUND, ROADWAY, RAIL, OR WATER SURFACES (232)

Generally, the height of the pole is determined by the required vertical clearance of a conductor over a particular surface with certain activities. The *NESC* lists and describes the vertical clearances of wires, conductors, cables, and equipment above ground, roadway, rail, or water surfaces.

The clearances for line designs of 22 kV (line-to-ground) and below are listed in **Tables 3.8**, **3.9**, and **3.10**. These clearances meet the requirements of the *NESC*. If the latest edition of the *NESC* has not been adopted in a particular locale, the clearances and the conditions found in these tables should be reviewed to ensure they meet the more stringent of the applicable requirements.

Figure 3.8 illustrates the specific table to use when determining the vertical clearance for a particular situation.

Application of Table 3.8

The vertical clearances specified in the *NESC* apply under certain conductor temperature and loading conditions. The controlling condition is the one that produces the largest final sag in the conductor. These conditions are:

1. 120°F, no wind displacement
2. The maximum conductor temperature for which the line is designed to operate, if greater than 120°F, with no wind displacement
3. 32°F, no wind displacement, with radial thickness of ice, if any, specified in Rule 230B for the loading zone concerned and shown in **Table 3.1**

Spaces and Ways Accessible to Pedestrians Only

These clearances should be applied very carefully. Spaces and ways subject to pedestrians or restricted traffic only are those areas where riders on horses or other large animals, vehicles, or other mobile units exceeding 8 feet in height are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered or not reasonably anticipated. It is expected that this type of clearance will be used with caution.

Tall Vehicles

In those areas where it can normally be expected that vehicles with an overall operating height greater than 14 feet will pass under the line, it is recommended that consideration be given to increasing the clearances given in **Table 3.8**.

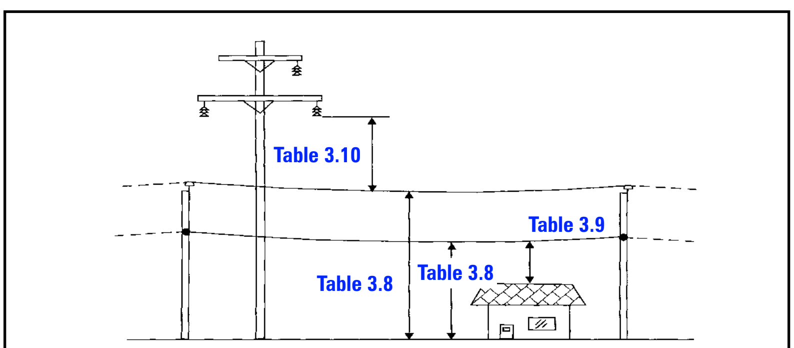


FIGURE 3.8: Application of Clearance Tables.

3

The amount by which the vertical clearance is increased is equal to the difference between the height of the tall vehicle and 14 feet. The appendix of the *NESC* is a good reference for determining unique clearance requirements such as for vehicles with heights greater than 14 feet.

Clearances Over Water

Clearances over navigable waterways are often governed by the U.S. Army Corps of Engineers and, therefore, the clearances over water given in Table 3.8 apply only where the Corps does not have jurisdiction.

TABLE 3.8: Vertical Clearances of Wires, Conductors, and Cables above Ground, Rails, or Water

Clearance Categories	Communications Conductors, Cable & Messengers, Neutrals, Guys (ft)	Insulated Supply Cable 0 to 750 V (ft)	Open Supply Conductors 0 to 750 V (ft)	Open Supply[2] Conductors 750 V to 22 kV (ft)
1. Railroad[1] tracks	23.5	24.0	24.5	26.5
2. Roads and other areas subject to truck traffic	15.5	16.0	16.5	18.5
3. Residential driveways	15.5	16.0	16.5	18.5
4. Other land traversed by vehicles	15.5	16.0	16.5	18.5
5. Spaces or ways accessible to pedestrians[3] only	9.5	12.0	12.5	14.5
6. Water areas not suitable to sailboating[5]	14.0	14.5	15.0	17.0
7. Water areas subject to sailboating[4,5]				
a) Less than 20 acres	17.5	18.0	18.5	20.5
b) 20 to 200 acres	25.5	26.0	26.5	28.5
c) 200 to 2,000 acres	31.5	32.0	32.5	34.5
d) Over 2,000 acres	37.5	38.0	38.5	40.5
8. Established boat ramps and associated rigging areas; areas posted with sign(s) for rigging or launching sailboats	Clearances above ground shall be 5 feet greater than in category 7 above.			

[1] Railroads may require greater clearance.

[2] Voltages are phase-to-ground on effectively grounded circuits.

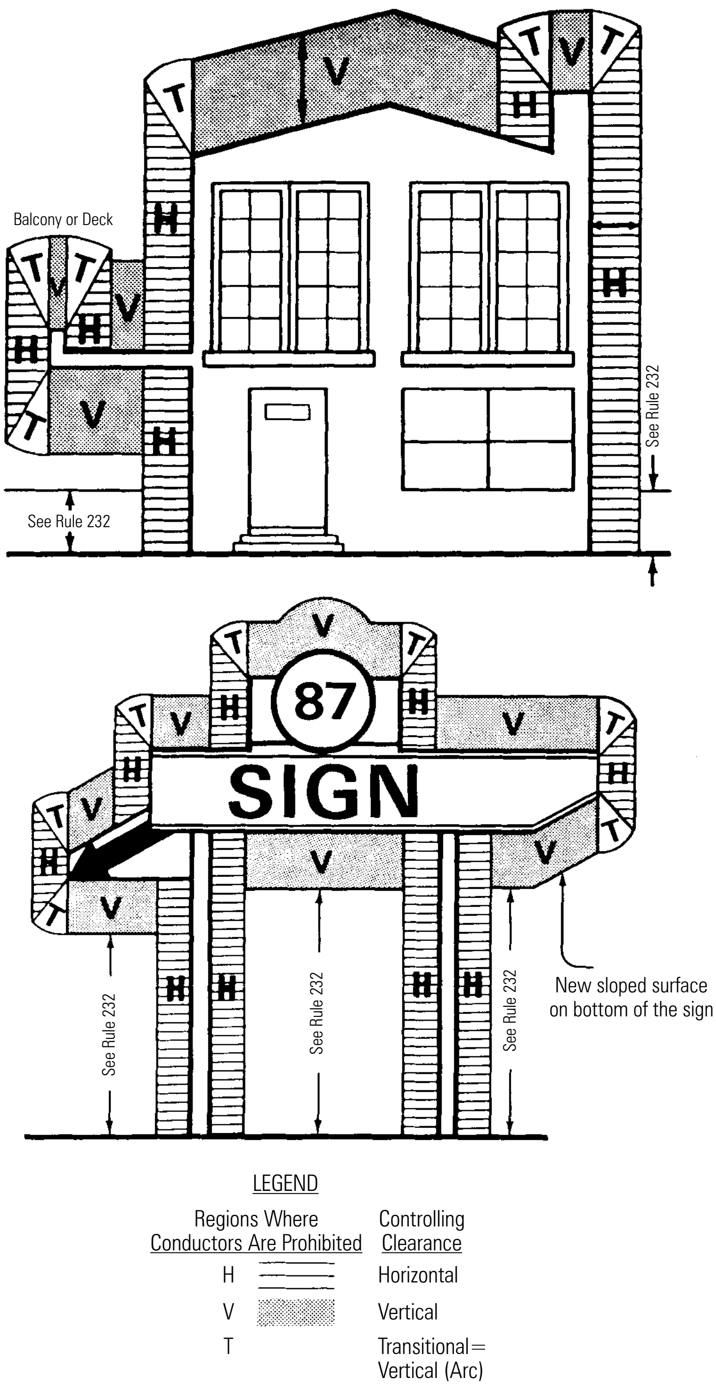
[3] Areas where riders on horses or other large animals, vehicles, or other mobile units exceeding 8 feet in height are prohibited by regulation or permanent terrain configurations or are otherwise not normally encountered or not reasonably anticipated.

[4] For controlled impoundments, the surface area and corresponding clearances shall be based upon the design high water level. For other waters, the surface area shall be that enclosed by its annual high water mark, and clearances shall be based on the normal flood level. The clearance over rivers, streams, and canals shall be based upon the largest surface area of any 1-mile segment that includes the crossing. The clearance over a canal, river, or stream normally used to provide access for sailboats to a larger body of water shall be the same as that required for the larger body of water. Reference *NESC* Table 234-1 for further details and requirements.

[5] Where the U.S. Army Corps of Engineers, or the state, or surrogate thereof has issued a crossing permit, clearances of that permit shall govern.

For more information or details, see Rule 232 and Table 232-1 in the *National Electrical Safety Code*, current edition.

Adapted from *NESC* Table 232-1.



Source: NESC Figs. 234-1(a) and 234-1(b).

FIGURE 3.9: Clearance Diagrams for Buildings and Other Structures.

BASIC CLEARANCE OF CONDUCTORS PASSING BY BUT NOT ATTACHED TO BUILDINGS, SIGNS, AND OTHER INSTALLATIONS EXCEPT BRIDGES (234C)

Table 3.9 shows the basic clearance of conductors passing by but not attached to buildings and signs and other installations. Figure 3.9 illustrates the zones of clearance around a building or other structures, such as signs, where the clearances shown in Table 3.9 apply. Table 3.9 also provides clearances to other supporting structures, which include lighting supports, traffic signal supports, and supporting structures of a second line.

Application of Table 3.9

The following two conditions must be considered in applying the basic clearance of conductors passing by, but not attached to, buildings, signs, and other installations except bridges:

1. Vertical and Horizontal Clearances
   (No Wind Displacement)
   The vertical and horizontal clearances specified in Rule 234 as shown in adapted Table 3.9 apply under whichever of the following conductor temperature and loading conditions produces the closest approach of the conductors to the subject installation. Conditions (a), (b), and (c) apply above and alongside subject installations; condition (d) applies below and alongside subject installations.
   a. 120°F, no wind displacement, final sag
   b. The maximum conductor temperature for which the line is designed to operate, if greater than 120°F, no wind displacement, final sag
   c. 32°F, no wind displacement, final sag, with radial thickness of ice, if any, specified in Rule 230B for the applicable loading zone
   d. The lowest conductor temperature for which the line is designed, no wind displacement, initial sag

TABLE 3.9: Basic Clearances of Conductors Passing by but Not Attached to Buildings, Signs, or Other Installations

Clearance Categories[1]	Voltage (Phase-to-Ground on Effectively Grounded Circuits)					
	Neutrals, Guys (ft)	0 to 750 V Insulated Supply Cables (ft)	0 to 750 V Open Supply Conductors (ft)	750 V to 22 kV Voltage Class		
				12.47/7.2 kV (ft)	24.9/14.4 kV (ft)	34.5/19.9 kV (ft)
BUILDINGS						
Horizontal: Walls,[1] projections,[1] unguarded windows,[1] balconies, porches, decks, and areas accessible to pedestrians	4.5	5.0	5.5[3]	7.5[2]	7.5[2]	7.5[2]
Vertical: Above or below roofs or projections not accessible to pedestrians[1]	3.0	3.5	10.5	12.5	12.5	12.5
Above or below roofs or projections accessible to pedestrians[1]	9.5	10.0	10.5	14.5	14.5	14.5
Above roofs accessible to vehicles but not to truck traffic[1]	9.5	10.0	10.5	14.5	14.5	14.5
Above roofs accessible to truck traffic[1]	15.5	16.0	16.5	18.5	18.5	18.5
OTHER INSTALLATIONS NOT CLASSIFIED AS BUILDINGS[4]						
Horizontal[1]	4.5	5.0	5.5[3]	7.5[2]	7.5[2]	7.5[2]
Vertical:[1] Over or under catwalks and other surfaces upon which personnel walk	9.5	10.0	10.5	14.5	14.5	14.5
Over or under other portions of such installations	3.0	3.5	6.0	8.0	8.0	8.0
OTHER SUPPORTING STRUCTURES						
Horizontal[5]	3.0	3.0	5.0[3]	5.0[2]	5.0[2]	5.0[2]
Vertical[5]	2.0	2.0	4.5	4.5	4.5	4.5

1 Clearances normally apply on rural distribution systems. See *NESC* Table 234-1 for exceptions and notations.
2 This clearance shall not be less than 4.5 ft with conductors displaced by a 6-psf wind. See **Figure 3.10**.
3 This clearance shall not be less than 3.5 ft with conductors displaced by a 6-psf wind. See **Figure 3.10**.
4 Flag poles and banners are included in this category. The specific clearance is with flag or banner fully extended.
5 See *NESC* Rule 234B for exceptions and notations.

Adapted from *NESC* Table 234-1 and Rule 234B.

TABLE 3.10: Basic Vertical Clearances of Wires, Conductors, and Cables Carried on Different Supporting Structures

	Supply Span Guys and Multigrounded Neutral (ft)	Insulated Supply Cables 0 to 750 V[3] (ft)	Open Supply Conductors 0 to 750 V (ft)	Open Supply Conductors (Voltages Phase to Ground)[2]	
				750 V to 22 kV (ft)	22 kV to 50 kV (ft)
Communication Conductors, Cables, and Messengers	2	2	2	4	5
Span Guys and Multigrounded Neutral	2	2	2	2	3
Insulated Supply Cable 0 to 750 V[3]	2	2	2	2	3
Open Supply Conductor 0 to 750 V	2	2	2	2	3
Open Supply Conductor 750 V to 22 kV	2	2	2	2	3

[1] If a crossing structure is under the line being crossed or within 5.5 feet, then the vertical and horizontal clearances of **Table 3.9** must be applied.
[2] Voltages are phase-to-ground for effectively grounded circuits and those others where all ground faults are cleared by promptly deenergizing the faulted section, both initially and following subsequent breaker operations.
[3] Multiconductor wires or cables, and duplex, triplex, or paired conductors supported on insulators or messengers.

Conditions Under Which Clearances Apply. The clearances apply for the final sag conditions. The condition (a or b below) that yields the least vertical clearance in the span is the condition to be used for determining span clearance.

a. Upper conductor is at final sag at a temperature of 32°F, no wind, with the radial thickness of ice for the applicable loading zone. The lower conductor is at initial sag at a temperature of 32°F, no ice, and no wind.
b. Upper conductor is at final sag at a temperature of 120°F or its maximum design conductor temperature, no wind. The lower conductor is at initial sag at a temperature of 60°F.

Adapted from *NESC* Table 233-1[1,2,3]

2. Horizontal Clearances
 (With Wind Displacement)
 Where consideration of horizontal displacement under wind conditions is required, the conductors or cables shall be considered to be displaced from rest toward the installation by a 6-psf wind at final sag at 60°F. The displacement of a conductor or cable shall include deflection of suspension insulators and flexible structures greater than 60 feet above grade. Trees are not to be considered to shelter the line.

A graph is provided in **Figure 3.10** that shows the horizontal clearance *with wind displacement* for seven different conductors. If the final sag of the conductor at 60°F is known, the horizontal clearance with wind displacement can be read directly from the horizontal, or *x*, axis.

CLEARANCE OF WIRES, CONDUCTORS, CABLES, AND RIGID LIVE PARTS FROM GRAIN BINS (234F)

The clearances in Rule 234F for grain bins apply to two different types of grain bins: those with permanently installed augers, conveyors, or elevators and those with *portable* augers, conveyors, or elevators. Grain bins that are loaded by *permanently installed* augers,

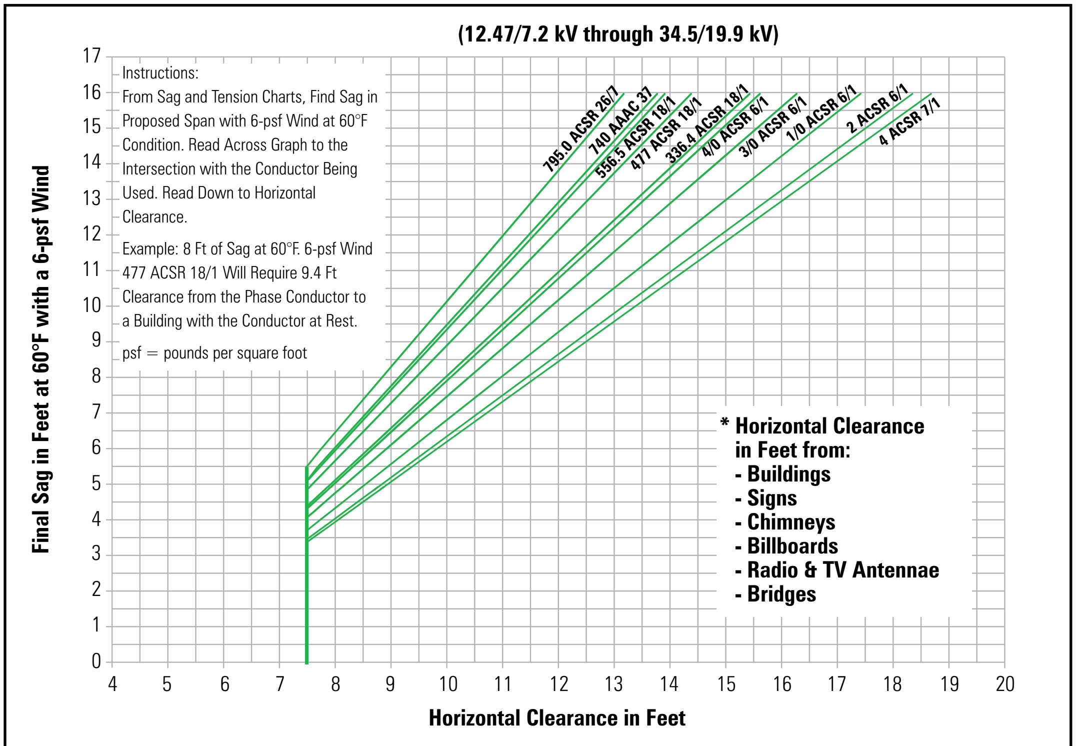


FIGURE 3.10: Horizontal Clearance with Wind Displacement.

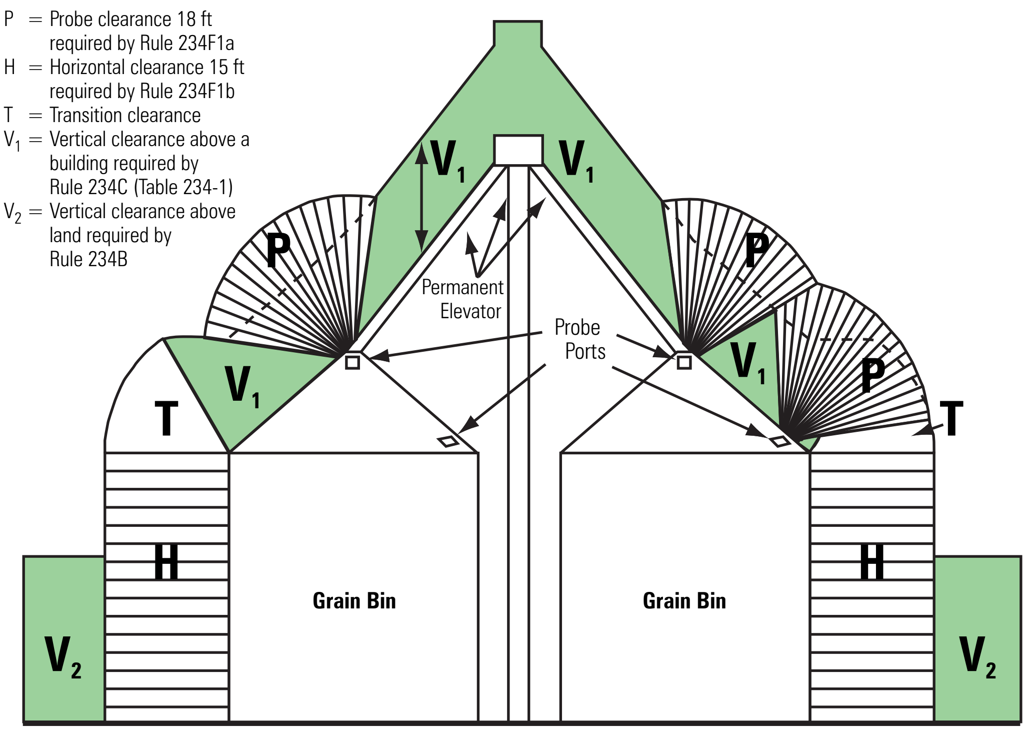
conveyors, and elevator systems must have clearances as shown in **Figure 3.11**. For a grain bin with a permanent auger, the vertical clearance above shall be the same as a structure not classified as a building (see **Table 3.9**) and will also meet a clearance of 18 feet for all cables and wires in any direction from the probe ports in the grain bin (see **Figure 3.11**). The horizontal clearance must meet the requirements shown in Table 3.9 and must also meet a horizontal clearance of 15 feet for all open supply conductors operating between 0 and 22 kV phase to ground. This 15-foot requirement for horizontal clearance does not apply to multi-grounded neutrals.

Figure 3.12 Illustrates the clearance envelope that must be maintained over and around a grain bin that uses a portable auger, conveyor, or elevator.

Table 3.11 provides calculated phase and neutral clearances for lines located specific distances from grain bins with portable augers, conveyors, or elevators.

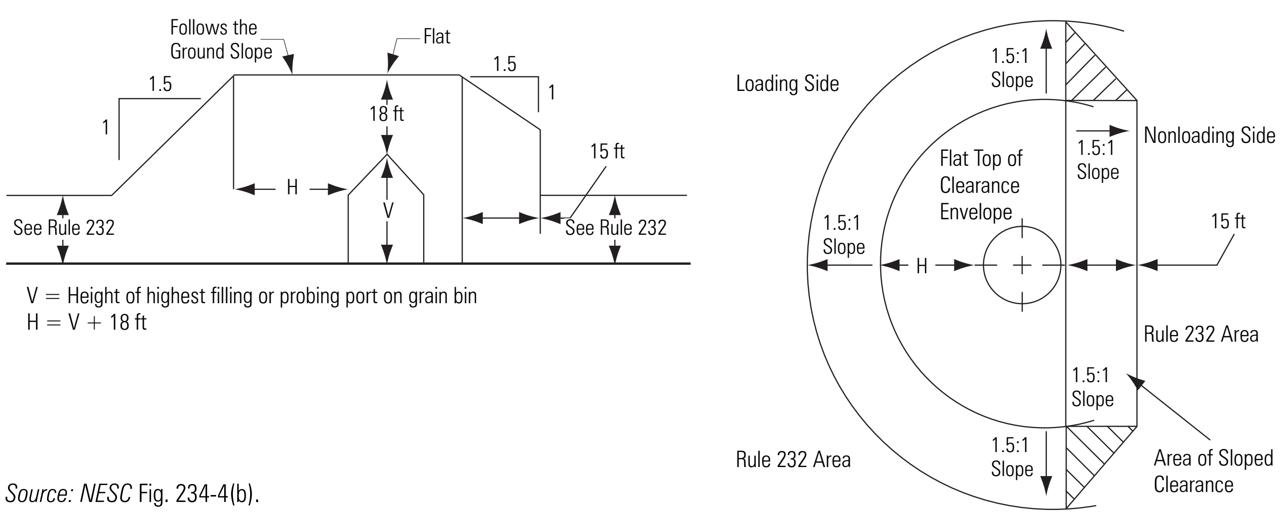
Triplexed secondary conductors need to have the same clearance as neutral conductors on the loading side of the grain bin but are permitted to be closer to the grain bin on the nonloading side (reference NESC Rule 234F for reduced clearances).

In general, the clearances for grain bins are required to be greater than for buildings that have numerous occurrences of electrical contact accidents. The staking technician must pay particular attention when staking a line near grain bins to ensure clearance requirements are met.



Source: NESC Fig. 234-4(a).

FIGURE 3.11: Clearance Envelope for Grain Bins Filled by Permanently Installed Augers, Conveyors, or Elevators.



Source: NESC Fig. 234-4(b).

FIGURE 3.12: Clearance Envelope for Grain Bins Filled by Portable Augers, Conveyors, or Elevators.

TABLE 3.11: Phase and Neutral Clearances from Grain Bin				
VOLTAGES 12.47/7.2 KV THROUGH 34.5/19.9 KV				
Height of Bin	**Loading Side of Grain Bin**		**Nonloading Side**	
	Horizontal Distance from Bin (ft)	**Necessary Conductor Height (ft)**	**Horizontal Distance from Bin (ft)**	**Necessary Conductor Height (ft)**
15	0 to 33	33.0	0	33.0
	40	28.4	10	26.4
	50	21.7	15	18.5
	54.8	18.5		
20	0 to 38	38.0	0	38.0
	50	30.0	10	31.4
	60	23.4	15	18.5
	67.3	18.5		
25	0 to 43	43.0	0	43.0
	50	38.4	10	36.4
	60	31.7	15	18.5
	70	25.0		
	79.8	18.5		
30	0 to 48	48.0	0	48.0
	60	40.0	10	41.4
	70	33.4	15	18.5
	80	26.7		
	90	20.0		
	92.3	18.5		
35	0 to 53	53.0	0	53.0
	60	48.4	10	46.4
	70	41.7	15	18.5
	80	35.0		
	90	28.4		
	100	21.7		
	104.8	18.5		

NOTE: Vertical clearances, however, must be met using the worst-case sag, as described previously in this subsection under Application of **Table 3.8**.

Adapted from *NESC* Rule 234F.

CLEARANCE OF WIRES, CONDUCTORS, OR CABLES INSTALLED OVER OR NEAR SWIMMING POOLS (234E)

The *NESC* lists the clearance of wires, conductors, or cables that are installed over or near swimming pools. When these lines are staked, the design should be carefully evaluated. It is suggested that, when feasible, distribution lines should not be installed over swimming pools.

Table 3.12: Conditions Under Which Clearances Apply

Condition	Upper Conductor at Final Sag	Lower Conductor or Cable at Initial Sag
1	32°F, no wind, with the radial thickness of ice for the applicable loading zone	32°F, no wind, no ice
2	Maximum design conductor temperature or 120°F, whichever produces the most sag	60°F

VERTICAL AND HORIZONTAL CLEARANCES FROM OTHER OBJECTS SUCH AS BRIDGES AND RAILCARS

Rule 234 also covers vertical and horizontal clearances from other objects such as bridges and railcars. When staking distribution lines near these objects, the staking technician must refer to the *NESC* as well as the local governing authority, such as the Department of Transportation or the railroad company, to determine the required clearance.

VERTICAL CLEARANCE BETWEEN CONDUCTORS WHERE ONE LINE CROSSES ANOTHER

The required vertical clearances between conductors when one line crosses another are shown in **Table 3.10** on page 31. These clearances should be maintained at the point where the conductors cross, regardless of where on the span the point of crossing is located. The clearances shown in Table 3.10 must be applied for the worst case (closest approach) as calculated from conditions 1 and 2 shown in the Table 3.12 (also in note 3 in Table 3.10).

LOAD FACTORS

The *NESC* provides specific "load factors," which are more commonly referred to as "overload factors" or "strength factors" that must be applied in calculations to determine the capacity of a distribution structure. These overload factors and strength factors are designated values that are applied in addition to the loading caused by tension, wind, gravity, ice, etc.

RUS Specifications and Drawings

Standard structures and assemblies used for the construction of electric distribution lines on RUS systems are defined with the aid of RUS standard construction drawings. These drawings show in detail the following:

- Dimensions of the components of the structure or assembly. (See example, **Figure 3.13**.)
- Design limits and recommendations. (See example, **Figure 3.13**.)
- Pole framing guides. (See example, **Figure 3.14.**)
- Bill of materials required for construction. (See example, **Figure 3.13**.)

In addition to these standard drawings, the specifications for construction set forth methods and requirements of construction, such as these for conductors:

Conductors

Conductors shall be handled with care and shall not be trampled on or run over by vehicles. Each reel shall be examined and the wire shall be inspected for cuts, kinks, or other damage. Damaged portions shall be cut out and the conductor spliced. The conductors shall be pulled over suitable rollers or stringing blocks properly mounted on the pole or crossarm to prevent binding or damage while stringing.

Conductors shall be sagged evenly and in accordance with the conductor manufacturer's recommendations. The air temperature at the time and place of sagging shall be determined *by the use of a certified thermometer. The sag of all conductors after stringing shall be in accordance with the engineer's instructions.*

For new construction, splices shall be no closer than 1,000 feet from one another and there shall be no more than three splices per mile in any primary phase or neutral conductor. Furthermore, splices shall not be located within 10 feet of any supporting structure. For all construction, splices shall not be located in Grade B crossing spans and preferably not in adjacent spans. Splices shall be installed in accordance with the manufacturer's specifications and recommendations.

All conductors shall be cleaned thoroughly by wirebrushing before splicing or installing connectors or clamps. A suitable oxidation inhibitor shall be applied before splicing or applying connectors over aluminum conductor.

Source: RUS Bulletin 1728F-804 Section 1-b

Specifications and drawings for the overhead pole line assembly units have been produced for each standard RUS primary voltage class distribution line and are published in the following RUS forms:

- REA Bulletin 50-4, Standard D-801, Specifications and Drawings for 34.5/19.9 kV Distribution Line Construction
- RUS Bulletin 1728F-803, Specifications and Drawings for 24.9/14.4 kV Line Construction
- RUS Bulletin 1728F-804, Specifications and Drawings for 12.47/7.2 kV Line Construction

Each drawing describes one construction unit installed in place. Material or components (such as poles) that are not part of the unit but are necessary for the clarity of the drawing are shown as dotted lines (**Figure 3.14**). Guide drawings are included to show the installation of two or more units on the same structure, positioning of transformers, and the method of application of various components of the assembly.

The RUS Specifications and Drawings have been formulated to provide for the safe and reliable construction of rural overhead distribution lines.

The following criteria were used in their development:

- Adequate clearance and separation between conductors
- Clearances to meet *NESC* requirements for conductor supports, vertical jumpers, and climbing and working space
- Clearances to permit safe hot line work
- Positive identification of the neutral conductor
- High impulse strength for the structure through the use of wood crossarms and braces

The specifications and drawings contain sufficient structures and assemblies to provide for most conditions encountered on the rural distribution system.

Pole-Top Assemblies: (A,B,C Units) consist of the material to support the primary conductor. The pole is not included.

A units designate single-phase units.
B units designate V-phase units.
C units designate three-phase units.
D prefix designates double circuit units.
V prefix (VA, VB, VC) designates 24.9/14.4-kV units.
Z prefix (ZA, ZB, ZC) designates 34.5/19.9-kV units.

Conductor Assemblies: (D units) consist of 1,000 feet of conductor or cable for primaries, secondaries, or services and include tie wires, splicing sleeves, connectors, and necessary armor.

Guy Assemblies: (E units) consist of guy strand and necessary hardware.

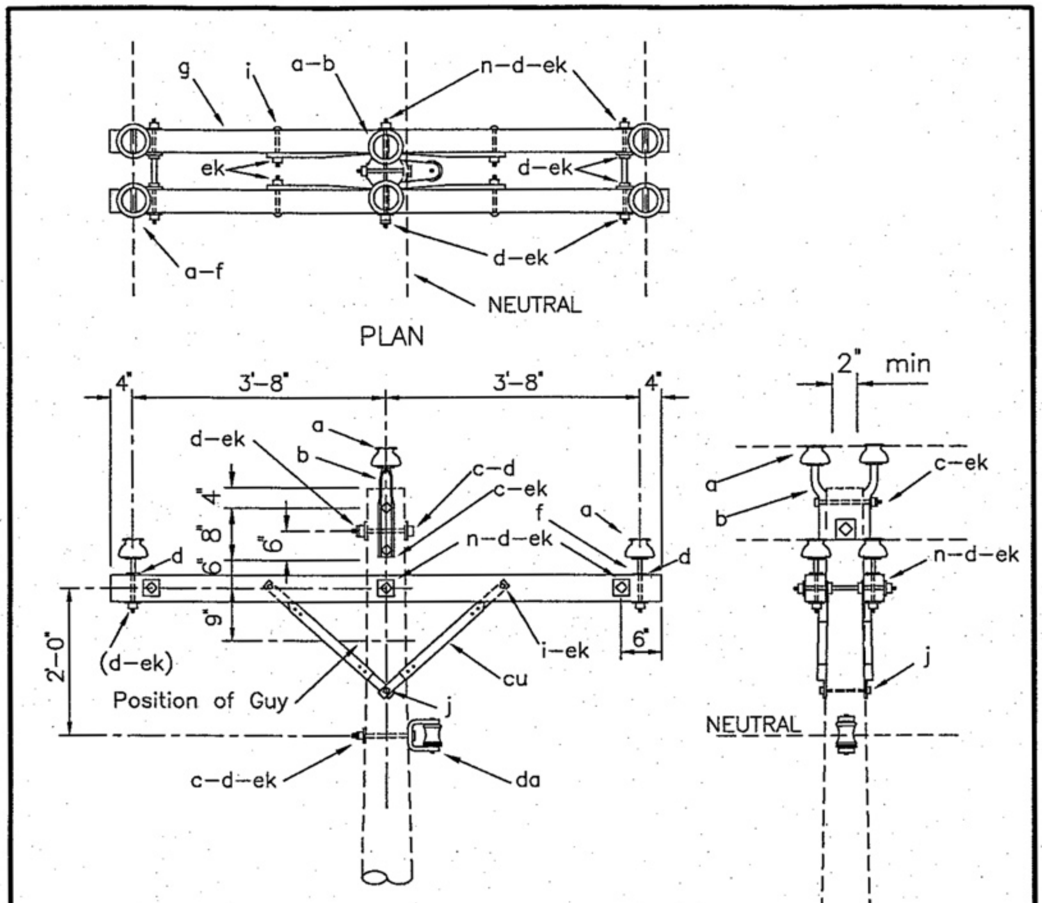
Anchor Assemblies: (F units) consist of the anchor and the rod.

Transformer Assemblies: (G units) consist of the transformer and its protective equipment, hardware, and leads with their connectors.

Grounding Assemblies: (H Units) consist of a ground rod assembly and other grounding units.

Secondary and Service Assemblies: (J and K units) consist of the hardware and insulators needed to support the secondary and service conductors or cable.

Dimensions of Components



Bill of Materials

ITEM	QTY	MATERIAL
a	6	Insulator, pin type (12.47/7.2 kV)
b	2	Pin, pole top, 20", straight or offset
c	4	Bolt, machine, 5/8" x req'd length
d	17	Washer, square, 2 1/4"
f	4	Pin, crossarm, steel, 5/8" x 10 3/4"
g	2	Crossarm, 3 5/8" x 4 5/8" x 8' 0"
i	4	Bolt, carriage, 3/8" x 4 1/2"
j	2	Screw, lag, 1/2" x 4"
n	3	Bolt, double arming, 5/8"xreq'd length
cu	4	Brace, 28"
da	1	Bracket, insulated
ek	18	Locknuts

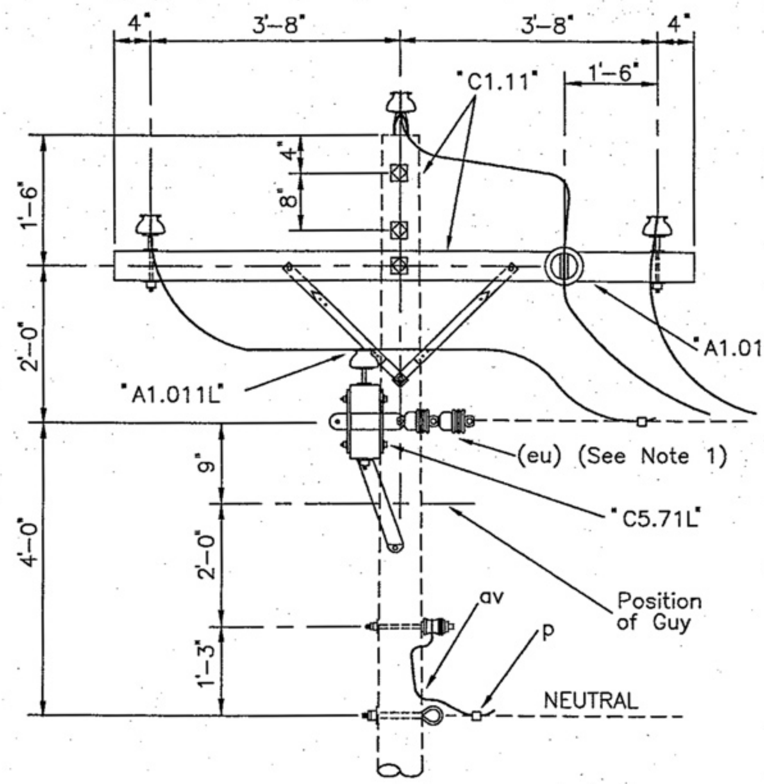
Design Limits

DESIGN PARAMETERS:
See TABLE III

DOUBLE SUPPORT ON CROSSARMS

APRIL 2005	3 – PHASE PRIMARY 12.47/7.2 kV	C2.21 (C2)
RUS		

FIGURE 3.13: Examples of Dimensions of Components, Design Limits, and Bill of Materials.



NOTES:

1. Install insulated extension link, item "eu", in center phase of tap.
2. Jumper wires to be a minum of 19 inches to surface of pole.

ITEM	QTY	MATERIAL
	1	C1.11 Primary Assembly
	1	C5.71L Primary Assembly
	(1)	(C5.21 or C5.31 Primary Assembly)
		(Use Table A – Exhibit 2)
	1	A1.011L Misc. Single Support
	1	A1.011P Misc. Single Support
p		Connectors, as req'd
av		Jumpers, as req'd
bo	1	Shackle, anchor
eu	1	Link, extension, insulated (18" min.)

DESIGN PARAMETERS:

PERMITTED LONGITUDINAL LOAD EQUALS LESSER OF:
5,000 lbs./Conductor, or
Manufacturer's specifications times NESC strength factor.

THREE PHASE HORIZONTAL TAP GUIDE		
APRIL 2005 / RUS	3 – PHASE PRIMARY 12.47/7.2 kV	C5.82G

FIGURE 3.14: Example of Pole Framing Guides.

Right-of-Way Clearing and Trimming: (M units) consist of a cleared section of right-of-way 1,000 feet in length to a designated width.

Neutral Assemblies: (N units) consist of the neutral spools and their associated strengths.

Protection Assemblies: (P units) consist of overvoltage protection and raptor protection.

Metering Assemblies: (Q units) consist of metering guides including primary meters.

Overcurrent Protection: (R and S units) consist of oil circuit reclosers, fuses, and switches.

Voltage Regulators/Capacitor Assemblies: (Y units) consist of assemblies that provide voltage alteration.

The RUS specifications and drawings provide the standard for safe and reliable construction of rural distribution lines.

They also provide, in addition to the *NESC*, a reference point from which judgments are made as to the safety of the electrical system when litigation is involved. For the above reasons, significant deviations from the specifications must first have the approval of RUS before being applied in the field.

RUS List of Materials

Material and equipment acceptable for use on systems of RUS borrowers are shown in RUS Information Publication 202-1, List of Materials Acceptable for Use on Systems of USDA Rural Development Electrification Borrowers. Included are material and equipment for transmission and distribution facilities and specific items of the electrical plant.

In addition to items accepted on a general basis, the list also includes items accepted on a conditional basis. One of the latter conditions states that contractors are required to obtain the borrower's concurrence prior to an item's use.

The acceptance or deletion of items is a function of the RUS Technical Standards Committee.

The materials and equipment included in the document are considered to be adequate when applied correctly for the safe and reliable construction of facilities. It is an RUS requirement that, for any construction using funds borrowed from RUS, all material used must either be listed in the List of Materials or must have RUS approval. To obtain special permission to use a nonapproved item, the borrower should submit the following to the RUS field representative:

- Description of the item, including catalog information
- Reasons for wanting to use the item on the system
- Applicable strength calculations or other technical data

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4 Conductor Characteristics

In This Section:

Conductors are the fundamental building blocks in the design and construction of overhead distribution lines. Conductor size, type, and design tension will control the selection of pole height and class, type of pole-top assembly, and the size and quantity of guys and anchors. Next to the requirements of the *NESC*, the selected conductor is the most important factor in total line design. Therefore, the staking technician must possess a working knowledge of conductor characteristics as well as an understanding of the effects of various design parameters on the behavior of the line.

Conductors are installed under tension between supporting structures. The *NESC* and the manufacturers set tension limits to prevent conductor stresses above the elastic limit of the conductor's material. Generally, the tension limits specified by the manufacturers provide lower unloaded conductor tensions than those of the *NESC*.

The tension limits used in this manual meet the requirements of both the manufacturers and the *NESC*.

Conductor Tension Limits

The *NESC* (261H1a.) sets the design tension limit to 60% of the rated breaking strength of the conductor for the loaded condition. The loaded condition is when the conductor is loaded with the assumed ice and wind conditions for the specified loading district as defined in *NESC* Rule 250B. The loading on the conductor occurs at specified temperatures and with a constant to be added to the resultant tension, known as the "k" factor. **Table 4.1** summarizes the loads to be applied without exceeding the design tension limit of 60% of the rated breaking strength of the conductor. Per *NESC* (261H1a(2)), for extreme wind loading and extreme ice loading, the design tension should not exceed 80% of the rated breaking strength of the conductor when the wind and ice loads are applied based on the location of the conductor related to the wind speed maps (**Figure 3.2(a)** and **Figure 3.2(b)**) and extreme ice loading maps (**Figure 3.3**).

TABLE 4.1: Loaded Condition for Design Tension Limit of 60%			
	Ice and Wind Loads (For Use with Rule 250B and Rule 251B)		
	Heavy	Medium	Light
Radial thickness of ice (inches)	0.5	0.25	0
Horizontal wind pressure (lb per sq ft)	4	4	9
Temperature (°F)	0	+15	+30
Constant to be added to conductor resultant tension (lb/ft)	0.3	0.2	0.05

A serious concern for distribution lines is damage caused by aeolian vibration, also known as wind-induced vibration. Aeolian vibration occurs when a steady wind passes across a conductor under tension. This can cause forces alternating from above and below, causing the conductor to vibrate. The overhead conductors do not have very good self-damping characteristics, resulting in continuous vibration. This concept is similar to plucking a guitar string, which results in a vibration that can last a long time. For overhead conductors, the vibration can cause mechanical fatigue or failure of the conductor or assemblies. For typical distribution lines, small conductors are generally more susceptible to this phenomenon.

Thus, the staking technician must consider the potential damage from aeolian vibration. In fact, *NESC* (261H1b) requires aeolian vibration damage to be considered and needs to be based on a qualified engineering study, manufacturer's recommendation, or experience from comparable installations. While there are several methods to mitigate aeolian vibration, a common technique is to reduce design tension limits for cold weather conditions. During cold weather, the conductor contracts and the tension of the conductor increases which increases the likelihood of aeolian vibration. *NESC* provides design tension limits to potentially mitigate aeolian vibration.

Design tension limits are based on the Loaded Condition, the Initial Unloaded Tension, and Final Unloaded Tension. The *NESC* suggests using the final unloaded tension after long-term creep and prior to ice or wind loading. For this manual, final unloaded tension is the greater of (1) sag caused by long-term creep, or (2) ice and wind loading. This design method has been used sucessfully for distribution lines for many years. The staking technician designing lines in areas of that are susceptible to aeolian vibration should consult with an engineer for guidance.

1. **Loaded Condition**
   When the conductor is loaded to the assumed ice and wind conditions for the specified loading district, the tension shall not (per the *NESC*) exceed 60% of the rated breaking strength of the conductor. This is referred to as the "loaded condition."
2. **Initial Unloaded Condition**
   Per *NESC* Rule 261H1c, when conductor tension is the only method to control vibration, for the condition when the conductor is initially strung and is carrying no wind or ice load, the tension shall not exceed 35% of the rated breaking strength of the conductor at a temperature of 0°F for heavy loading, 15°F for medium loading, and 30°F for light loading. This is referred to as the "initial unloaded condition."
3. **Final Unloaded Condition**
   For this condition, when considering vibration mitigation tension limits, final tension exists after long-term creep and prior to ice or wind loading. Creep is the permanent elongation of the conductor from everyday tensions over a period of time. When this condition is reached, the tension in the conductor without ice or wind loading shall not exceed 25% of the rated breaking strength of the conductor at a temperature of 0°F for heavy loading, 15°F for medium loading, and 30°F for light loading. This is referred to as the "final unloaded condition."

TABLE 4.2: *NESC* Tension Limits for ACSR Conductor: Percentage of Rated Breaking Strength of the Conductor

Loading Condition	Percentage of Rated Breaking Strength
LIGHT LOADING DISTRICT	
Loaded, 30°F, 0-in. ice, 9-lb-per-sq-ft wind	60.0%
Initial unloaded, 30°F (initial sag)	35.0%
Final unloaded, 30°F (final sag)	25.0%
MEDIUM LOADING DISTRICT	
Loading Condition	**Percentage of Rated Breaking Strength**
Loaded, 15°F, 0.25-in. ice, 4-lb-per-sq-ft wind	60.0%
Initial unloaded, 15°F (initial sag)	35.0%
Final unloaded, 15°F (final sag)	25.0%
HEAVY LOADING DISTRICT	
Loading Condition	**Percentage of Rated Breaking Strength**
Loaded, 0°F, 0.50-in. ice, 4-lb-per-sq-ft wind	60.0%
Initial unloaded, 0°F (initial sag)	35.0%
Final unloaded, 0°F (final sag)	25.0%

TABLE 4.3: Recommended Tension Limits for ACSR Conductor: Percentage of Rated Breaking Strength of Conductor

Loading Condition	Percentage of Rated Breaking Strength
LIGHT LOADING DISTRICT	
Loaded, 30°F, 0-in. ice, 9-lb-per-sq-ft wind	50.0%
Initial unloaded, 30°F (initial sag)	33.3%
Final unloaded, 30°F (final sag)	25.0%
MEDIUM LOADING DISTRICT	
Loading Condition	**Percentage of Rated Breaking Strength**
Loaded, 15°F, 0.25-in. ice, 4-lb-per-sq-ft wind	50.0%
Initial unloaded, 15°F (initial sag)	33.3%
Final unloaded, 15°F (final sag)	25.0%
HEAVY LOADING DISTRICT	
Loading Condition	**Percentage of Rated Breaking Strength**
Loaded, 0°F, 0.50-in. ice, 4-lb-per-sq-ft wind	50.0%
Initial unloaded, 0°F (initial sag)	33.3%
Final unloaded, 0°F (final sag)	25.0%

Sag and tension limits provided by the conductor manufacturers for copper and copper-clad conductors usually conform with the aforementioned *NESC* tension limits. However, most ACSR (aluminum conductor steel-reinforced) and other aluminum conductor sag and tension data are based on different criteria. A common method used in the industry, which meets or exceeds the requirements of the *NESC*, uses the following limits for conductor tension:

1. **Loaded Condition**
   For the loaded condition, the tension should not exceed 50% of the rated breaking strength of the conductor.
2. **Initial Unloaded Condition**
   For the initial unloaded condition, the tension should not exceed 33.3% of the rated breaking strength of ACSR conductors and 30% of the ultimate strength of AAAC (all-aluminum alloy conductor) conductors at a temperature of 0°F for heavy loading, 15°F for medium loading, and 30°F for light loading.
3. **Final Unloaded Condition**
   For the final unloaded condition, the tension should not exceed 25% of the rated breaking strength of ACSR conductors and 20% of the ultimate strength of AAAC conductors at a temperature of 0°F for heavy loading, 15°F for medium loading, and 30°F for light loading.

These three conditions for aluminum conductors provide lower conductor tensions than those specified in the *NESC* for mitigating aeolian vibration in cold weather loading and a lower than 60% limit for the loaded condition. The tension limits defined by these conditions have been accepted as good practice by cooperatives in the design and construction of distribution lines for many years.

Table 4.2, Table 4.3, and **Table 4.4** provide an easy reference for *NESC* and recommended design tension limits.

TABLE 4.4: Recommended Tension Limits for AAAC Conductor: Percentage of Rated Breaking Strength of Conductor

Loading Condition	Percentage of Rated Breaking Strength
LIGHT LOADING DISTRICT	
Loaded, 30°F, 0-in. ice, 9-lb-per-sq-ft wind	50.0%
Initial unloaded, 30°F (initial sag)	30.0%
Final unloaded, 30°F (final sag)	20.0%
MEDIUM LOADING DISTRICT	
Loading Condition	**Percentage of Rated Breaking Strength**
Loaded, 15°F, 0.25-in. ice, 4-lb-per-sq-ft wind	50.0%
Initial unloaded, 15°F (initial sag)	30.0%
Final unloaded, 15°F (final sag)	20.0%
HEAVY LOADING DISTRICT	
Loading Condition	**Percentage of Rated Breaking Strength**
Loaded, 0°F, 0.50-in. ice, 4-lb-per-sq-ft wind	50.0%
Initial unloaded, 0°F (initial sag)	30.0%
Final unloaded, 0°F (final sag)	20.0%

CONTROLLING CONDITIONS

For a given span, only one of the loading conditions will determine the design tension limit of the conductor. This condition is referred to as the controlling condition and can be any one of the three previously discussed loading conditions. Of the three conditions, the one that will control the design tension limit is usually determined by the length of the span.

Conductor manufacturers develop and provide sag and tension data that show various loading conditions for a specified span, usually referred to as the "ruling span." The definition of "ruling span" and its application are discussed later in this section. The sag and tension data provided by the manufacturer are commonly referred to as "sag charts." These charts will be used to demonstrate the controlling condition that determines the design tension limit. A more detailed discussion of manufacturer sag and tension data is also presented later in this section.

Example 4.1 demonstrates how to determine the controlling design tension for a typical conductor.

REDUCED CONDUCTOR TENSIONS

Sometimes it is necessary to use conductor tension limits that are less than the specified standard *NESC* tension limits. Three situations where reduced conductor tensions are necessary include:

1. Meeting RUS distribution hardware load limits
2. Urban construction
3. Lines susceptible to aeolian vibration

RUS requires that tension loads not exceed 5000 lb. This limit is dictated by the derated (*NESC* (277)) strength of the suspension insulators and the 3-inch-square curved washers. The requirements for the larger 3-inch washers was added by RUS in 1998 for the 25-kV specifications and in 2005 for the 12-kV specifications. However, years of field service have shown that a limit of 4000 lb per conductor works well on standard size distribution conductors. **Section 12** of this manual addresses extra-large conductors, which often require tensions greater than 4000 lb.

If the recommended design tension limits are used, as shown in **Table 4.3** and Table 4.4, some of the larger conductors will exceed this commonly applied 4000-lb limit. Therefore, when design tension limits are specified for these conductors, the maximum design tension needs to be reduced to 4000 lb.

In urban areas, the span lengths are generally short and space for guying is relatively limited. Conductors can be installed at reduced tension since the amount of sag will not be excessive for the short spans. By using a lower design tension, less strain is placed on the hardware, poles, and guys.

The staking technician must be mindful when staking lines with reduced conductor tension that allowances for the resulting increased sag of the conductor have to be considered.

Example 4.1

Determine the controlling design tension.

Given:	Conductor	=	2 ACSR 6/1
	Loading district	=	Heavy
	Spans	=	150 ft, 210 ft, and 350 ft
	Ultimate strength	=	2850 lb
	Tension limits	=	Recommended, **Table 4.3**
	Maximum operating temperature	=	120°F

Calculate the three limiting conductor design tensions.

$$DT = (T)(U)$$

Where:

DT = Calculated design tension (lb)

T = Tension limit of specified loading condition as a percentage (refer to **Table 4.3**)

U = Ultimate strength of conductor

Loaded condition: $DT = 0.50 \times 2850 \text{ lb} = 1425 \text{ lb}$

Initial unloaded condition: $DT = 0.333 \times 2850 \text{ lb} = 949 \text{ lb}$

Final unloaded condition: $DT = 0.25 \times 2850 \text{ lb} = 713 \text{ lb}$

Determine which of the calculated design tension limits controls for the specified spans of 150 ft, 210 ft, and 350 ft. Refer to the manufacturer's sag and tension data shown in **Table 4.5**. From this table, locate and tabulate the conductor tensions for each span corresponding to the three loading conditions.

Loading Condition	Tension Limits (lb)	Sag Table Tension for Spans		
		150 ft	210 ft	350 ft
Final Loaded	1425	11,196	1398	1425*
Initial Unloaded	949	864	949*	302
Final Unloaded	713	713*	708	208

* Denotes controlling condition.

As shown in the above tabulation, a different loading condition controls the design tension limit for each of the three spans.

TABLE 4.5: Aluminum Company of America Sag and Tension Data

Recommended Tension Limits, Percentage of Rated Breaking Strength
Loaded = 50%, Initial Unloaded = 33.3%, Final Unloaded = 25%
Conductor: SPARROW #2 AWG 6/1 Stranding ACSR
Area: 0.0608 sq in.
Data from Chart No. 1-1023
English Units

Span: 150 ft HEAVY LOADING
Creep is not a factor

Design Points					Final		Initial	
Temp °F	**Ice (in.)**	**Wind (psf)**	**K† (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	.50	4.00	.30	1.035	2.44	1196	2.44	1196
32	.50	.00	.00	.589	2.04	812	1.84	904
–20	.00	.00	.00	.091	.30	858	.27	960
0	.00	.00	.00	.091	.36	713*	.30	864
30	.00	.00	.00	.091	.51	501	.36	711
60	.00	.00	.00	.091	.82	313	.47	545
90	.00	.00	.00	.091	1.31	196	.69	374
120	.00	.00	.00	.091	1.53	167	1.12	229

Span: 210 ft HEAVY LOADING
Creep is not a factor

Design Points					Final		Initial	
Temp °F	**Ice (in.)**	**Wind (psf)**	**K† (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	.50	4.00	.30	1.035	4.09	1398	4.09	1398
32	.50	.00	.00	.589	3.46	949	3.05	1066
–20	.00	.00	.00	.091	.59	850	.48	1040
0	.00	.00	.00	.091	.71	708	.53	949*
30	.00	.00	.00	.091	.99	506	.63	803
60	.00	.00	.00	.091	1.49	336	.78	645
90	.00	.00	.00	.091	2.04	246	1.04	481
120	.00	.00	.00	.091	2.32	216	1.52	330

Span: 350 ft HEAVY LOADING
Creep is not a factor

Design Points					Final		Initial	
Temp °F	**Ice (in.)**	**Wind (psf)**	**K† (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	.50	4.00	.30	1.035	11.16	1425	11.26	1425*
32	.50	.00	.00	.589	10.24	885	9.50	953
–20	.00	.00	.00	.091	6.07	230	3.95	353
0	.00	.00	.00	.091	6.71	208	4.61	302
30	.00	.00	.00	.091	7.59	184	5.64	248
60	.00	.00	.00	.091	8.03	174	6.62	211
90	.00	.00	.00	.091	8.47	165	7.53	185
120	.00	.00	.00	.091	8.89	157	8.38	167

* Design Condition.
† K is an additive constant required by *NESC* Table 251-1.

Span Selection

The length of the span as determined by the size and type of conductor will control the selection of poles, pole-top assemblies, and guy/anchor assemblies.

Pole Height: The pole provides a vertical support to maintain clearance above ground of the conductor and other objects specified in the *NESC*. As the span length increases, so does the amount of sag in the conductor. Therefore, the pole height must also increase to provide the required clearances. Remember, clearance is based on the *worst-case condition* of final sag of the conductor.

Pole Strength: In addition to providing clearance, the pole must also provide sufficient mechanical strength to support the conductors. A load is placed on the conductor by the forces of wind and ice acting independently or together along with the weight of the conductor material. The mechanical strength of the pole must be adequate to prevent these forces from causing the structure to fail. As the span length increases, so does the amount of conductor load. Therefore, the strength of the pole must also increase to provide adequate support.

Pole-Top Assembly: The pole-top assembly provides a means to insulate and attach the conductors to the pole. It must also be of sufficient strength and configuration to provide adequate support and separation of the conductors. The same loads that affect pole strength also affect the pole-top assemblies. Longer spans produce greater loads and require stronger assemblies. To provide the *NESC*-specified vertical and horizontal clearances within the span, the pole-top assembly must be of a configuration to provide adequate separation of the conductors. As mentioned earlier, increased span length also produces greater conductor sag. This increase in sag allows greater side-to-side movement of the conductors, especially the smaller sizes. Longer spans require assemblies that produce the greatest amount of separation. Also, the span length will affect the separation of the conductors when the configuration is rolled from horizontal to vertical. Spans of 350 feet or less will generally provide adequate separation of conductors when the configuration is rolled from horizontal to vertical on standard RUS crossarm and vertical assemblies. Spans of greater lengths should be reviewed by the cooperative and/or consulting engineer to determine if adequate separations will be obtained. In summary, shorter spans provide more separation between conductors.

Guys and Anchors: Guys and anchors provide lateral support for the pole. The size and quantity of the guys and anchors must provide mechanical strength greater than the forces produced by the conductors. Since longer spans produce greater loads, more or larger guys and anchors will also be required.

The determination of the strength of poles, pole-top assemblies, and guy/anchor assemblies is discussed in Sections 5, 6, and 7, respectively.

Prior to going out in the field and actually staking a section of distribution line, the staking technician should have previously selected a design average span to use as a basis for determining the locations of structures. This estimated span is usually based on experience and engineering judgment. Many utilities have already determined which span lengths work best for specific conductors in the various types of service areas of the utility.

Selection of a design average span for a distribution line section involves consideration of the following limitations:

- The behavior of the conductor under tension
- The resulting sag of the conductor
- The terrain over which the conductor is strung
- The number and spacing of transformer and tap poles required to serve the consumers
- The standard height and class of poles used and stocked by the cooperative
- The loading district in which the line section is located

In flat, sparsely populated areas with few control points, the level ground clearance essentially sets the average span. In areas with rough terrain, irregular roads, and/or a high consumer density, the level ground clearance will not control the span length. The average span must be estimated, as well as possible, to suit these conditions.

LEVEL GROUND SPAN

The level ground span is the maximum span for a given conductor and a given pole height over level ground that will meet *NESC* requirements for a specified grade of construction.

The length of the level ground span is determined by the midspan clearance of the conductor that controls the clearance. For many RUS pole-top assemblies, the controlling conductor will be the neutral. RUS construction specifies 4-foot vertical spacing between the neutral and the primary. If the neutral has proper ground clearance, the primary will usually have proper ground clearance. The span length can be increased if there is a depression at midspan. Conversely, the span length must be decreased if there is a rise in the topography at midspan.

The level ground span is a function of conductor sag, clearance to ground with appropriate design and construction tolerance, and the height of the poles used to support the conductors. To determine the basic level ground span, the staking technician must refer to an appropriate sag table to ascertain the amount of sag at *worst-case conditions* for various span lengths. The span can then be selected by either of the following two procedures:

1. Select a level ground span that will provide adequate clearance for the conductors when supported by the standard height and class of poles used and stocked by the cooperative.
2. Determine the level ground span that provides adequate clearance when supported by several different pole heights, such as a span between two 35-foot poles, a span between two 40-foot poles, etc. Then select the basic pole height that will accommodate the majority of probable spans anticipated for the system.

RULING SPAN

"Ruling span" is one of the most frequently used and often misunderstood terms in the design, staking, and construction of overhead electric distribution lines. In the staking process, it is usually connected with the selection of a conductor design. The ruling span may be considered as an assumed "design span" that ensures the best average tension throughout a line section of unequal span lengths between guyed dead ends. It is based on the total length and average tension of the conductor in a series of spans sagged in one operation. The ruling span is a theoretical span whose sag and tension characteristics, when applied to the whole section, will result in the minimum difference in tension between the individual spans once they are "tied in" and thereby become individual deadend spans.

The ideal situation would be for all spans in a section of distribution line between dead ends to be of the same length. If this situation existed, the force caused by the ice and wind loading on the conductors would be evenly distributed over all the structures. A line section of even spans may possibly be obtained in rural areas of very flat land. However, in most cases, because of terrain and consumer requirements, in addition to roads, rivers, and buildings, the line is usually composed of spans of uneven lengths. When the individual spans in the section are of different lengths and are tied in to the supports, every change in temperature, ice, and wind loading will cause differences in tension between spans. This, in turn, causes the flexing or bending of poles, crossarms, and pins to compensate for the differences in tension.

Consider a simple line section of two spans between guyed deadend structures as shown in **Figure 4.1**.

Span A = 200 feet and span B = 400 feet. At full load, span B would have twice the amount of ice as span A and twice the amount of area to be affected by the wind. Therefore, the tension would be greater in span B and cause structure

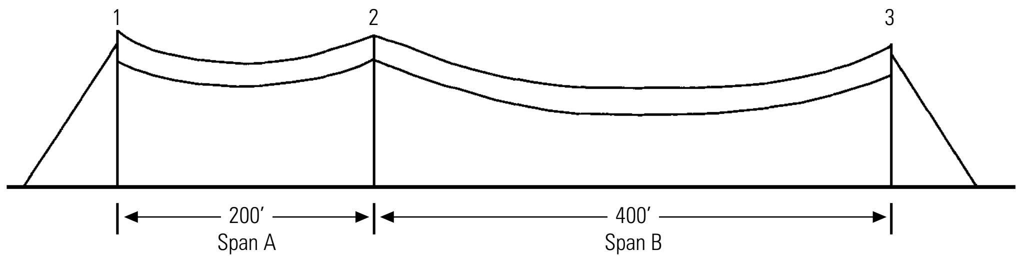


FIGURE 4.1: Two Spans Between Guyed Deadend Structures.

number 2 to flex toward structure 3 in an attempt to equalize the tensions. To minimize this flexing and maintain an acceptable amount of sag, the conductor should be initially sagged to tension for a span longer than 200 feet but shorter than 400 feet. This intermediate span is called the ruling span. A "rule-of-thumb" method used to determine the ruling span is:

Rule of Thumb 4.1

Ruling Span =
Avg. Span + 2/3 (Max. Span – Avg. Span)

Use this rule with caution. If used indiscriminately, answers significantly different from the true ruling span may result. A few spans or even one span much longer than the average span may cause error. To prevent this problem, another rule of thumb states that when a span exceeds the average span by 50%, then the line should be deadended and a different ruling span used for the longer span(s). For example, if the ruling span is 300 feet, then spans equal to or greater than 450 feet should be double deadended.

300 ft (0.50) = 150 ft

300 ft + 150 ft = 450 ft

Long spans have more impact on the ruling span than short spans. Therefore, control of the ruling span is generally achieved by controlling the long spans. The rule-of-thumb method of calculating the ruling span should be used for estimating ruling spans when the actual spans are not yet known. After the line is staked and the spans are known, a more accurate method can be used to calculate the ruling span. This method is expressed by Equation 4.1:

Equation 4.1

$$RS = \sqrt{\frac{S_1^3 + S_2^3 + S_3^3 + \ldots S_n^3}{S_1 + S_2 + S_3 + \ldots S_n}}$$

Where:

RS = Ruling Span
$S_1, S_2, S_3, \ldots, S_n$ = 1st, 2nd, 3rd, ..., nth span lengths

Example 4.2

Calculate the ruling span for the line section composed of spans of 300 feet, 325 feet, 275 feet, 315 feet, and 350 feet.

$$RS = \sqrt{\frac{300^3 + 325^3 + 275^3 + 350^3 + 315^3}{300 + 325 + 275 + 350 + 315}}$$

RS = 315.98 feet, or 316 feet

4

USING THE LEVEL GROUND SPAN AS A RULING SPAN

The use of the level ground span for a given pole height as the ruling span will result in the least number of poles and the most economical line construction. Use of the level ground span as the ruling span is satisfactory when the ground is level or slightly rolling. In rougher terrain, however, this practice may result in excessive conductor tensions. Conversely, if a ruling span longer than the level ground span is used in flat country, tensions may be lower and sags greater.

Once an examination of the terrain is made, the selection of the proper ruling span may be based on the staking technician's experience. In the absence of this experience, the level ground span for the height of the basic pole may be used to stake the line in flat or rolling country. In rougher country, the level ground span for a pole 5 feet longer may be used. For example, with 35-foot poles in moderately rough country, use the level ground span for 40-foot poles as the ruling span.

Conductor Sag

SAG AND TENSION DATA

To provide adequate ground clearance and determine the tension of a conductor at various loading conditions, the staking technician must obtain and use sag and tension data or what are commonly referred to as "sag tables." These tables show the amount of sag in feet and the tension in pounds for a specified span length under a specified loading condition.

The various loading conditions shown in the sag tables take into consideration the effects of temperature, ice, and wind of the loading district for which the table was produced. **Table 4.5**, which is used to demonstrate the controlling conditions, is an example of a sag table produced by a conductor manufacturer.

Sag tables are very important for use in field staking to determine the amount of clearance based on the worst-case sag condition of the conductor.

For reference, a collection of sag tables is contained in **Appendix B**. Alternatively, sag tables can be obtained from the conductor manufacturer or a consulting engineering firm. To receive the correct table, design specifications regarding the selected conductor must be sent, along with the request for sag and tension data. **Figure 4.2** shows an example of a correctly completed sag and tension data request form.

Stringing sag tables are used in the field to actually install or "sag" the conductor. They are prepared using the data previously developed for the sag and tension tables. Stringing sag tables differ from the sag and tension tables in that they show sag in either inches or feet for several temperatures and span lengths that might occur in a typical line under existing weather conditions based on a given ruling span. **Table 4.6** is an example of a stringing sag table.

REQUEST FOR CONDUCTOR SAG–TENSION DESIGN DATA

Requested By John C. Goodfellow Date 2-11-08

Utility/Consultant XYZ EMC

Address X Hwy., Your State, Zip Code

Fill in the request blanks with appropriate information or indicate not required. Indicate units of measurement used. For tension, give value or indicate percentage of breaking strength.

1. Conductor Size, Stranding, Type, Code Name If Known: 4/0 ACSR 6/1, Penguin
2. Design Loading, Indicate *NESC* Light, Medium, Heavy; or Special: Medium Loading
   If Special, Provide Loadings: Wind N/A Ice N/A
3. Design Loading Tension Limit: Customary
4. Other Tension Limits: 4000 lb Max Design Tension
5. List Ruling Spans Needed: 300 ft, 400 ft
6. Temperature Range Needed for Stringing Sag Data: 40°F to 100°F
7. Maximum Operating Temperature: 120°F
8. Extreme Wind Force or Velocity: NOT REQUIRED
9. Extreme Ice Thickness: NOT REQUIRED
10. Comments: Please include final and initial stringing sag charts.

FIGURE 4.2: Sag and Tension Data Request Form.

TABLE 4.6: Stringing Sag Table

336.4 ACSR 18/1 3272 lb Design Tension
300-ft Ruling Span

Medium Loading

SAG IN INCHES FOR CONDITION SHOWN

Conductor Weight
Bare: 0.3650 Iced: 0.0000 Loaded: 0.0000

Initial Conditions for Temperature and Tension

Temperature	40°F	50°F	60°F	70°F	80°F	90°F
Tension (lb)	2250	2043	1843	1655	1483	1331
Span (ft)						
200	10	11	12	13	15	16
210	11	12	13	15	16	18
220	12	13	14	16	18	20
230	13	14	16	18	20	22
240	14	15	17	19	21	24
250	15	17	19	21	23	26
260	16	18	20	22	25	28
270	18	20	22	24	27	30
280	19	21	23	26	29	32
290	20	23	25	28	31	35
300	22	24	27	30	33	37
310	23	26	29	32	35	40
320	25	27	30	34	38	42
330	26	29	32	36	40	45
340	28	31	34	38	43	48
350	30	33	36	41	45	50

SAG (CATENARY) CURVE

The curve shape assumed by a completely flexible conductor when suspended between two rigid supports is defined as a catenary curve. For level ground spans, the sag at any point in the span can be approximated as a percentage of the center sag by use of the curve shown in **Figure 4.3**. This curve can be used with negligible error where the center sag is less than 10% of the span length. This procedure provides a convenient method for determining crossing clearances when the obstruction crossed over is not at the center of the span.

RETURN WAVE METHOD FOR CHECKING SAG IN A CONDUCTOR

The sag in an overhead conductor can be determined by initiating a wave in the conductor and

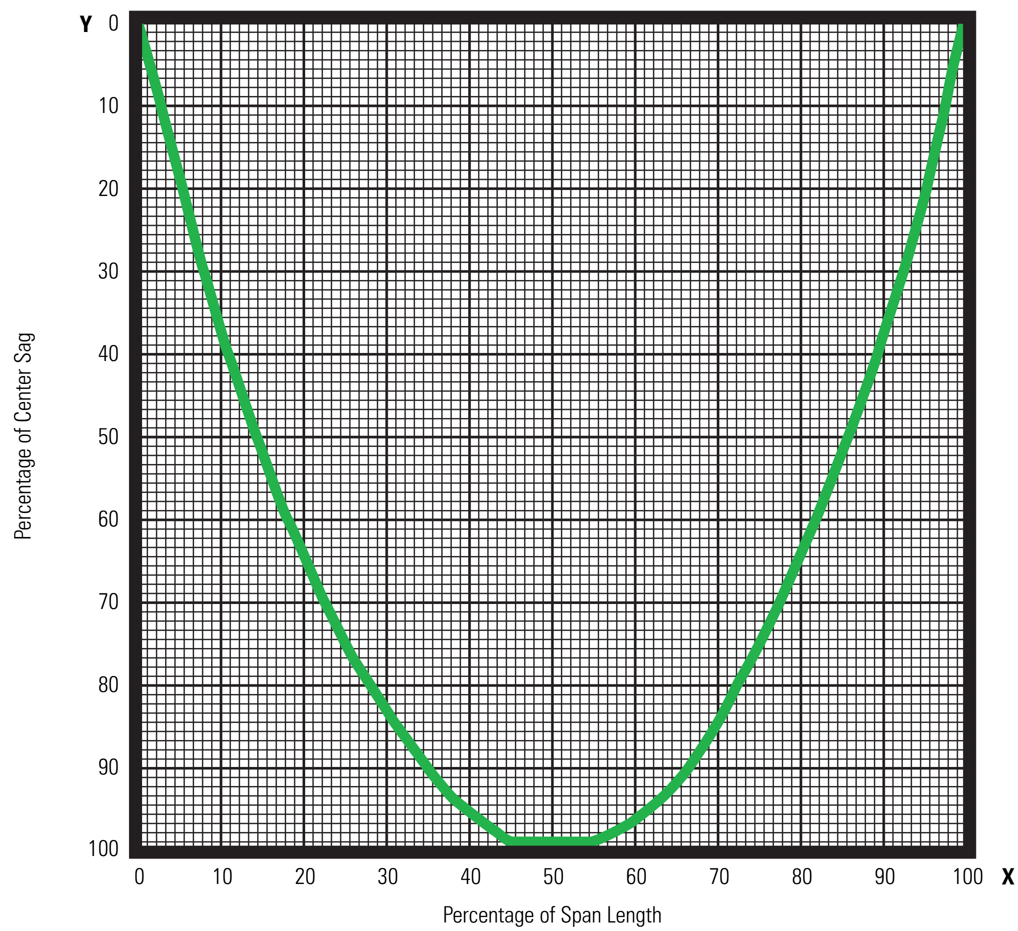


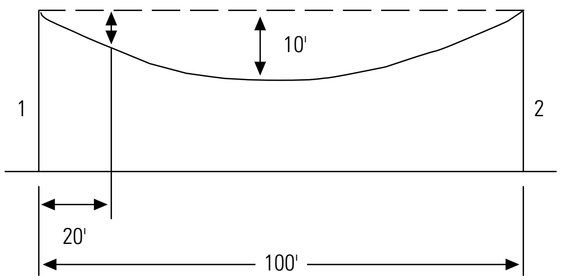
FIGURE 4.3: Sag (Catenary) Curve.

measuring the time required for the wave to travel between supports. When an overhead conductor is struck sharply at a point near one of its supports, a wave is initiated in the conductor that travels along the conductor to the support at the other end and is then reflected back. This back-and-forth action continues until the wave is eventually damped out. The time required for such a wave to make the round trip is a function of the amount of sag in the conductor.

The wave may be initiated in the conductor close to a support by striking the conductor with a tool or by throwing a light, dry, nonmetallic cord over the conductor, pulling down strongly, and suddenly releasing the cord. The return wave may be felt by placing a finger on the conductor or, if a cord is used, the return wave may be felt in the cord. The initial impulse does not count as a return wave. The stopwatch is started when the impulse is given and stopped on the number of return waves previously selected.

For an accurate determination of sag, it is important that the correct number of return waves be selected on the time-sag table (**Table 4.7**). The time-sag table was prepared for sags corresponding to 3rd, 5th, 10th, and 15th return waves. The choice of the number of return waves depends principally on the span length and size of conductor. For long spans and large conductors, the number of return waves that can be accurately counted is less than for short spans and small conductors. This is because of

Example 4.3



Find the amount of sag in the conductor at a point 20 ft from structure number 1.

STEP 1: Calculate the percentage of span length of the point 20 feet out from structure number 1.

$$\frac{20\text{ ft}}{100\text{ ft}} = 0.20 \text{ or } 20\%$$

STEP 2: Locate 20% of the span length on the X axis of the graph in **Figure 4.3**. Follow the vertical line to a point where it intersects the catenary curve.

STEP 3: Read across to the vertical or Y axis and read the percentage of center sag.

Percentage of center sag = 65%

STEP 4: Multiply the center sag by the percentage of center sag determined from the graph in Step 3.

Total center sag = 10 ft
(10 ft)(0.65) = 6.5 ft

Thus, 6.5 ft of sag exists at a point 20 feet from structure number 1.

the greater amount of energy required to initiate a strong wave with long spans and larger conductors. The largest number of return waves should be used consistent with the conditions encountered since this minimizes errors in recording time.

This method of sag determination will provide reasonably accurate results if the user does not apply it under the following conditions:

- When the conductor is in motion due to wind or work being done on the line
- When the conductor is touching an object, such as a tree branch
- When there are splicing sleeves in the span
- When the conductor is moving in the rollers during the stringing process

A sufficient number of tests should be made in each span until at least three equal readings are obtained.

Table 4.7 provides sag in inches for various quantities of return wave measurements. To measure the amount of sag in a conductor, initiate and count the return waves as previously described. Select the appropriate column under the heading “Return of Wave” and read the sag in inches in the left column. For example, if the fifth return wave results in a reading of 6.4 seconds on the stopwatch, then the amount of sag is 20 inches. More information is available for using the return wave method for checking sag in a conductor in RUS Bulletin 1726C-115.

SAG CALCULATIONS

Level Ground Span

The sag in a level ground span can be determined quite easily by the “parabolic method” of sag calculation. The parabolic method assumes the weight to be distributed evenly along a straight line between the conductor supports. This method can be used with a high degree of accuracy in cases where the sag is less than 5% of span length, as follows:

Equation 4.2

$$D = \frac{WS^2}{8H} \text{ (ft)}$$

Where:

D = Sag at center of span (ft)
W = Weight of conductor (lb per ft)
S = Span length (ft)
H = Horizontal tension (lb)

Inclined Span

In instances where the conductor supports are not at the same elevation, the sag in the span will not correspond to the sag given for a level ground span in regular sag and tension charts. Sags in these instances are determined by means of inclined span sag equations, which express the sag in terms of the sag of a level span of the same length, as shown in **Figure 4.4**.

TABLE 4.7: Time-Sag Table

Sag (inches)	Return of Wave 3rd Time (seconds)	5th Time (seconds)	10th Time (seconds)	15th Time (seconds)	Sag (inches)	Return of Wave 3rd Time (seconds)	5th Time (seconds)	10th Time (seconds)	15th Time (seconds)
5	1.9	3.2	6.4	9.7	55	6.4	10.7	21.3	32.0
6	2.1	3.5	7.0	10.6	56	6.5	10.8	21.5	32.3
7	2.3	3.8	7.6	11.4	57	6.5	10.9	21.7	32.6
8	2.4	4.1	8.1	12.2	58	6.6	11.0	21.9	32.9
9	2.6	4.3	8.6	13.0	59	6.6	11.1	22.1	33.2
10	2.7	4.6	9.1	13.7	60	6.7	11.1	22.3	33.4
11	2.9	4.8	9.5	14.3	61	6.7	11.2	22.5	33.7
12	3.0	5.0	10.0	15.0	62	6.8	11.3	22.7	34.0
13	3.1	5.2	10.4	15.6	63	6.9	11.4	22.8	34.3
14	3.2	5.4	10.8	16.2	64	6.9	11.5	23.0	34.5
15	3.3	5.6	11.1	16.7	65	7.0	11.6	23.2	34.8
16	3.5	5.8	11.5	17.3	66	7.0	11.7	23.4	35.1
17	3.6	5.9	11.9	17.8	67	7.1	11.8	23.6	35.3
18	3.7	6.1	12.2	18.3	68	7.1	11.9	23.7	35.6
19	3.8	6.3	12.5	18.8	69	7.2	12.0	23.9	35.9
20	3.9	6.4	12.9	19.3	70	7.2	12.0	24.1	36.1
21	4.0	6.6	13.2	19.8	71	7.3	12.1	24.2	36.4
22	4.0	6.7	13.5	20.2	72	7.3	12.2	24.4	36.6
23	4.1	6.9	13.8	20.7	73	7.4	12.3	24.6	36.9
24	4.2	7.0	14.1	21.1	74	7.4	12.4	24.8	37.1
25	4.3	7.2	14.4	21.6	75	7.5	12.5	24.9	37.4
26	4.4	7.3	14.7	22.0	76	7.5	12.5	25.1	37.6
27	4.5	7.5	15.0	22.4	77	7.6	12.6	25.3	37.9
28	4.6	7.6	15.2	22.8	78	7.6	12.7	25.4	38.1
29	4.6	7.7	15.5	23.2	79	7.7	12.8	25.6	38.4
30	4.7	7.9	15.8	23.6	80	7.7	12.9	25.7	38.6
31	4.8	8.0	16.0	24.0	81	7.8	13.0	25.9	38.9
32	4.9	8.1	16.3	24.4	82	7.8	13.0	26.1	39.1
33	5.0	8.3	16.5	24.8	83	7.9	13.1	26.2	39.3
34	5.0	8.4	16.8	25.2	84	7.9	13.2	26.4	39.6
35	5.1	8.5	17.0	25.5	85	8.0	13.3	26.5	39.8
36	5.2	8.6	17.3	25.9	86	8.0	13.3	26.7	40.0
37	5.3	8.8	17.5	26.3	87	8.1	13.4	26.8	40.3
38	5.3	8.9	17.7	26.6	88	8.1	13.5	27.0	40.5
39	5.4	9.0	18.0	27.0	89	8.1	13.6	27.1	40.7
40	5.5	9.1	18.2	27.3	90	8.2	13.7	27.3	41.0
41	5.5	9.2	18.4	27.6	91	8.2	13.7	27.5	41.2
42	5.6	9.3	18.7	28.0	92	8.3	13.8	27.6	41.4
43	5.7	9.4	18.9	28.3	93	8.3	13.9	27.8	41.6
44	5.7	9.5	19.1	28.6	94	8.4	14.0	27.9	41.9
45	5.8	9.7	19.3	29.0	95	8.4	14.0	28.0	42.1
46	5.9	9.8	19.5	29.3	96	8.5	14.1	28.2	42.3
47	5.9	9.9	19.7	29.6	97	8.5	14.2	28.3	42.5
48	6.0	10.0	19.9	29.9	98	8.5	14.2	28.5	42.7
49	6.0	10.1	20.1	30.2	99	8.6	14.3	28.6	43.0
50	6.1	10.2	20.3	30.5	100	8.6	14.4	28.8	43.2
51	6.2	10.3	20.6	30.8	101	8.7	14.5	28.9	43.4
52	6.2	10.4	20.8	31.1	102	8.7	14.5	29.1	43.6
53	6.3	10.5	21.0	31.4	103	8.8	14.6	29.2	43.8
54	6.3	10.6	21.1	31.7	104	8.8	14.7	29.3	44.0

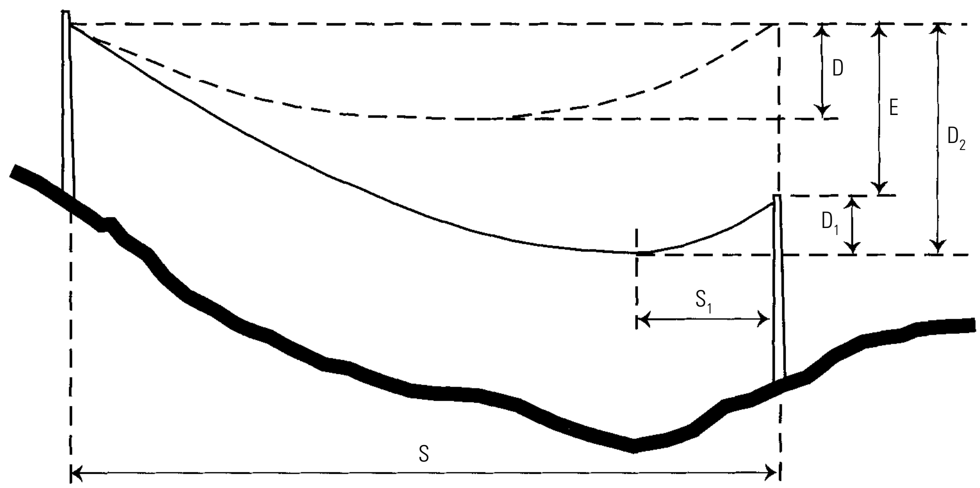


FIGURE 4.4: Inclined Span Nomenclature.

Equation 4.3

$$D_1 = D\left[1 - \left(\frac{E}{4D}\right)\right]^2 (ft)$$

Equation 4.4

$$D_2 = D\left[1 + \left(\frac{E}{4D}\right)\right]^2 (ft)$$

Equation 4.5

$$S_1 = \frac{S}{2}\left[1 - \left(\frac{E}{4D}\right)\right] (ft)$$

Where:

D = Sag in level ground span of the same length (ft)

D_1 = Conductor sag below lower support (ft)

D_2 = Conductor sag below upper support (ft)

E = Difference in elevation between supports (ft)

S = Span length measured horizontally (ft)

S_1 = Horizontal distance from low part of sag to lower support (ft)

Note: If $\left[1 - \left(\frac{E}{4D}\right)\right]$

is negative, this method of determining D_1 and D_2 cannot be used since the theoretical low point of the sag will be above the lower support and "uplift" will take place at the lower support.

Maximum Allowable Span Based on the Separation of Conductors

The maximum allowable span based on the *horizontal* separation of the conductors at the pole-top assemblies and the sag of the conductor in the span must be calculated. To perform this calculation, the following data are required:

- The ruling span
- The maximum allowable conductor sag for the standard RUS pole-top assembly
- The final unloaded sag at 60°F of the proposed conductor for the designated ruling span

Maximum allowable sags based on the horizontal spacing of conductors for standard RUS pole-top assemblies are listed in **Table 4.8**. This table can be used to determine the maximum allowable span based on the horizontal separation of the conductors.

TABLE 4.8: Maximum Allowable Final Unloaded Sag for Standard RUS Assemblies.
Based on NESC Rule 235B1b.

Assembly	Horizontal Separation (Inches)	Allowable Final Unloaded Conductor Sag (ft)	
		Smaller Than No. 2 AWG	No. 2 AWG and Larger
12.47/7.2 kV			
C1.11, C1.11P, C1.12, C1.12P, C1.13, C1.13L, C1.13P, C2.21, C2.21L, C2.21P, C2.24, C2.24P, C2.25, C2.25P, C5.11G, C5.82G	44	9.9	24.9
C1.11L, C1.12L	40	8.4	20.1
C1.41, C1.41L, C1.41P, C1.81G, C2.51, C2.51L, C2.51P, C2.52, C2.52L, C2.52P	37	7.3	16.9
C6.52, C6.52G, C6.53	33	6.0	13.0
C5.21, C5.21L, C5.22, C5.31, C5.31L, C5.32, C6.21, C6.21L, C6.31, C6.31L	42	9.1	22.4
C5.71L, C6.91G	43	9.5	23.6
24.9/14.4 kV			
VC1.11, VC1.11P, VC1.12, VC1.12P, VC1.13, VC1.13P, VC2.21, VC2.21P, VC5.11G, VC5.82G	44	8.5	20.4
VC1.11L, VC1.12L, VC1.13L, VC2.21L	40	7.1	16.1
VC1.41, VC1.41P, VC1.81G VC2.51, VC2.51P, VC2.52, VC2.52L, VC2.52P	37	6.1	13.2
VC1.41L, VC2.51L, VC6.51, VC6.52G	33	5.0	9.8
VC5.21, VC5.31, VC6.21, VC6.31	42	7.7	18.2
VC5.71L, VC6.91G	43	8.1	19.3
34.5/19.9 kV			
ZC1, ZC1-1, ZC1-2, ZC1-3, ZC1-4, ZC2	44	7.4	17.3
ZC2-1, ZC9, ZC9-1	37	5.3	10.7
ZC7, ZC7-1, ZC8, ZC8-2, ZC8-3	42	6.8	15.2
ZC7-2, ZC7-3, ZC8-1	33	4.3	7.6

NOTES:
Sag is at 60ºF final.
3-inch tolerance for conductor sag.
1/8-inch framing tolerance.

Example 4.4

Determine the maximum horizontal span as limited by conductor horizontal separation at the pole and conductor sag.

Given:

Conductor	=	477 ACSR 18/1
Ruling Span	=	425 ft
Final Sag at 60°F	=	11.88 ft
Pole-Top Assembly	=	C1.11L on each side of the span
Circuit Voltage	=	12.47/7.2 kV

Calculation of maximum allowable span based on horizontal separation of conductors:

Equation 4.6

$$S_M = RS\sqrt{\frac{D_M}{D_R}}$$

Where:

S_M = Maximum allowable span (horizontal) in feet

RS = Ruling span = 425 ft (given)

D_M = Allowable conductor sag = 20.1 ft (**Table 4.8**)

D_R = Ruling span final sag at 60°F = 11.88 ft (given)

$$S_M = 425\text{ ft}\sqrt{\frac{20.1\text{ ft}}{11.88\text{ ft}}}$$

$$= 553\text{ ft}$$

The maximum allowable span based on the *vertical* separation of the conductors at the pole-top assembly and the sag of the conductor in the span must also be calculated. To perform this calculation, the following data are required:

- The ruling span
- The allowable separation at midspan in feet
- The vertical separation at the support in feet
- Lower conductor sag at 60°F and/or 32°F
- Upper conductor sag at maximum operating temperature of 120°F and/or 32°F iced

The maximum allowable span is determined by calculating both conditions 1 and 2 below. The allowable span is the shortest calculated span. Final condition sags must be used in the calculations.

Condition	Upper Conductor	Lower Conductor or Cable
1	32°F, no wind, with the radial thickness of ice for the applicable loading zone	32°F, no wind, no ice
2	Maximum design conductor or 120°F, whichever produces the most sag	60°F[1]

[1] The *NESC* (235C2b) allows the neutral conductor to be at the same ambient temperature as the primary (i.e., both conductors starting at 90°F for checking summer loading). However, a neutral temperature of 60°F is suggested for distribution line design, especially on those systems where the line may be used to backfeed load at off-peak periods.

Example 4.5

Determine the maximum vertical span as limited by conductor vertical separation at the pole and conductor sag.

Given:

Loading District	=	Medium
Conductor	=	1/0 ACSR 6/1 Primary 2 ACSR 6/1 Neutral
Ruling Span	=	300 ft
1/0 ACSR Conductor Sag[1]	=	3.28 ft @ 32°F with 0.25 inch of ice
(Upper Conductor)	=	4.18 ft @ 120°F
2 ACSR Conductor Sag[1]	=	1.66 ft @ 32°F no ice
(Lower Conductor)	=	2.30 ft @ 60°F
Pole-Top Assembly	=	C1.11 on each side of the span
Circuit Voltage	=	12.47/7.2 kV

Calculation of maximum allowable span based on vertical separation of conductors:

Equation 4.7

$$S_M = RS\sqrt{\frac{B - A}{S_U - S_E}}$$

Where:

S_M = Maximum allowable span (vertical) in feet
RS = Ruling span in feet
A = The allowable separation at midspan in feet
B = Vertical separation at support in feet
S_E = Lower conductor sag at 60°F or 32°F
S_U = Upper conductor sag at maximum operating temperature, 120°F or 32°F iced

Calculate the maximum allowable span for Condition No. 1 (iced condition):

RS = 300 ft (given)
A = 12 in. or 1 ft (**Table 3.6**)
B = 4.25 ft (RUS Drawing C1.11)
S_E = 1.66 ft (given, 2 ACSR sag @ 32°F, no ice)
S_U = 3.28 ft (given, 1/0 ACSR sag @ 32°F with 0.25 inches of ice)

$$S_M = 300\sqrt{\frac{4.25 - 1}{3.28 - 1.66}}$$

= 424.92 ft = 425 ft (Condition No. 1)

Calculate the maximum allowable span for Condition No. 2 (Maximum Operating Condition):

S_E = 2.30 ft (given, 2 ACSR sag @ 60°F)
S_U = 4.18 ft (given, 1/0 ACSR sag @ 120°F)

$$S_M = 300\sqrt{\frac{4.25 - 1}{4.18 - 2.30}}$$

= 394.44 ft = 394 ft (Condition No. 2)

The maximum allowable span for the conditions of this example is limited by the maximum operating condition (No. 2) to 394 ft.

[1] Sag information obtained from sag tables in **Appendix B**.

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5 Pole Strength

In This Section:

The staking technician must select a pole strong enough to support the conductor, cable, and equipment installed on the pole as well as withstand wind blowing against the surfaces of the pole, conductors, and equipment.

To properly select a pole of adequate strength, the concepts of wood fiber strength, "ultimate resisting force" of wood poles, "bending moments" at the groundline of wood poles due to wind on the pole, and "wind span" must be understood. This section addresses these concepts, provides tables of pole ratings and classifications, and demonstrates how to determine the pole size for a standard distribution structure.

NESC Requirements

--The *NESC* (Rule 261) provides specific design limits, load factors, and strength factors for the determination of strength for wood structures.

UNGUYED POLES

Unguyed wood poles shall withstand maximum design vertical loading caused by the weight of the objects supported by the pole times the load factors shown in **Tables 5.1** and **5.2**.

These unguyed structures must also withstand the maximum design transverse loadings, which include the wind applied at right angles to the conductor (see **Figure 7.4**, Transverse Loading) and the component of the conductor tension pulling on the pole. These transverse loadings must be multiplied by the load factors shown in **Tables 5.1** and **5.2**.

UNGUYED LINE ANGLE POLES

Unguyed wood poles that are used at small line angles shall withstand the sum of the maximum design loadings multiplied by the appropriate load factor shown in **Table 5.1**. The maximum design loading shall include the following:

- Wind loading on the pole
- Wind loading on the conductors
- Loading caused by longitudinal conductor tension

GUYED LINE ANGLE POLES

When wood poles are guyed and used at line angles, the pole is assumed to act only as a strut. The guys are used to meet the transverse strength requirements and are considered as taking the maximum design loading, including wind loading on the conductors and the pole, and the tension of the conductors in the angle. For vertical loading on angled poles, the appropriate load factor shown in Tables 5.1 and 5.2 shall be used. It is recommended that the class of the guyed line angle pole with "1 to 1" guy leads (see **Section 7**) be equivalent to the class of the tangent poles used for similar spans. For guy leads shorter than 1 to 1, a higher class of pole may be required.

TABLE 5.1: Load Factors for Wood Structures. Adapted from *NESC* Table 253-1.

	Grade B	Grade C
Vertical	1.50	1.90
Transverse (Wind) Strength[1]	2.50	2.20
Transverse (Wire Tension) Strength	1.65	1.30
Longitudinal Strength		
In General	1.10	No requirement
At Deadends	1.65	1.30

[1] Transverse Wind at line crossing is used herein for conservative results

TABLE 5.2: Extreme Wind Load Factors for Wood Distribution Structures When Installed. Adapted from *NESC* Rule 253-1.

	Grade B Extreme Wind[1]	Grade C Extreme Wind[2]	Extreme Ice With Wind
Wind Loads	1.00	1.00	1.00
All Other Loads	1.00	0.87	1.00

[1] Use Grade B Extreme Wind Map, **Figure 3.2(a)**
[2] Use Grade C Extreme Wind Map, **Figure 3.2(b)**

DEADEND POLES

When wood poles are guyed and used at deadends, the pole is assumed to act as a strut only. The guys are used to meet the longitudinal strength requirements and are considered as taking the entire tension load produced by the conductors. For vertical and transverse loadings, the appropriate load factors shown in Tables 5.1 and 5.2 shall be used. Transverse loading at deadend poles is not usually significant, provided the deadend pole is of the same class as the tangent poles for similar spans. Vertical loading on deadend poles may become a problem with the use of short guy leads and/or heavy transformers.

Pole Size

The American National Standards Institute (ANSI) O5.1 standard classifies poles according to wood species, length, and strength class. These classes range from Class 10, which can withstand a 370-lb pull 2 feet from the top, to Class H-6, which can withstand an 11,400-lb pull. It is common practice to abbreviate pole classifications. A 35-foot pole with a strength classification of 5 would be abbreviated as 35-5.

Factors affecting the size or class of the pole to be used to support the distribution line include the following:

- The strength of the pole's wood fiber
- The size and type of conductors and cables supported by the pole
- The size and type of electrical distribution equipment mounted on the pole

Poles are produced from trees of different species. Each has an inherent natural fiber strength that varies from species to species. For example, southern yellow pine has a fiber strength twice that of northern white cedar. The staking technician must know the species of the wood pole to apply the available data relevant to the determination of the pole's strength. The application of fiber strength is discussed later in this section.

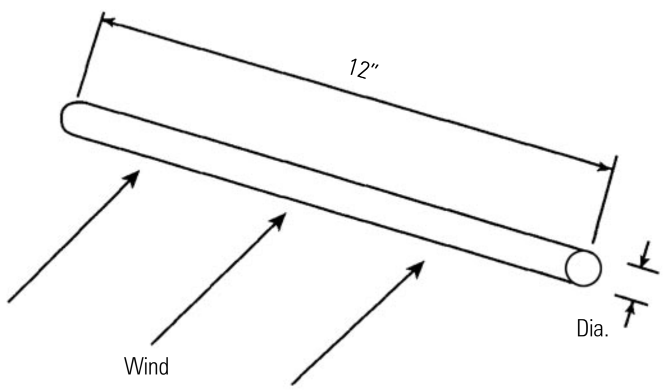
The size and type of conductor affect pole size because of the forces of wind and ice acting on the spans. The loading districts determine the amount of wind and ice to be used as a design loading condition. The transverse load—which, as noted, is the load applied at right angles to the conductor—is calculated using the value for the appropriate *NESC* loading district. This load is produced by the forces of wind pressure in pounds per square foot blowing against the surface of the conductor and is usually calculated for one linear foot of a given diameter (inches) of conductor with a specified radial thickness of ice (inches). Figure 5.1 illustrates the method of calculation of transverse load caused by wind and ice on one foot of the conductor.

The wind and ice values are shown in **Table 3.1**. **Table 3.2** shows the conversion of wind speed in miles per hour to wind pressure in pounds per square foot.

The transverse loads for one foot of conductor are shown in **Table 5.3**.

Pole size is also affected by the size and type of electrical equipment—such as transformers—mounted on the pole. The load produced by the equipment results from the weight of the equipment and the wind pressure blowing at right angles to the equipment. The transverse load (force) that is produced by the wind is equal to the cross-sectional area of the equipment multiplied by the wind pressure for the applicable *NESC* loading district.

To support the vertical weight and wind loading of transformers, the staking technician must select an appropriate class of pole. **Tables 5.4, 5.5**, and **5.6** shows a suggested pole class for one to three transformers mounted on a single pole.



	Light	Medium	Heavy
Wind	9 lb/ft^2	4 lb/ft^2	4 lb/ft^2
Ice	0.00 in.	0.25 in.	0.50 in.

$$W_C = \frac{P(D+2C)}{12}$$

W_C = Transverse wind load (lb/ft)
P = Wind pressure (lb/ft^2)
C = Thickness of ice (in.)
D = Diameter of conductor (in.)

FIGURE 5.1: Wind Force on Conductor.

TABLE 5.3: ACSR Conductor Specifications with Transverse *NESC* District Loadings

Size	Strand	Rated Strength (lb)	Diameter of Conductor (in.)	Transverse Wind Load (lb/ft)
LIGHT LOADING 0.00 inches ice, 9-psf wind (Zone 3)				
4	7/1	2360	0.257	0.1928
2	6/1	2850	0.316	0.2370
1/0	6/1	4380	0.398	0.2985
3/0	6/1	6620	0.502	0.3765
4/0	6/1	8350	0.563	0.4223
336.4	18/1	8680	0.684	0.5130
477.0	18/1	11,800	0.814	0.6105
MEDIUM LOADING 0.25 inches ice, 4-psf wind (Zone 2)				
Size	**Strand**	**Rated Strength (lb)**	**Diameter of Conductor (in.)**	**Transverse Wind Load (lb/ft)**
4	7/1	2360	0.257	0.2523
2	6/1	2850	0.316	0.2720
1/0	6/1	4380	0.398	0.2993
3/0	6/1	6620	0.502	0.3340
4/0	6/1	8350	0.563	0.3543
336.4	18/1	8680	0.684	0.3947
477.0	18/1	11,800	0.814	0.4380
HEAVY LOADING 0.50 inches ice, 4-psf wind (Zone 1)				
Size	**Strand**	**Rated Strength (lb)**	**Diameter of Conductor (in.)**	**Transverse Wind Load (lb/ft)**
4	7/1	2360	0.257	0.4190
2	6/1	2850	0.316	0.4387
1/0	6/1	4380	0.398	0.4660
3/0	6/1	6620	0.502	0.5007
4/0	6/1	8350	0.563	0.5210
336.4	18/1	8680	0.684	0.5613
477.0	18/1	11,800	0.814	0.6047

TABLE 5.4: Recommended Pole Class for *One Transformer* Installed on a Single Pole

Transformer (kVA)	5	7.5	10	15	25	37.5	50	75	100	167	250
Pole Class	5	5	5	5	5	5	5	4	4	3	1

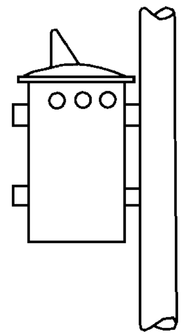


TABLE 5.5: Recommended Pole Class for a *Bank of Two Transformers* Installed on a Single Pole

Transformer A (kVA)	Transformer B (kVA)										
	5	7.5	10	15	25	37.5	50	75	100	167	250
5	5	5	5	5	5	5	5	4	4	3	1
7.5		5	5	5	5	5	5	4	4	3	1
10			5	5	5	5	4	4	4	3	1
15				5	5	5	4	4	4	3	1
25					5	4	3	3	3	3	1
37.5						3	3	3	3	3	1
50							3	3	3	3	1
75								3	3	2	1
100									3	2	1
167										2	1
250											1

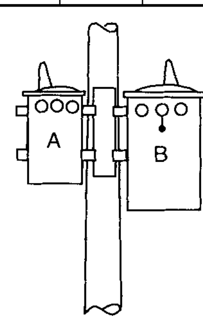
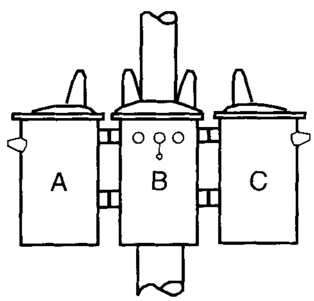


TABLE 5.6: Recommended Pole Class for a *Bank of Three Transformers* Installed on a Single Pole											
Transformers A & C (kVA)*	**Transformer B (kVA)**										
	5	7.5	10	15	25	37.5	50	75	100	167	250
(2) 5	5	5	5	*	*	*	*	*	*	*	*
(2) 7.5		5	5	5	*	*	*	*	*	*	*
(2) 10			5	5	*	*	*	*	*	*	*
(2) 15				4	4	*	*	*	*	*	*
(2) 25					4	4	3	*	*	*	*
(2) 37.5						3	3	3	*	*	*
(2) 50							3	3	2	*	*
(2) 75								2	2	*	*
(2) 100									2	2	*
(2) 167										2	1
(2) 250											1

* The kVA rating of transformer B cannot exceed twice the rating of either transformer A or C.



Ultimate Resisting Moment

The strength of a pole is determined by the following two factors:

1. The fiber strength of the wood species
2. The diameter of the pole

The various species of poles used in the United States are listed with their rated fiber stress in Bulletin 1728F-700, RUS Specification for Wood Poles, Stubs and Anchor Logs.

Five common species of poles used for distribution line construction are considered in this manual and listed in Table 5.7.

The strength of the pole is referred to as the ultimate resisting "moment" of the wood pole. If the fiber strength and the dimensions of the pole are known, then the ultimate resisting moment of the wood pole can be calculated. (A complete discussion of how to perform these calculations can be found in RUS Bulletin 1724E-150.)

NESC Rule 261A2a requires poles to withstand loads at the maximum stress point. For unguyed wood poles 55 feet or less in length, the maximum stress will be at groundline, as shown in **Table 5.8**. For unguyed poles with lengths greater than 55 feet, the maximum stress point may not be at groundline but, rather, the point of maximum stress occurs where the circumference is one and one-half times the circumference at the point of the applied load (reference ANSI O5.1-2022, *Wood Poles—Specifications and Dimensions,* for more information).

When the term "moment" is used in this manual, the reference is to the product of quantity (as a force) and the distance to a particular axis or point, as shown in Figure 5.2.

The ultimate resisting moments of commonly used wood pole species and sizes have been calculated and are provided in **Table 5.8**.

TABLE 5.7: Fiber Stress Ratings of Poles

Species	Fiber Stress (psi)
Southern Yellow Pine	8000
Douglas Fir	8000
Ponderosa Pine	6000
Western Red Cedar	6000
Northern White Cedar	4000

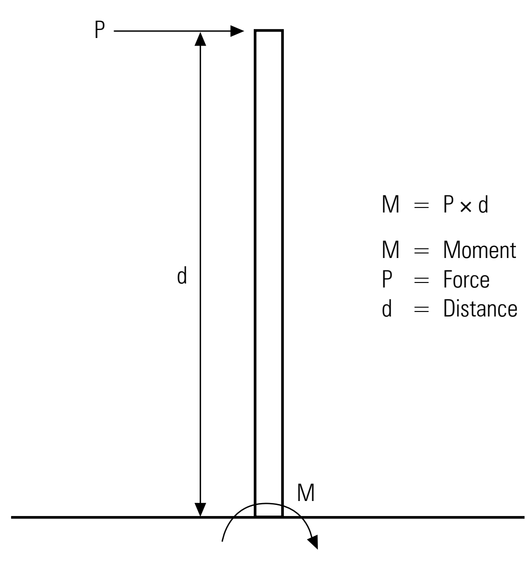


FIGURE 5.2: Pole Moment.

TABLE 5.8: Ultimate Resisting Moments of Wood Poles							
Southern Yellow Pine Douglas Fir Fiber Stress – 8000 psi							
					Derated Strength*		
Pole Length (ft)	ANSI Class	Minimum Circumference at Top (in.)	Groundline Circumference (in.)	Resisting Moment (ft-lb)	Grade B (ft-lb)	Grade C (ft-lb)	Extreme Ice or Extreme Wind (ft-lb)
30	5	19.0	27.7	44,900	29,185	38,165	33,675
30	6	17.0	25.2	33,800	21,970	28,730	25,350
30	7	15.0	23.7	28,100	18,265	23,885	21,075
35	4	21.0	31.5	66,000	42,900	56,100	49,500
35	5	19.0	29.0	51,500	33,475	43,775	38,625
35	6	17.0	27.0	41,600	27,040	35,360	31,200
40	3	23.0	36.0	98,500	64,025	83,725	73,875
40	4	21.0	33.5	79,400	51,610	67,490	59,550
40	5	19.0	31.0	62,900	40,885	53,465	47,175
40	6	17.0	28.5	48,900	31,785	41,565	36,675
45	3	23.0	37.3	109,600	71,240	93,160	82,200
45	4	21.0	34.8	89,000	57,850	75,650	66,750
45	5	19.0	32.3	71,200	46,280	60,520	53,400
45	6	17.0	29.8	55,900	36,335	47,515	41,925
50	2	25.0	41.6	152,000	98,800	129,200	114,000
50	3	23.0	38.6	121,500	78,975	103,275	91,125
50	4	21.0	36.1	99,400	64,610	84,490	74,550
50	5	19.0	33.7	80,800	52,520	68,680	60,600
55	1	27.0	45.9	204,200	132,730	173,570	153,150
55	2	25.0	42.9	166,700	108,355	141,695	125,025
55	3	23.0	40.0	135,200	87,880	114,920	101,400

* See **Table 5.9**.

Continued

TABLE 5.8: Ultimate Resisting Moments of Wood Poles (cont.)							
Ponderosa Pine Western Red Cedar Fiber Stress – 6000 psi							
					Derated Strength*		
Pole Length (ft)	**ANSI Class**	**Minimum Circumference at Top (in.)**	**Groundline Circumference (in.)**	**Resisting Moment (ft-lb)**	**Grade B (ft-lb)**	**Grade C (ft-lb)**	**Extreme Ice or Extreme Wind (ft-lb)**
30	5	19	30.2	43,600	28,340	37,060	32,700
30	6	17	28.2	35,500	23,075	30,175	26.625
30	7	15	26.2	28,500	18,525	24,225	21,375
35	4	21	34.5	65,000	42,250	55,250	48,750
35	5	19	32.0	51,900	33,735	44,115	38,925
35	6	17	30.0	42,800	27,820	36,380	32,100
40	3	23	39.5	97,600	63,440	82,960	73,200
40	4	21	36.5	77,000	50,050	65,450	57,750
40	5	19	34.0	62,300	40,495	52,955	46,725
40	6	17	31.5	49,500	32,175	42,075	37,125
45	3	23	41.3	111,600	72,540	94,860	83,700
45	4	21	38.3	89,000	57,850	75,650	66,750
45	5	19	35.8	72,700	47,255	61,795	54,525
45	6	17	32.8	55,900	36,335	47,515	41,925
50	2	25	46.0	154,200	100,230	131,070	115,650
50	3	23	43.0	125,900	81,835	107,015	94,425
50	4	21	39.6	98,400	63,960	83,640	73,800
50	5	19	37.1	80,900	52,585	68,765	60,675
55	1	27	50.8	207,700	135,005	176,545	155,775
55	2	25	47.8	173,000	112,450	147,050	129,750
55	3	23	44.3	137,700	89,505	117,045	103,275

* See **Table 5.9**.

Continued

TABLE 5.8: Ultimate Resisting Moments of Wood Poles (cont.)							
Northern White Cedar Fiber Stress – 4000 psi							
Pole Length (ft)	ANSI Class	Minimum Circumference at Top (in.)	Groundline Circumference (in.)	Resisting Moment (ft-lb)	Derated Strength*		
					Grade B (ft-lb)	Grade C (ft-lb)	Extreme Ice or Extreme Wind (ft-lb)
30	5	19	34.8	44,500	28,925	37,825	33,375
30	6	17	32.3	35,600	23,140	30,260	26,700
30	7	15	29.8	27,900	18,135	23,715	20,925
35	4	21	39.5	65,100	42,315	55,335	48,825
35	5	19	37.0	53,500	34,775	45,475	40,125
35	6	17	34.0	41,500	26,975	35,275	31,125
40	3	23	45.0	96,200	62,530	81,770	72,150
40	4	21	42.0	78,200	50,830	66,470	58,650
40	5	19	39.0	62,600	40,690	53,210	46,950
40	6	17	36.0	49,300	32,045	41,905	36,975
45	3	23	47.2	111,000	72,150	94,350	83,250
45	4	21	43.7	88,100	57,265	74,885	66,075
45	5	19	40.7	71,200	46,280	60,520	53,400
45	6	17	N/A	N/A	N/A	N/A	N/A
50	2	25	52.9	156,300	101,595	132,855	117,225
50	3	23	48.9	123,500	80,275	104,975	92,625
50	4	21	45.4	98,800	64,220	83,980	74,100
50	5	19	42.5	81,100	52,715	68,935	60,825
55	1	27	58.0	206,000	133,900	175,100	154,500
55	2	25	54.6	171,900	111,735	146,115	128,925
55	3	23	50.6	136,800	88,920	116,280	102,600

* See **Table 5.9**.

BENDING MOMENT DUE TO WIND ON THE POLE

The wind on the pole is a force that tends to overturn the pole. Some of the strength of the pole must be used to overcome the wind force, thereby reducing the available pole strength. The remaining strength, after derating the ultimate strength and subtracting the load due to wind on the pole, is the amount available to support the cables, conductors, and equipment.

Table 5.10 contains tabulations of the moment caused by the force of the wind on the pole.

To refresh your memory, a moment is a force multiplied by a distance.

The formula used in calculating the moment caused by the wind on a pole is shown in Equation 5.1.

Equation 5.1: Bending Moment Due to Wind on the Pole

$$W_P = \frac{FH^2(d_1 + 2d_2)}{72}$$

Where:

W_P = Bending moment due to wind (ft-lb)

F = *NESC* district wind load (lb/ft^2)
Heavy & Medium = 4 lb/ft^2
Light = 9 lb/ft^2

H = Height of pole above ground (ft)
(Height of pole – depth in ground)

d_1 = Diameter of pole at groundline (in.)
(Circumference ÷ π)

d_2 = Diameter of pole at top (in.)
(Circumference ÷ π)

DERATED STRENGTH OF WOOD POLES

The *NESC* requires that the ultimate strength of a wood pole must be derated. The method used is to multiply the ultimate strength of a wooden pole by a strength factor which essentially reduces the rated strength of the wood pole. These strength factors are provided in *NESC* Table 261-1 and are summarized in Table 5.9. In addition, the derated strength is included in **Table 5.8**.

Table 5.9: Strength Factors for Wood Poles

	Grade B	Grade C
Ice and Wind (250B)	0.65	0.85
Extreme Wind (250C)	0.75	0.75
Extreme Ice with Concurrent Wind (250D)	0.75	0.75

TABLE 5.10: Bending Moment of Wood Poles at Groundline Due to Wind on Pole						
Based on the Dimensions of:			Southern Yellow Pine Douglas Fir			
			Minimum Circumference		**Bending Moment (ft-lb)**	
Pole Length (ft)	**ANSI Class**	**Groundline Distance from Butt (ft)**	**Top (in.)**	**Groundline (in.)**	**Heavy/Medium Loading**	**Light Loading**
30	5	6	19.0	27.7	697	1569
30	6	6	17.0	25.2	628	1414
30	7	6	15.0	23.9	572	1287
35	4	6	21.0	31.5	1093	2459
35	5	6	19.0	29.0	996	2242
35	6	6	17.0	27.0	907	2041
40	3	6	23.0	36.0	1676	3772
40	4	6	21.0	33.5	1543	3473
40	5	6	19.0	31.0	1411	3174
40	6	6	17.0	28.5	1278	2875
45	3	7	23.0	37.3	2183	4913
45	4	7	21.0	34.8	2013	4529
45	5	7	19.0	32.3	1843	4146
45	6	7	17.0	29.8	1672	3763
50	2	7	25.0	41.6	2995	6739
50	3	7	23.0	38.6	2766	6224
50	4	7	21.0	36.1	2554	5746
50	5	7	19.0	33.7	2344	5275
55	1	8	27.0	45.9	3986	8968
55	2	8	25.0	42.9	3707	8340
55	3	8	23.0	40.0	3431	7721
NOTE: No load factor taken into consideration.						

Continued

TABLE 5.10: Bending Moment of Wood Poles at Groundline Due to Wind on Pole (cont.)						
Based on the Dimensions of:			Ponderosa Pine Western Red Cedar			
			Minimum Circumference		Bending Moment (ft-lb)	
Pole Length (ft)	ANSI Class	Groundline Distance from Butt (ft)	Top (in.)	Groundline (in.)	Heavy/Medium Loading	Light Loading
30	5	6	19.0	30.3	725	1631
30	6	6	17.0	28.3	661	1488
30	7	6	15.0	26.3	598	1345
35	4	6	21.0	34.5	1138	2560
35	5	6	19.0	32.0	1041	2342
35	6	6	17.0	30.0	952	2142
40	3	6	23.0	39.5	1748	3933
40	4	6	21.0	36.5	1605	3611
40	5	6	19.0	34.0	1472	3312
40	6	6	17.0	31.5	1339	3013
45	3	7	23.0	41.3	2288	5149
45	4	7	21.0	38.3	2105	4736
45	5	7	19.0	35.8	1934	4352
45	6	7	17.0	32.8	1751	3940
50	2	7	25.0	46.0	3139	7063
50	3	7	23.0	43.0	2910	6548
50	4	7	21.0	39.6	2668	6003
50	5	7	19.0	37.1	2456	5525
55	1	8	27.0	50.8	4181	9408
55	2	8	25.0	47.8	3902	8780
55	3	8	23.0	44.3	3603	8107

NOTE: No load factor taken into consideration.

Continued

TABLE 5.10: Bending Moment of Wood Poles at Groundline Due to Wind on Pole (cont.)						
Based on the Dimensions of:			Northern White Cedar			
			Minimum Circumference		Bending Moment (ft-lb)	
Pole Length (ft)	ANSI Class	Groundline Distance from Butt (ft)	Top (in.)	Groundline (in.)	Heavy/Medium Loading	Light Loading
30	5	6	19.0	34.3	767	1727
30	6	6	17.0	32.3	704	1583
30	7	6	15.0	29.8	635	1428
35	4	6	21.0	39.5	1212	2727
35	5	6	19.0	37.0	1115	2510
35	6	6	17.0	34.0	1011	2275
40	3	6	23.0	45.0	1860	4186
40	4	6	21.0	42.0	1717	3864
40	5	6	19.0	39.0	1574	3542
40	6	6	17.0	36.0	1431	3220
45	3	7	23.0	47.2	2443	5497
45	4	7	21.0	43.7	2246	5054
45	5	7	19.0	40.7	2063	4641
45	6	7	17.0	N/A	N/A	N/A
50	2	7	25.0	52.9	3365	7570
50	3	7	23.0	48.9	3103	6982
50	4	7	21.0	45.4	2858	6430
50	5	7	19.0	42.5	2632	5922
55	1	8	27.0	58.0	4469	10,055
55	2	8	25.0	54.6	4173	9390
55	3	8	23.0	50.6	3854	8672

NOTE: No load factor taken into consideration.

Maximum Wind Span

Generally, the maximum wind span is determined for a given pole class when staking data are prepared for a distribution line. This provides the staking technician with a reference from which to determine the pole class for a measured span. Also, the staking technician can determine the average span desirable for the standard pole size normally used by the cooperative.

The wind span is determined by taking the average of the two spans adjacent to the distribution structure as shown in **Figure 5.3**.

Table 5.11 shows calculated maximum allowable wind spans for some commonly used conductors and pole sizes. Extra-large conductors are included in **Section 12**.

IMPORTANT NOTE: These tables are *ONLY* for the quantity and size of conductors shown. If other conductors—such as telephone, fiber, or cable TV—are added, the maximum wind span must be recalculated. Also, if a transformer or other equipment is to be installed on the pole, the pole class shown in **Tables 5.4, 5.5**, and **5.6** will control.

Example 5.1 shows the procedure to calculate maximum allowable wind spans for conductors and poles other than those shown in Table 5.11.

TABLE 5.11: Maximum Wind Spans in Feet: Southern Yellow Pine and Douglas Fir

THREE-PHASE LINES • LIGHT LOADING

Pole Height/Class	ACSR Conductors (4)4 7/1	(4)2 6/1	(4)1/0 6/1	(4)3/0 6/1	(4)4/0 6/1	(4)336.4 18/1	(4)477.0 18/1
Grade C Construction							
35'/6	627	510	405	321	286	236	198
35'/5	789	642	510	404	360	297	249
35'/4	1030	838	665	528	470	387	325
40'/6	611	497	395	313	279	230	193
40'/5	806	656	520	413	368	303	254
40'/4	1038	844	670	531	474	390	328
45'/5	787	640	508	403	359	296	248
45'/4	1006	818	650	515	459	378	318
45'/3	1261	1026	814	646	576	474	398
Grade B Construction							
35'/6	392	319	253	201	179	147	124
35'/5	498	405	322	255	228	187	157
35'/4	657	535	425	337	300	247	208
40'/6	375	305	242	192	171	141	119
40'/5	503	409	325	257	229	189	159
40'/4	655	533	423	335	299	246	207
45'/5	484	394	313	248	221	182	153
45'/4	627	510	405	321	286	236	198
45'/3	794	646	513	407	363	299	251

This table is based on the 2023 edition of the *NESC*. Wind Load Factor: Grade C = 2.20, Grade B = 2.50

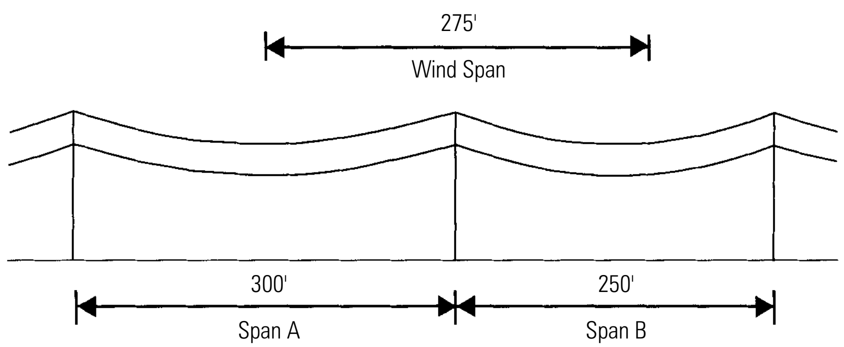
Continued

TABLE 5.11: Maximum Wind Spans in Feet: Southern Yellow Pine and Douglas Fir (cont.)							
THREE-PHASE LINES • MEDIUM LOADING							
	ACSR Conductors						
Pole Height/Class	(4)4 7/1	(4)2 6/1	(4)1/0 6/1	(4)3/0 6/1	(4)4/0 6/1	(4)336.4 18/1	(4)477.0 18/1
Grade C Construction							
35'/6	518	481	437	391	369	331	298
35'/5	646	599	544	488	460	413	372
35'/4	834	774	703	630	594	533	480
40'/6	513	476	433	388	366	328	296
40'/5	667	619	562	504	475	426	384
40'/4	849	788	716	641	605	543	489
45'/5	661	613	557	499	470	422	381
45'/4	833	773	702	629	593	533	480
45'/3	1034	959	871	781	736	661	595
Grade B Construction							
35'/6	339	314	285	256	241	216	195
35'/5	423	393	357	320	302	271	244
35'/4	549	509	463	415	391	351	316
40'/6	333	309	281	252	237	213	192
40'/5	435	404	367	329	310	278	251
40'/4	557	516	469	421	396	356	321
45'/5	429	398	362	324	306	274	247
45'/4	544	504	458	411	387	348	313
45'/3	677	628	571	512	482	433	390
This table is based on the 2023 edition of the *NESC*. Wind Load Factor: Grade C = 2.20, Grade B = 2.50							

Continued

TABLE 5.11: Maximum Wind Spans in Feet: Southern Yellow Pine and Douglas Fir (cont.)							
THREE-PHASE LINES • HEAVY LOADING							
Pole Height/Class	**ACSR Conductors**						
	(4)4 7/1	**(4)2 6/1**	**(4)1/0 6/1**	**(4)3/0 6/1**	**(4)4/0 6/1**	**(4)336.4 18/1**	**(4)477.0 18/1**
Grade C Construction							
35′/6	312	298	281	261	251	233	216
35′/5	389	371	350	325	313	290	269
35′/4	502	480	452	420	404	375	348
40′/6	309	295	278	259	249	231	214
40′/5	402	384	361	336	323	300	278
40′/4	511	488	460	428	411	382	354
45′/5	398	380	358	333	320	297	276
45′/4	502	479	451	420	403	375	348
45′/3	622	594	560	521	501	465	431
Grade B Construction							
35′/6	204	195	183	171	164	152	141
35′/5	255	244	229	213	205	190	177
35′/4	331	316	297	277	266	247	229
40′/6	201	192	180	168	161	150	139
40′/5	262	250	236	219	211	196	182
40′/4	335	320	301	281	270	250	232
45′/5	258	247	232	216	208	193	179
45′/4	327	313	294	274	263	244	227
45′/3	408	389	367	341	328	304	283

This table is based on the 2023 edition of the *NESC*. Wind Load Factor: Grade C = 2.20, Grade B = 2.50



$$\text{Wind Span} = \frac{(\text{Span A} + \text{Span B})}{2}$$

$$= \frac{(300' + 250')}{2} = 275'$$

FIGURE 5.3: Wind Span.

Example 5.1

Determine the maximum allowable wind span based on pole strength for the pole shown in **Figure 5.4** and given the following information:

Given:

Pole height	=	40'
Pole class	=	5
Wood species	=	Southern yellow pine (SYP)
Pole-top assembly	=	C1.13L
Conductor	=	(3) 336.4 ACSR 18/1 primary (1) 4/0 ACSR 6/1 neutral 1/2
Joint use cables	=	1/2" CATV with 1/4" messenger 1 1/2" telephone with 3/8" messenger
NESC loading district	=	Heavy
Grade of construction	=	C

Continued

Example 5.1 (cont.)

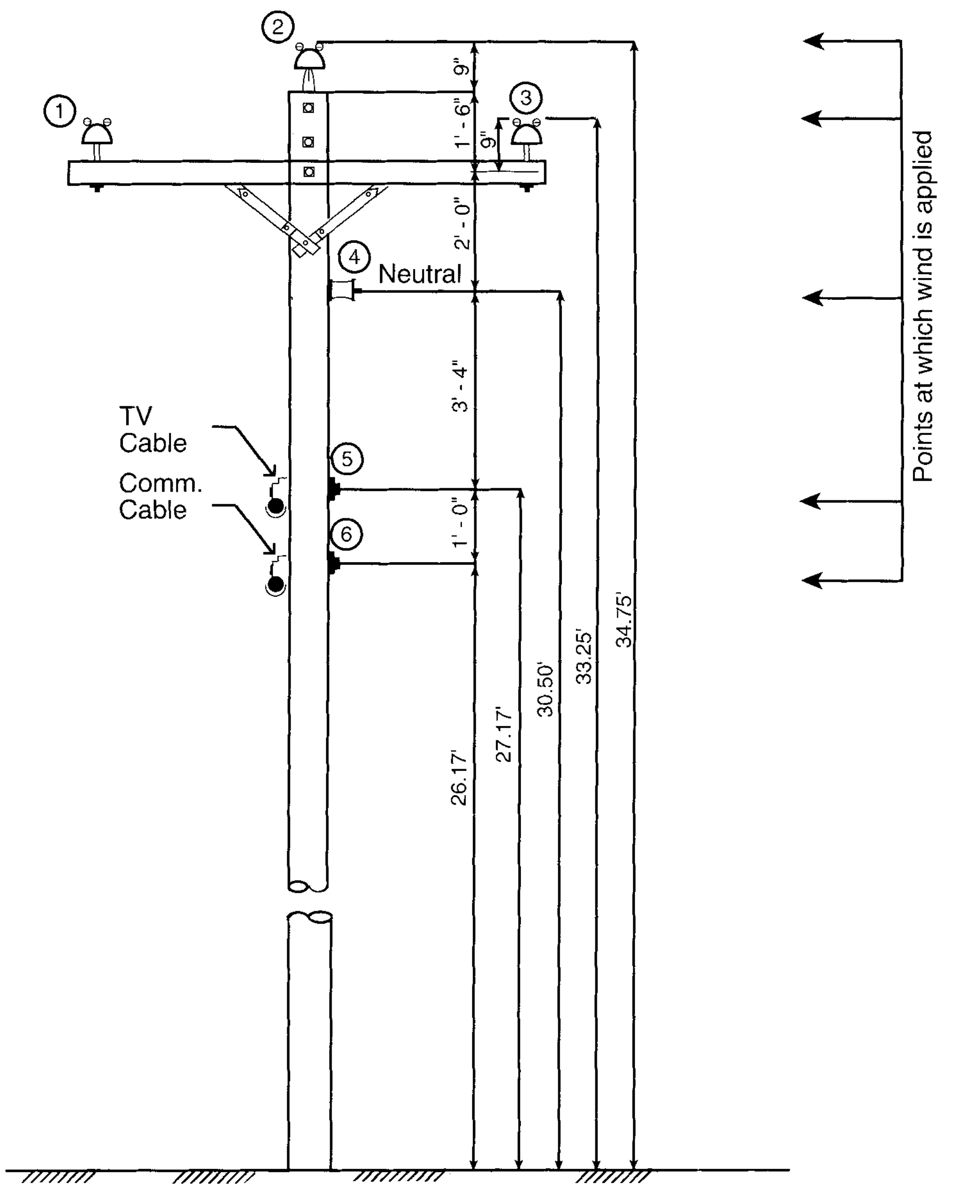


FIGURE 5.4: Transverse Loading on Structure.

Continued

Example 5.1 (cont.)

Tables 5.12 and 5.13 provide the transverse *NESC* district loadings for 1 foot of TV and communication cables.

TABLE 5.12: Transverse *NESC* District Loading on TV Cables

Description	*Diameter (in.)	Heavy Loading (lb/ft)	Medium Loading (lb/ft)	Light Loading (lb/ft)
1/4" messenger 1/2" cable	.840	0.6133	0.4467	0.6300
1/4" messenger 3/4" cable	1.090	0.6967	0.5300	0.8175

*Diameter is combined diameters of messenger, cable, and lashing wire. Lashing wire diameter is 0.045" and should be applied to top and bottom of the cable ($0.045 \times 2 = 0.09$).

TABLE 5.13: Transverse *NESC* District Loading on Communication Cables

Description	*Diameter (in.)	Heavy Loading (lb/ft)	Medium Loading (lb/ft)	Light Loading (lb/ft)
3/8" messenger 1" cable	1.480	0.8266	0.6600	1.1100
3/8" messenger 1 1/2" cable	1.980	0.9934	0.8267	1.4813
3/8" messenger 2" cable	2.480	1.1600	0.9934	1.8600
7/16" messenger 2" cable	2.530	1.1767	1.0100	1.8975
7/16" messenger 2 1/2" cable	3.030	1.3430	1.1767	2.2725
5/16" messenger 144 Pair Fiber	1.202	0.7340	0.5673	0.9015
ADSS Fiber 144 pair	0.6000	0.5333	0.3667	0.4500
ADSS Fiber 288 pair	0.9400	0.6467	0.4800	0.7050

*Diameter is combined diameters of messenger, cable, and lashing wire. Lashing wire diameter is 0.045" and should be applied to top and bottom of the cable ($0.045 \times 2 = 0.09$).

Continued

Example 5.1 (cont.)

STEP 1: Determine the transverse load on the conductors (TL_c) and cables. Heavy loading zone grade C.

Equation 5.2

$$TL_C = (W_C)(LF_W)$$

Where:

TL_C = Transverse load

W_C = *NESC* district transverse wind load (lb/ft), **Tables 5.3**, **5.12**, and **5.13**

LF_W = Load factor, **Table 5.1** = 2.20

Conductor/Cable	W_c (lb/ft)		LF_w		TL_c (lb/ft)
336.4 ACSR 18/1	.5613	×	2.20	=	1.2349
4/0 ACSR 6/1	.5210	×	2.20	=	1.1462
1/2" CATV Cable	.6133	×	2.20	=	1.3493
1 1/2" Telephone Cable	.9934	×	2.20	=	2.1855

STEP 2: Determine the moment with applied load factor for wind on the pole.

Equation 5.3

$$M_P = (W_P)(LF_W)$$

Where:

M_P = Moment due to wind on the pole with *NESC* LF_W

W_P = Bending moment due to wind on pole (ft-lb)
= 1411 ft-lb for 40'-5, SYP from **Table 5.9**

LF_W = Load factor = 2.20 from **Table 5.1**

M_P = (1411 ft-lb)(2.20) = 3.104 ft-lb

Continued

Example 5.1 (cont.)

STEP 3: Determine the moment due to wind on the conductors.

Equation 5.4

$$M_c = (H_c)(TL_c)$$

Where:

M_c = Moment due to wind on 1 conductor (ft-lb)

H_c = Height of conductor above grade (ft), **Figure 5.4** (determined from RUS specifications and drawings)

TL_c = Transverse load of conductors and cables (lb) (determined in Step 1)

M_c must be calculated for each conductor.

Conductor	TL_c		H_c		M_c
336 ACSR Primary	1.2349	×	33.25	=	41.06
336 ACSR Primary	1.2349	×	34.75	=	42.91
336 ACSR Primary	1.2349	×	33.25	=	41.06
4/0 ACSR Neutral	1.1462	×	30.50	=	34.96
CATV	1.3493	×	27.17	=	36.66
Telephone Cable	2.1855	×	26.17	=	57.19

Total moment due to wind on conductors = 253.84 ft-lb = 254 ft-lb

STEP 4: Calculate the maximum allowable wind span.

Compare this value of 198 feet to the value of 300 feet given in **Table 5.11** for three-phase 336.4 ACSR conductor on 40-foot Class 5 poles. The addition of cable TV and telephone can have a significant impact on the span length of a given line.

Equation 5.5

$$S_W = \frac{R_P - M_P}{M_C}$$

Where:

S_W = Maximum allowable wind span

R_P = Derated strength of the pole for Grade C (ft-lb) = 53,465 ft-lb from **Table 5.8**

M_P = Moment due to wind on the pole (ft-lb) = 3104 ft-lb from Step 2

M_C = Moment due to wind on the conductor (ft-lb) = 254 ft-lb from Step 3

$$S_W = \frac{53{,}465 - 3104}{254}$$

$$= 198 \text{ ft}$$

Unguyed Line Angle Poles

It is preferable to install guys to support line angle poles as described in **Section 7**. However, there are times when it is necessary to design line angle poles without guys. Unguyed line angle poles must support the wind load and the tension load of the conductors for the applicable *NESC* loading district. The derated strength of the wood pole must exceed the foot-pounds of load resulting from wind and tension. Deflection of the pole must be considered in the design process. Also, the embedment of the pole must be sufficient to provide a substantial foundation to prevent movement (leaning) of the pole in the soil. For wood poles, only slight line angles of 1° to 3° should be considered for self-support.

The calculation of the pole deflection is beyond the scope of this manual. The engineer or consultant should establish definite parameters and specifications for the staking technician to apply in the field. Wind span, design tension, line angle, height of conductors above grade, and the *NESC* load factors and loading districts are variables that must be considered to correctly determine if a particular pole size and class can effectively support a conductor load under worst-case conditions. Use the larger class poles (1 and 2) for self-supporting, small-line-angle structures.

A rule of thumb on setting self-supporting wood poles for small line angles is to set the pole to a depth of 10% of the pole length plus 4 feet. Heavy clay and sandy soils on dry sites provide greater stability than silts or swampy soils. Tamp the soil around the pole extra hard to provide proper embedment for the pole shaft. Backfill the pole hole with gravel or crushed stone to augment the embedment of the pole shaft.

Specially fabricated metal or concrete poles can support full deadend or large-angle loads. The size of the pole must be determined case by case. Each self-supporting pole must be designed according to the loads that will be applied to the structure. Standard wood-equivalent concrete and steel poles are not designed to support large angles and conductor dead ends without the additional support of guys and anchors. These standard poles come under the same guidelines as the small-line-angle structures above. Steel poles tend to be smaller in diameter than wood or concrete poles of equivalent strength. This reduction in bearing surface contacting the soil can result in leaning poles. Give careful consideration to proper embedment of small-diameter steel poles.

To calculate the transverse load on a small-line-angle pole, use the same method and equation as for tangent poles but include a factor for the conductor tension component. It is suggested that Grade B load factors be used to help limit deflection in wood poles when they are subjected to normal service loads and tensions (i.e., a clear spring day).

Extreme Wind Loading on Unguyed Poles

Extreme wind loading on poles and conductors is similar to considerations required for determining the maximum wind span. The strength of the pole must be able to resist the moment due to wind on the pole and wind on the conductors. The *NESC* requires the extreme wind loading to be considered if any portion of the structure or its supported facilities exceeds 60 feet above ground. Therefore, all wood poles 70 feet and taller must have sufficient strength to withstand the forces of extreme wind loading. This is because a 70-foot wood pole is set 9 feet into the ground, resulting in the top of the pole being 61 feet above ground (see **Table 5.15)**. Also, if the conductor at midspan is more than 60 feet above ground, then extreme wind must be considered. For example, it is possible to cross a canyon or river using 40-foot poles and have the conductors at midspan be more than 60 feet above ground.

The *NESC* requires that certain coefficients be applied to the extreme wind loading. For Grade B installations refer to **Figure 3.2(a)** and for Grade C refer to **Figure 3.2(b)**. **Table 5.14** provides those coefficients by combining several factors found in *NESC* Rule 250C. The values in

Table 5.14 should only be used on natural wood poles and overhead conductors for the spans and heights provided.

Load factors found in **Table 5.2** must be applied to the extreme wind loads. However, when determining the wind load on the conductor, it is *not* necessary to include a radial thickness of ice. Only the bare conductor diameter is used in the extreme wind loading calculation.

Example 5.2 shows the procedure to calculate the strength requirement for an unguyed wood pole based on extreme wind. Strength considerations from loads resulting from extreme wind must also be considered and applied to guyed poles using the method shown in **Example 5.2**. However, the load factors for extreme wind must be obtained from **Table 7.2** for guyed structures.

TABLE 5.14: Simplied Extreme Wind Loading Combined Product of k_z and G_{RF}. Reference Note 2 of *NESC* Rule 250C.

Height Above Groundline	Coefficient KG
	Span<2000 ft
165 feet and less	1.15

TABLE 5.15: Pole Setting Depths

Length of Pole (ft)	Setting in Soil (ft)
30	5.50
35	6.00
40	6.00
45	6.50
50	7.00
55	7.50
60	8.00
65	8.50
70	9.00

Note: Generally, determine pole burial depth in soil as 10% of pole length plus 2 feet, but shorter poles don't fit the formula. For self-supporting wood poles with small line angles, consider a depth of 10% of the pole length plus 4 feet for a stronger foundation.

Example 5.2

Determine if the pole class has sufficient strength to hold the forces of extreme wind when the conductor crosses a canyon and is 75 feet above the floor of the canyon.

Given:

Pole height	=	55 feet
Pole class	=	2
Wood species	=	Southern yellow pine
Pole-top assembly	=	C1.3
Conductor	=	4/0 ACSR 6/1 primary
	=	4/0 ACSR 6/1 neutral
Wind span	=	350 feet
Grade of construction	=	C
Location	=	Oklahoma

STEP 1: Determine the transverse load on the conductors (TL_C).

Equation 5.6

$$TL_C = (P)\left(\frac{D}{12}\right)(KG_W)(LF_{EW})$$

Where:

TL_C = Transverse load for extreme wind

P = Wind load in psf; **Figure 3.2(b)** shows 90 mph and **Table 3.2** converts 90 mph to 21 psf

D = Diameter of the conductor in inches shown in **Table 5.3**

KG_W = Wire coefficient from **Table 5.14** = 1.15

LF_{EW} = Load factor = 1.00 from **Table 5.2**

Conductor	P (psf)		D (inches)		KG_W		LF_{EW}	TL_C (lb/ft)
4/0 ACSR	21	×	$\left(\frac{0.563}{12}\right)$	×	1.15	×	1.00	= 1.133

STEP 2: Determine the moment with applied load factor for extreme wind on the pole

Equation 5.7

$$M_P = \frac{PH^2(d_1 + 2d_2)(KG_S)(LF_{EW})}{72}$$

Where:

M_P = Bending moment due to wind on the pole (ft-lb)

P = Wind load in psf; **Figure 3.2(b)** shows 90 mph and **Table 3.2** converts 90 mph to 21 psf

H = Height of pole above ground (ft)

d_1 = Diameter of the pole at groundline (inches); for a 55-foot SYP d_1 = 13.65 inches

d_2 = Diameter of the pole at the top (inches); for a 55-foot SYP d_2 = 7.96 inches

KG_S = The product of K_z and G_{RF} for structure heights less than 250 feet. Structure coefficient = 1.15 from **Table 5.14**

LF_{EW} = Load factor = 1.00 from **Table 5.2**

$$M_P = \frac{(21)(47.5)^2[13.65 + (2)(7.96)](1.15)(1.00)}{72} = 22{,}378 \text{ ft-lb}$$

Continued

HOME BACK

Example 5.2 (cont.)

STEP 3: Determine the ground-line moment due to wind on the conductors.

Equation 5.8

$$M_C = (H_A)(TL_{CA}) + (H_B)(TL_{CB}) + (H_C)(TL_{CC}) + (H_N)(TL_{CN})$$

Where:

M_C = Moment due to wind on conductors (ft-lb)
H_A = Height of A phase above ground (ft)
H_B = Height of B phase above ground (ft)
H_C = Height of C phase above ground (ft)
H_N = Height of neutral above ground (ft)
TL_{CA} = Transverse load for extreme wind on A phase Determined in Step 1 of this example
TL_{CB} = Transverse load for extreme wind on B phase Determined in Step 1 of this example
TL_{CC} = Transverse load for extreme wind on C phase Determined in Step 1 of this example
TL_{CN} = Transverse load for extreme wind on neutral Determined in Step 1 of this example

Conductor	H		TL_C		M_C (lb/ft)
A Phase 4/0 ACSR	46.75	×	1.133	=	52.97
B Phase 4/0 ACSR	48.25	×	1.133	=	54.67
C Phase 4/0 ACSR	46.75	×	1.133	=	52.97
Neutral 4/0 ACSR	44.00	×	1.133	=	49.85
			Total M_C	=	210.46

STEP 4: Determine the total moment due to wind on the conductors and wind on the pole. This value will be compared to the derated strength of the pole to determine if the pole has sufficient strength to withstand the extreme wind loading.

Equation 5.9

$$R_P \geq M_P + (M_C)(S)$$

Where:

R_P = Derated strength of the pole for extreme wind (ft-lb), 125,025 ft-lb[1]
M_P = Moment due to wind on pole (ft-lb), Step 2
M_C = Moment due to wind on conductors (ft-lb), Step 3
S = Wind span (ft), given in this problem as 350 feet

$125,025 \geq 22,378 + (210.46)(350)$

$125,025 \geq 96,039$ ft lb

Since R_P (125,025 ft-lb) is greater than the resulting 96,039 ft-lb, the pole class has adequate strength for extreme wind loading.

[1] Strength factor for extreme wind is 0.75. Use value in **Table 5.8**.

Extreme Ice with Concurrent Wind Loading on Unguyed Poles

The *NESC* (250D) requires that extreme ice with concurrent wind loading be considered if any portion of the structure or supported facilities exceeds 60 feet above ground or water level. If the structure or its supported facilities exceed 60 feet above ground or water level, the structure and its supported facilities need to be designed to withstand the ice load and wind speed load as shown in Figures 3.3(a) and 3.3(b). The wind pressures shall be applied to the entire structure without ice. The wind pressure will be applied to the iced conductor. Furthermore, the ice loading shall be multiplied by a factor as follows:

Grade B: Radial thickness of ice from **Figure 3.3** shall be multiplied by a factor of 1.00

Grade C: Radial thickness of ice from **Figure 3.3** shall be multiplied by a factor of 0.80

A load factor needs to be applied for extreme ice loading (see **Table 5.2**) and a strength factor for wood poles needs to be included in the calculation (see **Table 5.8**).

Example 5.3

Determine if the pole class has sufficient strength to hold the forces of extreme ice with concurrent wind when the conductor crosses a canyon and is 75 feet above the small valley.

Given:

Pole height	=	50 feet
Pole class	=	3
Wood species	=	Southern yellow pine
Pole-top assembly	=	C1.41L
Conductor	=	336 ACSR 18/1 primary
	=	4/0 ACSR 6/1 neutral
Wind span	=	310 feet
Grade of construction	=	C
Location	=	Central Kentucky

STEP 1: Determine the transverse load on the conductors (TL_C).

Equation 5.10

$$TL_C = (P)\left(\frac{D + 2C}{12}\right)(LF_{EW})$$

Where:

TL_C = Transverse load for extreme ice
P = Wind Load in psf; **Figure 3.3** shows 30 mph and **Table 3.2** converts 30 mph to 2.3 psf
D = Diameter of the conductor in inches shown in **Table 5.3**
C = Radial thickness of ice from **Figure 3.3**. For Grade C reduce ice thickness by multiplying by 0.8. **Figure 3.3** shows 0.75 inches of ice, reduced for Grade C to 0.6 inches.
LF_{EW} = Load factor = 1.0 from **Table 5.2**

Conductor	P		D (inches) C (inches)		LF_{EW}	TL_C
336 ACSR	2.3	×	$\left(\frac{0.684 + (2)0.6}{12}\right)$	×	1.0	= 0.3611
4/0 ACSR	2.3	×	$\left(\frac{0.563 + (2)0.6}{12}\right)$	×	1.0	= 0.3379

Example 5.3 (cont.)

STEP 2: Determine the moment with applied load factor for current wind on the pole. Note the thickness of ice on the pole is ignored in this calculation because of the negligible affect.

Equation 5.11

$$M_P = \frac{PH^2(d_1 + 2d_2)(LF_{EW})}{72}$$

Where:

M_P = Bending moment due to wind on the pole (ft-lb)

P = Wind load in psf; **Figure 3.3** shows 30 mph and **Table 3.2** converts 30 mph to 2.3 psf

H = Height of pole above ground (ft)

d_1 = Diameter of the pole at groundline (inches) for a 50-foot SYP Class 3 = 12.29 inches

d_2 = Diameter of the pole at the top (inches) for a 70-foot SYP Class 3 = 7.32 inches

LF_{EW} = Load factor for extreme ice = 1.0 from **Table 5.2**

$$M_P = \frac{(2.3)(43)^2[12.29 + (2)(7.32)](1.0)}{72} = 1591 \text{ ft-lb}$$

STEP 3: Determine the ground-line moment due to wind on the conductors.

Equation 5.12

$$M_C = (H_A)(TL_{CA}) + (H_B)(TL_{CB}) + (H_C)(TL_{CC}) + (H_N)(TL_{CN})$$

Where:

M_C = Moment due to wind on conductors (ft-lb)

H_A = Height of A phase above ground (ft)

H_B = Height of B phase above ground (ft)

H_C = Height of C phase above ground (ft)

H_N = Height of neutral above ground (ft)

TL_{CA} = Transverse load for extreme wind on A phase Determined in Step 1 of this example

TL_{CB} = Transverse load for extreme wind on B phase Determined in Step 1 of this example

TL_{CC} = Transverse load for extreme wind on C phase Determined in Step 1 of this example

TL_{CN} = Transverse load for extreme wind on neutral Determined in Step 1 of this example

Conductor	H		TL_C		M_C (lb/ft)
A Phase 336 ACSR	43.25	×	0.3611	=	15.62
B Phase 336 ACSR	43.25	×	0.3611	=	15.62
C Phase 336 ACSR	43.25	×	0.3611	=	15.62
Neutral 4/0 ACSR	43.25	×	0.3379	=	14.61
			Total M_C	=	61.47

Continued

Example 5.3 (cont.)

STEP 4: Determine the total moment due to wind on the conductors and wind on the pole. This value will be compared to the derated strength of the pole to determine if the pole has sufficient strength to withstand the extreme ice and concurrent wind loading.

Equation 5.13

$$R_P > M_P + (M_C)(S)$$

Where:

R_P = Derated strength of the pole for extreme ice (ft-lb); See **Table 5.9**
Strength factor = 0.75
121,500 ft-lb × 0.75 = 91,125 ft-lb

M_P = Moment due to wind on pole (ft-lb), Step 2

M_C = Moment due to wind on conductors (ft-lb), Step 3

S = Wind span (ft), given in this problem as 310 feet

91,125 ft-lb ≥ 1591 + (61.47)(310)

91,125 ft-lb ≥ 20,647 ft-lb

CONCLUSION: Since R_P (91,125 ft-lb) is greater than the resulting 20,647 ft-lb, the pole class has adequate strength for extreme ice loading.

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6 Strength of Pole-Top Assemblies

In This Section:

It is very important when staking a distribution line to select the proper pole-top assembly for each pole. To do this, the staking technician needs to know the limiting conditions for the various assemblies. This section provides information for the seven conductors selected for study in this manual.

This section will also provide methods to determine pole-top assembly limits for other conditions or conductors.

The basic principles discussed here can be applied to any pole-top assembly. However, this discussion is specifically limited to standard RUS assemblies found in RUS Standard D-801, Specifications and Drawings for 34.5/19.9-kV Distribution Line Construction; RUS Bulletin 1728F-803, Specifications and Drawings for 24.9/14.4 kV Line Construction; and Standard 1728F-804, Specifications and Drawings for for 12.47/7.2 kV Distribution Line Construction.

Crossarm Assemblies

Crossarm assemblies are divided into three general categories:

1. Tangent (straight-line) and slight line angle assemblies, which are typically constructed using a single crossarm and single pin supports
   Example: C1.11 assembly as specified in RUS Standard 1728F-804
2. Medium line angle assemblies, which are typically constructed using double crossarms and double pin supports
   Example: C2.52L assembly as specified in RUS Standard 1728F-804
3. Deadend assemblies, which are typically constructed using multiple crossarms and suspension insulators
   Example: C5.21 or C5.71L assembly as shown in RUS Standard 1728F-804

Heavy angle and some deadend assemblies are generally constructed without crossarms. Instead, conductors are supported by strain insulators mounted directly to the pole.
Example: C3.1 or C5.1 assembly as shown in RUS Standard 1728F-804

6

Strength of Crossarm

Crossarm assemblies are limited by their ability to support vertical loads. Vertical loads include the weight of the conductor and ice. In the case of an underbuild arm, it must also support the weight of a line worker. The *NESC* (261D5b) has this requirement because a line worker may be required to support his or her weight on the lower crossarm of a double-circuit structure.

The usual way to define the vertical strength capability of a crossarm is to specify the maximum span of iced conductor plus the appropriate load factor that the arm will support. The iced span, supported by a crossarm, is the distance in feet from the low point in the conductor sag in the span ahead to the low point in the conductor sag in the back span. This is called the "weight span" and is shown in Figure 6.1. It is important to note that, unlike the wind span, the weight span is not necessarily the average of the two spans.

The calculated maximum weight span for standard RUS Douglas fir crossarms is more than 500 feet for conductors smaller than 477 ACSR; thus, it is apparent that the vertical loading limits on crossarms will generally not control the maximum span length.

Typically, the maximum wind span, the *NESC* requirements for vertical and horizontal clearances, or the pin strength will control the maximum span that can be used for a given structure.

The staking technician should refer to the cooperative or consulting engineer for assistance in calculating the maximum weight span for underbuild circuits and abrupt changes in grade.

For extra-large conductors, the weight span can be a limiting factor; this is discussed in greater detail in **Section 12** of this manual.

A set of crossarms must also be strong enough to support the conductor longitudinal unbalances. **Figure 6.2** illustrates the two common occurrences of the longitudinal unbalances, one at single deadend assemblies similar to C5.21 and the other at double deadend assemblies similar to C6.21. The most severe unbalances occur on single deadend assemblies where the crossarm must support to the full design tension of the conductor. A torque is developed at the attachment point of the crossarm to the pole so the distance of the conductor(s) from the center of the pole must be considered along with the *NESC* load factor.

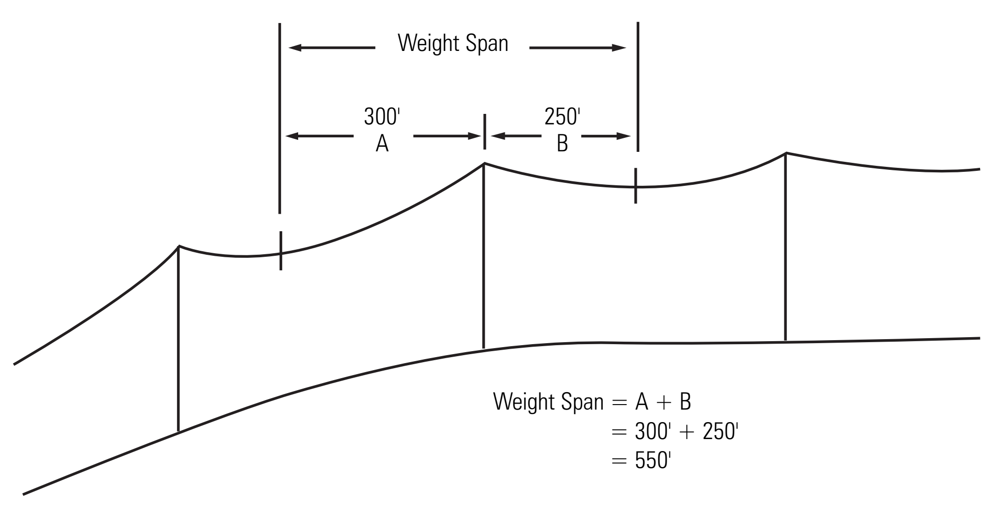

FIGURE 6.1: Weight Span.

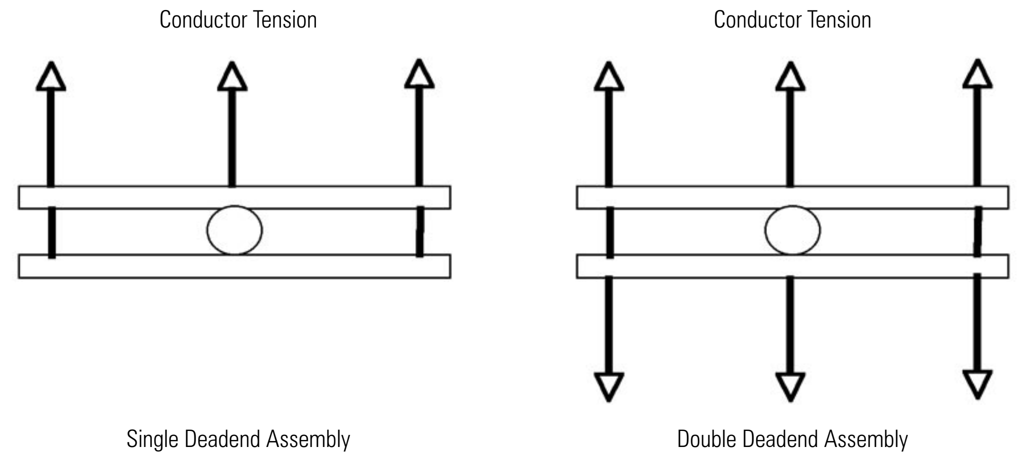

FIGURE 6.2: Examples of Longitudinal Unbalances on Crossarms.

TABLE 6.1: Deadend Assemblies for Smaller Conductors

Conductor Size	Design Tension (lb)	Grade C		Grade B	
		12.47/7.2 kV	24.9/14.4 kV	12.47/7.2 kV	24.9/14.4 kV
4 ACSR 7/1	1180	C5.21	VC5.21	C5.31	VC5.31
2 ACSR 6/1	1425	C5.21	VC5.21	C5.31	VC5.31
1/0 ACSR 6/1	2190	C5.31	VC5.31	C5.71L	VC5.71L

Table 6.1 shows the appropriate single deadend assembly for 12.47/7.2-kV and 24.9/14.4-kV assemblies based on the design tension of these smaller conductors at Grade C and Grade B.

Bulletin 1724F-151, Mechanical Loading on Distribution Crossarms, provides details for determining the strength and loading of wooden crossarms. In addition, **Example 6.2** illustrates how to calculate the strength requirement for deadend assemblies such as C5.21 and C5.31.

For double deadend assemblies with the conductors of the same size and tension, there is no unbalance load. However, in some cases, double deadend assemblies are used to change conductor size, such as from 336 ACSR to 1/0 ACSR. A simplified approach for determining the required strength of the crossarm is to ignore the tension of the smaller conductor.

For large-conductor single deadends, there are two options: a vertical deadend assembly or a buckarm deadend assembly.

TABLE 6.2: Load Factors for Wood Crossarms.
Adapted from NESC Table 253-1.

Conductor Loading	Grade B	Grade C
Ice and Wind (250B)		
Vertical Loads	1.50	1.90
Longitudinal Loads	1.65	1.30
Extreme Wind (250C)	1.00	1.00
Extreme Ice with Concurrent Wind (250D)	1.00	1.00

TABLE 6.3: Strength Factors for Wood Crossarms.
Adapted from NESC Table 261-1A.

Conductor Loading	Grade B	Grade C
Ice and Wind (250B)	0.65	0.85
Extreme Wind (250C)	0.75	0.75
Extreme Ice with Concurrent Wind (250D)	0.75	0.75

VERTICAL CONSTRUCTION (EXAMPLE C5.1)

This is the recommended method since vertical structures are economical, provide the greatest strength, and are relatively convenient to maintain or replace while the conductors are energized. The deadend tension for vertical assemblies is limited by the strength of the suspension insulator, through-bolt, and washer. The RUS specifications show a tension limit of 5,000 pounds for these assemblies.

BUCKARM CONSTRUCTION (EXAMPLE C5.71L)

For large conductors, it is necessary to use a manufactured wooden crossarm assembly (there are nonwood options available, but these are not addressed in this manual). It is recommended that the wooden crossarm assembly be designed for the load factors and strength factors as required by the *NESC*. The longitudinal load factors for wooden crossarms are shown in Table 6.2 and the strength factors are shown in Table 6.3.

For large conductors, it is recommended that these deadend assemblies be designed for Grade B strength. Typically, crossarm ratings are based on a maximum allowable tension at the conductor attachment point. To select an assembly with adequate strength, it is necessary to calculate the crossarm strength per attachment (conductor). Example 6.1 illustrates these calculations.

Several manufacturers produce packaged crossarm deadend assemblies approved by RUS. The manufacturers typically have additional loading limitations. The staking technician must be sure that loading meets the manufacturer's recommendations.

Example 6.1

Deadend 4/0 ACSR 6/1 on an RUS specification C5.71L crossarm assembly

Design or loaded tension on each conductor = 4000 lb

The breaking strength of 4/0 ACSR 6/1 conductor is 8350 lb. Because this is a large conductor (breaking strength greater than 4500 lb), the assembly will be designed for Grade B load factors.

Calculate the crossarm strength per attachment.

Equation 6.1

$$C_S = \frac{(LF)(DT)}{(SF)}$$

Where:

- C_S = Crossarm strength per attachment
- LF = Load factor for wood crossarms = 1.65 from **Table 6.2** (Grade B, ice and wind, longitudinal loads)
- DT = Design tension of the conductor = 4000 lb
- SF = Strength factor for wood crossarms = 0.65 from **Table 6.3** (Grade B, ice and wind loads)

$$C_S = \frac{(1.65)(4000)}{(0.65)} = 10{,}153 \text{ lb}$$

The assembly selected must have a strength rating of 10,153 lb or greater.

Example 6.2

Determine if a single deadend assembly C5.31 can support 2 ACSR conductor with a design tension of 1425 lb.

Given:

Conductor type	=	2 ACSR
Weight span	=	180 feet
Pole-top assembly	=	C5.31
Grade of construction	=	B
NESC Loading	=	Heavy

It is first necessary to determine the maximum longitudinal moment (ML) to support the design tension. The methodology reduces the longitudinal strength based on the vertical loading.

Equation 6.2

$$M_L = 1 - \left[\frac{M_{VL}}{S_V}\right] S_L$$

Where:

M_L	=	Maximum longitudinal moment (ft-lb)
M_{VL}	=	Moment due to vertical load (ft-lb)
S_V	=	Derated vertical strength of the crossarm(s) (ft-lb)
S_L	=	Derated longitudinal strength of the crossarm(s) (ft-lb)

STEP 1: Determine S_V, derated vertical strength of the crossarm(s).

Equation 6.3

$$S_V = (N)(C_{SV})(SF)$$

Where:

S_V	=	Derated vertical strength of the crossarm(s) (ft-lb)
N	=	Number of crossarms (a C5.31 has 3 crossarms) = 3
C_{SV}	=	Vertical strength for standard RUS crossarm (4 5/8" × 3 5/8") (ft-lb) = 7650 (from RUS Bulletin 1724E-151)
SF	=	*NESC* strength factor for wood crossarms = 0.65 from **Table 6.3** (Grade B, ice and wind loads)

$$S_V = (3)(7650)(0.65) = 14,917 \text{ ft-lb}$$

Continued

Example 6.2 (continued)

STEP 2: Determine S_L, derated longitudinal strength of the crossarm(s).

Equation 6.4

$$S_L = (N)(C_{SL})(SF)$$

Where:

S_L = Derated longitudinal strength of the crossarm(s)(ft-lb)
N = Number of crossarms = 3
C_{SL} = Longitudinal strength for standard RUS crossarm (4 5/8" × 3 5/8") (ft-lb) = 5060 (from RUS Bulletin 1724E-151)
SF = *NESC* strength factor for wood crossarms = 0.65 from **Table 6.3** (Grade B, ice and wind loads)
S_L = (3)(5060)(0.65) = 9867 ft-lb

STEP 3: Determine M_{VL}, moment due to vertical load.

Equation 6.5

$$M_{VL} = [(L)(C_{WT})(S_{WT})(LF_V)] + 1000$$

Where:

M_{VL} = Moment due to vertical load (ft-lb)
L = Distance of wire from the center of the crossarm (ft) = typically 3.5 feet (reference construction specification for actual distance)
C_{WT} = Weight of the conductor plus ice (lb/ft); this value can be found in Appendix B (**Table B.65**; 32 degrees with ice) = 0.599
S_{WT} = Weight span (ft) = 180
LF_V = *NESC* load factor—**Table 6.2** (Grade B, vertical loads, ice and wind) = 1.5

1000 ft-lb load is added to allow for the weight of a lineman on the crossarm 2 feet from the center of the pole with a safety factor of 2.0

$$M_{VL} = (3.5)(0.599)(180)(1.5) + 1000 = 1566 \text{ ft-lb}$$

Continued

Example 6.2 (continued)

STEP 4: Determine M_L, maximum longitudinal moment (ft-lb).

Equation 6.6

$$M_L = \left[1 - \frac{M_{VL}}{S_V}\right] S_L$$

$$M_L = \left[1 - \frac{1566}{14{,}917}\right](9867) = 8831 \text{ ft-lb}$$

STEP 5: Determine DT, the maximum design tension that the crossarms can support for the given vertical weight on the crossarms.

Equation 6.7

$$DT = \frac{M_L}{(L)(LF_L)}$$

Where:

DT	=	Design tension (lb)
L	=	Distance from the center of the crossarm to the conductor attachment point (ft) = 3.5
LF_L	=	*NESC* load factor for wood crossarms—**Table 6.2** (Grade B, ice and wind, longitudinal load) = 1.65

$$DT = \frac{8831}{(3.5)(1.65)} = 1529 \text{ lb}$$

CONCLUSION: Since DT (1529 lb), the maximum design tension that the crossarms can support, is greater than design tension of 1425 lb, the single deadend assembly C5.31 can support the design tension.

Pin- and Post-Type Insulator Assemblies

Pin- and post-type insulator assemblies are used for supporting conductors on small and medium line angle pole-top assemblies such as C1.11 and C2.21.

The capability for these assemblies to withstand the transverse loads imposed by conductors is usually determined by the most critical of the following:

- Ability of the pole and crossarm to resist splitting due to the torque or twisting action of the insulator pin
- Ability of the pole-top and crossarm insulator pins to withstand bending or compression of wood members under flanges
- Ability of a porcelain post-type insulator to withstand *NESC*-specified cantilever loading without exceeding 40% strength rating of the porcelain pin or post-insulator as required by *NESC* Rule 277. Cantilever loading is loading produced on a beam or member supported at only one end.

The various insulator assemblies used in RUS standard drawings are given nominal strength ratings based on the most critical of the aforementioned strength capabilities.

Strength ratings of the various RUS insulator assemblies are listed in Table 6.4.

The maximum transverse strength rating is shown in the Design Parameters found in the lower left-hand corner of the RUS construction specifications. These construction specification strength ratings are limited by the individual assemblies shown in Table 6.4 (single pole-top, single crossarm pin, etc).

The neutral attachment will limit the maximum permissible angle. For example, the C1.11L has a 3-inch spool (also known as a single upset bolt) on which the neutral conductor is tied. Since the conductor simply rests on top of the spool, only a limited angle is permitted. Typically, this angle is 5 degrees for small conductors and 2 degrees for large conductors. For larger angles, it is necessary to use a neutral clevis with a bracket as shown in N2.1. The neutral clevis is limited by the crushing force of the line angle on the insulator. The N2.1L assembly has a greater strength and can be used for large conductors and large angles. These neutral attachments are shown in Figure 6.3.

TABLE 6.4: Strength of Pin- and Post-Type Insulator Assemblies

Description of Insulator Assembly	Nominal Rating (lb)
Single pole-top as used in A1.1 assembly	500
Double pole-top pin without split bolt as used in A2.1 assembly	500
Double pole-top pin with split bolt as used in A2.3 assembly	1000
Single pole-top post insulator and bracket as used in A1.3P assembly	750
Double pole-top post insulator and bracket with split bolt as used in A2.1P assembly	1500
Single crossarm pin as used in C2.51 assembly	500
Single crossarm pin with 2 1/4-inch square washer under shoulder of pin as in C1.1 assembly	750
Single saddle pin as used in C1.1L assembly	1000
Double saddle pin as used in C2.52L assembly	2000
Single post insulator as used in C1.13P assembly	750
Double post insulator as used in C2.21P assembly	1500

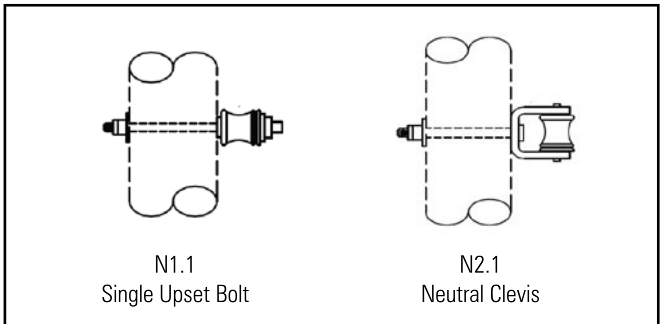

FIGURE 6.3: Typical Neutral Attachments.

It is recommended to limit the maximum line angle within load limits for assemblies. For example a C2.21L assembly has a maximum transverse load of 1000 lb per conductor and a recommended maximum line angle of 20 degrees. This maximum line angle within load limits means that the assembly can adequately handle line angles from 0 degrees to 20 degrees, provided the transverse load does not exceed 1000 lb per conductor.

If the angle at which the transverse load equals 1000 lb is greater than the 20 degree line angle limit, then the 20 degree line angle controls.

FIGURE 6.4: Pin Overload on C2.21 Pole-Top Assembly.

Figure 6.4 shows a C2.21 pole-top assembly where the pins are overloaded because the line angle exceeds the design limits of the assembly.

Maximum permissible line angles have been calculated for various conductors. To determine the maximum permissible line angle for a particular assembly, find the proposed assembly in **Table 6.5**. In this table, locate the assembly in the left-hand column. Maximum allowable transverse load and recommended maximum line angle within load limits are shown across the row.

Table 6.6 provides the maximum permissible line angle for various wind spans based on design tension of the conductors, *NESC* loading district, grade of construction, at line crossings, and loading parameters of the pole-top assemblies given in Table 6.5. Match the values found for the maximum transverse load and recommended maximum line angle within load limits in Table 6.5 to those in Table 6.6. Then locate the particular conductor, grade of construction, and loading zone and read across the row to the maximum permissible line angle for various wind spans.

Example 6.3 (following Tables 6.5 and 6.6) demonstrates how to find the maximum permissible line angle from Tables 6.5 and 6.6.

TABLE 6.5: Recommended Maximum Permissible Line Angle for Pin-Type Pole-Top Assemblies		
VOLTAGE: 12.47/7.2 kV RUS Bulletin 1728F-804 (See **Appendix A** for cross reference to old assembly names)		
Pole-Top Assembly	**Maximum Transverse Load (lb)**	**Recommended Maximum Line Angle within Load Limits**
A1.1, A1.2, A2.1, A2.2 (small conductor)	500	5°
A1.1, A1.2, A2.1, A2.2 (large conductor)	500	2°
A1.11, A1.3	500	20°
A2.21, A2.3	1000	20°
B1.11, B1.12 (small conductors)	500	5°
B1.11, B1.12 (large conductors)	500	2°
B1.13, B1.14	500	20°
B2.21, B2.22	1000	20°
B2.24, B2.25 (small conductor)	1000	5°
B2.24, B2.25 (large conductor)	1000	2°
C1.11, C1.12 (small conductors)	500	5°
C1.11, C1.12 (large conductors)	500	2°
C1.11L, C1.21L	500	5°
C1.13	500	5°
C1.13L	1000	20°
C1.14L	1000	20°
C1.41	750	20°
C2.21, C2.21L	1000	20°
C2.24, C2.25 (small conductor)	500	5°
C2.24, C2.25 (large conductor)	500	2°
C2.51, C2.52	1000	20°
C2.51L, C2.52L	2000	20°

Continued

TABLE 6.5: Recommended Maximum Permissible Line Angle for Pin-Type Pole-Top Assemblies (cont.)		
VOLTAGE: 12.47/7.2 kV RUS Bulletin 1728F-804 (See **Appendix A** for cross reference to old assembly names)		
Pole-Top Assembly	**Maximum Transverse Load (lb)**	**Recommended Maximum Line Angle within Load Limits**
A1.1P, A1.2P, A2.1P, A2.2P (small conductor)	750	5°
A1.1P, A1.2P, A2.1P, A2.2P (large conductor)	750	2°
A1.11P	500	20°
A1.3P	750	20°
A2.21P	1000	20°
A2.3P	1500	20°
B1.11P, B1.12P (small conductors)	750	5°
B1.11P, B1.12P (large conductors)	750	2°
B1.13P, B1.14P	750	20°
B2.21P, B2.22P	1500	20°
B2.24P, B2.25P (small conductor)	1000	5°
B2.24P, B2.25P (large conductor)	1000	2°
C1.11P, C1.12P (small conductors)	750	5°
C1.11P, C1.12P (large conductors)	750	2°
C1.13P	750	20°
C1.41P	750	20°
C2.21P	1500	20°
C2.24P, C2.25P (small conductor)	750	5°
C2.24P, C2.25P (large conductor)	750	2°
C2.51P	1500	20°
C2.52P	2000	20°

Continued

TABLE 6.5: Recommended Maximum Permissible Line Angle for Pin-Type Pole-Top Assemblies (cont.)

VOLTAGE: 24.9/14.4 kV
RUS Bulletin 1728F-803, December 1998

Pole-Top Assembly	Maximum Transverse Load (lb)	Max. Line Angle Within Load Limits
VA1.1, VA1.2 (#2 and smaller)	500	5º
VA1.1, VA1.2 (1/0 and larger)	500	2º
VA1.11	750	5º
VA1.3	500	5º
VA2.1	1000	20º
VA2.21	1500	20º
VB1.11, VB1.12 (#2 and smaller)	500	5º
VB1.11, VB1.12 (1/0 and larger)	500	2º
VB1.13	750	5º
VB1.14	750	5º
VB2.21	1500	20º
VB2.22	1500	20º
VC1.11, VC1.12	500	5º
*VC1.11L, VC1.12L	500	2º
VC1.13	500	5º
*VC1.13L	1000	5º
VC1.41	750	5º
*VC1.41L	1000	5º
VC2.21	1000	20º
*VC2.21L	1000	5º
VC2.51	1500	20º
*VC2.51L	2000	20º
VC2.52	1500	20º
*VC2.52L	2000	20º
VD1.81, VD1.82	500	5º
*VD1.81L, *VD1.82L	500	2º
VD1.83	750	5º
*VD1.83L	1000	5º
VD2.91	1500	20º
*VD2.91L	2000	20º

* L suffix indicates the pole-top assembly should be used for large conductors, conductors with a rated breaking strength of 4500 lb or more.

Continued

TABLE 6.5: Recommended Maximum Permissible Line Angle for Pin-Type Pole-Top Assemblies (cont.)		
VOLTAGE: 24.9/14.4 kV RUS Bulletin 1728F-803, December 1998		
Pole-Top Assembly	**Maximum Transverse Load (lb)**	**Max. Line Angle Within Load Limits**
VA1.1P, VA1.2P (#2 and smaller)	500	5º
VA1.1P, VA1.2P (1/0 and larger)	500	2º
VA1.11P	750	5º
VA1.3P	750	5º
VA2.1P	1500	20º
VA2.21P	1500	20º
VB1.11P, VB1.12P (#2 and smaller)	500	5º
VB1.11P, VB1.12P (1/0 and larger)	500	2º
VB1.13P	750	5º
VB1.14P	750	5º
VB2.21P	1500	20º
VB2.22P	1500	20º
VC1.11P, VC1.12P (#2 and smaller)	500	5º
VC1.11P, VC1.12P (1/0 and larger)	500	2º
VC1.13P	750	5º
VC1.41P	750	5º
VC2.21P	1500	20º
VC2.51P	1500	20º
VC2.52P	1500	20º
VD1.81P, VD1.82P (#2 and smaller)	500	5º
VD1.81P, VD1.82P (1/0 and larger)	500	2º
VD1.83P	750	5º
VD2.91P	1500	20º

Continued

TABLE 6.5: Recommended Maximum Permissible Line Angle for Pin-Type Pole-Top Assemblies (cont.)

VOLTAGE: 34.5/19.9 kV
RUS Bulletin 50-4, Standard D-801, November 1986

Pole-Top Assembly	Maximum Transverse Load (lbs)	Max. Line Angle Within Load Limits
ZA1	750	5º
ZA1-1	1500	5º
ZA2	1500	20º
ZA9	1500	20º
ZA9-1	750	5º
ZB1	750	5º
ZB1-1	1500	5º
ZB2	1500	20º
ZB9	1500	20º
ZB9-1	750	5º
ZB9-2	1500	20º
ZB9-3	750	5º
ZC1	750	5º
ZC1-1	1500	5º
*ZC1-2	750	2º
*ZC1-3	1500	5º
*ZC1-4	750	5º
ZC2	1500	20º
ZC2-1	1500	20º
ZC9	1500	20º
ZC9-1	750	5º
ZDC-C1	750	5º
ZDC-C2-1	1500	20º

* Indicates the pole-top assembly should be used for large conductors, conductors with a rated breaking strength of 4500 lb or more.

TABLE 6.6: Maximum Line Angles

Design Limits [3]		Grade C Wind Load Factor	2.20
Maximum transverse load (lb):	500	Grade C Tension Load Factor	1.30
Maximum angle within load limits (deg):	2	Grade B Wind Load Factor	2.50
		Grade B Tension Load Factor	1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	**200**	**250**	**300**	**350**	**400**	**450**	**500**
Grade C			LIGHT LOADING							
4 ACSR 7/1	0.1928	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2370	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2985	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3765	3310	2.0	2.0	2.0	2.0	2.0	2.0	1.7	1.1
4/0 ACSR 6/1	0.4223	4000	2.0	2.0	2.0	2.0	1.9	1.4	0.9	0.4
336 ACSR 18/1	0.5130	4000	2.0	2.0	2.0	1.8	1.2	0.5	(-)	(-)
477 ACSR 18/1	0.6105	4000	2.0	2.0	1.8	1.1	0.3	(-)	(-)	(-)
Grade B										
4 ACSR 7/1	0.1928	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2370	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2985	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3765	3310	2.0	2.0	2.0	2.0	1.8	1.3	0.8	0.3
4/0 ACSR 6/1	0.4223	4000	2.0	2.0	2.0	1.6	1.1	0.7	0.2	(-)
336 ACSR 18/1	0.5130	4000	2.0	2.0	1.6	1.0	0.4	(-)	(-)	(-)
477 ACSR 18/1	0.6105	4000	2.0	1.7	1.0	0.4	(-)	(-)	(-)	(-)
Grade C			MEDIUM LOADING							
4 ACSR 7/1	0.2523	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2720	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2993	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3340	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8
4/0 ACSR 6/1	0.3543	4000	2.0	2.0	2.0	2.0	2.0	2.0	1.6	1.2
336 ACSR 18/1	0.3947	4000	2.0	2.0	2.0	2.0	2.0	1.7	1.2	0.7
477 ACSR 18/1	0.4380	4000	2.0	2.0	2.0	2.0	1.8	1.3	0.7	0.2
Grade B										
4 ACSR 7/1	0.2523	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2720	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2993	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3340	3310	2.0	2.0	2.0	2.0	2.0	1.7	1.3	0.9
4/0 ACSR 6/1	0.3543	4000	2.0	2.0	2.0	2.0	1.6	1.3	0.9	0.5
336 ACSR 18/1	0.3947	4000	2.0	2.0	2.0	1.8	1.3	0.9	0.5	0.1
477 ACSR 18/1	0.4380	4000	2.0	2.0	2.0	1.5	1.0	0.5	0.1	(-)
Grade C			HEAVY LOADING							
4 ACSR 7/1	0.4190	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.5
2 ACSR 6/1	0.4387	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.5
1/0 ACSR 6/1	0.4660	2190	2.0	2.0	2.0	2.0	2.0	1.8	0.8	(-)
3/0 ACSR 6/1	0.5007	3310	2.0	2.0	2.0	2.0	1.5	0.8	0.1	(-)
4/0 ACSR 6/1	0.5210	4000	2.0	2.0	2.0	1.7	1.1	0.5	(-)	(-)
336 ACSR 18/1	0.5613	4000	2.0	2.0	2.0	1.4	0.7	0.1	(-)	(-)
477 ACSR 18/1	0.6047	4000	2.0	2.0	1.8	1.1	0.4	(-)	(-)	(-)
Grade B										
4 ACSR 7/1	0.4190	1180	2.0	2.0	2.0	2.0	2.0	2.0	0.8	(-)
2 ACSR 6/1	0.4387	1425	2.0	2.0	2.0	2.0	2.0	1.5	0.2	(-)
1/0 ACSR 6/1	0.4660	2190	2.0	2.0	2.0	2.0	1.5	0.5	(-)	(-)
3/0 ACSR 6/1	0.5007	3310	2.0	2.0	2.0	1.3	0.6	0.0	(-)	(-)
4/0 ACSR 6/1	0.5210	4000	2.0	2.0	1.5	0.9	0.4	(-)	(-)	(-)
336 ACSR 18/1	0.5613	4000	2.0	1.9	1.3	0.7	0.1	(-)	(-)	(-)
477 ACSR 18/1	0.6047	4000	2.0	1.7	1.1	0.4	(-)	(-)	(-)	(-)

NOTES: 1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits [3]
Maximum transverse load (lb): 500
Maximum angle within load limits (deg): 5

Grade C Wind Load Factor 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	200	250	300	350	400	450	500
Grade C			LIGHT LOADING							
4 ACSR 7/1	0.1928	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2370	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2985	2190	5.0	5.0	5.0	5.0	5.0	4.3	4.1	3.5
3/0 ACSR 6/1	0.3765	3310	5.0	4.5	3.9	3.3	2.8	2.2	1.7	1.1
4/0 ACSR 6/1	0.4223	4000	4.0	3.5	3.0	2.4	1.9	1.4	0.9	0.4
336 ACSR 18/1	0.5130	4000	3.6	3.0	2.4	1.8	1.2	0.5	(-)	(-)
477 ACSR 18/1	0.6105	4000	3.3	2.5	1.8	1.1	0.3	(-)	(-)	(-)
Grade B										
4 ACSR 7/1	0.1928	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2370	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2985	2190	5.0	5.0	5.0	4.4	3.8	3.2	2.6	2.0
3/0 ACSR 6/1	0.3765	3310	3.8	3.3	2.8	2.3	1.8	1.3	0.8	0.3
4/0 ACSR 6/1	0.4223	4000	3.0	2.5	2.0	1.6	1.1	0.7	0.2	(-)
336 ACSR 18/1	0.5130	4000	2.7	2.1	1.6	1.0	0.4	(-)	(-)	(-)
477 ACSR 18/1	0.6105	4000	2.4	1.7	1.0	0.4	(-)	(-)	(-)	(-)
Grade C			MEDIUM LOADING							
4 ACSR 7/1	0.2523	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2720	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2993	2190	5.0	5.0	5.0	5.0	5.0	4.8	4.1	3.4
3/0 ACSR 6/1	0.3340	3310	5.0	4.7	4.2	3.7	3.2	2.7	2.3	1.8
4/0 ACSR 6/1	0.3543	4000	4.2	3.8	3.4	2.9	2.5	2.1	1.6	1.2
336 ACSR 18/1	0.3947	4000	4.1	3.6	3.1	2.6	2.2	1.7	1.2	0.7
477 ACSR 18/1	0.4380	4000	3.9	3.4	2.9	2.3	1.8	1.3	0.7	0.2
Grade B										
4 ACSR 7/1	0.2523	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2720	1425	5.0	5.0	5.0	5.0	5.0	5.0	4.7	3.9
1/0 ACSR 6/1	0.2993	2190	5.0	5.0	5.0	4.4	3.8	3.2	2.6	2.0
3/0 ACSR 6/1	0.3340	3310	3.9	3.5	3.1	2.6	2.2	1.7	1.3	0.9
4/0 ACSR 6/1	0.3543	4000	3.2	2.8	2.4	2.0	1.6	1.3	0.9	0.5
336 ACSR 18/1	0.3947	4000	3.1	2.6	2.2	1.8	1.3	0.9	0.5	0.1
477 ACSR 18/1	0.4380	4000	2.9	2.4	2.0	1.5	1.0	0.5	0.1	(-)
Grade C			HEAVY LOADING							
4 ACSR 7/1	0.4190	1180	5.0	5.0	5.0	5.0	5.0	4.9	3.2	1.5
2 ACSR 6/1	0.4387	1425	5.0	5.0	5.0	5.0	5.0	3.5	2.0	0.5
1/0 ACSR 6/1	0.4660	2190	5.0	5.0	4.9	3.9	2.8	1.8	0.8	(-)
3/0 ACSR 6/1	0.5007	3310	4.5	3.7	3.0	2.3	1.5	0.8	0.1	(-)
4/0 ACSR 6/1	0.5210	4000	3.6	3.0	2.4	1.7	1.1	0.5	(-)	(-)
336 ACSR 18/1	0.5613	4000	3.5	2.8	2.1	1.4	0.7	0.1	(-)	(-)
477 ACSR 18/1	0.6047	4000	3.3	2.6	1.8	1.1	0.4	(-)	(-)	(-)
Grade B										
4 ACSR 7/1	0.4190	1180	5.0	5.0	5.0	5.0	3.9	2.4	0.8	(-)
2 ACSR 6/1	0.4387	1425	5.0	5.0	5.0	4.2	2.8	1.5	0.2	(-)
1/0 ACSR 6/1	0.4660	2190	5.0	4.2	3.3	2.4	1.5	0.5	(-)	(-)
3/0 ACSR 6/1	0.5007	3310	3.3	2.6	2.0	1.3	0.6	(-)	(-)	(-)
4/0 ACSR 6/1	0.5210	4000	2.6	2.1	1.5	0.9	0.4	(-)	(-)	(-)
336 ACSR 18/1	0.5613	4000	2.5	1.9	1.3	0.7	0.1	(-)	(-)	(-)
477 ACSR 18/1	0.6047	4000	2.4	1.7	1.1	0.4	(-)	(-)	(-)	(-)

NOTES: 1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits [3]

Maximum transverse load (lb):	500	Grade C Wind Load Factor	2.20
Maximum angle within load limits (deg):	20	Grade C Tension Load Factor	1.30
		Grade B Wind Load Factor	2.50
		Grade B Tension Load Factor	1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	200	250	300	350	400	450	500
Grade C					LIGHT LOADING					
4 ACSR 7/1	0.1928	1180	16.4	15.6	14.8	14.0	13.2	12.4	11.6	10.8
2 ACSR 6/1	0.2370	1425	13.1	12.3	11.5	10.6	9.8	9.0	8.2	7.4
1/0 ACSR 6/1 [1]	0.2985	2190	8.1	7.4	6.8	6.1	5.4	4.3	4.1	3.5
3/0 ACSR 6/1	0.3765	3310	5.0	4.5	3.9	3.3	2.8	2.2	1.7	1.1
4/0 ACSR 6/1	0.4223	4000	4.0	3.5	3.0	2.4	1.9	1.4	0.9	0.4
336 ACSR 18/1	0.5130	4000	3.6	3.0	2.4	1.8	1.2	0.5	(0)	(0)
477 ACSR 18/1	0.6105	4000	3.3	2.5	1.8	1.1	0.3	(-)	(-)	(-)
Grade B										
4 ACSR 7/1	0.1928	1180	12.6	11.9	11.2	10.5	9.8	9.0	8.3	7.6
2 ACSR 6/1	0.2370	1425	10.0	9.3	8.6	7.9	7.1	6.4	5.7	5.0
1/0 ACSR 6/1	0.2985	2190	6.2	5.6	5.0	4.4	3.8	3.2	2.6	2.0
3/0 ACSR 6/1	0.3765	3310	3.8	3.3	2.8	2.3	1.8	1.3	0.8	0.3
4/0 ACSR 6/1	0.4223	4000	3.0	2.5	2.0	1.6	1.1	0.7	0.2	(-)
336 ACSR 18/1	0.5130	4000	2.7	2.1	1.6	1.0	0.4	(-)	(-)	(-)
477 ACSR 18/1	0.6105	4000	2.4	1.7	1.0	0.4	(-)	(-)	(-)	(-)
Grade C					MEDIUM LOADING					
4 ACSR 7/1	0.2523	1180	15.6	14.6	13.5	12.5	11.4	10.4	9.4	8,3
2 ACSR 6/1	0,2720	1425	12.7	11.8	10.9	9.9	9.0	8.1	7.1	6.2
1/0 ACSR 6/1	0,2993	2190	8.1	7.4	6.8	6.1	5.4	4.8	4,1	3.4
3/0 ACSR 6/1	0.3340	3310	5.2	4.7	4.2	3.7	3.2	2.7	2.3	1.8
4/0 ACSR 6/1	0.3543	4000	4.2	3.8	3.4	2.9	2.5	2.1	1.6	1.2
336 ACSR 18/1	0.3947	4000	4.1	3.6	3.1	2.6	2.2	1.7	1.2	0.7
477 ACSR 18/1	0.4380	4000	3.9	3.4	2.9	2.3	1.8	1.3	0.7	0.2
Grade B										
4 ACSR 7/1	0.2523	1180	12.0	11.0	10.1	9.2	8.2	7.3	6.4	5.4
2 ACSR 6/1	0.2720	1425	9.7	8.9	8.0	7.2	6.4	5.6	4.7	3.9
1/0 ACSR 6/1	0.2993	2190	6.2	5.6	5.0	4.4	3.8	3.2	2.6	2.0
3/0 ACSR 6/1	0.3340	3310	3.9	3.5	3.1	2.6	2.2	1.7	1.3	0.9
4/0 ACSR 6/1	0.3543	4000	3.2	2.8	2.4	2.0	1.6	1.3	0.9	0.5
336 ACSR 18/1	0.3947	4000	3.1	2.6	2.2	1.8	1.3	0.9	0.5	0.1
477 ACSR 18/1	0.4380	4000	2.9	2.4	2.0	1.5	1.0	0.5	0.1	(-)
Grade C					HEAVY LOADING					
4 ACSR 7/1	0.4190	1180	13.5	11.8	10.1	8.4	6.6	4.9	3.2	1.5
2 ACSR 6/1	0.4387	1425	11.0	9.5	8.0	6.5	5.0	3.5	2.0	0.5
1/0 ACSR 6/1	0.4660	2190	7.0	5.9	4.9	3.9	2.8	1.8	0.8	(-)
3/0 ACSR 6/1	0.5007	3310	4.5	3.7	3.0	2,3	1.5	0.8	0.1	(-)
4/0 ACSR 6/1	0.5210	4000	3.6	3.0	2.4	1.7	1.1	0.5	(-)	(-)
336 ACSR 18/1	0.5613	4000	3.5	2.8	2.1	1.4	0.7	0.1	(-)	(-)
477 ACSR 18/1	0.6047	4000	3.3	2.6	1.8	1.1	0.4	(-)	(-)	(-)
Grade B										
4 ACSR 7/1	0.4190	1180	10.1	8.6	7.0	5.5	3.9	2.4	0.8	(-)
2 ACSR 6/1	0.4387	1425	8.2	6.8	5.5	4.2	2.8	1.5	0.2	(-)
1/0 ACSR 6/1	0.4660	2190	5.2	4.2	3.3	2.4	1.5	0.5	(-)	(-)
3/0 ACSR 6/1	0.5007	3310	3.3	2.6	2.0	1.3	0.6	(-)	(-)	(-)
4/0 ACSR 6/1	0.5210	4000	2.6	2.1	1.5	0.9	0.4	(-)	(-)	(-)
336 ACSR 18/1	0.5613	4000	2.5	1.9	1.3	0.7	0.1	(-)	(-)	(-)
477 ACSR 18/1	0.6047	4000	2.4	1.7	1.1	0.4	(-)	(-)	(-)	(-)

NOTES:
1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for the application of these design limits on large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits (3)
Maximum transverse load (lb): 750
Maximum angle within load limits (deg): 2

Grade C Wind Load Factor 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) (2)							
			150	200	250	300	350	400	450	500
Grade C			LIGHT LOADING							
4 ACSR 7/1	0.1928	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2370	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2985	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3765	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.4223	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.5130	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.6105	4000	2.0	2.0	2.0	2.0	2.0	2.0	1.6	0.9
Grade B										
4 ACSR 7/1	0.1928	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2370	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2985	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3765	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.4223	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9
336 ACSR 18/1	0.5130	4000	2.0	2.0	2.0	2.0	2.0	2.0	1.5	0.9
477 ACSR 18/1	0.6105	4000	2.0	2.0	2.0	2.0	1.9	1.2	0.5	(-)
Grade C			MEDIUM LOADING							
4 ACSR 7/1	0.2523	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2720	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2993	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3340	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.3543	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.3947	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.4380	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Grade B										
4 ACSR 7/1	0.2523	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2720	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2993	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3340	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.3543	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.3947	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.4380	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8
Grade C			HEAVY LOADING							
4 ACSR 7/1	04190	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.4387	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.4660	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.5007	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.5210	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9
336 ACSR 18/1	0.5613	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.5
477 ACSR 18/1	0.6047	4000	2.0	2.0	2.0	2.0	2.0	2.0	1.7	0.9
Grade B										
4 ACSR 7/1	04190	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.4387	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.4660	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.5007	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.3
4/0 ACSR 6/1	0.5210	4000	2.0	2.0	2.0	2.0	2.0	2.0	1.4	0.9
336 ACSR 18/1	0.5613	4000	2.0	2.0	2.0	2.0	2.0	1.6	1.0	0.4
477 ACSR 18/1	0.6047	4000	2.0	2.0	2.0	2.0	1.9	1.3	0.6	(-)

NOTES: 1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

	Design Limits [3]		Grade C Wind Load Factor	2.20
	Maximum transverse load (lb):	750	Grade C Tension Load Factor	1.30
	Maximum angle within load limits (deg):	5	Grade B Wind Load Factor	2.50
			Grade B Tension Load Factor	1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	200	250	300	350	400	450	500
Grade C			LIGHT LOADING							
4 ACSR 7/1	0.1928	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2370	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2985	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3765	3310	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5
4/0 ACSR 6/1	0.4223	4000	5.0	5.0	5.0	5.0	4.7	4.2	3.7	3.1
336 ACSR 18/1	0.5130	4000	5.0	5.0	5.0	4.5	3.9	3.3	2.7	2.0
477 ACSR 18/1	0.6105	4000	5.0	5.0	4.6	3.8	3.1	2.3	1.6	0.9
Grade B										
4 ACSR 7/1	0.1928	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2370	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2985	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3765	3310	5.0	5.0	5.0	4.9	4.4	3.9	3.4	2.9
4/0 ACSR 6/1	0.4223	4000	5.0	4.7	4.2	3.8	3.3	2.8	2.4	1.9
336 ACSR 18/1	0.5130	4000	4.8	4.3	3.7	3.2	2.6	2.1	1.5	0.9
477 ACSR 18/1	0.6105	4000	4.5	3.9	3.2	2.5	1.9	1.2	0.5	(-)
Grade C			MEDIUM LOADING							
4 ACSR 7/1	0.2523	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2720	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2993	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3340	3310	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4/0 ACSR 6/1	0.3543	4000	5.0	5.0	5.0	5.0	5.0	4.8	4.4	4.0
336 ACSR 18/1	0.3947	4000	5.0	5.0	5.0	5.0	4.9	4.4	4.0	3.5
477 ACSR 18/1	0.4380	4000	5.0	5.0	5.0	5.0	4.5	4.0	3.5	3.0
Grade B										
4 ACSR 7/1	0.2523	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2720	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2993	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3340	3310	5.0	5.0	5.0	5.0	4.8	4.4	3.9	3.5
4/0 ACSR 6/1	0.3543	4000	5.0	5.0	4.6	4.2	3.8	3.4	3.1	2.7
336 ACSR 18/1	0.3947	4000	5.0	4.8	4.4	3.9	3.5	3.1	2.7	2.2
477 ACSR 18/1	0.4380	4000	5.0	4.6	4.1	3.7	3.2	2.7	2.2	1.8
Grade C			HEAVY LOADING							
4 ACSR 7/1	0.4190	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.4387	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.4660	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.8
3/0 ACSR 6/1	0.5007	3310	5.0	5.0	5.0	5.0	4.9	4.1	3.4	2.7
4/0 ACSR 6/1	0.5210	4000	5.0	5.0	5.0	4.5	3.8	3.2	2.6	1.9
336 ACSR 18/1	0.5613	4000	5.0	5.0	4.9	4.2	3.5	2.8	2.1	1.5
477 ACSR 18/1	0.6047	4000	5.0	5.0	4.6	3.9	3.1	2.4	1.7	0.9
Grade B										
4 ACSR 7/1	0.4190	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.4387	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.9
1/0 ACSR 6/1	0.4660	2190	5.0	5.0	5.0	5.0	5.0	4.5	3.6	2.7
3/0 ACSR 6/1	0.5007	3310	5.0	5.0	4.6	3.9	3.3	2.6	2.0	1.3
4/0 ACSR 6/1	0.5210	4000	4.8	4.3	3.7	3.1	2.6	2.0	1.4	0.9
336 ACSR 18/1	0.5613	4000	4.7	4.1	3.5	2.9	2.2	1.6	1.0	0.4
477 ACSR 18/1	0.6047	4000	4.5	3.9	3.2	2.6	1.9	1.3	0.6	(-)

NOTES: 1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits [3]
Maximum transverse load (lb): 750
Maximum angle within load limits (deg): 20

Grade C Wind Load Factor--- 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	200	250	300	350	400	450	500
Grade C					LIGHT LOADING					
4 ACSR 7/1	0.1928	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2370	1425	20.0	20.0	19.3	18.4	17.6	16.8	16.0	15.2
1/0 ACSR 6/1	0.2985	2190	13.1	12.5	11.8	11.1	10.5	9.8	9.2	8.5
3/0 ACSR 6/1	0.3765	3310	8.3	7.8	7.2	6.7	6.1	5.6	5.0	4.5
4/0 ACSR 6/1	0.4223	4000	6.7	6.2	5.7	5.2	4.7	4.2	3.7	3.1
336 ACSR 18/1	0.5130	4000	6.4	5.8	5.2	4.5	3.9	3.3	2.7	2.0
477 ACSR 18/1	0.6105	4000	6.0	5.3	4.6	3.8	3.1	2.3	1.6	0.9
Grade B										
4 ACSR 7/1	0.1928	1180	20.0	19.3	18.6	17.9	17.2	16.5	15.7	15.0
2 ACSR 6/1	0.2370	1425	16.2	15.4	14.7	14.0	13.3	12.5	11.8	11.1
1/0 ACSR 6/1	0.2985	2190	10.1	9.5	8.9	8.3	7.8	7.2	6.6	6.0
3/0 ACSR 6/1	0.3765	3310	6.4	5.9	5.4	4.9	4.4	3.9	3.4	2.9
4/0 ACSR 6/1	0.4223	4000	5.1	4.7	4.2	3.8	3.3	2.8	2.4	1.9
336 ACSR 18/1	0.5130	4000	4.8	4.3	3.7	3.2	2.6	2.1	1.5	0.9
477 ACSR 18/1	0.6105	4000	4.5	3.9	3.2	2.5	1.9	1.2	0.5	(-)
Grade C					MEDIUM LOADING					
4 ACSR 7/1	0.2523	1180	20.0	20.0	20.0	20.0	20.0	19.8	18.8	17.7
2 ACSR 6/1	0.2720	1425	20.0	19.6	18.7	17.7	16.8	15.8	14.9	14.0
1/0 ACSR 6/1	0.2993	2190	13.1	12.5	11.8	11.1	10.5	9.8	9.1	8.5
3/0 ACSR 6/1	0.3340	3310	8.5	8.0	7.5	7.1	6.6	6.1	5.6	5.1
4/0 ACSR 6/1	0.3543	4000	7.0	6.5	6.1	5.7	5.3	4.8	4.4	4.0
336 ACSR 18/1	0.3947	4000	6.8	6.4	5.9	5.4	4.9	4.4	4.0	3.5
477 ACSR 18/1	0.4380	4000	6.7	6.1	5.6	5.1	4.5	4.0	3.5	3.0
Grade B										
4 ACSR 7/1	0.2523	1180	19.4	18.4	17.5	16.6	15.6	14.7	13.8	12.8
2 ACSR 6/1	0.2720	1425	15.8	15.0	14.2	13.3	12.5	11.7	10.8	10.0
1/0 ACSR 6/1	0.2993	2190	10.1	9.5	8.9	8.3	7.7	7.2	6.6	6.0
3/0 ACSR 6/1	0.3340	3310	6.6	6.1	5.7	5.2	4.8	4.4	3.9	3.5
4/0 ACSR 6/1	0.3543	4000	5.4	5.0	4.6	4.2	3.8	3.4	3.1	2.7
336 ACSR 18/1	0.3947	4000	5.2	4.8	4.4	3.9	3.5	3.1	2.7	2.2
477 ACSR 18/1	0.4380	4000	5.1	4.6	4.1	3.7	3.2	2.7	2.2	1.8
Grade C					HEAVY LOADING					
4 ACSR 7/1	0.4190	1180	20.0	20.0	19.5	17.8	16.0	14.3	12.5	10.8
2 ACSR 6/1	0.4387	1425	18.8	17.3	15.8	14.3	12.8	11.3	9.8	8.3
1/0 ACSR 6/1	0.4660	2190	12.0	11.0	9.9	8.9	7.9	6.8	5.8	4.8
3/0 ACSR 6/1	0.5007	3310	7.8	7.1	6.3	5.6	4.9	4.1	3.4	2.7
4/0 ACSR 6/1	0.5210	4000	6.4	5.7	5.1	4.5	3.8	3.2	2.6	1.9
336 ACSR 18/1	0.5613	4000	6.2	5.5	4.9	4.2	3.5	2.8	2.1	1.5
477 ACSR 18/1	0.6047	4000	6.1	5.3	4.6	3.9	3.1	2.4	1.7	0.9
Grade B										
4 ACSR 7/1	0.4190	1180	17.5	16.0	14.4	12.9	11.3	9.8	8.2	6.7
2 ACSR 6/1	0.4387	1425	14.3	13.0	11.6	10.3	8.9	7.6	6.3	4.9
1/0 ACSR 6/1	0.4660	2190	9.1	8.2	7.3	6.4	5.4	4.5	3.6	2.7
3/0 ACSR 6/1	0.5007	3310	5.9	5.2	4.6	3.9	3.3	2.6	2.0	1.3
4/0 ACSR 6/1	0.5210	4000	4.8	4.3	3.7	3.1	2.6	2.0	1.4	0.9
336 ACSR 18/1	0.5613	4000	4.7	4.1	3.5	2.9	2.2	1.6	1.0	0.4
477 ACSR 18/1	0.6047	4000	4.5	3.9	3.2	2.6	1.9	1.3	0.6	(-)

NOTES:
1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for the application of these design limits on large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits [3]
Maximum transverse load (lb): 1000
Maximum angle within load limits (deg): 2

Grade C Wind Load Factor 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	200	250	300	350	400	450	500
Grade C					LIGHT LOADING					
4 ACSR 7/1	0.1928	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2370	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2985	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3765	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.4223	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.5130	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.6105	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Grade B										
4 ACSR 7/1	0.1928	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2370	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2985	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3765	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.4223	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.5130	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.6105	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Grade C					MEDIUM LOADING					
4 ACSR 7/1	0.2523	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2720	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2993	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3340	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.3543	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.3947	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.4380	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Grade B										
4 ACSR 7/1	0.2523	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.2720	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.2993	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.3340	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.3543	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.3947	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.4380	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Grade C					HEAVY LOADING					
4 ACSR 7/1	0.4190	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.4387	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.4660	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.5007	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.5210	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.5613	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.6047	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Grade B										
4 ACSR 7/1	0.4190	1180	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2 ACSR 6/1	0.4387	1425	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1/0 ACSR 6/1	0.4660	2190	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
3/0 ACSR 6/1	0.5007	3310	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4/0 ACSR 6/1	0.5210	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
336 ACSR 18/1	0.5613	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
477 ACSR 18/1	0.6047	4000	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

NOTES:
1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits (3)
Maximum transverse load (lb): 1000
Maximum angle within load limits (deg): 5

Grade C Wind Load Factor 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) (2)							
			150	200	250	300	350	400	450	500
Grade C					LIGHT LOADING					
4 ACSR 7/1	0.1928	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2370	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2985	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3765	3310	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4/0 ACSR 6/1	0.4223	4000	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
336 ACSR 18/1	0.5130	4000	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.8
477 ACSR 18/1	0.6105	4000	5.0	5.0	5.0	5.0	5.0	5.0	4.4	3.6
Grade B										
4 ACSR 7/1	0.1928	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2370	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2985	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3765	3310	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4/0 ACSR 6/1	0.4223	4000	5.0	5.0	5.0	5.0	5.0	5.0	4.6	4.1
336 ACSR 18/1	0.5130	4000	5.0	5.0	5.0	5.0	4.8	4.2	3.7	3.1
477 ACSR 18/1	0.6105	4000	5.0	5.0	5.0	4.7	4.0	3.4	2.7	2.1
Grade C					MEDIUM LOADING					
4 ACSR 7/1	0.2523	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2720	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2993	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3340	3310	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4/0 ACSR 6/1	0.3543	4000	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
336 ACSR 18/1	0.3947	4000	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
477 ACSR 18/1	0.4380	4000	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade B										
4 ACSR 7/1	0.2523	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.2720	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.2993	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.3340	3310	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4/0 ACSR 6/1	0.3543	4000	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.8
336 ACSR 18/1	0.3947	4000	5.0	5.0	5.0	5.0	5.0	5.0	4.8	4.4
477 ACSR 18/1	0.4380	4000	5.0	5.0	5.0	5.0	5.0	4.9	4.4	3.9
Grade C					HEAVY LOADING					
4 ACSR 7/1	0.4190	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.4387	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.4660	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.5007	3310	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4/0 ACSR 6/1	0.5210	4000	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.7
336 ACSR 18/1	0.5613	4000	5.0	5.0	5.0	5.0	5.0	5.0	4.9	4.2
477 ACSR 18/1	0.6047	4000	5.0	5.0	5.0	5.0	5.0	5.0	4.4	3.7
Grade B										
4 ACSR 7/1	0.4190	1180	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2 ACSR 6/1	0.4387	1425	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1/0 ACSR 6/1	0.4660	2190	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3/0 ACSR 6/1	0.5007	3310	5.0	5.0	5.0	5.0	5.0	5.0	4.6	3.9
4/0 ACSR 6/1	0.5210	4000	5.0	5.0	5.0	5.0	4.7	4.2	3.6	3.0
336 ACSR 18/1	0.5613	4000	5.0	5.0	5.0	5.0	4.4	3.8	3.2	2.6
477 ACSR 18/1	0.6047	4000	5.0	5.0	5.0	4.7	4.1	3.4	2.8	2.1

NOTES: 1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits [3]
Maximum transverse load (lb): 1000
Maximum angle within load limits (deg): 20

Grade C Wind Load Factor 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	200	250	300	350	400	450	500
Grade C			LIGHT LOADING							
4 ACSR 7/1	0.1928	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2370	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1 [1]	0.2985	2190	15.0	14.5	14.0	13.5	13.0	12.5	12.0	11.5
3/0 ACSR 6/1 [1]	0.3765	3310	11.7	11.1	10.6	10.0	9.5	8.9	8.4	7.8
4/0 ACSR 6/1	0.4223	4000	9.5	9.0	8.5	8.0	7.4	6.9	6.4	5.9
336 ACSR 18/1	0.5130	4000	9.2	8.5	7.9	7.3	6.7	6.0	5.4	4.8
477 ACSR 18/1	0.6105	4000	8.8	8.1	7.3	6.6	5.8	5.1	4.4	3.6
Grade B										
4 ACSR 7/1	0.1928	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2370	1425	20.0	20.0	20.0	20.0	19.4	18.7	17.9	17.2
1/0 ACSR 6/1	0.2985	2190	14.1	13.5	12.9	12.3	11.7	11.1	10.5	10.0
3/0 ACSR 6/1	0.3765	3310	9.0	8.5	8.0	7.5	7.0	6.5	6.1	5.6
4/0 ACSR 6/1	0.4223	4000	7.3	6.9	6.4	5.9	5.5	5.0	4.6	4.1
336 ACSR 18/1	0.5130	4000	7.0	6.5	5.9	5.3	4.8	4.2	3.7	3.1
477 ACSR 18/1	0.6105	4000	6.7	6.0	5.4	4.7	4.0	3.4	2.7	2.1
Grade C			MEDIUM LOADING							
4 ACSR 7/1	0.2523	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2720	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1 [1]	0.2993	2190	18.0	17.4	16.8	16.2	15.5	14.9	14.2	13.5
3/0 ACSR 6/1 [1]	0.3340	3310	11.9	11.3	10.9	10.4	9.9	9.4	8.9	8.4
4/0 ACSR 6/1	0.3543	4000	9.7	9.3	8.9	8.4	8.0	7.6	7.2	6.7
336 ACSR 18/1	0.3947	4000	9.6	9.1	8.6	8.2	7.7	7.2	6.7	6.2
477 ACSR 18/1	0.4380	4000	9.4	8.9	8.4	7.8	7.3	6.8	6.2	5.7
Grade B										
4 ACSR 7/1	0.2523	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2720	1425	20.0	20.0	20.0	19.5	18.7	17.8	17.0	16.1
1/0 ACSR 6/1	0.2993	2190	14.1	13.5	12.9	12.3	11.7	11.1	10.5	9.9
3/0 ACSR 6/1	0.3340	3310	9.2	8.7	8.3	7.9	7.4	7.0	6.6	6.1
4/0 ACSR 6/1	0.3543	4000	7.5	7.1	6.8	6.4	6.0	5.6	5.2	4.8
336 ACSR 18/1	0.3947	4000	7.4	7.0	6.5	6.1	5.7	5.3	4.8	4.4
477 ACSR 18/1	0.4380	4000	7.3	6.8	6.3	5.8	5.4	4.9	4.4	3.9
Grade C			HEAVY LOADING							
4 ACSR 7/1	0.4190	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.4387	1425	20.0	20.0	20.0	20.0	20.0	19.1	17.6	16.1
1/0 ACSR 6/1	0.4660	2190	17.1	16.1	15.0	14.0	12.9	11.9	10.9	9.8
3/0 ACSR 6/1	0.5007	3310	11.1	10.4	9.7	8.9	8.2	7.5	6.7	6.0
4/0 ACSR 6/1	0.5210	4000	9.1	8.5	7.9	7.2	6.6	6.0	5.3	4.7
336 ACSR 18/1	0.5613	4000	9.0	8.3	7.6	6.9	6.3	5.6	4.9	4.2
477 ACSR 18/1	0.6047	4000	8.8	8.1	7.4	6.6	5.9	5.2	4.4	3.7
Grade B										
4 ACSR 7/1	0.4190	1180	20.0	20.0	20.0	20.0	18.7	17.2	15.6	14.1
2 ACSR 6/1	0.4387	1425	20.0	19.1	17.8	16.4	15.1	13.7	12.4	11.0
1/0 ACSR 6/1	0.4660	2190	13.1	12.2	11.3	10.3	9.4	8.5	7.5	6.6
3/0 ACSR 6/1	0.5007	3310	8.5	7.9	7.2	6.6	5.9	5.2	4.6	3.9
4/0 ACSR 6/1	0.5210	4000	7.0	6.4	5.9	5.3	4.7	4.2	3.6	3.0
336 ACSR 18/1	0.5613	4000	6.9	6.2	5.6	5.0	4.4	3.8	3.2	2.6
477 ACSR 18/1	0.6047	4000	6.7	6.1	5.4	4.7	4.1	3.4	2.8	2.1

NOTES:
1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits (3)
Maximum transverse load (lb): 1500
Maximum angle within load limits (deg): 20

Grade C Wind Load Factor 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) (2)							
			150	200	250	300	350	400	450	500
Grade C			LIGHT LOADING							
4 ACSR 7/1	0.1928	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2370	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2985	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.3765	3310	18.1	17.8	17.1	16.7	16.1	15.6	15.1	14.5
4/0 ACSR 6/1	0.4223	4000	15.0	14.5	14.0	13.5	13.0	12.5	11.9	11.4
336 ACSR 18/1	0.5130	4000	14.7	14.1	13.4	12.8	12.2	11.6	10.9	10.3
477 ACSR 18/1	0.6105	4000	14.3	13.6	12.9	12.1	11.4	10.6	9.9	9.1
Grade B										
4 ACSR 7/1	0.1928	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2370	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2985	2190	20.0	20.0	20.0	20.0	19.7	19.1	18.5	17.9
3/0 ACSR 6/1	0.3765	3310	14.3	13.8	13.3	12.8	12.3	11.8	11.3	10.8
4/0 ACSR 6/1	0.4223	4000	11.7	11.2	10.7	10.3	9.8	9.4	8.9	8.4
336 ACSR 18/1	0.5130	4000	11.4	10.8	10.3	9.7	9.1	8.6	8.0	7.5
477 ACSR 18/1	0.6105	4000	11.1	10.4	9.7	9.1	8.4	7.7	7.1	6.4
Grade C			MEDIUM LOADING							
4 ACSR 7/1	0.2523	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2720	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2993	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.3340	3310	18.3	17.9	17.4	17.1	16.6	16.1	15.6	15.1
4/0 ACSR 6/1	0.3543	4000	15.3	14.9	14.4	14.0	13.6	13.1	12.7	12.3
336 ACSR 18/1	0.3947	4000	15.1	14.7	14.2	13.7	13.2	12.7	12.2	11.8
477 ACSR 18/1	0.4380	4000	15.0	14.4	13.9	13.4	12.8	12.3	11.8	11.2
Grade B										
4 ACSR 7/1	0.2523	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2720	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2993	2190	20.0	20.0	20.0	20.0	19.7	19.1	18.5	17.9
3/0 ACSR 6/1	0.3340	3310	14.5	14.0	13.6	13.1	12.7	12.3	11.8	11.4
4/0 ACSR 6/1	0.3543	4000	11.9	11.5	11.1	10.7	10.3	10.0	9.6	9.2
336 ACSR 18/1	0.3947	4000	11.8	11.3	10.9	10.5	10.0	9.6	9.2	8.7
477 ACSR 18/1	0.4380	4000	11.6	11.1	10.7	10.2	9.7	9.2	8.8	8.3
Grade C			HEAVY LOADING							
4 ACSR 7/1	0.4190	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.4387	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.4660	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.5007	3310	17.8	17.0	16.3	15.6	14.9	14.1	13.4	12.7
4/0 ACSR 6/1	0.5210	4000	14.7	14.0	13.4	12.8	12.1	11.5	10.9	10.2
336 ACSR 18/1	0.5613	4000	14.5	13.8	13.2	12.5	11.8	11.1	10.4	9.7
477 ACSR 18/1	0.6047	4000	14.4	13.6	12.9	12.2	11.4	10.7	9.9	9.2
Grade B										
4 ACSR 7/1	0.4190	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.4387	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.4660	2190	20.0	20.0	19.3	18.3	17.4	16.5	15.5	14.6
3/0 ACSR 6/1	0.5007	3310	13.8	13.1	12.5	11.8	11.2	10.5	9.8	9.2
4/0 ACSR 6/1	0.5210	4000	11.3	10.8	10.2	9.6	9.1	8.5	7.9	7.4
336 ACSR 18/1	0.5613	4000	11.2	10.6	10.0	9.4	8.8	8.2	7.5	6.9
477 ACSR 18/1	0.6047	4000	11.1	10.4	9.8	9.1	8.4	7.8	7.1	6.5

NOTES: 1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Continued

TABLE 6.6: Maximum Line Angles (cont.)

Design Limits [3]		Grade C Wind Load Factor	2.20
Maximum transverse load (lb):	2000	Grade C Tension Load Factor	1.30
Maximum angle within load limits (deg):	20	Grade B Wind Load Factor	2.50
		Grade B Tension Load Factor	1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft) [2]							
			150	200	250	300	350	400	450	500
Grade C					LIGHT LOADING					
4 ACSR 7/1	0.1928	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2370	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2985	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.3765	3310	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
4/0 ACSR 6/1	0.4223	4000	20.0	20.0	19.6	19.1	18.5	18.0	17.5	17.0
336 ACSR 18/1	0.5130	4000	20.0	19.6	19.0	18.4	17.8	17.1	16.5	15.9
477 ACSR 18/1	0.6105	4000	19.9	19.2	18.4	17.7	16.9	16.2	15.4	14.7
Grade B										
4 ACSR 7/1	0.1928	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2370	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2985	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.3765	3310	19.6	19.1	18.6	18.1	17.6	17.1	16.6	16.1
4/0 ACSR 6/1	0.4223	4000	16.0	15.6	15.1	14.7	14.2	13.7	13.3	12.8
336 ACSR 18/1	0.5130	4000	15.7	15.2	14.6	14.1	13.5	12.9	12.4	11.8
477 ACSR 18/1	0.6105	4000	15.4	14.8	14.1	13.4	12.8	12.1	11.4	10.8
Grade C					MEDIUM LOADING					
4 ACSR 7/1	0.2523	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2720	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2993	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.3340	3310	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
4/0 ACSR 6/1	0.3543	4000	20.0	20.0	20.0	19.6	19.1	18.7	18.2	17.8
336 ACSR 18/1	0.3947	4000	20.0	20.0	19.7	19.3	18.8	18.3	17.8	17.3
477 ACSR 18/1	0.4380	4000	20.0	20.0	19.5	18.9	18.4	17.9	17.3	16.8
Grade B										
4 ACSR 7/1	0.2523	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.2720	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.2993	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.3340	3310	19.8	19.3	18.9	18.4	18.0	17.5	17.1	16.7
4/0 ACSR 6/1	0.3543	4000	16.3	15.9	15.5	15.1	14.7	14.3	13.9	13.5
336 ACSR 18/1	0.3947	4000	16.1	15.7	15.3	14.8	14.4	14.0	13.5	13.1
477 ACSR 18/1	0.4380	4000	16.0	15.5	15.0	14.5	14.1	13.6	13.1	12.6
Grade C					HEAVY LOADING					
4 ACSR 7/1	0.4190	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.4387	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.4660	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.5007	3310	20.0	20.0	20.0	20.0	20.0	20.0	20.0	19.4
4/0 ACSR 6/1	0.5210	4000	20.0	19.6	19.0	18.3	17.7	17.0	16.4	15.8
336 ACSR 18/1	0.5613	4000	20.0	19.4	18.7	18.0	17.3	16.7	16.0	15.3
477 ACSR 18/1	0.6047	4000	19.9	19.2	18.5	17.7	17.0	16.2	15.5	14.7
Grade B										
4 ACSR 7/1	0.4190	1180	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2 ACSR 6/1	0.4387	1425	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/0 ACSR 6/1	0.4660	2190	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
3/0 ACSR 6/1	0.5007	3310	19.1	18.4	17.8	17.1	16.4	15.8	15.1	14.5
4/0 ACSR 6/1	0.5210	4000	15.7	15.1	14.6	14.0	13.4	12.9	12.3	11.7
336 ACSR 18/1	0.5613	4000	15.6	15.0	14.4	13.7	13.1	12.5	11.9	11.3
477 ACSR 18/1	0.6047	4000	15.4	14.8	14.1	13.5	12.8	12.1	11.5	10.8

NOTES:
1. Some values in this row had to be limited to comply with the Maximum Line Angles on Pin Insulator Assemblies tables found in RUS Bulletin 1728F-803.
2. For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.
3. See **Table 6.5** or applicable RUS specifications for use of this assembly with large conductors.
4. This table is based on the 2023 edition of the *NESC*.

Example 6.3

Given:

Pole-top assembly	=	C2.21
Wind span	=	400 ft
Conductor	=	1/0 ACSR 6/1
Design tension	=	2190 lb
Loading district	=	Medium
Construction grade	=	C

STEP 1: Locate C2.21 Assembly in **Table 6.5**.

STEP 2: Read across to Maximum Transverse Load (1000 lb) and Max. Line Angle Within Load Limits (20°).

STEP 3: Locate in **Table 6.6** the Maximum Transverse Load and Max. Line Angle found in Step 2.

STEP 4: Locate the section for medium loading.

STEP 5: Locate 1/0 ACSR 6/1 under Grade C construction for 2190 lb design tension.

STEP 6: Read across the row to the wind span column for 400 feet. The maximum permissible line angle is 14.9°.

The maximum line angle values shown in **Table 6.6** are based on the conductors, *design tensions*, and *NESC* load factors listed on the table. These values are based on experience and standard construction. They are to be used as a design guide when selecting a pin-type assembly for use on a distribution line. For wind spans falling between two values shown on the table, such as 375 feet, use the next higher value of 400 feet to obtain the maximum line angle. Line angle values must be calculated for design parameters other than those shown in Table 6.6. The next subsection provides formulas and examples for calculating the maximum line angle for a specified assembly.

Maximum Permissible Line Angle

Equation 6.8

$$\text{Sine } \theta/2 = \frac{P - (LF_W)(S)(W_C)}{(2)(DT)(LF_T)}$$

Where:

θ	=	Maximum permissible line angle (degrees)
P	=	Nominal rating of insulator assembly (lb) (**Table 6.4**)
LF_W	=	Load factor for transverse wind (**Table 6.7**)
S	=	Wind span (ft)
W_C	=	*NESC* district wind load on conductor (lb/ft) (**Table 5.3**)
DT	=	Design tension (lb) (**Table 6.6**)
LF_T	=	Load factor for transverse wire tension (**Table 6.7**)

This example demonstrates the use of **Equation 6.8** to calculate the maximum permissible line angle for an RUS pole-top assembly.

Example 6.4

Calculate the maximum allowable line angle for a C2.21 assembly based on insulator strength. *NESC* load factors for support hardware are shown in Table 6.7 and should be used for these calculations. The transverse wind load is based on "at line crossing" from *NESC* Table 261-1, which will yield conservative results.

TABLE 6.7: Load Factors for Support Hardware. Adapted from *NESC* Table 253-1.

Transverse Load	Grade B	Grade C
Wind	2.50	2.20
Conductor Tension	1.65	1.30

Given:

- Pole-top assembly = C2.21
- Wind span = 400 ft
- Conductor = 1/0 ACSR 6/1
- Design tension = 2190 lb (50%)
- Loading district = Medium
- Construction grade = C

$$\text{Sine}\ (\theta/2) = \frac{P - (LF_W)(S)(W_C)}{(2)(DT)(LF_T)}$$

Where:

- P = 1000 lb (**Table 6.5**, C2.21 maximum transverse load)
- LF_W = 2.20 (Table 6.7, transverse wind load, grade C)
- S = 400 ft (given)
- W_C = 0.2993 (**Table 5.3**)
- DT = 2190 lb (given)
- LF_T = 1.30 (Table 6.7, transverse conductor tension load, grade C)

$$\text{Sine}\ (\theta/2) = \frac{1000 - [(2.20)(400\ \text{ft})(0.2993\ \text{lb/ft})]}{(2)(2190\ \text{lb})(1.30)}$$

$$\text{Sine}\ (\theta/2) = 0.1294$$

To solve for θ:

Scientific calculator: Enter .1294 and press the SIN^{-1} or ASIN key. Multiply the answer by 2 to get the angle:

0.1294 ASIN = 7.4349

7.4349 × 2 = 14.9°

Table method: Refer to **Table 6.8** and find the value nearest 0.1294 in the Sine $\theta/2$ column. Then read the line angle in the column to the left.

Sine $\theta/2$ = .1305 in **Table 6.8**, which is nearest the calculated value of 0.1294.

Line angle = 15°

TABLE 6.8: Sine θ/2 for Line Angles			
Line Angle θ (Degrees)	Sine θ/2	Line Angle θ (Degrees)	Sine θ/2
1	0.0087	31	0.2672
2	0.0175	32	0.2756
3	0.0262	33	0.2840
4	0.0349	34	0.2924
5	0.0436	35	0.3007
6	0.0523	36	0.3090
7	0.0611	37	0.3173
8	0.0698	38	0.3256
9	0.0785	39	0.3338
10	0.0872	40	0.3420
11	0.0959	41	0.3502
12	0.1045	42	0.3584
13	0.1132	43	0.3665
14	0.1219	44	0.3746
15	0.1305	45	0.3827
16	0.1392	46	0.3907
17	0.1478	47	0.3988
18	0.1564	48	0.4067
19	0.1651	49	0.4147
20	0.1737	50	0.4226
21	0.1822	51	0.4305
22	0.1908	52	0.4384
23	0.1944	53	0.4462
24	0.2079	54	0.4540
25	0.2164	55	0.4618
26	0.2250	56	0.4695
27	0.2335	57	0.4772
28	0.2419	58	0.4848
29	0.2504	59	0.4924
30	0.2588	60	0.5000

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7 Guying Practices and Procedures

In This Section:

Guys are tensioned cables attached to distribution structures to prevent them from being pulled over by the conductors. Usually, the percentage of guyed structures in a major line section or circuit is relatively small. However, from the standpoint of line strength, the guyed structures are the most important. When a deadend or large-angle structure fails, the line remains out of service longer than for failure of a tangent structure. When the guyed structure fails, especially during an ice or windstorm, it is very likely that several of the adjacent tangent structures will also be pulled over and possibly broken.

Guyed structures are usually the most difficult to design and stake, often because the best theoretical guying design cannot be adapted to the structure's location. It is frequently difficult to secure permission from property owners to place a guy and anchor on their property. Guying seems to follow its own Murphy's law for distribution line design: "The more complicated the guying needs to be so the pole won't fall, the greater will be the probability there won't be any place to guy at all."

The staking technician will probably have to use guying design data and calculations more often than any other structure design procedure. To effectively do this, the staking technician should have a working knowledge of the following:

- The horizontal pull produced by forces that act on the structure and the conductors
- The total guy load placed on the structure at the anchor resulting from the length of the guy lead
- The methods to determine the magnitude of these loads
- The available assemblies and materials that can be used to effectively guy a distribution structure

Guying Situations

Situations exist along the course of a typical distribution line that require the application of guys and anchors to support the structures. The most common situation is at a change in the direction of the line. Guys applied to this type of structure are referred to as ---line angle bisect guys." See **Figure 7.1**. Generally, bisect guys are used for line angles up to 45°. Refer to **Section 2** for methods to bisect line angles. Structures with line angles of 45° to 90° are best guyed by placing deadend guys in both directions (ahead and back) as shown in Figure 7.2. This is especially true for structures supporting large conductors.

All wood pole structures located at the ends of a distribution line require deadend guys. These guys should be set in line with the pull of the conductors. Any offset from straight in line reduces the effectiveness of the guy and will also cause the pole to lean.

Poles must also be guyed where there is a change in the horizontal pull. Examples of these situations include:

- Change in ruling span
- Change in conductor size
- New wire being sagged against old wire
- Change in grade of construction (grade C to grade B)

In the above cases, the guys and anchors must be capable of withstanding the difference in conductor tension produced by the design loading condition plus appropriate safety or load factors.

It is recommended that the total longitudinal load be guyed for double deadended structures located at major or controlled-access highway crossings, railroad crossings, and water crossings that require a permit. Reference *NESC* Rule 252C1 for further details. One of the reasons for this recommendation is to prevent the conductors from sagging to dangerous levels over the traveled way in the event all conductors are severed in the backspan. The guys and anchors on these types of structures should always back (support) the crossing span as shown in Figure 7.3.

Side guys are used to increase the transverse strength of a straight-line pole. These are sometimes called storm guys and are generally used where high winds frequently blow against the distribution line in mountainous areas or along the coast. Although not required, side guys can also be used to provide additional transverse strength for poles located at major (grade B) crossings. A double deadended structure (C6.21) with a high degree of uplift requires guying to literally tie the pole to the ground. The tension in the conductors, especially during periods of cold temperatures, can create sufficient force to cause the pole to move upward.

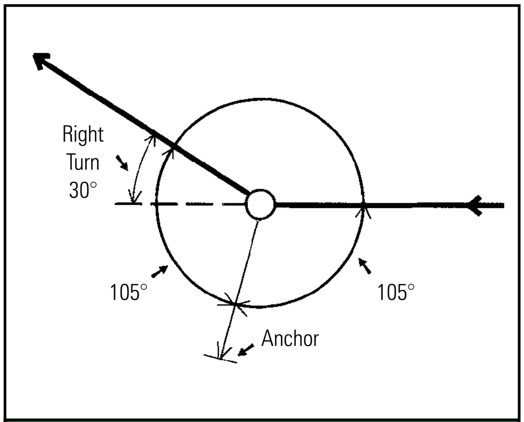


FIGURE 7.1: 30° Line Angle with Bisect Guy.

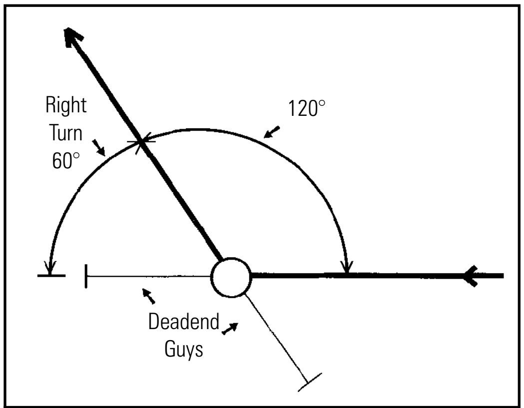


FIGURE 7.2: 60° Line Angle with Deadend Guys in Both Directions.

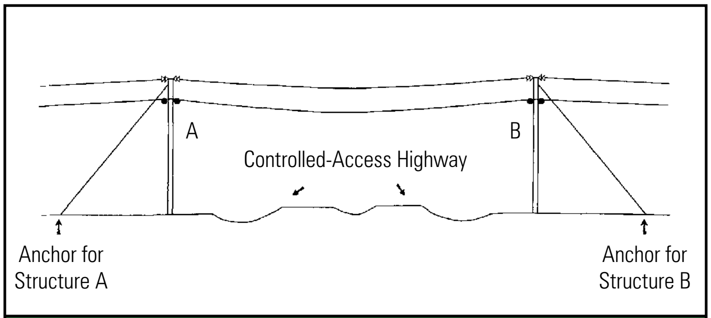


FIGURE 7.3: Guying Configuration for Crossing Span Structures.

Forces That Make Guying Necessary

A guyed structure is affected by forces that attempt to pull it over. These forces act on the structure both horizontally and vertically.

As shown in Figure 7.4, the transverse load affects the structure in a horizontal direction perpendicular to the run of the line. It consists of tension in the conductors on line angle structures, wind blowing perpendicular to the conductors on all types of structures, and wind blowing on the pole. On line angle structures, the wind is considered blowing perpendicular to the conductors when it is blowing perpendicular to the bisect of the angle.

Longitudinal load also affects the structure horizontally but parallel to the run of the line. It consists of the maximum loaded design tension in the conductors.

Vertical forces are produced by the weight of the conductor and the vertical component of guy tension.

One of the most ignored or misunderstood factors affecting the strength of a guyed structure is the length of the guy lead. The force produced at the anchor is *not* equal to the horizontal force alone pulling on the structure. The vertical force produced when the guy is pulled down toward the ground to attach it to an anchor must also be considered. The resultant force acting on the guy and anchor assembly is determined by multiplying the horizontal force by a "guy factor." The guy factor is determined by the length of the guy lead. The guy factor is a multiplier derived from the geometrical relationship of the length of the guy lead to the height of the guy attachment. As the numerical value of the guy factor increases, the total guy load at the anchor will also increase. Shorter guy leads produce higher guy factors. The method of calculating guy factors will be shown in **Equation 7.5** and **Example 7.10** of this section. Guy factors for lead to height ratios of 1-to-1, 2-to-3, and 1-to-2 are shown in Figure 7.5.

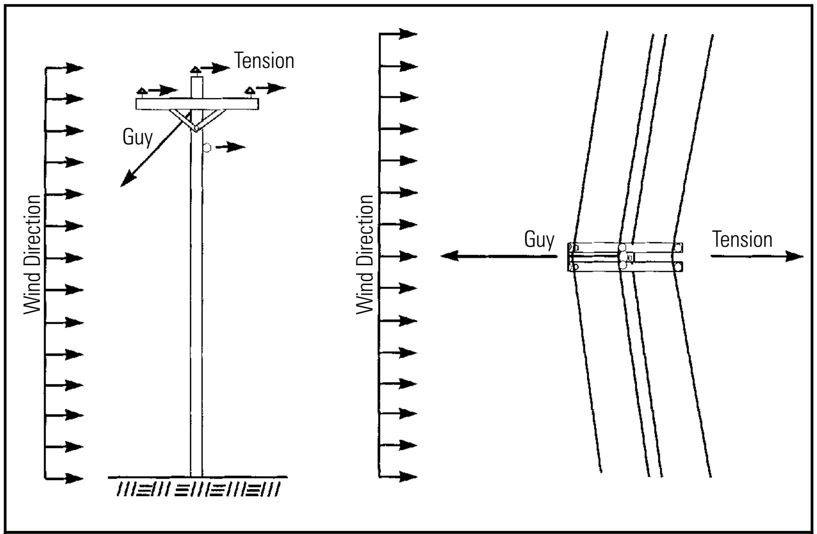


FIGURE 7.4: Transverse Loading.

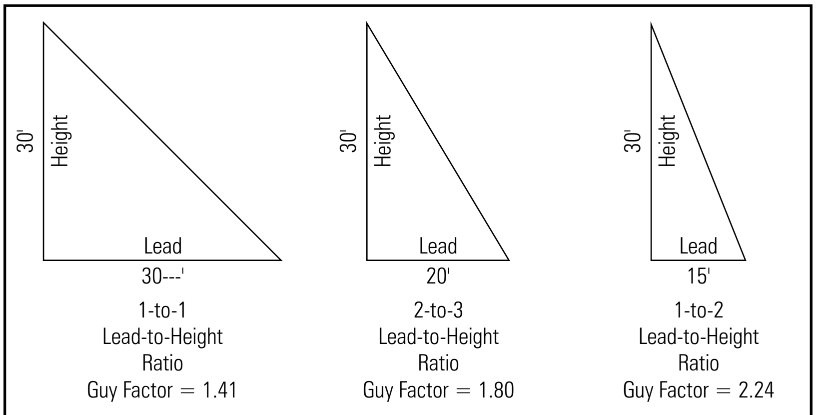


FIGURE 7.5: Guy Lead Ratios and Guy Factors.

It is evident from **Figure 7.5** that the shorter the guy lead, the greater the force acting on the guy and anchor assembly. In other words, the closer the anchor is to the pole, the easier it is to pull the pole over. RUS recommends that 1-to-1 guy leads be used to guy all structures. The shorter guy leads should be used only when it is not possible to obtain a 1-to-1 guy lead. Guy leads shorter than 1-to-2 should not be used with standard distribution structures.

Where multiple guys and anchors are used, the average guy attachment height and the average guy lead must be determined to use the available guying tables and/or perform horizontal pull and total guy load calculations. The *average guy attachment height* is the average of the heights of the guy attachments from grade. The *average guy lead* is the average of the distances in feet of the anchors from the pole. See Figure 7.6.

Average guy attachment heights and their corresponding average guy lead lengths for some typical RUS distribution structures are shown in **Table 7.1**.

Because of the increase in the vertical component of guy tension, short guy leads can also affect the column strength of the pole. When guy lead ratios shorter than 2-to-3 are used, the staking technician should consider increasing the pole class by a minimum value of 1 over the standard design pole class of the line. For example, if the standard pole is a class 4, increase the size to a class 3 for guy lead ratios shorter than 2-to-3 but equal or longer than 1-to-2. The guyed pole acts as a column supporting the loads created by the vertical weight of the conductor, the vertical component of the load supported by the guys, and the vertical weight of any equipment mounted on the pole, such as transformers. A pole acting as a column becomes unstable when these forces become large enough to cause large lateral deflections. This instability is commonly referred to as pole buckling. See **Figure 7.7**.

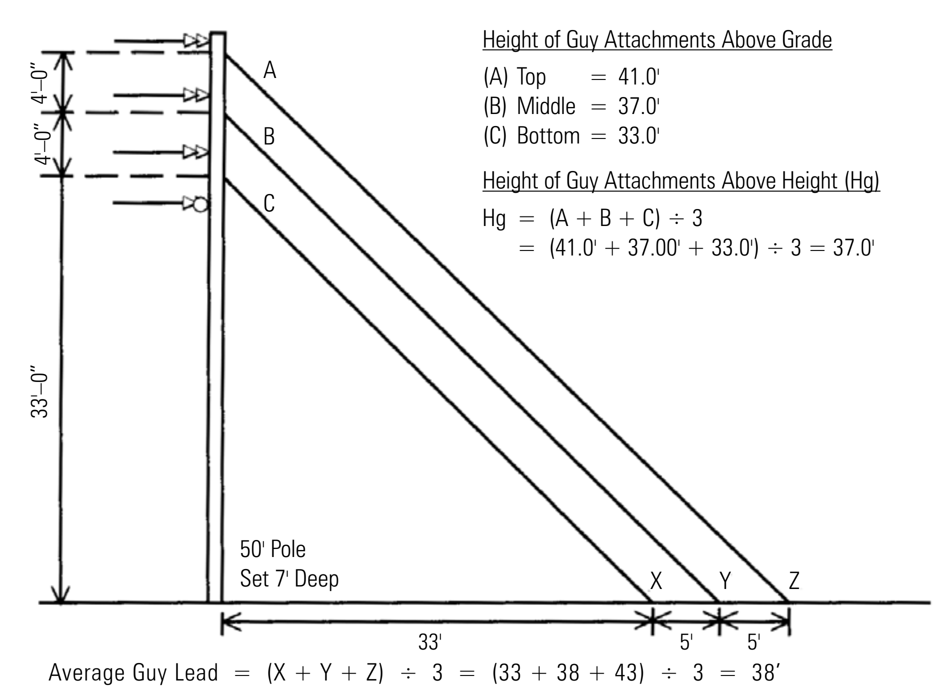


FIGURE 7.6: Average Guy Attachment Height and Average Guy Lead.

TABLE 7.1: Average Guy Attachment Heights and Corresponding Guy Leads for Typical RUS Distribution Structures

Pole Height (ft)	Average Guy Attach. Ht. (ft)	1-to-1 Guy Lead (ft)	2-to-3 Guy Lead (ft)	1-to-2 Guy Lead (ft)
C1.11, C1.12, C1.13, C1.14, C2.21, C2.24, C2.25, C2.51, C2.52 SINGLE DOWN GUY (E1.1, E1.1L)				
35	26.75	27	18	14
40	31.75	32	22	16
45	36.25	37	25	19
50	40.75	41	28	21
55	45.25	46	31	23
C1.11L, C1.21L, C1.31L, C1.41L, C2.21L, C2.51L, C2.52L SINGLE DOWN GUY (E1.1, E1.1L)				
35	26.75	27	19	14
40	31.75	32	22	16
45	36.25	37	25	19
50	40.75	41	28	21
55	45.25	46	31	23
C3.1, C3.2, C3.3, C5.1, C5.2, C5.3 DOUBLE DOWN GUY (E2.1G)				
45	32.50	33	22	17
50	37.00	37	25	19
55	41.50	42	28	21
C3.1, C3.2, C3.3, C5.1, C5.2, C5.3 THREE DOWN GUYS (E3.1LG)				
45	32.50	33	22	17
50	37.00	37	25	19
55	41.50	42	28	21
C3.1, C3.2, C3.3, C5.1, C5.2, C5.3 FOUR DOWN GUYS (E4.3LG)				
45	30.50	31	21	16
50	35.00	35	24	18
55	39.50	40	27	20
C3.1L FOUR DOWN GUYS (E4.3LG)				
45	29.50	30	20	15
50	34.00	34	23	18
55	38.50	39	26	20

NOTES: Guy leads were always rounded to the next higher whole foot regardless of the magnitude of the decimal amount. Example: 20.17 was rounded to 21.
Average guy heights are based on a pole setting depth of 10% of length plus 2 feet.

One example of a structure that should be examined for column strength is a three-phase deadend heavy transformer bank pole with large conductors guyed with a short guy lead.

Heavy transformers are considered to be 50 kVA and larger. Other examples are tall poles of small classes used at heavy line angles and deadends. Tall poles of small classes are considered to be poles 50 feet and longer and classes of 4 and smaller.

The staking technician should refer these situations to the cooperative or consulting engineer for analysis if a long guy lead cannot be obtained.

The sum of the horizontal forces on the structure is called the "horizontal pull." The resulting force as a function of the length of the guy lead produced at the anchor is called the "total guy load."

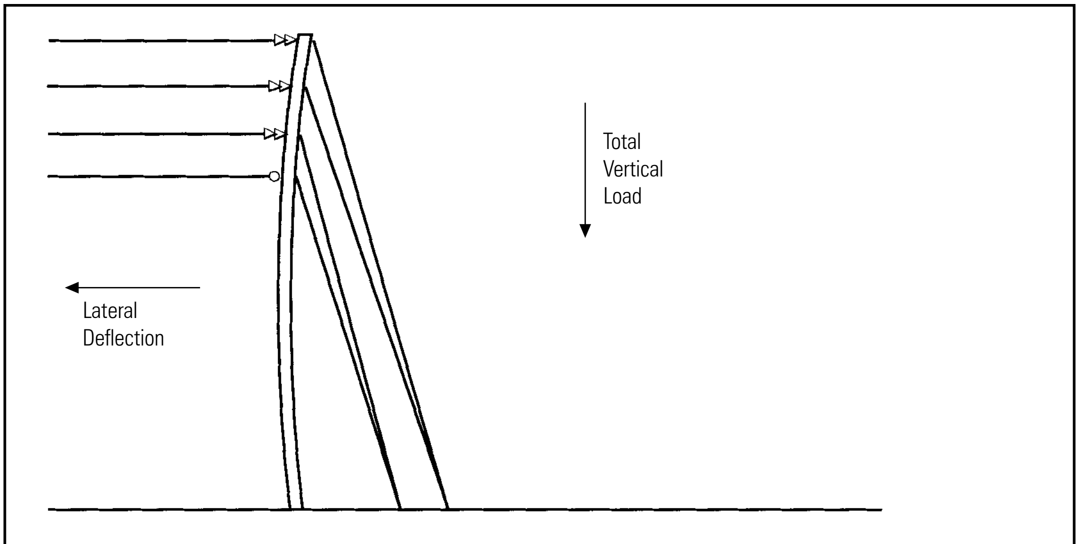


FIGURE 7.7: Lateral Deflection of Pole Due to Short Guy Lead and Vertical Load.

NESC Requirements

The *National Electrical Safety Code* provides design standards for the application of guys and anchors to distribution pole lines. In determining the transverse strength of a guyed structure, the *NESC* requires that load factors be applied in addition to the loading produced on the structure by the tension and wind. Also, load factors are to be applied in determining the longitudinal loading of a structure. These load factors are shown in Table 7.2.

TABLE 7.2: Load Factors for Guys. Adapted from *NESC* Table 253-1.

Transverse Strength	Grade B	Grade C
Wind load	2.50	2.20
Wire tension load	1.65	1.10
Extreme wind	1.00[1]	1.00[2]
Extreme Ice	1.00	1.00
Longitudinal Strength	**Grade B**	**Grade C**
At deadends	1.65	1.10
Extreme wind	1.00[1]	1.00[2]
Extreme ice	1.00	1.00

[1] Use Extreme Wind Map for Grade B (**Figure 3.2(a)**)

[2] Use Extreme Wind Map for Grade C (**Figure 3.2(b)**)

TABLE 7.3: Guy Wire Strength Data			
Type Strand	**Size**	**Breaking Strength (lb)**	**Maximum *NESC* Load (lb)**
Siemens Martin Steel	1/4 in. 3/8 in. 7/16 in.	3150 6950 9350	2835 6255 8415
High-Strength Steel	1/4 in. 3/8 in. 7/16 in.	4750 10,800 14,500	4275 9720 13,050
Aluminum-Clad Steel	6M 8M 10M 12.5M	6000 8000 10,000 12,500	5400 7200 9000 11,250

The load factors are used in the guying calculations to determine the horizontal pull. These calculations will be addressed later in this section. However, even if the staking technician does not actually perform the calculations, it is necessary to be familiar with the load factors used in determining the horizontal pull. This is important because these factors may possibly change with future editions of the *NESC*. The staking technician must be able to recognize that the values used for horizontal pull are based on the load factors of the current edition of the *NESC*.

The *NESC* states in Rule 264B and Table 261-1 that the guy wire must be derated to 90% of its rated breaking strength. For example, if the guy wire is rated for 10,000 lb, the ultimate loading cannot exceed 90% or 9,000 lb (10,000 × .90 = 9,000 lb). Strength data for various types of guy wire are shown in Table 7.3.

The *NESC* (215C2) requires that all guys be grounded or insulated. RUS also requires that all guys be grounded. In some instances, RUS allows cooperatives to insulate down guys (Reference Bulletin 1728F-804).

RUS and other electric utilities use guy insulator links (E1.5), also known as fiberglass extensions, at the top of down guys. One of the reasons to use these guy insulators is to improve the basic insulation impulse levels (BIL), which simply increases the performance of the structure to withstand a lightning-caused flashover. Another reason to use the guy insulators is to aide the line workers by increasing the distance between grounded guys and phase-associated hardware. When the guy insulator link is used, the bottom portion of the guy is grounded to meet safety requirements of the *NESC* (215C2).

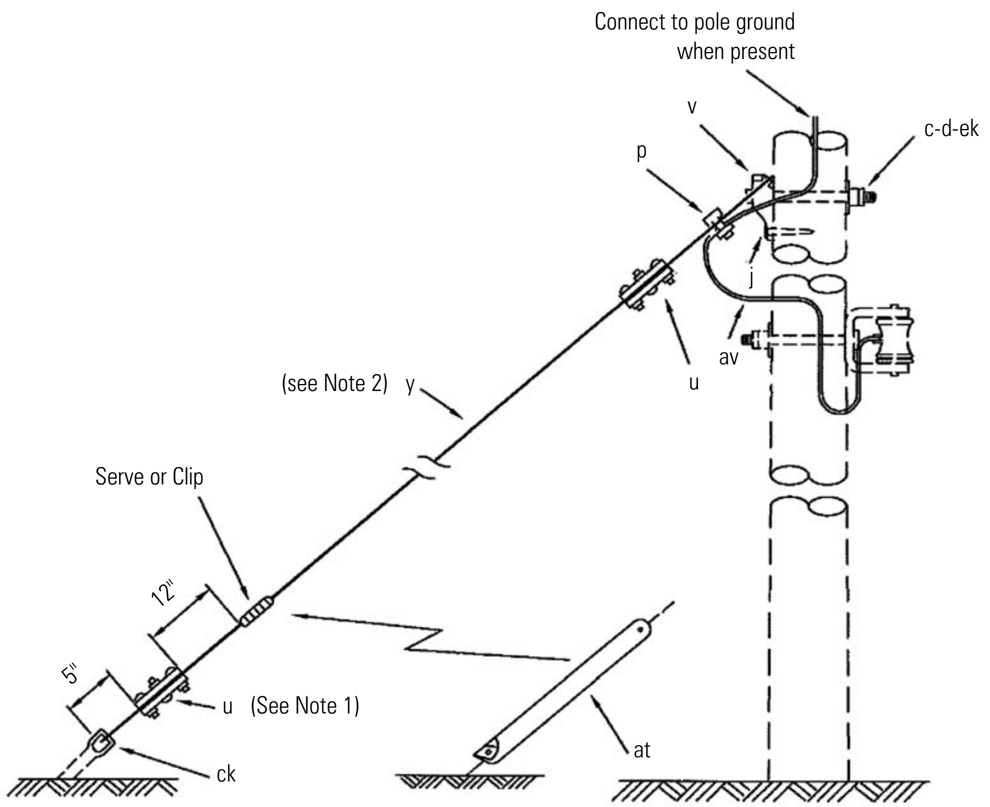
RUS's specifications are evolving and the 24.9/14.4-kV construction specification requires that guy insulator links be used when there is less than 12 inches of wood between the phase assembly and the guy attachment (reference E.2.2G). The newer 12.47/7.2-kV construction specification requires that a guy insulator link be used when there is less than 15 inches of wood between the phase hardware and the guy attachment.

In general, guy insulator links are not required on single-phase assemblies because the specifications maintain 15 inches of wood between the phase hardware and the guy attachment. On some two-phase assemblies and many three-phase assemblies, a guy insulator will be required.

RUS Requirements

The design standards for the guying of distribution pole lines can be found in RUS Specifications and Drawings and the RUS List of Materials.

One of the most frequently overlooked items in the selection of a guying system is the strength of the guy attachment assembly. If a wrapped (E1.2) or pole band (E1.3L) type of guy assembly is used, then the guy could be rated to the full strength of the guy wire with *NESC* safety factors applied. For example, an E1.2 guy using 10,000-lb guy wire would have a rating of 9,000 lb. Remember, the *NESC* requires the guy wire to be derated to 90% of the rated breaking strength. If a through-bolt type of guy assembly (E1.1, E1.1L) is selected, the rated strength of the attachment will usually be the limiting factor for the strength rating of the guy. The RUS strength ratings can be found in the List of Materials, section v, and each guy assembly drawing can be found in the Specifications and Drawings, Section E. **Figure 7.8** shows an example of a guy attachment strength rating for an E1.1L guy assembly.



Item	Qty.	Material
c	1	Bolt, machine, 3/4" × required length
d	1	Washer, square, 4", curved
p		Connectors, guy bond and as required
j	1	Screw, lag, 1/2" × 4"
u	2	Deadend for guy strand, heavy duty
v	1	Guy attachment, guy hook type
y		Guy wire, as required (See Note 4)
at	1	Guy marker
av		Jumpers, as required)
ck	1	Clamp, anchor bonding
ek	1	Locknuts

Notes:

1. Other accepted and equivalent heavy-duty guy deadend material (item "u") may be substituted for the ones shown.
2. Pole eye plate guy attachment and anchor shackle may be used instead.
3. Two 5/8" machine bolts and 2–3 square curved washers may be used to install guy attachment.
4. Specify guy wire size, type, and required length.

DESIGN PARAMETERS PERMITTED LOAD IS LEAST OF: 8500 lb (in any direction) or 90% of RATED BREAKING STRENGTH OF GUY WIRE	SINGLE DOWN GUY – HEAVY DUTY (THROUGH-BOLT TYPE)	
	April 2005 RUS	E1.1L (E1-3)

FIGURE 7.8: Sample Guy Attachment Strength Rating, E1.1L (E1-3) Guy Assembly.

The RUS Specifications and Drawings dictate where the guys are to be attached to the pole. The staking technician should be familiar with the framing to determine the average guy attachment height. This value is necessary to determine the guy lead ratio (lead to height). It is also used in calculating the horizontal pull on the structure.

As mentioned in the discussion of *NESC* requirements, RUS requires that all guys be grounded. Even if a guy strain insulator is used at the attachment for additional clearance, the guy must be grounded below the insulator.

The RUS design standards for the guying of distribution lines also include specifications for anchors. These specifications include types of anchors, characteristics, and ratings.

The RUS-designated maximum holding power rating for an anchor is equal to the maximum allowable load, including load factors for which the anchor should be used. Note that the RUS rating is not the same as the manufacturer's ultimate holding power rating shown in a catalog. The RUS rating includes safety factors and should be used in selecting an anchor to hold a design load. The RUS strength rating also applies only when the anchor is installed in Class 1 through Class 5 soils. When the anchor is installed in poorer soils, it should be derated. A rule of thumb is to derate the anchor by 25% in Class 6 soil and by 50% in Class 7 soil. In Class 8 soil, a swamp anchor (see below) must be used.

For example, an F1-3 anchor has an RUS rating of 10,000 lb in Class 5 soil. When this anchor is used in Class 6 soil, the rating would be:

$$10{,}000 \text{ lb} - (10{,}000 \text{ lb} \times .25) = 7500 \text{ lb}$$

If the same anchor were used in Class 7 soil, the rating would be:

$$10{,}000 \text{ lb} - (10{,}000 \text{ lb} \times .50) = 5000 \text{ lb}$$

Table 7.4 lists the RUS soil classifications and their descriptions.

TABLE 7.4: Soil Classification for Anchor Design

Class	Engineering Description
0	Sound hard rock, unweathered
1	Very dense and/or cemented sands; coarse gravel and cobbles
2	Dense fine sand; very hard silts and clays (may be preloaded)
3	Dense clayey sands and gravel; hard silts and clays
4	Medium dense sandy gravel; very stiff to hard silts and clays
5	Medium dense coarse sand and sandy gravels; stiff to very stiff silts and clays
6	Loose to medium dense fine to coarse sand; firm to stiff clays and silts
7	Loose fine sand; alluvium; loose soft-firm clays; varied clays; fill
8	Peat, organic silts; inundated silts, fly ash

Soil testing is seldom, if ever, performed for distribution line construction. If it were, the results would probably show that the class of soil varies from one end of the line to the other and even within one anchor hole. For this reason, load factors should be liberal.

The type of anchor used will usually be determined by the condition of the soil into which the anchor is installed. RUS Bulletin 1724E-153, Electric Distribution Line Guys and Anchors, along with Information Publication 202-1, List of Materials, section z, list the holding strength for various types and sizes of anchors for the poorest soil conditions in which the anchor might be used. Many systems standardize on one or two sizes of anchors of the types most suitable for the soil conditions found in the operating area. Drawings of the different types of anchors are shown in the RUS Specifications and Drawings, Section F.

There are numerous anchors available for use:

1. **Expanding Anchor:** This anchor is suitable for general use except in marshy or swampy land, in very loose soils, or in rock or hardpan where the blades will not expand. There is little difference in cost between the smallest and largest expanding anchor, and many systems stock only one size. The holding strength of these anchors is based on the square inches of the expanded anchor surface and the soil conditions.

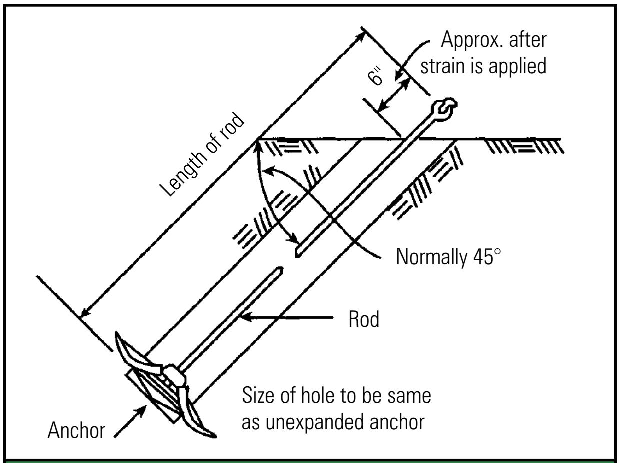


FIGURE 7.9: Expanding Anchor Assembly.

2. **Plate Anchor:** Because this anchor bears completely against undisturbed earth, it develops large holding power in most soils.

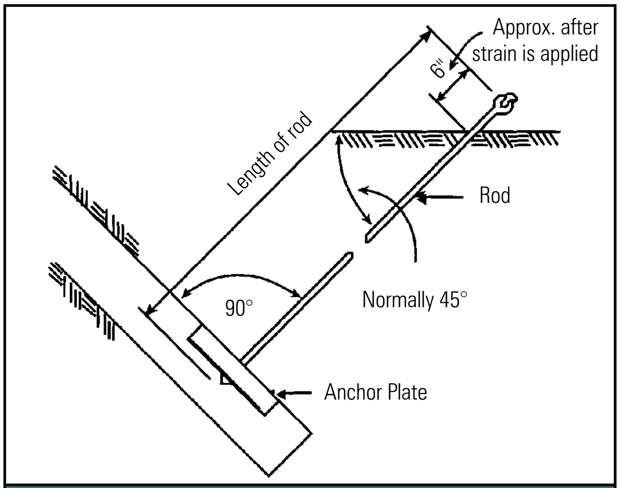


FIGURE 7.10: Plate Anchor Assembly.

3. **Cone Anchor:** This anchor is used principally in hardpan and rocky soil where other types of anchors would be difficult to install.

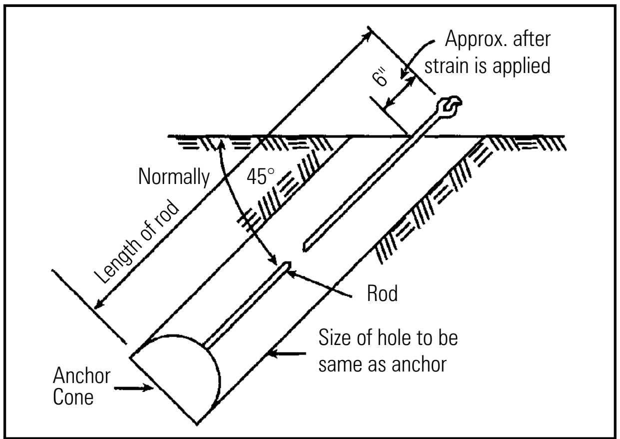


FIGURE 7.11: Cone Anchor Assembly.

4. **Screw Anchors:**
   a. **Service:** Six-inch screw anchors may be used on services. Their rated holding power in Class 7 soil is 2500 lb.
   b. **Power-Installed:** Power-installed screw anchors of various ratings may be obtained. On some of these anchors, the installation torque is used as a measure of the holding power, and each anchor is installed to a specified torque for a specific load. These anchors are becoming the anchor of choice because of their ease to install and their holding power. The increased hydraulic capability and tooling of newer line trucks enable these anchors to be put down in very difficult soil conditions.

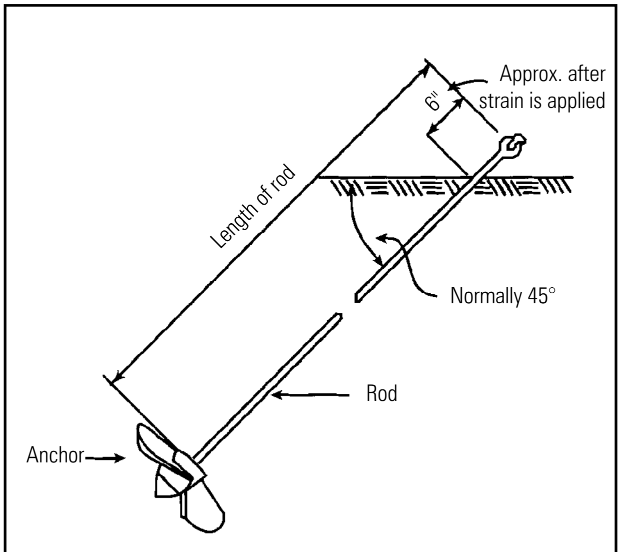


FIGURE 7.12: Screw Anchor Assembly.

   c. **Swamp Anchor:** This is a large screw anchor and is used in swampy areas where other anchors are not practical.

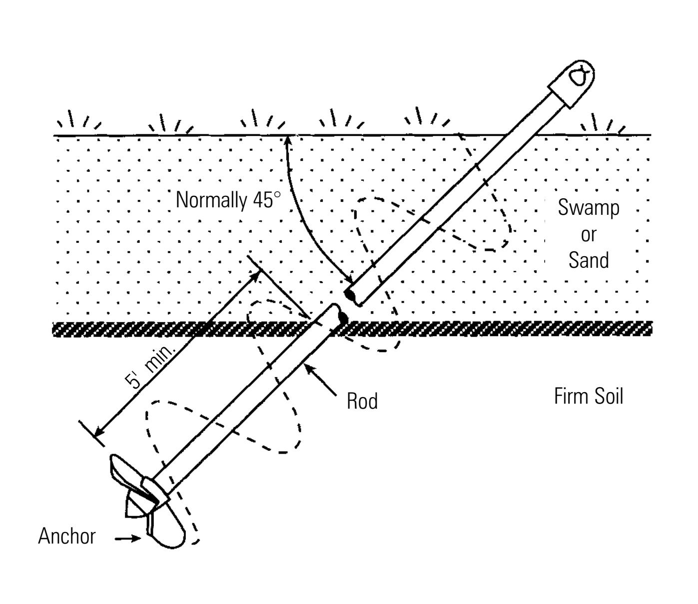


FIGURE 7.13: Swamp Anchor Assembly.

5. **Log Anchor:** This anchor is used when the load exceeds the strength limitations of other available anchors. Its holding power is related to the length and diameter of the log used.

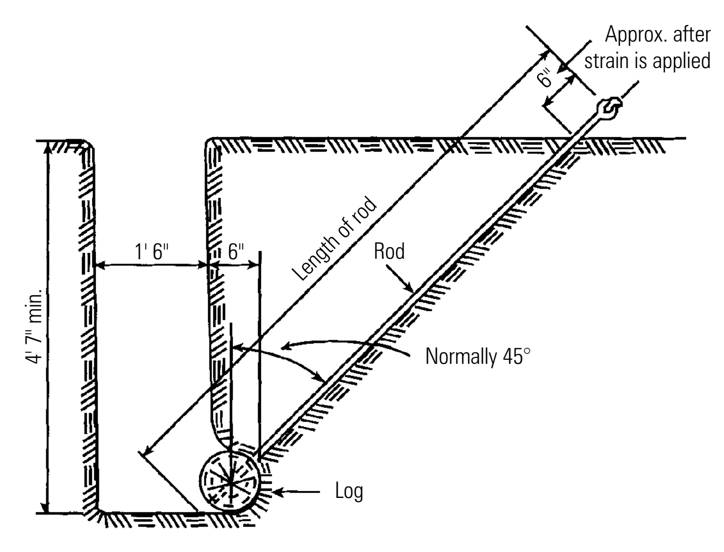
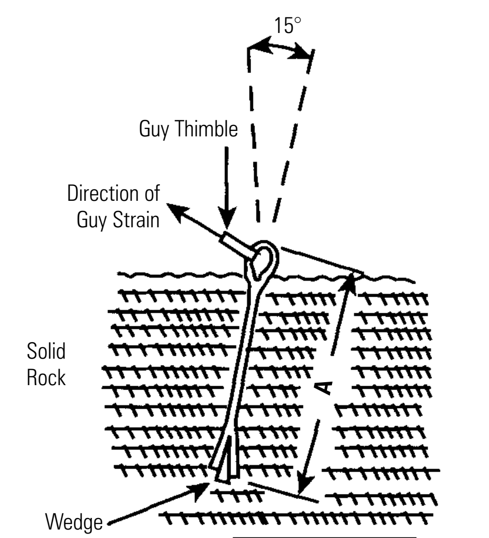


FIGURE 7.14: Log Anchor Assembly.

6. **Rock Anchor:** This anchor is used in solid rock areas.

If power-installed screw anchors are selected, additional conditions must be observed. Power-installed anchors work well in sandy soils. These anchors are installed using equipment to measure the torque applied to the rod. The anchor manufacturers provide tables showing the ultimate holding power of a particular type of anchor that corresponds to a particular rod torque. The holding power of the anchor also depends on the capability of the anchor machine operator, who must apply the proper down pressure when installing the anchor or the desired rating may not be obtained. If the torque on the rod is reached before the anchor plate is a minimum of 5 feet below grade, then additional torque should be applied to drive the anchor to its proper depth. However, care must be taken not to exceed the allowable torque on the rod, which is generally 5,000 to 6,000 ft-lb. Because of the rod torque limitation, these anchors are generally not suitable for denser soils.



Dimension A	
Guy Bolt	18"
Rock Anchor	15"

FIGURE 7.15: Rock Anchor Assembly.

TYPICAL ANCHOR AND GUY STRENGTH COMBINATIONS

To correctly select a guy/anchor assembly, the staking technician must know the strengths of the material stored in the cooperative's warehouse. A small table of available assemblies will aid in the selection. Table 7.5 lists the common RUS guy/anchor assemblies as examples. Each individual cooperative should establish the nomenclature and strength of its specific assemblies and ratings for the soil conditions existing in its service area. The system engineer or consultant can help provide this information.

To use Table 7.5, first establish the total guy load and then select guy and anchor assemblies that will adequately support the load.

TABLE 7.5: Example of Strength of Guy and Anchor Assemblies

Guy Assembly	Strength (lb)	Anchor Assembly	Strength (lb)
E1.1	6600	F1.8, F2.8, F3.8	8000
E1.1L	8500	F1.10, F2.10, F3.10	10,000
E1.2	9000	F1.12, F2.12, F3.12	12,000
E1.3L	8500	TA-5	20,000

Example 7.1

Select guy and anchor assemblies for a structure with a total guy load of 16,145 lb. Using Table 7.5, select two E1.1L guy assemblies (8500 lb each) and two F1.10 anchors (10,000 lb each) or two E1.2 guy assemblies (9000 lb) and one TA-5 anchor (20,000 lb).

Line Angle Guying

Line angle structures are guyed on the bisect of the angle. To select a guy and anchor assembly to support the structure, the total guy load must be determined. Guying tables are used to provide the horizontal pull and total guy load for a selected group of design parameters. The values for horizontal pull are usually calculated for a worst-case condition and are used for other conditions included in a range less than the worst case. This means that the conditions less than the worst case will be overguyed but not enough to justify a smaller range of parameters. **Table 7.6** is an example of a typical line angle guying table used to stake distribution lines. The table lists angles in 2° increments. If the angle of the structure is between the increments, always use the next higher value. For example, if the angle is 15°, use 16° to determine the horizontal pull and total guy load. Line angle guying tables for the combinations of conductors commonly used on cooperative distribution systems are shown in Tables C.1 through C.39 of **Appendix C**. These tables are designed to cover single-phase and three-phase structures with standard RUS pole-top assemblies.

When choosing a guying table, the staking technician must first determine the design parameters for the particular line to be staked and select a table based on those parameters. These parameters include:

- *NESC* loading district (heavy, medium, or light)
- Grade of construction (C or B)
- Conductor size and type
- Design tension of the conductor
- Pole size
- Line configuration (single-phase or three-phase)
- Wind span length
- Line angle
- Average guy lead ratio
- Applicable edition of the *NESC*

The wind span is determined by taking the average of the two spans adjacent to the line angle structure.

In addition to the horizontal pull, the guying table will show values for total guy load. Guy lead ratios of 1-to-1, 2-to-3, and 1-to-2 are usually included. If the measured guy lead ratio does not equal one shown on the table, select the

TABLE 7.6: Medium Loading District—Three-Phase, 1/0 ACSR Primary and 2 ACSR Neutral		
MEDIUM LOADING DISTRICT	POLES: 30 TO 55 FT	GRADE C CONSTRUCTION (AT CROSSING)
Primary = (3) 1/0 ACSR 6/1 Neutral = (1) 2 ACSR 6/1 Pole = 55'/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 2190 Design Tension (lb) = 1425 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.2993 Wind Load (lb/ft) = 0.2720 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1328	1873	2391	2975	1860	2622	3347	4166
4	1645	2319	2961	3685	2177	3069	3918	4875
6	1962	2766	3531	4394	2493	3515	4488	5585
8	2278	3212	4100	5103	2810	3962	5057	6294
10	2594	3658	4669	5811	3126	4407	5626	7001
12	2910	4103	5237	6518	3441	4852	6194	7708
14	3225	4547	5804	7223	3756	5296	6761	8414
16	3539	4990	6370	7927	4070	5739	7327	9118
18	3852	5432	6934	8629	4384	6181	7891	9820
20	4165	5873	7497	9330	4697	6622	8454	10,520
22	4477	6312	8058	10,028	5008	7062	9015	11,219
24	4787	6750	8617	10,724	5319	7500	9574	11,914
26	5097	7187	9174	11,417	5628	7936	10,131	12,608
28	5405	7621	9729	12,107	5937	8371	10,686	13,298
30	5712	8054	10,282	12,795	6243	8803	11,238	13,985
32	6017	8485	10,831	13,479	6549	9234	11,788	14,670
34	6321	8913	11,378	14,160	6853	9663	12,335	15,350
36	6624	9339	11,923	14,837	7155	10,089	12,879	16,028
38	6924	9763	12,464	15,510	7456	10,513	13,421	16,701
40	7223	10,185	13,002	16,180	7755	10,934	13,958	17,370
42	7520	10,603	13,536	16,845	8052	11,353	14,493	18,035
44	7815	11,019	14,067	17,505	8346	11,769	15,024	18,696
46	8108	11,432	14,594	18,162	8639	12,181	15,551	19,352

NOTE: This table is based on the 2023 edition of the *NESC*.

value from the next shorter lead-to-height ratio. For example, if the measured guy lead ratio is between 1-to-1 and 2-to-3, use the value for the 2-to-3 ratio. The best policy is always to be overguyed rather than underguyed.

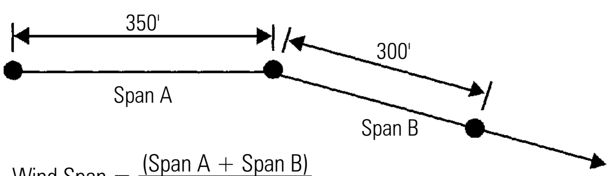
Once the appropriate guying table is chosen, the staking technician's next step is to select the total guy load for the line angle structure to be guyed. This value is selected from the table and based on the magnitude of the line angle in degrees, the wind span length in feet, and the guy lead ratio. Example 7.2 demonstrates how to use a guying table to determine the total guy load for a line angle structure.

After the total guy load has been determined, the staking technician must select a guy and anchor assembly that will adequately support the structure. Decisions must be made as to which guying configuration or combination of guys and anchors provides the best support. Knowledge of where the guys will be framed on the pole is essential.

For horizontal pole-top assemblies where the line angles are relatively small, the guy will be applied near the crossarms since this is the point at which the greatest amount of horizontal load occurs. If more than one guy is needed, the second guy may be framed 9 inches below the top guy. Whatever the case, the sum of the individual guy wire strengths must be equal to or greater than the total guy load.

For vertical pole-top assemblies, the guys will be applied along the length of the pole top. For small conductors, a double-down guy assembly such as an E2.1G is usually sufficient to support the structure. For large conductors with moderate to large line angles, a four-down guy (E3.3LG) assembly should be used so one guy will be positioned nearer the pole top and the other two will be evenly distributed over the lower primary and neutral conductors. If this is not done, the larger neutral conductor will tend to bow the pole over a period of time. On 24.9/14.4-kV construction, the E2.3G assembly does not specify a neutral guy; however, an additional neutral guy, as shown in E4.4LG, should be considered for large-size neutrals on large angles to prevent pole bowing.

If multiple anchors are required, the sum of the ratings must be equal to or greater than the amount of total guy load. One anchor of equivalent or greater rating than the guy wire may be used per guy, or two guys may be attached to



$$\text{Wind Span} = \frac{(\text{Span A} + \text{Span B})}{2}$$

$$\text{Wind Span} = \frac{(350' + 300')}{2} = 325'$$

FIGURE 7.16: Wind Span Calculation.

Example 7.2

Determine the total guy load for the following line angle structure:

Given:

Medium loading district		
Grade C construction		
Pole height	=	40 ft
Pole-top assembly	=	C2.21
Conductor	=	(3) 1/0 ACSR 6/1 primary and (1) 2 ACSR 6/1 neutral
Design tension	=	50%
Span	=	350 ft
Line angle	=	14°
Guy lead ratio	=	2-to-3

Table 7.6 conforms to the above design parameters; therefore, it can be used to determine the total guy load.

Locate the central section of the table that lists total guy loads for a maximum wind span of 400 feet.

Read down the "Line Angle" column to 14°.

Read across the row to the 2-to-3 guy lead column.

Total guy load = 6761 lb

one anchor with a high strength rating. If two guys are attached to one anchor, RUS requires that the anchor rod be a minimum of 3/4" × 8'. Example 7.3 shows how a guy and anchor assembly is selected for a typical distribution structure.

Example 7.3

Select a guy and anchor assembly for the structure described in **Example 7.2**. The total guy load is 6761 lb. The assemblies selected should equal or exceed the total guy load.

Guy wire = 3/8-in. high-strength steel. **Table 7.3** shows that it has an *NESC* strength rating of 9720 lb.

Guy assembly = E1.1L. **Table 7.5** shows this assembly to be capable of holding 8500 lb.

Anchor assembly = F1.8. **Table 7.5** shows this assembly to be capable of holding 8000 lb.

NOTE: If a 1-to-1 guy lead had been used, the total guy load would have been 5296 lb (**Table 7.6**). In that case, 3/8-in. Siemens Martin Steel wire and an E1.1 guy assembly would have been adequate.

Deadend Guying

Deadend structures are guyed in the opposite direction of the horizontal pull. The load that must be guyed is the longitudinal force caused by the loaded design tension of the conductors combined with the *NESC* load factors. Determination of the total guy load with a guying table is basically the same as for the previous line angle guy. Refer to the Line Angle Guying subsection above for information on the use and structure of a guying table. Following are the design parameters that must be determined prior to choosing the correct deadend guying table:

- *NESC* loading district (heavy, medium, or light)
- Grade of construction (C or B)
- Conductor size and type
- Design tension of the conductor
- Pole size
- Line configuration (single-phase or three-phase)
- Guy lead ratio
- Applicable edition of the *NESC*

Table 7.7 is an example of a typical deadend guying table used to stake distribution lines. It provides the deadend horizontal pull and total guy load for typical combinations of conductors commonly found on cooperative distribution systems. From the deadend guying table, the staking technician can determine the total guy load corresponding to the parameters of the structure to be staked.

Example 7.4 shows how the total guy load is determined for a distribution deadend structure.

After the total guy load has been determined, the staking technician must select a guy and anchor assembly that will adequately support the structure. Decisions must be made as to which guying configuration or combination of guys and anchors provides the best support. Knowledge of where the guys will be framed on the pole is essential.

For horizontal pole-top assemblies, most of the guys will be applied near the crossarms, since this is the point at which the greatest amount of horizontal load occurs. If a large-size conductor such as 4/0 ACSR is used for the neutral, then one guy may be attached 6 inches below the neutral assembly to provide support and prevent the pole from bowing over time. Whatever the case, the sum of the individual guy wire strengths must be equal to or greater than the total guy load. If through-bolt-type guys (E1.1, E1.1L) are used, then consideration must be given to the number of holes to be bored in the pole top. For large conductor deadends, the use of numerous smaller-size guys may weaken

TABLE 7.7: Horizontal Pull and Total Guy Load at Deadends

LIGHT, MEDIUM, AND HEAVY LOADING DISTRICTS
Poles = 35 ft to 55 ft
Wire Height (ft) = 47.5

GRADE C CONSTRUCTION
Tension LF = 1.1
Guy Attachment Height (ft) = 46

Conductor	Design Tension (lb)	Horizontal Pull (lb)	Total Load (lb)		
			1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
(1) 4 ACSR 7/1 Primary (1) 4 ACSR 7/1 Neutral	1180 1180	2681	3791	4833	5994
(1) 2 ACSR 6/1 Primary (1) 2 ACSR 6/1 Neutral	1425 1425	3237	4578	5836	7239
(1) 1/0 ACSR 6/1 Primary (1) 1/0 ACSR 6/1 Neutral	2190 2190	4975	7036	8969	11,125
(3) 4 ACSR 7/1 Primary (1) 4 ACSR 7/1 Neutral	1180 1180	5361	7582	9665	11,988
(3) 2 ACSR 6/1 Primary (1) 2 ACSR 6/1 Neutral	1425 1425	6474	9156	11,672	14,477
(3) 1/0 ACSR 6/1 Primary (1) 2 ACSR 6/1 Neutral	2190 1425	9081	12,843	16,372	20,306
(3) 3/0 ACSR 6/1 Primary (1) 1/0 ACSR 6/1 Neutral	3310 2190	13,767	19,469	24,818	30,783
(3) 4/0 ACSR 6/1 Primary (1) 1/0 ACSR 6/1 Neutral	4000 2,190	16,118	22,794	29,057	36,041
(3) 336 ACSR 18/1 Primary (1) 4/0 ACSR 6/1 Neutral	4000 4000	18,174	25,702	32,763	40,638
(3) 477 ACSR 18/1 Primary (1) 4/0 ACSR 6/1 Neutral	4000 4000	18,174	25,702	32,763	40,638

Note: This table is based on the 2023 edition of the *NESC*.

Example 7.4

Determine the total guy load for the following deadend structure:

Given:

Medium loading district
Grade C construction
Pole height = 45 ft
Pole-top assembly = C5.1
Conductor = (3) 1/0 ACSR 6/1 primary and (1) 2 ACSR 6/1 neutral
Design tension = 50% = 2190 lb primary and 1425 lb neutral
Guy lead ratio = 2-to-3

Table 7.7 conforms to the above design parameters; therefore, it can be used to determine the total guy load.

Locate the combination of conductors to be guyed in the left-hand column (6th group down from the top).

Read across the row to the 2-to-3 guy lead column.

Total guy load = 16,372 lb

the pole. A better choice for this situation is to use the higher-strength guy wire with wrapped or pole band attachments. This allows the full rating of the guy wire to be used, resulting in fewer individual guys being attached to the pole.

The guys will be applied along the length of the pole top on vertical pole-top assemblies. For small conductors, a double-down guy assembly such as an E2.1G is usually sufficient to support the structure. However, when guying for 1/0 ACSR, some utilities use a three-down guy assembly (E3.1LG), so one guy will be positioned nearer the pole top and the other two will be evenly distributed over the lower primary and neutral conductors. For large conductors, one guy per phase (E4.3LG) is usually required for deadend structures. The wrapped or pole band attachment provides the best support. However, if long guy leads are used, standard, heavy-duty guy attachments will usually be adequate. If this is done, the staking technician should specify four single-down guy assemblies with notes as to the framing locations. These links are evident on typical 24.9/14.4-kV assemblies such as VC4.2L and VC5.2L.

If multiple anchors are required, the sum of the ratings must be equal to or greater than the amount of total guy load. One anchor of equivalent or greater rating than the guy wire may be used per guy, or two guys may be attached to one anchor with a high strength rating. If two guys are attached to one anchor, RUS requires that the anchor rod be a minimum of 3/4" × 8'.

Example 7.5 shows how a guy-and-anchor assembly is selected for a distribution structure.

The recommended separation between anchor rods is 5 feet for anchors up to 12,000-lb capacity and 8 feet for anchors of 18,000 lb and larger. A good rule of thumb is to stake the anchors at 1 foot greater separation than these values to allow for construction tolerance.

SPREAD GUYS

Anchors for multiple guys are placed in line with the load, or one directly behind the other, as required by the *NESC* (264F). This provides the maximum holding power, but this arrangement requires larger amounts of right-of-way easement. Where right-of-way easements allow only a minimum of guy lead, anchors may be "spread" apart horizontally. The guy load will be slightly increased due to the anchor/guy not being directly in line with the load. This is not a significant increase and can usually be ignored as a result of the load factors used in the calculations and the increments in size of the assemblies. The designer should apply the average guy attachment height and the average guy lead principles described in **Figure 7.6** to calculate the total guy load. **Figure 7.17** illustrates the relationship of various anchor arrangements.

SIDEWALK GUYS

It is very rare to find a sidewalk guy that has been properly designed. Sidewalk guys require careful design and should be used only in rare situations (see **Example 7.6**). The sidewalk guy is exactly what the name implies. A metal strut is placed along the axis of the pole to hold the guy strand out from the pole so that a pedestrian may pass under the guy without having to duck (**Figure 7.18**). The strut does not increase the holding capacity of the guy. The strength of the guy assembly is still dependent on the ratio of the guy lead to the attachment height. Because of the short leads used for sidwalkguys,

Example 7.5

Select a guy and anchor assembly for the structure described in **Example 7.4**.

The first step is to determine how many guys to use. Since the pole-top assembly is a vertical configuration, a multiple-type down guy assembly would best support the structure.

The total guy load is 16,372 lb. An E2.1G assembly (double-down guy) using high-strength steel guy wire (9720-lb rating) and the 8500-lb heavy-duty attachment will adequately support the structure. Specify one E2.1G guy assembly. If more support is desired in between the phases, one E3.1LG assembly could be specified.

The RUS rating on an F1.10 anchor is 10,000 lb. Two of these anchors would support 20,000 lb, which exceeds the minimum 16,145-lb total guy load of the structure. Specify two F1.10 anchor assemblies. These two anchor assemblies would also be sufficient for the E3.1LG guy assembly. Two of the three guys attach to one anchor. Since the F1.10 anchor assembly uses a 3/4" × 8' rod, it meets the RUS requirement for attachment of two guys to one anchor.

Remember when staking multiple anchors to space them a minimum of 5 feet apart. Some of the very large anchors should be spaced 8 feet apart. Refer to the *RUS Specifications and Drawings*, Section E, for the correct separation.

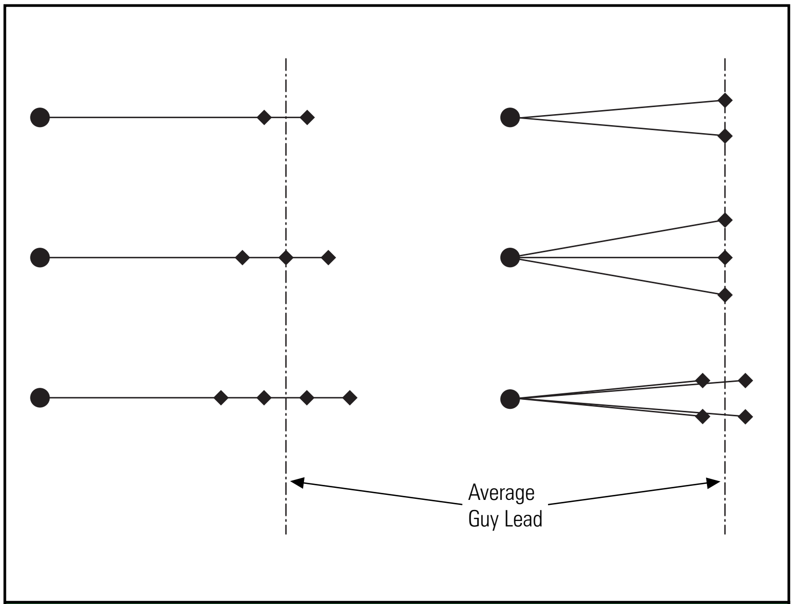


FIGURE 7.17: Multiple Anchor Configurations.

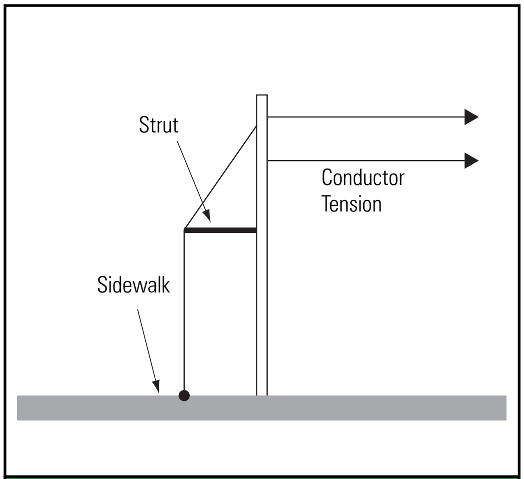


FIGURE 7.18: Sidewalk Guy.

significant total guy loads are developed in the assembly.

Another consideration is the force applied to the center of the pole by the strut. This section previously discussed pole buckling caused by short guy leads. The same rules apply but with the addition of the force being concentrated at the point of the strut attachment. This can cause extreme bowing and failure due to buckling for smaller-class poles. A rule of thumb is to specify a Class 2 or Class 1 pole for all sidewalk applications. The actual load at the strut can be calculated, but is beyond the scope of this manual. To establish a sidewalk guy drawing and specification for the cooperative, contact the engineer or a consultant for detailed information. If the cooperative is an RUS borrower, special permission must be obtained to use a sidewalk guy assembly.

Example 7.6

Take, for example, a structure with the following parameters: 40-foot pole, 6-foot guy lead, 32-foot guy attachment height, and a horizontal pull of 2160 lb. The horizontal pull is the resultant for two 2 ACSR conductors with a 200-foot ruling span in the medium loading district. The calculated total guy load for this structure is 12,893 lb. To hold the tension and meet the requirements of the *NESC*, a double helix anchor with two 10,000-lb high-strength guys must be installed. One can easily see that sidewalk or short-lead guys must be designed carefully and only applied to lightly tensioned conductor deadends or small line angles.

Tap Guying

When staking primary tap lines off a main line structure, special consideration must be given to the selection of the guy and anchor assembly to support the tap. These tap guys should be sized to support the entire structure. This load includes the sum of the longitudinal load of the tap line conductors and the transverse wind load of the tangent line conductors. In some cases, the transverse wind load on a long span of large-conductor three-phase line may be greater than the longitudinal load of the small conductor of a single-phase tap line. A wood pole is designed to flex and gradually absorb the load produced by the wind blowing on the conductors. If the guy and anchor for the tap line are not strong enough to prevent the pole from bending with the wind, it may pull out the anchor or break the guy assembly. When this happens, the conductor can sag and cause a clearance violation.

Generally, if standard RUS guying procedures and materials are used for tap guys, the transverse wind load of the tangent pole will also be adequately guyed. However, if any of the following conditions is encountered, the tap guying should be analyzed by the cooperative or consulting engineer:

- Long tangent spans of large conductors
- Double circuit tangent lines
- Tall structures in high wind areas

With the increasing incidence of large multiplex service conductors being run from large-conductor primary lines, the staking technician should carefully consider installing guys to support these service lines. A common error is to assume that, since there is little or no tension in the service line, it will not require a guy and anchor. However, if the service lines are not properly supported, the transformer pole, over time, will lean toward the pull of the service line as a result of the wind and ice loads placed on the service conductors. Since service lines can tap from a main line tangent pole, the service guys are affected by the same conditions as the primary guys. When selecting a service guy, the wind load on the tangent line should also be included in the determination of the guy load.

REDUCED-TENSION SPANS

Occasionally, it is necessary to use a reduced-tension span. This is a span where the wire is strung with very low tension for a short distance. These reduced-tension spans are necessary where an easement for a guy and anchor cannot be obtained. Figure 7.19 illustrates a typical reduced-tension span.

In Figure 7.19, an off-build tap is designed to take off from pole 1. No easement could be obtained to install a guy and anchor to support the full tension of the tap conductors. A reduced-tension span was pulled to pole 2 for a short distance, and a down guy and anchor installed for support. Pole 1 supports main line conductor(s) and the reduced tension span. The load of the reduced tension span plus ice and wind loads on the main line conductor cannot exceed the resisting moment of Pole 1.

Larger pole classes should be specified for the unguyed pole since it essentially becomes a self-supporting structure for the short deadend span. The reduced-tension span should be as short as possible. Smaller conductors can extend

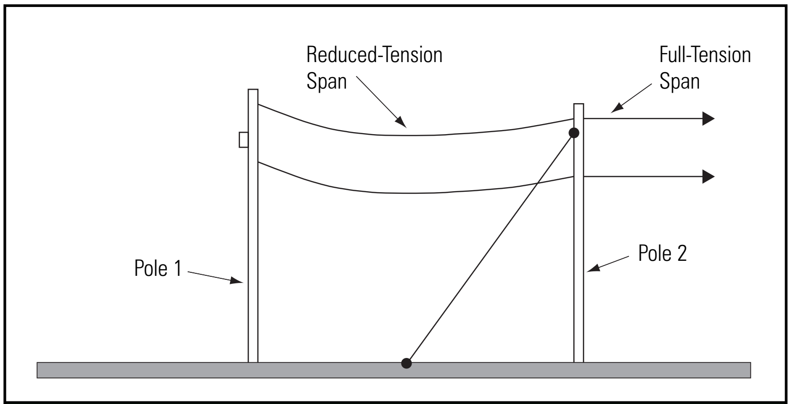


FIGURE 7.19: Guying with Reduced-Tension Spans.

for longer distances than larger conductors. A good rule of thumb is to limit the reduced tension span to 50 feet for conductors up to 336 ACSR.

Overhead Guys

Overhead or span guys provide support for poles by attaching the guy at the normal attachment height and pulling it to a stub pole that is sized slightly shorter than the primary pole (Figure 7.20).

There is no significant increase in total guy load in an overhead guy if the stub pole and primary pole are almost the same height, as shown in Figure 7.20. For most cases, the overhead guy can be sized according to the horizontal pull of the conductors with the applied *NESC* load factor. For significant differences in the height of the stub to the primary pole, calculations should be made to correctly determine the total guy load. They are the same as the total guy load calculations in **Example 7.7**, **Example 7.8**, and **Example 7.9**. The attachment height H_G (see **Equation 7.2**) is the distance from where the overhead guy attaches to the primary pole down to a point where a ground-level-parallel line from the stub attachment intersects the pole. The dashed line in Figure 7.20 illustrates the parallel line. The guy lead is equal to the length of the parallel line. The down guy on the stub pole should be sized according to the guy tables or calculations for the horizontal pull of the conductors with *NESC* applied load factor and total guy load. The total guy load is determined from the ratio of attachment height of the down guy on the stub to the guy lead out from the stub.

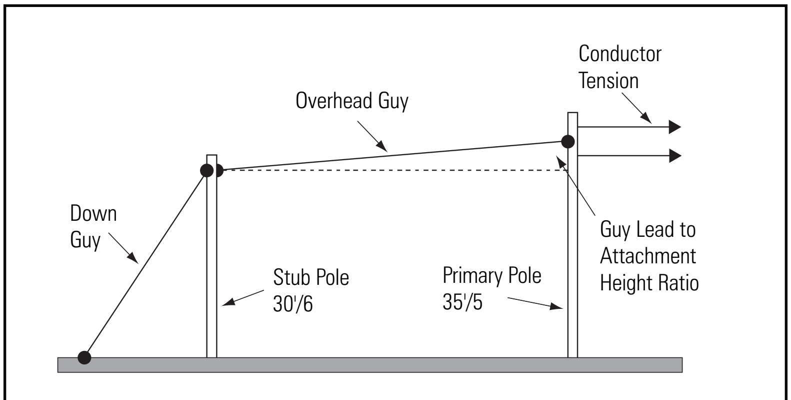


FIGURE 7.20: Overhead Guy.

Guying Calculations

Since guying tables are generally based on a worst-case guying situation, it may be desirable to determine the horizontal pull and total guy load for a specific structure. To do this, the staking technician must perform guying calculations. Equations, with examples, are provided to describe, in a step-by-step procedure, how to calculate the horizontal pull and the total guy load for the following:

- Line angle structures
- Deadend structures
- Tap guyed structures

LINE ANGLE STRUCTURE GUYING CALCULATIONS

Prior to calculating the horizontal pull for a given structure, the staking technician must first understand how to calculate the transverse load on one conductor. **Example 7.7** demonstrates this procedure.

Example 7.7

Given:

Loading district = Heavy
Grade of construction = C
Line angle = 15°
Conductor = 1/0 ACSR 6/1
Design tension = 2190 lb (50%)

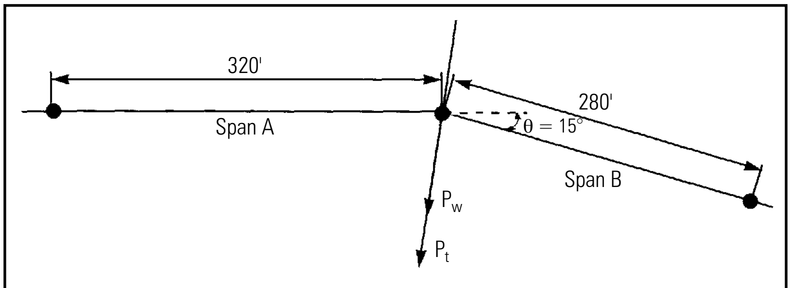


FIGURE 7.21: Span Lengths and Deflection Angle for Example 7.7.

Calculate the transverse load on a single conductor.

The transverse load is caused by the combined "pulls" of tension in the conductor and wind blowing on the conductor.

P_T = Pull due to tension in the conductor
= $(LF_T)(DT)(2)(\text{Sine } (\theta/2))$
LF_T = Load factor for wire tension load (**Table 7.2**) = 1.10
DT = Design tension of conductor (lb) = 2190 lb (given)
θ = Line angle = 15° (given)

In lieu of calculating sine (θ/2), it can be read directly from **Table 7.8**. Sine (θ/2) for 15° = 0.1305.

P_T = (1.10)(2190 lb)(2)(0.1305) = 628.75 lb
P_W = Pull due to wind blowing on the conductor
= $(LF_W)(S)(W_C)$
LF_W = Load factor for wind load (**Table 7.2**) = 2.20
S = Wind span = (Span A + Span B) ÷ 2 = 300 ft
W_C = *NESC* district wind load on conductor (**Table 5.3**) = 0.4660
P_W = (2.20)(300 ft)(0.4660 lb/ft) = 307.56 lb
T = Transverse load
T = $P_T + P_W$
= 628.75 lb + 307.56 lb
= 936.31 lb

The equation for calculating transverse load can now be written as:

Equation 7.1

$$T = [(LF_T)(DT)(2)(\text{Sine } (\theta/2))] + [(LF_W)(S)(W_C)]$$

This is the general equation for finding the transverse load resulting from the forces of tension and wind acting on a single conductor.

TABLE 7.8: Sine θ/2 for Line Angles

Line Angle θ (Degrees)	Sine θ/2	Line Angle θ (Degrees)	Sine θ/2
1	0.0087	31	0.2672
2	0.0175	32	0.2756
3	0.0262	33	0.2840
4	0.0349	34	0.2924
5	0.0436	35	0.3007
6	0.0523	36	0.3090
7	0.0611	37	0.3173
8	0.0698	38	0.3256
9	0.0785	39	0.3338
10	0.0872	40	0.3420
11	0.0959	41	0.3502
12	0.1045	42	0.3584
13	0.1132	43	0.3665
14	0.1219	44	0.3746
15	0.1305	45	0.3827
16	0.1392	46	0.3907
17	0.1478	47	0.3988
18	0.1564	48	0.4067
19	0.1651	49	0.4147
20	0.1737	50	0.4226
21	0.1822	51	0.4305
22	0.1908	52	0.4384
23	0.1944	53	0.4462
24	0.2079	54	0.4540
25	0.2164	55	0.4618
26	0.2250	56	0.4695
27	0.2335	57	0.4772
28	0.2419	58	0.4848
29	0.2504	59	0.4924
30	0.2588	60	0.5000

Equation 7.2 is the equation for calculating total horizontal pull for a complete *single-phase* structure. In addition to the transverse load on the conductor, it also takes into consideration the height of the conductors above grade, wind load on the pole, and the height of the guy attachment above grade.

Equation 7.2

$$HP = \frac{[(H_C)(T_C)] + [(H_N)(T_N)] + [(LF_W)(W_P)]}{H_G}$$

Where:

HP	=	Horizontal pull (lb)
H_C	=	Height of primary conductor above grade (ft)
T_C	=	Transverse load of primary conductor (lb) (Use **Equation 7.1** to calculate T_C)
H_N	=	Height of neutral conductor above grade (ft)
T_N	=	Transverse load of neutral conductor (lb) (Use **Equation 7.1** to calculate T_N)
LF_W	=	Load factor for wind load (**Table 7.2**)
W_P	=	Bending moment at groundline of pole due to wind for applicable loading district (ft-lb) (Refer to **Table 5.9**)
H_G	=	Average guy attachment height

Example 7.8 demonstrates the use of Equation 7.2 to calculate the horizontal pull on a single-phase line angle structure.

Example 7.8

Given:

Loading district	=	Medium
Grade of construction	=	C
Wind span	=	400 ft
Line angle	=	36°
Pole	=	40 ft class 5, Southern Yellow Pine (SYP)
Pole-top assembly	=	A3.1
Conductor	=	1/0 ACSR 6/1 primary 2 ACSR 6/1 neutral
Design tension	=	50%
	=	2190 lb primary 1425 lb neutral

Calculate the horizontal pull:

$$HP = \frac{[(H_C)(T_C)] + [(H_N)(T_N)] + [(LF_W)(W_P)]}{H_G}$$

Continued

Example 7.8 (cont.)

First, calculate the transverse load (T_c) of the primary conductor and the neutral conductor (T_n) using **Equation 7.1**.

$T = [(LF_T)(DT)(2)(\text{Sine }(\theta/2))] + [(LF_W)(S)(W_C)]$

LF_T = Load factor for wire tension load (**Table 7.2**) = 1.10

DT = Design tension = 2190 lb primary
1425 lb neutral (given)

Sine (θ/2) = 0.3090 from **Table 7.8**

LF_W = Load factor for wind load (**Table 7.2**) = 2.20 (at crossing)

S = Wind span = 400 ft (given)

W_C = *NESC* medium loading district transverse load on conductor from **Table 5.3**. Primary = 0.2993
Neutral = 0.2720

$$T_C = [(1.10)(2190\text{ lb})(2)(0.3090)] + [(2.20)(400\text{ ft})(0.2993\text{ lb/ft})]$$
$$= 1488.76\text{ lb} + 263.38\text{ lb}$$
$$= 1752.14\text{ lb}$$

$$T_N = [(1.10)(1425\text{ lb})(2)(0.3090)] + [(2.20)(400\text{ ft})(0.2720\text{ lb/ft})]$$
$$= 968.72\text{ lb} + 239.36\text{ lb}$$
$$= 1208.08\text{ lb}$$

The next step is to determine the height of the primary and neutral above grade. From the RUS Specifications and Drawings, the A3.1 drawing shows the primary to be attached at 6 inches (0.50 feet) below the pole top. The neutral is attached at 4 feet below the primary. A 40-foot pole is set 6 feet into the ground (see **Table 5.15**). The height of each conductor above grade can be calculated:

H_C = 40 ft – (6.0 ft + 0.5 ft) = 33.5 ft

H_N = 33.5 ft – 4.0 ft = 29.5 ft

W_P = Moment due to wind on the pole. Referring to **Table 5.10**, the bending moment for a 40-foot class 5 SYP pole in the medium loading district is 1411 ft/lb.

H_G = Average guy attachment height. Since only one guy will probably be used to guy the structure, the average guy attachment height will be the same as the single guy height. RUS drawing A3.1 shows the guy attachment to be positioned at 1 ft 6 in. below the primary conductor attachment. The decimal equivalent of 1 ft 6 in. is equal to 1.5 ft. Since the height of the primary conductor was previously determined to be 33.5 ft, the guy attachment height can be calculated.

H_G = 33.5 ft – 1.5 ft = 32.0 ft

The final step is to calculate the horizontal pull:

$$HP = \frac{[(H_C)(T_C)] + [(H_N)(T_N)] + [(LF_W)(W_P)]}{H_g}$$

$$= \frac{[(33.25)(1752.14)] + [(29.25)(1208.08)] + [(2.20)(1411)]}{32.0}$$

$$= \frac{[58{,}258.66] + [35{,}336.34] + [3104.2]}{32.0}$$

$$= \frac{96{,}699.2}{32.0}$$

$$= 3021.85\text{ lb} = 3022\text{ lb}$$

Equation 7.3 is the equation for the horizontal pull on a *multiphase* line angle structure.

Equation 7.3

$$HP = \frac{[(H_B)(T_C)] + [(H_A)(T_C)] + [(H_C)(T_C)] + [(H_N)(T_N)] + [(LF_W)(W_P)]}{H_G}$$

Where:

HP	=	Horizontal pull (lb)
H_B	=	Height of B-phase conductor above grade (ft)
H_A	=	Height of A-phase conductor above grade (ft)
H_C	=	Height of C-phase conductor above grade (ft)
H_N	=	Height of neutral conductor above grade (ft)
T_C	=	Transverse load of primary conductor (lb) (Use **Equation 7.1** to calculate T_C)
T_N	=	Transverse load of neutral conductor (lb) (Use **Equation 7.1** to calculate T_N)
LF_W	=	Load factor for wind load, **Table 7.2**
W_P	=	Bending moment at groundline of pole due to wind for applicable loading district (ft-lb) (Refer to **Table 5.10**)
H_G	=	Average height of guy attachment (ft)

Example 7.9 demonstrates the use of Equation 7.3 to calculate the horizontal pull on a three-phase line angle structure.

Example 7.9

Given:

Loading district	=	Heavy
Grade of construction	=	C
Wind span	=	400 ft
Line angle	=	36°
Pole	=	50-ft class 3, Southern Yellow Pine (SYP)
Pole-top assembly	=	C3.3 with 3 guys
Conductor	=	477 ACSR 18/1 Primary 4/0 ACSR 6/1 Neutral
Design tension	=	3500 lb for 477 ACSR 2332 lb for 4/0 ACSR

Calculate the horizontal pull:

$$HP = \frac{[(H_B)(T_C)] + [(H_a)(P_C)] + [(H_C)(P_C)] + (H_N)(P_N)] + [(LF_W)(W_P)]}{H_G}$$

Continued

Example 7.9 (cont.)

Calculate the transverse load of the primary conductor (T_c) and the neutral conductor (T_n) using Equation 7.1.

$T = [(LF_T)(DT)(2)(\text{Sine }(\theta/2))] + [(LF_W)(S)(W_C)]$

LF_T = Load factor for wire tension load (**Table 7.2**) = 1.10

DT = Design tension = 3500 lb for 477 ACSR primary (given)
2332 lb for 4/0 ACSR neutral (given)

Sine (θ/2) = 0.3090 from **Table 7.8**

LF_W = Load factor for wind load (**Table 7.2**) = 2.20

S = Wind span = 400 ft (given)

W_C = *NESC* heavy loading district transverse load on conductor from **Table 5.3**
477 ACSR primary = 0.6047 lb/ft
4/0 ACSR neutral = 0.5210 lb/ft

T_C = [(1.10)(3500 lb)(2)(0.3090)] + [(2.20)(400 ft)(0.6047 lb/ft)]
= 2379.30 lb + 532.14 lb = 2911.44 lb = 2911 lb

T_N = [(1.10)(2332 lb)(2)(0.3090)] + [(2.20)(400 ft)(0.5210 lb/ft)]
= 1585.29 + 458.48 = 2043.77 lb = 2044 lb

Calculate the horizontal pull using Equation 7.3.

$$HP = \frac{[(H_B)(T_C)] + [(H_A)(T_C)] + [(H_C)(T_C)] + [(H_N)(T_N)] + [(LF_W)(W_P)]}{H_G}$$

From RUS drawing C3.3, determine the height of each conductor above grade.

H_B = 42.50 ft
H_A = 38.50 ft
H_C = 34.50 ft
H_N = 30.50 ft

From **Table 7.1**, determine the average guy attachment height for a C3.3 assembly with 3 guys on a 50-foot pole.

H_G = 37.0 ft

From **Table 5.10**, determine the moment due to wind on the pole for a 50-foot class 3 SYP pole.

W_P = 2766 ft-lb

$$HP = \frac{[(42.50)(2911)] + [(38.50)(2911)] + [(34.50)(2911)] + [(30.50)(2044)] + [(2.20)(2766)]}{37.0}$$

= 10,936 lb

Once the horizontal pull has been calculated, the next step is to calculate the total guy load at the anchor. As stated in the first part of this subsection, the total guy load is greater than the horizontal pull and is determined by the height of the guy attachment and length of the guy lead.

The total guy load can be calculated using Equation 7.4.

Example 7.10 demonstrates the calculation of the total guy load for the horizontal pull calculated in **Example 7.9**.

The equation for the total guy load is:

Example 7.10

Given:

Horizontal pull = 10,936 lb (**Example 7.9**)
Average guy attachment height = 37.0 ft (**Example 7.9**)
Average guy lead = 24 ft

$$TGL = HP\left(\frac{\sqrt{H_G^2 + L_G^2}}{L_G}\right)$$

$$= 10{,}936\left(\frac{\sqrt{37^2 + 24^2}}{24}\right)$$

$$= 20{,}096 \text{ lb}$$

Equation 7.4

$$TGL = HP\left(\frac{\sqrt{H_G^2 + L_G^2}}{L_G}\right)$$

Where:

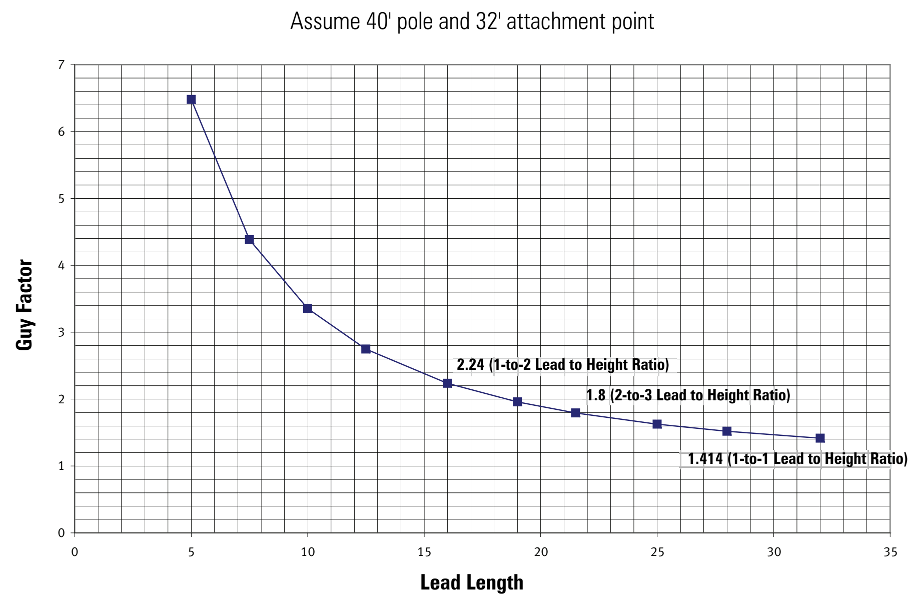
TGL = Total guy load (lb)
HP = Horizontal pull (lb)
H_G = Average height of guy attachment (ft)
L_G = Average length of guy lead (ft)

As stated previously in this section, the horizontal pull can be multiplied by a "guy factor" to determine the total guy load. Equation 7.4 performs this procedure. To calculate the guy factor, use only the right-hand portion of Equation 7.4 as shown in Equation 7.5.

Equation 7.5

$$\text{Guy factor (GF)} = \left(\frac{\sqrt{H_G^2 + L_G^2}}{L_G}\right)$$

FIGURE 7.22: Guying Factor Graph



Example 7.11 demonstrates the calculation of guy factors.

Figure 7.22 illustrates the effect of the lead length on the guy factor. The horizontal pull is multiplied by the guy factor to determine the total load on the guy and anchor assemblies. Higher multipliers mean more guys and anchors. Figure 7.22 shows that reducing the guy lead from 32 feet to 5 feet, increases the guy factor from 1.41 to nearly 6.5. It is apparent from this illustration why guy leads shorter than 1-to-2 are not generally recommended.

DEADEND GUYING CALCULATIONS

Calculation of the horizontal pull for a deadend structure is similar to the procedure for line angle structures. However, only the longitudinal conductor tension is used to determine the pull produced by the conductor. The pull due to tension in one conductor is calculated using Equation 7.6.

Equation 7.7 is the equation for calculating total horizontal pull for a complete single-phase structure. In addition to the longitudinal load of the conductor, it also takes into consideration the height of the conductors above grade and the height of the guy attachment.

Example 7.11

Calculate the guy factors for a 1-to-1, 2-to-3, and 1-to-2 lead to height ratio using the lead and height values shown in Figure 7.5.

1-to-1 ratio: Height = 30 ft
Lead = 30 ft

$$GF = \frac{\sqrt{30^2 + 30^2}}{30} = 1.41$$

2-to-3 ratio: Height = 30 ft
Lead = 20 ft

$$GF = \frac{\sqrt{30^2 + 20^2}}{20} = 1.80$$

1-to-2: Height = 30 ft
Lead = 15 ft

$$GF = \frac{\sqrt{30^2 + 15^2}}{15} = 2.24$$

Equation 7.6

$$P = (LF_L)(DT)$$

Where:

- P = Pull due to tension in the conductor (lb)
- LF_L = Load factor for longitudinal strength at deadends (Refer to Table 7.2)
- DT = Design tension of conductor (lb)

Equation 7.7

$$HP = \frac{[(H_C)(P_C)] + [(H_N)(P_N)]}{H_G}$$

Where:

- HP = Horizontal pull (lb)
- H_C = Height of primary conductor above grade (ft)
- P_C = Longitudinal pull on primary conductor (lb) (Use Equation 7.6 to calculate P_C)
- H_N = Height of neutral conductor above grade (ft)
- P_N = Longitudinal pull of neutral conductor (lb) (Use Equation 7.6 to calculate P_N)
- H_G = Average height of guy attachment (ft)

Equation 7.8 is the formula for calculating total horizontal pull on a multiphase deadend structure.

Equation 7.8

$$HP = \frac{[(H_B)(P_C)] + [(H_A)(P_C)] + [(H_C)(P_C)] + [(H_N)(P_N)]}{H_G}$$

Where:

HP	=	Horizontal pull (lb)
H_B	=	Height of B-phase conductor above grade (ft)
H_A	=	Height of A-phase conductor above grade (ft)
H_C	=	Height of C-phase conductor above grade (ft)
P_C	=	Longitudinal pull of primary conductor (lb) (Use **Equation 7.6** to calculate P_C)
H_N	=	Height of neutral conductor above grade (ft)
P_N	=	Longitudinal pull of neutral conductor (lb) (Use **Equation 7.6** to calculate P_N)
H_G	=	Average height of guy attachment (ft)

Example 7.12 demonstrates the use of Equation 7.8 to calculate the total horizontal pull and total guy load for a three-phase deadend structure.

Example 7.12

Given:

Loading district	=	Heavy
Grade of construction	=	C
Wind span	=	400 ft
Pole	=	50-ft class 3, Southern Yellow Pine (SYP)
Pole-top assembly	=	C5.3 with 3 guys
Conductor	=	477 ACSR 18/1 Primary 4/0 ACSR 6/1 Neutral
Design tension	=	3500 lb for 477 ACSR 2332 lb for 4/0 ACSR
Guy lead	=	24 ft

Calculate the pull due to tension in the primary using **Equation 7.6**:

$P_C = (LF_L)(DT)$

P_C = Pull due to tension in the primary conductor (lb)

LF_L = 1.10 (**Table 7.2**)

DT = 3500 lb (given)

$P_C = (1.10)(3500 \text{ lb}) = 3850 \text{ lb}$

Calculate the pull due to tension in the neutral conductor using **Equation 7.6**:

$P_N = (LF_L)(DT)$

P_N = Pull due to tension in the neutral conductor (lb)

LF_L = 1.10 (**Table 7.2**)

DT = 2332 lb

$P_N = (1.10)(2332 \text{ lb}) = 2565 \text{ lb}$

Continued

Example 7.12 (cont.)

From RUS Drawing C5.3, determine the height of each conductor above grade:

$H_B = 42.50$ ft
$H_A = 38.50$ ft
$H_C = 34.50$ ft
$H_N = 30.50$ ft

From **Table 7.1**, determine the average guy attachment height for a C5.3 assembly with 3 guys on a 50-foot pole:

$H_G = 37.0$ ft

Calculate the total horizontal pull:

$$HP = \frac{[(H_B)(P_C)]+[(H_A)(P_C)]+[(H_C)(P_C)]+[(H_N)(P_N)]}{H_G}$$

$$= \frac{[(42.50)(3850)]+[(38.50)(3850)]+[(34.50)(3850)]+[(30.50)(2565)]}{37.0}$$

$$= 14{,}630 \text{ lb}$$

Calculate total guy load using **Equation 7.4**:

TGL = Total guy load (lb)

$$TGL = HP\left(\frac{\sqrt{H_G^2 + L_G^2}}{L_G}\right)$$

HP = Total horizontal pull (previously calculated) = 14,630 lb
H_G = Average guy attachment height (**Table 7.1**) = 37.0 ft
L_G = Length of guy lead (given) = 24 ft

$$TGL = 14{,}630\left(\frac{\sqrt{37^2 + 24^2}}{24}\right)$$

$$= 26{,}822 \text{ lb}$$

TAP GUYING CALCULATIONS

The horizontal pull for a tap guy should be calculated for *both* of the following conditions:

1. Wind blowing perpendicular to the tap line with the conductors at maximum design tension (Figure 7.23)
2. Wind blowing perpendicular to the tangent line conductors at maximum transverse loading and the tension in the tap line conductors at the same temperatures with no wind (**Figure 7.24**)

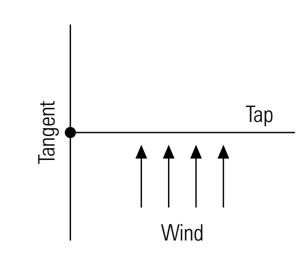


FIGURE 7.23: Wind Blowing Perpendicular to Tap Line.

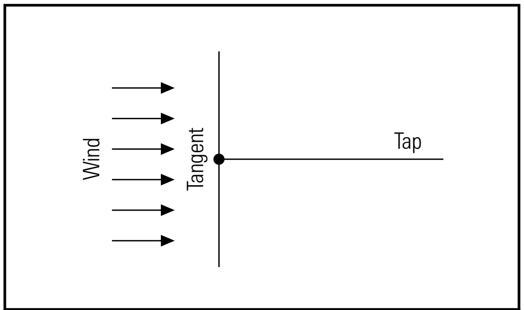


FIGURE 7.24: Wind Blowing Perpendicular to Tangent Line.

The strength of the guys and anchors must be sufficient to support the greatest amount of load produced by either of the above conditions.

For condition 1, the total horizontal pull (HP_{TAP1}) is simply the deadend guy horizontal pull shown in **Equation 7.7**:

$$HP_{TAP1} = \frac{[(H_C)(P_C)] + [(H_N)(P_N)]}{H_G}$$

For condition 1, the total horizontal pull (HP2) is determined by the sum of equations as follows.

First, calculate the horizontal pull produced by the transverse loading of the tangent line conductors and pole using **Equation 7.3**:

$$HP_{TANGENT} = \frac{[(H_B)(T_C)] + [(H_A)(T_C)] + [(H_C)(T_C)] + [(H_N)(T_N)] + [(LF_W)(W_P)]}{H_G}$$

If there was an angle on this line, the transverse load would include a tension component. However, for this example, the line is straight (i.e., tangent line). Therefore, only the load produced by wind must be calculated for the transverse load (T) to be used in the previous equation.

$$T = (LF_W)(S)(W_C)$$

The next step, for condition 2, is to calculate the horizontal pull (HP_{TAP2}) produced by the longitudinal loading of the tap conductors using **Equation 7.7**:

$$HP_{TAP2} = \frac{[(H_C)(P_C)] + [(H_N)(P_N)]}{H_G}$$

Since the wind is not blowing perpendicular to the tap line in condition 2, the longitudinal tension in the tap conductors is equal to the tension produced at the loaded condition with 0 lb of wind.

The total horizontal pull can now be determined:

$$HP2 = HP_{TANGENT} + HP_{TAP2}$$

After determination of the greatest amount of horizontal pull produced by either condition 1 or 2, the total guy load can be calculated using **Equation 7.4**:

$$TGL = HP\left(\frac{\sqrt{H_G^2 + L_G^2}}{L_G}\right)$$

8 Joint Use

In This Section:

Instead of constructing a completely new pole line, it may be desirable for the cooperative to attach its assemblies and conductors to existing distribution structures owned by another utility. Likewise, it is common for communications, cable TV companies, and broadband to request attachment of their equipment to the cooperative's structures. This is called joint use. This is becoming more frequent, largely because of a desire to get broadband service to more customers.

Joint use of transmission line structures is generally not recommended because of high cost and stringent and highly technical design requirements. Distribution circuits cannot be added to existing transmission structures unless they were originally designed for underbuild. If it becomes necessary to attach distribution lines to transmission structures not originally designed to accept the underbuild, the transmission poles may require replacement. The staking technician should refer the designing of underbuild on a transmission line to the cooperative or consulting engineer.

Strength Requirements

Poles, guys, and anchors selected for use on joint-use structures must meet the strength requirements of the highest grade of construction for the existing circuit supported by the pole. In other words, if the existing line is built to grade B specifications, any poles, guys, and anchors that are required to support the new joint-use assemblies and conductors must be of grade B also. The assemblies that support the new joint-use conductors, such as crossarms, pins, and suspension insulators, only need to meet the normal *NESC* grade of construction strength requirements.

Crossarms must meet only the strength requirements for the grade of construction required for support of the conductors. (Refer to *NESC* Table 242-1 for applicable grades of construction.)

8

Clearance Requirements

VERTICAL CLEARANCE TO GROUND

Vertical clearances will generally be controlled by the underbuilt conductors. All attachments must meet the vertical clearance requirements of Table 232-1 of the *NESC*. A condensed version can be found in **Table 3.8** of this manual.

VERTICAL CLEARANCE TO UNDERBUILD AT SUPPORTS

The required vertical clearances between conductors of different utility lines are given in **Table 3.5**. The clearance between the supports may have to be increased beyond the code allowance to provide for the required vertical clearance in midspan. This is due to the sag differential. Figure 8.1 illustrates the increased vertical clearance at supports.

VERTICAL CLEARANCE TO UNDERBUILD AT ANY POINT IN THE SPAN

The required vertical clearance at any point along the span is given in **Table 3.6**, Required Vertical Clearance at Any Point in the Span from Distribution Conductors to Underbuild Conductors.

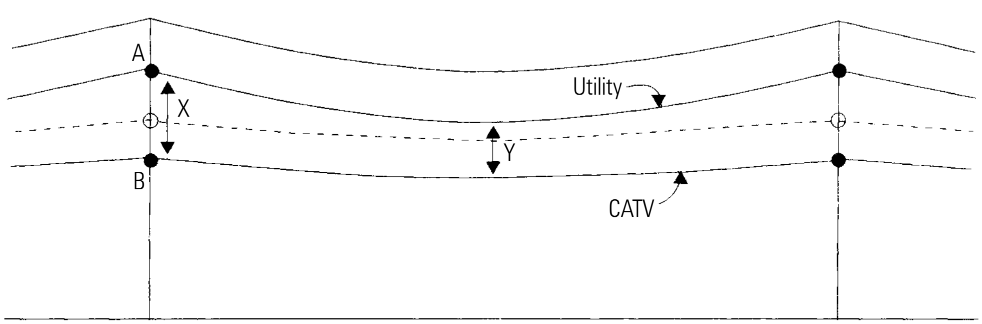
Conditions Under Which Clearances Apply

The clearances apply for the final sag conditions. The condition (a or b below) that yields the least vertical clearance in the span is the condition to be used for determining span clearance:

a. Upper conductor at a temperature of 120°F or its maximum design conductor temperature, no wind. The lower conductor at the ambient temperature of the upper conductor, no wind.
b. Upper conductor at a temperature of 32°F, no wind, with the radial thickness of ice for the applicable loading district as shown in **Table 3.1**. The lower conductor at a temperature of 32°F, no ice, and no wind.

CLIMBING SPACE

The *NESC* requires that climbing space through the lower circuits be preserved on one side or one quadrant of the pole from the ground to the top of the pole. Working space should be provided in the vicinity of the crossarms. Jumpers should be kept short enough to prevent their being displaced into the climbing space.



The clearance (X) between supports A and B must be such that clearance (Y) between conductors at midspan will meet the *NESC*.

Sometimes clearance (X) must be increased beyond *NESC* values to provide for adequate clearance (Y) at midspan.

The dashed line illustrates the position of the lower conductor attached at the required *NESC* clearance between supports. As can be seen, midspan clearance is less than required *NESC* clearance at any point in the span.

FIGURE 8.1. Midspan Vertical Clearance

Joint-Use Construction on Different Utility Distribution Lines

STEP 1: Determine the route of the joint-use line section.

The first step in staking the joint-use line section is to determine the route. This may be as simple as preparing a sketch of the proposed line. The following items should be included in the preliminary work:

- Utility structure identification numbers of the existing line
- Names of roads and towns along the proposed route
- Detailed map locations or coordinates

STEP 2: Schedule a pre-staking meeting with the other utility.

The staking technician should notify the other utility of the utility's desire to install joint-use pole-top assemblies on other utility's poles and schedule a meeting to thoroughly discuss the details. This meeting should also include a survey of the site of the project. The following items should be obtained and/or recorded during the meeting:

- Names and phone numbers of contact personnel
- The design requirements and clearances required by the owner of the existing line
- Necessary forms and documents required by the other utility to be completed prior to construction

STEP 3: Determine the position on the pole.

The position of the cooperative's pole-top assembly on the joint-use pole must be determined. Basically, this means whether the cooperative will be located on the top of the pole or as an underbuild below the existing utility assemblies. Several factors dictate the position of the proposed joint-use pole-top assembly:

- The service area of the utility: Utilities wanting attachment to poles that are not in their service area are usually required to be express feeders located at the top of the pole.
- Territorial agreements: Agreements specifying the service areas may also be in effect, thus specifying the position on the pole.
- A joint-use contract: The two utilities may have a joint-use contract specifying pole attachment positions.

STEP 4: Determine the type of pole-top construction.

The next step for the staking technician is to select the pole-top assemblies and guys and anchors to support the joint-use conductors. The size and type are determined by the following:

- Grade of construction
- Conductor size and type
- Design tension and resulting sag
- Right-of-way constraints

Once the assemblies are selected, the staking technician can determine if additional pole height or upgrade in pole class is required to accommodate the joint-use conductors.

The vertical separation between different utilities is shown in **Table 3.5**.

STEP 5: Present the formal request for joint use to the other utility.

After the previous items have been completed to the satisfaction of the cooperative, the formal request for joint use may then be presented to the owner of the existing line. This request should contain the following information:

- Completed forms and documents required by the owner
- A description of the utility poles or structures proposed for attachment
- A description of the proposed construction assemblies

- Staking sheets and drawings
- Sag charts for the cooperative's proposed conductors and ruling spans of the project
- An agreement for compensation for the make-ready construction done by the owner and possible rental charges

STEP 6: Receive approval to proceed with construction.

Once approval has been received to begin construction, all applicable documents and staking sheets should be collected and filed. The job is then ready to be released for construction.

Communication, Broadband, or Cable TV Joint-Use Construction on Existing Cooperative Structures

Communication, broadband, and cable television attachments are becoming standard fixtures on utility pole lines. If the line was not originally designed for the attachments, they could overload the poles or cause clearance problems. The owner must also take into consideration the probable attachment of communication, broadband, and television cables on any new line to be constructed or any existing line to be upgraded. Depending on the size of the cables, significant changes in pole size or span length may be required to adequately support the future users' equipment

ATTACHMENT TO EXISTING COOPERATIVE POLES

The attachment of communication, broadband, or TV cables to existing distribution poles generally cannot be denied. These attachments can cause problems for the pole owner. Sometimes, attachments are made without permission, and the construction does not meet applicable codes and specifications. On the positive side, the attachment does provide a source of revenue for the cooperative through rental charges. Cooperative members usually desire the service provided by the telephone, broadband, or cable TV company.

CONTROLLING POLE ATTACHMENTS

Often, the staking technician is given the responsibility of controlling the communication, broadband, or cable TV attachments. To effectively control these attachments, the following procedures are suggested:

- Prepare, revise, or obtain a good joint-use agreement
- Educate other pole users to the joint-use procedures
- Require pole users to obtain a permit for their attachments
- Establish a precedent for proper construction
- Survey existing lines for unauthorized attachments

DETERMINING MAKE-READY CONSTRUCTION

To determine the construction required to make the cooperative's structures ready for the attachment of the joint-use equipment, the staking technician may be required to inspect and stake the project. The first step is to schedule a preliminary ride-through survey of the route. It is recommended that the ride-through survey be conducted with the joint-use operator (user). Then obtain maps or drawings from the user showing the poles on which attachments are to be placed.

Required structure changes to make the line ready for the new attachments are then staked. This work is best done by the cooperative or the cooperative's consultant. During the staking, each affected structure must be identified and evaluated for the new attachment. Staking sheets are then prepared along with a cost estimate for the make-ready construction.

MAKE-READY STAKING CONSIDERATIONS

When performing make-ready staking, the staking technician should evaluate the existing structure with regard to the following factors:

- Clearances
  - Vertical above ground, roads, rails, and water, etc.
  - Vertical below utility lines, cables, and equipment
  - Any other applicable *NESC* clearance requirement

- Pole strength
  - Wind load on cables
  - Tension
  - Pole deterioration
- Span length
  - Wind load on cables
  - Cooperative design standards
  - Operational problems

FUTURE JOINT-USE CONSIDERATIONS FOR NEW CONSTRUCTION

When staking new lines or rebuilding existing lines, consider future joint-use attachments. It may be prudent to select pole sizes to accommodate this equipment even though a formal request has not yet been made. The following are suggestions to aid the cooperative in its decision to construct new lines to accommodate joint-use equipment:

- Make inquiries to potential users:
  - Do they desire future attachment?
  - Will the cooperative be compensated for the necessary additional height and strength?
- Research the pole attachment agreement:
  - Does it already require additional height or strength?
  - Does it define the space on the pole for the potential user?
- Determine what effects future make-ready construction will have on current design:
  - Will poles be required to be set in midspan for clearance and, thus, alter the ruling span?
  - Will random increased pole heights cause the grading of the line to be undesirable?
- Assume future joint use and design accordingly:
  - If the area is urban, the cooperative can assume attachments will eventually occur. Even if the area is rural, space on poles may be necessary for advanced communication facilities.

Some of the above decisions must be made by the cooperative's management based on costs and policy. However, the staking technician should be aware of areas and instances where joint use may occur and be prepared to make an accurate field evaluation. This evaluation can then be used to make the decision to either go ahead and build for joint use or wait and perform make-ready construction as needed.

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9 Staking for Unit Price Contracts

In This Section:

Accuracy

There are two commonly used distribution line construction contracts: RUS Form 830 contract (site specific) and RUS Form 790 contract (non–site specific). RUS Bulletin 1726I-602 provides attachments that can be used with the 830 contract and 790 contract. Rules for determining which contract form to use can be found in Title 7, Code of Federal Regulations, Part 1726 (7 CFR 1726).

Staking of new distribution lines and/or conversion of existing lines for inclusion in an RUS construction contract requires greater detail and precision than staking performed for routine construction by in-house crews. A contractor determines the bid price based on the units, specifications, and special conditions listed in the contract. Errors in the number and types of units and unclear specifications result in increased construction cost because of change orders and possible waste of materials. Once a line section is released to the contractor, it will be constructed according to the data on the staking sheet. If a stake is incorrectly placed or a pole-top assembly is incorrectly specified, the contractor must be paid as set out by the contract to reset the pole or change the assembly.

Units

The cost of work done by the contractor is usually based on unit prices: "LCR" = removal construction assembly units and "LCN" = new construction assembly units. Therefore, all work must have a unit designation and be included in the contract. Units other than those shown in the *RUS Specifications and Drawings* must be described in detail, given a unit designation, and shown on the staking sheet.

For example, repulling of an existing guy ("LCN" Unit) should be designated as follows:

> M—Repull Guy: Repull and tighten existing guy to specification. Includes removal and installation of existing clamps and connectors as required.

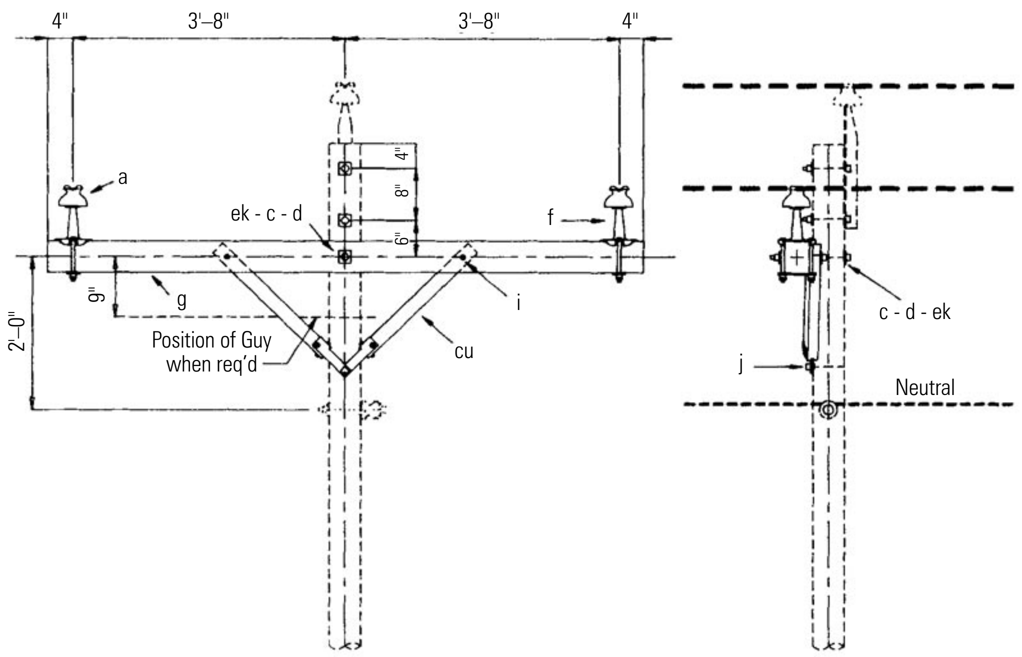
Sometimes, to clarify the work to be done, it is necessary to rename a standard assembly that has been altered for use in the conversion of an existing assembly.

For example, in the conversion of an existing A1.1 assembly to a C1.11 assembly, to reuse the existing pole-top pin and neutral assembly without removing them, a B1.11X could be specified as an "LCN" unit only. The "X" suffix is an arbitrary designation. In this case it denotes that the assembly is the standard B1.11 but without the neutral assembly. The resulting pole-top assembly includes the crossarm, braces, insulators, and pins. Addition of the altered B1.11 assembly (B1.11X) to the existing A1.1 assembly will result in a final assembly that conforms to the requirements of a C1.11. The use of the "X" suffix and its description must be included in the contract in the "Special Units and Drawings" section so that the contractor knows what it means.

Figure 9.1 illustrates the B1.11X assembly as used to convert an existing A1.1 to a C1.11.

If the cooperative has obtained permission from RUS to use special units, the drawings and specifications for these "special" units must also be included in the contract under the "Special Units and Drawings" section.

When staking for the contract work, the staking technician should also make notes of any non-standard or special removal units. Keeping careful note of special units, both installed and removed, will greatly expedite the preparation of the contract. It will also prevent additional fieldwork at the last minute to find an odd unit that must be described before the contract can be completed.



ITEM	NO.	MATERIAL	ITEM	NO.	MATERIAL
a	2	Insulator, pin type			
c	1	Bolt, machine, 5/8" × required length	cu	2	Brace, wood 28"
d	4	Washer, square 2 1/4"			
f	2	Pin, crossarm, steel, 5/8" × 10 3/4"	ek		Locknuts, as required
g	1	Crossarm, 3 5/8" × 4 5/8" × 8'–0"			
i	2	Bolt, carriage, 3/8" × 4 1/2"			
j	1	Screw, lag, 1/2" × 4"			

DESIGN LIMITS Max. transverse load 500 lb per conductor Max. line angle within load limits: 5°	12.47/7.2 kV TWO-PHASE CROSSARM CONSTRUCTION SINGLE PRIMARY SUPPORT	B1.11X

FIGURE 9.1: An Example of Special Unit Specification.

Contract Specifications

The staking technician must understand the standard contract specifications and the descriptions of what removal or installation of a certain assembly entails. This is necessary to accurately specify the correct unit of construction, eliminate duplication of work, and achieve the desired result at the lowest possible cost. The following example is an excerpt from the RUS Form 830 contract that describes the removal of a pole-top assembly:

> "Pole-top assemblies. The unit of removal of pole-top assemblies includes, in addition to the removal of the construction assembly itself, any necessary handling, resagging, and retying of conductors in those cases where an existing pole-top construction assembly will be removed and replaced by a new pole-top construction assembly and where any existing conductor is to be reused." It also includes, "any holding or handling of mainline or tap conductors at tap lines, angles, and deadends where such is involved, and reinstalling of such conductor in accordance with the specifications."

Note that the removal of the pole-top assembly includes more than just the simple removal of the assembly. It also includes the handling of the conductors. It is important to understand this so that the owner will not pay unnecessarily for handling of the conductors.

Staking Sheets

Staking sheets should be clear and detailed. Sketches and notes regarding the structures and environment are helpful and greatly clarify the work to be done. Removal (LCR) units and install (LCN) units should be shown for each pole on separate lines labeled "LCR" and "LCN." Units appearing on these lines should only be for actual work to be done. Existing units to be left in place should not appear on these lines. If the cooperative desires the existing units to be inventoried and appear on the staking sheet, an additional line labeled "E" should be included for each structure.

Stakes

All stakes must be set prior to releasing the staking sheets for construction of a particular work order or line section to the contractor for construction. Stakes should be set for all poles, anchors, or any other equipment used in the line section. It is recommended that stakes be labeled only with the staking sheet pole reference number and the cooperative's initials such as EMC. If a change in pole size or assembly is required, the staking technician need only alter the staking sheet. A field correction will not need to be made. Other information—such as pole size or assembly—if incorrectly marked on the stake, will cause confusion and can lead to an unnecessary change order.

All stakes should be clearly marked and flagged with brightly colored flagging. Since significant delays can occur between the staking of the line and actual construction, it is recommended that stakes be driven deeply into the ground to preserve their locations.

Sometimes it may be prudent or necessary to modify RUS standard distribution assemblies, such as the B1X in this example. Also, as discussed in RUS Bulletin 1728F-804, Specifications and Drawings for 12.47kV Line Construction, cooperatives may develop and use assemblies similar to RUS assemblies without RUS approval. These would be minor changes, such as neutral spacing, heavy-duty braces, bracket types, types of connectors, etc. The Staking Technician should consult with the system engineer for any modifications to RUS construction specifications.

9

Sample RUS Form 830 Contract Documents

Following are typical examples of:

- Staking sheet (Figure 9.2)
- Sketch of line (**Figure 9.3**)
- Removal Assembly Units List (**Figure 9.4**)
- New Assembly Units List (**Figure 9.5**)
- Special unit descriptions (**Figure 9.6**)
- Special drawing—Bog Shoe Assembly M31, M31-1 (**Figure 9.7**)

LCR = REMOVE
LCN = INSTALL

STAKING SHEET

BIG CREEK ELECTRIC COOPERATIVE
SOUTH CAROLINA 125

BILLY NANCE LINE

12/5/2009

Pole No.		Poles H - C	Primary Assembly	Primary Span	Primary Wire	Transformer	Ground	Guy	Anchor	Secondary Assembly	Secondary Span	Service Assembly	Service Span	Secondary or Service Wire	Miscellaneous
1	LCR	SOP 35-6	C5.31 A5.1					(2) E1.1	(2) F1.8						
1	LCN	40-5	C6.31L				H1.1	(2) E1.1	(2) F1.8 (GUY WIRE = 3/8" HS STEEL)						A1.01
2	LCR														
2	LCN	40-5	C1.11	250	(3) 1/0 ACSR (1) 2 ACSR		H5.1								M31-1
3	LCR		A5.1	500	(2) 4 ACSR	G1.2.10		(2) E1.1							
3	LCN		B1.11X A5.2	250	(3) 1/0 ACSR (1) 2 ACSR	G1.2.15		(1) E1.1		(USE 1ST FUSE IN CUTOUT)					M - REPULL GUY S1.01 P1.01
4	LCR	35-6	A5.1	300	(2) 4 ACSR	G1.3.15		(1) E1.1	(1) F1.8						
4	LCN	40-4	C5.71L	300	(3) 1/0 ACSR (1) 2 ACSR	G3.3.15,15,15	H1.1	(2) E1.1	(2) F1.8	K1.1					
4L1	LCR	30-6								J1.1	80			(1) 2 TPX	
4L1	LCN	35-6								J1.1	80			(1) 1/0 QPX	
4L2 (STORE)	LCR											K2.2	65	(1) 2 TPX	
4L2 (STORE)	LCN											K3.2	65	(1) 1/0 QPX	

FIGURE 9.2: Completed Staking Sheet.

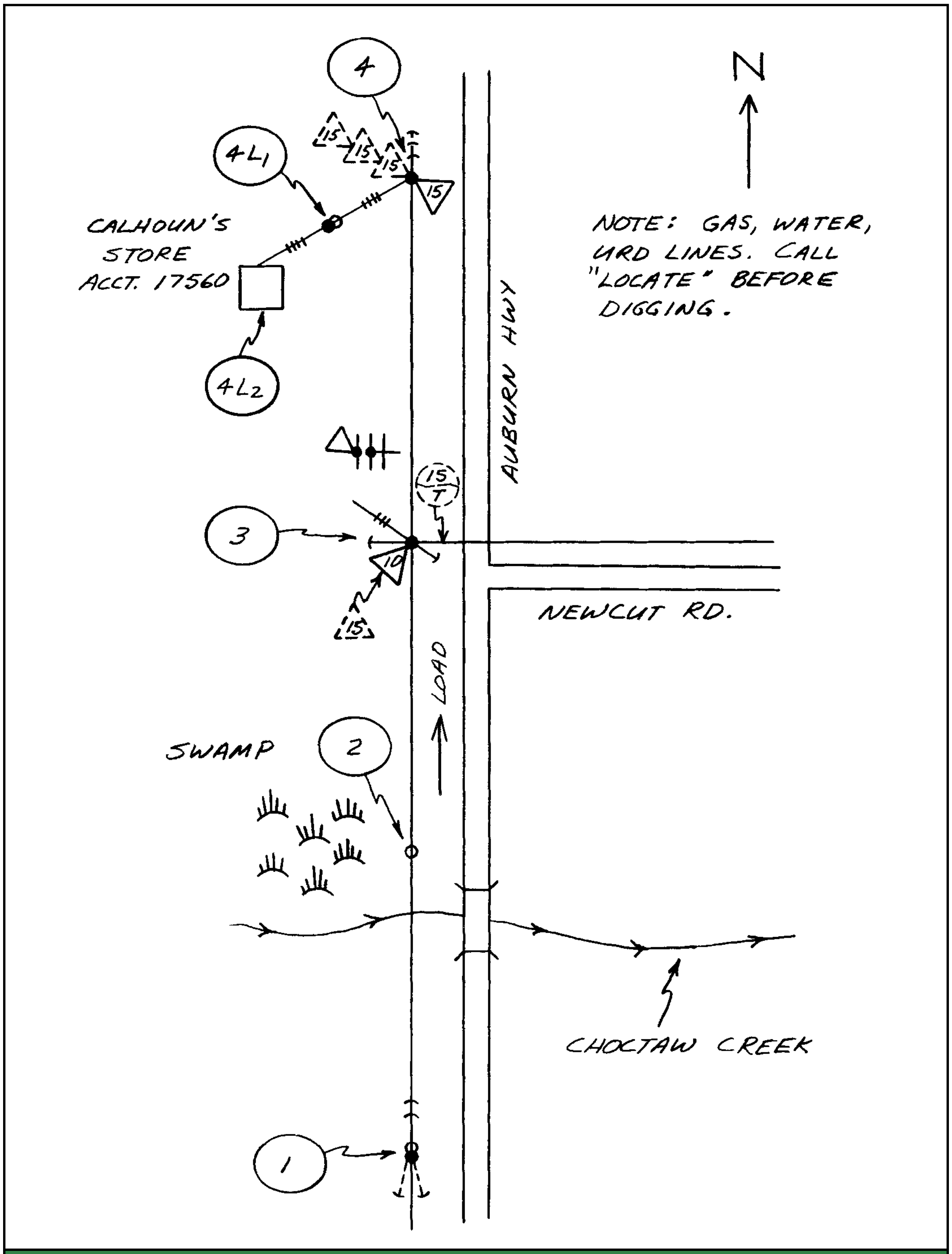


FIGURE 9.3: Sketch of Line.

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DISTRIBUTION CONSTRUCTION ASSEMBLY UNITS--LINE CHANGES

Part LCR--REMOVAL CONSTRUCTION ASSEMBLY UNITS

UNIT NO.	NO. OF UNITS	LABOR	
		Unit Price	Extended Price
LCR 30' POLE	1		
LCR 35' POLE	1		
LCR A5.1	3		
LCR C5.31	1		
LCR D#4 ACSR	1.6		
LCR D#2 TPX	0.145		
LCR E1.1	5		
LCR F1.8	3		
LCR G1.2.10	1		
LCR G1.3.15	1		
LCR J1.1	1		
LCR K2.2	1		
LCR SOP	1		
TOTAL Part LCR--Removal Construction Assembly Units			

FIGURE 9.4: Removal Assembly Units List.

DISTRIBUTION CONSTRUCTION ASSEMBLY UNITS--LINE CHANGES

Part LCN--NEW CONSTRUCTION ASSEMBLY UNITS

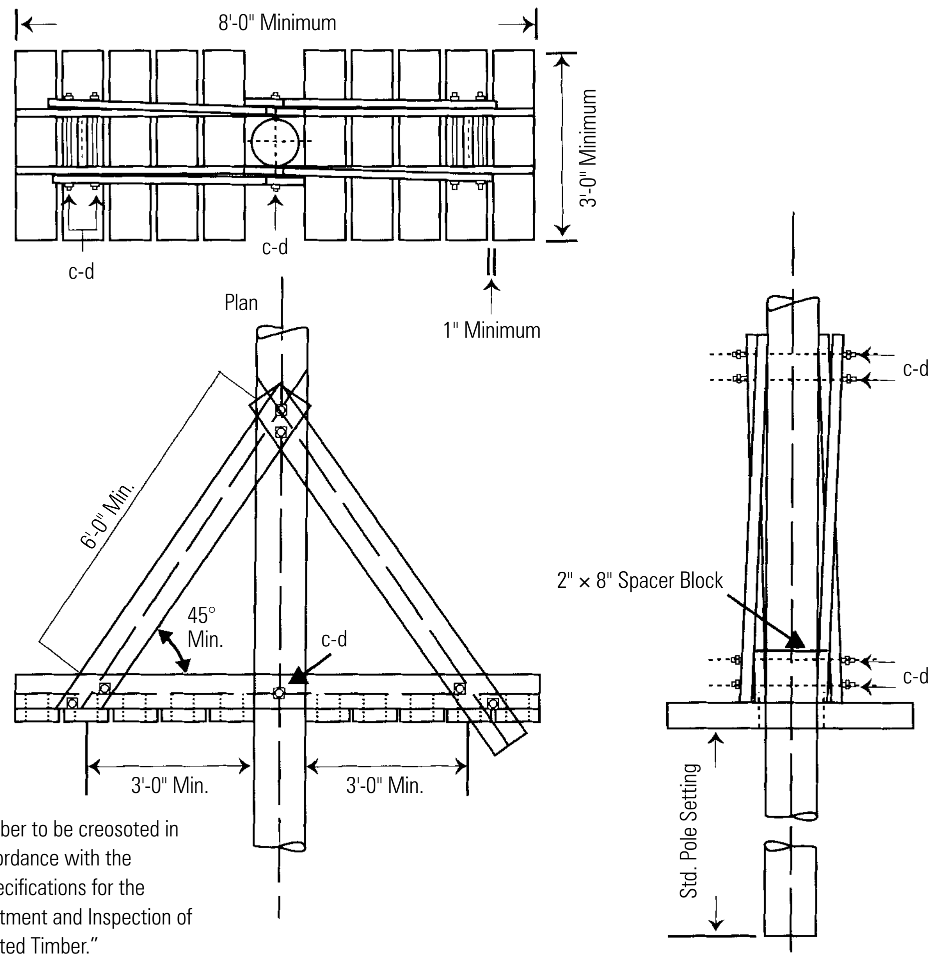
UNIT NO.	NO. OF UNITS	LABOR	
		Unit Price	Extended Price
LCN 35-6	1		
LCN 40-4	1		
LCN 40-5	2		
LCN A1.01	1		
LCN A5.2	1		
LCN B1.11X	1		
LCN C1.11	1		
LCN C5.71L	1		
LCN C6.31L	1		
LCN D#1/0 ACSR	2.4		
LCN D#2 ACSR	0.8		
LCN D#1/0 QPX	0.145		
LCN E1.1	5		
LCN F1.8	4		
LCN G1.2.15	1		
LCN G3.3.15,15,15	1		
LCN J1.1	1		
LCN K1.1	1		
LCN K3.2	1		
LCN H1.1	2		
LCN H5.1	1		
LCN P1.01	1		
LCN S1.01	1		
LCN M31-1	1		
LCN REPULL GUY	1		
TOTAL Part LCR--Removal Construction Assembly Units			

FIGURE 9.5: New Assembly Units List.

List of Non-Standard Units Not Explicit in the Contract and List of Special Drawings

"LCR"	"LCR" prefix indicates Line Construction Unit to be removed.
"LCN"	"LCN" prefix indicates Line Construction Unit (NEW) to be installed.
"X"	"X" suffix indicates standard unit less neutral assembly.
M31-1	Bog shoe assembly. Drawing attached.
SOP	Saw off pole. Saw existing pole off above telephone/CATV or indicated assembly.
M-REPULL GUY	Repull and tighten existing guy to specification. Includes removal and installation of existing clamps and connectors as required.

FIGURE 9.6: Special Unit Descriptions.



Note:
Lumber to be creosoted in accordance with the "Specifications for the Treatment and Inspection of Treated Timber."

Item	No.	Material	Item	No.	Material
c	7	Bolt, machine, 5/8" x required length		4	Lumber, 2" x 8" x 7'-0", creosoted
d	14	Washer, 2 1/4" x 2 1/4" x 3/16", 13/16" hole		10	Lumber, 2" x 8" x 3'-0", creosoted
bp		Nail, 20d.		2	Spacer block, 2" x 8", creosoted
	2	Lumber 2"x 8" x 8'-0", creosoted			

BOG SHOE ASSEMBLY

No.	Revision	Date	Scale: 1/2=1'-0"		Date:
1	Reissued	8-56			M31-1

FIGURE 9.7: Special Drawing—Bog Shoe Assembly, M31, M31-1.

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10 Sizing Transformer and Service

In This Section:

A staking technician is often responsible for extending the distribution system to provide service to a new consumer or group of consumers. In addition to learning the mechanical requirements of staking, the technician must also have an understanding of sizing transformers based on residential loads and of how to determine the proper length of service cables within voltage drop limitations.

Rule-of-thumb lookup tables are provided for easy reference but should not be used as a substitute for tables and procedures that may already be in place at the cooperative. Many different procedures are used in the industry for sizing transformers and services. The approach presented in this section is widely applicable and generally conservative.

The complexity of this subject is presented in a simple overview for general understanding. Optional considerations such as losses and common underground secondary conductors are not presented. Equations used to derive the lookup tables are contained in this section for reference, but guidance should be sought from the system engineer before applying these equations.

Transformer Loading

To size a transformer, it is necessary to understand the thermal loading characteristics of a transformer. ANSI C57.12.20 is the industry standard used to rate the size of a pole-mounted transformer. A transformer is designed to carry its rated load continuously over its expected lifetime at an ambient temperature of 86°F without exceeding an average winding temperature rise of 149°F. Industry experience has shown that normal life expectancy under these conditions should be at least 30 years. **Table 10.1** is a list of standard pole-mounted transformer ratings as defined by ANSI C57.12.20.

One of the important considerations in applying load to a transformer is its ability to dissipate or expel the heat inside itself that is caused by the load current running through the transformer windings. The outside ambient temperature plays a significant role in cooling the transformer. So, the hotter it is outside, the less the transformer can cool itself, and, conversely, the cooler it is outside, the more the transformer can cool itself. Thus, it is possible to get more kVA load through a transformer in the winter than in the summer.

Other factors to consider in loading trans-

TABLE 10.1: Ratings for Single-Phase Overhead Distribution Transformers. Source: ANSI C57.12.20-2017.

Single-Phase Transformers	Low-Side Voltage Ratings in Volts
10 kVA	120/240
15 kVA	120/240
25 kVA	120/240
37.5 kVA	120/240
50 kVA	120/240
75 kVA	120/240
100 kVA	120/240
167 kVA	120/240
250 kVA	120/240
333 kVA	120/240
500 kVA	120/240

formers include the duration of the peak load and the level of preloading or initial load. An example of the effect of the duration of peak load is a truck engine that can be pushed past the tachometer's red line for a short period without damaging the engine. Similarly, preloading is like the same truck engine used for towing a heavy trailer all day, which will affect the engine's limit to be pushed over the red line.

The preloading for a residential transformer varies with the load on the transformer. However, an efficiently sized transformer will have preloading in the range of 80% to 90% based on the most recent twelve 1-hour intervals prior to the peak load. The duration of the peak load is affected by local weather conditions, which make heating or cooling systems in a home run longer. Typical peak durations are 2 to 3 hours for residential loads. Figure 10.1 illustrates the concept of initial load and peak load.

When sizing a transformer, the peak load is estimated and compared to the available transformer sizes shown in Table 10.1. For efficiency, it is generally recommended to fully load a transformer. In fact, it is common practice to select transformers that are anticipated to serve winter loads that slightly exceed their kVA ratings (110% to 120%). According to ANSI/IEEE Std. C57.91, a transformer with a 4-hour peak overload and preloading of 90% can be loaded to 136% of its nameplate rating in the summer (86°F) and nearly 173% of its nameplate rating in the winter (32°F) without significant loss of life. **Table 10.2** shows various values from this industry standard. However, these high load levels (136% to 173%) are typically not used because the voltage drop through an overloaded transformer approaches the limit of allowable voltage drop.

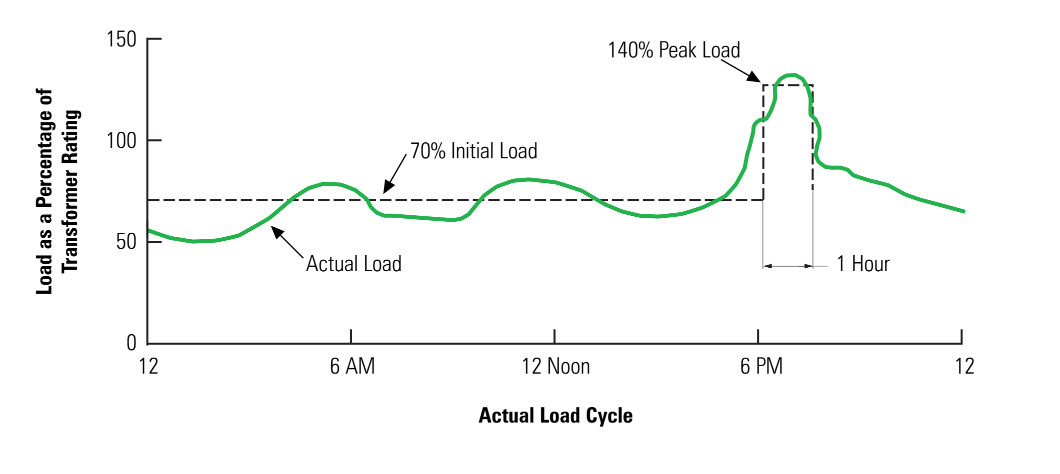


FIGURE 10.1: Example of Load Cycle. Source: IEEE Std. C57.91-1995.

TABLE 10.2: Daily Peak Loads in Per Unit of Nameplate Rating to Give Minimum 20-Year Life Expectancy.
Excerpted from Table 5, page 20, ANSI/IEEE C57.91-1981.

Peak Load Time in Hours	SELF-COOLED (OA)																
	Continuous Equivalent Load as Percentage of Rated kVA Preceding Peak Load																
	50%						**75%**						**90%**				
	Ambient Temperature in °F						**Ambient Temperature in °F**						**Ambient Temperature in °F**				
	32	**50/**	**68**	**86**	**104**	**122**	**32**	**50/**	**68**	**86**	**104**	**122**	**32**	**50/**	**68**	**86**	**104**
1	2.52	2.39	2.26	2.12	1.96	1.79	2.40	2.26	2.12	1.96	1.77	1.49	2.31	2.16	2.02	1.82	1.43
2	2.15	2.03	1.91	1.79	1.65	1.50	2.06	1.94	1.82	1.68	1.52	1.26	2.00	1.87	1.74	1.57	1.26
4	1.82	1.72	1.61	1.50	1.38	1.25	1.77	1.66	1.56	1.44	1.30	1.09	1.73	1.62	1.50	1.36	1.13
8	1.57	1.48	1.39	1.28	1.18	1.05	1.55	1.46	1.36	1.25	1.13	0.96	1.53	1.44	1.33	1.21	1.02
24	1.36	1.27	1.18	1.08	0.97	0.86	1.36	1.27	1.17	1.07	0.97	0.84	1.35	1.26	1.16	1.07	0.95

Notes: For transformer operation above 122°F or below 32°F, contact the manufacturer. Peak loads shown assume 0.0137% per day loss of life for normal life expectancy. The ambient temperature to use in the table is the average temperature over a 24-hour period, with the maximum temperature not exceeding the average temperature by more than 18°F.

Transformer Sizing

Most utilities have some type of transformer sizing methodology in place for their particular situations. These methodologies are typically developed using marketing and load research data. This research helps to determine the diversity of the load when several homes are served by one transformer. Primary considerations are types of heating and cooling systems in the homes (all-electric, gas heat, air conditioning, etc.) and the sizes of the homes.

Sizing a transformer based on the main panel rating in a home is a common misapplication of information. The *National Electrical Code* sets forth the rules by which a main panel is sized. These rules provide sufficient capacity to prevent overheating in the main panel. Therefore, the panel will rarely, if ever, be overloaded. Basing transformer and service sizes solely on the panel size will result in oversizing and inefficiency. A typical peak load in a 1,500-square-foot all-electric home is 11 kVA to 16 kVA, but its 200-amp panel is rated for 48 kVA. One reason for this difference is that the chance of all the load being turned on at the same time is very small. This is referred to as diversity of load. The lower the diversity value, the less chance of the loads occurring at the same time.

It would be simple to select a 15-kV transformer for every new home served, but this would not be an efficient design. Rather, it is preferred to serve more than one home from each transformer if proper delivery voltage can be maintained. By combining loads on a single transformer, it is possible to take advantage of the diversity and density of two or more homes.

It is important to address the seasonal loads on the transformer. Both the winter and summer loads should be estimated. The cooling effect of the ambient temperature in the winter can then be factored into the selection of a transformer size. Based on the data in Table 10.2, it is suggested that, if the winter load is greater than 1.25 times the summer load, the winter load should be used to size the transformer.

Table 10.3 uses the principles discussed in this section to provide a guide for sizing transformers based on the number of homes and the type(s) of heating and cooling system(s) in the homes. These tables are a rule of thumb only and should not be applied without the approval of the cooperative's engineer. In addition, the voltage drop and flicker will affect the size of the transformer and must be considered before the final selection of a transformer.

Table 10.4 contains the data for estimating the diversified electrical demand for multiple consumers served by a single transformer. Data from Table 10.4 were used to develop Table 10.3.

TABLE 10.3: Guide for Sizing Single-Phase Overhead Distribution Transformers, Based on Number of Homes Served, in kVA

	1500-Square-Foot House					
	Number of Homes Served by Transformer					
	1	2	3	4	5	6
No Air Conditioning with Gas Heat	10	10	10	15	15	15
Air Conditioning[1] with Gas Heat	15	15	25	37.5	37.5	50
No Air Conditioning with Electric Heat[2]	15	25	37.5	37.5	50	50
Air Conditioning[1] with Electric Heat[2]	15	25	37.5	37.5	50	50

[1] Assumes a 3-ton air conditioning unit.
[2] Heating load represents either heat pump with booster strip heat or an electric furnace.

	Up to 3000-Square-Foot House					
	Number of Homes Served by Transformer					
	1	2	3	4	5	6
No Air Conditioning with Gas Heat	10	10	15	25	25	25
Air Conditioning[1] with Gas Heat	25	25	37.5	50	75	75
No Air Conditioning with Electric Heat[2]	25	37.5	50	75	75	100
Air Conditioning[1] with Electric Heat[2]	25	37.5	50	75	75	100

[1] Assumes a 5-ton air conditioning unit.
[2] Heating load represents either heat pump with booster strip heat or an electric furnace.
Notes: The transformer sizes do not include unusual motor loads such as pools, hot tubs, pumps, etc.

TABLE 10.4: Guide for Estimating Load on Transformer, Based on Number of Homes Served

BASE LOAD IN kVA							
Home Size		**Number of Homes**					
		1	**2**	**3**	**4**	**5**	**6**
Less than 1500 sq ft		4.0	6.8	8.9	11.0	13.0	15.1
1501 to 3000 sq ft		5.5	9.4	13.2	16.5	18.7	22.1
COOLING LOAD IN kVA							
Air Conditioning	**Space Cooled**	**Number of Homes**					
		1	**2**	**3**	**4**	**5**	**6**
2.5 tons	1500 sq ft	5.0	9.0	12.8	16.4	19.5	23.1
3.0 tons	1800 sq ft	5.5	9.9	14.0	18.0	21.5	25.4
3.5 tons	2100 sq ft	7.0	12.6	17.9	23.0	27.3	32.3
4.0 tons	2400 sq ft	8.0	14.4	20.4	26.2	31.2	37.0
5.0 tons	3000 sq ft	10.0	18.0	25.5	32.8	39.0	46.2
HEATING LOAD IN kVA							
Heat Pump	**Space Heated[1]**	**Number of Homes**					
		1	**2**	**3**	**4**	**5**	**6**
2.5 tons	1500 sq ft	8.0	14.4	20.4	26.2	31.2	37.0
3.0 tons	1800 sq ft	9.0	16.2	23.0	29.5	35.1	41.6
3.5 tons	2100 sq ft	10.5	18.9	26.8	34.4	41.0	48.5
4.0 tons	2400 sq ft	12.5	22.5	31.9	41.0	48.8	57.8
5.0 tons	3000 sq ft	16.0	28.8	40.8	52.5	62.4	73.9

[1] Heating load represents either heat pump with booster strip heat or an electric furnace.

HOW TO USE THE TABLE TO DETERMINE SUMMER AND WINTER LOADS

Base Load for the Number of Homes
\+ Cooling Load for the Number of Homes
= Peak Summer Demand in kVA

Base Load for the Number of Homes
\+ Heating Load for the Number of Homes
= Peak Winter Demand in kVA

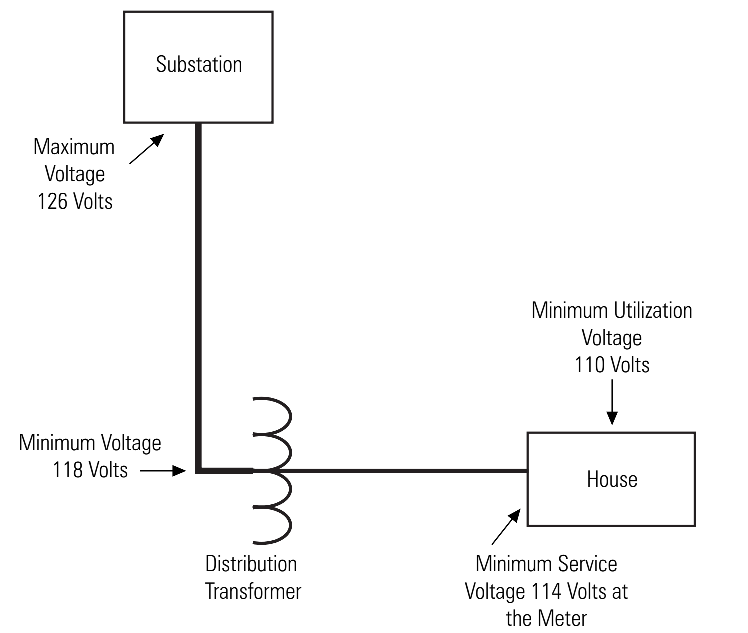
Voltage Levels

RUS Bulletin 1724D-113, ANSI C84.1, and the *National Electrical Code* taken together establish permissible service voltages and utilization voltages. A range of voltages is recommended in RUS Bulletin 1724D-113 for the service voltage, which also can be defined as the voltage delivered to the meter at a residence. The utilization voltage is the voltage at the equipment using the energy (televisions, ovens, lights, air conditioners, etc.). This range is based on sustained voltage levels and not on momentary voltage fluctuations that may result from starting an air conditioner. The voltage fluctuation from starting an air conditioner is commonly referred to as "voltage flicker" and is discussed in greater detail later in this section.

Figure 10.2 illustrates the voltage levels beginning at the substation bus and ending at the last receptacle in a house. The substation is regulated at a maximum voltage of 126 volts on a 120-volt base. The primary line is allowed to have a voltage drop of 8 volts, resulting in a minimum primary line voltage of 118 volts. From the minimum voltage level on the primary line of 118 volts, the service drop, which includes the distribution transformer and the service wire, is allowed a 4-volt drop. This yields a minimum voltage level at the meter or service point of 114 volts. The electrician wiring the house on the load side of the meter is then allowed a 4-volt drop to the last outlet or a minimum utilization voltage level of 110 volts. Thus, from the last outlet in a house all the way to the substation, there is a coordinated set of voltage levels. The staking technician's main concern is that the voltage drop on a residential service should be no more than 4 volts. When near a substation, it is permissible to allow for a greater voltage drop because the full primary voltage drop of 8 volts does not occur close to the substation. RUS standards allow a maximum voltage drop of 6 volts for services near substations. The voltage drop limit is normally set by the cooperative system engineer, who should be consulted before applying the methods described by this manual.

The voltage drop through the service is expressed as a percentage on a 120-volt base. Therefore, a 4-volt drop is expressed as a 3.33% voltage drop.

The voltage drop through the transformer and service conductor is calculated at peak load periods. This will occur in the summer with the air conditioners running or in the winter with the electric heat turned on. **Table 10.4** can be used to estimate these seasonal loads.



Location	Maximum Voltage	Minimum Voltage	Allowable Voltage Drop	% Drop on 120-Volt Base
Primary Line	126 volts	118 volts	8 volts	6.67%
Service to Meter[1]	126 volts	114 volts	4 volts[2]	3.33%

1 Service includes distribution transformer and 120/240-volt service conductors.
2 Voltage drop can be increased to a maximum of 6 volts for homes nearest to the substation bus.

FIGURE 10.2: Allowable Service Voltages. Source: ANSI C84.1 and RUS Bulletin 1724D-113.

Voltage Flicker from Starting Motors

Voltage flicker from a motor starting is different than the voltage drop from steady-state loads. When an air conditioner or heat pump motor starts, the stator and rotor of the motor appear to be a short circuit until the magnetic field is established and the rotation of the motor begins. This is commonly referred to as "locked rotor amps" (LRA). The locked rotor amps are typically five times the full load current. Table 10.5 contains practical values for full load running amps and locked rotor amps obtained from a survey of leading manufacturers of air conditioners and heat pumps.

The effect of locked rotor amps is that the delivery voltage will change very quickly. First, the voltage will dip from the locked rotor amps, and then it will rise back to nearly its starting voltage when only the running current is drawn by the motor. Since the voltage drop is equal to the impedance of the system times the load current, a rapid change in the load current will yield a rapid change in the delivery voltage. The change or fluctuation is referred to as "voltage flicker." In most cases, these fluctuations are not outside the permissible voltage ranges set forth by ANSI C84.1. However, this change in voltage can be perceived in the variation of intensity or brightness of incandescent light bulbs. Consumers become very irritated by the constant brightening and dimming of their lights—thus the problem of voltage flicker.

One of the difficulties in dealing with voltage flicker is that fluctuations bothersome to one consumer may be acceptable to another. In a survey of electric utilities, it was found that the flicker curve, shown in Figure 10.3, is the most popular curve used to apply flicker limits. Since air conditioners and heat pumps cycle only once or twice an hour, 4% to 5% flicker levels are commonly used with 4% being slightly more conservative. IEEE Standard 1453 is a more definitive method to determine voltage flicker limits, but for residential HVAC systems, IEEE standard 141 is still a good reference.

Typically, the cooperative system engineer determines the acceptable flicker limits, which should be reviewed before applying the methods presented in this manual.

TABLE 10.5: Practical Electrical Operating Characteristics of Residential Cooling Units[1]

Tons A/C	Btus	Running Load Amps[2]	Locked Rotor Amps[2]
1.0	12,000	6	35
1.5	18,000	10	48
2.0	24,000	13	61
2.5	30,000	15	75
3.0	36,000	18	86
3.5	42,000	23	97
4.0	48,000	27	118
5.0	60,000	33	140

[1] Cooling units include heat pumps and air conditioners.
[2] Practical values derived from a survey of leading manufacturers of heat pumps and air conditioners.

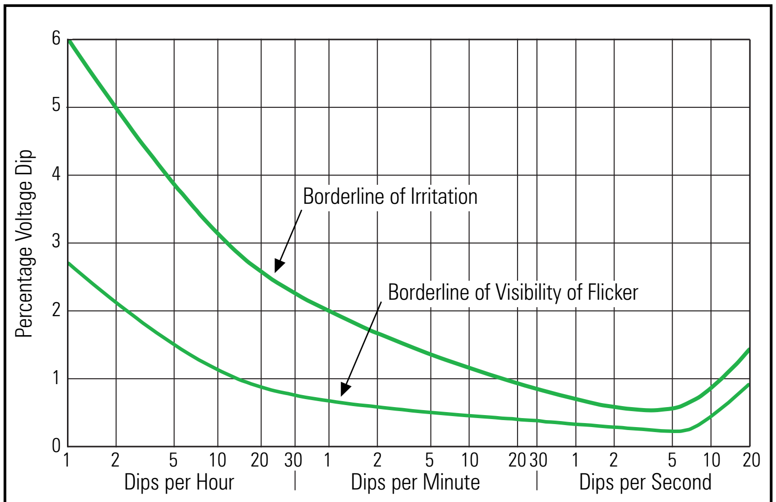


FIGURE 10.3: Range of Observable and Objectionable Voltage Flicker versus Time. Source: IEEE Std. 141-1993.

10

Maximum Service Lengths

Three different voltage drop calculations must be considered when selecting the transformer size and the service conductor's length and type:

1. Steady-state voltage drop in the winter
2. Steady-state voltage drop in the summer
3. Voltage flicker from starting an air conditioner

TABLE 10.6: Summary of Voltage Drop Considerations

Load Condition	Type of Voltage Drop	Voltage Drop Limit (% on a 120-Volt Base)
Winter Peak Load	Steady-State	3.33%
Summer Peak Load	Steady-State	3.33%
Motor Starting	Voltage Flicker	4.00%[1]

[1] 4% is a reasonable value but can differ from utility to utility.

These are summarized in Table 10.6. Different flicker limits are used throughout the industry, but generally a flicker limit of 4% is recommended.

Flicker is only an issue for those transformers serving homes with air conditioners or heat pumps. Other motors typically found in a home are not large enough to warrant consideration. However, if the home has a workshop or unusually large motors, then the system engineer or consultant will need to assist in analyzing the problem.

Flicker calculations consider only one motor starting at a time, and the voltage levels when the motor starts are ignored because by definition flicker is the rapid change in voltage.

Steady-state voltage drops and voltage flicker calculations were solved to determine the maximum service lengths summarized in **Table 10.7**. This easy-to-use reference provides guidance for determining the maximum service length of three different service conductors. This table assumes a single transformer with separate service laterals to each home. Further, this table is based on the transformer sizes presented in **Table 10.3** with loads estimated using **Tables 10.4** and **10.5**.

The impedance of a distribution transformer plays a significant role in determining the maximum service conductor length. The impedance of a transformer can be described as a measure of its resistance. The lower the impedance, the lower the resistance. The impedance of a transformer is listed on the nameplate and is often shown as Z%. Typically, transformers purchased based on the cost of life-cycle losses will have lower impedance values than other transformers. **Table 10.7** assumes all transformer sizes have an impedance of 2.0%. This is not the lowest impedance unit available nor is it the highest. The value is selected to yield reasonable service conductor length without exceeding the design criteria of 4% of voltage flicker and 3.33% steady-state voltage drop. Consultation with the cooperative's engineer to determine the voltage drops limits used by the cooperative is recommended.

TABLE 10.7: Maximum Service Wire Lengths in Feet Based on Voltage Drop Limits[1]						
	1500-Square-Foot House Number of Homes Served by Transformer[4]					
	1	2	3	4	5	6
NO AIR CONDITIONING WITH GAS HEAT						
Transformer Size[3]	**10 kVA**	**10 kVA**	**10 kVA**	**15 kVA**	**15 kVA**	**15 kVA**
#2 Triplex	614	504	413	480	422	360
1/0 Triplex	960	783	641	745	655	559
4/0 Triplex	1860	1495	1224	1422	1252	1068
AIR CONDITIONING[2] WITH GAS HEAT						
Transformer Size[3]	**15 kVA**	**15 kVA**	**25 kVA**	**37.5 kVA**	**37.5 kVA**	**50 kVA**
#2 Triplex	68	68	126	152	152	167
1/0 Triplex	104	104	193	234	234	256
4/0 Triplex	194	194	394	434	434	476
NO AIR CONDITIONING WITH ELECTRIC HEAT						
Transformer Size[3]	**15 kVA**	**25 kVA**	**37.5 kVA**	**37.5 kVA**	**50 kVA**	**50 kVA**
#2 Triplex	133	134	142	116	137	119
1/0 Triplex	207	210	222	181	214	185
4/0 Triplex	403	407	432	352	415	360
AIR CONDITIONING[2] WITH ELECTRIC HEAT						
Transformer Size[3]	**15 kVA**	**25 kVA**	**37.5 kVA**	**37.5 kVA**	**50 kVA**	**50 kVA**
#2 Triplex	68	126	142	116	137	119
1/0 Triplex	104	193	222	181	214	185
4/0 Triplex	194	358	432	352	415	360

1 Steady-state voltage drop limit = 3.33% and voltage flicker limit = 4.0%.
2 A 3-ton air conditioner was assumed with starting current obtained from **Table 10.5**.
3 Transformer size is based on **Table 10.3**; the estimated kVA loads can be found in **Table 10.4**.
4 This table assumes separate service laterals for each house.

Continued

TABLE 10.7: Maximum Service Wire Lengths in Feet Based on Voltage Drop Limits[1] (cont.)						
	3000-Square-Foot House Number of Homes Served by Transformer[4]					
	1	**2**	**3**	**4**	**5**	**6**
NO AIR CONDITIONING WITH GAS HEAT						
Transformer Size[3]	**10 kVA**	**10 kVA**	**15 kVA**	**25 kVA**	**25 kVA**	**25 kVA**
#2 Triplex	404	285	303	385	358	317
1/0 Triplex	631	443	470	597	556	492
4/0 Triplex	1211	846	898	1140	1061	939
AIR CONDITIONING[2] WITH GAS HEAT						
Transformer Size[3]	**25 kVA**	**25 kVA**	**37.5 kVA**	**50 kVA**	**75 kVA**	**75 kVA**
#2 Triplex	46	46	73	88	101	101
1/0 Triplex	71	71	112	134	155	155
4/0 Triplex	132	132	208	250	288	288
NO AIR CONDITIONING WITH ELECTRIC HEAT						
Transformer Size[3]	**25 kVA**	**37.5 kVA**	**50 kVA**	**75 kVA**	**75 kVA**	**100 kVA**
#2 Triplex	85	75	75	88	78	89
1/0 Triplex	133	116	117	137	122	140
4/0 Triplex	259	226	228	266	237	272
AIR CONDITIONING[3] WITH ELECTRIC HEAT						
Transformer Size[3]	**25 kVA**	**37.5 kVA**	**50 kVA**	**75 kVA**	**75 kVA**	**100 kVA**
#2 Triplex	46	73	75	88	78	89
1/0 Triplex	71	112	117	137	122	140
4/0 Triplex	132	208	228	266	237	272

[1] Steady-state voltage drop limit = 3.33% and voltage flicker limit = 4.0%.
[2] A 3-ton air conditioner was assumed with starting current obtained from **Table 10.5**.
[3] Transformer size is based on **Table 10.3**; the estimated kVA loads can be found in **Table 10.4**.
[4] This table assumes separate service laterals for each house.

Voltage Drop and Flicker Equations

The following equations are intended to assist the system engineer in developing tables similar to **Tables 10.7** and **10.3**. The staking technician is not expected to utilize these equations in day-to-day design of new services.

Equation 10.1

$$VD = [VD_{TRANSFORMER} + VD_{SERVICE}]\left(\frac{100}{240}\right)\%$$

Where:

VD = Total voltage drop as a percentage

$VD_{TRANSFORMER}$ = Voltage drop through the transformer in volts

$VD_{SERVICE}$ = Voltage drop through the service in volts

Equation 10.2

$$VD_{TRANSFORMER} = (I_T)(PF)(R_T) + (I_T)[\sin(\cos^{-1}(PF))](X_T)$$

Where:

$VD_{TRANSFORMER}$ = Voltage drop through the transformer in volts

I_T = Total load current through the transformer in amps or locked rotor amps of air conditioner

$= \dfrac{\text{Total kVA served by the transformer}}{\text{kV}}$

kV = 240 V = 0.240 kV

kVA = kVA rating of the transformer

PF = Power factor of load current expressed as a decimal

R_T = Resistance of the transformer in ohms

$= \dfrac{(10)(R_T\%)(kV)^2}{kVA}$

$R_T\%$ = Resistance of the transformer as a per-unit percentage

$= \dfrac{(\text{Load losses in watts})}{(10)(\text{transformer kVA})}\%$

X_T = Reactance of the transformer in ohms

$= \sqrt{(Z_T)^2 - (R_T)^2}$

Z_T = Impedance of the transformer in ohms

$= \dfrac{(10)(Z_T\%)(kV)^2}{kVA}$

$Z_T\%$ = Impedance of the transformer as a per-unit percentage found on the nameplate of all transformers

Equation 10.3

$$VD_{SERVICE} = (I_H)(PF)\left[(R_H)(2)\left(\frac{L}{1000}\right)\right] + (I_H)[\sin(\cos^{-1}(PF))]\left[(X_H)(2)\left(\frac{L}{1000}\right)\right]$$

Where:

$VD_{SERVICE}$ = Voltage drop through the service conductor in volts

I_H = Load current of one home in amps or locked rotor amps of air conditioner

$= \frac{\text{kVA load of one home}}{\text{kV}}$

kV = 0.240 kV

PF = Power factor of load current expressed as a decimal

R_H = Resistance of the service in ohms per 1000 feet (see Table 10.8)

X_H = Reactance of the service in ohms per 1000 feet (see Table 10.8)

L = Length of service conductor in feet measured from the secondary terminals of the transformer to the weatherhead connection

TABLE 10.8: Impedance Values of 600-Volt Triplexed Cable

Triplex Conductor Size	Conductor Diameter (in.)	Insulation Thickness (in.)	Cable Diameter (in.)	A-C Resistance (ohm/1000 ft)	Inductive Reactance[1] (ohm/1000 ft)	Ampacity (amps)
#2	0.283	0.045	0.373	0.318	0.028	120
1/0	0.362	0.060	0.482	0.200	0.028	160
4/0	0.512	0.060	0.632	0.099	0.027	245

[1] Inductive reactance is calculated using the following formula:

$$X_H = \left(\frac{2\pi f}{1000}\right)\left[.0153 + .1404 \log_{10}\left(\frac{s}{r}\right)\right] \text{ohms per 1000 feet}$$

Where:

X_H = Inductive reactance to neutral of one conductor in ohms per 1000 feet

f = Frequency in hertz (60 hertz)

s = Spacing between the centers of the conductors in inches

r = Radius of the metal portion of the conductor in inches

11 Application

In This Section:

As stated in **Section 1**, the staking of a distribution line consists of the selection of the various physical components—including conductors, poles, pole-top assemblies, guys, and anchors—that comprise the structures and line. These components are considered to be the building blocks and were discussed in detail in the previous sections of this manual. This section will demonstrate the application of these building blocks by example. This will be done by presenting two typical staking situations and working through the staking process of each.

An assumed cooperative with the following standard materials and design criteria will be used in working the problems:

- *NESC* loading district: Medium
- Voltage: 12.47/7.2 kV
- Conductors: 2 ACSR 6/1 and 1/0 ACSR 6/1
- Design average span: 325 ft
- Base pole: 40-ft class 5, Southern Yellow Pine
- Guy wire: 3/8" high-strength steel
- Guy attachment: heavy-duty with 4" × 4" curved washers
- Anchors: 8000-lb expanding type
- Maximum design tension for 2 ACSR 6/1: 50% of its ultimate strength
- Maximum design tension for 1/0 ACSR 6/1: 50% of its ultimate strength

Single-Phase Line Extension for Residential Service

The first problem describes the staking of a two-pole single-phase tap to a new residence. A drawing of the line extension is shown in **Figure 11.1**.

GRADE OF CONSTRUCTION

There are no major crossings of controlled access highways, railroads, bodies of water requiring a crossing permit, or other utilities. The grade of construction will be C.

CONDUCTOR

The conductor for the new single-phase tap will be 2 ACSR 6/1 for both primary and neutral. This is the standard conductor used by the cooperative for single-phase line extensions to residential consumers. It has been found to adequately meet the electrical requirements of a residential load and is stocked in the warehouse.

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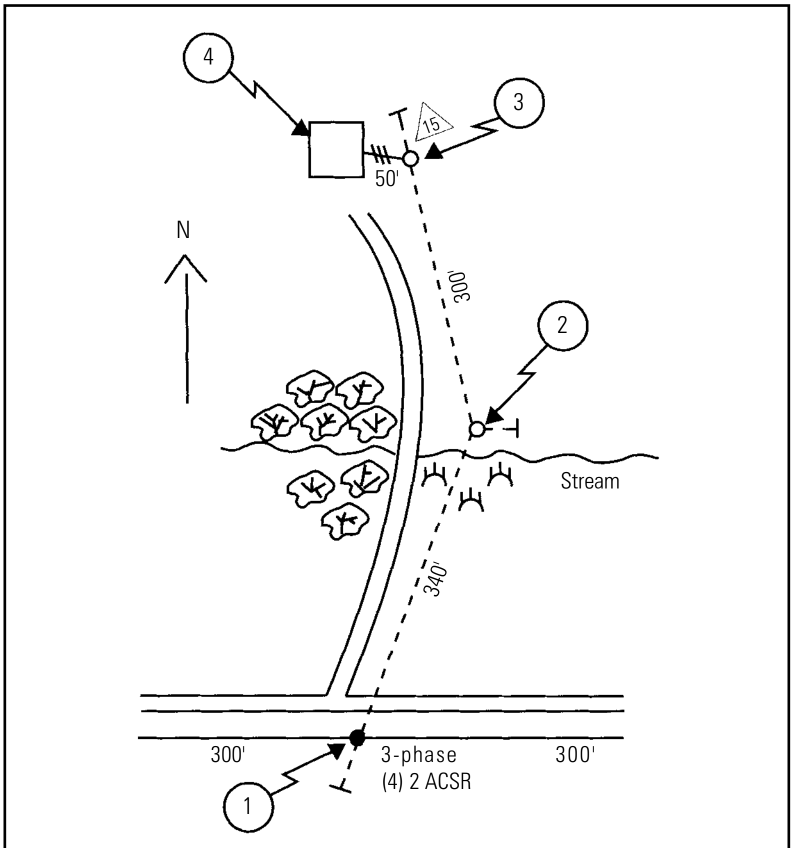

FIGURE 11.1: Line Extension, Single-Phase.

EXAMINATION OF THE LOCAL CONDITIONS

The consumer's new house is positioned at the end of a curved drive connecting with the main highway. There is a small group of tall pine trees on the west side of the drive, and the consumer does not want them cut or trimmed if at all possible. If this requirement is met, the line must follow the east side of the drive. Where the line changes direction in the curve will become a control point.

Preliminary measurement of the distance from the main three-phase line at the highway to the house is approximately 640 feet. This distance will require only one intermediate pole to meet the design average span of the cooperative. There is a marshy area on the south side of the small stream with fairly firm soil on the north side. If possible, the intermediate pole should be located on the north side of the stream. This area appears to be about 2 feet lower in elevation than the two adjacent pole locations.

The location of the deadend pole (3) is set, and the span distances measured. The distance from the proposed main line take-off pole (1) near the consumer's driveway to the proposed location of the intermediate pole (2) is 340 feet. The distance from the intermediate pole (2) to the deadend pole (3) is 300 feet. These distances meet the requirements of the cooperative's design average span and will not result in an excessively long or short span.

Stakes are set at the pole locations. The line angle is measured at pole 2 and found to be 34°.

DETERMINE THE RULING SPAN

The ruling span is determined using Equation 4.1, which is 321 feet for the two span lengths of 340 feet and 300 feet. **Appendix B** contains sag and tension tables for Medium Loading. A ruling span of 300 feet (**Table B.35**) is selected because it is within 25 feet of the actual ruling span as described in **Section 4**.

SELECTION OF POLES, POLE-TOP ASSEMBLIES, GUYS, AND ANCHORS

Pole No. 1

A 40-foot class 4 pole exists in the main three-phase line near the consumer's driveway. Visual inspection and sounding with a hammer verify that the pole is not rotten or damaged. The birthmark indicates that the pole was processed and treated in 2016. The tap will be guyed. Therefore, the pole will act as a strut only and not be required to independently support the load of the main line plus tap conductors. Provided that clearance can be obtained, this pole will meet the strength requirements for the take-off of the new 2 ACSR single-phase tap.

The existing pole-top assembly is a C1.11 that supports the three 2 ACSR 6/1 conductors. The RUS specifications require the use of an A5.2 assembly for a single-phase tap take-off associated with a C1.11. To provide for connection and disconnection of the tap, a hot line clamp will also be specified with the tap assembly.

The new tap must cross over the highway toward pole 2. For initial consideration, pole 2 will be assumed to be the height of the standard pole stocked by the cooperative. On pole 1, the position of the A5.2 is 31 feet 3 inches above grade, and the neutral is 27 feet 3 inches above grade. This information is obtained from review of the measurements found in RUS Specifications C1.11 and A5.2G. The neutral will control the clearance for the tap due to its standard 4-foot spacing below the primary. The final sag must be obtained from **Sag and Tension Table B.35**. to determine the lowest point to which the neutral will sag. **Table 11.1** shows the largest final sag for the conductor in a 340-foot span to be 5.23 feet or approximately 6 feet. The neutral pole attachment height of 27 feet 3 inches minus the final sag of 6 feet minus 1 foot construction tolerance results in a final clearance of approximately 20 feet (20 feet 3 inches). This clearance exceeds the 15.5 feet of clearance required by the *NESC* for clearance over a road (reference **Table 3.8**). However, since the highway is adjacent to the take-off pole (1), the clearance will almost be the same as the attachment height, which is illustrated in **Figure 4.3**. Either way, the neutral will have proper clearance and the height of the existing pole (1) is adequate.

The new tap will require a guy and anchor for support. A 1-to-1 guy lead can be obtained. The total guy load for the tap conductors found in **Table 7.7** is 4578 lb. Notice that this load is based on a design tension of 1425 lb, which is 50% of the ultimate strength of 2 ACSR. From **Table B.35**, the actual maximum tension for 2 ACSR in medium loading with a 300-foot ruling span is 1243 lb. Using a design tension of 1425 lb will result in an increased safety factor. To adequately support the total guy load of 4578 lb, use one E1.1L guy and one F1.8 anchor (reference **Table 7.5**). In **Section 7**, it was shown that this type of guy anchor assembly using the materials stocked and used by the cooperative adequately supports 8000 lb. Since this guy and anchor must also support the wind load of the three-phase 2 ACSR line, an evaluation must be made of the combined loads. Instead of performing the extensive tap guying calculations, the total guy load for a 1-to-1 lead of the smallest line angle shown in the line angle guy tables in **Appendix C** may be added to the tap guy load. If this revised load can be effectively guyed with the one guy and anchor evaluated for the tap conductors alone, then assurance of total tap guying will be confirmed. If the load exceeds the strength limit of the one guy and anchor assembly, then the staking technician or staff engineer should perform the calculations to determine the actual guy load. From **Table C.18**, the total guy load for a 1-to-1 guy lead with a 301- to 500-ft wind span with a 2° line angle is 2363 lb. The tap guy load of 4578 lb plus the three-phase line wind load of 2363 lb is 6941 lb. The guy/anchor assembly described above will still have sufficient strength to support the total load.

Since this is a junction pole, an H1.1 pole ground assembly will be specified. Although not specifically required, this cooperative's standard procedure is to install a ground rod at all primary junction poles.

Pole No. 2

This pole will support some type of line angle assembly. Even though the pole will be guyed and act as a strut, it should be sized the same as if it were a straight-line pole. If a 1-to-1 guy lead cannot be obtained, the class determined in the above step should be increased by 1 as discussed in **Section 7** under pole buckling. The wind span for pole 2 is 320 feet. Using Table 5.11, it can be seen that the maximum allowable wind span for the standard 40-foot class 5 pole of the cooperative is 812 feet for four 2 ACSR conductors. Since the tap has only two conductors and a wind span of 320 feet, the strength of the 40-foot class 5 pole will be more than adequate. A guy lead of 1-to-1 can be obtained.

The height will also be sufficient when considering the clearance of the backspan that was calculated for pole 1. In fact, it should be greater since the conductors will be installed nearer the top of pole 2 instead of beneath an existing C1.11, which was the case for pole 1.

The line angle for pole 2 was measured to be 34°. An A3 pole-top assembly will be specified. The RUS specifications require an A3 when the line angle is 20° to 60°.

The pole will require a guy and anchor assembly to support the horizontal pull caused by the line angle. The wind span for pole 2 is 320 feet. Referring to **Table C.15**, the total guy load for a span of 301 to 500 feet with a line angle of 34° and a 1-to-1 guy lead is 3842 lb. An E1.1L guy with an F1.8 anchor will adequately support the pole.

An H5.1 pole grounding assembly can be

TABLE 11.1: Sag and Tension Data—2 ACSR 6/1—Medium Loading (from Table B.35)

Conductor: SPARROW — 2 kcmil — 6/1 Stranding ACSR
Area = 0.0608 sq in. — Weight = 0.091 lb/ft
Diameter = 0.316 in. — RTS = 2850 lb
Design data from Sag10 Chart No. 1-1023 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					**Final**		**Initial**	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.579	5.25	1243	5.25	1243
32	0.25	0	0	0.264	3.63	818	3.22	924
60	0	6	0	0.182	3.48	589	2.79	736
0	0	0	0	0.091	1.26	814	1.09	943
15	0	0	0	0.091	1.44	713*	1.17	873
30	0	0	0	0.091	1.66	616	1.28	800
60	0	0	0	0.091	2.30	446	1.58	648
90	0	0	0	0.091	3.17	323	2.06	498
120	0	0	0	0.091	4.07	252	2.78	368

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		750	**699**	**648**	**598**	**547**	**498**	**451**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.81	**200**	0.61	0.65	0.70	0.76	0.83	0.92	1.01
1.99	**210**	0.67	0.72	0.77	0.84	0.92	1.01	1.11
2.19	**220**	0.74	0.79	0.85	0.92	1.01	1.11	1.22
2.39	**230**	0.81	0.86	0.93	1.01	1.10	1.21	1.33
2.60	**240**	0.88	0.93	1.01	1.09	1.20	1.32	1.45
2.83	**250**	0.95	1.02	1.10	1.19	1.30	1.43	1.58
3.06	**260**	1.03	1.10	1.19	1.28	1.40	1.55	1.71
3.30	**270**	1.11	1.18	1.28	1.39	1.51	1.67	1.84
3.55	**280**	1.19	1.27	1.38	1.49	1.63	1.79	1.98
3.80	**290**	1.28	1.36	1.48	1.60	1.75	1.92	2.12
4.07	**300**	1.37	1.46	1.58	1.71	1.87	2.06	2.27
4.35	**310**	1.46	1.56	1.69	1.83	2.00	2.20	2.42
4.63	**320**	1.56	1.66	1.80	1.95	2.13	2.34	2.58
4.92	**330**	1.66	1.77	1.91	2.07	2.26	2.49	2.75
5.23	**340**	1.76	1.88	2.03	2.20	2.40	2.65	2.92
5.54	**350**	1.86	1.99	2.15	2.33	2.55	2.80	3.09
5.86	**360**	1.97	2.10	2.28	2.46	2.69	2.97	3.27
6.19	**370**	2.08	2.22	2.40	2.60	2.84	3.13	3.45
6.53	**380**	2.20	2.34	2.54	2.74	3.00	3.31	3.64
6.88	**390**	2.32	2.47	2.67	2.89	3.16	3.48	3.84
7.24	**400**	2.44	2.60	2.81	3.04	3.32	3.66	4.04

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

used to ground the pole. The backspan is 340 feet. The conductor specified is two 2 ACSR 6/1. This indicates that the primary is 2 ACSR and the neutral is 2 ACSR, and 340 feet will be required for each.

Pole No. 3

This pole will be the deadend structure for the residential tap. A transformer must be installed to provide service to the house. The house will be 1500 square feet with a 3-ton air conditioner and electric heat. **Table 10.3** shows for this size home that a 15-kVA transformer will be required to meet the electrical needs of the residence. As determined for pole 2, the 40-foot class 5 standard pole will be strong enough to support the conductors. However, the pole must also be evaluated for strength to support the transformer weight. Referring to **Table 5.4**, it can be seen that a class 5 pole is adequate for one 15-kVA transformer. The standard 40-foot class 5 pole will be specified.

An A5.1 pole-top assembly will be specified for the deadend. As long as the conductor design tension does not exceed 4000 lb, this assembly will provide adequate strength. The design tension for the 2 ACSR is 1425 lb. Therefore, the A5.1 will provide more than adequate strength.

A deadend guy and anchor must be specified to support the horizontal pull produced by the tension in the conductors. A 1-to-1 guy lead can be obtained at pole 3. Referring to **Table 7.7**, the total guy load for a 2 ACSR primary and a 2 ACSR neutral is 4578 lb. An E1.1L guy and an F1.8 anchor will adequately support the load.

Since this is a transformer pole, an H1.1 grounding assembly must be specified.

The transformers used by the cooperative are the self-protected type (CSP). Since pole 3 is a single-phase deadend, a G1.3-15 transformer assembly is specified.

A secondary assembly must be specified for the attachment of the triplex serving the house. A K1.2 is the standard bracket used by the cooperative.

The backspan is 300 feet. The conductor specified is two 2 ACSR 6/1.

House—No. 4

It is necessary to check if the cooperative's standard No. 2 triplex service conductor is adequate to service the house. **Table 10.7** provides the maximum service wire lengths for services to residences with living space up to 1500 square feet. This table shows that, with a 15-kVA transformer, a maximum length of 68 feet of No. 2 triplex conductor will maintain adequate steady-state voltage drop and maintain voltage flicker below 4%. The span from the deadend pole to the house is 50 feet. The conductor specified will be 50 feet of No. 2 triplex. A K3.2 service bracket is specified for attachment of the triplex to the house service mast.

Table B.35 (Stringing Sag Table) is included with the final staking sheets. This table is based on the 325-foot ruling span of the residential tap and is to be used to sag the conductors.

Three-Phase Extension for Industrial Service

The second problem describes the staking of a three-phase line extension to a small industrial consumer. A drawing of the line extension is shown in **Figure 11.2**.

GRADE OF CONSTRUCTION

There are no major crossings of controlled access highways, railroads, bodies of water requiring a crossing permit, or other utilities. The grade of construction will be C.

CONDUCTOR

The conductor for the new three-phase tap will be 1/0 ACSR 6/1 for the primary and 2 ACSR 6/1 for the neutral. This is the standard conductor used by the cooperative for three-phase line extensions.

EXAMINATION OF LOCAL CONDITIONS

An examination of local conditions was made using methods similar to those described in problem No. 1. Control points were established at points 1, 3, 4, and 6. Intermediate poles were lined in at points 2 and 5. The spans were measured. The average span was calculated and found to be 324 feet. The ruling span between the deadend points 1 and 3 was calculated using

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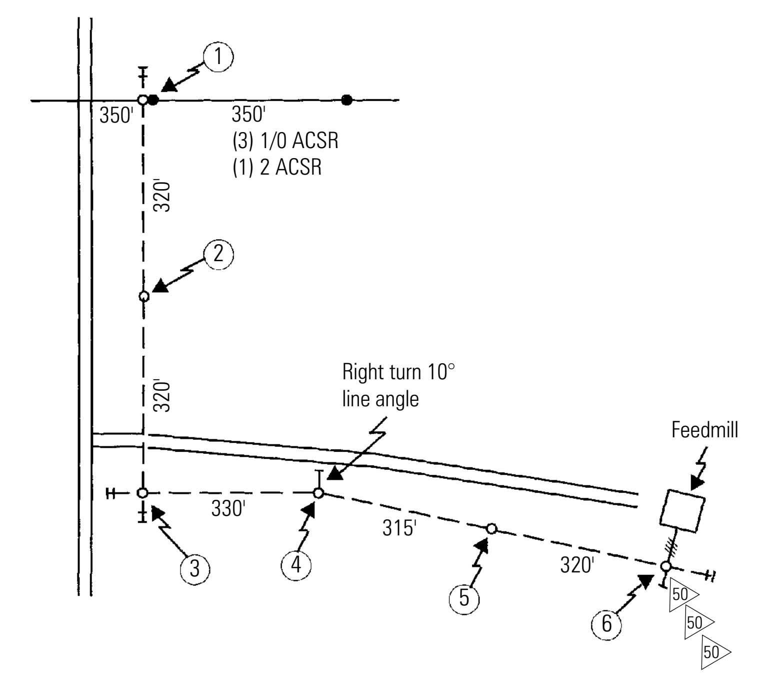

FIGURE 11.2: Line Extension, Three-Phase.

Equation 4.1 and found to be 320 feet. The ruling span between points 3 and 6 was found to be 321.8 feet. These spans meet the design average span and design ruling span used by the cooperative. The sag and tension data for the 300-foot ruling span shown in **Table B.38** can be used for this line extension. Field experience has shown that the sag and tension data for a set ruling span may be applied to actual ruling spans that differ from the set ruling span by 10% or less.

Pole stakes are set at the control points and intermediate points. The line angle is measured at pole 4 and found to be 10°.

SELECTION OF POLES, POLE-TOP ASSEMBLIES, GUYS, AND ANCHORS

Pole No. 1

This pole is evaluated using methods similar to problem No. 1. Replacement of the existing 40-foot class 5 pole is required because of woodpecker damage. The spans adjacent to pole 1 are 350 feet each, and the conductors are three 1/0 ACSR primary and a 2 ACSR neutral. The wind span is 350 feet. To provide the greatest strength and lowest maintenance cost, the new pole will be a 45-foot pole with a vertical deadend assembly. The standard 45-foot pole stocked by the cooperative is a class 4. Referring to **Table 5.11**, the maximum wind span for a 45-foot class 4 pole with four 1/0 ACSR conductors is 702 feet. The class 4 pole will be more than adequate for the wind span of 350 feet.

Table 5.11 uses three 1/0 ACSR primary conductors and a 1/0 ACSR neutral. Our problem has a three 1/0 ACSR primary conductors and a 2 ACSR neutral conductor. Since 1/0 ACSR is larger than 2 ACSR, Table 5.11 will provide a conservative result and, therefore, is applicable to this problem.

The existing C1.11 pole-top assembly will be replaced with a C4.1G and a C5.2 assembly to accommodate the new three-phase tap. This assembly can handle conductor loads of up to 4000 lb as mentioned in **Section 4**. The maximum tension as shown in **Table 11.2** for 1/0 ACSR is 1663 lb. This tension is based on RUS tension limits.

The greatest final sag of the 2 ACSR neutral found in **Table 11.1** is 4.07 feet for a 300-foot span and 4.63 feet for a 320-foot span. For a 45-foot pole set 6.5 feet in the ground and framed using C4.1G and C5.2 assemblies, the neutral attachment for the three-phase tap has a vertical height over grade of 25 feet. Therefore, the clearance of the conductor at its maximum final sag in the 320-foot span will be 25 feet minus 4.63 feet of sag minus 1 foot for construction tolerance yielding a final clearance of 19 feet 4 inches. This exceeds the requirements shown in **Table 3.8**. Also to be considered is that the neutral attachment on pole 2 will be higher than pole 1, which helps to increase the total clearance.

Guys and anchors must be selected to support the horizontal pull of the new three-phase tap plus the wind load of the existing three-phase main line. The total guy load for a 1-to-1 guy lead for a deadend structure with three 1/0 ACSR and one 2 ACSR is 12,843 lb (**Table 7.7**). An E2.1G guy assembly with two F1.8 anchors will support this load. The rating of this guy/anchor assembly is 16,000 lb. The small line angle total guy load from **Table C.19** for 2°, 301- to 500-foot span, 1-to-1 guy lead, is 2622 lb.

Adding the wind load of the main line to the total guy load of the three-phase tap yields a

TABLE 11.2: Sag and Tension Data—1/0 ACSR—Medium Loading (from Table B.38)

Conductor: RAVEN — 1/0 kcmil — 6/1 Stranding ACSR
Area = 0.0968 sq in. — Weight = 0.145 lb/ft
Diameter = 0.398 in. — RTS = 4380 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.655	4.44	1663	4.44	1663
32	0.25	0	0	0.343	3.28	1176	2.96	1305
60	0	6	0	0.246	3.26	849	2.65	1047
0	0	0	0	0.145	1.30	1252	1.19	1376
15	0	0	0	0.145	1.49	1095*	1.28	1271
30	0	0	0	0.145	1.72	946	1.40	1164
60	0	0	0	0.145	2.38	686	1.72	948
90	0	0	0	0.145	3.26	501	2.21	739
120	0	0	0	0.145	4.18	391	2.90	562

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1092	**1020**	**948**	**876**	**807**	**739**	**676**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.86	**200**	0.66	0.71	0.76	0.83	0.90	0.98	1.08
2.05	**210**	0.73	0.78	0.84	0.91	0.99	1.08	1.19
2.25	**220**	0.80	0.86	0.92	1.00	1.09	1.19	1.30
2.46	**230**	0.88	0.94	1.01	1.09	1.19	1.30	1.42
2.68	**240**	0.95	1.02	1.10	1.19	1.29	1.41	1.55
2.90	**250**	1.04	1.11	1.20	1.29	1.40	1.53	1.68
3.14	**260**	1.12	1.20	1.29	1.40	1.52	1.66	1.82
3.39	**270**	1.21	1.30	1.39	1.51	1.64	1.79	1.96
3.64	**280**	1.30	1.39	1.50	1.62	1.76	1.93	2.11
3.91	**290**	1.39	1.50	1.61	1.74	1.89	2.07	2.26
4.18	**300**	1.49	1.60	1.72	1.86	2.02	2.21	2.42
4.46	**310**	1.59	1.71	1.84	1.99	2.16	2.36	2.58
4.76	**320**	1.70	1.82	1.96	2.12	2.30	2.51	2.75
5.06	**330**	1.80	1.94	2.08	2.25	2.44	2.67	2.93
5.37	**340**	1.91	2.06	2.21	2.39	2.59	2.84	3.11
5.69	**350**	2.03	2.18	2.34	2.53	2.75	3.01	3.29
6.02	**360**	2.15	2.30	2.48	2.68	2.91	3.18	3.48
6.36	**370**	2.27	2.43	2.62	2.83	3.07	3.36	3.68
6.71	**380**	2.39	2.57	2.76	2.98	3.24	3.55	3.88
7.06	**390**	2.52	2.70	2.91	3.14	3.41	3.73	4.09
7.43	**400**	2.65	2.84	3.06	3.31	3.59	3.93	4.30

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

revised total guy load of 15,465 lb as shown in Table 11.3. The E2.1G guy assembly previously specified and rated at 16,000 lb is also adequate for the revised guy load.

The pole ground assembly is an H1.1 for the junction.

Pole No. 2

A 40-foot class 5 pole is specified for pole 2. Referring to **Table 5.11**, the maximum wind span for a 40-foot class 5 pole with four 1/0 ACSR conductors is 716 feet. Since none of the spans in this line extension exceeds 350 feet, the standard 40-foot class 5 pole will be strong enough for the remainder of the structures, provided clearance can be obtained.

TABLE 11.3: Total Guy Load for Pole 1

Tap guy load	= 12,843 lb
2° main line wind load	= 2,622 lb
Revised total guy load	= 12,843 lb + 2,622 lb
	= 15,465 lb

The greatest final sag for the neutral as shown in **Table 11.1** for 2 ACSR is approximately 4.63 feet. As shown in Table 11.4, the neutral-to-grade vertical clearance for a level ground span of 320 feet on 40-foot poles set 6 feet in the ground with C1.11 pole-top assemblies is 24 feet 5 inches.

TABLE 11.4: Vertical Clearance for Pole 2

Clearance = 40 ft – (6 ft depth + 4.63 ft sag
+ 4 ft neutral spacing
+ 1 ft const. tolerance)
Clearance = 40 ft – 15.63 ft
Clearance = 24 ft 5 inches

The actual spacing of the neutral on a C1.11 assembly is 3 feet 6 inches from the pole top. The 4-foot spacing is convenient and easy to remember. It also provides an additional 6-inch safety margin. This amount of clearance should be adequate for the total line extension if 40-foot poles are used and the ground is relatively level.

The pole-top assembly specified is a C1.11. The 8-foot arm will provide adequate separation of conductors when rolling to horizontal from the vertical assembly of pole 1, as discussed in **Section 4**.

The horizontal separation of the pins on a C1.11 allows for sags in 1/0 ACSR conductors of up to 24.9 feet, as shown in **Table 4.8**. Since the sag in this problem is much less than 24.9 feet, a C1.11 assembly is acceptable.

An H1.1 pole grounding assembly is specified for pole 2.

The conductor specified will be 320 feet of three 1/0 ACSR and one 2 ACSR.

Pole No. 3

The line makes a 90° turn at this point. A vertical deadend structure is specified to provide strength and ease of maintenance. The standard 45-foot class 4 pole used by the cooperative will be strong enough based on both requirements mentioned for pole 1 and the fact that the pole is guyed.

The pole-top assembly is a C4.1G. Strength requirements are the same as for those of pole 1.

The clearance calculated on pole 1 will apply in both directions on this pole.

The guy/anchor assemblies are determined from **Table 7.7**. Guy leads of only a 2-to-3 ratio can be obtained. Table 7.7 shows that for three 1/0 ACSR primaries and one 2 ACSR neutral, the total guy load at a 2-to-3 guy lead is 16,372 lb. This load exceeds the rating of two F1.8 anchors, which is 16,000 lb. An E3.1LG guy assembly with one F1.12 and one F1.8 anchor will provide the necessary support for each side of the deadend. If the F1.12 anchor is not available, three F1.8 anchors can be specified for each side.

The pole grounding assembly will be an H1.1. The cooperative's design policy requires a driven ground at double deadend structures.

The conductor specified will be 320 feet of three 1/0 ACSR and one 2 ACSR.

Pole No. 4

The first step is to select a pole-top assembly 322.5 feet. This assembly may be horizontal (C2.21) or vertical (C3.1), depending on the load limits. The pole height will then be selected to support the assembly and "grade out" with the remainder of the line. Referring to **Table 6.5** first and then to **Table 6.6**, the maximum line angle for a C2.21 assembly with 1/0 ACSR conductor in the medium loading district and with a wind span of 350 feet is 15.5°. The measured line angle of pole 4 is 10° and the wind span is less than 350 feet, allowing for rolling from horizontal to vertical as discussed in **Section 4**; therefore, a C2.21 assembly will be adequate. If the C2.21 is used, then the standard 40-foot class 5 pole can also be specified since it will provide sufficient strength, provide more than adequate clearance, and "grade out" with the 45-foot class 4 pole in the backspan.

Vertical clearance on this pole will be the same as on pole 2.

The guy/anchor assembly must support the total guy load produced by the 10° line angle and the 330-foot wind span. A 1-to-1 guy lead may be obtained at this pole. **Table C.19** shows the total guy load for the parameters of pole 4 to be 4407 lb. An E1.1L guy and F1.8 anchor will support the load.

The grounding assembly is an H1.11.

The conductor is 330 feet of three 1/0 ACSR and one 2 ACSR.

Pole No. 5

Specification for this pole will be the same as for pole 2 except for the conductor. It will be 315 feet of three 1/0 ACSR and one 2 ACSR.

Pole No. 6

This pole is the deadend structure for the three-phase line extension. The cooperative staff engineer has determined that a 480-volt bank of three 50-kVA transformers will be required to supply the electrical demand of the feedmill. The pole must be sized to support the weight of the transformers. Referring to **Table 5.6**, the recommended pole class for three 50-kVA transformers is class 3.

Before selecting a pole height, the pole-top assembly must be chosen. Since a transformer bank is to be installed on pole 6, a horizontal configuration provides the best clearance and construction. As discussed in **Section 6**, a standard C5.31 must be bridle-guyed to support conductors with design tensions greater than 1500 lb. The 1/0 ACSR conductor used for this line has a design tension of 1663 lb (**Table 11.2**).

Standard down guys are better suited for the location of pole 6 than bridle guys. Therefore, a C5.71L pole-top assembly must be specified and a crossarm assembly must be ordered to support 3326 lb per conductor. This value of 3326 lb was calculated by multiplying 1663 lb by an overload capacity factor of 2.0, which is discussed in detail in **Section 6**.

A 1-to-1 guy lead can be obtained at this location. Using **Table 7.7**, the total guy load for pole 6 is 12,843 lb. To adequately support the total guy load, use two E1.1L guys and two F1.8 anchors.

To provide adequate clearance around the industrial site and room for the transformer bank, a 45-foot pole is selected. The calculated vertical height of the neutral attachment is 27.5 feet above grade. The clearance of the neutral conductor above ground will be 21.58 feet when allowing a largest final sag of 4.92 feet for a 330-foot span as shown in **Table 11.1**, plus one foot for construction tolerance. The pole class has already been determined by the weight of the transformers, and a 45-foot class 3 pole is specified for pole 6.

The transformer bank is a G3.2-50,50,50. This is a transformer bank that will provide 480-volt power to the connected loads.

The grounding assembly is an H1.1, which is required for transformer poles.

The conductor will be 320 feet of three 1/0 ACSR and one 2 ACSR.

The cooperative staff engineer has determined that a 4/0 quadruplex cable is adequate for a service requiring three 50-kVA transformers. A K1.1 large-spool secondary assembly is specified to support the quadruplex serving the feedmill.

A guy and anchor are also specified to support the secondary to the feedmill. An E1.1L guy and F1.8 anchor will more than adequately support the quadruplex since it will not be sagged under tension. If this guy and anchor assembly is not installed, the pole will probably lean toward the building over time.

Feedmill

The span from the pole to the building is 50 feet. The conductor specified will be 50 feet of one 4/0 quadruplex. A K3.2 service bracket is specified to attach the quadruplex to the feedmill service mast.

11

The Staking Package

As can be seen after working the examples, a collection of the tables pertinent to the conductors, ruling spans, etc., of the line being staked would be very helpful to the staking technician in the field. This collection of data is commonly referred to as a staking package. The basic staking package should include the following items:

- Sag and tension tables (**Appendix B**)
- Staking tables (**Table 2.1**)
- Pole strength tables (**Tables 5.11** and **5.4**, **5.5**, and **5.6**)
- Pole-top assembly strength tables (**Tables 6.5** and **6.6**)
- Line angle guying tables (**Appendix C**)
- Deadend guying tables (**Tables 7.5** and **7.7**)

Tables specific to the parameters of the cooperative can be prepared using the format of the tables and the equations shown in this manual. Simply substitute the new parameters and variables and calculate the new table.

The staking package along with the procedures and guidelines described in this *Staking Manual* should equip the staking technician with the necessary tools and knowledge to stake a safe and reliable distribution line.

12 Designing for Extra-Large Conductors

In This Section:

Extra-Large Conductors

The decision to use extra-large conductors is beyond the scope of this manual. However, if requested to design a line using these extra-large conductors, it is necessary to understand the limitations of distribution grade assemblies. The extra-large conductors which often are installed at high tensions have historically been used on transmission assemblies with stronger assemblies, thus allowing for longer spans.

To properly select the assemblies, guying, and anchoring for extra-large conductors, it is necessary to understand the tension limitations and the resulting sags of the conductors. This section addresses these concepts and provides tables and equations for application of the concepts. In general, extra-large conductors are defined as conductors larger than 477 ACSR. These extra-large conductors have a high rated breaking strength, often referred to as rated tensile strength or ultimate strength of the conductor. The added strength allows designers to specify a high tension to reduce sag and allow long spans on transmission structures. However, for distribution assemblies there is a limit in the maximum tension allowed and this limit is 5000 lb. This tension limit of 5000 lb will result in potentially more sag in the extra-large conductors. The result is that the spans must be shorter.

This manual will address the design limitations for three extra-large conductors, which are shown in Table 12.1. The methodology used for these conductors can be applied to other conductors.

These conductors are not currently on the RUS Information Publication 202-1, *List of Materials Acceptable for Use on Systems of*

Table 12.1: Extra-Large Conductors

Conductor Size/Type	Stranding	Code Name	Rated Breaking Strength (lb)
556 ACSR	18/1	OSPREY	13,700
740 AAAC	37	FLINT	24,700
795 ACSR	36/1	COOT	16,800

RUS Electrifications Borrowers. Therefore, it is necessary to obtain RUS approval prior to using the conductors listed in **Table 12.1**.

The engineering decision to use extra-large conductors is not addressed by this manual. There are numerous engineering issues which must be weighed, including, but not limited to, ampacity requirements, voltage drop considerations, right-of-way limitations, terrain, and system reliability.

CONDUCTOR TENSION LIMITS

As discussed in **Section 4**, the *NESC* and the manufacturers of conductors have established limits on the conductor tensions. These tension limits maintain tensions within reason and prevent conductor stress from exceeding the elastic limit of the material when fully loaded. For ACSR and AAAC conductors, the recommended conductor tension limit is 50% of the Ultimate Strength of the Conductor (reference **Table 4.3** and **4.4**). When applied to extra-large conductors, the maximum tension can exceed 6800 lb. This high tension causes two problems on distribution lines. First, the higher tension results in more guys and anchors. Second, the high tension will exceed the strength of the distribution assemblies. Therefore, it is recommended that the tension be limited to no more than 5000 lb. This will match with the strength of the assemblies and reduce the number of guys and anchors required for the structures. A lower value of 4500 lb will meet the strength limitations and provide some margin for error in installation.

Another consideration is the vibration of the conductor. At higher tensions, wind can cause the conductor to vibrate (aeolian vibration). The lower tension limit of 4500 lb will help to reduce this vibration.

HARDWARE LIMITATIONS

The deadend assemblies used in the RUS specifications show a 5000 lb maximum tension limit (C5.1, and VC5.1). Distribution porcelain suspension insulators and polymer are rated for 10,000 lb of tension. However, these strengths must be derated by 50% for loads from Rule 250B shown in Table 3.1 and 65% for extreme wind and extreme ice. This results in a working strength of 5000 lb. Polymer suspension insulators often have a rating over 10,000 lb and, like the porcelain insulators, the *NESC* derates the polymer insulators 50% for loads from Rule 250B Table 3.1 and 65% for extreme wind and extreme ice. In addition, RUS changed to a 3-inch square, curved washer to support a maximum 5000 lb of tension. If higher tensions are desired, then the designer must make a selection of suspension insulators (derated strength) and the appropriate bolt and washer necessary to support the higher tension.

GRADE OF CONSTRUCTION

According to the requirements of the *NESC*, Grade C construction can be used for extra-large conductors within the limitations of *NESC* Rule 242 (Reference **Table 3.3** of this manual). However, it is prudent to consider if Grade B construction should be used for extra-large conductors. The higher grade of construction can improve system reliability. These large conductors will be serving more consumers and the extra cost for the higher grade could be justified. Keep in mind, however, that Grade C is considered acceptable by the *NESC* for distribution lines.

CONDUCTOR SAGS

Using a lower tension limit will result in more sag of the conductors. This can be offset by reducing the span length. The maximum tension for these extra-large conductors could vary from 4000 lb to 5000 lb. A tension limit of 4500 lb is suggested for ruling spans less than or equal to 300 feet. Long spans may require 5000 lb of tension with taller poles and more separation between the phase conductor and the neutral conductor. The increased separation is needed to comply with the *NESC* vertical spacing at mid-span, which is discussed in **Section 4** of this manual.

The designer should consider designing for a conductor temperature of 167°F for extra-large conductors. This results in more sag, but the higher operating temperature allows the conductor to carry more current. **Table 12.2** depicts the extra sag of 0.96 feet for 167°F operating temperature compared to 120°F.

Sag tables for the three extra-large conductors are contained in **Appendix B**. An example of a sag table for 795 ACSR for a 250-foot ruling span under heavy loading is shown in **Table 12.2**.

TABLE 12.2: Sag Table for a 250-Foot Ruling Span of 795 ACSR under Heavy Loading

Conductor: COOT — 795 kcmil — 36/1 Stranding ACSR
Area = 0.6417 sq in. — Weight = 0.804 lb/ft
Diameter = 1.04 in. — RTS = 16,800 lb
Design data from Sag10 Chart No. 1-898 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	2.173	4.22	4028	3.78	4500*
32	0.5	0	0	1.745	4.73	2886	4.13	3304
–20	0	0	0	0.804	2.47	2542	1.79	3506
0	0	0	0	0.804	3.12	2016	2.28	2758
30	0	0	0	0.804	4.05	1551	3.18	1979
60	0	0	0	0.804	4.89	1285	4.08	1539
90	0	0	0	0.804	5.64	1115	4.91	1281
120	0	0	0	0.804	6.32	996	5.66	1113
167	0	0	0	0.804	7.28	866	6.69	942

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1802	**1658**	**1538**	**1438**	**1353**	**1279**	**1216**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.62	**150**	1.26	1.36	1.47	1.57	1.67	1.77	1.86
2.98	**160**	1.43	1.55	1.67	1.79	1.90	2.01	2.12
3.37	**170**	1.61	1.75	1.89	2.02	2.15	2.27	2.39
3.77	**180**	1.81	1.96	2.12	2.27	2.41	2.55	2.68
4.20	**190**	2.02	2.19	2.36	2.52	2.69	2.84	2.99
4.66	**200**	2.23	2.43	2.61	2.80	2.98	3.14	3.31
5.14	**210**	2.46	2.67	2.88	3.08	3.28	3.46	3.65
5.64	**220**	2.70	2.93	3.16	3.38	3.60	3.80	4.00
6.16	**230**	2.95	3.21	3.45	3.70	3.94	4.16	4.38
6.71	**240**	3.22	3.49	3.76	4.03	4.29	4.53	4.76
7.28	**250**	3.49	3.79	4.08	4.37	4.65	4.91	5.17
7.87	**260**	3.77	4.10	4.41	4.73	5.03	5.31	5.59
8.49	**270**	4.07	4.42	4.76	5.10	5.42	5.73	6.03
9.13	**280**	4.38	4.75	5.12	5.48	5.83	6.16	6.49
9.80	**290**	4.70	5.10	5.49	5.88	6.26	6.61	6.96
10.48	**300**	5.03	5.46	5.88	6.29	6.70	7.07	7.44
11.19	**310**	5.37	5.83	6.27	6.72	7.15	7.55	7.95
11.93	**320**	5.72	6.21	6.68	7.16	7.62	8.04	8.47
12.68	**330**	6.08	6.60	7.11	7.61	8.10	8.56	9.01
13.47	**340**	6.46	7.01	7.55	8.08	8.60	9.08	9.56
14.27	**350**	6.84	7.43	8.00	8.57	9.11	9.62	10.13

[1] Largest final sag is defined by 2023 *NESC* Rule 232A. (From Table B.89)

12

Spans

MAXIMUM SPAN BASED ON VERTICAL SEPARATION AT THE POLE

In **Section 4**, the analysis for determining the maximum allowable span within a specific ruling span was discussed. **Equation 4.7** is used to determine the maximum allowable span based solely on the vertical separation at the pole. The goal of the vertical separation at the pole is to maintain a certain separation between the phase conductor and neutral conductor at mid-span during either an iced condition or a condition caused by thermal loading. Obviously, this mid-span separation will be a function of the sag of the primary and neutral conductors. RUS specifications show a 4-foot separation between the neutral and the phase conductors. This vertical separation is often the limiting factor on maximum span lengths. Therefore, for extra-large conductors, it is suggested that a 6-foot separation be used to allow for longer spans within the ruling span. The increase in separation is permissible by RUS as defined in the construction specifications.

Section 4 suggests using the sag of the neutral at a temperature of 60°F even though *NESC* Rule 235C2b allows the designer to use a higher temperature. This is especially true for extra-large conductors. The use of a neutral temperature of 60°F will yield a more conservative span length and allows for maximum capacity for backfeeding during nonpeak periods.

Example 12.1 shows how to calculate the maximum vertical span as limited by conductor vertical separation at the pole. The problem assumes an operating temperature of 167°F and a neutral temperature of 60°F.

SELECTION OF POLE HEIGHT

Since extra-large conductors have to be installed with relatively low tensions, the result is relatively large conductor sags. These sags appear in the phase conductor as well as the selected neutral conductor. **Table 12.2** is the sag table for 795 ACSR 36/1 stranding in Heavy Loading on a 250-ft ruling span. This sag table shows a worst case sag of 7.28 feet at 167°F for this conductor. The designer would use this information to help determine the required pole height. The required attachment height of the conductor will be the worst case sag plus the *NESC*-required clearance above ground. **Section 3** of this manual discusses the required ground clearance of neutral and phase conductors over various surfaces (roads, fields, water, etc). These clearances are summarized in **Table 3.8**, Vertical Clearances of Wires, Conductors, and Cables above Ground, Rails, or Water. Note that the measurement is from the surface of the ground, so rolling hills will require greater pole heights than flat terrain.

For extra-large conductors, the clearance of the neutral conductor should control the height of the pole because the vertical separation between neutral and phase conductors at the structure is typically 6 feet. At a minimum, a 40-foot pole should be used, while experience has shown that, in most cases, a 45-foot pole is often better suited for extra-large conductors.

Example 12.1

Determine the maximum vertical span as limited by conductor vertical separation at the pole and conductor sag.

Given:

Loading District	=	Light
Conductor	=	795 ACSR (COOT) Primary 336 ACSR (MERLIN) Neutral
Ruling Span	=	250 ft
795 ACSR Conductor	=	2.65 feet @ 32°F with ice loading (0.0 inches of ice)
336 ACSR Conductor	=	1.37 feet @ 32°F with no ice loading
795 ACSR Conductor	=	6.34 feet @ 167°F (Maximum operating temperature)
336 ACSR Conductor	=	2.01 feet @ 60°F
Vertical Separation between Phase Conductor and Neutral Conductor	=	6 feet
Circuit Voltage	=	12.47/7.2 kV

Use Equation 4.7

Calculate the maximum allowable span for Condition No. 1 (iced condition)

RS = 250 feet
A = 1 foot (reference **Table 3.6**)
B = 6 feet (vertical separation)
S_E = 1.37 feet (lower conductor)
S_U = 2.65 feet (upper conductor)

$$S_M = 250\sqrt{\frac{6-1}{1.65-1.37}} = 494 \text{ ft}$$

Calculate the maximum allowable span for Condition No.2 (maximum operating condition)

RS = 250 feet
A = 1 foot (reference **Table 3.6**)
B = 6 feet (vertical separation)
S_E = 2.01 feet (lower conductor)
S_U = 6.34 feet (upper conductor)

$$S_M = 250\sqrt{\frac{6-1}{6.34-2.01}} = 268 \text{ ft}$$

Equation 4.7

$$S_M = RS\sqrt{\frac{B-A}{S_U-S_E}}$$

Where:

S_M = Maximum allowable span (vertical) in feet
RS = Ruling span in feet
A = The allowable separation at midspan in feet
B = Vertical separation at support in feet
S_E = Lower conductor sag at 60°F or 32°F
S_U = Upper conductor sag at maximum operating temperature, 120°F or 32°F iced

The maximum allowable span based on vertical separation on the pole is limited by the maximum operating condition (No. 2) to 268 feet.

12

MAXIMUM WIND SPAN

The calculation of the maximum wind span is provided in **Section 5** and is illustrated in **Example 5.1**. The methodology presented for distribution lines would be applicable to extra-large conductors. The wind loading on the conductors needs to be determined as required by the *NESC*. The method for determining the transverse wind loading on a foot of conductor is detailed in **Section 5** of this manual and summarized in **Table 5.3**. For extra-large conductors, Table 12.3 provides similar information to be used in the calculation of the maximum wind span. This table is developed using the equation shown in **Figure 5.1**.

Table 12.3: Conductor Specifications with Transverse *NESC* District Loadings

Size	Strand	Rated Breaking Strength (lb)	Diameter of Conductor (in.)	Transverse Wind Load (lb/ft)
LIGHT LOADING 0.00 inches ice, 9-lb-per-sq-ft wind (Zone 3)				
556 ACSR	18/1	13,700	0.879	0.6593
740 AAAC	37	24,400	0.991	0.7433
795 ACSR	36/1	16,800	1.04	0.7800
MEDIUM LOADING 0.25 inches ice, 4-lb-per-sq-ft wind (Zone 2)				
Size	**Strand**	**Rated Breaking Strength (lb)**	**Diameter of Conductor (in.)**	**Transverse Wind Load (lb/ft)**
556 ACSR	18/1	13,700	0.879	0.4597
740 AAAC	37	24,400	0.991	0.4970
795 ACSR	36/1	16,800	1.04	0.5133
HEAVY LOADING 0.50 inches ice, 4-lb-per-sq-ft wind (Zone 1)				
Size	**Strand**	**Rated Breaking Strength (lb)**	**Diameter of Conductor (in.)**	**Transverse Wind Load (lb/ft)**
556 ACSR	18/1	13,700	0.879	0.6263
740 AAAC	37	24,400	0.991	0.6637
795 ACSR	36/1	16,800	1.04	0.6800

The maximum wind spans for the extra-large conductors considered in this manual for standard pole sizes and classes are shown in Table 12.4. This table assumes a full-size neutral even though it is more common to use a reduced neutral. The full-size neutral results in a more conservative value for the maximum wind span.

Note also that these tables do not include the loading from joint-use attachments. The wind loading from communication cables attaching to the pole can be significant and should be factored in to the selection of the pole class. Also note that using Grade B construction may be appropriate for extra-large conductors.

TABLE 12.4: Maximum Wind Spans in Feet: Southern Yellow Pine and Douglas Fir

THREE-PHASE LINES LIGHT LOADING			
Pole Height/Class	**Conductors**		
	(4)556 ACSR 18/1	**(4)740 AAAC 37**	**(4)795 ACSR 36/1**
Grade C Construction			
40'/4	391	347	331
40'/3	492	436	415
45'/4	381	338	322
45'/3	476	422	402
50'/3	466	413	393
50'/2	592	525	500
Grade B Construction			
40'/4	192	170	162
40'/3	244	216	206
45'/4	183	163	155
45'/3	232	206	196
50'/3	224	198	189
50'/2	289	256	244

Continued

TABLE 12.4: Maximum Wind Spans in Feet: Southern Yellow Pine and Douglas Fir (cont.)

MEDIUM LOADING			
	Conductors		
Pole Height/Class	**(4)556 ACSR 18/1**	**(4)740 AAAC 37**	**(4)795 ACSR 36/1**
Grade C Construction			
40'/4	592	548	530
40'/3	738	683	661
45'/4	582	538	521
45'/3	721	667	646
50'/3	711	658	637
50'/2	896	829	802
Grade B Construction			
40'/4	306	283	274
40'/3	383	354	343
45'/4	298	276	267
45'/3	372	344	333
50'/3	365	337	326
50'/2	462	427	414
HEAVY LOADING			
	Conductors		
Pole Height/Class	**(4)556 ACSR 18/1**	**(4)740 AAAC 37**	**(4)795 ACSR 36/1**
Grade C Construction			
40'/4	435	410	400
40'/3	542	511	499
45'/4	427	403	394
45'/3	529	500	488
50'/3	522	493	481
50'/2	658	621	606
Grade B Construction			
40'/4	224	212	207
40'/3	281	265	259
45'/4	219	207	202
45'/3	273	257	251
50'/3	268	253	246
50'/2	339	320	312

SELECTION OF TANGENT ASSEMBLIES

Extra-large conductors can be installed with a limited number of tangent assemblies. The tangent assemblies should have a clevis-type neutral and may require a larger-size clevis for extra-large neutral conductors. The standard 12.47/7.2-kV assemblies normally used for extra-large conductors are C1.13L, C1.41L, C2.21L, C1.13P, C1.41P, and C2.21P. The assembly units ending in "P" indicate post-type insulators. Some designers prefer the post-type insulators over the saddle pins for these assemblies. Another consideration is that the C2.21L and C2.21P have double arms, which add additional strength to the structure. It is unlikely that the conductor will break on this type of pole structure. The added strength in the arms stiffens the structure and provides for a second insulator for tying in the conductor.

NESC Rule 261D5c requires, for Grade B construction, that structures at crossings have double arms. Note that "at crossing" as defined by the *NESC* is crossing another line (distribution line or communication line) even if on a common structure (reference *NESC* Rule 241C for details and exceptions). Keep in mind, there is no *NESC* requirement for double arms for Grade C construction.

Angles

MAXIMUM LINE ANGLE

Placing a line angle on a distribution structure creates compressive forces on the insulators and torque on the pins used to support the conductors. The force that creates this torque is a combination of wind on the conductor and the tension caused by the deflection angle. There is a limit to the amount of deflection angle that can be used on pole-top assemblies for a given wind span.

Table 12.5 contains a list of typical angle assemblies that can be used for extra-large conductors. Each assembly is assigned a nominal strength rating for the combination of pin and insulators used on the assemblies. Also, a maximum angle is suggested for these assemblies.

Section 6 addresses maximum angles permitted on standard RUS assemblies. **Table 6.6** depicts the maximum line angle for certain parameters,

TABLE 12.5: Maximum Permissible Line Angle for Pin-Type Pole-Top Assemblies

THREE-PHASE LINES LIGHT LOADING			
Angle Assembly		**Maximum Transverse Load (lb)**	**Max. Line Angle Within Load Limits**
12.47/7.2 kV	**24.9/14.4 kV**		
C1.13L	VC1.13L	1000	5°
C1.13P	VC1.13P	750	5°
C1.41L	VC1.41L	1000	5°
C1.41P	VC1.41P	750	5°
C2.3N	N/A	1000	5°
C2.3NG	N/A	1000	5°
C2.3NP	N/A	1500	5°
C2.6N	N/A	1500	20°
C2.6NP	N/A	1500	20°
C2.9N	N/A	1500	20°
C2.9NP	N/A	1500	20°
C2.21L	VC2.21L	1000	5°
C2.21P	VC2.21P	1500	5°
C2.51L	VC2.51L	2000	20°
C2.52L	VC2.52L	2000	20°
C2.52P	VC2.52P	1500	20°

and **Equation 6.7** is the equation used to determine the maximum line angle within the loading limits of the support assembly. The same equation applies to extra-large conductors. The strength of the assemblies for extra-large conductors is provided in **Table 12.5**. The Load Factors shown in **Table 6.7** are used in the calculations, along with a conductor design tension of 4500 lb. Note that this table uses the *NESC* Load Factor for "at crossing" on Grade C construction where "at crossing" means crossing another utility line or communication line. Using this "at crossing" value yields slightly more conservative results. Table 12.6 provides the maximum permissible line angle for various wind spans based on the design tension of the conductors, *NESC* loading district, grade of construction, and loading parameters of the pole-top assemblies given in **Table 12.5**.

TABLE 12.6: Maximum Line Angles

Design Limits		
Maximum transverse load (lb):	750	
Maximum angle within load limits (deg):	5	
Grade C Wind Load Factor	2.20	
Grade C Tension Load Factor	1.30	
Grade B Wind Load Factor	2.50	
Grade B Tension Load Factor	1.65	

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft)[1] 150	200	250	300	350	400	450	500
Grade C				LIGHT LOADING						
556 ACSR 18/1	0.6593	4500	5.0	4.5	3.8	3.1	2.4	1.7	1.0	0.2
740 AAAC 37	0.7433	4500	4.9	4.1	3.3	2.5	1.7	0.9	0.1	(-)[(1)]
795 ACSR 36/1	0.7800	4500	4.8	4.0	3.1	2.3	1.5	0.6	(-)	(-)
Grade B										
556 ACSR 18/1	0.6593	4500	3.9	3.2	2.6	2.0	1.3	0.7	0.1	(-)
740 AAAC 37	0.7433	4500	3.6	2.9	2.2	1.5	0.8	0.1	(-)	(-)
795 ACSR 36/1	0.7800	4500	3.5	2.8	2.0	1.3	0.5	(-)	(-)	(-)
Grade C				MEDIUM LOADING						
556 ACSR 18/1	0.4597	4500	5.0	5.0	4.9	4.4	3.9	3.4	2.9	2.4
740 AAAC 37	0.4970	4500	5.0	5.0	4.7	4.1	3.6	3.1	2.5	2.0
795 ACSR 36/1	0.5133	4500	5.0	5.0	4.6	4.0	3.5	2.9	2.4	1.8
Grade B										
556 ACSR 18/1	0.4597	4500	4.5	4.0	3.6	3.1	2.7	2.2	1.8	1.4
740 AAAC 37	0.4970	4500	4.4	3.9	3.4	2.9	2.4	2.0	1.5	1.0
795 ACSR 36/1	0.5133	4500	4.3	3.8	3.3	2.8	2.3	1.8	1.3	0.8
Grade C				HEAVY LOADING						
556 ACSR 18/1	0.6263	4500	5.0	4.6	4.0	3.3	2.6	1.9	1.3	0.6
740 AAAC 37	0.6637	4500	5.0	4.5	3.8	3.1	2.3	1.6	0.9	0.2
795 ACSR 36/1	0.6800	4500	5.0	4.4	3.7	3.0	2.2	1.5	0.8	0.0
Grade B										
556 ACSR 18/1	0.6263	4500	4.0	3.4	2.8	2.2	1.6	1.0	0.4	(-)
740 AAAC 37	0.6637	4500	3.9	3.2	2.6	1.9	1.3	0.7	0.0	(-)
795 ACSR 36/1	0.6800	4500	3.8	3.2	2.5	1.9	1.2	0.5	(-)	(-)

[1] The 2023 *NESC* Load Factor for wind uses "at crossing" to yield more conservative results.

NOTE: For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.

Continued

TABLE 12.6: Maximum Line Angles (cont.)										
	Design Limits					Grade C Wind Load Factor			2.20	
	Maximum transverse load (lb):		1000			Grade C Tension Load Factor			1.30	
	Maximum angle within load limits (deg):		5			Grade B Wind Load Factor			2.50	
						Grade B Tension Load Factor			1.65	
Conductor Size and Type	**Transverse Load (lb/ft)**	**Design Tension (lb)**	**Wind Span (ft)[1]**							
			150	**200**	**250**	**300**	**350**	**400**	**450**	**500**
Grade C				LIGHT LOADING						
556 ACSR 18/1	0.6593	4500	5.0	5.0	5.0	5.0	4.8	4.1	3.4	2.7
740 AAAC 37	0.7433	4500	5.0	5.0	5.0	5.0	4.2	3.4	2.6	1.8
795 ACSR 36/1	0.7800	4500	5.0	5.0	5.0	4.8	3.9	3.1	2.2	1.4
Grade B										
556 ACSR 18/1	0.6593	4500	5.0	5.0	4.5	3.9	3.3	2.6	2.0	1.4
740 AAAC 37	0.7433	4500	5.0	4.9	4.1	3.4	2.7	2.0	1.3	0.5
795 ACSR 36/1	0.7800	4500	5.0	4.7	4.0	3.2	2.5	1.7	0.9	0.2
Grade C				MEDIUM LOADING						
556 ACSR 18/1	0.4597	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.8
740 AAAC 37	0.4970	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.4
795 ACSR 36/1	0.5133	4500	5.0	5.0	5.0	5.0	5.0	5.0	4.8	4.3
Grade B										
556 ACSR 18/1	0.4597	4500	5.0	5.0	5.0	5.0	4.6	4.2	3.7	3.3
740 AAAC 37	0.4970	4500	5.0	5.0	5.0	4.8	4.4	3.9	3.4	2.9
795 ACSR 36/1	0.5133	4500	5.0	5.0	5.0	4.7	4.3	3.8	3.3	2.8
Grade C				HEAVY LOADING						
556 ACSR 18/1	0.6263	4500	5.0	5.0	5.0	5.0	5.0	4.4	3.7	3.0
740 AAAC 37	0.6637	4500	5.0	5.0	5.0	5.0	4.8	4.1	3.4	2.6
795 ACSR 36/1	0.6800	4500	5.0	5.0	5.0	5.0	4.7	3.9	3.2	2.5
Grade B										
556 ACSR 18/1	0.6263	4500	5.0	5.0	4.7	4.1	3.5	2.9	2.3	1.7
740 AAAC 37	0.6637	4500	5.0	5.0	4.5	3.9	3.2	2.6	2.0	1.3
795 ACSR 36/1	0.6800	4500	5.0	5.0	4.4	3.8	3.1	2.5	1.8	1.2

[1] The 2023 *NESC* Load Factor for wind uses “at crossing” to yield more conservative results.

NOTE: For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.

Continued

TABLE 12.6: Maximum Line Angles (cont.)

	Design Limits		Grade C Wind Load Factor	2.20
	Maximum transverse load (lb):	1500	Grade C Tension Load Factor	1.30
	Maximum angle within load limits (deg):	5	Grade B Wind Load Factor	2.50
			Grade B Tension Load Factor	1.65

Conductor Size and Type	**Transverse Load (lb/ft)**	**Design Tension (lb)**	**Wind Span (ft)[1]**							
			150	**200**	**250**	**300**	**350**	**400**	**450**	**500**
Grade C						LIGHT LOADING				
556 ACSR 18/1	0.6593	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.7433	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.7800	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade B										
556 ACSR 18/1	0.6593	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.7433	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.4
795 ACSR 36/1	0.7800	4500	5.0	5.0	5.0	5.0	5.0	5.0	4.8	4.1
Grade C						MEDIUM LOADING				
556 ACSR 18/1	0.4597	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.4970	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.5133	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade B										
556 ACSR 18/1	0.4597	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.4970	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.5133	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade C						HEAVY LOADING				
556 ACSR 18/1	0.6263	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.6637	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.6800	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade B										
556 ACSR 18/1	0.6263	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.6637	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.6800	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

[1] The 2023 *NESC* Load Factor for wind uses "at crossing" to yield more conservative results.

NOTE: For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.

Continued

TABLE 12.6: Maximum Line Angles (cont.)

Design Limits
Maximum transverse load (lb): 1500
Maximum angle within load limits (deg): 20

Grade C Wind Load Factor 2.20
Grade C Tension Load Factor 1.30
Grade B Wind Load Factor 2.50
Grade B Tension Load Factor 1.65

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft)[1]							
			150	200	250	300	350	400	450	500
Grade C			LIGHT LOADING							
556 ACSR 18/1	0.6593	4500	12.6	11.9	11.2	10.4	9.7	9.0	8.3	7.6
740 AAAC 37	0.7433	4500	12.3	11.5	10.7	9.9	9.1	8.3	7.5	6.7
795 ACSR 36/1	0.7800	4500	12.2	11.3	10.5	9.7	8.8	8.0	7.1	6.3
Grade B										
556 ACSR 18/1	0.6593	4500	9.7	9.0	8.4	7.8	7.1	6.5	5.9	5.2
740 AAAC 37	0.7433	4500	9.4	8.7	8.0	7.3	6.6	5.8	5.1	4.4
795 ACSR 36/1	0.7800	4500	9.3	8.6	7.8	7.1	6.3	5.6	4.8	4.1
Grade C			MEDIUM LOADING							
556 ACSR 18/1	0.4597	4500	13.2	12.7	12.2	11.7	11.2	10.7	10.2	9.8
740 AAAC 37	0.4970	4500	13.1	12.6	12.0	11.5	11.0	10.4	9.9	9.3
795 ACSR 36/1	0.5133	4500	13.1	12.5	11.9	11.4	10.8	10.3	9.7	9.2
Grade B										
556 ACSR 18/1	0.4597	4500	10.3	9.8	9.4	8.9	8.5	8.0	7.6	7.1
740 AAAC 37	0.4970	4500	10.1	9.7	9.2	8.7	8.2	7.7	7.3	6.8
795 ACSR 36/1	0.5133	4500	10.1	9.6	9.1	8.6	8.1	7.6	7.1	6.6
Grade C			HEAVY LOADING							
556 ACSR 18/1	0.6263	4500	12.7	12.0	11.3	10.7	10.0	9.3	8.6	7.9
740 AAAC 37	0.6637	4500	12.6	11.9	11.1	10.4	9.7	9.0	8.3	7.5
795 ACSR 36/1	0.6800	4500	12.5	11.8	11.0	10.3	9.6	8.8	8.1	7.4
Grade B										
556 ACSR 18/1	0.6263	4500	9.8	9.2	8.6	8.0	7.4	6.7	6.1	5.5
740 AAAC 37	0.6637	4500	9.7	9.0	8.4	7.7	7.1	6.5	5.8	5.2
795 ACSR 36/1	0.6800	4500	9.6	9.0	8.3	7.6	7.0	6.3	5.7	5.0

[1] The 2023 *NESC* Load Factor for wind uses "at crossing" to yield more conservative results.

NOTE: For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.

Continued

TABLE 12.6: Maximum Line Angles (cont.)

	Design Limits					Grade C Wind Load Factor		2.20		
	Maximum transverse load (lb):		2000			Grade C Tension Load Factor		1.30		
	Maximum angle within load limits (deg):		5			Grade B Wind Load Factor		2.50		
						Grade B Tension Load Factor		1.65		
Conductor Size and Type	**Transverse Load (lb/ft)**	**Design Tension (lb)**	**Wind Span (ft)[1]**							
			150	**200**	**250**	**300**	**350**	**400**	**450**	**500**
Grade C			LIGHT LOADING							
556 ACSR 18/1	0.6593	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.7433	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.7800	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade B										
556 ACSR 18/1	0.6593	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.7433	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.7800	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade C			MEDIUM LOADING							
556 ACSR 18/1	0.4597	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.4970	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.5133	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade B										
556 ACSR 18/1	0.4597	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.4970	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.5133	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade C			HEAVY LOADING							
556 ACSR 18/1	0.6263	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.6637	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.6800	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Grade B										
556 ACSR 18/1	0.6263	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
740 AAAC 37	0.6637	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
795 ACSR 36/1	0.6800	4500	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

[1] The 2023 *NESC* Load Factor for wind uses "at crossing" to yield more conservative results.

NOTE: For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.

Continued

TABLE 12.6: Maximum Line Angles (cont.)

Design Limits				Grade C Wind Load Factor	2.20		
Maximum transverse load (lb):	2000			Grade C Tension Load Factor	1.30		
Maximum angle within load limits (deg):	20			Grade B Wind Load Factor	2.50		
				Grade B Tension Load Factor	1.65		

Conductor Size and Type	Transverse Load (lb/ft)	Design Tension (lb)	Wind Span (ft)[1]							
			150	**200**	**250**	**300**	**350**	**400**	**450**	**500**
Grade C				LIGHT LOADING						
556 ACSR 18/1	0.6593	4500	17.5	16.8	16.1	15.4	14.7	13.9	13.2	12.5
740 AAAC 37	0.7433	4500	17.3	16.4	15.6	14.8	14.0	13.2	12.4	11.6
795 ACSR 36/1	0.7800	4500	17.1	16.3	15.4	14.6	13.7	12.9	12.0	11.2
Grade B										
556 ACSR 18/1	0.6593	4500	13.9	13.4	12.9	12.4	11.9	11.4	10.9	10.4
740 AAAC 37	0.7433	4500	13.7	13.2	12.6	12.0	11.4	10.9	10.3	9.7
795 ACSR 36/1	0.7800	4500	13.7	13.1	12.4	11.8	11.2	10.6	10.0	9.4
Grade C				MEDIUM LOADING						
556 ACSR 18/1	0.4597	4500	18.2	17.7	17.2	16.7	16.2	15.7	15.2	14.7
740 AAAC 37	0.4970	4500	18.1	17.5	17.0	16.4	15.9	15.4	14.8	14.3
795 ACSR 36/1	0.5133	4500	18.0	17.4	16.9	16.3	15.8	15.2	14.7	14.1
Grade B										
556 ACSR 18/1	0.4597	4500	14.4	14.0	13.7	13.3	13.0	12.6	12.3	11.9
740 AAAC 37	0.4970	4500	14.3	13.9	13.5	13.2	12.8	12.4	12.0	11.6
795 ACSR 36/1	0.5133	4500	14.3	13.9	13.5	13.1	12.7	12.3	11.9	11.5
Grade C				HEAVY LOADING						
556 ACSR 18/1	0.6263	4500	17.6	17.0	16.3	15.6	14.9	14.2	13.5	12.9
740 AAAC 37	0.6637	4500	17.5	16.8	16.1	15.3	14.6	13.9	13.2	12.5
795 ACSR 36/1	0.6800	4500	17.5	16.7	16.0	15.2	14.5	13.8	13.0	12.3
Grade B										
556 ACSR 18/1	0.6263	4500	14.0	13.5	13.0	12.6	12.1	11.6	11.1	10.6
740 AAAC 37	0.6637	4500	13.9	13.4	12.9	12.4	11.9	11.4	10.8	10.3
795 ACSR 36/1	0.6800	4500	13.9	13.4	12.8	12.3	11.8	11.3	10.7	10.2

[1] The 2023 *NESC* Load Factor for wind uses "at crossing" to yield more conservative results.

NOTE: For spaces marked (-), the wind span exceeds the allowable span for tangent construction. A stronger assembly is required to support the conductors.

Weight Spans

For most conductors, the standard crossarm assemblies can support the weight of conductor and ice for normal spans limits. However, the ice buildup on extra-large conductors can limit the span lengths. The weight of the conductors at the end of the crossarm creates a torque back at the pole attachment. This is the assumed point of failure of the crossarm. Note that it is a common practice to ignore the strength of the braces. Table 12.7 shows the maximum weight spans for the number and length of crossarms used for extra-large conductors. Extreme ice loading will also limit the span lengths for extra-large conductors. **Example 12.2** shows how to calculate the maximum weight span for wooden crossarms.

TABLE 12.7: Maximum Weight Span Limited by Vertical Load on Crossarms

			Grade B			Grade C		
			Heavy	**Medium**	**Light**	**Heavy**	**Medium**	**Light**
		LF	1.50	1.50	1.50	1.90	1.90	1.90
		SF	0.65	0.65	0.65	0.85	0.85	0.85
		Ice (in.)	0.50	0.25	0.00	0.50	0.25	0.00
Conductor Size and Type	**Weight[1] (lb/ft)**	**Diameter of Conductor (in.)**	**One 8-foot Crossarm with an Ultimate Strength of 7650 lb**					
556 ACSR	0.604	0.879	494	756	1196	540	827	1308
740 AAAC	0.695	0.991	445	668	1039	487	731	1136
795 ACSR	0.805	1.040	410	599	897	448	655	981
Conductor Size and Type	**Weight[1] (lb/ft)**	**Diameter of Conductor (in.)**	**Two 8-foot Crossarms with an Ultimate Strength of 7650 lb**					
556 ACSR	0.604	0.879	1113	1703	2692	1179	1804	2853
740 AAAC	0.695	0.991	1003	1505	2340	1062	1594	2479
795 ACSR	0.805	1.040	923	1348	2020	978	1429	2140
Conductor Size and Type	**Weight[1] (lb/ft)**	**Diameter of Conductor (in.)**	**One 10-foot Crossarm with an Ultimate Strength of 7650 lb**					
556 ACSR	0.604	0.879	290	444	702	317	485	768
740 AAAC	0.695	0.991	261	392	610	286	429	667
795 ACSR	0.805	1.040	241	352	527	263	384	576
Conductor Size and Type	**Weight[1] (lb/ft)**	**Diameter of Conductor (in.)**	**Two 10-foot Crossarms with an Ultimate Strength of 7650 lb**					
556 ACSR	0.604	0.879	653	1000	1580	692	1,059	1675
740 AAAC	0.695	0.991	589	883	1374	624	936	1455
795 ACSR	0.805	1.040	542	792	1186	574	839	1256

[1] Weight is given for the conductor without ice load.

Example 12.2

Determine the maximum weight span limited by vertical loads for a C1.13L with 795 ACSR built to Grade B construction in the heavy loading district.

Given: 795 ACSR (36/1 COOT)
Grade B construction
C1.13L assembly with one 8-foot Douglas fir crossarm
Heavy loading district

Equation 12.1

$$S_{WT} = \frac{(N \times M_V \times SF) - 1000}{C_{WT} \times D \times LF_V}$$

Where:

S_{WT} = Maximum weight span
N = Number of crossarms
M_V = Vertical strength for standard RUS crossarm (4 5/8" × 3 5/8") which is given by RUS as 7650 ft-lb
SF = *NESC* Strength Factor (**Table 6.3**) 0.65 for Grade B for wooden crossarms
C_{WT} = Unit weight of conductor plus ice loading in lb/ft. For heavy loading, this value can be found in Appendix B (See **Table B.88**; 32 degrees with ice = 1.745 lb/ft)
D = Distance from the center of the crossarm to the conductor attachment (ft). For C1.13L, this distance is 3.6667 ft
LF_V = *NESC* Load Factor for vertical loading (**Table 6.2**) 1.5 for Grade B for wooden crossarms

Note the 1000 adjustment in the equation is suggested by RUS in Bulletin 1724E-151 to account for the weight of a lineman on the crossarm.

Therefore:

$$S_{WT} = \frac{(1 \times 7650 \times 0.65) - 1000}{1.745 \times 3.6667 \times 1.5} = 414.58 \text{ or } 415 \text{ feet}$$

Therefore, the "weight span" would have to be equal to or less than 415 feet to not exceed the crossarm's vertical loading withstand capability.

If a C2.21L is used, which has two 8-foot Douglas fir crossarms, the weight span would more than double. In fact, the calculation shows, with N = 2, the weight span would be 931 feet.

Example 12.3

Determine weight of conductor with ice loading for 795 ACSR (36/1) with 0.75 inches of radial ice due to extreme ice loading. The sag tables are a good source for the weight of the conductor with ice. However, when working an extreme ice loading problem it is necessary to calculate the weight of the conductor with the specific ice loading as shown in **Figure 3.3**.

The problem can be simplified by visualizing a 1-foot-long cylinder of ice that encapsulates a 1-foot-long piece of 795 ACSR. Subtract the volume of the 1-foot-long piece of 795 ACSR from the total cylinder, and what is left is the volume of ice. Per *NESC* Rule 250B, ice is assumed to weigh 56 lb per cubic foot, so once the volume of ice is known, it is possible to convert this into a weight.

Equation 12.2

$$V_{IC} = \frac{3\pi\,[(D_1^{\,2} - D_2^{\,2})]}{1728} \quad (\text{ft}^3)$$

Where:

V_{IC} = Volume of the ice cylinder in cubic feet (ft^3)
D_1 = Diameter (inches) of encapsulating cylinder, which is 1.04 + 0.75 + 0.75 = 2.54 inches
D_2 = Diameter (inches) of 795 ACSR conductor, which is 1.04 inches

The volume of ice is:

$$V_{IC} = \frac{3\pi\,[(2.54^2 - 1.04^2)]}{1728} \quad (\text{ft}^3) = 0.02929\ \text{ft}^3$$

Equation 12.3

$$C_{WT} = (V_{IC})(56) + W_C$$

Where:

C_{WT} = Unit weight of conductor plus ice loading in lb/ft
V_{IC} = Volume of the ice cylinder in cubic feet (ft^3)
W_C = Weight of the conductor in lb/ft, which for 795 ACSR = 0.805 lb/ft

$$C_{WT} = (0.02929)(56) + 0.805 = 2.445\ \text{lb/ft}$$

Note: For extreme ice at Grade C, the *NESC* allows a reduction in the ice thickness by 0.80.

LARGE LINE ANGLES

Table 12.5 shows the few line angle assemblies which can be used for extra-large conductors. When the line angle exceeds the maximum permissible angle as depicted in Table 12.5, the designer has only a few choices for the larger angles.

One of these options is a suspension turn using a C3.1 and a C3.1L. These assemblies call for a deadend shoe for the neutral attachment. The C3.1 assembly has a neutral spool for the neutral attachment. The neutral spool has a limit on the tension it can support, which is why these assemblies are not suitable for extra-large conductors. The C3.1L uses a bracket to support the suspension insulators. This helps to keep the conductors off of the pole surface on light angles and has a greater holding strength since it uses two bolts to support the bracket. The C3.1 does not call for these brackets and only uses a single bolt and washer for support. The maximum angle for the C3.1 is 60 degrees while the maximum angle on the C3.1L is 30 degrees. The difference can be attributed to the type of suspension clamp assembly that is used. Some of the suspension shoes are only rated for 30 degrees, while other manufacturers provide shoes rated for 60 degrees. It is possible to use a yoke plate to connect two 30 degree suspension shoes to the conductor to achieve more than 30 degrees. Keep in mind, at an angle of more than 60 degrees, the suspension insulator and bisect guy will be required to hold a tension greater than the deadend tension of one conductor.

A common mistake is to try to use a C6.31L (double deadend assembly) to turn an angle on large conductors. RUS limits the permission angle on this assembly to 15 degrees if an anchor shackle is installed on the eye bolt used to attach the suspension insulator (reference Note 2 on the specification).

A vertical assembly, such as C4.1G or C4.2G, can be used for large angles. Another possible assembly is a pair of buckarms as shown in C6.91G. The C6.91G works very well on a 90-degree turn. However, angles less than 90 degrees can result in conflicts between the down guys and the lateral conductors. *NESC* Rule 239E requires a minimum clearance between the phase conductor and the down guy, which will vary based on the operating voltage of the circuit. Even if a guy insulator link is used, a minimum clearance is required between the phase conductor and the guy insulator.

Guys and Anchors

The methods for guying are the same for extra-large conductors and for other distribution conductors. The methods and calculations for guying found in Section 7 would, therefore, also apply to extra-large conductors.

The relatively high tension of 4500 lb makes guying more difficult. Short guy leads generally are not effective for use with extra-large conductors. This is one of the main reasons for reducing the tension of the conductors even further, if possible. Since extra-large conductors are always used as three-phase lines, there is a significant tension to hold with the down guys. The use of down guys results in a vertical force pushing down through the pole. In some soft soils, this force can cause the pole to sink into the earth. Another problem is buckling of the pole (see Figure 7.7). Buckling can be managed by using larger-class poles and longer guy leads. A class 2 or 3 pole is generally suggested for deadend assemblies on extra-large conductors.

The E1.3L down guy is rated for 8500 lb, assuming a large enough guy wire is used. For Grade C construction, if the guy lead is set at a lead-to-height ratio of 1-to-1, then one down guy can generally support one extra-large conductor installed at 4500 lb maximum tension. If a 2-to-3 ratio is used, then more than one guy per conductor is required. For Grade B construction, more than one 8500-lb down guy is required for each conductor. Another option is transmission-grade down guys, which have two down guys on one attachment and one anchor. These types of down guys can be rated for 18,000 lb or more, depending on the strength of the attachment and the guy wire.

The anchoring used for extra-large conductors is the same as for distribution lines. F.10 and F.12 anchors are commonly used for each down guy. Alternatively, the designer could use a

20,000-lb anchor and attach two 8500-lb down guys. The space requirement for the anchors is a problem in designing extra-large conductor lines. Property owners resist providing the space necessary for the guy leads that are required for the higher tensions.

DEADEND GUYING

The calculation of deadend guying is shown in **Example 7.12**. The method shown in this example will also apply to extra-large conductors. Table 12.8 is a deadend guying table which can be used to help stake lines. It provides the deadend horizontal pull and total guy load for typical combinations of extra-large conductors. Note that a typical neutral conductor with a maximum tension is paired with each set of conductors. The tension level selected for the neutral conductor is slighter higher than might be required but provides more conservative designs. This table would not be applicable for full-sized neutrals. **Example 12.4** illustrates the use of this deadend guying table.

TABLE 12.8: Horizontal Pull and Total Guy Load at Deadends

LIGHT, MEDIUM, AND HEAVY LOADING DISTRICTS
Wire Height (ft) = 47.5 Guy Attachment Height (ft) = 46 Poles = 35 ft to 55 ft

Conductor	Design Tension (lb)	Horizontal Pull (lb)	Total Load (lb)		
			1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
GRADE C CONSTRUCTION Tension LF = 1.1					
(3) 556 ACSR 18/1 Primary (1) 336 ACSR 18/1 Neutral	4500 3500	19,310	27,308	34,811	43,178
(3) 740 AAAC Primary (1) 394 AAAC Neutral	4500 3000	18,742	26,505	33,787	41,908
(3) 795 ACSR 36/1 Primary (1) 336 ACSR 18/1 Neutral	4500 2600	18,288	25,862	32,968	40,892
GRADE B CONSTRUCTION Tension LF = 1.65					
(3) 556 ACSR 18/1 Primary (1) 336 ACSR 18/1 Neutral	4500 3500	28,965	40,962	52,217	64,767
(3) 740 AAAC Primary (1) 394 AAAC Neutral	4500 3000	28,113	39,757	50,681	62,862
(3) 795 ACSR 36/1 Primary (1) 336 ACSR 18/1 Neutral	4500 2600	27,431	38,794	49,452	61,338

Note: This table is based on the 2023 edition of the *NESC*.

Example 12.4

Determine the total guy load for the following deadend structure:

Given: Heavy Loading District
Grade C Construction
Pole Height = 55 ft
Pole Top Assembly = C5.3
Conductor (3) 795 ACSR 36/1 Primary and (1) 336 ACSR 18/1 Neutral
Design Tension: 4,500 lb for Primary and 2,600 lb for Neutral
Guy Lead Ratio = 1-to-1

Table 12.8 conforms to the above design parameters; therefore, it can be used to determine the total guy load.

Locate the combination of conductors to be guyed in the left-hand column and then read across the row to the 1-to-1 guy lead column. The total guy load = 25,862 lb.

LINE ANGLE GUYING

Line angle structures are typically guyed on the bisect of the angle. Guying tables are contained in **Appendix C** for the extra-large conductors. Note that the wind spans for extra-large conductors have been reduced in **Appendix C** to coincide with typical limitations of span lengths for these conductors. These tables provide the horizontal pull and total guy load for a selected group of design parameters. **Table 12.9** is an example of a line angle guying table for extra-large conductors. **Example 12.5** illustrates how to apply the information from these line angle guying tables.

TABLE 12.9: Heavy Loading District: Three Phase—795 ACSR Primary and 336 ACSR Neutral		
Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 795 ACSR 36/1 Neutral = (1) 336 ACSR 18/1 Pole = 55'/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4500 Design Tension (lb) = 2600 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.6800 Wind Load (lb/ft) = 0.5613 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2034	2868	3661	4556	2920	4118	5257	6542
4	2672	3768	4810	5986	3559	5018	6405	7971
6	3310	4667	5958	7414	4196	5917	7553	9400
8	3947	5565	7105	8841	4833	6815	8700	10,827
10	4583	6463	8250	10,267	5470	7713	9846	12,253
12	5219	7359	9394	11,690	6105	8608	10,989	13,676
14	5853	8253	10,536	13,111	6740	9503	12,131	15,097
16	6486	9145	11,675	14,529	7372	10,395	13,270	16,514
18	7117	10,035	12,811	15,943	8004	11,285	14,407	17,928
20	7747	10,923	13,944	17,353	8633	12,173	15,540	19,339
22	8375	11,808	15,074	18,759	9261	13,058	16,670	20,745
24	9000	12,690	16,200	20,160	9887	13,940	17,796	22,146
26	9623	13,569	17,322	21,556	10,510	14,819	18,918	23,542
28	10,244	14,444	18,439	22,947	11,130	15,694	20,035	24,932
30	10,862	15,315	19,552	24,331	11,748	16,565	21,147	26,317
32	11,477	16,183	20,659	25,709	12,364	17,433	22,254	27,694
34	12,089	17,046	21,761	27,080	12,976	18,296	23,356	29,065
36	12,698	17,904	22,856	28,444	13,584	19,154	24,452	30,429
38	13,303	18,758	23,946	29,800	14,190	20,008	25,542	31,785
40	13,905	19,606	25,029	31,147	14,792	20,856	26,625	33,133
42	14,503	20,449	26,105	32,487	15,389	21,699	27,701	34,472
44	15,097	21,287	27,175	33,817	15,983	22,537	28,770	35,803
46	15,687	22,118	28,236	35,138	16,573	23,368	29,832	37,124

NOTE: This table is based on the 2023 edition of the *NESC*.

Example 12.5

Use the line angle guying tables to determine guy assembly and anchor requirements. First, determine the total guy load for the given structure parameters:

Given: Heavy Loading District
Grade C Construction
Pole Height = 55 ft
Pole-Top Assembly = C3.1L
Conductor = (3) 795 ACSR 36/1 Primary, (1) 336 ACSR 18/1 Neutral
Design Tension = 4500 lb for Primary Conductor, 2600 lb for Neutral Conductor
Span = 250 ft
Line Angle = 20°
Guy Lead Ratio = 2-to-3

Table 12.9 conforms to the above design parameters; therefore, it can be used to determine the total guy load.

Locate the line angle degrees (20°). Read across the row and match up the proper range for the wind span, which for this example is 250 feet. The horizontal pull is 8633 lb, which is the load on a set of span guys if used on this structure. For this example, however, the goal was to find the total guy load for a 2-to-3 guy lead ratio. Reading across from the horizontal pull value to the 2-to-3 guy lead, the total guy load is given as 15,540 lb.

To select a guy and anchor assembly for this structure, it is necessary to find guys and anchors that can hold the total guy load of 15,540 lb.

An E1.1L guy assembly has a strength rating for the guy attachment of 8500 lb. Assuming a 10M guy wire is used, **Table 7.3** shows that the 10M guy wire has an *NESC* strength rating of 9000 lb. Thus, the strength rating of the guy assembly (attachment and guy wire) is the lesser amount, 8500 lb. This structure will require two E1.1L assemblies. For the anchor assembly, an F2.8 has a holding power of 8000 lb. in class 5 soil. Therefore, two F2.8 anchors would be required.

GROUNDING CONSIDERATIONS

The *NESC* requires that the grounding conductor which connects the system neutral to the driven ground rod have sufficient ampacity to carry the available fault current that may occur on the system. Specifically, in *NESC* Rule 093C2, the grounding conductor must have the ampacity of at least 20% of the neutral conductor. The designer needs to compare the conductivity of the grounding conductor to the system neutral. A #4 copper conductor could be used with a 336 ACSR neutral, but a general recommendation is to use a #2 copper conductor due to increased fault current and potentially high harmonic content on the system neutral.

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Assembly Numbering RUS Bulletin 1728F-804 12.47/7.2-kV Specs

In October 2005, RUS issued the new RUS Bulletin 1728F-804, Specifications and Drawings for 12.47/7.2 kV Line Construction. The introductory pages and the Disposition of Assemblies in the old Bulletin 50-3 (D804) are included as reference. The old bulletin was dated May 9, 1983, and the new bulletin is a significant upgrade, including a new numbering system and the inclusion of narrow profile assemblies in the bulletin itself, instead of the special bulletin and drawings used heretofore.

Table begins on next page.

A

TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly # (Bulletin 50-3)	New Assembly # (1728F-804)	Material Changes and Comments
A1	A1.1	No material changes
A1A	A1.2	No material changes
A1-1	A2.1	No material changes
A1-1A	A2.2	No material changes
A1P	A1.1P	No material changes
A1AP	A1.2P	No material changes
A1-1AP	A2.2P	No material changes
A1-1P	A2.1P	No material changes
A2	A2.3	No material changes
A2P	A2.3P	No material changes
A3	A3.1	Replace 2 washers abutting pole
A4	A4.1	Replace 4 washers abutting pole
A5	A5.1	Replace 2 washers abutting pole
A5-1	Discontinued	*(Material same as A5.1; Replaced with guide drawing A5.2G)*
A5-2	A5.2	Replace 2 washers abutting pole
A5-2A	Discontinued	*(Same as A5.2)*
A5-3	Discontinued	*(Same as A5.1)*
A5-4	Discontinued	*(Combination of A5.1, A1.1, and guide drawing A5.2G)*
A6	A6.1	Replace 4 washers abutting pole
A7	A5.21	No material changes
A7-1	A5.31	No material changes
A8	A6.21	No material changes
A9	A2.21	Add 4 washers under crossarm pins
A9P	A2.21P	Add 2 washers under crossarm pins
A9-1	A1.11	Add 2 washers under crossarm pins
A9-1P	A1.11P	Add 1 washer under crossarm pin
A22	Discontinued	*(Combination of A1.1, A1.11, and guide drawing A1.12G)*
A22P	Discontinued	*(Combination of A1.1, A1.11P, and guide drawing A1.12G)*
B1	B1.11	Add 2 washers under crossarm pins
B1A	B1.12	Add 2 washers under crossarm pins
B1P	B1.11P	No material changes
B1AP	B1.12P	No material changes
B1-1	B2.24	Add 4 washers under crossarm pins
B1-1A	B2.25	Add 4 washers under crossarm pins
B1-1P	B2.24P	No material changes
B1-1AP	B2.25P	No material changes
B2	B2.21	Add 4 washers under crossarm pins
B2P	B2.21P	No material changes

Continued

TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804) (cont.).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly # (Bulletin 50-3)	New Assembly # (1728F-804)	Material Changes and Comments
B3	B3.1	Replace 2 washers abutting pole and slight material changes
B3A	Discontinued	*(Similar to B3.1)*
B4-1	Discontinued	*(Replaced with guide B4.1G)*
B4-1A	Discontinued	*(Replaced with guide B4.1G)*
B5-1	B5.1	Replace 3 washers abutting pole and slight material changes
B5-1A	Discontinued	*(Similar to B5.1)*
B7	B5.21	Neutral position and material slightly different
B7-1	B5.31	Neutral position and material slightly different
B8	B6.21	Neutral and material slightly different
B9	B2.22	Add 6 washers under crossarm pins
B9-1	B1.14	Add 3 washers under crossarm pins
B9-2	Discontinued	*(Same as B2.22 except for 10-foot crossarms)*
B9-3	Discontinued	*(Same as B1.14 except for 10-foot crossarms)*
B9P	B2.22P	Add 2 washers under crossarm pins
B9-1P	B1.14P	Add 1 washer under crossarm pin
B9-2P	Discontinued	*(Same as B2.22P except for 10-foot crossarms)*
B9-3P	Discontinued	*(Same as B1.14P except for 10-foot crossarms)*
B22	Discontinued	*(Same as two B1.11s)*
B22P	Discontinued	*(Same as two B1.11Ps)*
C1	C1.11	Add 2 washers under crossarm pins
C1A	C1.12	Add 2 washers under crossarm pins
C1P	C1.11P	No material changes
C1AP	C1.12P	No material changes
C1PL	Discontinued	*(Same as C1.11P except crossarm braces)*
C1-1	C2.24	Add 4 washers under crossarm pins
C1-1A	C2.25	Add 4 washers under crossarm pins
C1-1AP	C2.24P	No material changes
C1-1P	C2.25P	No material changes
C1-3P	C2.21P	No material changes
C1-4PL	Discontinued	*(Second center insulator not needed)*
C1-2	C1.11L	No material changes
C1-3	C2.21L	No material changes
C1-4	C1.13L	No material changes
C2	C2.21	Add 4 washers under crossarm pins
C2-1	C2.52	Add 6 washers under crossarm pins
C2-2	C2.52L	No material changes
C2-2PL	C2.52P	2 fewer double arming bolts—optional
C3	C3.1	Replace 4 washers abutting pole; add neutral eyebolt

Continued

A

TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804) (cont.).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly	New Assembly	Material Changes Required for New RUS Specifications
C3-1	C3.1L	Replace 8 washers abutting pole
C4-1	Discontinued	*(Replaced with guide C4.1G)*
C5-1	C5.2	Replace 4 washers abutting pole
C7	C5.21	Replace 1 washer abutting pole
C7-1	C5.31	Replace 1 washer abutting pole
C7A	C5.71L	Replace 1 washer abutting pole
C7-2	C5.22	Slight material changes
C8	C6.21	Different neutral and crossarm brace materials
C8-1	Discontinued	*(Replaced with C6.52)*
C8-2	Discontinued	*(Similar to C5.21)*
C8-3	C6.31L	Different neutral position and materials
C9	C2.51	Add 8 washers under crossarm pins and anti-split bolt
C9-1	C1.41	Add 4 washers under crossarm pins
C9-2	C2.51L	Replace 2 crossarm pins with clamp-type
C9-3	C1.41L	Replace 1 crossarm pin with clamp-type
C9-1P	C1.41P	Add 1 washer under crossarm pin
C9-2PL	C2.51P	Add 2 washers under crossarm pins; 2 fewer double arming bolts—optional
C9-3PL	Discontinued	*(Similar to C1.41P)*
C22	Discontinued	*(Combination of C1.11 and A1.11, with spacing as shown in guide drawing C6.91G)*
C24	Discontinued	*(Combination of C1.11 and B1.11, with spacing as shown in guide drawing C6.91G)*
DC-C1	D1.81	Add 6 washers under crossarm pins
DC-C1A	Discontinued	
DC-C1-1A	Discontinued	
DC-C1PL	Discontinued	*(Replaced with D1.81P from RUS Bulletin 1728F-804*
DC-C1-3PL	Discontinued	*(Replaced with D2.91P from RUS Bulletin 1728F-804*
DC-C2	Discontinued	*(Wrong neutral for line angle)*
DC-C2-1	D2.91	Add 12 washers under crossarm pins
DC-C3	Discontinued	*(Replaced by two C3s and guide drawing D3.1G from RUS Bulletin 1728F-804)*
DC-C4-1	Discontinued	*(Replaced by four C3s and guide drawing D4.1G from RUS Bulletin 1728F-804)*
DC-C8	D6.91	Slightly different neutral and other material
DC-C25	Discontinued	*(Replace with guide drawing D5.91G from RUS Bulletin 1728F-804)*
E1-1	Discontinued	*(See E1.1)*
E1-2	E1.1	Add guy marker

Continued

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TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804) (cont.).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly # (Bulletin 50-3)	New Assembly # (1728F-804)	Material Changes and Comments
E1-3	E1.1L	Add guy marker
E2-1	Discontinued	
E2-2	E1.4	Different guy strand wire *(Different permitted loads)*
E2-3	E1.4L	Replace 5/8" thimble eyebolt and nut with 3/4"
E3-2	Discontinued	
E3-3	E1.2	Add guy marker *(Different permitted loads)*
E3-10	Discontinued	
E4-2	Discontinued	*(See note 3 on E1.4)*
E4-3	Discontinued	*(See note 3 on E1.4)*
E5-1	Discontinued	
E5-2	Discontinued	
E6-2	Discontinued	*(See guide drawing E2.1G)*
E6-3	Discontinued	*(See guide drawing E2.1G)*
E7-2	Discontinued	*(See guide drawing E3.1LG)*
E7-3	Discontinued	*(See guide drawing E3.1LG)*
E8-2	Discontinued	*(See guide drawing E4.3LG)*
E8-3	Discontinued	*(See guide drawing E4.3LG)*
E11	Discontinued	*(See E1.2)*
E12	Discontinued	*(See E1.2)*
F1-1	F1.6	No material changes
F1-2	F1.8	No material changes
F1-3	F1.10	No material changes
F1-4	F1.12	No material changes
F1-1C	Discontinued	*(Not in List of Materials)*
F1-2C	Discontinued	*(Not in List of Materials)*
F1-3C	Discontinued	*(Not in List of Materials)*
F1-1P	F3.6	No material changes
F1-2P	F3.8	No material changes
F1-3P	F3.10	No material changes
F1-4P	F3.12	No material changes
F1-1S	F2.6	No material changes
F1-2S	F2.8	No material changes
F1-3S	F2.10	No material changes
F1-4S	F2.12	No material changes
F2-1	Discontinued	
F2-2	Discontinued	
F2-3	Discontinued	
F2-4	Discontinued	

Continued

A

TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804) (cont.).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly	New Assembly	Material Changes Required for New RUS Specifications
F4-1E	F4.1	No material changes
F4-1S	F4.2	No material changes
F5-1	F5.1	No material changes
F5-2	F5.2	No material changes
F5-3	F5.3	No material changes
F6-1	F6.6	No material changes
F6-2	F6.8	No material changes
F6-3	F6.10	No material changes
G9-	G1.7	No material changes
G65-	Discontinued	
G105-	G1.2	No material changes
G10-	G1.8	No material changes
G66-	Discontinued	
G106-	G1.3	No material changes
G39-	Discontinued	*(See G1.7)*
G67-	Discontinued	
G136-	Discontinued	*(Same as G1.2)*
G210-	G2.1	No material changes *(Drawing modified)*
G310-	G3.1	No material changes *(Drawing modified)*
G311-	G3.2	No material changes *(Drawing modified)*
G312-	G3.3	No material changes *(Drawing modified)*
J5	J1.2	No material changes
J6	J3.1	No material changes
J7	J2.2	No material changes
J7C	Discontinued	*(See J2.2)*
J8	J1.1	No material changes
J10	J2.1	No material changes
J11	Discontinued	*(See J3.1)*
J12	J4.1	No material changes
K10	K2.1	No material changes
K11	K1.4	No material changes
K14	K1.3	No material changes
K10C	K2.2	No material changes
(K10C)	K2.3	No material changes
K10L	Discontinued	*(See K2.1)*
K11L	Discontinued	*(See K1.4)*
K14L	Discontinued	*(See K1.3)*
K11C	K1.2	No material changes

Continued

TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804) (cont.).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly # (Bulletin 50-3)	New Assembly # (1728F-804)	Material Changes and Comments
K14C	K1.1	No material changes
K15C	K1.5	No material changes
K16C	K3.2	No material changes
K17	K3.1	No material changes
K17L	Discontinued	*(See K3.1)*
M2-1	Discontinued	
M2-11	H1.1	No material changes
M2-2	Discontinued	
M2-12	H5.1	No material changes
M2-2A	Discontinued	
M2-12A	H5.2	No material changes
M2-2A2	Discontinued	
M2-12A2	Discontinued	
M2-3	Discontinued	
M2-13	H2.1	No material changes
M2-7	Discontinued	
M2-17	Discontinued	
M2-9	Discontinued	
M2-15	H3.1	No material changes
M2-15A	H4.1	No material changes
M3-1A	Discontinued	
M3-4	S1.1	Replace lag screw with machine bolt and washer
M3-2A	S2.21	Slight material changes
M3-3A	S2.31	Slight material changes
M3-3B	S2.3	No material changes
M3-10	R1.1	Slight material changes *(Add bracket)*
M3-41	S3.1	Slight material changes *(Add bracket)*
M3-11	Discontinued	*(See R3.1)*
M3-12	Discontinued	*(Replaced with R3.1)*
M3-11A	R2.1	No material changes
M3-12A	R3.1	No material changes
M3-15	S2.32	Slight material changes
M3-23	Discontinued	
M3-24	Discontinued	
M3-25	Discontinued	
M3-23A	R1.2	Slight material changes *(Add bracket)*
M3-24A	R2.2	Slight material changes
M3-25A	R3.2	Slight material changes

Continued

TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804) (cont.).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly	New Assembly	Material Changes Required for New RUS Specifications
M3-30	R3.3	Slight material changes
M5-1	Discontinued	
M5-2	A1.01	No material changes
M5-5	A1.011	Add 1 washer under crossarm pin
M5-6	P1.01	No material changes
M5-7	A1.011P	No material changes
M5-8	A5.02	No material changes
M5-9	S1.01	No material changes
M5-10	S1.02	No material changes
M5-11	Discontinued	
M5-12	Discontinued	
M5-13	W3.2	No material changes
M5-14	Discontinued	
M5-16	Discontinued	
M5-17	W3.1	No material changes
M5-18	A1.01P	No material changes
M5-19	N1.2	No material changes
M5-20	Discontinued	*(See A5.3)*
M5-21	Discontinued	
M5-22	Discontinued	
M5-23	Discontinued	
M5-24	A5.01	No material changes
M5-25	N5.1	Replace 1 washer abutting pole
M5-26	N5.3	Replace 1 washer abutting pole
M7-11	Y1.1	Minor material changes (Replace crossarms with bracket)
M7-13	Y1.3	Minor material changes
M8	Q1.1	Minor material changes
M8-6	Q3.1	No material changes
M8-9	Q2.2G	Modified guide drawing; no material
M8-10	Q2.1G	Modified guide drawing; no material
M8-11	Q3.3	Minor material changes
M8-12	Q3.2	Minor material changes
M8-15	Q4.1	Minor material changes
M9-11	Y3.1	No material changes
M9-12	Y3.2	Minor material changes
M9-13	Y3.3	Minor material changes
M19	W2.1G	Modified guide drawing; no material
M20	W1.1G	Modified guide drawing; no material

Continued

TABLE A.1: Disposition of Assemblies in RUS Bulletin 50-3 (D 804) (cont.).
Source: RUS Bulletin 1728F-804, Exhibit 3

Old Assembly # (Bulletin 50-3)	New Assembly # (1728F-804)	Material Changes and Comments
M21	Discontinued	*(Guide drawing)*
M22-1	Discontinued	*(Guide drawing)*
M22-2	Discontinued	*(Guide drawing)*
M24	K4.1G	Modified guide drawing; no material
M24-1	Discontinued	*(Guide drawing)*
M24-10	K4.2G	Modified guide drawing; no material
M26-5	Discontinued	*(Guide drawing)*
M27	Discontinued	*(Guide drawing)*
M27-1	Discontinued	*(Guide drawing)*
M27-1A	G1.1G	Modified guide drawing; no material
M27-2	Discontinued	*(Guide drawing)*
M28	Discontinued	*(See G1.1G)*
M29-1	Discontinued	*(See guide drawings in Sections A and C of RUS Bulletin 1728F-804)*
M29-2	Discontinued	*(See guide drawings in Sections A and C of RUS Bulletin 1728F-804)*
M30-1	Discontinued	*(Guide drawing)*
M30-2	Discontinued	*(Guide drawing)*
M40-11	Discontinued	*(Guide drawing)*
M41-1	Discontinued	*(Replaced assemblies L1.1 and L3.1)*
M41-10	Discontinued	*(Replaced assemblies L1.2 and L3.2)*
M42-3	Discontinued	*(Replaced assemblies L1.3 and L3.4)*
M42-11	Discontinued	*(Replaced assemblies L1.5 and L3.5)*
M42-13	Discontinued	*(Replaced assembly L2.5)*
M42-21	Discontinued	*(Replaced assemblies L1.4 and L3.3)*
M43-4	Discontinued	*(Guide drawing)*
M43-10	Discontinued	*(Guide drawing)*
M52-3	Discontinued	*(Guide drawing)*
M52-4	Discontinued	*(Guide drawing)*
R1	M1.30G	Modified guide drawing; no material

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B Sag and Tension Tables

How to Use Sag and Tension Tables

The tables in this manual contain pertinent data for the following conductors and ruling spans for a maximum operating voltage of 34.5 kV and assume standard RUS construction is used. These tables **DO NOT** apply to narrow profile construction.

Primary Conductors
4 ACSR 7/1 Stranding
2 ACSR 6/1 Stranding
1/0 ACSR 6/1 Stranding
3/0 ACSR 6/1 Stranding
4/0 ACSR 6/1 Stranding
336 ACSR 18/1 Stranding
477 ACSR 18/1 Stranding

Loading District	Ruling Spans
Light	250 ft, 300 ft, 350 ft
Medium	250 ft, 300 ft, 350 ft
Heavy	200 ft, 250 ft, 300 ft

Extra-Large Conductors
556 ACSR 18/1 Stranding
740 AAAC 37 Stranding
795 ACSR 36/1 Stranding

Loading District	Ruling Spans
Light	200 ft, 250 ft, 300 ft
Medium	200 ft, 250 ft, 300 ft
Heavy	200 ft, 250 ft, 300 ft

It is assumed in these sag tables that the neutral will be the same size as the phase conductor. This assumption is generally true for smaller conductors. The complexity of determining all the combinations of possible neutral conductors prohibits including neutral sag tables. Further, during construction, it is common that the neutral is pulled to the same sag as the primary, although this is inaccurate since the neutral conductor will react differently to changes in weather conditions. It is the goal of the engineer to select a neutral conductor whose sag and tension will closely match those of the phase conductors for a wide range of conditions. It is recommended that the staking technician consult the cooperative's engineer for guidance regarding the sags and tensions of the neutral conductors.

Detailed conductor data is given at the top of each table, including the cross-sectional area of the wires and a chart number. The chart number refers to an ALCOA stress-strain chart that provides the data necessary to calculate the sags and tensions using a graphing method developed in 1926. Also shown is the conductors' rated breaking strength. Conductor creep is a function of time and temperature and can cause a microstrain increase in elongation. Creep is considered in these sag calculations, and the tables state whether it is, or is not, a factor in the final sag values.

NESC (261H1b) requires aeolian vibration damage to be considered in the design of a new line and it shall be based on a qualified engineering study, manufacturer's recommendation, or experience from comparable installations. The sag tables contained in this Appendix use a common technique to reduce design tension limits for cold weather conditions, which is

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described in **Section 4**. For distribution conductors with tensions less than 5000 lb, vibration is generally limited to areas that have specific issues with vibration, such as Midwest states. Thus, the sag tables herein use the method described in **Section 4** to determine the sag and tension.

However, the staking technician is cautioned that this technique of reducing conductor tensions will not be appropriate for all locations, especially when the cooperative routinely experiences aeolian vibration.

The design points or conditions for the maximum conductor tension meet the requirements of *NESC* 261H2 and those listed in **Table 4.2**. In addition, the maximum tension is limited to 3500 lb for primary conductors, even though RUS design specifications allow for 5000 lb maximum tension. Experience has shown that reducing the tension limit yields more efficient structure designs while sacrificing only a small increase in conductor sag.

The maximum operating temperature of conductors covered by these tables is 120°F. Care should be exercised in electrically loading the conductor so this limit is not exceeded. Most manufacturers list the ampacity of their conductors based on a maximum operating temperature of approximately 167°F, which will **NOT** be applicable to those lines designed using these tables.

For extra-large conductors, a maximum tension of 4500 lb is used, as discussed in **Section 12**.

It is suggested that extra-large conductors be designed for maximum operating temperature of 167°F.

Sags and tensions are given for the ruling span for both the initial and final condition. An asterisk (*) marks the condition that controls the design tension.

To aid in using **Figure 3.9** for determining horizontal blowout, which is required by *NESC* Rules 233B and 234A2, the final and initial sags are given at 60°F with 6 lb-per-square-foot (psf) wind applied on the conductor. The sag for other span lengths in the section of line designed with a specific ruling span can be determined, knowing the sag of the ruling span, with the following formula:

Equation B.1

$$\text{Sag}_{\text{ALTERNATIVE SPAN}} = \text{Sag}_{\text{RULING SPAN}} \times \frac{(\text{Length}_{\text{ALTERNATIVE SPAN}})^2}{(\text{Length}_{\text{RULING SPAN}})^2}$$

A stringing table is provided for constructing the line. The spans range from 100 feet over to 100 feet under the ruling span in 10-foot increments. The temperatures range from 40°F to 100°F in 10° increments. Values in between should be interpolated. The sags are in decimal feet, which can be converted to inches simply by multiplying by 12.

The largest vertical sag is based on the 2023 *NESC*, which defines the largest sag in several rules: 232A, 233A1a(3), 234A, and 235C2b(1).

These rules state that vertical clearances apply under the following conductor temperature and loading conditions, whichever produces the largest final sag:

1. 120°F, no wind displacement
2. Maximum conductor operating temperature if greater than 120°F, no wind displacement
3. 32°F, no wind displacement, with radial thickness of ice as specified in Table 230-1.

These tables are based on a maximum operating temperature of 120°F. An operating temperature of 120°F must also be applied to the neutral conductors. Operating lines designed using these tables at temperatures in excess of 120°F may violate *NESC* code clearances. The additive constant “K” is required by and defined in *NESC* Table 251-1.

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TABLE B.1: Light Loading, 4 ACSR, Ruling Span = 250 Feet

Conductor: SWANATE	4 kcmil	7/1 Stranding ACSR
Area = 0.0411 sq in.	Weight = 0.067 lb/ft	
Diameter = 0.257 in.	RTS = 2360 lb	
Design data from Sag10 Chart No. 1-670	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp. (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.254	2.70	734	2.46	806
60	0	6	0	0.145	2.16	524	1.75	649
30	0	0	0	0.067	0.89	590*	0.73	716
32	0	0	0	0.067	0.90	580	0.74	710
60	0	0	0	0.067	1.16	450	0.86	608
90	0	0	0	0.067	1.61	325	1.07	491
120	0	0	0	0.067	2.28	230	1.42	370

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		681	**644**	**607**	**569**	**530**	**490**	**450**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.82	**150**	0.28	0.29	0.31	0.33	0.36	0.39	0.42
0.93	**160**	0.32	0.33	0.35	0.38	0.41	0.44	0.48
1.05	**170**	0.36	0.37	0.40	0.43	0.46	0.49	0.54
1.18	**180**	0.40	0.42	0.45	0.48	0.51	0.55	0.60
1.32	**190**	0.44	0.47	0.50	0.53	0.57	0.62	0.67
1.46	**200**	0.49	0.52	0.55	0.59	0.63	0.68	0.74
1.61	**210**	0.54	0.57	0.61	0.65	0.70	0.75	0.82
1.77	**220**	0.60	0.63	0.67	0.71	0.77	0.83	0.90
1.93	**230**	0.65	0.69	0.73	0.78	0.84	0.91	0.98
2.10	**240**	0.71	0.75	0.79	0.85	0.91	0.99	1.07
2.28	**250**	0.77	0.81	0.86	0.92	0.99	1.07	1.16
2.47	**260**	0.83	0.88	0.93	1.00	1.07	1.16	1.25
2.66	**270**	0.90	0.94	1.00	1.07	1.15	1.25	1.35
2.86	**280**	0.97	1.02	1.08	1.15	1.24	1.34	1.46
3.07	**290**	1.04	1.09	1.16	1.24	1.33	1.44	1.56
3.28	**300**	1.11	1.17	1.24	1.32	1.43	1.54	1.67
3.51	**310**	1.18	1.25	1.32	1.41	1.52	1.65	1.78
3.74	**320**	1.26	1.33	1.41	1.51	1.62	1.75	1.90
3.97	**330**	1.34	1.41	1.50	1.60	1.72	1.86	2.02
4.22	**340**	1.42	1.50	1.59	1.70	1.83	1.98	2.15
4.47	350	1.51	1.59	1.69	1.80	1.94	2.10	2.27

[1] Largest final sag is defined by 2023 NESC Rule 232A.

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TABLE B.2: Light Loading, 4 ACSR, Ruling Span = 300 Feet

Conductor: SWANATE | 4 kcmil | 7/1 Stranding ACSR
Area = 0.0411 sq in. | Weight = 0.067 lb/ft
Diameter = 0.257 in. | RTS = 2360 lb
Design data from Sag10 Chart No. 1-670 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp. (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.254	3.69	774	3.42	835
60	0	6	0	0.145	2.98	548	2.45	665
30	0	0	0	0.067	1.28	590*	1.05	717
32	0	0	0	0.067	1.30	581	1.06	710
60	0	0	0	0.067	1.66	454	1.24	610
90	0	0	0	0.067	2.24	337	1.52	496
120	0	0	0	0.067	3.04	248	1.98	381

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		682	**646**	**610**	**572**	**534**	**496**	**457**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.35	**200**	0.49	0.52	0.55	0.59	0.63	0.68	0.73
1.49	**210**	0.54	0.57	0.61	0.65	0.69	0.74	0.81
1.63	**220**	0.59	0.63	0.67	0.71	0.76	0.82	0.89
1.79	**230**	0.65	0.69	0.73	0.78	0.83	0.89	0.97
1.95	**240**	0.70	0.75	0.79	0.84	0.90	0.97	1.06
2.11	**250**	0.76	0.81	0.86	0.92	0.98	1.06	1.15
2.28	**260**	0.83	0.88	0.93	0.99	1.06	1.14	1.24
2.46	**270**	0.89	0.95	1.00	1.07	1.14	1.23	1.34
2.65	**280**	0.96	1.02	1.08	1.15	1.23	1.32	1.44
2.84	**290**	1.03	1.09	1.16	1.23	1.32	1.42	1.54
3.04	**300**	1.10	1.17	1.24	1.32	1.41	1.52	1.65
3.25	**310**	1.17	1.25	1.32	1.41	1.51	1.62	1.76
3.46	**320**	1.25	1.33	1.41	1.50	1.60	1.73	1.88
3.68	**330**	1.33	1.42	1.50	1.60	1.71	1.84	2.00
3.90	**340**	1.41	1.50	1.59	1.70	1.81	1.95	2.12
4.14	**350**	1.50	1.59	1.69	1.80	1.92	2.07	2.25
4.38	**360**	1.58	1.68	1.79	1.90	2.03	2.19	2.38
4.62	**370**	1.67	1.78	1.89	2.01	2.14	2.31	2.51
4.88	**380**	1.76	1.88	1.99	2.12	2.26	2.44	2.65
5.14	**390**	1.86	1.98	2.10	2.23	2.38	2.57	2.79
5.40	**400**	1.96	2.08	2.20	2.35	2.51	2.70	2.93

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.3: Light Loading, 4 ACSR, Ruling Span = 350 Feet

Conductor: SWANATE	4 kcmil	7/1 Stranding ACSR
Area = 0.0411 sq in.	Weight = 0.067 lb/ft	
Diameter = 0.257 in.	RTS = 2360 lb	
Design data from Sag10 Chart No. 1-670	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp. (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.254	4.78	814	4.50	866
60	0	6	0	0.145	3.88	573	3.25	682
30	0	0	0	0.067	1.74	590*	1.43	718
32	0	0	0	0.067	1.77	581	1.44	711
60	0	0	0	0.067	2.23	459	1.68	612
90	0	0	0	0.067	2.95	348	2.05	502
120	0	0	0	0.067	3.86	266	2.61	392

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		683	**648**	**612**	**576**	**539**	**502**	**464**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.97	**250**	0.77	0.81	0.86	0.91	0.97	1.05	1.13
2.13	**260**	0.83	0.87	0.93	0.98	1.05	1.13	1.22
2.30	**270**	0.89	0.94	1.00	1.06	1.13	1.22	1.32
2.47	**280**	0.96	1.01	1.08	1.14	1.22	1.31	1.41
2.65	**290**	1.03	1.08	1.15	1.22	1.30	1.41	1.52
2.84	**300**	1.10	1.16	1.23	1.31	1.40	1.51	1.62
3.03	**310**	1.18	1.24	1.32	1.40	1.49	1.61	1.73
3.23	**320**	1.25	1.32	1.40	1.49	1.59	1.71	1.85
3.43	**330**	1.33	1.40	1.49	1.58	1.69	1.82	1.96
3.64	**340**	1.42	1.49	1.59	1.68	1.79	1.93	2.09
3.86	**350**	1.50	1.58	1.68	1.78	1.90	2.05	2.21
4.08	**360**	1.59	1.67	1.78	1.88	2.01	2.17	2.34
4.31	**370**	1.68	1.77	1.88	1.99	2.12	2.29	2.47
4.55	**380**	1.77	1.86	1.98	2.10	2.24	2.42	2.61
4.79	**390**	1.86	1.96	2.09	2.21	2.36	2.55	2.74
5.04	**400**	1.96	2.06	2.19	2.32	2.48	2.68	2.89
5.30	**410**	2.06	2.17	2.31	2.44	2.61	2.81	3.03
5.56	**420**	2.16	2.28	2.42	2.56	2.74	2.95	3.18
5.83	**430**	2.26	2.38	2.54	2.69	2.87	3.09	3.34
6.10	**440**	2.37	2.50	2.66	2.81	3.00	3.24	3.49
6.38	**450**	2.48	2.61	2.78	2.94	3.14	3.39	3.65

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

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TABLE B.4: Light Loading, 2 ACSR, Ruling Span = 250 Feet

Conductor: SPARROW	2 kcmil	6/1 Stranding ACSR
Area = 0.0608 sq in.	Weight = 0.091 lb/ft	
Diameter = 0.316 in.	RTS = 2850 lb	
Design data from Sag10 Chart No. 1-1023	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp. (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.304	2.66	894	2.30	1031
60	0	6	0	0.182	2.30	619	1.72	829
30	0	0	0	0.091	1.00	712*	0.76	930
32	0	0	0	0.091	1.02	699	0.77	920
60	0	0	0	0.091	1.38	517	0.91	780
90	0	0	0	0.091	1.99	357	1.15	621
120	0	0	0	0.091	2.65	269	1.54	461

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		881	**831**	**780**	**728**	**674**	**621**	**567**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.95	**150**	0.29	0.31	0.33	0.35	0.38	0.41	0.45
1.09	**160**	0.33	0.35	0.37	0.40	0.43	0.47	0.51
1.23	**170**	0.37	0.40	0.42	0.45	0.49	0.53	0.58
1.37	**180**	0.42	0.45	0.47	0.51	0.54	0.60	0.65
1.53	**190**	0.47	0.50	0.53	0.57	0.61	0.66	0.72
1.70	**200**	0.52	0.55	0.58	0.63	0.67	0.74	0.80
1.87	**210**	0.57	0.61	0.64	0.69	0.74	0.81	0.88
2.05	**220**	0.63	0.67	0.70	0.76	0.81	0.89	0.97
2.24	**230**	0.69	0.73	0.77	0.83	0.89	0.97	1.06
2.44	**240**	0.75	0.79	0.84	0.90	0.97	1.06	1.15
2.65	**250**	0.81	0.86	0.91	0.98	1.05	1.15	1.25
2.87	**260**	0.88	0.93	0.98	1.06	1.14	1.24	1.35
3.09	**270**	0.94	1.00	1.06	1.14	1.22	1.34	1.46
3.32	**280**	1.02	1.08	1.14	1.23	1.32	1.44	1.57
3.57	**290**	1.09	1.16	1.22	1.32	1.41	1.55	1.68
3.82	**300**	1.17	1.24	1.31	1.41	1.51	1.66	1.80
4.07	**310**	1.25	1.32	1.40	1.51	1.61	1.77	1.92
4.34	**320**	1.33	1.41	1.49	1.61	1.72	1.88	2.05
4.62	**330**	1.41	1.50	1.59	1.71	1.83	2.00	2.18
4.90	**340**	1.50	1.59	1.68	1.81	1.94	2.13	2.31
5.19	**350**	1.59	1.69	1.78	1.92	2.06	2.25	2.45

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.5: Light Loading, 2 ACSR, Ruling Span = 300 Feet

Conductor: SPARROW	2 kcmil	6/1 Stranding ACSR
Area = 0.0608 sq in.	Weight = 0.091 lb/ft	
Diameter = 0.316 in.	RTS = 2850 lb	
Design data from Sag10 Chart No. 1-1023	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp. (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.304	3.63	944	3.21	1066
60	0	6	0	0.182	3.14	653	2.41	851
30	0	0	0	0.091	1.44	713*	1.10	933
32	0	0	0	0.091	1.46	699	1.11	923
60	0	0	0	0.091	1.95	526	1.30	786
90	0	0	0	0.091	2.71	378	1.62	631
120	0	0	0	0.091	3.57	287	2.14	479

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		885	**836**	**785**	**734**	**683**	**631**	**579**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.59	**200**	0.52	0.55	0.58	0.62	0.67	0.72	0.79
1.75	**210**	0.57	0.60	0.64	0.68	0.74	0.79	0.87
1.92	**220**	0.62	0.66	0.70	0.75	0.81	0.87	0.95
2.10	**230**	0.68	0.72	0.76	0.82	0.88	0.95	1.04
2.28	**240**	0.74	0.79	0.83	0.89	0.96	1.04	1.13
2.48	**250**	0.81	0.85	0.90	0.97	1.04	1.13	1.23
2.68	**260**	0.87	0.92	0.98	1.04	1.13	1.22	1.33
2.89	**270**	0.94	1.00	1.05	1.13	1.22	1.31	1.43
3.11	**280**	1.01	1.07	1.13	1.21	1.31	1.41	1.54
3.34	**290**	1.08	1.15	1.21	1.30	1.40	1.51	1.65
3.57	**300**	1.16	1.23	1.30	1.39	1.50	1.62	1.77
3.81	**310**	1.24	1.31	1.39	1.48	1.60	1.73	1.89
4.06	**320**	1.32	1.40	1.48	1.58	1.71	1.84	2.01
4.32	**330**	1.40	1.49	1.57	1.68	1.82	1.96	2.14
4.59	**340**	1.49	1.58	1.67	1.79	1.93	2.08	2.27
4.86	**350**	1.58	1.67	1.77	1.89	2.04	2.21	2.41
5.14	**360**	1.67	1.77	1.87	2.00	2.16	2.33	2.55
5.43	**370**	1.76	1.87	1.98	2.11	2.28	2.46	2.69
5.73	**380**	1.86	1.97	2.09	2.23	2.41	2.60	2.84
6.03	**390**	1.96	2.08	2.20	2.35	2.54	2.74	2.99
6.35	**400**	2.06	2.19	2.31	2.47	2.67	2.88	3.15

[1] Largest final sag is defined by 2023 NESC Rule 232A.

TABLE B.6: Light Loading, 2 ACSR, Ruling Span = 350 Feet

Conductor: SPARROW	2 kcmil	6/1 Stranding ACSR
Area = 0.0608 sq in.	Weight = 0.091 lb/ft	
Diameter = 0.316 in.	RTS = 2850 lb	
Design data from Sag10 Chart No. 1-1023	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp. (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.304	4.70	991	4.22	1102
60	0	6	0	0.182	4.08	686	3.20	873
30	0	0	0	0.091	1.96	713*	1.49	935
32	0	0	0	0.091	1.99	700	1.51	926
60	0	0	0	0.091	2.60	535	1.76	791
90	0	0	0	0.091	3.51	397	2.18	641
120	0	0	0	0.091	4.57	306	2.81	497

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		888	**839**	**790**	**740**	**690**	**640**	**591**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.33	**250**	0.80	0.85	0.90	0.96	1.03	1.11	1.20
2.52	**260**	0.87	0.92	0.97	1.04	1.11	1.20	1.30
2.72	**270**	0.93	0.99	1.05	1.12	1.20	1.30	1.40
2.92	**280**	1.00	1.06	1.13	1.20	1.29	1.40	1.51
3.14	**290**	1.08	1.14	1.21	1.29	1.39	1.50	1.62
3.36	**300**	1.15	1.22	1.29	1.38	1.48	1.60	1.73
3.59	**310**	1.23	1.30	1.38	1.47	1.58	1.71	1.85
3.82	**320**	1.31	1.39	1.47	1.57	1.69	1.82	1.97
4.06	**330**	1.40	1.48	1.56	1.67	1.80	1.94	2.10
4.31	**340**	1.48	1.57	1.66	1.77	1.91	2.06	2.23
4.57	**350**	1.57	1.66	1.76	1.88	2.02	2.18	2.36
4.83	**360**	1.66	1.76	1.86	1.99	2.14	2.31	2.50
5.11	**370**	1.75	1.86	1.97	2.10	2.26	2.44	2.64
5.39	**380**	1.85	1.96	2.07	2.22	2.38	2.57	2.78
5.67	**390**	1.95	2.06	2.19	2.33	2.51	2.71	2.93
5.97	**400**	2.05	2.17	2.30	2.46	2.64	2.85	3.08
6.27	**410**	2.15	2.28	2.42	2.58	2.77	2.99	3.24
6.58	**420**	2.26	2.39	2.53	2.71	2.91	3.14	3.40
6.90	**430**	2.37	2.51	2.66	2.84	3.05	3.29	3.56
7.22	**440**	2.48	2.62	2.78	2.97	3.19	3.45	3.73
7.55	**450**	2.60	2.74	2.91	3.11	3.34	3.60	3.90

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.7: Light Loading, 1/0 ACSR, Ruling Span = 250 Feet

Conductor: RAVEN	1/0 kcmil	6/1 Stranding ACSR
Area = 0.0968 sq in.	Weight = 0.145 lb/ft	
Diameter = 0.398 in.	RTS = 4380 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp. (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.382	2.31	1294	2.07	1440
60	0	6	0	0.246	2.12	908	1.66	1162
30	0	0	0	0.145	1.04	1095	0.85	1325*
32	0	0	0	0.145	1.06	1073	0.86	1311
60	0	0	0	0.145	1.43	793	1.03	1105
90	0	0	0	0.145	2.06	550	1.29	878
120	0	0	0	0.145	2.84	400	1.71	661

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1253	**1179**	**1105**	**1029**	**954**	**878**	**804**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.02	**150**	0.32	0.35	0.37	0.40	0.43	0.46	0.51
1.16	**160**	0.37	0.39	0.42	0.45	0.49	0.53	0.58
1.31	**170**	0.42	0.44	0.48	0.51	0.55	0.60	0.65
1.47	**180**	0.47	0.50	0.53	0.57	0.62	0.67	0.73
1.64	**190**	0.52	0.55	0.59	0.64	0.69	0.75	0.81
1.82	**200**	0.58	0.61	0.66	0.70	0.76	0.83	0.90
2.00	**210**	0.64	0.68	0.73	0.78	0.84	0.91	0.99
2.20	**220**	0.70	0.74	0.80	0.85	0.92	1.00	1.09
2.40	**230**	0.76	0.81	0.87	0.93	1.01	1.09	1.19
2.62	**240**	0.83	0.88	0.95	1.01	1.10	1.19	1.30
2.84	**250**	0.90	0.96	1.03	1.10	1.19	1.29	1.41
3.07	**260**	0.97	1.04	1.11	1.19	1.29	1.40	1.53
3.31	**270**	1.05	1.12	1.20	1.28	1.39	1.50	1.64
3.56	**280**	1.13	1.20	1.29	1.38	1.49	1.62	1.77
3.82	**290**	1.21	1.29	1.39	1.48	1.60	1.74	1.90
4.09	**300**	1.30	1.38	1.48	1.58	1.71	1.86	2.03
4.37	**310**	1.38	1.48	1.58	1.69	1.83	1.98	2.17
4.65	**320**	1.47	1.57	1.69	1.80	1.95	2.11	2.31
4.95	**330**	1.57	1.67	1.79	1.92	2.07	2.25	2.46
5.25	**340**	1.66	1.78	1.91	2.03	2.20	2.39	2.61
5.57	**350**	1.76	1.88	2.02	2.16	2.33	2.53	2.76

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.8: Light Loading, 1/0 ACSR, Ruling Span = 300 Feet								
Conductor: RAVEN				1/0 kcmil		6/1 Stranding ACSR		
Area = 0.0968 sq in.				Weight = 0.145 lb/ft				
Diameter = 0.398 in.				RTS = 4380 lb				
Design data from Sag10 Chart No. 1-938				Ice = 56 lb/ft^3				
Design Points								
Creep IS a Factor					**Final**		**Initial**	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.382	3.18	1352	2.90	1483
60	0	6	0	0.246	2.91	952	2.33	1191
30	0	0	0	0.145	1.49	1095*	1.23	1330
32	0	0	0	0.145	1.52	1075	1.24	1315
60	0	0	0	0.145	2.02	808	1.46	1114
90	0	0	0	0.145	2.80	583	1.82	895
120	0	0	0	0.145	3.74	437	2.36	691

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1258	**1186**	**1114**	**1041**	**968**	**895**	**824**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.66	**200**	0.58	0.61	0.65	0.70	0.75	0.81	0.88
1.83	**210**	0.64	0.67	0.72	0.77	0.83	0.89	0.97
2.01	**220**	0.70	0.74	0.79	0.84	0.91	0.98	1.06
2.20	**230**	0.76	0.81	0.86	0.92	0.99	1.07	1.16
2.39	**240**	0.83	0.88	0.93	1.00	1.08	1.16	1.27
2.60	**250**	0.90	0.95	1.01	1.09	1.17	1.26	1.38
2.81	**260**	0.98	1.03	1.10	1.18	1.27	1.37	1.49
3.03	**270**	1.05	1.11	1.18	1.27	1.37	1.47	1.60
3.26	**280**	1.13	1.19	1.27	1.37	1.47	1.59	1.72
3.49	**290**	1.21	1.28	1.36	1.47	1.58	1.70	1.85
3.74	**300**	1.30	1.37	1.46	1.57	1.69	1.82	1.98
3.99	**310**	1.39	1.46	1.56	1.68	1.80	1.94	2.11
4.26	**320**	1.48	1.56	1.66	1.79	1.92	2.07	2.25
4.53	**330**	1.57	1.66	1.77	1.90	2.04	2.20	2.40
4.80	**340**	1.67	1.76	1.88	2.02	2.17	2.34	2.54
5.09	**350**	1.77	1.86	1.99	2.14	2.30	2.48	2.70
5.39	**360**	1.87	1.97	2.10	2.26	2.43	2.62	2.85
5.69	**370**	1.98	2.08	2.22	2.39	2.57	2.77	3.01
6.00	**380**	2.09	2.20	2.34	2.52	2.71	2.92	3.18
6.32	**390**	2.20	2.32	2.47	2.65	2.86	3.08	3.35
6.65	**400**	2.31	2.44	2.60	2.79	3.00	3.24	3.52

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.9: Light Loading, 1/0 ACSR, Ruling Span = 350 Feet

Conductor: RAVEN | 1/0 kcmil | 6/1 Stranding ACSR
Area = 0.0968 sq in. | Weight = 0.145 lb/ft
Diameter = 0.398 in. | RTS = 4380 lb
Design data from Sag10 Chart No. 1-938 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	Ice (in.)	Wind (psf)	K (lb/ft)	Weight (lb/ft)	Sag (ft)	Tension (lb)	Sag (ft)	Tension (lb)
30	0	9	0.05	0.382	4.15	1409	3.83	1526
60	0	6	0	0.246	3.79	994	3.09	1220
30	0	0	0	0.145	2.03	1095*	1.67	1333
32	0	0	0	0.145	2.06	1075	1.68	1319
60	0	0	0	0.145	2.70	824	1.98	1122
90	0	0	0	0.145	3.61	615	2.44	912
120	0	0	0	0.145	4.67	476	3.09	718

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1263	1193	1122	1051	981	912	844
		Temperature (°F)						
		40	50	60	70	80	90	100
2.38	**250**	0.90	0.95	1.01	1.08	1.15	1.24	1.34
2.58	**260**	0.97	1.03	1.09	1.16	1.25	1.35	1.45
2.78	**270**	1.05	1.11	1.18	1.26	1.34	1.45	1.57
2.99	**280**	1.13	1.19	1.27	1.35	1.45	1.56	1.68
3.21	**290**	1.21	1.28	1.36	1.45	1.55	1.68	1.81
3.43	**300**	1.29	1.37	1.45	1.55	1.66	1.79	1.93
3.66	**310**	1.38	1.46	1.55	1.66	1.77	1.91	2.06
3.90	**320**	1.47	1.55	1.66	1.76	1.89	2.04	2.20
4.15	**330**	1.56	1.65	1.76	1.88	2.01	2.17	2.34
4.41	**340**	1.66	1.76	1.87	1.99	2.13	2.30	2.48
4.67	**350**	1.76	1.86	1.98	2.11	2.26	2.44	2.63
4.94	**360**	1.86	1.97	2.09	2.23	2.39	2.58	2.78
5.22	**370**	1.97	2.08	2.21	2.36	2.53	2.73	2.94
5.50	**380**	2.07	2.19	2.33	2.49	2.66	2.88	3.10
5.80	**390**	2.19	2.31	2.46	2.62	2.81	3.03	3.27
6.10	**400**	2.30	2.43	2.59	2.76	2.95	3.19	3.44
6.41	**410**	2.42	2.55	2.72	2.90	3.10	3.35	3.61
6.72	**420**	2.53	2.68	2.85	3.04	3.25	3.51	3.79
7.05	**430**	2.66	2.81	2.99	3.18	3.41	3.68	3.97
7.38	**440**	2.78	2.94	3.13	3.33	3.57	3.86	4.16
7.72	**450**	2.91	3.07	3.27	3.49	3.74	4.03	4.35

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.10: Light Loading, 3/0 ACSR, Ruling Span = 250 Feet

Conductor: PIGEON | 3/0 kcmil | 6/1 Stranding ACSR
Area = 0.1537 sq in. | Weight = 0.230 lb/ft
Diameter = 0.502 in. | RTS = 6620 lb
Design data from Sag10 Chart No. 1-938 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.491	2.04	1878	1.80	2128
60	0	6	0	0.340	2.02	1319	1.55	1715
30	0	0	0	0.230	1.09	1655*	0.90	2001
32	0	0	0	0.230	1.11	1622	0.91	1978
60	0	0	0	0.230	1.51	1187	1.09	1648
90	0	0	0	0.230	2.19	822	1.39	1291
120	0	0	0	0.230	2.97	606	1.87	960

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1885	**1767**	**1648**	**1529**	**1409**	**1291**	**1176**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.07	**150**	0.34	0.37	0.39	0.42	0.46	0.50	0.55
1.22	**160**	0.39	0.42	0.45	0.48	0.52	0.57	0.63
1.37	**170**	0.44	0.47	0.50	0.55	0.59	0.64	0.71
1.54	**180**	0.49	0.53	0.57	0.61	0.66	0.72	0.79
1.72	**190**	0.55	0.59	0.63	0.68	0.74	0.80	0.88
1.90	**200**	0.61	0.65	0.70	0.76	0.82	0.89	0.98
2.10	**210**	0.67	0.72	0.77	0.83	0.90	0.98	1.08
2.30	**220**	0.74	0.79	0.84	0.91	0.99	1.08	1.18
2.51	**230**	0.80	0.86	0.92	1.00	1.08	1.18	1.29
2.74	**240**	0.88	0.94	1.00	1.09	1.18	1.28	1.41
2.97	**250**	0.95	1.02	1.09	1.18	1.28	1.39	1.53
3.21	**260**	1.03	1.10	1.18	1.28	1.38	1.50	1.65
3.46	**270**	1.11	1.19	1.27	1.38	1.49	1.62	1.78
3.73	**280**	1.19	1.28	1.37	1.48	1.61	1.74	1.92
4.00	**290**	1.28	1.37	1.47	1.59	1.72	1.87	2.06
4.28	**300**	1.37	1.47	1.57	1.70	1.84	2.00	2.20
4.57	**310**	1.46	1.57	1.68	1.81	1.97	2.14	2.35
4.87	**320**	1.56	1.67	1.79	1.93	2.10	2.28	2.51
5.17	**330**	1.66	1.78	1.90	2.06	2.23	2.42	2.67
5.49	**340**	1.76	1.89	2.02	2.18	2.37	2.57	2.83
5.82	**350**	1.86	2.00	2.14	2.31	2.51	2.72	3.00

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.11: Light Loading, 3/0 ACSR, Ruling Span = 300 Feet

Conductor: PIGEON	3/0 kcmil	6/1 Stranding ACSR
Area = 0.1537 sq in.	Weight = 0.230 lb/ft	
Diameter = 0.502 in.	RTS = 6620 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.491	2.84	1946	2.54	2179
60	0	6	0	0.340	2.78	1377	2.19	1753
30	0	0	0	0.230	1.56	1655*	1.29	2007
32	0	0	0	0.230	1.59	1623	1.30	1985
60	0	0	0	0.230	2.13	1213	1.56	1663
90	0	0	0	0.230	2.95	877	1.96	1321
120	0	0	0	0.230	3.90	663	2.56	1010

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1893	**1779**	**1663**	**1548**	**1433**	**1321**	**1212**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.73	**200**	0.61	0.64	0.69	0.74	0.80	0.87	0.95
1.91	**210**	0.67	0.71	0.76	0.82	0.89	0.96	1.05
2.10	**220**	0.74	0.78	0.84	0.90	0.97	1.05	1.15
2.29	**230**	0.81	0.85	0.92	0.98	1.06	1.15	1.26
2.50	**240**	0.88	0.93	1.00	1.07	1.16	1.25	1.37
2.71	**250**	0.95	1.01	1.08	1.16	1.26	1.36	1.49
2.93	**260**	1.03	1.09	1.17	1.25	1.36	1.47	1.61
3.16	**270**	1.11	1.17	1.26	1.35	1.47	1.59	1.73
3.40	**280**	1.19	1.26	1.36	1.45	1.58	1.71	1.86
3.64	**290**	1.28	1.35	1.46	1.56	1.69	1.83	2.00
3.90	**300**	1.37	1.45	1.56	1.67	1.81	1.96	2.14
4.16	**310**	1.46	1.55	1.67	1.78	1.93	2.09	2.29
4.44	**320**	1.56	1.65	1.77	1.90	2.06	2.23	2.43
4.72	**330**	1.66	1.75	1.89	2.02	2.19	2.37	2.59
5.01	**340**	1.76	1.86	2.00	2.15	2.32	2.52	2.75
5.31	**350**	1.86	1.97	2.12	2.27	2.46	2.67	2.91
5.62	**360**	1.97	2.09	2.25	2.40	2.61	2.82	3.08
5.93	**370**	2.08	2.21	2.37	2.54	2.75	2.98	3.26
6.26	**380**	2.20	2.33	2.50	2.68	2.90	3.14	3.43
6.59	**390**	2.32	2.45	2.64	2.82	3.06	3.31	3.62
6.93	**400**	2.44	2.58	2.77	2.97	3.22	3.48	3.80

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.12: Light Loading, 3/0 ACSR, Ruling Span = 350 Feet

Conductor: PIGEON — 3/0 kcmil — 6/1 Stranding ACSR
Area = 0.1537 sq in. — Weight = 0.230 lb/ft
Diameter = 0.502 in. — RTS = 6620 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.491	3.74	2013	3.37	2231
60	0	6	0	0.340	3.64	1434	2.91	1791
30	0	0	0	0.230	2.13	1655*	1.75	2012
32	0	0	0	0.230	2.17	1625	1.77	1990
60	0	0	0	0.230	2.84	1239	2.10	1677
90	0	0	0	0.230	3.80	928	2.61	1350
120	0	0	0	0.230	4.86	726	3.33	1058

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1901	**1789**	**1677**	**1566**	**1456**	**1350**	**1247**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.48	**250**	0.94	1.01	1.07	1.15	1.23	1.33	1.44
2.68	**260**	1.02	1.09	1.16	1.24	1.34	1.44	1.56
2.89	**270**	1.10	1.17	1.25	1.34	1.44	1.55	1.68
3.11	**280**	1.18	1.26	1.34	1.44	1.55	1.67	1.81
3.34	**290**	1.27	1.35	1.44	1.54	1.66	1.79	1.94
3.57	**300**	1.36	1.45	1.54	1.65	1.78	1.92	2.08
3.81	**310**	1.45	1.55	1.65	1.77	1.90	2.05	2.22
4.06	**320**	1.55	1.65	1.76	1.88	2.02	2.18	2.37
4.32	**330**	1.64	1.75	1.87	2.00	2.15	2.32	2.52
4.59	**340**	1.75	1.86	1.98	2.12	2.28	2.46	2.67
4.86	**350**	1.85	1.97	2.10	2.25	2.42	2.61	2.83
5.14	**360**	1.96	2.08	2.22	2.38	2.56	2.76	2.99
5.43	**370**	2.07	2.20	2.35	2.51	2.70	2.92	3.16
5.73	**380**	2.18	2.32	2.48	2.65	2.85	3.08	3.34
6.03	**390**	2.30	2.45	2.61	2.79	3.00	3.24	3.51
6.35	**400**	2.42	2.57	2.74	2.94	3.16	3.41	3.70
6.67	**410**	2.54	2.70	2.88	3.09	3.32	3.58	3.88
7.00	**420**	2.66	2.84	3.02	3.24	3.48	3.76	4.08
7.34	**430**	2.79	2.97	3.17	3.40	3.65	3.94	4.27
7.68	**440**	2.92	3.11	3.32	3.56	3.82	4.12	4.47
8.03	**450**	3.06	3.26	3.47	3.72	4.00	4.31	4.68

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.13: Light Loading, 4/0 ACSR, Ruling Span = 250 Feet								
Conductor: PENGUIN			4/0 kcmil			6/1 Stranding ACSR		
Area = 0.1939 sq in.			Weight = 0.291 lb/ft					
Diameter = 0.563 in.			RTS = 8350 lb					
Design data from Sag10 Chart No. 1-938			Ice = 56 lb/ft^3					
Design Points								
Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.563	1.90	2315	1.66	2651
60	0	6	0	0.405	1.94	1633	1.47	2147
30	0	0	0	0.291	1.09	2087*	0.90	2524
32	0	0	0	0.291	1.11	2046	0.91	2494
60	0	0	0	0.291	1.52	1497	1.09	2079
90	0	0	0	0.291	2.19	1037	1.40	1629
120	0	0	0	0.291	2.97	765	1.88	1211

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2377	**2229**	**2079**	**1928**	**1778**	**1629**	**1483**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.07	**150**	0.35	0.37	0.39	0.42	0.46	0.50	0.55
1.22	**160**	0.39	0.42	0.45	0.48	0.52	0.57	0.63
1.37	**170**	0.44	0.47	0.50	0.55	0.59	0.65	0.71
1.54	**180**	0.50	0.53	0.57	0.61	0.66	0.73	0.79
1.72	**190**	0.55	0.59	0.63	0.68	0.74	0.81	0.88
1.90	**200**	0.61	0.65	0.70	0.76	0.82	0.90	0.98
2.10	**210**	0.68	0.72	0.77	0.83	0.90	0.99	1.08
2.30	**220**	0.74	0.79	0.84	0.91	0.99	1.08	1.18
2.51	**230**	0.81	0.86	0.92	1.00	1.08	1.18	1.29
2.74	**240**	0.88	0.94	1.00	1.09	1.18	1.29	1.41
2.97	**250**	0.96	1.02	1.09	1.18	1.28	1.40	1.53
3.21	**260**	1.04	1.10	1.18	1.28	1.38	1.51	1.65
3.46	**270**	1.12	1.19	1.27	1.38	1.49	1.63	1.78
3.73	**280**	1.20	1.28	1.37	1.48	1.61	1.76	1.92
4.00	**290**	1.29	1.37	1.47	1.59	1.72	1.88	2.06
4.28	**300**	1.38	1.47	1.57	1.70	1.84	2.02	2.20
4.57	**310**	1.48	1.57	1.68	1.81	1.97	2.15	2.35
4.87	**320**	1.57	1.67	1.79	1.93	2.10	2.29	2.51
5.17	**330**	1.67	1.78	1.90	2.06	2.23	2.44	2.67
5.49	**340**	1.78	1.89	2.02	2.18	2.37	2.59	2.83
5.82	**350**	1.88	2.00	2.14	2.31	2.51	2.74	3.00

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.14: Light Loading, 4/0 ACSR, Ruling Span = 300 Feet

Conductor: PENGUIN — 4/0 kcmil — 6/1 Stranding ACSR
Area = 0.1939 sq in. — Weight = 0.291 lb/ft
Diameter = 0.563 in. — RTS = 8350 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.563	2.65	2386	2.34	2705
60	0	6	0	0.405	2.68	1700	2.08	2190
30	0	0	0	0.291	1.57	2088*	1.29	2532
32	0	0	0	0.291	1.60	2048	1.31	2504
60	0	0	0	0.291	2.14	1531	1.56	2098
90	0	0	0	0.291	2.96	1107	1.96	1667
120	0	0	0	0.291	3.91	838	2.57	1275

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2389	**2244**	**2098**	**1953**	**1808**	**1666**	**1529**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.74	**200**	0.61	0.65	0.69	0.75	0.80	0.87	0.95
1.92	**210**	0.67	0.72	0.76	0.82	0.89	0.96	1.05
2.10	**220**	0.74	0.79	0.84	0.90	0.97	1.05	1.15
2.30	**230**	0.81	0.86	0.92	0.99	1.06	1.15	1.26
2.50	**240**	0.88	0.93	1.00	1.08	1.16	1.25	1.37
2.72	**250**	0.95	1.01	1.08	1.17	1.26	1.36	1.49
2.94	**260**	1.03	1.10	1.17	1.26	1.36	1.47	1.61
3.17	**270**	1.11	1.18	1.26	1.36	1.47	1.59	1.73
3.41	**280**	1.19	1.27	1.36	1.46	1.58	1.71	1.86
3.65	**290**	1.28	1.36	1.46	1.57	1.69	1.83	2.00
3.91	**300**	1.37	1.46	1.56	1.68	1.81	1.96	2.14
4.18	**310**	1.46	1.56	1.67	1.79	1.93	2.09	2.29
4.45	**320**	1.56	1.66	1.77	1.91	2.06	2.23	2.43
4.73	**330**	1.66	1.77	1.89	2.03	2.19	2.37	2.59
5.02	**340**	1.76	1.88	2.00	2.16	2.32	2.52	2.75
5.32	**350**	1.86	1.99	2.12	2.29	2.46	2.67	2.91
5.63	**360**	1.97	2.10	2.25	2.42	2.61	2.82	3.08
5.95	**370**	2.08	2.22	2.37	2.56	2.75	2.98	3.26
6.27	**380**	2.20	2.34	2.50	2.70	2.90	3.14	3.43
6.61	**390**	2.32	2.47	2.64	2.84	3.06	3.31	3.62
6.95	**400**	2.44	2.60	2.77	2.99	3.22	3.48	3.80

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.15: Light Loading, 4/0 ACSR, Ruling Span = 350 Feet

Conductor: PENGUIN | 4/0 kcmil | 6/1 Stranding ACSR
Area = 0.1939 sq in. | Weight = 0.291 lb/ft
Diameter = 0.563 in. | RTS = 8350 lb
Design data from Sag10 Chart No. 1-938 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.563	3.51	2458	3.12	2760
60	0	6	0	0.405	3.51	1765	2.78	2232
30	0	0	0	0.291	2.14	2087*	1.76	2538
32	0	0	0	0.291	2.17	2049	1.78	2510
60	0	0	0	0.291	2.85	1563	2.11	2116
90	0	0	0	0.291	3.80	1172	2.62	1703
120	0	0	0	0.291	4.86	917	3.34	1336

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2398	**2257**	**2116**	**1975**	**1837**	**1703**	**1573**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.48	**250**	0.95	1.01	1.08	1.15	1.24	1.34	1.44
2.68	**260**	1.03	1.09	1.16	1.25	1.34	1.45	1.56
2.89	**270**	1.11	1.17	1.26	1.34	1.45	1.56	1.68
3.11	**280**	1.19	1.26	1.35	1.45	1.56	1.68	1.81
3.34	**290**	1.28	1.35	1.45	1.55	1.67	1.80	1.94
3.57	**300**	1.37	1.45	1.55	1.66	1.79	1.92	2.08
3.81	**310**	1.46	1.55	1.66	1.77	1.91	2.06	2.22
4.06	**320**	1.55	1.65	1.76	1.89	2.03	2.19	2.37
4.32	**330**	1.65	1.75	1.88	2.01	2.16	2.33	2.52
4.59	**340**	1.76	1.86	1.99	2.13	2.29	2.47	2.67
4.86	**350**	1.86	1.97	2.11	2.26	2.43	2.62	2.83
5.14	**360**	1.97	2.08	2.23	2.39	2.57	2.77	2.99
5.43	**370**	2.08	2.20	2.36	2.53	2.72	2.93	3.16
5.73	**380**	2.19	2.32	2.49	2.66	2.86	3.09	3.34
6.03	**390**	2.31	2.45	2.62	2.81	3.02	3.25	3.51
6.35	**400**	2.43	2.57	2.76	2.95	3.17	3.42	3.70
6.67	**410**	2.55	2.70	2.90	3.10	3.33	3.60	3.88
7.00	**420**	2.68	2.84	3.04	3.25	3.50	3.77	4.08
7.34	**430**	2.81	2.97	3.18	3.41	3.67	3.95	4.27
7.68	**440**	2.94	3.11	3.33	3.57	3.84	4.14	4.47
8.03	**450**	3.07	3.26	3.49	3.74	4.02	4.33	4.68

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.16: Light Loading, 336 ACSR, Ruling Span = 250 Feet

Conductor: MERLIN	336 kcmil	18/1 Stranding ACSR
Area = 0.2789 sq in.	Weight = 0.365 lb/ft	
Diameter = 0.684 in.	RTS = 8680 lb	
Design data from Sag10 Chart No. 1-844	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.680	2.15	2470	1.74	3058
60	0	6	0	0.500	2.40	1626	1.67	2341
30	0	0	0	0.365	1.34	2136	0.99	2891*
32	0	0	0	0.365	1.37	2082	1.00	2848
60	0	0	0	0.365	2.01	1420	1.28	2235
90	0	0	0	0.365	2.93	974	1.79	1594
120	0	0	0	0.365	3.86	739	2.60	1099

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2675	**2456**	**2235**	**2014**	**1799**	**1594**	**1406**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.39	**150**	0.39	0.42	0.46	0.51	0.57	0.64	0.73
1.58	**160**	0.44	0.48	0.52	0.58	0.65	0.73	0.83
1.78	**170**	0.49	0.54	0.59	0.66	0.74	0.83	0.94
2.00	**180**	0.55	0.60	0.66	0.74	0.82	0.93	1.05
2.23	**190**	0.62	0.67	0.74	0.82	0.92	1.03	1.17
2.47	**200**	0.68	0.74	0.82	0.91	1.02	1.15	1.30
2.72	**210**	0.75	0.82	0.90	1.00	1.12	1.26	1.43
2.99	**220**	0.83	0.90	0.99	1.10	1.23	1.39	1.57
3.27	**230**	0.91	0.98	1.08	1.20	1.35	1.52	1.72
3.56	**240**	0.99	1.07	1.18	1.31	1.47	1.65	1.87
3.86	**250**	1.07	1.16	1.28	1.42	1.59	1.79	2.03
4.17	**260**	1.16	1.25	1.38	1.54	1.72	1.94	2.20
4.50	**270**	1.25	1.35	1.49	1.66	1.85	2.09	2.37
4.84	**280**	1.34	1.46	1.61	1.78	1.99	2.25	2.55
5.19	**290**	1.44	1.56	1.72	1.91	2.14	2.41	2.73
5.56	**300**	1.54	1.67	1.84	2.04	2.29	2.58	2.92
5.94	**310**	1.65	1.78	1.97	2.18	2.44	2.75	3.12
6.32	**320**	1.75	1.90	2.10	2.33	2.61	2.93	3.33
6.73	**330**	1.86	2.02	2.23	2.47	2.77	3.12	3.54
7.14	**340**	1.98	2.15	2.37	2.63	2.94	3.31	3.75
7.57	**350**	2.10	2.27	2.51	2.78	3.12	3.51	3.98

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.17: Light Loading, 336 ACSR, Ruling Span = 300 Feet

Conductor: MERLIN	336 kcmil	18/1 Stranding ACSR
Area = 0.2789 sq in.	Weight = 0.365 lb/ft	
Diameter = 0.684 in.	RTS = 8680 lb	
Design data from Sag10 Chart No. 1-844	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.680	3.00	2552	2.45	3117
60	0	6	0	0.500	3.28	1717	2.35	2396
30	0	0	0	0.365	1.93	2124	1.42	2890*
32	0	0	0	0.365	1.98	2073	1.44	2849
60	0	0	0	0.365	2.79	1473	1.82	2257
90	0	0	0	0.365	3.85	1067	2.48	1658
120	0	0	0	0.365	4.90	839	3.42	1201

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2681	**2469**	**2257**	**2048**	**1847**	**1657**	**1485**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.18	**200**	0.68	0.74	0.81	0.89	0.99	1.10	1.23
2.40	**210**	0.75	0.81	0.89	0.98	1.09	1.22	1.36
2.64	**220**	0.82	0.89	0.98	1.08	1.19	1.33	1.49
2.88	**230**	0.90	0.98	1.07	1.18	1.30	1.46	1.63
3.14	**240**	0.98	1.06	1.16	1.29	1.42	1.59	1.77
3.40	**250**	1.06	1.15	1.26	1.40	1.54	1.72	1.92
3.68	**260**	1.15	1.25	1.37	1.51	1.67	1.86	2.08
3.97	**270**	1.24	1.34	1.47	1.63	1.80	2.01	2.24
4.27	**280**	1.33	1.45	1.59	1.75	1.93	2.16	2.41
4.58	**290**	1.43	1.55	1.70	1.88	2.07	2.32	2.59
4.90	**300**	1.53	1.66	1.82	2.01	2.22	2.48	2.77
5.23	**310**	1.63	1.77	1.94	2.15	2.37	2.65	2.96
5.58	**320**	1.74	1.89	2.07	2.29	2.53	2.82	3.15
5.93	**330**	1.85	2.01	2.20	2.43	2.69	3.00	3.35
6.29	**340**	1.97	2.13	2.34	2.58	2.85	3.19	3.56
6.67	**350**	2.08	2.26	2.48	2.74	3.02	3.38	3.77
7.06	**360**	2.20	2.39	2.62	2.89	3.20	3.57	3.99
7.45	**370**	2.33	2.53	2.77	3.06	3.38	3.77	4.21
7.86	**380**	2.45	2.66	2.92	3.22	3.56	3.98	4.44
8.28	**390**	2.59	2.81	3.08	3.40	3.75	4.19	4.68
8.71	**400**	2.72	2.95	3.24	3.57	3.95	4.41	4.92

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.18: Light Loading, 336 ACSR, Ruling Span = 350 Feet

Conductor: MERLIN — 336 kcmil — 18/1 Stranding ACSR
Area = 0.2789 sq in. — Weight = 0.365 lb/ft
Diameter = 0.684 in. — RTS = 8680 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.680	3.95	2637	3.27	3180
60	0	6	0	0.500	4.25	1804	3.12	2454
30	0	0	0	0.365	2.64	2119	1.93	2890*
32	0	0	0	0.365	2.70	2072	1.96	2850
60	0	0	0	0.365	3.66	1526	2.45	2281
90	0	0	0	0.365	4.85	1153	3.25	1720
120	0	0	0	0.365	6.01	930	4.32	1295

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2687	**2483**	**2280**	**2083**	**1895**	**1719**	**1559**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.07	**250**	1.06	1.15	1.25	1.37	1.51	1.66	1.83
3.32	**260**	1.15	1.24	1.35	1.48	1.63	1.79	1.98
3.58	**270**	1.24	1.34	1.46	1.59	1.76	1.93	2.13
3.85	**280**	1.33	1.44	1.57	1.72	1.89	2.08	2.29
4.13	**290**	1.43	1.54	1.68	1.84	2.03	2.23	2.46
4.42	**300**	1.53	1.65	1.80	1.97	2.17	2.39	2.63
4.71	**310**	1.63	1.77	1.92	2.10	2.31	2.55	2.81
5.02	**320**	1.74	1.88	2.05	2.24	2.47	2.72	2.99
5.34	**330**	1.85	2.00	2.18	2.38	2.62	2.89	3.18
5.67	**340**	1.96	2.12	2.31	2.53	2.78	3.07	3.38
6.01	**350**	2.08	2.25	2.45	2.68	2.95	3.25	3.58
6.36	**360**	2.20	2.38	2.59	2.84	3.12	3.44	3.79
6.72	**370**	2.32	2.51	2.74	3.00	3.30	3.63	4.00
7.08	**380**	2.45	2.65	2.89	3.16	3.48	3.83	4.22
7.46	**390**	2.58	2.79	3.04	3.33	3.66	4.04	4.45
7.85	**400**	2.72	2.94	3.20	3.50	3.85	4.24	4.68
8.25	**410**	2.85	3.09	3.36	3.68	4.05	4.46	4.91
8.65	**420**	3.00	3.24	3.53	3.86	4.25	4.68	5.16
9.07	**430**	3.14	3.40	3.70	4.05	4.45	4.91	5.40
9.50	**440**	3.29	3.56	3.87	4.24	4.66	5.14	5.66
9.93	**450**	3.44	3.72	4.05	4.43	4.88	5.37	5.92

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.19: Light Loading, 477 ACSR, Ruling Span = 250 Feet

Conductor: PELICAN | 477 kcmil | 18/1 Stranding ACSR
Area = 0.3955 sq in. | Weight = 0.517 lb/ft
Diameter = 0.814 in. | RTS = 11,800 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.850	2.35	2832	1.90	3500*
60	0	6	0	0.658	2.80	1835	2.06	2502
30	0	0	0	0.517	1.69	2391	1.25	3241
32	0	0	0	0.517	1.74	2325	1.27	3179
60	0	0	0	0.517	2.53	1595	1.73	2332
90	0	0	0	0.517	3.49	1160	2.51	1608
120	0	0	0	0.517	4.37	926	3.44	1175

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2930	2625	2332	2060	1818	1609	1435
		Temperature (°F)						
		40	50	60	70	80	90	100
1.57	**150**	0.50	0.55	0.62	0.71	0.80	0.90	1.02
1.79	**160**	0.57	0.63	0.71	0.80	0.91	1.03	1.16
2.02	**170**	0.64	0.71	0.80	0.91	1.03	1.16	1.30
2.27	**180**	0.72	0.80	0.90	1.02	1.16	1.30	1.46
2.52	**190**	0.80	0.89	1.00	1.13	1.29	1.45	1.63
2.80	**200**	0.88	0.99	1.11	1.25	1.43	1.61	1.80
3.08	**210**	0.97	1.09	1.22	1.38	1.57	1.77	1.99
3.38	**220**	1.07	1.19	1.34	1.52	1.73	1.94	2.18
3.70	**230**	1.17	1.30	1.46	1.66	1.89	2.12	2.39
4.03	**240**	1.27	1.42	1.59	1.81	2.06	2.31	2.60
4.37	**250**	1.38	1.54	1.73	1.96	2.23	2.51	2.82
4.73	**260**	1.49	1.67	1.87	2.12	2.41	2.71	3.05
5.10	**270**	1.61	1.80	2.02	2.29	2.60	2.93	3.29
5.48	**280**	1.73	1.93	2.17	2.46	2.80	3.15	3.54
5.88	**290**	1.86	2.07	2.33	2.64	3.00	3.38	3.79
6.29	**300**	1.99	2.22	2.49	2.82	3.21	3.61	4.06
6.72	**310**	2.12	2.37	2.66	3.01	3.43	3.86	4.34
7.16	**320**	2.26	2.52	2.83	3.21	3.65	4.11	4.62
7.61	**330**	2.40	2.68	3.01	3.42	3.89	4.37	4.91
8.08	**340**	2.55	2.85	3.20	3.63	4.12	4.64	5.22
8.57	**350**	2.70	3.02	3.39	3.84	4.37	4.92	5.53

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.20: Light Loading, 477 ACSR, Ruling Span = 300 Feet

Conductor: PELICAN — 477 kcmil — 18/1 Stranding ACSR
Area = 0.3955 sq in. — Weight = 0.517 lb/ft
Diameter = 0.814 in. — RTS = 11,800 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.850	3.33	2876	2.73	3500*
60	0	6	0	0.658	3.85	1923	2.93	2525
30	0	0	0	0.517	2.51	2322	1.85	3143
32	0	0	0	0.517	2.57	2265	1.89	3084
60	0	0	0	0.517	3.53	1648	2.52	2308
90	0	0	0	0.517	4.60	1265	3.47	1677
120	0	0	0	0.517	5.59	1042	4.51	1290

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		2851	**2570**	**2308**	**2069**	**1859**	**1678**	**1525**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.48	**200**	0.91	1.01	1.12	1.25	1.40	1.54	1.70
2.74	**210**	1.00	1.11	1.23	1.38	1.54	1.70	1.87
3.01	**220**	1.10	1.22	1.36	1.52	1.69	1.87	2.05
3.29	**230**	1.20	1.33	1.48	1.66	1.85	2.04	2.25
3.58	**240**	1.31	1.45	1.61	1.80	2.01	2.22	2.44
3.88	**250**	1.42	1.58	1.75	1.96	2.18	2.41	2.65
4.20	**260**	1.53	1.71	1.89	2.12	2.36	2.61	2.87
4.53	**270**	1.65	1.84	2.04	2.28	2.54	2.81	3.09
4.87	**280**	1.78	1.98	2.20	2.46	2.74	3.02	3.33
5.22	**290**	1.91	2.12	2.35	2.64	2.93	3.24	3.57
5.59	**300**	2.04	2.27	2.52	2.82	3.14	3.47	3.82
5.97	**310**	2.18	2.42	2.69	3.01	3.35	3.71	4.08
6.36	**320**	2.32	2.58	2.87	3.21	3.57	3.95	4.35
6.76	**330**	2.47	2.75	3.05	3.41	3.80	4.20	4.62
7.18	**340**	2.62	2.92	3.24	3.62	4.03	4.46	4.91
7.61	**350**	2.78	3.09	3.43	3.84	4.27	4.72	5.20
8.05	**360**	2.94	3.27	3.63	4.06	4.52	5.00	5.50
8.50	**370**	3.10	3.45	3.83	4.29	4.78	5.28	5.81
8.97	**380**	3.27	3.64	4.04	4.52	5.04	5.57	6.13
9.45	**390**	3.45	3.84	4.26	4.77	5.31	5.86	6.46
9.94	**400**	3.63	4.04	4.48	5.01	5.58	6.17	6.79

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.21: Light Loading, 477 ACSR, Ruling Span = 350 Feet

Conductor: PELICAN | 477 kcmil | 18/1 Stranding ACSR
Area = 0.3955 sq in. | Weight = 0.517 lb/ft
Diameter = 0.814 in. | RTS = 11,800 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.850	4.46	2922	3.72	3500*
60	0	6	0	0.658	5.04	2001	3.96	2546
30	0	0	0	0.517	3.49	2268	2.60	3040
32	0	0	0	0.517	3.57	2220	2.65	2985
60	0	0	0	0.517	4.67	1696	3.47	2285
90	0	0	0	0.517	5.84	1356	4.56	1736
120	0	0	0	0.517	6.93	1144	5.71	1387

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2771	**2518**	**2285**	**2077**	**1894**	**1763**	**1601**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.54	**250**	1.46	1.61	1.77	1.95	2.14	2.33	2.53
3.82	**260**	1.58	1.74	1.91	2.11	2.31	2.52	2.73
4.12	**270**	1.70	1.87	2.07	2.27	2.49	2.71	2.95
4.44	**280**	1.83	2.02	2.22	2.44	2.68	2.92	3.17
4.76	**290**	1.96	2.16	2.38	2.62	2.88	3.13	3.40
5.09	**300**	2.10	2.31	2.55	2.81	3.08	3.35	3.64
5.44	**310**	2.24	2.47	2.72	3.00	3.29	3.58	3.88
5.79	**320**	2.39	2.63	2.90	3.19	3.50	3.81	4.14
6.16	**330**	2.54	2.80	3.08	3.40	3.72	4.05	4.40
6.54	**340**	2.70	2.97	3.27	3.60	3.95	4.30	4.67
6.93	**350**	2.86	3.15	3.47	3.82	4.19	4.56	4.95
7.33	**360**	3.03	3.33	3.67	4.04	4.43	4.82	5.24
7.74	**370**	3.20	3.52	3.88	4.27	4.68	5.10	5.53
8.17	**380**	3.37	3.71	4.09	4.50	4.94	5.38	5.83
8.60	**390**	3.55	3.91	4.31	4.74	5.20	5.66	6.15
9.05	**400**	3.74	4.11	4.53	4.99	5.47	5.96	6.47
9.51	**410**	3.92	4.32	4.76	5.24	5.75	6.26	6.79
9.98	**420**	4.12	4.54	5.00	5.50	6.03	6.57	7.13
10.46	**430**	4.32	4.75	5.24	5.77	6.32	6.88	7.47
10.95	**440**	4.52	4.98	5.48	6.04	6.62	7.21	7.82
11.46	**450**	4.73	5.21	5.74	6.31	6.93	7.54	8.18

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.22: Light Loading, 556 ACSR, Ruling Span = 200 Feet

Conductor: OSPREY — 556 kcmil — 18/1 Stranding ACSR
Area = 0.4612 sq in. — Weight = 0.603 lb/ft
Diameter = 0.879 in. — RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.943	1.34	3529	1.05	4500*
30	0	0	0	0.603	0.93	3248	0.69	4362
32	0	0	0	0.603	0.96	3155	7.00	4289
60	0	0	0	0.603	1.48	2033	0.93	3228
90	0	0	0	0.603	2.28	1323	1.40	2149
120	0	0	0	0.603	3.07	983	2.15	1405
167	0	0	0	0.603	4.00	755	3.36	899

*Design Condition.

Initial Stringing Table (decimal ft)

Largest Final Sag[1] (ft)	Stringing Span (ft)	Tension (lb) 3990	3610	3228	2850	2486	2149	1853
		Temperature (°F) 40	**50**	**60**	**70**	**80**	**90**	**100**
1.00	**100**	0.19	0.21	0.23	0.27	0.30	0.35	0.41
1.21	**110**	0.23	0.25	0.28	0.32	0.37	0.42	0.49
1.44	**120**	0.27	0.30	0.33	0.38	0.44	0.50	0.59
1.69	**130**	0.32	0.35	0.39	0.45	0.51	0.59	0.69
1.96	**140**	0.37	0.41	0.46	0.52	0.59	0.69	0.80
2.25	**150**	0.43	0.47	0.52	0.60	0.68	0.79	0.92
2.56	**160**	0.49	0.54	0.60	0.68	0.77	0.90	1.04
2.89	**170**	0.55	0.61	0.67	0.77	0.87	1.01	1.18
3.24	**180**	0.62	0.68	0.75	0.86	0.98	1.13	1.32
3.61	**190**	0.69	0.76	0.84	0.96	1.09	1.26	1.47
4.00	**200**	0.76	0.84	0.93	1.06	1.21	1.40	1.63
4.41	**210**	0.84	0.93	1.03	1.17	1.33	1.54	1.80
4.84	**220**	0.92	1.02	1.13	1.28	1.46	1.69	1.97
5.29	**230**	1.01	1.11	1.23	1.40	1.60	1.85	2.16
5.76	**240**	1.09	1.21	1.34	1.53	1.74	2.02	2.35
6.25	**250**	1.19	1.31	1.45	1.66	1.89	2.19	2.55
6.76	**260**	1.28	1.42	1.57	1.79	2.04	2.37	2.75
7.29	**270**	1.39	1.53	1.69	1.93	2.21	2.55	2.97
7.84	**280**	1.49	1.65	1.82	2.08	2.37	2.74	3.19
8.41	**290**	1.60	1.77	1.96	2.23	2.54	2.94	3.43
9.00	**300**	1.71	1.89	2.09	2.39	2.72	3.15	3.67

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.23: Light Loading, 556 ACSR, Ruling Span = 250 Feet

Conductor: OSPREY — 556 kcmil — 18/1 Stranding ACSR
Area = 0.4612 sq in. — Weight = 0.603 lb/ft
Diameter = 0.879 in. — RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.943	2.07	3565	1.64	4500*
30	0	0	0	0.603	1.49	3163	1.10	4290
32	0	0	0	0.603	1.53	3079	1.12	4218
60	0	0	0	0.603	2.25	2095	1.47	3202
90	0	0	0	0.603	3.20	1475	2.12	2225
120	0	0	0	0.603	4.11	1148	3.01	1566
167	0	0	0	0.603	5.34	883	4.41	1069

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		3927	**3563**	**3202**	**2852**	**2523**	**2225**	**1965**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.92	**150**	0.43	0.48	0.53	0.59	0.67	0.76	0.86
2.19	**160**	0.49	0.54	0.60	0.68	0.77	0.87	0.98
2.47	**170**	0.55	0.61	0.68	0.76	0.86	0.98	1.11
2.77	**180**	0.62	0.68	0.76	0.86	0.97	1.10	1.24
3.08	**190**	0.69	0.76	0.85	0.95	1.08	1.22	1.39
3.42	**200**	0.77	0.84	0.94	1.06	1.20	1.36	1.54
3.77	**210**	0.85	0.93	1.04	1.16	1.32	1.50	1.69
4.14	**220**	0.93	1.02	1.14	1.28	1.45	1.64	1.86
4.52	**230**	1.02	1.12	1.24	1.40	1.58	1.79	2.03
4.92	**240**	1.11	1.22	1.35	1.52	1.72	1.95	2.21
5.34	**250**	1.20	1.32	1.47	1.65	1.87	2.12	2.40
5.78	**260**	1.30	1.43	1.59	1.78	2.02	2.29	2.60
6.23	**270**	1.40	1.54	1.71	1.92	2.18	2.47	2.80
6.70	**280**	1.51	1.66	1.84	2.07	2.35	2.66	3.01
7.19	**290**	1.61	1.78	1.98	2.22	2.52	2.85	3.23
7.69	**300**	1.73	1.90	2.12	2.38	2.69	3.05	3.46
8.21	**310**	1.85	2.03	2.26	2.54	2.88	3.26	3.69
8.75	**320**	1.97	2.16	2.41	2.70	3.06	3.47	3.93
9.30	**330**	2.09	2.30	2.56	2.87	3.26	3.69	4.18
9.88	**340**	2.22	2.44	2.72	3.05	3.46	3.92	4.44
10.47	**350**	2.35	2.59	2.88	3.23	3.67	4.16	4.70

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.24: Light Loading, 556 ACSR, Ruling Span = 300 Feet

Conductor: OSPREY | 556 kcmil | 18/1 Stranding ACSR
Area = 0.4612 sq in. | Weight = 0.603 lb/ft
Diameter = 0.879 in. | RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	0.943	2.94	3608	2.36	4500*
30	0	0	0	0.603	2.20	3089	1.61	4207
32	0	0	0	0.603	2.25	3014	1.64	4137
60	0	0	0	0.603	3.15	2155	2.14	3175
90	0	0	0	0.603	4.23	1607	2.96	2294
120	0	0	0	0.603	5.25	1294	3.98	1705
167	0	0	0	0.603	6.66	1021	5.56	1222

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		3857	**3511**	**3175**	**2855**	**2559**	**2295**	**2065**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.96	**200**	0.78	0.86	0.95	1.06	1.18	1.32	1.46
3.26	**210**	0.86	0.95	1.05	1.17	1.30	1.45	1.61
3.58	**220**	0.95	1.04	1.15	1.28	1.43	1.59	1.77
3.91	**230**	1.03	1.14	1.26	1.40	1.56	1.74	1.93
4.26	**240**	1.13	1.24	1.37	1.52	1.70	1.89	2.11
4.63	**250**	1.22	1.35	1.49	1.65	1.85	2.06	2.28
5.00	**260**	1.32	1.46	1.61	1.79	2.00	2.22	2.47
5.39	**270**	1.43	1.57	1.73	1.93	2.15	2.40	2.66
5.80	**280**	1.53	1.69	1.86	2.07	2.32	2.58	2.87
6.22	**290**	1.64	1.81	2.00	2.22	2.49	2.77	3.07
6.66	**300**	1.76	1.94	2.14	2.38	2.66	2.96	3.29
7.11	**310**	1.88	2.07	2.29	2.54	2.84	3.16	3.51
7.58	**320**	2.00	2.21	2.43	2.71	3.03	3.37	3.74
8.06	**330**	2.13	2.35	2.59	2.88	3.22	3.58	3.98
8.55	**340**	2.26	2.49	2.75	3.06	3.42	3.80	4.23
9.07	**350**	2.40	2.64	2.91	3.24	3.62	4.03	4.48
9.59	**360**	2.53	2.79	3.08	3.43	3.83	4.26	4.74
10.13	**370**	2.68	2.95	3.26	3.62	4.05	4.50	5.00
10.69	**380**	2.82	3.11	3.43	3.82	4.27	4.75	5.28
11.26	**390**	2.97	3.28	3.62	4.02	4.50	5.00	5.56
11.84	**400**	3.13	3.45	3.80	4.23	4.73	5.26	5.85

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.25: Light Loading, 740 AAAC, Ruling Span = 200 Feet

Conductor: FLINT | 740 kcmil | 37 Stranding AAAC
Area = 0.5818 sq in. | Weight = 0.691 lb/ft
Diameter = 0.991 in. | RTS = 24,400 lb
Design data from Sag10 Chart No. 1-1155 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	1.065	1.49	3582	1.18	4500*
30	0	0	0	0.691	1.08	3198	0.81	4285
32	0	0	0	0.691	1.12	3087	0.83	4184
60	0	0	0	0.691	1.83	1884	1.21	2867
90	0	0	0	0.691	2.73	1267	1.89	1831
120	0	0	0	0.691	3.53	981	2.71	1276
167	0	0	0	0.691	4.57	758	3.87	893

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		3788	**3312**	**2867**	**2469**	**2122**	**1835**	**1605**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.14	**100**	0.23	0.26	0.30	0.35	0.41	0.47	0.54
1.38	**110**	0.28	0.32	0.37	0.43	0.50	0.57	0.66
1.65	**120**	0.33	0.38	0.44	0.51	0.59	0.68	0.78
1.93	**130**	0.39	0.44	0.51	0.60	0.69	0.80	0.92
2.24	**140**	0.45	0.51	0.59	0.69	0.80	0.93	1.06
2.57	**150**	0.52	0.59	0.68	0.79	0.92	1.06	1.22
2.92	**160**	0.59	0.67	0.77	0.90	1.05	1.21	1.39
3.30	**170**	0.66	0.76	0.87	1.02	1.18	1.37	1.57
3.70	**180**	0.75	0.85	0.98	1.14	1.33	1.53	1.76
4.12	**190**	0.83	0.95	1.09	1.27	1.48	1.71	1.96
4.57	**200**	0.92	1.05	1.21	1.41	1.64	1.89	2.17
5.04	**210**	1.01	1.16	1.33	1.55	1.81	2.08	2.39
5.53	**220**	1.11	1.27	1.46	1.71	1.98	2.29	2.63
6.04	**230**	1.22	1.39	1.60	1.86	2.17	2.50	2.87
6.58	**240**	1.32	1.51	1.74	2.03	2.36	2.72	3.12
7.14	**250**	1.44	1.64	1.89	2.20	2.56	2.95	3.39
7.72	**260**	1.55	1.77	2.04	2.38	2.77	3.19	3.67
8.33	**270**	1.68	1.91	2.21	2.57	2.99	3.44	3.95
8.96	**280**	1.80	2.06	2.37	2.76	3.21	3.70	4.25
9.61	**290**	1.93	2.21	2.54	2.96	3.45	3.97	4.56
10.28	**300**	2.07	2.36	2.72	3.17	3.69	4.25	4.88

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.26: Light Loading, 740 AAAC, Ruling Span = 250 Feet

Conductor: FLINT	740 kcmil	37 Stranding AAAC
Area = 0.5818 sq in.	Weight = 0.691 lb/ft	
Diameter = 0.991 in.	RTS = 24,400 lb	
Design data from Sag10 Chart No. 1-1155	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	1.065	2.31	3598	1.85	4500*
30	0	0	0	0.691	1.76	3067	1.29	4179
32	0	0	0	0.691	1.82	2973	1.32	4084
60	0	0	0	0.691	2.73	1976	1.88	2873
90	0	0	0	0.691	3.77	1435	2.75	1966
120	0	0	0	0.691	4.69	1153	3.70	1458
167	0	0	0	0.691	5.92	913	5.06	1068

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		3712	**3274**	**2873**	**2523**	**2221**	**1971**	**1766**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.13	**150**	0.53	0.60	0.68	0.77	0.88	0.99	1.11
2.42	**160**	0.60	0.68	0.77	0.88	1.00	1.13	1.26
2.74	**170**	0.68	0.77	0.87	0.99	1.13	1.27	1.42
3.07	**180**	0.76	0.86	0.97	1.11	1.26	1.43	1.60
3.42	**190**	0.84	0.96	1.09	1.24	1.41	1.59	1.78
3.79	**200**	0.93	1.06	1.20	1.38	1.56	1.76	1.97
4.18	**210**	1.03	1.17	1.33	1.52	1.72	1.94	2.17
4.58	**220**	1.13	1.29	1.46	1.66	1.89	2.13	2.39
5.01	**230**	1.24	1.41	1.59	1.82	2.07	2.33	2.61
5.46	**240**	1.35	1.53	1.73	1.98	2.25	2.53	2.84
5.92	**250**	1.46	1.66	1.88	2.15	2.44	2.75	3.08
6.40	**260**	1.58	1.80	2.03	2.33	2.64	2.97	3.33
6.91	**270**	1.70	1.94	2.19	2.51	2.85	3.21	3.59
7.43	**280**	1.83	2.08	2.36	2.70	3.06	3.45	3.86
7.97	**290**	1.96	2.23	2.53	2.89	3.28	3.70	4.14
8.52	**300**	2.10	2.39	2.71	3.10	3.51	3.96	4.44
9.10	**310**	2.24	2.55	2.89	3.31	3.75	4.23	4.74
9.70	**320**	2.39	2.72	3.08	3.52	4.00	4.51	5.05
10.32	**330**	2.54	2.89	3.28	3.75	4.25	4.79	5.37
10.95	**340**	2.70	3.07	3.48	3.98	4.51	5.09	5.70
11.60	**350**	2.86	3.25	3.68	4.21	4.78	5.39	6.04

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.27: Light Loading, 740 AAAC, Ruling Span = 300 Feet

Conductor: FLINT — 740 kcmil — 37 Stranding AAAC
Area = 0.5818 sq in. — Weight = 0.691 lb/ft
Diameter = 0.991 in. — RTS = 24,400 lb
Design data from Sag10 Chart No. 1-1155 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	1.065	3.30	3634	2.66	4500*
30	0	0	0	0.691	2.62	2973	1.91	4063
32	0	0	0	0.691	2.69	2894	1.96	3974
60	0	0	0	0.691	3.77	2061	2.70	2878
90	0	0	0	0.691	4.93	1580	3.74	2082
120	0	0	0	0.691	5.96	1306	4.82	1616
167	0	0	0	0.691	7.37	1057	6.35	1225

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		3632	**3236**	**2878**	**2572**	**2308**	**2087**	**1903**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.28	**200**	0.96	1.08	1.20	1.35	1.51	1.66	1.83
3.61	**210**	1.05	1.19	1.32	1.49	1.66	1.83	2.01
3.96	**220**	1.16	1.30	1.45	1.63	1.82	2.01	2.21
4.33	**230**	1.26	1.42	1.59	1.79	1.99	2.20	2.42
4.72	**240**	1.38	1.55	1.73	1.95	2.17	2.39	2.63
5.12	**250**	1.49	1.68	1.88	2.11	2.35	2.60	2.85
5.54	**260**	1.61	1.82	2.03	2.28	2.55	2.81	3.09
5.97	**270**	1.74	1.96	2.19	2.46	2.75	3.03	3.33
6.42	**280**	1.87	2.11	2.35	2.65	2.95	3.26	3.58
6.89	**290**	2.01	2.26	2.52	2.84	3.17	3.49	3.84
7.37	**300**	2.15	2.42	2.70	3.04	3.39	3.74	4.11
7.87	**310**	2.30	2.58	2.88	3.25	3.62	3.99	4.39
8.39	**320**	2.45	2.75	3.07	3.46	3.86	4.26	4.68
8.92	**330**	2.60	2.93	3.27	3.68	4.10	4.53	4.97
9.47	**340**	2.76	3.11	3.47	3.90	4.35	4.80	5.28
10.03	**350**	2.93	3.29	3.68	4.14	4.61	5.09	5.59
10.61	**360**	3.10	3.48	3.89	4.38	4.88	5.39	5.92
11.21	**370**	3.27	3.68	4.11	4.62	5.16	5.69	6.25
11.82	**380**	3.45	3.88	4.33	4.88	5.44	6.00	6.59
12.46	**390**	3.63	4.09	4.56	5.14	5.73	6.32	6.95
13.10	**400**	3.82	4.30	4.80	5.40	6.03	6.65	7.31

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.28: Light Loading, 795 ACSR, Ruling Span = 200 Feet

Conductor: COOT — 795 kcmil — 36/1 Stranding ACSR
Area = 0.6417 sq in. — Weight = 0.804 lb/ft
Diameter = 1.04 in. — RTS = 16,800 lb
Design data from Sag10 Chart No. 1-898 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	1.170	1.97	2976	1.30	4500*
30	0	0	0	0.804	1.62	2488	0.94	4272
32	0	0	0	0.804	1.67	2411	0.96	4178
60	0	0	0	0.804	2.44	1649	1.38	2920
90	0	0	0	0.804	3.23	1247	2.09	1925
120	0	0	0	0.804	3.92	1028	2.89	1394
167	0	0	0	0.804	4.84	832	3.98	1011

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		3806	3351	2920	2533	2200	1926	1707
		Temperature (°F)						
		40	50	60	70	80	90	100
1.21	**100**	0.27	0.30	0.35	0.40	0.46	0.52	0.59
1.46	**110**	0.32	0.36	0.42	0.48	0.55	0.63	0.71
1.74	**120**	0.38	0.43	0.50	0.57	0.66	0.75	0.85
2.04	**130**	0.45	0.51	0.58	0.67	0.77	0.88	1.00
2.37	**140**	0.52	0.59	0.68	0.78	0.90	1.02	1.16
2.72	**150**	0.60	0.68	0.78	0.89	1.03	1.18	1.33
3.10	**160**	0.68	0.77	0.88	1.02	1.17	1.34	1.51
3.50	**170**	0.77	0.87	1.00	1.15	1.32	1.51	1.71
3.92	**180**	0.86	0.97	1.12	1.29	1.48	1.69	1.91
4.37	**190**	0.96	1.08	1.25	1.43	1.65	1.89	2.13
4.84	**200**	1.06	1.20	1.38	1.59	1.83	2.09	2.36
5.34	**210**	1.17	1.32	1.52	1.75	2.02	2.30	2.60
5.86	**220**	1.28	1.45	1.67	1.92	2.21	2.53	2.86
6.40	**230**	1.40	1.59	1.83	2.10	2.42	2.76	3.12
6.97	**240**	1.53	1.73	1.99	2.29	2.64	3.01	3.40
7.56	**250**	1.66	1.88	2.16	2.48	2.86	3.27	3.69
8.18	**260**	1.79	2.03	2.33	2.69	3.09	3.53	3.99
8.82	**270**	1.93	2.19	2.52	2.90	3.34	3.81	4.30
9.49	**280**	2.08	2.35	2.70	3.12	3.59	4.10	4.63
10.18	**290**	2.23	2.52	2.90	3.34	3.85	4.39	4.96
10.89	**300**	2.39	2.70	3.11	3.58	4.12	4.70	5.31

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.29: Light Loading, 795 ACSR, Ruling Span = 250 Feet

Conductor: COOT	795 kcmil	36/1 Stranding ACSR
Area = 0.6417 sq in.	Weight = 0.804 lb/ft	
Diameter = 1.04 in.	RTS = 16,800 lb	
Design data from Sag10 Chart No. 1-898	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	1.170	3.02	3031	2.03	4500*
30	0	0	0	0.804	2.59	2429	1.51	4163
32	0	0	0	0.804	2.65	2370	1.54	4075
60	0	0	0	0.804	3.55	1769	2.14	2943
90	0	0	0	0.804	4.45	1414	3.01	2088
120	0	0	0	0.804	5.25	1200	3.93	1601
167	0	0	0	0.804	6.34	994	5.21	1208

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		3730	**3320**	**2943**	**2610**	**2326**	**2089**	**1894**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.28	**150**	0.61	0.68	0.77	0.87	0.97	1.08	1.20
2.60	**160**	0.69	0.77	0.88	0.99	1.11	1.23	1.36
2.93	**170**	0.78	0.87	0.99	1.11	1.25	1.39	1.54
3.29	**180**	0.88	0.98	1.11	1.25	1.40	1.56	1.72
3.66	**190**	0.98	1.09	1.24	1.39	1.56	1.74	1.92
4.06	**200**	1.08	1.21	1.37	1.54	1.73	1.93	2.12
4.47	**210**	1.19	1.33	1.51	1.70	1.91	2.12	2.34
4.91	**220**	1.31	1.46	1.66	1.87	2.09	2.33	2.57
5.37	**230**	1.43	1.60	1.81	2.04	2.29	2.55	2.81
5.84	**240**	1.56	1.74	1.97	2.22	2.49	2.77	3.06
6.34	**250**	1.69	1.89	2.14	2.41	2.70	3.01	3.32
6.86	**260**	1.83	2.04	2.31	2.61	2.92	3.26	3.59
7.39	**270**	1.97	2.20	2.50	2.81	3.15	3.51	3.87
7.95	**280**	2.12	2.37	2.68	3.02	3.39	3.78	4.16
8.53	**290**	2.27	2.54	2.88	3.24	3.63	4.05	4.47
9.13	**300**	2.43	2.72	3.08	3.47	3.89	4.33	4.78
9.75	**310**	2.60	2.91	3.29	3.71	4.15	4.63	5.10
10.39	**320**	2.77	3.10	3.51	3.95	4.42	4.93	5.44
11.05	**330**	2.94	3.29	3.73	4.20	4.70	5.24	5.78
11.73	**340**	3.13	3.50	3.96	4.46	4.99	5.57	6.14
12.43	**350**	3.31	3.70	4.19	4.72	5.29	5.90	6.51

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.30: Light Loading, 795 ACSR, Ruling Span = 300 Feet

Conductor: COOT | 795 kcmil | 36/1 Stranding ACSR
Area = 0.6417 sq in. | Weight = 0.804 lb/ft
Diameter = 1.04 in. | RTS = 16,800 lb
Design data from Sag10 Chart No. 1-898 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
30	0	9	0.05	1.170	4.24	3107	2.93	4500*
30	0	0	0	0.804	3.74	2419	2.24	4047
32	0	0	0	0.804	3.81	2373	2.28	3966
60	0	0	0	0.804	4.82	1879	3.05	2963
90	0	0	0	0.804	5.81	1559	4.07	2224
120	0	0	0	0.804	6.70	1352	5.10	1777
167	0	0	0	0.804	7.94	1142	6.54	1385

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		3654	**3290**	**2963**	**2677**	**2431**	**2224**	**2049**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.53	**200**	1.10	1.22	1.36	1.50	1.66	1.81	1.96
3.89	**210**	1.22	1.35	1.49	1.66	1.83	1.99	2.17
4.27	**220**	1.33	1.48	1.64	1.82	2.01	2.19	2.38
4.67	**230**	1.46	1.62	1.79	1.99	2.19	2.39	2.60
5.08	**240**	1.59	1.76	1.95	2.16	2.39	2.60	2.83
5.51	**250**	1.72	1.91	2.12	2.35	2.59	2.83	3.07
5.96	**260**	1.86	2.07	2.29	2.54	2.80	3.06	3.32
6.43	**270**	2.01	2.23	2.47	2.74	3.02	3.30	3.58
6.92	**280**	2.16	2.40	2.66	2.94	3.25	3.55	3.85
7.42	**290**	2.32	2.57	2.85	3.16	3.49	3.80	4.13
7.94	**300**	2.48	2.75	3.05	3.38	3.73	4.07	4.42
8.48	**310**	2.65	2.94	3.26	3.61	3.98	4.35	4.72
9.03	**320**	2.82	3.13	3.47	3.85	4.24	4.63	5.03
9.61	**330**	3.00	3.33	3.69	4.09	4.51	4.92	5.35
10.20	**340**	3.19	3.53	3.92	4.34	4.79	5.23	5.68
10.81	**350**	3.38	3.74	4.15	4.60	5.08	5.54	6.02
11.43	**360**	3.57	3.96	4.39	4.87	5.37	5.86	6.36
12.08	**370**	3.77	4.18	4.64	5.14	5.67	6.19	6.72
12.74	**380**	3.98	4.41	4.89	5.42	5.98	6.53	7.09
13.42	**390**	4.19	4.65	5.15	5.71	6.30	6.88	7.47
14.12	**400**	4.41	4.89	5.42	6.01	6.63	7.24	7.86

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.31: Medium Loading, 4 ACSR, Ruling Span = 250 Feet

Conductor: SWANATE	4 kcmil	7/1 Stranding ACSR
Area = 0.0411 sq in.	Weight = 0.067 lb/ft	
Diameter = 0.257 in.	RTS = 2360 lb	
Design data from Sag10 Chart No. 1-670	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.536	4.28	979	4.28	979
32	0.25	0	0	0.222	2.69	646	2.37	731
60	0	6	0	0.145	2.40	471	1.91	592
0	0	0	0	0.067	0.79	663	0.69	757
15	0	0	0	0.067	0.89	590*	0.74	707
30	0	0	0	0.067	1.01	519	0.80	654
60	0	0	0	0.067	1.36	385	0.97	542
90	0	0	0	0.067	1.92	273	1.24	423
120	0	0	0	0.067	2.60	202	1.70	308

*Design Condition

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		617	**580**	**541**	**502**	**463**	**423**	**383**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.97	**150**	0.31	0.32	0.35	0.37	0.41	0.45	0.49
1.10	**160**	0.35	0.37	0.40	0.43	0.46	0.51	0.56
1.24	**170**	0.39	0.42	0.45	0.48	0.52	0.57	0.63
1.39	**180**	0.44	0.47	0.50	0.54	0.59	0.64	0.71
1.55	**190**	0.49	0.52	0.56	0.60	0.65	0.72	0.79
1.72	**200**	0.54	0.58	0.62	0.67	0.72	0.79	0.88
1.90	**210**	0.60	0.64	0.68	0.73	0.80	0.87	0.97
2.08	**220**	0.66	0.70	0.75	0.81	0.88	0.96	1.06
2.28	**230**	0.72	0.76	0.82	0.88	0.96	1.05	1.16
2.48	**240**	0.78	0.83	0.89	0.96	1.04	1.14	1.26
2.69	**250**	0.85	0.90	0.97	1.04	1.13	1.24	1.37
2.91	**260**	0.92	0.97	1.05	1.12	1.22	1.34	1.48
3.14	**270**	0.99	1.05	1.13	1.21	1.32	1.45	1.60
3.37	**280**	1.07	1.13	1.22	1.30	1.42	1.56	1.72
3.62	**290**	1.14	1.21	1.31	1.40	1.52	1.67	1.84
3.87	**300**	1.22	1.30	1.40	1.50	1.63	1.79	1.97
4.14	**310**	1.31	1.38	1.49	1.60	1.74	1.91	2.11
4.41	**320**	1.39	1.47	1.59	1.70	1.85	2.03	2.24
4.69	**330**	1.48	1.57	1.69	1.81	1.97	2.16	2.39
4.98	**340**	1.57	1.66	1.79	1.92	2.09	2.29	2.53
5.27	**350**	1.67	1.76	1.90	2.04	2.22	2.43	2.69

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.32: Medium Loading, 4 ACSR, Ruling Span = 300 Feet

Conductor: SWANATE — 4 kcmil — 7/1 Stranding ACSR
Area = 0.0411 sq in. — Weight = 0.067 lb/ft
Diameter = 0.257 in. — RTS = 2360 lb
Design data from Sag10 Chart No. 1-670 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.536	5.69	1062	5.69	1062
32	0.25	0	0	0.222	3.65	684	3.18	785
60	0	6	0	0.145	3.26	500	2.54	642
0	0	0	0	0.067	1.14	661	0.95	791
15	0	0	0	0.067	1.28	590*	1.02	742
30	0	0	0	0.067	1.45	521	1.09	691
60	0	0	0	0.067	1.92	393	1.30	582
90	0	0	0	0.067	2.62	288	1.61	468
120	0	0	0	0.067	3.35	225	2.12	355

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		655	**619**	**582**	**544**	**506**	**468**	**429**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.62	**200**	0.51	0.54	0.58	0.61	0.66	0.72	0.78
1.79	**210**	0.56	0.60	0.64	0.68	0.73	0.79	0.86
1.96	**220**	0.62	0.66	0.70	0.74	0.80	0.87	0.95
2.15	**230**	0.68	0.72	0.76	0.81	0.88	0.95	1.03
2.34	**240**	0.74	0.78	0.83	0.88	0.95	1.03	1.13
2.53	**250**	0.80	0.85	0.90	0.96	1.03	1.12	1.22
2.74	**260**	0.86	0.92	0.98	1.04	1.12	1.21	1.32
2.96	**270**	0.93	0.99	1.05	1.12	1.21	1.30	1.43
3.18	**280**	1.00	1.06	1.13	1.20	1.30	1.40	1.53
3.41	**290**	1.07	1.14	1.21	1.29	1.39	1.50	1.64
3.65	**300**	1.15	1.22	1.30	1.38	1.49	1.61	1.76
3.90	**310**	1.23	1.30	1.39	1.47	1.59	1.72	1.88
4.15	**320**	1.31	1.39	1.48	1.57	1.70	1.83	2.00
4.42	**330**	1.39	1.48	1.57	1.67	1.80	1.95	2.13
4.69	**340**	1.48	1.57	1.67	1.77	1.91	2.07	2.26
4.97	**350**	1.57	1.66	1.77	1.88	2.03	2.19	2.40
5.26	**360**	1.66	1.76	1.87	1.99	2.15	2.32	2.53
5.55	**370**	1.75	1.86	1.98	2.10	2.27	2.45	2.68
5.86	**380**	1.85	1.96	2.09	2.21	2.39	2.58	2.82
6.17	**390**	1.94	2.06	2.20	2.33	2.52	2.72	2.97
6.49	**400**	2.04	2.17	2.31	2.45	2.65	2.86	3.13

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.33: Medium Loading, 4 ACSR, Ruling Span = 350 Feet

Conductor: SWANATE — 4 kcmil — 7/1 Stranding ACSR
Area = 0.0411 sq in. — Weight = 0.067 lb/ft
Diameter = 0.257 in. — RTS = 2360 lb
Design data from Sag10 Chart No. 1-670 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.536	7.20	1141	7.20	1141
32	0.25	0	0	0.222	4.72	721	4.05	840
60	0	6	0	0.145	4.21	527	3.21	692
0	0	0	0	0.067	1.56	660	1.24	826
15	0	0	0	0.067	1.74	590*	1.32	779
30	0	0	0	0.067	1.96	523	1.41	729
60	0	0	0	0.067	2.56	401	1.64	624
90	0	0	0	0.067	3.38	303	2.00	513
120	0	0	0	0.067	4.13	248	2.54	403

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		695	**660**	**624**	**588**	**551**	**513**	**476**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.41	**250**	0.75	0.79	0.84	0.89	0.95	1.02	1.10
2.60	**260**	0.82	0.86	0.91	0.97	1.03	1.10	1.19
2.81	**270**	0.88	0.92	0.98	1.04	1.11	1.19	1.29
3.02	**280**	0.95	0.99	1.05	1.12	1.19	1.28	1.38
3.24	**290**	1.02	1.06	1.13	1.20	1.28	1.37	1.48
3.47	**300**	1.09	1.14	1.20	1.29	1.37	1.47	1.59
3.70	**310**	1.16	1.22	1.29	1.37	1.46	1.57	1.69
3.95	**320**	1.24	1.30	1.37	1.46	1.55	1.67	1.81
4.20	**330**	1.32	1.38	1.46	1.56	1.65	1.78	1.92
4.45	**340**	1.40	1.46	1.55	1.65	1.76	1.89	2.04
4.72	**350**	1.48	1.55	1.64	1.75	1.86	2.00	2.16
4.99	**360**	1.57	1.64	1.74	1.85	1.97	2.12	2.29
5.27	**370**	1.65	1.73	1.83	1.96	2.08	2.24	2.41
5.56	**380**	1.74	1.83	1.93	2.06	2.19	2.36	2.55
5.86	**390**	1.84	1.92	2.04	2.17	2.31	2.48	2.68
6.16	**400**	1.93	2.02	2.14	2.29	2.43	2.61	2.82
6.48	**410**	2.03	2.13	2.25	2.40	2.55	2.74	2.96
6.80	**420**	2.13	2.23	2.36	2.52	2.68	2.88	3.11
7.12	**430**	2.23	2.34	2.48	2.64	2.81	3.02	3.26
7.46	**440**	2.34	2.45	2.59	2.77	2.94	3.16	3.41
7.80	**450**	2.45	2.56	2.71	2.89	3.07	3.31	3.57

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.34: Medium Loading, 2 ACSR, Ruling Span = 250 Feet

Conductor: SPARROW 2 kcmil 6/1 Stranding ACSR
Area = 0.0608 sq in. Weight = 0.091 lb/ft
Diameter = 0.316 in. RTS = 2850 lb
Design data from Sag10 Chart No. 1-1023 Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.579	3.94	1149	3.90	1161
32	0.25	0	0	0.264	2.67	771	2.35	879
60	0	6	0	0.182	2.59	550	2.04	699
0	0	0	0	0.091	0.87	817	0.76	931
15	0	0	0	0.091	1.00	712*	0.83	859
30	0	0	0	0.091	1.16	612	0.91	784
60	0	0	0	0.091	1.65	431	1.13	629
90	0	0	0	0.091	2.39	298	1.51	472
120	0	0	0	0.091	3.12	228	2.13	335

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		733	**681**	**629**	**576**	**523**	**472**	**422**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.12	**150**	0.35	0.37	0.41	0.44	0.49	0.54	0.60
1.28	**160**	0.40	0.43	0.46	0.50	0.56	0.62	0.69
1.44	**170**	0.45	0.48	0.52	0.57	0.63	0.70	0.78
1.62	**180**	0.50	0.54	0.59	0.64	0.71	0.78	0.87
1.80	**190**	0.56	0.60	0.65	0.71	0.79	0.87	0.97
2.00	**200**	0.62	0.67	0.72	0.79	0.87	0.97	1.08
2.20	**210**	0.68	0.73	0.80	0.87	0.96	1.07	1.19
2.42	**220**	0.75	0.81	0.88	0.95	1.05	1.17	1.30
2.64	**230**	0.82	0.88	0.96	1.04	1.15	1.28	1.42
2.88	**240**	0.89	0.96	1.04	1.13	1.25	1.39	1.55
3.12	**250**	0.97	1.04	1.13	1.23	1.36	1.51	1.68
3.37	**260**	1.05	1.12	1.22	1.33	1.47	1.63	1.82
3.64	**270**	1.13	1.21	1.32	1.43	1.59	1.76	1.96
3.91	**280**	1.22	1.30	1.42	1.54	1.71	1.89	2.11
4.20	**290**	1.31	1.40	1.52	1.66	1.83	2.03	2.26
4.49	**300**	1.40	1.50	1.63	1.77	1.96	2.17	2.42
4.80	**310**	1.49	1.60	1.74	1.89	2.09	2.32	2.58
5.11	**320**	1.59	1.70	1.85	2.02	2.23	2.47	2.75
5.44	**330**	1.69	1.81	1.97	2.14	2.37	2.63	2.93
5.77	**340**	1.79	1.92	2.09	2.28	2.52	2.79	3.11
6.12	**350**	1.90	2.04	2.21	2.41	2.67	2.96	3.29

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.35: Medium Loading, 2 ACSR, Ruling Span = 300 Feet

Conductor: SPARROW	2 kcmil	6/1 Stranding ACSR
Area = 0.0608 sq in.	Weight = 0.091 lb/ft	
Diameter = 0.316 in.	RTS = 2850 lb	
Design data from Sag10 Chart No. 1-1023	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.579	5.25	1243	5.25	1243
32	0.25	0	0	0.264	3.63	818	3.22	924
60	0	6	0	0.182	3.48	589	2.79	736
0	0	0	0	0.091	1.26	814	1.09	943
15	0	0	0	0.091	1.44	713*	1.17	873
30	0	0	0	0.091	1.66	616	1.28	800
60	0	0	0	0.091	2.30	446	1.58	648
90	0	0	0	0.091	3.17	323	2.06	498
120	0	0	0	0.091	4.07	252	2.78	368

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		750	**699**	**648**	**598**	**547**	**498**	**451**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.81	**200**	0.61	0.65	0.70	0.76	0.83	0.92	1.01
1.99	**210**	0.67	0.72	0.77	0.84	0.92	1.01	1.11
2.19	**220**	0.74	0.79	0.85	0.92	1.01	1.11	1.22
2.39	**230**	0.81	0.86	0.93	1.01	1.10	1.21	1.33
2.60	**240**	0.88	0.93	1.01	1.09	1.20	1.32	1.45
2.83	**250**	0.95	1.02	1.10	1.19	1.30	1.43	1.58
3.06	**260**	1.03	1.10	1.19	1.28	1.40	1.55	1.71
3.30	**270**	1.11	1.18	1.28	1.39	1.51	1.67	1.84
3.55	**280**	1.19	1.27	1.38	1.49	1.63	1.79	1.98
3.80	**290**	1.28	1.36	1.48	1.60	1.75	1.92	2.12
4.07	**300**	1.37	1.46	1.58	1.71	1.87	2.06	2.27
4.35	**310**	1.46	1.56	1.69	1.83	2.00	2.20	2.42
4.63	**320**	1.56	1.66	1.80	1.95	2.13	2.34	2.58
4.92	**330**	1.66	1.77	1.91	2.07	2.26	2.49	2.75
5.23	**340**	1.76	1.88	2.03	2.20	2.40	2.65	2.92
5.54	**350**	1.86	1.99	2.15	2.33	2.55	2.80	3.09
5.86	**360**	1.97	2.10	2.28	2.46	2.69	2.97	3.27
6.19	**370**	2.08	2.22	2.40	2.60	2.84	3.13	3.45
6.53	**380**	2.20	2.34	2.54	2.74	3.00	3.31	3.64
6.88	**390**	2.32	2.47	2.67	2.89	3.16	3.48	3.84
7.24	**400**	2.44	2.60	2.81	3.04	3.32	3.66	4.04

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.36: Medium Loading, 2 ACSR, Ruling Span = 350 Feet

Conductor: SPARROW — 2 kcmil — 6/1 Stranding ACSR
Area = 0.0608 sq in. — Weight = 0.091 lb/ft
Diameter = 0.316 in. — RTS = 2850 lb
Design data from Sag10 Chart No. 1-1023 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.579	6.66	1333	6.66	1333
32	0.25	0	0	0.264	4.68	864	4.11	984
60	0	6	0	0.182	4.47	626	3.53	791
0	0	0	0	0.091	1.72	810	1.43	976
15	0	0	0	0.091	1.96	713*	1.54	907
30	0	0	0	0.091	2.25	620	1.67	836
60	0	0	0	0.091	3.03	461	2.02	689
90	0	0	0	0.091	4.03	346	2.56	544
120	0	0	0	0.091	5.00	279	3.36	415

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		788	**739**	**689**	**640**	**591**	**544**	**498**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.55	**250**	0.90	0.96	1.03	1.11	1.20	1.31	1.43
2.76	**260**	0.98	1.04	1.11	1.20	1.30	1.41	1.55
2.98	**270**	1.05	1.12	1.20	1.30	1.40	1.52	1.67
3.20	**280**	1.13	1.21	1.29	1.40	1.51	1.64	1.79
3.43	**290**	1.22	1.30	1.39	1.50	1.62	1.76	1.92
3.67	**300**	1.30	1.39	1.48	1.60	1.73	1.88	2.06
3.92	**310**	1.39	1.48	1.58	1.71	1.85	2.01	2.20
4.18	**320**	1.48	1.58	1.69	1.82	1.97	2.14	2.34
4.44	**330**	1.57	1.68	1.80	1.94	2.10	2.28	2.49
4.72	**340**	1.67	1.78	1.91	2.06	2.23	2.42	2.64
5.00	**350**	1.77	1.89	2.02	2.18	2.36	2.56	2.80
5.29	**360**	1.87	2.00	2.14	2.31	2.50	2.71	2.96
5.59	**370**	1.98	2.11	2.26	2.44	2.64	2.86	3.13
5.89	**380**	2.09	2.23	2.38	2.57	2.78	3.02	3.30
6.21	**390**	2.20	2.35	2.51	2.71	2.93	3.18	3.48
6.53	**400**	2.31	2.47	2.64	2.85	3.08	3.34	3.66
6.86	**410**	2.43	2.59	2.77	2.99	3.24	3.51	3.84
7.20	**420**	2.55	2.72	2.91	3.14	3.40	3.69	4.03
7.55	**430**	2.67	2.85	3.05	3.29	3.56	3.86	4.23
7.90	**440**	2.80	2.99	3.19	3.45	3.73	4.05	4.43
8.27	**450**	2.93	3.12	3.34	3.60	3.90	4.23	4.63

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.37: Medium Loading, 1/0 ACSR, Ruling Span = 250 Feet

Conductor: RAVEN	1/0 kcmil	6/1 Stranding ACSR
Area = 0.0968 sq in.	Weight = 0.145 lb/ft	
Diameter = 0.398 in.	RTS = 4380 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.655	3.30	1554	3.28	1559
32	0.25	0	0	0.343	2.40	1118	2.16	1241
60	0	6	0	0.246	2.41	797	1.94	989
0	0	0	0	0.145	0.90	1256	0.84	1350
15	0	0	0	0.145	1.03	1095*	0.91	1243
30	0	0	0	0.145	1.21	939	1.00	1133
60	0	0	0	0.145	1.71	662	1.24	910
90	0	0	0	0.145	2.46	461	1.64	693
120	0	0	0	0.145	3.24	350	2.23	507

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1059	**985**	**910**	**836**	**763**	**693**	**626**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.17	**150**	0.39	0.41	0.45	0.49	0.53	0.59	0.65
1.33	**160**	0.44	0.47	0.51	0.56	0.61	0.67	0.74
1.50	**170**	0.49	0.53	0.57	0.63	0.68	0.76	0.84
1.68	**180**	0.55	0.60	0.64	0.71	0.77	0.85	0.94
1.87	**190**	0.62	0.66	0.72	0.79	0.85	0.95	1.05
2.07	**200**	0.68	0.74	0.79	0.87	0.95	1.05	1.16
2.29	**210**	0.75	0.81	0.87	0.96	1.04	1.16	1.28
2.51	**220**	0.83	0.89	0.96	1.05	1.15	1.27	1.40
2.74	**230**	0.91	0.97	1.05	1.15	1.25	1.39	1.53
2.99	**240**	0.99	1.06	1.14	1.25	1.36	1.51	1.67
3.24	**250**	1.07	1.15	1.24	1.36	1.48	1.64	1.81
3.50	**260**	1.16	1.24	1.34	1.47	1.60	1.77	1.96
3.78	**270**	1.25	1.34	1.45	1.59	1.73	1.91	2.11
4.06	**280**	1.34	1.44	1.56	1.71	1.86	2.06	2.27
4.36	**290**	1.44	1.55	1.67	1.83	1.99	2.21	2.44
4.67	**300**	1.54	1.66	1.79	1.96	2.13	2.36	2.61
4.98	**310**	1.65	1.77	1.91	2.09	2.28	2.52	2.78
5.31	**320**	1.75	1.88	2.03	2.23	2.42	2.69	2.97
5.65	**330**	1.86	2.00	2.16	2.37	2.58	2.86	3.15
5.99	**340**	1.98	2.13	2.29	2.52	2.74	3.03	3.35
6.35	**350**	2.10	2.25	2.43	2.67	2.90	3.21	3.55

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.38: Medium Loading, 1/0 ACSR, Ruling Span = 300 Feet

Conductor: RAVEN	1/0 kcmil	6/1 Stranding ACSR
Area = 0.0968 sq in.	Weight = 0.145 lb/ft	
Diameter = 0.398 in.	RTS = 4380 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.655	4.44	1663	4.44	1663
32	0.25	0	0	0.343	3.28	1176	2.96	1305
60	0	6	0	0.246	3.26	849	2.65	1047
0	0	0	0	0.145	1.30	1252	1.19	1376
15	0	0	0	0.145	1.49	1095*	1.28	1271
30	0	0	0	0.145	1.72	946	1.40	1164
60	0	0	0	0.145	2.38	686	1.72	948
90	0	0	0	0.145	3.26	501	2.21	739
120	0	0	0	0.145	4.18	391	2.90	562

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1092	**1020**	**948**	**876**	**807**	**739**	**676**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.86	**200**	0.66	0.71	0.76	0.83	0.90	0.98	1.08
2.05	**210**	0.73	0.78	0.84	0.91	0.99	1.08	1.19
2.25	**220**	0.80	0.86	0.92	1.00	1.09	1.19	1.30
2.46	**230**	0.88	0.94	1.01	1.09	1.19	1.30	1.42
2.68	**240**	0.95	1.02	1.10	1.19	1.29	1.41	1.55
2.90	**250**	1.04	1.11	1.20	1.29	1.40	1.53	1.68
3.14	**260**	1.12	1.20	1.29	1.40	1.52	1.66	1.82
3.39	**270**	1.21	1.30	1.39	1.51	1.64	1.79	1.96
3.64	**280**	1.30	1.39	1.50	1.62	1.76	1.93	2.11
3.91	**290**	1.39	1.50	1.61	1.74	1.89	2.07	2.26
4.18	**300**	1.49	1.60	1.72	1.86	2.02	2.21	2.42
4.46	**310**	1.59	1.71	1.84	1.99	2.16	2.36	2.58
4.76	**320**	1.70	1.82	1.96	2.12	2.30	2.51	2.75
5.06	**330**	1.80	1.94	2.08	2.25	2.44	2.67	2.93
5.37	**340**	1.91	2.06	2.21	2.39	2.59	2.84	3.11
5.69	**350**	2.03	2.18	2.34	2.53	2.75	3.01	3.29
6.02	**360**	2.15	2.30	2.48	2.68	2.91	3.18	3.48
6.36	**370**	2.27	2.43	2.62	2.83	3.07	3.36	3.68
6.71	**380**	2.39	2.57	2.76	2.98	3.24	3.55	3.88
7.06	**390**	2.52	2.70	2.91	3.14	3.41	3.73	4.09
7.43	**400**	2.65	2.84	3.06	3.31	3.59	3.93	4.30

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.39: Medium Loading, 1/0 ACSR, Ruling Span = 350 Feet

Conductor: RAVEN — 1/0 kcmil — 6/1 Stranding ACSR
Area = 0.0968 sq in. — Weight = 0.145 lb/ft
Diameter = 0.398 in. — RTS = 4380 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.655	5.68	1768	5.68	1768
32	0.25	0	0	0.343	4.26	1234	3.82	1374
60	0	6	0	0.246	4.20	898	3.40	1109
0	0	0	0	0.145	1.78	1246	1.58	1409
15	0	0	0	0.145	2.03	1095*	1.70	1306
30	0	0	0	0.145	2.33	953	1.85	1202
60	0	0	0	0.145	3.13	710	2.24	992
90	0	0	0	0.145	4.13	538	2.81	791
120	0	0	0	0.145	5.20	428	3.59	619

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1132	**1062**	**992**	**923**	**856**	**791**	**729**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.65	**250**	1.00	1.07	1.14	1.23	1.32	1.43	1.55
2.87	**260**	1.08	1.15	1.24	1.33	1.43	1.55	1.68
3.09	**270**	1.17	1.24	1.33	1.43	1.54	1.67	1.81
3.33	**280**	1.25	1.34	1.43	1.54	1.66	1.80	1.95
3.57	**290**	1.35	1.43	1.54	1.65	1.78	1.93	2.09
3.82	**300**	1.44	1.54	1.65	1.77	1.90	2.06	2.23
4.08	**310**	1.54	1.64	1.76	1.89	2.03	2.20	2.38
4.35	**320**	1.64	1.75	1.87	2.01	2.17	2.35	2.54
4.62	**330**	1.74	1.86	1.99	2.14	2.30	2.50	2.70
4.91	**340**	1.85	1.97	2.11	2.27	2.44	2.65	2.87
5.20	**350**	1.96	2.09	2.24	2.41	2.59	2.81	3.04
5.50	**360**	2.07	2.21	2.37	2.55	2.74	2.97	3.22
5.81	**370**	2.19	2.34	2.50	2.69	2.89	3.14	3.40
6.13	**380**	2.31	2.46	2.64	2.84	3.05	3.31	3.58
6.46	**390**	2.43	2.60	2.78	2.99	3.22	3.49	3.77
6.79	**400**	2.56	2.73	2.93	3.15	3.38	3.67	3.97
7.14	**410**	2.69	2.87	3.07	3.31	3.55	3.86	4.17
7.49	**420**	2.82	3.01	3.23	3.47	3.73	4.05	4.38
7.85	**430**	2.96	3.15	3.38	3.64	3.91	4.24	4.59
8.22	**440**	3.10	3.30	3.54	3.81	4.09	4.44	4.80
8.60	**450**	3.24	3.45	3.70	3.98	4.28	4.65	5.03

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.40: Medium Loading, 3/0 ACSR, Ruling Span = 250 Feet

Conductor: PIGEON | 3/0 kcmil | 6/1 Stranding ACSR
Area = 0.1537 sq in. | Weight = 0.230 lb/ft
Diameter = 0.502 in. | RTS = 6620 lb
Design data from Sag10 Chart No. 1-938 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.768	2.79	2148	2.72	2212
32	0.25	0	0	0.460	2.22	1621	1.97	1826
60	0	6	0	0.340	2.33	1144	1.84	1442
0	0	0	0	0.230	0.94	1909	0.88	2049
15	0	0	0	0.230	1.09	1655*	0.96	1877
30	0	0	0	0.230	1.27	1412	1.06	1703
60	0	0	0	0.230	1.82	987	1.33	1349
90	0	0	0	0.230	2.60	692	1.77	1013
120	0	0	0	0.230	3.37	533	2.42	742

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1585	**1467**	**1349**	**1233**	**1121**	**1013**	**913**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.21	**150**	0.41	0.44	0.48	0.53	0.58	0.64	0.71
1.38	**160**	0.46	0.50	0.54	0.60	0.66	0.72	0.81
1.56	**170**	0.52	0.57	0.61	0.68	0.74	0.82	0.91
1.75	**180**	0.59	0.64	0.69	0.76	0.83	0.92	1.02
1.95	**190**	0.65	0.71	0.77	0.84	0.92	1.02	1.14
2.16	**200**	0.72	0.79	0.85	0.93	1.02	1.13	1.26
2.38	**210**	0.80	0.87	0.94	1.03	1.13	1.25	1.39
2.61	**220**	0.88	0.95	1.03	1.13	1.24	1.37	1.53
2.85	**230**	0.96	1.04	1.13	1.24	1.35	1.50	1.67
3.11	**240**	1.04	1.13	1.23	1.35	1.47	1.63	1.82
3.37	**250**	1.13	1.23	1.33	1.46	1.60	1.77	1.97
3.64	**260**	1.22	1.33	1.44	1.58	1.73	1.91	2.13
3.93	**270**	1.32	1.43	1.55	1.70	1.87	2.06	2.30
4.23	**280**	1.42	1.54	1.67	1.83	2.01	2.22	2.47
4.53	**290**	1.52	1.66	1.79	1.96	2.15	2.38	2.65
4.85	**300**	1.63	1.77	1.92	2.10	2.30	2.55	2.84
5.18	**310**	1.74	1.89	2.05	2.24	2.46	2.72	3.03
5.52	**320**	1.85	2.02	2.18	2.39	2.62	2.90	3.23
5.87	**330**	1.97	2.14	2.32	2.54	2.79	3.08	3.43
6.23	**340**	2.09	2.28	2.46	2.70	2.96	3.27	3.64
6.61	**350**	2.21	2.41	2.61	2.86	3.14	3.47	3.86

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.41: Medium Loading, 3/0 ACSR, Ruling Span = 300 Feet		
Conductor: PIGEON	3/0 kcmil	6/1 Stranding ACSR
Area = 0.1537 sq in.	Weight = 0.230 lb/ft	
Diameter = 0.502 in.	RTS = 6620 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	Ice (in.)	Wind (psf)	K (lb/ft)	Weight (lb/ft)	Sag (ft)	Tension (lb)	Sag (ft)	Tension (lb)
15	0.25	4	0.2	0.768	3.80	2275	3.73	2321
32	0.25	0	0	0.460	3.05	1697	2.73	1893
60	0	6	0	0.340	3.15	1216	2.55	1501
0	0	0	0	0.230	1.36	1900	1.26	2061
15	0	0	0	0.230	1.56	1655*	1.37	1893
30	0	0	0	0.230	1.82	1424	1.50	1723
60	0	0	0	0.230	2.52	1029	1.87	1382
90	0	0	0	0.230	3.42	756	2.43	1066
120	0	0	0	0.230	4.38	591	3.19	811

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1609	1495	1382	1272	1166	1066	972
		Temperature (°F)						
		40	50	60	70	80	90	100
1.95	**200**	0.72	0.77	0.83	0.90	0.99	1.08	1.18
2.15	**210**	0.79	0.85	0.92	0.99	1.09	1.19	1.30
2.36	**220**	0.87	0.93	1.01	1.09	1.19	1.31	1.43
2.57	**230**	0.95	1.02	1.10	1.19	1.30	1.43	1.56
2.80	**240**	1.03	1.11	1.20	1.30	1.42	1.56	1.70
3.04	**250**	1.12	1.20	1.30	1.41	1.54	1.69	1.85
3.29	**260**	1.21	1.30	1.40	1.52	1.67	1.83	2.00
3.55	**270**	1.30	1.40	1.51	1.64	1.80	1.97	2.15
3.82	**280**	1.40	1.51	1.63	1.77	1.93	2.12	2.32
4.09	**290**	1.50	1.62	1.75	1.90	2.07	2.27	2.49
4.38	**300**	1.61	1.73	1.87	2.03	2.22	2.43	2.66
4.68	**310**	1.72	1.85	2.00	2.17	2.37	2.59	2.84
4.98	**320**	1.83	1.97	2.13	2.31	2.53	2.76	3.03
5.30	**330**	1.95	2.09	2.26	2.46	2.69	2.94	3.22
5.63	**340**	2.07	2.22	2.40	2.61	2.85	3.12	3.42
5.96	**350**	2.19	2.35	2.55	2.76	3.02	3.31	3.62
6.31	**360**	2.32	2.49	2.69	2.92	3.20	3.50	3.83
6.66	**370**	2.45	2.63	2.84	3.09	3.38	3.70	4.05
7.03	**380**	2.58	2.78	3.00	3.26	3.56	3.90	4.27
7.40	**390**	2.72	2.92	3.16	3.43	3.75	4.11	4.50
7.79	**400**	2.86	3.08	3.32	3.61	3.95	4.32	4.73

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.42: Medium Loading, 3/0 ACSR, Ruling Span = 350 Feet

Conductor: PIGEON	3/0 kcmil	6/1 Stranding ACSR
Area = 0.1537 sq in.	Weight = 0.230 lb/ft	
Diameter = 0.502 in.	RTS = 6620 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.768	4.91	2398	4.85	2429
32	0.25	0	0	0.460	3.98	1771	3.60	1958
60	0	6	0	0.340	4.06	1283	3.35	1558
0	0	0	0	0.230	1.86	1890	1.70	2071
15	0	0	0	0.230	2.13	1655*	1.85	1907
30	0	0	0	0.230	2.45	1436	2.02	1741
60	0	0	0	0.230	3.30	1069	2.49	1414
90	0	0	0	0.230	4.32	815	3.16	1115
120	0	0	0	0.230	5.38	655	4.03	875

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1631	**1521**	**1414**	**1309**	**1209**	**1114**	**1027**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.74	**250**	1.10	1.18	1.27	1.37	1.49	1.61	1.75
2.97	**260**	1.19	1.28	1.37	1.48	1.61	1.74	1.89
3.20	**270**	1.29	1.38	1.48	1.60	1.73	1.88	2.04
3.44	**280**	1.38	1.48	1.59	1.72	1.86	2.02	2.20
3.69	**290**	1.48	1.59	1.71	1.85	2.00	2.17	2.35
3.95	**300**	1.59	1.70	1.83	1.98	2.14	2.32	2.52
4.22	**310**	1.69	1.82	1.95	2.11	2.28	2.48	2.69
4.50	**320**	1.81	1.94	2.08	2.25	2.43	2.64	2.87
4.78	**330**	1.92	2.06	2.21	2.39	2.59	2.81	3.05
5.08	**340**	2.04	2.19	2.35	2.54	2.75	2.98	3.24
5.38	**350**	2.16	2.32	2.49	2.69	2.91	3.16	3.43
5.69	**360**	2.29	2.45	2.63	2.85	3.08	3.34	3.63
6.01	**370**	2.41	2.59	2.78	3.01	3.25	3.53	3.83
6.34	**380**	2.55	2.73	2.94	3.17	3.43	3.72	4.04
6.68	**390**	2.68	2.88	3.09	3.34	3.61	3.92	4.26
7.03	**400**	2.82	3.03	3.25	3.51	3.80	4.13	4.48
7.38	**410**	2.96	3.18	3.42	3.69	3.99	4.34	4.71
7.75	**420**	3.11	3.34	3.59	3.87	4.19	4.55	4.94
8.12	**430**	3.26	3.50	3.76	4.06	4.39	4.77	5.18
8.50	**440**	3.41	3.67	3.94	4.25	4.60	4.99	5.42
8.89	**450**	3.57	3.84	4.12	4.45	4.81	5.22	5.67

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.43: Medium Loading, 4/0 ACSR, Ruling Span = 250 Feet

Conductor: PENGUIN — 4/0 kcmil — 6/1 Stranding ACSR
Area = 0.1939 sq in. — Weight = 0.291 lb/ft
Diameter = 0.563 in. — RTS = 8350 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.845	2.55	2588	2.45	2700
32	0.25	0	0	0.539	2.11	1999	1.85	2274
60	0	6	0	0.405	2.25	1408	1.76	1797
0	0	0	0	0.291	0.94	2407	0.88	2584
15	0	0	0	0.291	1.09	2087*	0.96	2368
30	0	0	0	0.291	1.28	1781	1.06	2148
60	0	0	0	0.291	1.82	1246	1.34	1702
90	0	0	0	0.291	2.60	874	1.78	1279
120	0	0	0	0.291	3.38	673	2.43	937

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1999	**1850**	**1702**	**1556**	**1414**	**1279**	**1153**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.22	**150**	0.41	0.44	0.48	0.53	0.58	0.64	0.71
1.38	**160**	0.47	0.50	0.55	0.60	0.66	0.73	0.81
1.56	**170**	0.53	0.57	0.62	0.68	0.74	0.82	0.91
1.75	**180**	0.59	0.64	0.69	0.76	0.83	0.92	1.02
1.95	**190**	0.66	0.71	0.77	0.84	0.93	1.03	1.14
2.16	**200**	0.73	0.79	0.86	0.93	1.03	1.14	1.26
2.38	**210**	0.80	0.87	0.95	1.03	1.14	1.26	1.39
2.62	**220**	0.88	0.95	1.04	1.13	1.25	1.38	1.53
2.86	**230**	0.96	1.04	1.13	1.24	1.36	1.51	1.67
3.12	**240**	1.05	1.13	1.23	1.35	1.48	1.64	1.82
3.38	**250**	1.14	1.23	1.34	1.46	1.61	1.78	1.97
3.66	**260**	1.23	1.33	1.45	1.58	1.74	1.93	2.13
3.94	**270**	1.33	1.43	1.56	1.70	1.88	2.08	2.30
4.24	**280**	1.43	1.54	1.68	1.83	2.02	2.23	2.47
4.55	**290**	1.53	1.66	1.80	1.96	2.17	2.40	2.65
4.87	**300**	1.64	1.77	1.93	2.10	2.32	2.56	2.84
5.20	**310**	1.75	1.89	2.06	2.24	2.48	2.74	3.03
5.54	**320**	1.87	2.02	2.20	2.39	2.64	2.92	3.23
5.89	**330**	1.99	2.14	2.33	2.54	2.81	3.10	3.43
6.25	**340**	2.11	2.28	2.48	2.70	2.98	3.29	3.64
6.62	**350**	2.23	2.41	2.63	2.86	3.16	3.49	3.86

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.44: Medium Loading, 4/0 ACSR, Ruling Span = 300 Feet

Conductor: PENGUIN	4/0 kcmil	6/1 Stranding ACSR
Area = 0.1939 sq in	Weight = 0.291 lb/ft	
Diameter = 0.563 in.	RTS = 8350 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.845	3.49	2723	3.38	2819
32	0.25	0	0	0.539	2.91	2086	2.58	2350
60	0	6	0	0.405	3.05	1492	2.44	1866
0	0	0	0	0.291	1.37	2396	1.26	2600
15	0	0	0	0.291	1.57	2088*	1.37	2389
30	0	0	0	0.291	1.82	1796	1.51	2174
60	0	0	0	0.291	2.52	1299	1.88	1745
90	0	0	0	0.291	3.43	956	2.43	1346
120	0	0	0	0.291	4.38	747	3.20	1025

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		2030	**1886**	**1744**	**1606**	**1472**	**1345**	**1228**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.95	**200**	0.72	0.77	0.84	0.91	0.99	1.08	1.19
2.15	**210**	0.79	0.85	0.92	1.00	1.09	1.19	1.31
2.36	**220**	0.87	0.94	1.01	1.10	1.19	1.31	1.44
2.57	**230**	0.95	1.02	1.11	1.20	1.30	1.43	1.57
2.80	**240**	1.03	1.11	1.20	1.31	1.42	1.56	1.71
3.04	**250**	1.12	1.21	1.30	1.42	1.54	1.69	1.85
3.29	**260**	1.21	1.31	1.41	1.53	1.67	1.83	2.01
3.55	**270**	1.30	1.41	1.52	1.65	1.80	1.97	2.16
3.82	**280**	1.40	1.52	1.64	1.78	1.93	2.12	2.33
4.09	**290**	1.50	1.63	1.76	1.91	2.07	2.27	2.49
4.38	**300**	1.61	1.74	1.88	2.04	2.22	2.43	2.67
4.68	**310**	1.72	1.86	2.01	2.18	2.37	2.59	2.85
4.98	**320**	1.83	1.98	2.14	2.32	2.53	2.76	3.04
5.30	**330**	1.95	2.11	2.27	2.47	2.69	2.94	3.23
5.63	**340**	2.07	2.23	2.41	2.62	2.85	3.12	3.43
5.96	**350**	2.19	2.37	2.56	2.78	3.02	3.31	3.63
6.31	**360**	2.32	2.51	2.71	2.94	3.20	3.50	3.84
6.66	**370**	2.45	2.65	2.86	3.10	3.38	3.70	4.06
7.03	**380**	2.58	2.79	3.02	3.27	3.56	3.90	4.28
7.40	**390**	2.72	2.94	3.18	3.45	3.75	4.11	4.51
7.79	**400**	2.86	3.09	3.34	3.63	3.95	4.32	4.75

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.45: Medium Loading, 4/0 ACSR, Ruling Span = 350 Feet

Conductor: PENGUIN — 4/0 kcmil — 6/1 Stranding ACSR
Area = 0.1939 sq in. — Weight = 0.291 lb/ft
Diameter = 0.563 in. — RTS = 8350 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.845	4.54	2855	4.41	2935
32	0.25	0	0	0.539	3.81	2170	3.41	2424
60	0	6	0	0.405	3.95	1572	3.21	1932
0	0	0	0	0.291	1.87	2384	1.71	2613
15	0	0	0	0.291	2.13	2088*	1.85	2406
30	0	0	0	0.291	2.46	1812	2.03	2197
60	0	0	0	0.291	3.30	1349	2.50	1784
90	0	0	0	0.291	4.33	1030	3.17	1407
120	0	0	0	0.291	5.39	828	4.03	1105

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2057	**1919**	**1784**	**1652**	**1526**	**1407**	**1296**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.75	**250**	1.10	1.18	1.27	1.38	1.49	1.62	1.75
2.97	**260**	1.20	1.28	1.38	1.49	1.61	1.75	1.90
3.21	**270**	1.29	1.38	1.49	1.61	1.74	1.89	2.05
3.45	**280**	1.39	1.48	1.60	1.73	1.87	2.03	2.20
3.70	**290**	1.49	1.59	1.72	1.85	2.00	2.18	2.36
3.96	**300**	1.59	1.70	1.84	1.98	2.15	2.33	2.53
4.23	**310**	1.70	1.82	1.96	2.12	2.29	2.49	2.70
4.51	**320**	1.81	1.94	2.09	2.26	2.44	2.65	2.88
4.79	**330**	1.93	2.06	2.22	2.40	2.60	2.82	3.06
5.09	**340**	2.05	2.19	2.36	2.55	2.76	2.99	3.25
5.39	**350**	2.17	2.32	2.50	2.70	2.92	3.17	3.44
5.70	**360**	2.30	2.45	2.64	2.86	3.09	3.35	3.64
6.02	**370**	2.43	2.59	2.79	3.02	3.26	3.54	3.84
6.35	**380**	2.56	2.73	2.95	3.18	3.44	3.74	4.05
6.69	**390**	2.69	2.88	3.10	3.35	3.63	3.94	4.27
7.04	**400**	2.83	3.03	3.27	3.53	3.81	4.14	4.49
7.40	**410**	2.98	3.18	3.43	3.71	4.01	4.35	4.72
7.76	**420**	3.12	3.34	3.60	3.89	4.20	4.56	4.95
8.14	**430**	3.28	3.50	3.77	4.08	4.41	4.78	5.19
8.52	**440**	3.43	3.67	3.95	4.27	4.61	5.01	5.44
8.91	**450**	3.59	3.84	4.13	4.46	4.83	5.24	5.69

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.46: Medium Loading, 336 ACSR, Ruling Span = 250 Feet

Conductor: MERLIN — 336 kcmil — 18/1 Stranding ACSR
Area = 0.2789 sq in. — Weight = 0.365 lb/ft
Diameter = 0.684 in. — RTS = 8680 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.961	2.67	2809	2.40	3124
32	0.25	0	0	0.650	2.42	2100	1.97	2583
60	0	6	0	0.500	2.78	1406	2.04	1913
0	0	0	0	0.365	1.10	2599	0.93	3055
15	0	0	0	0.365	1.31	2170*	1.04	2739
30	0	0	0	0.365	1.60	1779	1.18	2413
60	0	0	0	0.365	2.41	1182	1.62	1762
90	0	0	0	0.365	3.37	848	2.35	1216
120	0	0	0	0.365	4.26	670	3.26	874

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2193	**1975**	**1762**	**1561**	**1377**	**1216**	**1079**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.53	**150**	0.47	0.52	0.58	0.66	0.75	0.85	0.95
1.74	**160**	0.53	0.59	0.66	0.75	0.85	0.96	1.08
1.97	**170**	0.60	0.67	0.75	0.85	0.96	1.09	1.22
2.21	**180**	0.67	0.75	0.84	0.95	1.07	1.22	1.37
2.46	**190**	0.75	0.83	0.94	1.06	1.20	1.36	1.52
2.73	**200**	0.83	0.92	1.04	1.17	1.32	1.50	1.69
3.01	**210**	0.92	1.02	1.14	1.29	1.46	1.66	1.86
3.30	**220**	1.01	1.12	1.25	1.42	1.60	1.82	2.04
3.61	**230**	1.10	1.22	1.37	1.55	1.75	1.99	2.23
3.93	**240**	1.20	1.33	1.49	1.69	1.91	2.17	2.43
4.26	**250**	1.30	1.44	1.62	1.83	2.07	2.35	2.64
4.61	**260**	1.41	1.56	1.75	1.98	2.24	2.54	2.86
4.97	**270**	1.52	1.68	1.89	2.13	2.41	2.74	3.08
5.34	**280**	1.63	1.81	2.03	2.30	2.60	2.95	3.31
5.73	**290**	1.75	1.94	2.18	2.46	2.79	3.16	3.55
6.13	**300**	1.87	2.07	2.33	2.64	2.98	3.38	3.80
6.55	**310**	2.00	2.21	2.49	2.81	3.18	3.61	4.06
6.98	**320**	2.13	2.36	2.65	3.00	3.39	3.85	4.33
7.42	**330**	2.27	2.51	2.82	3.19	3.61	4.09	4.60
7.88	**340**	2.40	2.66	3.00	3.38	3.83	4.35	4.88
8.35	**350**	2.55	2.82	3.18	3.59	4.06	4.61	5.17

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.47: Medium Loading, 336 ACSR, Ruling Span = 300 Feet

Conductor: MERLIN — 336 kcmil — 18/1 Stranding ACSR
Area = 0.2789 sq in. — Weight = 0.365 lb/ft
Diameter = 0.684 in. — RTS = 8680 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.961	3.65	2965	3.31	3268
32	0.25	0	0	0.650	3.31	2215	2.72	2692
60	0	6	0	0.500	3.70	1523	2.78	2026
0	0	0	0	0.365	1.59	2575	1.33	3083
15	0	0	0	0.365	1.89	2170*	1.48	2776
30	0	0	0	0.365	2.27	1808	1.67	2461
60	0	0	0	0.365	3.24	1266	2.23	1843
90	0	0	0	0.365	4.32	951	3.09	1331
120	0	0	0	0.365	5.34	771	4.12	998

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2250	**2043**	**1843**	**1655**	**1483**	**1331**	**1200**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.37	**200**	0.81	0.89	0.99	1.10	1.23	1.37	1.52
2.62	**210**	0.90	0.98	1.09	1.22	1.36	1.51	1.68
2.87	**220**	0.98	1.08	1.20	1.33	1.49	1.66	1.84
3.14	**230**	1.08	1.18	1.31	1.46	1.63	1.82	2.01
3.42	**240**	1.17	1.29	1.43	1.59	1.77	1.98	2.19
3.71	**250**	1.27	1.40	1.55	1.72	1.92	2.14	2.38
4.01	**260**	1.37	1.51	1.67	1.86	2.08	2.32	2.57
4.33	**270**	1.48	1.63	1.81	2.01	2.24	2.50	2.77
4.65	**280**	1.59	1.75	1.94	2.16	2.41	2.69	2.98
4.99	**290**	1.71	1.88	2.08	2.32	2.59	2.89	3.20
5.34	**300**	1.83	2.01	2.23	2.48	2.77	3.09	3.42
5.70	**310**	1.95	2.15	2.38	2.65	2.96	3.30	3.65
6.08	**320**	2.08	2.29	2.54	2.82	3.15	3.52	3.89
6.46	**330**	2.21	2.43	2.70	3.00	3.35	3.74	4.14
6.86	**340**	2.35	2.58	2.86	3.19	3.56	3.97	4.39
7.27	**350**	2.49	2.74	3.04	3.38	3.77	4.21	4.66
7.69	**360**	2.64	2.89	3.21	3.57	3.99	4.45	4.92
8.12	**370**	2.78	3.06	3.39	3.77	4.21	4.70	5.20
8.57	**380**	2.94	3.22	3.58	3.98	4.44	4.96	5.49
9.02	**390**	3.09	3.40	3.77	4.19	4.68	5.22	5.78
9.49	**400**	3.25	3.57	3.96	4.41	4.92	5.49	6.08

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.48: Medium Loading, 336 ACSR, Ruling Span = 350 Feet

Conductor: MERLIN	336 kcmil	18/1 Stranding ACSR
Area = 0.2789 sq in.	Weight = 0.365 lb/ft	
Diameter = 0.684 in.	RTS = 8680 lb	
Design data from Sag10 Chart No. 1-844	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	0.961	4.73	3114	4.33	3403
32	0.25	0	0	0.650	4.29	2322	3.57	2790
60	0	6	0	0.500	4.70	1629	3.61	2125
0	0	0	0	0.365	2.19	2550	1.80	3101
15	0	0	0	0.365	2.58	2170*	2.00	2801
30	0	0	0	0.365	3.04	1837	2.24	2497
60	0	0	0	0.365	4.17	1342	2.93	1911
90	0	0	0	0.365	5.36	1044	3.91	1431
120	0	0	0	0.365	6.48	863	5.05	1108

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2296	**2099**	**1911**	**1735**	**1574**	**1431**	**1306**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.31	**250**	1.24	1.36	1.49	1.64	1.81	1.99	2.18
3.58	**260**	1.34	1.47	1.62	1.78	1.96	2.16	2.36
3.86	**270**	1.45	1.58	1.74	1.92	2.11	2.33	2.55
4.15	**280**	1.56	1.70	1.88	2.06	2.27	2.50	2.74
4.45	**290**	1.67	1.83	2.01	2.21	2.44	2.68	2.94
4.76	**300**	1.79	1.95	2.15	2.37	2.61	2.87	3.14
5.08	**310**	1.91	2.09	2.30	2.53	2.78	3.07	3.36
5.42	**320**	2.03	2.22	2.45	2.69	2.97	3.27	3.58
5.76	**330**	2.16	2.36	2.60	2.86	3.16	3.48	3.80
6.12	**340**	2.29	2.51	2.76	3.04	3.35	3.69	4.04
6.48	**350**	2.43	2.66	2.93	3.22	3.55	3.91	4.28
6.86	**360**	2.57	2.81	3.10	3.41	3.76	4.14	4.53
7.24	**370**	2.72	2.97	3.27	3.60	3.97	4.37	4.78
7.64	**380**	2.86	3.14	3.45	3.80	4.18	4.61	5.05
8.05	**390**	3.02	3.30	3.64	4.00	4.41	4.85	5.31
8.46	**400**	3.17	3.47	3.83	4.21	4.64	5.11	5.59
8.89	**410**	3.33	3.65	4.02	4.42	4.87	5.37	5.87
9.33	**420**	3.50	3.83	4.22	4.64	5.11	5.63	6.16
9.78	**430**	3.67	4.01	4.42	4.86	5.36	5.90	6.46
10.24	**440**	3.84	4.20	4.63	5.09	5.61	6.18	6.76
10.71	**450**	4.02	4.40	4.84	5.32	5.87	6.46	7.08

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.49: Medium Loading, 477 ACSR, Ruling Span = 250 Feet

Conductor: PELICAN	477 kcmil	18/1 Stranding ACSR
Area = 0.3955 sq in	Weight = 0.517 lb/ft	
Diameter = 0.814 in.	RTS = 11,800 lb	
Design data from Sag10 Chart No. 1-844	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.149	2.87	3124	2.57	3500*
32	0.25	0	0	0.842	2.85	2311	2.37	2777
60	0	6	0	0.658	3.35	1534	2.68	1920
0	0	0	0	0.517	1.45	2790	1.20	3367
15	0	0	0	0.517	1.78	2272	1.39	2906
30	0	0	0	0.517	2.19	1847	1.64	2456
60	0	0	0	0.517	3.13	1292	2.38	1698
90	0	0	0	0.517	4.05	999	3.30	1226
120	0	0	0	0.517	4.87	831	4.19	965

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2176	**1921**	**1697**	**1509**	**1353**	**1225**	**1121**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.75	**150**	0.67	0.76	0.86	0.96	1.08	1.19	1.30
1.99	**160**	0.76	0.86	0.97	1.10	1.22	1.35	1.47
2.25	**170**	0.86	0.97	1.10	1.24	1.38	1.53	1.66
2.52	**180**	0.96	1.09	1.23	1.39	1.55	1.71	1.87
2.81	**190**	1.07	1.21	1.37	1.55	1.73	1.91	2.08
3.12	**200**	1.19	1.34	1.52	1.72	1.91	2.11	2.30
3.44	**210**	1.31	1.48	1.68	1.89	2.11	2.33	2.54
3.77	**220**	1.44	1.63	1.84	2.08	2.32	2.56	2.79
4.12	**230**	1.57	1.78	2.01	2.27	2.53	2.79	3.05
4.49	**240**	1.71	1.94	2.19	2.47	2.76	3.04	3.32
4.87	**250**	1.86	2.10	2.38	2.68	2.99	3.30	3.60
5.27	**260**	2.01	2.27	2.57	2.90	3.23	3.57	3.89
5.68	**270**	2.17	2.45	2.78	3.13	3.49	3.85	4.20
6.11	**280**	2.33	2.63	2.99	3.36	3.75	4.14	4.52
6.55	**290**	2.50	2.83	3.20	3.61	4.02	4.44	4.84
7.01	**300**	2.68	3.02	3.43	3.86	4.31	4.75	5.18
7.49	**310**	2.86	3.23	3.66	4.12	4.60	5.07	5.54
7.98	**320**	3.05	3.44	3.90	4.39	4.90	5.41	5.90
8.49	**330**	3.24	3.66	4.15	4.67	5.21	5.75	6.27
9.01	**340**	3.44	3.88	4.40	4.96	5.53	6.10	6.66
9.55	**350**	3.65	4.12	4.66	5.25	5.86	6.47	7.06

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.50: Medium Loading, 477 ACSR, Ruling Span = 300 Feet

Conductor: PELICAN | 477 kcmil | 18/1 Stranding ACSR
Area = 0.3955 sq in. | Weight = 0.517 lb/ft
Diameter = 0.814 in. | RTS = 11,800 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.149	4.09	3160	3.70	3500*
32	0.25	0	0	0.842	4.06	2336	3.45	2745
60	0	6	0	0.658	4.62	1604	3.83	1934
0	0	0	0	0.517	2.30	2526	1.86	3123
15	0	0	0	0.517	2.77	2103	2.16	2694
30	0	0	0	0.517	3.28	1771	2.53	2297
60	0	0	0	0.517	4.36	1335	3.48	1673
90	0	0	0	0.517	5.37	1084	4.52	1288
120	0	0	0	0.517	6.29	927	5.51	1058

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2060	**1852**	**1673**	**1521**	**1394**	**1288**	**1198**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.80	**200**	1.25	1.40	1.55	1.70	1.85	2.01	2.16
3.08	**210**	1.38	1.54	1.71	1.87	2.04	2.21	2.38
3.38	**220**	1.52	1.69	1.87	2.05	2.24	2.43	2.61
3.70	**230**	1.66	1.85	2.05	2.25	2.45	2.66	2.86
4.03	**240**	1.80	2.01	2.23	2.44	2.67	2.89	3.11
4.37	**250**	1.96	2.18	2.42	2.66	2.90	3.14	3.37
4.72	**260**	2.12	2.36	2.61	2.87	3.13	3.40	3.65
5.09	**270**	2.28	2.54	2.82	3.09	3.38	3.66	3.94
5.48	**280**	2.46	2.74	3.03	3.33	3.63	3.94	4.23
5.88	**290**	2.64	2.93	3.25	3.57	3.90	4.22	4.54
6.29	**300**	2.82	3.14	3.48	3.82	4.17	4.52	4.86
6.72	**310**	3.01	3.35	3.72	4.08	4.45	4.83	5.19
7.16	**320**	3.21	3.57	3.96	4.35	4.74	5.14	5.53
7.61	**330**	3.41	3.80	4.21	4.62	5.05	5.47	5.88
8.08	**340**	3.62	4.03	4.47	4.91	5.36	5.81	6.24
8.56	**350**	3.84	4.27	4.74	5.20	5.68	6.15	6.62
9.06	**360**	4.06	4.52	5.01	5.50	6.00	6.51	7.00
9.57	**370**	4.29	4.78	5.29	5.81	6.34	6.88	7.39
10.09	**380**	4.52	5.04	5.58	6.13	6.69	7.25	7.80
10.63	**390**	4.77	5.31	5.88	6.46	7.05	7.64	8.21
11.18	**400**	5.01	5.58	6.19	6.79	7.41	8.04	8.64

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.51: Medium Loading, 477 ACSR, Ruling Span = 350 Feet

Conductor: PELICAN	477 kcmil	18/1 Stranding ACSR
Area = 0.3955 sq in.	Weight = 0.517 lb/ft	
Diameter = 0.814 in.	RTS = 11,800 lb	
Design data from Sag10 Chart No. 1-844	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.149	5.51	3195	5.03	3500*
32	0.25	0	0	0.842	5.46	2362	4.75	2717
60	0	6	0	0.658	6.07	1661	5.18	1946
0	0	0	0	0.517	3.43	2306	2.76	2870
15	0	0	0	0.517	4.01	1976	3.18	2491
30	0	0	0	0.517	4.61	1719	3.67	2157
60	0	0	0	0.517	5.78	1370	4.79	1654
90	0	0	0	0.517	6.87	1153	5.93	1337
120	0	0	0	0.517	7.87	1008	7.00	1134

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1964	**1797**	**1653**	**1531**	**1426**	**1336**	**1258**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
4.02	250	2.06	2.25	2.44	2.64	2.83	3.02	3.21
4.34	260	2.22	2.43	2.64	2.85	3.06	3.27	3.47
4.68	270	2.40	2.62	2.85	3.08	3.30	3.53	3.74
5.04	280	2.58	2.82	3.07	3.31	3.55	3.80	4.03
5.40	290	2.77	3.03	3.29	3.55	3.81	4.07	4.32
5.78	300	2.96	3.24	3.52	3.80	4.08	4.36	4.62
6.17	310	3.16	3.46	3.76	4.06	4.35	4.65	4.93
6.58	320	3.37	3.69	4.00	4.32	4.64	4.96	5.26
7.00	330	3.58	3.92	4.26	4.60	4.93	5.27	5.59
7.43	340	3.80	4.16	4.52	4.88	5.24	5.60	5.94
7.87	350	4.03	4.41	4.79	5.17	5.55	5.93	6.29
8.33	360	4.26	4.67	5.07	5.47	5.87	6.27	6.65
8.80	370	4.50	4.93	5.35	5.78	6.20	6.63	7.03
9.28	380	4.75	5.20	5.65	6.09	6.54	6.99	7.41
9.77	390	5.00	5.48	5.95	6.42	6.89	7.36	7.81
10.28	400	5.26	5.76	6.26	6.75	7.25	7.75	8.22
10.80	410	5.53	6.05	6.57	7.09	7.62	8.14	8.63
11.33	420	5.80	6.35	6.90	7.44	7.99	8.54	9.06
11.88	430	6.08	6.66	7.23	7.80	8.38	8.95	9.49
12.44	440	6.37	6.97	7.57	8.17	8.77	9.37	9.94
13.01	450	6.66	7.29	7.92	8.55	9.17	9.80	10.40

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.52: Medium Loading, 556 ACSR, Ruling Span = 200 Feet

Conductor: OSPREY — 556 kcmil — 18/1 Stranding ACSR
Area = 0.4612 sq in. — Weight = 0.603 lb/ft
Diameter = 0.879 in. — RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.253	1.60	3907	1.39	4500*
32	0.25	0	0	0.948	1.59	2976	1.26	3753
0	0	0	0	0.603	0.74	4099	0.64	4730
15	0	0	0	0.603	0.90	3367	0.72	4185
30	0	0	0	0.603	1.12	2694	0.83	3623
60	0	0	0	0.603	1.80	1676	1.20	2504
90	0	0	0	0.603	2.62	1153	1.86	1618
120	0	0	0	0.603	3.37	896	2.67	1132
167	0	0	0	0.603	4.26	708	3.79	797

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		3243	**2867**	**2503**	**2166**	**1868**	**1618**	**1416**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.07	**100**	0.23	0.26	0.30	0.35	0.40	0.47	0.53
1.29	**110**	0.28	0.32	0.36	0.42	0.49	0.56	0.64
1.53	**120**	0.33	0.38	0.43	0.50	0.58	0.67	0.77
1.80	**130**	0.39	0.44	0.51	0.59	0.68	0.79	0.90
2.09	**140**	0.46	0.51	0.59	0.68	0.79	0.91	1.04
2.40	**150**	0.52	0.59	0.68	0.78	0.91	1.05	1.20
2.73	**160**	0.60	0.67	0.77	0.89	1.03	1.19	1.36
3.08	**170**	0.67	0.76	0.87	1.00	1.16	1.34	1.54
3.45	**180**	0.75	0.85	0.97	1.13	1.30	1.51	1.73
3.84	**190**	0.84	0.95	1.08	1.25	1.45	1.68	1.92
4.26	**200**	0.93	1.05	1.20	1.39	1.61	1.86	2.13
4.70	**210**	1.03	1.16	1.32	1.53	1.78	2.05	2.35
5.15	**220**	1.13	1.27	1.45	1.68	1.95	2.25	2.58
5.63	**230**	1.23	1.39	1.59	1.84	2.13	2.46	2.82
6.13	**240**	1.34	1.51	1.73	2.00	2.32	2.68	3.07
6.66	**250**	1.45	1.64	1.88	2.18	2.52	2.91	3.33
7.20	**260**	1.57	1.77	2.03	2.35	2.72	3.14	3.60
7.76	**270**	1.69	1.91	2.19	2.53	2.93	3.39	3.88
8.35	**280**	1.82	2.06	2.35	2.72	3.16	3.65	4.17
8.96	**290**	1.96	2.21	2.52	2.92	3.39	3.91	4.48
9.59	**300**	2.09	2.36	2.70	3.13	3.62	4.19	4.79

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.53: Medium Loading, 556 ACSR, Ruling Span = 250 Feet

Conductor: OSPREY | 556 kcmil | 18/1 Stranding ACSR
Area = 0.4612 sq in. | Weight = 0.603 lb/ft
Diameter = 0.879 in. | RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.253	2.49	3936	2.18	4500*
32	0.25	0	0	0.948	2.47	2999	1.99	3718
0	0	0	0	0.603	1.23	3835	1.03	4555
15	0	0	0	0.603	1.49	3162	1.17	4020
30	0	0	0	0.603	1.83	2572	1.35	3477
60	0	0	0	0.603	2.72	1735	1.92	2455
90	0	0	0	0.603	3.66	1287	2.76	1706
120	0	0	0	0.603	4.53	1042	3.69	1278
167	0	0	0	0.603	5.70	829	4.99	945

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		3120	**2776**	**2455**	**2166**	**1915**	**1706**	**1533**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.05	**150**	0.54	0.61	0.69	0.78	0.89	0.99	1.11
2.33	**160**	0.62	0.70	0.79	0.89	1.01	1.13	1.26
2.64	**170**	0.70	0.79	0.89	1.01	1.14	1.28	1.42
2.95	**180**	0.78	0.88	1.00	1.13	1.28	1.43	1.59
3.29	**190**	0.87	0.98	1.11	1.26	1.42	1.59	1.77
3.65	**200**	0.97	1.09	1.23	1.40	1.57	1.77	1.96
4.02	**210**	1.07	1.20	1.35	1.54	1.74	1.95	2.17
4.41	**220**	1.17	1.32	1.49	1.69	1.91	2.14	2.38
4.82	**230**	1.28	1.44	1.63	1.85	2.08	2.34	2.60
5.25	**240**	1.39	1.57	1.77	2.01	2.27	2.54	2.83
5.70	**250**	1.51	1.70	1.92	2.18	2.46	2.76	3.07
6.17	**260**	1.63	1.84	2.08	2.36	2.66	2.99	3.32
6.65	**270**	1.76	1.98	2.24	2.54	2.87	3.22	3.58
7.15	**280**	1.89	2.13	2.41	2.73	3.09	3.46	3.85
7.67	**290**	2.03	2.29	2.58	2.93	3.31	3.71	4.13
8.21	**300**	2.17	2.45	2.76	3.14	3.54	3.97	4.42
8.76	**310**	2.32	2.61	2.95	3.35	3.78	4.24	4.72
9.34	**320**	2.47	2.79	3.15	3.57	4.03	4.52	5.03
9.93	**330**	2.63	2.96	3.35	3.80	4.29	4.81	5.35
10.54	**340**	2.79	3.14	3.55	4.03	4.55	5.10	5.68
11.17	**350**	2.96	3.33	3.76	4.27	4.82	5.41	6.02

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.54: Medium Loading, 556 ACSR, Ruling Span = 300 Feet

Conductor: OSPREY | 556 kcmil | 18/1 Stranding ACSR
Area = 0.4612 sq in. | Weight = 0.603 lb/ft
Diameter = 0.879 in. | RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.253	3.55	3974	3.13	4500*
32	0.25	0	0	0.948	3.52	3028	2.90	3683
0	0	0	0	0.603	1.90	3569	1.56	4350
15	0	0	0	0.603	2.28	2973	1.77	3831
30	0	0	0	0.603	2.74	2475	2.04	3320
60	0	0	0	0.603	3.80	1787	2.82	2411
90	0	0	0	0.603	4.85	1399	3.82	1778
120	0	0	0	0.603	5.82	1168	4.85	1399
167	0	0	0	0.603	7.15	951	6.32	1076

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2994	**2688**	**2410**	**2165**	**1955**	**1777**	**1628**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.18	**200**	1.01	1.12	1.25	1.39	1.54	1.70	1.85
3.50	**210**	1.11	1.23	1.38	1.53	1.70	1.87	2.04
3.85	**220**	1.22	1.36	1.52	1.68	1.87	2.05	2.24
4.20	**230**	1.33	1.48	1.66	1.84	2.04	2.25	2.45
4.58	**240**	1.45	1.61	1.80	2.00	2.22	2.44	2.67
4.97	**250**	1.57	1.75	1.95	2.17	2.41	2.65	2.89
5.37	**260**	1.71	1.89	2.12	2.35	2.61	2.87	3.13
5.79	**270**	1.84	2.04	2.28	2.54	2.81	3.09	3.38
6.23	**280**	1.98	2.20	2.46	2.73	3.02	3.33	3.63
6.68	**290**	2.12	2.35	2.64	2.92	3.24	3.57	3.90
7.15	**300**	2.27	2.52	2.82	3.13	3.47	3.82	4.17
7.63	**310**	2.42	2.69	3.01	3.34	3.71	4.08	4.45
8.14	**320**	2.58	2.87	3.21	3.56	3.95	4.35	4.74
8.65	**330**	2.75	3.05	3.41	3.79	4.20	4.62	5.05
9.18	**340**	2.92	3.24	3.62	4.02	4.46	4.91	5.36
9.73	**350**	3.09	3.43	3.84	4.26	4.72	5.20	5.68
10.30	**360**	3.27	3.63	4.06	4.51	5.00	5.50	6.00
10.88	**370**	3.45	3.83	4.29	4.76	5.28	5.81	6.34
11.47	**380**	3.64	4.04	4.52	5.02	5.57	6.13	6.69
12.08	**390**	3.84	4.26	4.77	5.29	5.86	6.46	7.05
12.71	**400**	4.04	4.48	5.01	5.56	6.17	6.79	7.41

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.55: Medium Loading, 740 AAAC, Ruling Span = 200 Feet

Conductor: FLINT | 740 kcmil | 37 Stranding AAAC
Area = 0.5818 sq in. | Weight = 0.691 lb/ft
Diameter = 0.991 in. | RTS = 24,400 lb
Design data from Sag10 Chart No. 1-1155 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.380	1.72	4018	1.53	4500 *
32	0.25	0	0	1.070	1.82	2946	1.51	3545
0	0	0	0	0.691	0.82	4238	0.72	4800
15	0	0	0	0.691	1.04	3329	0.86	4037
30	0	0	0	0.691	1.36	2548	1.04	3314
60	0	0	0	0.691	2.22	1559	1.63	2121
90	0	0	0	0.691	3.08	1122	2.43	1420
120	0	0	0	0.691	3.83	904	3.23	1071
167	0	0	0	0.691	4.82	719	4.30	804

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2869	**2468**	**2120**	**1832**	**1601**	**1419**	**1276**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.21	**100**	0.30	0.35	0.41	0.47	0.54	0.61	0.68
1.46	**110**	0.36	0.42	0.49	0.57	0.65	0.74	0.82
1.74	**120**	0.43	0.50	0.59	0.68	0.78	0.87	0.98
2.04	**130**	0.51	0.59	0.69	0.80	0.91	1.03	1.14
2.36	**140**	0.59	0.69	0.80	0.93	1.06	1.19	1.33
2.71	**150**	0.68	0.79	0.92	1.06	1.22	1.37	1.52
3.08	**160**	0.77	0.90	1.04	1.21	1.38	1.56	1.73
3.48	**170**	0.87	1.01	1.18	1.37	1.56	1.76	1.96
3.90	**180**	0.97	1.13	1.32	1.53	1.75	1.97	2.20
4.35	**190**	1.08	1.26	1.47	1.71	1.95	2.19	2.45
4.82	**200**	1.20	1.40	1.63	1.89	2.16	2.43	2.71
5.31	**210**	1.32	1.54	1.80	2.08	2.38	2.68	2.99
5.83	**220**	1.45	1.69	1.97	2.29	2.61	2.94	3.28
6.37	**230**	1.59	1.85	2.16	2.50	2.86	3.21	3.58
6.94	**240**	1.73	2.02	2.35	2.72	3.11	3.50	3.90
7.53	**250**	1.88	2.19	2.55	2.95	3.38	3.80	4.23
8.15	**260**	2.03	2.37	2.75	3.19	3.65	4.11	4.58
8.78	**270**	2.19	2.55	2.97	3.44	3.94	4.43	4.94
9.45	**280**	2.35	2.74	3.19	3.70	4.23	4.76	5.31
10.13	**290**	2.52	2.94	3.43	3.97	4.54	5.11	5.70
10.85	**300**	2.70	3.15	3.67	4.25	4.86	5.47	6.10

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.56: Medium Loading, 740 AAAC, Ruling Span = 250 Feet

Conductor: FLINT — 740 kcmil — 37 Stranding AAAC
Area = 0.5818 sq in. — Weight = 0.691 lb/ft
Diameter = 0.991 in. — RTS = 24,400 lb
Design data from Sag10 Chart No. 1-1155 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.380	2.69	4008	2.40	4500*
32	0.25	0	0	1.070	2.82	2969	2.36	3537
0	0	0	0	0.691	1.41	3830	1.19	4533
15	0	0	0	0.691	1.77	3043	1.42	3815
30	0	0	0	0.691	2.23	2416	1.71	3159
60	0	0	0	0.691	3.28	1648	2.52	2144
90	0	0	0	0.691	4.26	1269	3.48	1554
120	0	0	0	0.691	5.12	1056	4.39	1231
167	0	0	0	0.691	6.29	861	5.65	958

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2771	**2431**	**2143**	**1905**	**1711**	**1554**	**1425**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.26	**150**	0.70	0.80	0.91	1.02	1.14	1.25	1.36
2.58	**160**	0.80	0.91	1.03	1.16	1.29	1.43	1.55
2.91	**170**	0.90	1.03	1.17	1.31	1.46	1.61	1.75
3.26	**180**	1.01	1.15	1.31	1.47	1.64	1.80	1.96
3.63	**190**	1.13	1.28	1.46	1.63	1.83	2.01	2.19
4.03	**200**	1.25	1.42	1.61	1.81	2.02	2.23	2.43
4.44	**210**	1.38	1.57	1.78	2.00	2.23	2.46	2.67
4.87	**220**	1.51	1.72	1.95	2.19	2.45	2.69	2.93
5.32	**230**	1.65	1.88	2.13	2.40	2.67	2.95	3.21
5.80	**240**	1.80	2.05	2.32	2.61	2.91	3.21	3.49
6.29	**250**	1.95	2.22	2.52	2.83	3.16	3.48	3.79
6.80	**260**	2.11	2.40	2.73	3.06	3.42	3.76	4.10
7.34	**270**	2.27	2.59	2.94	3.30	3.69	4.06	4.42
7.89	**280**	2.45	2.78	3.16	3.55	3.96	4.37	4.75
8.46	**290**	2.62	2.99	3.39	3.81	4.25	4.68	5.10
9.06	**300**	2.81	3.20	3.63	4.08	4.55	5.01	5.46
9.67	**310**	3.00	3.41	3.87	4.35	4.86	5.35	5.83
10.31	**320**	3.19	3.64	4.13	4.64	5.18	5.70	6.21
10.96	**330**	3.40	3.87	4.39	4.93	5.51	6.06	6.60
11.63	**340**	3.61	4.11	4.66	5.23	5.84	6.44	7.01
12.33	**350**	3.82	4.35	4.94	5.55	6.19	6.82	7.43

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.57: Medium Loading, 740 AAAC, Ruling Span = 300 Feet

Conductor: FLINT | 740 kcmil | 37 Stranding AAAC
Area = 0.5818 sq in. | Weight = 0.691 lb/ft
Diameter = 0.991 in. | RTS = 24,400 lb
Design data from Sag10 Chart No. 1-1155 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.380	3.86	4022	3.45	4500*
32	0.25	0	0	1.070	4.01	3007	3.41	3531
0	0	0	0	0.691	2.24	3466	1.83	4238
15	0	0	0	0.691	2.75	2823	2.17	3583
30	0	0	0	0.691	3.33	2335	2.58	3010
60	0	0	0	0.691	4.51	1726	3.60	2163
90	0	0	0	0.691	5.59	1392	4.68	1662
120	0	0	0	0.691	6.56	1188	5.70	1366
167	0	0	0	0.691	7.88	989	7.12	1095

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2681	**2400**	**2162**	**1964**	**1799**	**1661**	**1546**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.50	**200**	1.29	1.44	1.60	1.76	1.92	2.08	2.24
3.86	**210**	1.42	1.59	1.76	1.94	2.12	2.29	2.46
4.24	**220**	1.56	1.74	1.94	2.13	2.32	2.52	2.71
4.63	**230**	1.70	1.90	2.12	2.33	2.54	2.75	2.96
5.04	**240**	1.86	2.07	2.30	2.53	2.76	3.00	3.22
5.47	**250**	2.01	2.25	2.50	2.75	3.00	3.25	3.49
5.92	**260**	2.18	2.43	2.70	2.97	3.24	3.52	3.78
6.38	**270**	2.35	2.62	2.92	3.21	3.50	3.79	4.07
6.86	**280**	2.53	2.82	3.14	3.45	3.76	4.08	4.38
7.36	**290**	2.71	3.03	3.36	3.70	4.04	4.37	4.70
7.88	**300**	2.90	3.24	3.60	3.96	4.32	4.68	5.03
8.41	**310**	3.10	3.46	3.84	4.23	4.61	5.00	5.37
8.97	**320**	3.30	3.69	4.10	4.51	4.92	5.32	5.72
9.53	**330**	3.51	3.92	4.36	4.79	5.23	5.66	6.09
10.12	**340**	3.72	4.16	4.62	5.09	5.55	6.01	6.46
10.73	**350**	3.95	4.41	4.90	5.39	5.88	6.37	6.85
11.35	**360**	4.18	4.67	5.18	5.70	6.22	6.74	7.24
11.99	**370**	4.41	4.93	5.48	6.02	6.57	7.12	7.65
12.64	**380**	4.65	5.20	5.78	6.35	6.93	7.51	8.07
13.32	**390**	4.90	5.48	6.08	6.69	7.30	7.91	8.50
14.01	**400**	5.16	5.76	6.40	7.04	7.68	8.32	8.94

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.58: Medium Loading, 795 ACSR, Ruling Span = 200 Feet								
Conductor: COOT				795 kcmil		36/1 Stranding ACSR		
Area = 0.6417 sq in.				Weight = 0.804 lb/ft				
Diameter = 1.04 in.				RTS = 16,800 lb				
Design data from Sag10 Chart No. 1-898				Ice = 56 lb/ft^3				
Design Points								
Creep IS a Factor					Final		Initial	
Temp (°F)	Ice (in.)	Wind (psf)	K (lb/ft)	Weight (lb/ft)	Sag (ft)	Tension (lb)	Sag (ft)	Tension (lb)
15	0.25	4	0.2	1.503	2.17	3460	1.67	4500*
32	0.25	0	0	1.198	2.35	2554	1.67	3592
0	0	0	0	0.804	1.23	3276	0.86	4691
15	0	0	0	0.804	1.56	2572	1.01	3991
30	0	0	0	0.804	1.96	2050	1.22	3305
60	0	0	0	0.804	2.79	1442	1.85	2169
90	0	0	0	0.804	3.53	1139	2.65	1517
120	0	0	0	0.804	4.19	962	3.40	1183
167	0	0	0	0.804	5.07	795	4.41	913

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2879	2495	2168	1900	1686	1516	1381
		Temperature (°F)						
		40	50	60	70	80	90	100
1.27	**100**	0.35	0.40	0.46	0.53	0.60	0.66	0.73
1.53	**110**	0.42	0.49	0.56	0.64	0.72	0.80	0.88
1.83	**120**	0.50	0.58	0.67	0.76	0.86	0.95	1.05
2.14	**130**	0.59	0.68	0.78	0.90	1.01	1.12	1.23
2.48	**140**	0.69	0.79	0.91	1.04	1.17	1.30	1.43
2.85	**150**	0.79	0.91	1.04	1.19	1.34	1.49	1.64
3.24	**160**	0.90	1.03	1.18	1.36	1.52	1.70	1.86
3.66	**170**	1.01	1.16	1.34	1.53	1.72	1.91	2.10
4.11	**180**	1.13	1.30	1.50	1.72	1.93	2.15	2.36
4.58	**190**	1.26	1.45	1.67	1.91	2.15	2.39	2.63
5.07	**200**	1.40	1.61	1.85	2.12	2.38	2.65	2.91
5.59	**210**	1.54	1.78	2.04	2.34	2.62	2.92	3.21
6.13	**220**	1.69	1.95	2.24	2.57	2.88	3.21	3.52
6.71	**230**	1.85	2.13	2.45	2.80	3.15	3.50	3.85
7.30	**240**	2.02	2.32	2.66	3.05	3.43	3.82	4.19
7.92	**250**	2.18	2.52	2.90	3.31	3.72	4.14	4.55
8.57	**260**	2.37	2.72	3.13	3.58	4.02	4.48	4.92
9.24	**270**	2.55	2.93	3.37	3.86	4.34	4.83	5.30
9.94	**280**	2.74	3.16	3.63	4.16	4.66	5.19	5.70
10.66	**290**	2.94	3.39	3.89	4.46	5.00	5.57	6.12
11.41	**300**	3.15	3.62	4.16	4.77	5.36	5.96	6.55

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.59: Medium Loading, 795 ACSR, Ruling Span = 250 Feet		
Conductor: COOT	795 kcmil	36/1 Stranding ACSR
Area = 0.6417 sq in.	Weight = 0.804 lb/ft	
Diameter = 1.04 in.	RTS = 16,800 lb	
Design data from Sag10 Chart No. 1-898	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.503	3.36	3501	2.61	4500*
32	0.25	0	0	1.198	3.56	2633	2.61	3591
60	0	6	0	0.804	2.15	2917	1.42	4410
0	0	0	0	0.804	2.62	2400	1.67	3756
15	0	0	0	0.804	3.10	2025	2.00	3149
30	0	0	0	0.804	4.04	1556	2.84	2215
60	0	0	0	0.804	4.88	1288	3.76	1672
90	0	0	0	0.804	5.64	1117	4.62	1362
120	0	0	0	0.804	6.67	944	5.80	1086

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2790	**2478**	**2215**	**1997**	**1818**	**1671**	**1549**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.40	**150**	0.81	0.91	1.02	1.13	1.25	1.35	1.46
2.73	**160**	0.92	1.04	1.16	1.29	1.42	1.54	1.66
3.08	**170**	1.04	1.17	1.31	1.46	1.60	1.74	1.88
3.46	**180**	1.17	1.32	1.47	1.63	1.79	1.95	2.10
3.85	**190**	1.30	1.47	1.64	1.82	2.00	2.17	2.35
4.27	**200**	1.44	1.63	1.82	2.02	2.21	2.41	2.60
4.71	**210**	1.59	1.79	2.00	2.22	2.44	2.65	2.86
5.17	**220**	1.74	1.97	2.20	2.44	2.68	2.91	3.14
5.65	**230**	1.90	2.15	2.40	2.67	2.93	3.18	3.44
6.15	**240**	2.07	2.34	2.62	2.90	3.19	3.47	3.74
6.67	**250**	2.25	2.54	2.84	3.15	3.46	3.76	4.06
7.21	**260**	2.43	2.75	3.07	3.41	3.74	4.07	4.39
7.78	**270**	2.62	2.96	3.31	3.67	4.04	4.39	4.74
8.37	**280**	2.82	3.19	3.56	3.95	4.34	4.72	5.09
8.98	**290**	3.03	3.42	3.82	4.24	4.66	5.06	5.46
9.60	**300**	3.24	3.66	4.09	4.54	4.98	5.41	5.85
10.26	**310**	3.46	3.91	4.37	4.84	5.32	5.78	6.24
10.93	**320**	3.69	4.16	4.65	5.16	5.67	6.16	6.65
11.62	**330**	3.92	4.43	4.95	5.49	6.03	6.55	7.07
12.34	**340**	4.16	4.70	5.25	5.83	6.40	6.95	7.51
13.07	**350**	4.41	4.98	5.57	6.17	6.78	7.37	7.96

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.60: Medium Loading, 795 ACSR, Ruling Span = 300 Feet

Conductor: COOT	795 kcmil	36/1 Stranding ACSR
Area = 0.6417 sq in.	Weight = 0.804 lb/ft	
Diameter = 1.04 in.	RTS = 16,800 lb	
Design data from Sag10 Chart No. 1-898	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
15	0.25	4	0.2	1.503	4.75	3567	3.76	4500*
32	0.25	0	0	1.198	4.96	2719	3.76	3590
60	0	6	0	0.804	3.36	2693	2.20	4106
0	0	0	0	0.804	3.91	2315	2.57	3522
15	0	0	0	0.804	4.45	2033	3.01	3008
30	0	0	0	0.804	5.48	1653	4.02	2252
60	0	0	0	0.804	6.40	1415	5.05	1794
90	0	0	0	0.804	7.24	1252	6.00	1510
120	0	0	0	0.804	8.42	1078	7.33	1238

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2715	**2464**	**2251**	**2071**	**1920**	**1793**	**1684**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.74	**200**	1.48	1.63	1.79	1.94	2.09	2.24	2.39
4.13	**210**	1.63	1.80	1.97	2.14	2.31	2.47	2.63
4.53	**220**	1.79	1.97	2.16	2.35	2.53	2.72	2.89
4.95	**230**	1.96	2.16	2.36	2.57	2.77	2.97	3.16
5.39	**240**	2.13	2.35	2.57	2.80	3.01	3.23	3.44
5.85	**250**	2.31	2.55	2.79	3.03	3.27	3.50	3.73
6.32	**260**	2.50	2.76	3.02	3.28	3.54	3.79	4.03
6.82	**270**	2.70	2.97	3.26	3.54	3.82	4.09	4.35
7.33	**280**	2.90	3.20	3.50	3.81	4.10	4.40	4.68
7.87	**290**	3.11	3.43	3.76	4.08	4.40	4.72	5.02
8.42	**300**	3.33	3.67	4.02	4.37	4.71	5.05	5.37
8.99	**310**	3.56	3.92	4.29	4.67	5.03	5.39	5.73
9.58	**320**	3.79	4.18	4.57	4.97	5.36	5.75	6.11
10.19	**330**	4.03	4.44	4.86	5.29	5.70	6.11	6.50
10.82	**340**	4.28	4.71	5.16	5.61	6.05	6.49	6.90
11.46	**350**	4.53	5.00	5.47	5.95	6.41	6.87	7.31
12.12	**360**	4.80	5.28	5.79	6.29	6.78	7.27	7.73
12.81	**370**	5.07	5.58	6.11	6.65	7.16	7.68	8.17
13.51	**380**	5.34	5.89	6.45	7.01	7.56	8.10	8.62
14.23	**390**	5.63	6.20	6.79	7.39	7.96	8.53	9.08
14.97	**400**	5.92	6.52	7.15	7.77	8.37	8.98	9.55

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.61: Heavy Loading, 4 ACSR, Ruling Span = 200 Feet

Conductor: SWANATE	4 kcmil	7/1 Stranding ACSR
Area = 0.0411 sq in.	Weight = 0.067 lb/ft	
Diameter = 0.257 in.	RTS = 2360 lb	
Design data from Sag10 Chart No. 1-670	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	0.975	4.21	1161	4.21	1161
32	0.5	0	0	0.529	3.39	783	2.99	887
60	0	6	0	0.145	1.94	374	1.22	595
–20	0	0	0	0.067	0.51	660	0.40	842
0	0	0	0	0.067	0.60	561	0.43	779*
30	0	0	0	0.067	0.80	418	0.50	676
60	0	0	0	0.067	1.16	290	0.59	563
90	0	0	0	0.067	1.55	216	0.76	441
120	0	0	0	0.067	1.82	184	1.06	317

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		639	**602**	**563**	**523**	**483**	**441**	**400**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.85	**100**	0.13	0.14	0.15	0.16	0.17	0.19	0.21
1.03	**110**	0.16	0.17	0.18	0.19	0.21	0.23	0.25
1.22	**120**	0.19	0.20	0.21	0.23	0.25	0.27	0.30
1.43	**130**	0.22	0.24	0.25	0.27	0.29	0.32	0.35
1.66	**140**	0.25	0.27	0.29	0.31	0.34	0.37	0.41
1.91	**150**	0.29	0.32	0.33	0.36	0.39	0.43	0.47
2.17	**160**	0.33	0.36	0.38	0.41	0.44	0.49	0.54
2.45	**170**	0.38	0.40	0.43	0.46	0.50	0.55	0.61
2.75	**180**	0.42	0.45	0.48	0.52	0.56	0.62	0.68
3.06	**190**	0.47	0.51	0.53	0.58	0.62	0.69	0.76
3.39	**200**	0.52	0.56	0.59	0.64	0.69	0.76	0.84
3.74	**210**	0.57	0.62	0.65	0.71	0.76	0.84	0.93
4.10	**220**	0.63	0.68	0.71	0.77	0.83	0.92	1.02
4.48	**230**	0.69	0.74	0.78	0.85	0.91	1.01	1.11
4.88	**240**	0.75	0.81	0.85	0.92	0.99	1.09	1.21
5.30	**250**	0.81	0.88	0.92	1.00	1.08	1.19	1.31
5.73	**260**	0.88	0.95	1.00	1.08	1.17	1.28	1.42
6.18	**270**	0.95	1.02	1.08	1.17	1.26	1.39	1.53
6.64	**280**	1.02	1.10	1.16	1.25	1.35	1.49	1.65
7.13	**290**	1.09	1.18	1.24	1.35	1.45	1.60	1.77
7.63	**300**	1.17	1.26	1.33	1.44	1.55	1.71	1.89

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.62: Heavy Loading, 4 ACSR, Ruling Span = 250 Feet

Conductor: SWANATE — 4 kcmil — 7/1 Stranding ACSR
Area = 0.0411 sq in. — Weight = 0.067 lb/ft
Diameter = 0.257 in. — RTS = 2360 lb
Design data from Sag10 Chart No. 1-670 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	0.975	6.47	1180	6.47	1180*
32	0.5	0	0	0.529	5.48	756	4.90	846
60	0	6	0	0.145	3.93	289	2.58	438
–20	0	0	0	0.067	1.33	394	0.81	647
0	0	0	0	0.067	1.67	314	0.91	576
30	0	0	0	0.067	2.35	223	1.13	463
60	0	0	0	0.067	2.93	179	1.50	349
90	0	0	0	0.067	3.32	158	2.10	250
120	0	0	0	0.067	3.73	141	2.88	182

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		425	**387**	**349**	**313**	**280**	**250**	**223**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.97	**150**	0.44	0.49	0.54	0.60	0.67	0.76	0.85
2.24	**160**	0.50	0.55	0.61	0.68	0.77	0.86	0.96
2.53	**170**	0.57	0.62	0.69	0.77	0.86	0.97	1.09
2.84	**180**	0.64	0.70	0.78	0.87	0.97	1.09	1.22
3.17	**190**	0.71	0.78	0.87	0.96	1.08	1.21	1.36
3.51	**200**	0.79	0.86	0.96	1.07	1.20	1.34	1.50
3.87	**210**	0.87	0.95	1.06	1.18	1.32	1.48	1.66
4.24	**220**	0.95	1.05	1.16	1.29	1.45	1.63	1.82
4.64	**230**	1.04	1.14	1.27	1.41	1.58	1.78	1.99
5.05	**240**	1.13	1.24	1.38	1.54	1.72	1.94	2.17
5.48	**250**	1.23	1.35	1.50	1.67	1.87	2.10	2.35
5.93	**260**	1.33	1.46	1.62	1.81	2.02	2.27	2.54
6.39	**270**	1.43	1.57	1.75	1.95	2.18	2.45	2.74
6.87	**280**	1.54	1.69	1.88	2.09	2.35	2.63	2.95
7.37	**290**	1.66	1.82	2.02	2.25	2.52	2.83	3.16
7.89	**300**	1.77	1.94	2.16	2.40	2.69	3.02	3.38
8.43	**310**	1.89	2.08	2.31	2.57	2.88	3.23	3.61
8.98	**320**	2.02	2.21	2.46	2.74	3.06	3.44	3.85
9.55	**330**	2.14	2.35	2.61	2.91	3.26	3.66	4.09
10.14	**340**	2.28	2.50	2.77	3.09	3.46	3.88	4.35
10.74	**350**	2.41	2.65	2.94	3.27	3.67	4.12	4.61

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.63: Heavy Loading, 4 ACSR, Ruling Span = 300 Feet

Conductor: SWANATE	4 kcmil	7/1 Stranding ACSR
Area = 0.0411 sq in.	Weight = 0.067 lb/ft	
Diameter = 0.257 in.	RTS = 2360 lb	
Design data from Sag10 Chart No. 1-670	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	0.975	9.33	1180	9.33	1180*
32	0.5	0	0	0.529	8.25	724	7.52	794
60	0	6	0	0.145	6.77	241	5.23	312
–20	0	0	0	0.067	3.99	189	2.12	355
0	0	0	0	0.067	4.58	165	2.56	294
30	0	0	0	0.067	5,26	144	3.38	223
60	0	0	0	0.067	5.71	132	4.28	176
90	0	0	0	0.067	6.14	123	5.14	147
120	0	0	0	0.067	6.57	115	5.94	127

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		205	**189**	**176**	**165**	**155**	**147**	**139**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.67	**200**	1.64	1.77	1.90	2.03	2.16	2.28	2.40
4.04	**210**	1.80	1.95	2.10	2.24	2.38	2.52	2.65
4.44	**220**	1.98	2.14	2.30	2.46	2.61	2.76	2.91
4.85	**230**	2.16	2.34	2.52	2.69	2.86	3.02	3.18
5.28	**240**	2.36	2.55	2.74	2.92	3.11	3.29	3.46
5.73	**250**	2.56	2.76	2.97	3.17	3.38	3.57	3.76
6.20	**260**	2.76	2.99	3.21	3.43	3.65	3.86	4.06
6.68	**270**	2.98	3.22	3.47	3.70	3.94	4.16	4.38
7.19	**280**	3.21	3.47	3.73	3.98	4.23	4.48	4.71
7.71	**290**	3.44	3.72	4.00	4.27	4.54	4.80	5.06
8.25	**300**	3.68	3.98	4.28	4.57	4.86	5.14	5.41
8.81	**310**	3.93	4.25	4.57	4.88	5.19	5.49	5.78
9.39	**320**	4.19	4.53	4.87	5.20	5.53	5.85	6.16
9.98	**330**	4.45	4.82	5.18	5.53	5.88	6.22	6.55
10.60	**340**	4.73	5.11	5.50	5.87	6.24	6.60	6.95
11.23	**350**	5.01	5.42	5.83	6.22	6.62	7.00	7.36
11.88	**360**	5.30	5.73	6.16	6.58	7.00	7.40	7.79
12.55	**370**	5.60	6.05	6.51	6.95	7.39	7.82	8.23
13.24	**380**	5.90	6.39	6.87	7.33	7.80	8.25	8.68
13.94	**390**	6.22	6.73	7.23	7.72	8.21	8.69	9.14
14.67	**400**	6.54	7.08	7.61	8.12	8.64	9.14	9.62

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.64: Heavy Loading, 2 ACSR, Ruling Span = 200 Feet

Conductor: SPARROW — 2 kcmil — 6/1 Stranding ACSR
Area = 0.0608 sq in. — Weight = 0.091 lb/ft
Diameter = 0.316 in. — RTS = 2850 lb
Design data from Sag10 Chart No. 1-1023 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.035	3.79	1367	3.79	1367
32	0.5	0	0	0.589	3.18	929	2.83	1042
60	0	6	0	0.182	2.05	445	1.34	680
–20	0	0	0	0.091	0.53	855	0.44	1030
0	0	0	0	0.091	0.64	713*	0.49	938
30	0	0	0	0.091	0.89	508	0.58	790
60	0	0	0	0.091	1.36	335	0.72	631
90	0	0	0	0.091	1.90	239	0.98	466
120	0	0	0	0.091	2.17	209	1.44	315

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		739	**686**	**631**	**576**	**521**	**466**	**413**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.80	**100**	0.16	0.17	0.18	0.20	0.22	0.25	0.28
0.96	**110**	0.19	0.20	0.22	0.24	0.26	0.30	0.33
1.14	**120**	0.22	0.24	0.26	0.28	0.31	0.35	0.40
1.34	**130**	0.26	0.28	0.30	0.33	0.37	0.41	0.46
1.56	**140**	0.30	0.32	0.35	0.39	0.43	0.48	0.54
1.79	**150**	0.35	0.37	0.41	0.44	0.49	0.55	0.62
2.04	**160**	0.40	0.42	0.46	0.51	0.56	0.63	0.70
2.30	**170**	0.45	0.48	0.52	0.57	0.63	0.71	0.79
2.58	**180**	0.50	0.53	0.58	0.64	0.70	0.79	0.89
2.87	**190**	0.56	0.60	0.65	0.71	0.79	0.88	0.99
3.18	**200**	0.62	0.66	0.72	0.79	0.87	0.98	1.10
3.51	**210**	0.68	0.73	0.79	0.87	0.96	1.08	1.21
3.85	**220**	0.75	0.80	0.87	0.96	1.05	1.19	1.33
4.21	**230**	0.82	0.87	0.95	1.04	1.15	1.30	1.45
4.58	**240**	0.89	0.95	1.04	1.14	1.25	1.41	1.58
4.97	**250**	0.97	1.03	1.13	1.23	1.36	1.53	1.72
5.37	**260**	1.05	1.12	1.22	1.34	1.47	1.66	1.86
5.80	**270**	1.13	1.20	1.31	1.44	1.59	1.79	2.00
6.23	**280**	1.22	1.29	1.41	1.55	1.71	1.92	2.16
6.69	**290**	1.30	1.39	1.51	1.66	1.83	2.06	2.31
7.16	**300**	1.40	1.49	1.62	1.78	1.96	2.21	2.48

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.65: Heavy Loading, 2 ACSR, Ruling Span = 250 Feet

Conductor: SPARROW — 2 kcmil — 6/1 Stranding ACSR
Area = 0.0608 sq in. — Weight = 0.091 lb/ft
Diameter = 0.316 in. — RTS = 2850 lb
Design data from Sag10 Chart No. 1-1023 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.035	5.68	1425	5.68	1425*
32	0.5	0	0	0.589	4.91	940	4.40	1048
60	0	6	0	0.182	3.59	397	2.40	593
–20	0	0	0	0.091	1.11	640	0.79	901
0	0	0	0	0.091	1.39	513	0.88	805
30	0	0	0	0.091	2.01	354	1.09	654
60	0	0	0	0.091	2.83	251	1.43	499
90	0	0	0	0.091	3.24	220	1.99	358
120	0	0	0	0.091	3.60	198	2.78	256

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		602	**550**	**499**	**449**	**401**	**358**	**319**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.77	**150**	0.42	0.46	0.51	0.57	0.64	0.72	0.80
2.01	**160**	0.48	0.53	0.59	0.65	0.72	0.82	0.91
2.27	**170**	0.55	0.60	0.66	0.73	0.82	0.92	1.03
2.55	**180**	0.61	0.67	0.74	0.82	0.92	1.03	1.16
2.84	**190**	0.68	0.75	0.83	0.91	1.02	1.15	1.29
3.14	**200**	0.76	0.83	0.92	1.01	1.13	1.27	1.43
3.46	**210**	0.83	0.91	1.01	1.11	1.25	1.40	1.57
3.80	**220**	0.91	1.00	1.11	1.22	1.37	1.54	1.73
4.16	**230**	1.00	1.09	1.21	1.34	1.50	1.68	1.89
4.53	**240**	1.09	1.19	1.32	1.46	1.63	1.83	2.06
4.91	**250**	1.18	1.29	1.43	1.58	1.77	1.99	2.23
5.31	**260**	1.28	1.40	1.55	1.71	1.91	2.15	2.41
5.73	**270**	1.38	1.50	1.67	1.84	2.06	2.32	2.60
6.16	**280**	1.48	1.62	1.79	1.98	2.22	2.50	2.80
6.61	**290**	1.59	1.74	1.92	2.13	2.38	2.68	3.00
7.07	**300**	1.70	1.86	2.06	2.28	2.55	2.87	3.21
7.55	**310**	1.81	1.98	2.20	2.43	2.72	3.06	3.43
8.04	**320**	1.93	2.11	2.34	2.59	2.90	3.26	3.65
8.56	**330**	2.06	2.25	2.49	2.75	3.08	3.47	3.89
9.08	**340**	2.18	2.39	2.64	2.92	3.27	3.68	4.12
9.62	**350**	2.31	2.53	2.80	3.10	3.47	3.90	4.37

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.66: Heavy Loading, 2 ACSR, Ruling Span = 300 Feet

Conductor: SPARROW	2 kcmil	6/1 Stranding ACSR
Area = 0.0608 sq in.	Weight = 0.091 lb/ft	
Diameter = 0.316	RTS = 2850 lb	
Design data from Sag10 Chart No. 1-1023	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.035	8.19	1425	8.19	1425*
32	0.5	0	0	0.589	7.33	907	6.69	994
60	0	6	0	0.182	6.03	340	4.56	451
–20	0	0	0	0.091	2.91	352	1.67	614
0	0	0	0	0.091	3.55	289	1.97	519
30	0	0	0	0.091	4.51	227	2.62	391
60	0	0	0	0.091	5.14	199	3.49	294
90	0	0	0	0.091	5.56	184	4.43	231
120	0	0	0	0.091	5.97	172	5.33	192

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		354	**322**	**294**	**269**	**249**	**231**	**216**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.26	**200**	1.28	1.41	1.55	1.69	1.83	1.97	2.11
3.59	**210**	1.42	1.56	1.71	1.86	2.02	2.17	2.32
3.94	**220**	1.55	1.71	1.87	2.04	2.22	2.38	2.55
4.31	**230**	1.70	1.87	2.05	2.23	2.42	2.60	2.79
4.69	**240**	1.85	2.04	2.23	2.43	2.64	2.84	3.03
5.09	**250**	2.01	2.21	2.42	2.64	2.86	3.08	3.29
5.51	**260**	2.17	2.39	2.61	2.85	3.09	3.33	3.56
5.94	**270**	2.34	2.58	2.82	3.08	3.34	3.59	3.84
6.39	**280**	2.52	2.77	3.03	3.31	3.59	3.86	4.13
6.85	**290**	2.70	2.97	3.25	3.55	3.85	4.14	4.43
7.33	**300**	2.89	3.18	3.48	3.80	4.12	4.43	4.74
7.83	**310**	3.09	3.40	3.72	4.06	4.40	4.73	5.06
8.34	**320**	3.29	3.62	3.96	4.32	4.69	5.04	5.39
8.87	**330**	3.50	3.85	4.21	4.60	4.99	5.36	5.74
9.41	**340**	3.71	4.08	4.47	4.88	5.29	5.69	6.09
9.98	**350**	3.93	4.33	4.74	5.17	5.61	6.03	6.45
10.56	**360**	4.16	4.58	5.01	5.47	5.93	6.38	6.83
11.15	**370**	4.40	4.84	5.29	5.78	6.27	6.74	7.21
11.76	**380**	4.64	5.10	5.58	6.10	6.61	7.11	7.61
12.39	**390**	4.88	5.37	5.88	6.42	6.96	7.49	8.01
13.03	**400**	5.14	5.65	6.19	6.76	7.32	7.88	8.43

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.67: Heavy Loading, 1/0 ACSR, Ruling Span = 200 Feet

Conductor: RAVEN — 1/0 kcmil — 6/1 Stranding ACSR
Area = 0.0968 sq in. — Weight = 0.145 lb/ft
Diameter = 0.398 in. — RTS = 4380 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.136	3.16	1796	3.16	1796
32	0.5	0	0	0.694	2.77	1254	2.49	1396
60	0	6	0	0.246	1.92	640	1.31	942
–20	0	0	0	0.145	0.55	1316	0.49	1473
0	0	0	0	0.145	0.66	1095*	0.54	1334
30	0	0	0	0.145	0.93	779	0.65	1114
60	0	0	0	0.145	1.41	514	0.82	884
90	0	0	0	0.145	2.04	355	1.11	655
120	0	0	0	0.145	2.33	312	1.59	457

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1038	**961**	**884**	**806**	**730**	**655**	**583**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.69	**100**	0.18	0.19	0.21	0.23	0.25	0.28	0.31
0.84	**110**	0.21	0.23	0.25	0.27	0.30	0.34	0.38
1.00	**120**	0.25	0.27	0.30	0.32	0.36	0.40	0.45
1.17	**130**	0.30	0.32	0.35	0.38	0.42	0.47	0.52
1.36	**140**	0.34	0.37	0.40	0.44	0.49	0.54	0.61
1.56	**150**	0.39	0.42	0.46	0.51	0.56	0.62	0.70
1.77	**160**	0.45	0.48	0.52	0.58	0.63	0.71	0.79
2.00	**170**	0.51	0.54	0.59	0.65	0.72	0.80	0.90
2.24	**180**	0.57	0.61	0.66	0.73	0.80	0.90	1.00
2.50	**190**	0.63	0.68	0.74	0.81	0.89	1.00	1.12
2.77	**200**	0.70	0.75	0.82	0.90	0.99	1.11	1.24
3.05	**210**	0.77	0.83	0.90	0.99	1.09	1.22	1.37
3.35	**220**	0.85	0.91	0.99	1.09	1.20	1.34	1.50
3.66	**230**	0.93	0.99	1.08	1.19	1.31	1.47	1.64
3.99	**240**	1.01	1.08	1.18	1.30	1.43	1.60	1.79
4.33	**250**	1.09	1.17	1.28	1.41	1.55	1.73	1.94
4.68	**260**	1.18	1.27	1.39	1.52	1.67	1.88	2.10
5.05	**270**	1.28	1.37	1.49	1.64	1.80	2.02	2.26
5.43	**280**	1.37	1.47	1.61	1.76	1.94	2.18	2.43
5.82	**290**	1.47	1.58	1.72	1.89	2.08	2.33	2.61
6.23	**300**	1.58	1.69	1.85	2.03	2.23	2.50	2.79

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.68: Heavy Loading, 1/0 ACSR, Ruling Span = 250 Feet

Conductor: RAVEN	1/0 kcmil	6/1 Stranding ACSR
Area = 0.0968 sq in.	Weight = 0.145 lb/ft	
Diameter = 0.398 in.	RTS = 4380 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.136	4.48	1984	4.48	1984
32	0.5	0	0	0.694	3.90	1389	3.50	1549
60	0	6	0	0.246	2.74	703	1.84	1047
–20	0	0	0	0.145	0.86	1311	0.73	1548
0	0	0	0	0.145	1.03	1095*	0.80	1413
30	0	0	0	0.145	1.43	793	0.95	1199
60	0	0	0	0.145	2.06	550	1.16	976
90	0	0	0	0.145	2.80	404	1.50	754
120	0	0	0	0.145	3.13	362	2.04	555

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1125	**1051**	**976**	**901**	**826**	**754**	**683**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.40	**150**	0.36	0.39	0.42	0.45	0.49	0.54	0.60
1.60	**160**	0.41	0.44	0.48	0.52	0.56	0.61	0.68
1.80	**170**	0.47	0.50	0.54	0.58	0.63	0.69	0.77
2.02	**180**	0.52	0.56	0.60	0.65	0.71	0.78	0.86
2.25	**190**	0.58	0.62	0.67	0.73	0.79	0.87	0.96
2.50	**200**	0.65	0.69	0.74	0.81	0.88	0.96	1.06
2.75	**210**	0.71	0.76	0.82	0.89	0.97	1.06	1.17
3.02	**220**	0.78	0.84	0.90	0.98	1.06	1.16	1.29
3.30	**230**	0.85	0.91	0.98	1.07	1.16	1.27	1.41
3.59	**240**	0.93	1.00	1.07	1.16	1.26	1.38	1.53
3.90	**250**	1.01	1.08	1.16	1.26	1.37	1.50	1.66
4.22	**260**	1.09	1.17	1.25	1.36	1.48	1.62	1.80
4.55	**270**	1.18	1.26	1.35	1.47	1.60	1.75	1.94
4.89	**280**	1.27	1.35	1.46	1.58	1.72	1.88	2.08
5.25	**290**	1.36	1.45	1.56	1.70	1.84	2.02	2.23
5.62	**300**	1.45	1.56	1.67	1.81	1.97	2.16	2.39
6.00	**310**	1.55	1.66	1.78	1.94	2.11	2.31	2.55
6.39	**320**	1.65	1.77	1.90	2.06	2.24	2.46	2.72
6.80	**330**	1.76	1.88	2.02	2.20	2.39	2.61	2.89
7.21	**340**	1.87	2.00	2.15	2.33	2.53	2.77	3.07
7.64	**350**	1.98	2.12	2.27	2.47	2.69	2.94	3.25

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.69: Heavy Loading, 1/0 ACSR, Ruling Span = 300 Feet		
Conductor: RAVEN	1/0 kcmil	6/1 Stranding ACSR
Area = 0.0968 sq in.	Weight = 0.145 lb/ft	
Diameter = 0.398 in.	RTS = 4380 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.136	5.92	2162	5.92	2162
32	0.5	0	0	0.694	5.15	1516	4.60	1697
60	0	6	0	0.246	3.64	761	2.41	1152
–20	0	0	0	0.145	1.25	1305	1.00	1625
0	0	0	0	0.145	1.49	1095*	1.09	1493
30	0	0	0	0.145	2.02	808	1.26	1285
60	0	0	0	0.145	2.80	583	1.53	1069
90	0	0	0	0.145	3.61	452	1.91	852
120	0	0	0	0.145	3.98	410	2.50	654

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1214	**1142**	**1069**	**996**	**924**	**852**	**783**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.29	**200**	0.60	0.64	0.68	0.73	0.79	0.85	0.92
2.52	**210**	0.66	0.70	0.75	0.80	0.87	0.94	1.02
2.77	**220**	0.72	0.77	0.82	0.88	0.95	1.03	1.12
3.03	**230**	0.79	0.84	0.90	0.96	1.04	1.12	1.22
3.30	**240**	0.86	0.92	0.98	1.05	1.13	1.22	1.33
3.58	**250**	0.93	0.99	1.06	1.14	1.23	1.33	1.44
3.87	**260**	1.01	1.07	1.15	1.23	1.33	1.43	1.56
4.17	**270**	1.09	1.16	1.24	1.33	1.43	1.55	1.68
4.49	**280**	1.17	1.25	1.33	1.43	1.54	1.66	1.81
4.81	**290**	1.25	1.34	1.43	1.53	1.65	1.78	1.94
5.15	**300**	1.34	1.43	1.53	1.64	1.77	1.91	2.08
5.50	**310**	1.43	1.53	1.63	1.75	1.89	2.04	2.22
5.86	**320**	1.52	1.63	1.74	1.87	2.01	2.17	2.37
6.23	**330**	1.62	1.73	1.85	1.98	2.14	2.31	2.52
6.61	**340**	1.72	1.84	1.97	2.11	2.27	2.45	2.67
7.01	**350**	1.82	1.95	2.08	2.23	2.41	2.60	2.83
7.42	**360**	1.93	2.06	2.20	2.36	2.55	2.75	3.00
7.83	**370**	2.04	2.18	2.33	2.49	2.69	2.91	3.16
8.26	**380**	2.15	2.29	2.45	2.63	2.84	3.06	3.34
8.70	**390**	2.26	2.42	2.59	2.77	2.99	3.23	3.52
9.16	**400**	2.38	2.54	2.72	2.92	3.15	3.40	3.70

1 Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.70: Heavy Loading, 3/0 ACSR, Ruling Span = 200 Feet

Conductor: PIGEON	3/0 kcmil	6/1 Stranding ACSR
Area = 0.1537 sq in.	Weight = 0.23 lb/ft	
Diameter = 0.502 in.	RTS = 6620 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.280	2.65	2416	2.65	2416
32	0.5	0	0	0.842	2.46	1714	2.24	1883
60	0	6	0	0.340	1.88	907	1.36	1248
–20	0	0	0	0.230	0.57	2004	0.54	2117
0	0	0	0	0.230	0.69	1655*	0.61	1889
30	0	0	0	0.230	0.99	1162	0.75	1531
60	0	0	0	0.230	1.51	762	0.99	1167
90	0	0	0	0.230	2.22	519	1.39	829
120	0	0	0	0.230	2.58	446	1.99	578

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1409	**1287**	**1167**	**1049**	**935**	**829**	**733**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.65	**100**	0.21	0.22	0.25	0.28	0.31	0.35	0.39
0.78	**110**	0.25	0.27	0.30	0.33	0.37	0.42	0.47
0.93	**120**	0.30	0.32	0.36	0.40	0.44	0.50	0.57
1.09	**130**	0.35	0.38	0.42	0.46	0.52	0.59	0.66
1.26	**140**	0.40	0.44	0.49	0.54	0.60	0.68	0.77
1.45	**150**	0.46	0.50	0.56	0.62	0.69	0.78	0.88
1.65	**160**	0.52	0.57	0.63	0.70	0.79	0.89	1.00
1.86	**170**	0.59	0.64	0.72	0.79	0.89	1.00	1.13
2.09	**180**	0.66	0.72	0.80	0.89	1.00	1.13	1.27
2.33	**190**	0.74	0.80	0.89	0.99	1.11	1.25	1.42
2.58	**200**	0.82	0.89	0.99	1.10	1.23	1.39	1.57
2.84	**210**	0.90	0.98	1.09	1.21	1.36	1.53	1.73
3.12	**220**	0.99	1.08	1.20	1.33	1.49	1.68	1.90
3.41	**230**	1.08	1.18	1.31	1.45	1.63	1.84	2.08
3.72	**240**	1.18	1.28	1.43	1.58	1.77	2.00	2.26
4.03	**250**	1.28	1.39	1.55	1.72	1.92	2.17	2.45
4.36	**260**	1.39	1.50	1.67	1.86	2.08	2.35	2.65
4.70	**270**	1.49	1.62	1.80	2.00	2.24	2.53	2.86
5.06	**280**	1.61	1.74	1.94	2.16	2.41	2.72	3.08
5.42	**290**	1.72	1.87	2.08	2.31	2.59	2.92	3.30
5.81	**300**	1.85	2.00	2.23	2.48	2.77	3.13	3.53

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.71: Heavy Loading, 3/0 ACSR, Ruling Span = 250 Feet

Conductor: PIGEON | 3/0 kcmil | 6/1 Stranding ACSR
Area = 0.1537 sq in. | Weight = 0.23 lb/ft
Diameter = 0.502 in. | RTS = 6620 lb
Design data from Sag10 Chart No. 1-938 | Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.280	3.79	2638	3.79	2638
32	0.5	0	0	0.842	3.49	1886	3.18	2068
60	0	6	0	0.340	2.67	996	1.94	1368
–20	0	0	0	0.230	0.90	1995	0.82	2189
0	0	0	0	0.230	1.09	1655*	0.91	1965
30	0	0	0	0.230	1.51	1187	1.11	1617
60	0	0	0	0.230	2.19	822	1.42	1266
90	0	0	0	0.230	3.02	595	1.91	942
120	0	0	0	0.230	3.49	515	2.60	692

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1500	**1382**	**1266**	**1153**	**1044**	**942**	**848**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.26	**150**	0.43	0.47	0.51	0.56	0.62	0.69	0.76
1.43	**160**	0.49	0.53	0.58	0.64	0.70	0.78	0.87
1.61	**170**	0.55	0.60	0.66	0.72	0.80	0.88	0.98
1.81	**180**	0.62	0.67	0.74	0.81	0.89	0.99	1.10
2.02	**190**	0.69	0.75	0.82	0.90	0.99	1.10	1.22
2.23	**200**	0.77	0.83	0.91	1.00	1.10	1.22	1.36
2.46	**210**	0.85	0.92	1.00	1.10	1.21	1.35	1.50
2.70	**220**	0.93	1.01	1.10	1.21	1.33	1.48	1.64
2.95	**230**	1.02	1.10	1.20	1.32	1.46	1.62	1.79
3.22	**240**	1.11	1.20	1.31	1.44	1.59	1.76	1.95
3.49	**250**	1.20	1.30	1.42	1.56	1.72	1.91	2.12
3.77	**260**	1.30	1.41	1.54	1.69	1.86	2.07	2.29
4.07	**270**	1.40	1.52	1.66	1.82	2.01	2.23	2.47
4.38	**280**	1.51	1.63	1.78	1.96	2.16	2.40	2.66
4.70	**290**	1.61	1.75	1.91	2.10	2.31	2.57	2.85
5.03	**300**	1.73	1.87	2.04	2.25	2.48	2.75	3.05
5.37	**310**	1.85	2.00	2.18	2.40	2.64	2.94	3.26
5.72	**320**	1.97	2.13	2.33	2.56	2.82	3.13	3.47
6.08	**330**	2.09	2.27	2.47	2.72	3.00	3.33	3.69
6.46	**340**	2.22	2.40	2.63	2.89	3.18	3.53	3.92
6.84	**350**	2.35	2.55	2.78	3.06	3.37	3.74	4.16

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.72: Heavy Loading, 3/0 ACSR, Ruling Span = 300 Feet

Conductor: PIGEON	3/0 kcmil	6/1 Stranding ACSR
Area = 0.1537 sq in.	Weight = 0.23 lb/ft	
Diameter = 0.502 in.	RTS = 6620 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.280	5.06	2850	5.06	2850
32	0.5	0	0	0.842	4.63	2048	4.22	2245
60	0	6	0	0.340	3.55	1079	2.58	1484
–20	0	0	0	0.230	1.30	1984	1.15	2260
0	0	0	0	0.230	1.56	1655 *	1.27	2041
30	0	0	0	0.230	2.13	1213	1.52	1703
60	0	0	0	0.230	2.95	877	1.90	1363
90	0	0	0	0.230	3.90	663	2.47	1049
120	0	0	0	0.230	4.46	580	3.24	799

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1588	**1475**	**1363**	**1253**	**1148**	**1049**	**957**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.06	**200**	0.72	0.78	0.84	0.92	1.00	1.10	1.20
2.27	**210**	0.80	0.86	0.93	1.01	1.10	1.21	1.32
2.49	**220**	0.88	0.94	1.02	1.11	1.21	1.33	1.45
2.72	**230**	0.96	1.03	1.12	1.21	1.32	1.45	1.59
2.96	**240**	1.04	1.12	1.22	1.32	1.44	1.58	1.73
3.22	**250**	1.13	1.22	1.32	1.43	1.56	1.72	1.88
3.48	**260**	1.22	1.31	1.43	1.55	1.69	1.86	2.03
3.75	**270**	1.32	1.42	1.54	1.67	1.82	2.00	2.19
4.03	**280**	1.42	1.52	1.66	1.79	1.96	2.15	2.35
4.33	**290**	1.52	1.64	1.78	1.92	2.10	2.31	2.52
4.63	**300**	1.63	1.75	1.90	2.06	2.25	2.47	2.70
4.94	**310**	1.74	1.87	2.03	2.20	2.40	2.64	2.88
5.27	**320**	1.85	1.99	2.16	2.34	2.56	2.81	3.07
5.60	**330**	1.97	2.12	2.30	2.49	2.72	2.99	3.27
5.95	**340**	2.09	2.25	2.44	2.65	2.89	3.17	3.47
6.30	**350**	2.22	2.38	2.59	2.80	3.06	3.36	3.68
6.67	**360**	2.35	2.52	2.74	2.97	3.24	3.56	3.89
7.04	**370**	2.48	2.66	2.89	3.13	3.42	3.76	4.11
7.43	**380**	2.62	2.81	3.05	3.31	3.61	3.96	4.33
7.82	**390**	2.75	2.96	3.21	3.48	3.80	4.17	4.56
8.23	**400**	2.90	3.11	3.38	3.66	4.00	4.39	4.80

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.73: Heavy Loading, 4/0 ACSR, Ruling Span = 200 Feet

Conductor: PENGUIN	4/0 kcmil	6/1 Stranding ACSR
Area = 0.1939 sq in.	Weight = 0.291 lb/ft	
Diameter = 0.563 in.	RTS= 8350 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.375	2.40	2863	2.40	2863
32	0.5	0	0	0.940	2.30	2048	2.10	2244
60	0	6	0	0.405	1.82	1112	1.35	1497
–20	0	0	0	0.291	0.58	2528	0.56	2608
0	0	0	0	0.291	0.70	2087*	0.63	2318
30	0	0	0	0.291	0.99	1466	0.78	1866
60	0	0	0	0.291	1.51	962	1.03	1409
90	0	0	0	0.291	2.22	655	1.46	995
120	0	0	0	0.291	2.64	551	2.08	698

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1712	**1559**	**1408**	**1262**	**1123**	**995**	**880**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.66	**100**	0.21	0.23	0.26	0.29	0.33	0.37	0.41
0.80	**110**	0.26	0.28	0.31	0.35	0.39	0.44	0.50
0.95	**120**	0.31	0.33	0.37	0.41	0.47	0.53	0.59
1.12	**130**	0.36	0.39	0.44	0.49	0.55	0.62	0.70
1.29	**140**	0.42	0.46	0.50	0.56	0.64	0.72	0.81
1.49	**150**	0.48	0.52	0.58	0.65	0.73	0.82	0.93
1.69	**160**	0.54	0.60	0.66	0.74	0.83	0.93	1.06
1.91	**170**	0.61	0.67	0.74	0.83	0.94	1.05	1.19
2.14	**180**	0.69	0.75	0.83	0.93	1.05	1.18	1.34
2.38	**190**	0.77	0.84	0.93	1.04	1.17	1.32	1.49
2.64	**200**	0.85	0.93	1.03	1.15	1.30	1.46	1.65
2.91	**210**	0.94	1.03	1.14	1.27	1.43	1.61	1.82
3.19	**220**	1.03	1.13	1.25	1.39	1.57	1.77	2.00
3.49	**230**	1.12	1.23	1.36	1.52	1.72	1.93	2.18
3.80	**240**	1.22	1.34	1.48	1.66	1.87	2.10	2.38
4.13	**250**	1.33	1.45	1.61	1.80	2.03	2.28	2.58
4.46	**260**	1.44	1.57	1.74	1.94	2.20	2.47	2.79
4.81	**270**	1.55	1.69	1.88	2.10	2.37	2.66	3.01
5.17	**280**	1.67	1.82	2.02	2.25	2.55	2.86	3.23
5.55	**290**	1.79	1.96	2.17	2.42	2.73	3.07	3.47
5.94	**300**	1.91	2.09	2.32	2.59	2.93	3.29	3.71

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.74: Heavy Loading, 4/0 ACSR, Ruling Span = 250 Feet

Conductor: PENGUIN	4/0 kcmil	6/1 Stranding ACSR
Area = 0.1939 sq in.	Weight = 0.291 lb/ft	
Diameter = 0.563 in.	RTS= 8350 lb	
Design data from Sag10 Chart No. 1-938	Ice = 56 lb/ft^3	

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.375	3.46	3103	3.46	3103
32	0.5	0	0	0.940	3.28	2243	3.00	2448
60	0	6	0	0.405	2.60	1219	1.94	1628
–20	0	0	0	0.291	0.90	2516	0.85	2679
0	0	0	0	0.291	1.09	2087*	0.95	2395
30	0	0	0	0.291	1.52	1497	1.16	1956
60	0	0	0	0.291	2.19	1037	1.50	1517
90	0	0	0	0.291	3.03	751	2.03	1122
120	0	0	0	0.291	3.58	636	2.75	828

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1808	**1661**	**1516**	**1377**	**1244**	**1122**	**1011**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.29	**150**	0.45	0.49	0.54	0.59	0.66	0.73	0.81
1.47	**160**	0.52	0.56	0.61	0.68	0.75	0.83	0.92
1.66	**170**	0.58	0.63	0.69	0.76	0.85	0.94	1.04
1.86	**180**	0.65	0.71	0.78	0.86	0.95	1.05	1.17
2.07	**190**	0.73	0.79	0.87	0.95	1.06	1.17	1.30
2.29	**200**	0.81	0.88	0.96	1.06	1.17	1.30	1.44
2.53	**210**	0.89	0.97	1.06	1.16	1.29	1.43	1.59
2.77	**220**	0.98	1.06	1.16	1.28	1.42	1.57	1.74
3.03	**230**	1.07	1.16	1.27	1.40	1.55	1.72	1.90
3.30	**240**	1.16	1.26	1.38	1.52	1.69	1.87	2.07
3.58	**250**	1.26	1.37	1.50	1.65	1.83	2.03	2.25
3.87	**260**	1.36	1.48	1.62	1.78	1.98	2.20	2.43
4.18	**270**	1.47	1.60	1.75	1.92	2.13	2.37	2.62
4.49	**280**	1.58	1.72	1.88	2.07	2.30	2.55	2.82
4.82	**290**	1.70	1.84	2.02	2.22	2.46	2.73	3.03
5.16	**300**	1.81	1.97	2.16	2.38	2.64	2.92	3.24
5.50	**310**	1.94	2.11	2.31	2.54	2.81	3.12	3.46
5.87	**320**	2.06	2.24	2.46	2.70	3.00	3.33	3.69
6.24	**330**	2.20	2.39	2.61	2.87	3.19	3.54	3.92
6.62	**340**	2.33	2.53	2.77	3.05	3.38	3.75	4.16
7.02	**350**	2.47	2.69	2.94	3.23	3.59	3.98	4.41

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.75: Heavy Loading, 4/0 ACSR, Ruling Span = 300 Feet

Conductor: PENGUIN — 4/0 kcmil — 6/1 Stranding ACSR
Area = 0.1939 sq in. — Weight = 0.291 lb/ft
Diameter = 0.563 in. — RTS= 8350 lb
Design data from Sag10 Chart No. 1-938 — Ice = 56 lb/ft^3

Design Points

Creep IS NOT a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.375	4.65	3333	4.65	3333
32	0.5	0	0	0.940	4.36	2427	4.01	2643
60	0	6	0	0.405	3.46	1317	2.60	1755
–20	0	0	0	0.291	1.31	2502	1.19	2749
0	0	0	0	0.291	1.57	2088*	1.32	2472
30	0	0	0	0.291	2.14	1531	1.60	2044
60	0	0	0	0.291	2.96	1107	2.02	1621
90	0	0	0	0.291	3.91	838	2.64	1241
120	0	0	0	0.291	4.59	714	3.45	951

*Design Condition: Final Loading based on conductor creep only.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1901	**1759**	**1621**	**1487**	**1360**	**1241**	**1133**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.04	**200**	0.76	0.83	0.90	0.98	1.07	1.17	1.28
2.25	**210**	0.84	0.91	0.99	1.08	1.18	1.29	1.42
2.47	**220**	0.92	1.00	1.09	1.18	1.30	1.42	1.55
2.70	**230**	1.01	1.09	1.19	1.29	1.42	1.55	1.70
2.94	**240**	1.10	1.19	1.29	1.41	1.54	1.69	1.85
3.19	**250**	1.19	1.29	1.40	1.53	1.67	1.83	2.01
3.45	**260**	1.29	1.40	1.52	1.65	1.81	1.98	2.17
3.72	**270**	1.39	1.51	1.64	1.78	1.95	2.14	2.34
4.00	**280**	1.50	1.62	1.76	1.92	2.10	2.30	2.52
4.29	**290**	1.61	1.74	1.89	2.06	2.25	2.47	2.70
4.59	**300**	1.72	1.86	2.02	2.20	2.41	2.64	2.89
4.90	**310**	1.84	1.99	2.16	2.35	2.57	2.82	3.09
5.22	**320**	1.96	2.12	2.30	2.50	2.74	3.00	3.29
5.55	**330**	2.08	2.25	2.44	2.66	2.92	3.19	3.50
5.90	**340**	2.21	2.39	2.59	2.83	3.10	3.39	3.71
6.25	**350**	2.34	2.53	2.75	2.99	3.28	3.59	3.93
6.61	**360**	2.48	2.68	2.91	3.17	3.47	3.80	4.16
6.98	**370**	2.62	2.83	3.07	3.35	3.67	4.02	4.40
7.36	**380**	2.76	2.98	3.24	3.53	3.87	4.24	4.64
7.76	**390**	2.91	3.14	3.41	3.72	4.07	4.46	4.88
8.16	**400**	3.06	3.31	3.59	3.91	4.28	4.69	5.14

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.76: Heavy Loading, 336 ACSR, Ruling Span = 200 Feet

Conductor: MERLIN	336 kcmil	18/1 Stranding ACSR
Area = 0.2789 sq in.	Weight = 0.365 lb/ft	
Diameter = 0.684 in.	RTS = 8680 lb	
Design data from Sag10 Chart No. 1-844	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.525	2.44	3131	2.39	3197
32	0.5	0	0	1.088	2.52	2161	2.27	2401
60	0	6	0	0.500	2.33	1075	1.80	1387
–20	0	0	0	0.365	0.66	2773	0.62	2964
0	0	0	0	0.365	0.84	2170*	0.72	2531
30	0	0	0	0.365	1.32	1380	0.99	1850
60	0	0	0	0.365	2.08	876	1.49	1222
90	0	0	0	0.365	2.89	632	2.26	809
120	0	0	0	0.365	3.61	507	3.04	601

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1627	**1414**	**1222**	**1055**	**918**	**809**	**723**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
0.90	**100**	0.28	0.32	0.37	0.43	0.50	0.57	0.63
1.09	**110**	0.34	0.39	0.45	0.52	0.60	0.68	0.77
1.30	**120**	0.40	0.46	0.54	0.62	0.72	0.81	0.91
1.53	**130**	0.47	0.55	0.63	0.73	0.84	0.95	1.07
1.77	**140**	0.55	0.63	0.73	0.85	0.98	1.11	1.24
2.03	**150**	0.63	0.73	0.84	0.97	1.12	1.27	1.42
2.31	**160**	0.72	0.83	0.95	1.11	1.27	1.45	1.62
2.61	**170**	0.81	0.93	1.08	1.25	1.44	1.63	1.83
2.92	**180**	0.91	1.04	1.21	1.40	1.61	1.83	2.05
3.26	**190**	1.01	1.16	1.34	1.56	1.80	2.04	2.28
3.61	**200**	1.12	1.29	1.49	1.73	1.99	2.26	2.53
3.98	**210**	1.23	1.42	1.64	1.91	2.19	2.49	2.79
4.37	**220**	1.36	1.56	1.80	2.09	2.41	2.73	3.06
4.77	**230**	1.48	1.71	1.97	2.29	2.63	2.99	3.35
5.20	**240**	1.61	1.86	2.15	2.49	2.87	3.25	3.64
5.64	**250**	1.75	2.02	2.33	2.70	3.11	3.53	3.95
6.10	**260**	1.89	2.18	2.52	2.92	3.36	3.82	4.28
6.58	**270**	2.04	2.35	2.72	3.15	3.63	4.12	4.61
7.08	**280**	2.20	2.53	2.92	3.39	3.90	4.43	4.96
7.59	**290**	2.35	2.71	3.13	3.64	4.18	4.75	5.32
8.12	**300**	2.52	2.90	3.35	3.89	4.48	5.09	5.69

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.77: Heavy Loading, 336 ACSR, Ruling Span = 250 Feet

Conductor: MERLIN 336 kcmil 18/1 Stranding ACSR
Area = 0.2789 sq in. Weight = 0.365 lb/ft
Diameter = 0.684 in. RTS = 8680 lb
Design data from Sag10 Chart No. 1-844 Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.525	3.50	3408	3.45	3455
32	0.5	0	0	1.088	3.55	2400	3.22	2638
60	0	6	0	0.500	3.21	1218	2.52	1550
–20	0	0	0	0.365	1.04	2748	0.95	3016
0	0	0	0	0.365	1.31	2170*	1.10	2595
30	0	0	0	0.365	1.97	1445	1.47	1944
60	0	0	0	0.365	2.89	988	2.10	1355
90	0	0	0	0.365	3.82	746	2.99	954
120	0	0	0	0.365	4.67	611	3.91	731

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1733	**1535**	**1355**	**1197**	**1064**	**954**	**864**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.68	**150**	0.59	0.67	0.76	0.86	0.96	1.08	1.19
1.91	**160**	0.68	0.76	0.86	0.97	1.10	1.22	1.35
2.16	**170**	0.76	0.86	0.97	1.10	1.24	1.38	1.53
2.42	**180**	0.86	0.96	1.09	1.23	1.39	1.55	1.71
2.70	**190**	0.95	1.07	1.21	1.37	1.55	1.73	1.91
2.99	**200**	1.06	1.19	1.34	1.52	1.72	1.91	2.11
3.30	**210**	1.16	1.31	1.48	1.68	1.89	2.11	2.33
3.62	**220**	1.28	1.44	1.63	1.84	2.08	2.32	2.56
3.95	**230**	1.40	1.57	1.78	2.01	2.27	2.53	2.79
4.30	**240**	1.52	1.71	1.94	2.19	2.47	2.76	3.04
4.67	**250**	1.65	1.86	2.10	2.38	2.68	2.99	3.30
5.05	**260**	1.78	2.01	2.27	2.57	2.90	3.23	3.57
5.45	**270**	1.92	2.17	2.45	2.78	3.13	3.49	3.85
5.86	**280**	2.07	2.33	2.63	2.99	3.36	3.75	4.14
6.28	**290**	2.22	2.50	2.83	3.20	3.61	4.02	4.44
6.72	**300**	2.38	2.68	3.02	3.43	3.86	4.31	4.75
7.18	**310**	2.54	2.86	3.23	3.66	4.12	4.60	5.07
7.65	**320**	2.70	3.05	3.44	3.90	4.39	4.90	5.41
8.14	**330**	2.87	3.24	3.66	4.15	4.67	5.21	5.75
8.64	**340**	3.05	3.44	3.88	4.40	4.96	5.53	6.10
9.15	**350**	3.23	3.65	4.12	4.66	5.25	5.86	6.47

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.78: Heavy Loading, 336 ACSR, Ruling Span = 300 Feet

Conductor: MERLIN — 336 kcmil — 18/1 Stranding ACSR
Area = 0.2789 sq in. — Weight = 0.365 lb/ft
Diameter = 0.684 in. — RTS = 8680 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.525	4.94	3477	4.91	3500*
32	0.5	0	0	1.088	4.98	2463	4.62	2655
60	0	6	0	0.500	4.57	1232	3.78	1488
–20	0	0	0	0.365	1.72	2381	1.51	2728
0	0	0	0	0.365	2.19	1876	1.78	2313
30	0	0	0	0.365	3.14	1309	2.39	1716
60	0	0	0	0.365	4.21	975	3.30	1245
90	0	0	0	0.365	5.24	785	4.34	947
120	0	0	0	0.365	6.17	667	5.34	770

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1539	**1382**	**1244**	**1127**	**1029**	**946**	**877**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.74	**200**	1.19	1.32	1.47	1.62	1.77	1.93	2.08
3.02	**210**	1.31	1.46	1.62	1.78	1.96	2.13	2.29
3.32	**220**	1.44	1.60	1.77	1.96	2.15	2.33	2.52
3.63	**230**	1.57	1.75	1.94	2.14	2.35	2.55	2.75
3.95	**240**	1.71	1.90	2.11	2.33	2.55	2.78	3.00
4.28	**250**	1.85	2.06	2.29	2.53	2.77	3.01	3.25
4.63	**260**	2.01	2.23	2.48	2.73	3.00	3.26	3.52
5.00	**270**	2.16	2.41	2.67	2.95	3.23	3.52	3.79
5.37	**280**	2.33	2.59	2.87	3.17	3.48	3.78	4.08
5.77	**290**	2.49	2.78	3.08	3.40	3.73	4.06	4.37
6.17	**300**	2.67	2.97	3.30	3.64	3.99	4.34	4.68
6.59	**310**	2.85	3.17	3.52	3.89	4.26	4.63	5.00
7.02	**320**	3.04	3.38	3.75	4.14	4.54	4.94	5.32
7.47	**330**	3.23	3.59	3.99	4.40	4.83	5.25	5.66
7.93	**340**	3.43	3.81	4.24	4.68	5.12	5.57	6.01
8.40	**350**	3.63	4.04	4.49	4.95	5.43	5.91	6.37
8.88	**360**	3.84	4.28	4.75	5.24	5.75	6.25	6.74
9.39	**370**	4.06	4.52	5.02	5.54	6.07	6.60	7.12
9.90	**380**	4.28	4.77	5.29	5.84	6.40	6.96	7.51
10.43	**390**	4.51	5.02	5.58	6.15	6.74	7.33	7.91
10.97	**400**	4.75	5.28	5.87	6.47	7.09	7.72	8.32

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.79: Heavy Loading, 477 ACSR, Ruling Span = 200 Feet

Conductor: PELICAN	477 kcmil	18/1 Stranding ACSR
Area = 0.3955 sq in.	Weight = 0.517 lb/ft	
Diameter = 0.814 in.	RTS = 11,800 lb	
Design data from Sag10 Chart No. 1-844	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.752	2.60	3370	2.50	3500*
32	0.5	0	0	1.320	2.88	2290	2.64	2502
60	0	6	0	0.658	2.96	1112	2.56	1287
–20	0	0	0	0.517	0.94	2761	0.84	3092
0	0	0	0	0.517	1.27	2029	1.05	2455
30	0	0	0	0.517	2.02	1280	1.61	1609
60	0	0	0	0.517	2.83	914	2.39	1084
90	0	0	0	0.517	3.55	728	3.16	819
120	0	0	0	0.517	4.19	618	3.84	674

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1394	**1221**	**1083**	**975**	**889**	**819**	**762**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.05	**100**	0.46	0.53	0.60	0.66	0.73	0.79	0.85
1.27	**110**	0.56	0.64	0.72	0.80	0.88	0.96	1.03
1.51	**120**	0.67	0.76	0.86	0.95	1.05	1.14	1.22
1.77	**130**	0.78	0.90	1.01	1.12	1.23	1.34	1.44
2.05	**140**	0.91	1.04	1.17	1.30	1.43	1.55	1.67
2.36	**150**	1.04	1.19	1.34	1.49	1.64	1.78	1.91
2.68	**160**	1.18	1.36	1.53	1.70	1.86	2.02	2.18
3.03	**170**	1.34	1.53	1.73	1.91	2.10	2.28	2.46
3.39	**180**	1.50	1.72	1.94	2.15	2.36	2.56	2.75
3.78	**190**	1.67	1.91	2.16	2.39	2.63	2.85	3.07
4.19	**200**	1.85	2.12	2.39	2.65	2.91	3.16	3.40
4.62	**210**	2.04	2.34	2.63	2.92	3.21	3.48	3.75
5.07	**220**	2.24	2.57	2.89	3.21	3.52	3.82	4.11
5.54	**230**	2.45	2.80	3.16	3.50	3.85	4.18	4.50
6.03	**240**	2.66	3.05	3.44	3.82	4.19	4.55	4.90
6.55	**250**	2.89	3.31	3.73	4.14	4.55	4.94	5.31
7.08	**260**	3.13	3.58	4.04	4.48	4.92	5.34	5.75
7.64	**270**	3.37	3.86	4.36	4.83	5.30	5.76	6.20
8.21	**280**	3.63	4.16	4.68	5.19	5.70	6.19	6.66
8.81	**290**	3.89	4.46	5.02	5.57	6.12	6.64	7.15
9.43	**300**	4.16	4.77	5.38	5.96	6.55	7.11	7.65

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.80: Heavy Loading, 477 ACSR, Ruling Span = 250 Feet

Conductor: PELICAN | 477 kcmil | 18/1 Stranding ACSR
Area = 0.3955 sq in. | Weight = 0.517 lb/ft
Diameter = 0.814 in. | RTS = 11,800 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.752	4.04	3387	3.91	3500*
32	0.5	0	0	1.320	4.37	2361	4.08	2532
60	0	6	0	0.658	4.44	1160	3.97	1297
–20	0	0	0	0.517	1.87	2164	1.58	2556
0	0	0	0	0.517	2.44	1653	2.01	2010
30	0	0	0	0.517	3.40	1190	2.87	1410
60	0	0	0	0.517	4.29	943	3.78	1068
90	0	0	0	0.517	5.08	796	4.63	873
120	0	0	0	0.517	5.80	698	5.39	751

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1272	**1160**	**1068**	**991**	**927**	**873**	**826**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.09	**150**	1.14	1.25	1.36	1.47	1.57	1.67	1.76
2.38	**160**	1.30	1.43	1.55	1.67	1.79	1.90	2.00
2.68	**170**	1.47	1.61	1.75	1.89	2.02	2.14	2.26
3.01	**180**	1.65	1.80	1.96	2.12	2.26	2.40	2.53
3.35	**190**	1.84	2.01	2.18	2.36	2.52	2.67	2.82
3.71	**200**	2.04	2.23	2.42	2.61	2.79	2.96	3.13
4.09	**210**	2.24	2.46	2.67	2.88	3.08	3.27	3.45
4.49	**220**	2.46	2.69	2.93	3.16	3.38	3.59	3.79
4.91	**230**	2.69	2.95	3.20	3.45	3.69	3.92	4.14
5.35	**240**	2.93	3.21	3.48	3.76	4.02	4.27	4.51
5.80	**250**	3.18	3.48	3.78	4.08	4.36	4.63	4.89
6.27	**260**	3.44	3.76	4.09	4.41	4.72	5.01	5.29
6.77	**270**	3.71	4.06	4.41	4.76	5.09	5.40	5.70
7.28	**280**	3.99	4.37	4.74	5.12	5.47	5.81	6.13
7.80	**290**	4.28	4.68	5.09	5.49	5.87	6.23	6.58
8.35	**300**	4.58	5.01	5.44	5.88	6.28	6.67	7.04
8.92	**310**	4.89	5.35	5.81	6.27	6.70	7.12	7.52
9.50	**320**	5.21	5.70	6.19	6.68	7.14	7.59	8.01
10.11	**330**	5.54	6.06	6.59	7.11	7.60	8.07	8.52
10.73	**340**	5.88	6.44	6.99	7.55	8.06	8.56	9.04
11.37	**350**	6.23	6.82	7.41	8.00	8.55	9.07	9.58

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

HOME BACK

TABLE B.81: Heavy Loading, 477 ACSR, Ruling Span = 300 Feet

Conductor: PELICAN — 477 kcmil — 18/1 Stranding ACSR
Area = 0.3955 sq in. — Weight = 0.517 lb/ft
Diameter = 0.814 in. — RTS = 11,800 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.752	5.80	3404	5.64	3500*
32	0.5	0	0	1.320	6.16	2416	5.82	2554
60	0	6	0	0.658	6.21	1194	5.70	1300
–20	0	0	0	0.517	3.35	1736	2.83	2054
0	0	0	0	0.517	4.07	1429	3.48	1671
30	0	0	0	0.517	5.11	1140	4.52	1289
60	0	0	0	0.517	6.05	963	5.50	1059
90	0	0	0	0.517	6.90	845	6.40	911
120	0	0	0	0.517	7.67	760	7.22	808

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1199	**1123**	**1058**	**1001**	**952**	**909**	**871**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.41	**200**	2.16	2.30	2.44	2.58	2.72	2.84	2.97
3.76	**210**	2.38	2.54	2.70	2.85	2.99	3.14	3.27
4.12	**220**	2.61	2.79	2.96	3.12	3.29	3.44	3.59
4.51	**230**	2.85	3.04	3.23	3.41	3.59	3.76	3.93
4.91	**240**	3.10	3.32	3.52	3.72	3.91	4.10	4.28
5.33	**250**	3.37	3.60	3.82	4.03	4.24	4.44	4.64
5.76	**260**	3.64	3.89	4.13	4.36	4.59	4.81	5.02
6.21	**270**	3.93	4.20	4.46	4.71	4.95	5.18	5.41
6.68	**280**	4.22	4.51	4.79	5.06	5.32	5.58	5.82
7.17	**290**	4.53	4.84	5.14	5.43	5.71	5.98	6.24
7.67	**300**	4.85	5.18	5.50	5.81	6.11	6.40	6.68
8.19	**310**	5.18	5.53	5.87	6.20	6.52	6.83	7.13
8.73	**320**	5.52	5.89	6.26	6.61	6.95	7.28	7.60
9.28	**330**	5.87	6.27	6.66	7.03	7.39	7.74	8.08
9.85	**340**	6.23	6.65	7.06	7.46	7.85	8.22	8.58
10.44	**350**	6.60	7.05	7.49	7.91	8.32	8.71	9.09
11.04	**360**	6.98	7.46	7.92	8.37	8.80	9.22	9.62
11.67	**370**	7.38	7.88	8.37	8.84	9.29	9.74	10.16
12.31	**380**	7.78	8.31	8.82	9.32	9.80	10.27	10.72
12.96	**390**	8.20	8.75	9.30	9.82	10.33	10.82	11.29
13.64	**400**	8.62	9.21	9.78	10.33	10.86	11.38	11.88

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.82: Heavy Loading, 556 ACSR, Ruling Span = 200 Feet

Conductor: OSPREY | 556 kcmil | 18/1 Stranding ACSR
Area = 0.4612 sq in. | Weight = 0.603 lb/ft
Diameter = 0.879 in. | RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 | Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.875	2.19	4281	2.08	4500*
32	0.5	0	0	1.445	2.46	2936	2.18	3314
–20	0	0	0	0.603	0.74	4069	0.68	4411
0	0	0	0	0.603	0.97	3107	0.82	3674
30	0	0	0	0.603	1.56	1936	1.18	2562
60	0	0	0	0.603	2.36	1276	1.82	1660
90	0	0	0	0.603	3.14	960	2.62	1153
120	0	0	0	0.603	3.83	789	3.36	897
167	0	0	0	0.603	4.65	649	4.36	692

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2221	**1917**	**1660**	**1450**	**1284**	**1153**	**1049**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.16	**100**	0.34	0.39	0.46	0.52	0.59	0.66	0.72
1.41	**110**	0.41	0.47	0.55	0.63	0.71	0.79	0.87
1.67	**120**	0.49	0.57	0.66	0.75	0.85	0.94	1.03
1.96	**130**	0.57	0.66	0.77	0.88	0.99	1.11	1.21
2.28	**140**	0.67	0.77	0.89	1.02	1.15	1.28	1.41
2.62	**150**	0.77	0.88	1.02	1.17	1.32	1.47	1.61
2.98	**160**	0.87	1.00	1.16	1.33	1.50	1.68	1.84
3.36	**170**	0.98	1.13	1.31	1.50	1.70	1.89	2.07
3.77	**180**	1.10	1.27	1.47	1.68	1.90	2.12	2.32
4.20	**190**	1.23	1.42	1.64	1.88	2.12	2.36	2.59
4.65	**200**	1.36	1.57	1.82	2.08	2.35	2.62	2.87
5.13	**210**	1.50	1.73	2.01	2.29	2.59	2.89	3.16
5.63	**220**	1.65	1.90	2.20	2.52	2.84	3.17	3.47
6.15	**230**	1.80	2.08	2.41	2.75	3.11	3.46	3.80
6.70	**240**	1.96	2.26	2.62	3.00	3.38	3.77	4.13
7.27	**250**	2.13	2.45	2.84	3.25	3.67	4.09	4.48
7.86	**260**	2.30	2.65	3.08	3.52	3.97	4.43	4.85
8.47	**270**	2.48	2.86	3.32	3.79	4.28	4.77	5.23
9.11	**280**	2.67	3.08	3.57	4.08	4.61	5.14	5.63
9.78	**290**	2.86	3.30	3.83	4.37	4.94	5.51	6.03
10.46	**300**	3.06	3.53	4.10	4.68	5.29	5.90	6.46

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.83: Heavy Loading, 556 ACSR, Ruling Span = 250 Feet

Conductor: OSPREY 556 kcmil 18/1 Stranding ACSR
Area = 0.4612 sq in. Weight = 0.603 lb/ft
Diameter = 0.879 in. RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.875	3.41	4302	3.26	4500*
32	0.5	0	0	1.445	3.73	3026	3.38	3341
–20	0	0	0	0.603	1.35	3479	1.19	3965
0	0	0	0	0.603	1.78	2654	1.45	3253
30	0	0	0	0.603	2.65	1781	2.07	2279
60	0	0	0	0.603	3.59	1312	2.94	1602
90	0	0	0	0.603	4.47	1056	3.86	1222
120	0	0	0	0.603	5.24	900	4.70	1004
167	0	0	0	0.603	6.31	749	5.84	808

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		2013	**1788**	**1602**	**1449**	**1324**	**1221**	**1136**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.27	**150**	0.84	0.95	1.06	1.17	1.28	1.39	1.49
2.58	**160**	0.96	1.08	1.20	1.33	1.46	1.58	1.70
2.92	**170**	1.08	1.22	1.36	1.50	1.65	1.78	1.92
3.27	**180**	1.21	1.36	1.52	1.68	1.85	2.00	2.15
3.64	**190**	1.35	1.52	1.70	1.88	2.06	2.23	2.40
4.04	**200**	1.50	1.68	1.88	2.08	2.28	2.47	2.66
4.45	**210**	1.65	1.86	2.07	2.29	2.51	2.72	2.93
4.89	**220**	1.81	2.04	2.28	2.52	2.76	2.99	3.21
5.34	**230**	1.98	2.23	2.49	2.75	3.01	3.27	3.51
5.82	**240**	2.16	2.42	2.71	3.00	3.28	3.56	3.82
6.31	**250**	2.34	2.63	2.94	3.25	3.56	3.86	4.15
6.82	**260**	2.53	2.84	3.18	3.52	3.85	4.17	4.49
7.36	**270**	2.73	3.07	3.43	3.79	4.15	4.50	4.84
7.92	**280**	2.94	3.30	3.69	4.08	4.47	4.84	5.21
8.49	**290**	3.15	3.54	3.96	4.37	4.79	5.19	5.58
9.09	**300**	3.37	3.79	4.23	4.68	5.13	5.56	5.98
9.70	**310**	3.60	4.04	4.52	5.00	5.47	5.94	6.38
10.34	**320**	3.83	4.31	4.82	5.32	5.83	6.32	6.80
10.99	**330**	4.08	4.58	5.12	5.66	6.20	6.73	7.23
11.67	**340**	4.33	4.86	5.44	6.01	6.58	7.14	7.68
12.37	**350**	4.59	5.15	5.76	6.37	6.98	7.57	8.13

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.84: Heavy Loading, 556 ACSR, Ruling Span = 300 Feet

Conductor: OSPREY — 556 kcmil — 18/1 Stranding ACSR
Area = 0.4612 sq in. — Weight = 0.603 lb/ft
Diameter = 0.879 in. — RTS = 13,700 lb
Design data from Sag10 Chart No. 1-844 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	1.875	4.88	4325	4.69	4500*
32	0.5	0	0	1.445	5.25	3100	4.84	3364
–20	0	0	0	0.603	2.33	2916	1.96	3462
0	0	0	0	0.603	2.96	2290	2.40	2822
30	0	0	0	0.603	4.04	1682	3.31	2051
60	0	0	0	0.603	5.07	1338	4.35	1563
90	0	0	0	0.603	6.02	1129	5.34	1271
120	0	0	0	0.603	6.87	990	6.26	1086
167	0	0	0	0.603	8.06	844	7.53	903

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1859	1697	1562	1448	1352	1270	1199
		Temperature (°F)						
		40	50	60	70	80	90	100
3.58	**200**	1.62	1.78	1.93	2.08	2.23	2.37	2.52
3.95	**210**	1.79	1.96	2.13	2.30	2.46	2.62	2.77
4.33	**220**	1.96	2.15	2.34	2.52	2.70	2.87	3.04
4.74	**230**	2.15	2.35	2.56	2.76	2.95	3.14	3.33
5.16	**240**	2.34	2.56	2.78	3.00	3.21	3.42	3.62
5.60	**250**	2.53	2.78	3.02	3.26	3.49	3.71	3.93
6.05	**260**	2.74	3.00	3.27	3.52	3.77	4.01	4.25
6.53	**270**	2.96	3.24	3.52	3.80	4.07	4.33	4.58
7.02	**280**	3.18	3.48	3.79	4.09	4.37	4.65	4.93
7.53	**290**	3.41	3.74	4.06	4.38	4.69	4.99	5.29
8.06	**300**	3.65	4.00	4.35	4.69	5.02	5.34	5.66
8.61	**310**	3.90	4.27	4.64	5.01	5.36	5.70	6.04
9.17	**320**	4.15	4.55	4.95	5.34	5.71	6.08	6.44
9.75	**330**	4.42	4.84	5.26	5.67	6.07	6.46	6.85
10.35	**340**	4.69	5.14	5.59	6.02	6.45	6.86	7.27
10.97	**350**	4.97	5.44	5.92	6.38	6.83	7.27	7.70
11.61	**360**	5.26	5.76	6.26	6.75	7.23	7.69	8.15
12.26	**370**	5.55	6.08	6.62	7.13	7.64	8.12	8.61
12.93	**380**	5.86	6.42	6.98	7.52	8.05	8.57	9.08
13.62	**390**	6.17	6.76	7.35	7.93	8.48	9.02	9.57
14.33	**400**	6.49	7.11	7.73	8.34	8.92	9.49	10.06

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.85: Heavy Loading, 740 AAAC, Ruling Span = 200 Feet

Conductor: FLINT	740 kcmil	37 Stranding AAAC
Area = 0.5818 sq in.	Weight = 0.691 lb/ft	
Diameter = 0.991 in.	RTS = 24,400 lb	
Design data from Sag10 Chart No. 1-1155	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	2.034	2.30	4432	2.26	4500*
32	0.5	0	0	1.602	2.72	2949	2.55	3141
–20	0	0	0	0.691	0.83	4160	0.80	4319
0	0	0	0	0.691	1.16	2985	1.03	3343
30	0	0	0	0.691	1.95	1771	1.61	2141
60	0	0	0	0.691	2.84	1217	2.42	1430
90	0	0	0	0.691	3.62	955	3.22	1076
120	0	0	0	0.691	4.30	805	3.92	882
167	0	0	0	0.691	5.21	665	4.88	710

*Design Condition.

Largest Final Sag[1] (ft)	**Stringing Span (ft)**	**Initial Stringing Table (decimal ft)**						
		Tension (lb)						
		1849	**1614**	**1430**	**1284**	**1168**	**1075**	**998**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.30	**100**	0.47	0.54	0.61	0.67	0.74	0.81	0.87
1.58	**110**	0.57	0.65	0.73	0.81	0.90	0.97	1.05
1.88	**120**	0.67	0.77	0.87	0.97	1.07	1.16	1.25
2.20	**130**	0.79	0.90	1.02	1.14	1.25	1.36	1.46
2.55	**140**	0.92	1.05	1.19	1.32	1.45	1.58	1.70
2.93	**150**	1.05	1.20	1.36	1.51	1.67	1.81	1.95
3.33	**160**	1.20	1.37	1.55	1.72	1.89	2.06	2.21
3.76	**170**	1.35	1.55	1.75	1.94	2.14	2.33	2.50
4.22	**180**	1.51	1.73	1.96	2.18	2.40	2.61	2.80
4.70	**190**	1.69	1.93	2.18	2.43	2.67	2.91	3.12
5.21	**200**	1.87	2.14	2.42	2.69	2.96	3.22	3.46
5.74	**210**	2.06	2.36	2.67	2.97	3.26	3.55	3.81
6.30	**220**	2.26	2.59	2.93	3.25	3.58	3.90	4.19
6.89	**230**	2.47	2.83	3.20	3.56	3.91	4.26	4.58
7.50	**240**	2.69	3.08	3.48	3.87	4.26	4.64	4.98
8.14	**250**	2.92	3.34	3.78	4.20	4.63	5.03	5.41
8.80	**260**	3.16	3.62	4.09	4.55	5.00	5.44	5.85
9.50	**270**	3.41	3.90	4.41	4.90	5.39	5.87	6.31
10.21	**280**	3.67	4.19	4.74	5.27	5.80	6.31	6.78
10.95	**290**	3.93	4.50	5.09	5.66	6.22	6.77	7.27
11.72	**300**	4.21	4.82	5.45	6.05	6.66	7.25	7.79

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.86: Heavy Loading, 740 AAAC, Ruling Span = 250 Feet

Conductor: FLINT	740 kcmil	37 Stranding AAAC
Area = 0.5818 sq in.	Weight = 0.691 lb/ft	
Diameter = 0.991 in.	RTS = 24,400 lb	
Design data from Sag10 Chart No. 1-1155	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	2.034	3.61	4401	3.53	4500*
32	0.5	0	0	1.602	4.11	3046	3.89	3222
–20	0	0	0	0.691	1.61	3350	1.46	3702
0	0	0	0	0.691	2.20	2459	1.88	2865
30	0	0	0	0.691	3.24	1669	2.75	1962
60	0	0	0	0.691	4.22	1280	3.71	1456
90	0	0	0	0.691	5.09	1062	4.60	1174
120	0	0	0	0.691	5.86	923	5.41	1000
167	0	0	0	0.691	6.92	783	6.51	831

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1756	**1590**	**1455**	**1344**	**1251**	**1173**	**1106**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.49	**150**	1.11	1.22	1.34	1.45	1.56	1.66	1.76
2.83	**160**	1.26	1.39	1.52	1.65	1.77	1.88	2.00
3.20	**170**	1.42	1.57	1.72	1.86	2.00	2.13	2.26
3.59	**180**	1.59	1.76	1.92	2.08	2.24	2.38	2.53
4.00	**190**	1.77	1.96	2.14	2.32	2.50	2.66	2.82
4.43	**200**	1.96	2.18	2.37	2.57	2.76	2.94	3.12
4.88	**210**	2.17	2.40	2.62	2.84	3.05	3.25	3.44
5.36	**220**	2.38	2.63	2.87	3.11	3.35	3.56	3.78
5.86	**230**	2.60	2.88	3.14	3.40	3.66	3.89	4.13
6.38	**240**	2.83	3.13	3.42	3.70	3.98	4.24	4.50
6.92	**250**	3.07	3.40	3.71	4.02	4.32	4.60	4.88
7.48	**260**	3.32	3.68	4.01	4.35	4.67	4.98	5.28
8.07	**270**	3.58	3.97	4.33	4.69	5.04	5.37	5.69
8.68	**280**	3.85	4.26	4.65	5.04	5.42	5.77	6.12
9.31	**290**	4.13	4.58	4.99	5.41	5.81	6.19	6.57
9.96	**300**	4.42	4.90	5.34	5.79	6.22	6.62	7.03
10.64	**310**	4.72	5.23	5.70	6.18	6.64	7.07	7.50
11.34	**320**	5.03	5.57	6.08	6.59	7.08	7.54	8.00
12.06	**330**	5.35	5.92	6.46	7.00	7.53	8.02	8.50
12.80	**340**	5.68	6.29	6.86	7.44	7.99	8.51	9.03
13.56	**350**	6.02	6.66	7.27	7.88	8.47	9.02	9.56

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

HOME BACK

TABLE B.87: Heavy Loading, 740 AAAC, Ruling Span = 300 Feet

Conductor: FLINT — 740 kcmil — 37 Stranding AAAC
Area = 0.5818 sq in. — Weight = 0.691 lb/ft
Diameter = 0.991 in. — RTS = 24,400 lb
Design data from Sag10 Chart No. 1-1155 — Ice = 56 lb/ft^3

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	2.034	5.21	4393	5.09	4500*
32	0.5	0	0	1.602	5.77	3128	5.49	3284
–20	0	0	0	0.691	2.87	2708	2.51	3103
0	0	0	0	0.691	3.65	2129	3.15	2470
30	0	0	0	0.691	4.82	1616	4.23	1840
60	0	0	0	0.691	5.87	1327	5.28	1473
90	0	0	0	0.691	6.80	1145	6.25	1246
120	0	0	0	0.691	7.65	1019	7.13	1093
167	0	0	0	0.691	8.83	883	8.36	933

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1695	**1574**	**1472**	**1385**	**1310**	**1245**	**1187**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
3.92	**200**	2.04	2.20	2.35	2.50	2.64	2.78	2.91
4.33	**210**	2.25	2.42	2.59	2.75	2.91	3.06	3.21
4.75	**220**	2.47	2.66	2.84	3.02	3.19	3.36	3.52
5.19	**230**	2.70	2.90	3.10	3.30	3.49	3.67	3.85
5.65	**240**	2.94	3.16	3.38	3.60	3.80	4.00	4.19
6.13	**250**	3.19	3.43	3.67	3.90	4.13	4.34	4.55
6.63	**260**	3.45	3.71	3.97	4.22	4.46	4.69	4.92
7.15	**270**	3.72	4.00	4.28	4.55	4.81	5.06	5.31
7.69	**280**	4.00	4.30	4.60	4.90	5.17	5.44	5.71
8.25	**290**	4.29	4.62	4.93	5.25	5.55	5.84	6.12
8.83	**300**	4.59	4.94	5.28	5.62	5.94	6.25	6.55
9.43	**310**	4.90	5.27	5.64	6.00	6.34	6.67	6.99
10.05	**320**	5.22	5.62	6.01	6.39	6.76	7.11	7.45
10.68	**330**	5.55	5.98	6.39	6.80	7.19	7.56	7.93
11.34	**340**	5.90	6.35	6.78	7.22	7.63	8.03	8.41
12.02	**350**	6.25	6.72	7.19	7.65	8.09	8.51	8.92
12.72	**360**	6.61	7.11	7.60	8.09	8.55	9.00	9.43
13.43	**370**	6.98	7.51	8.03	8.55	9.04	9.51	9.96
14.17	**380**	7.36	7.93	8.47	9.02	9.53	10.03	10.51
14.92	**390**	7.76	8.35	8.92	9.50	10.04	10.56	11.07
15.70	**400**	8.16	8.78	9.39	9.99	10.56	11.11	11.64

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.88: Heavy Loading, 795 ACSR, Ruling Span = 200 Feet

Conductor: COOT	795 kcmil	36/1 Stranding ACSR
Area = 0.6417 sq in.	Weight = 0.804 lb/ft	
Diameter = 1.04 in.	RTS = 16,800 lb	
Design data from Sag10 Chart No. 1-898	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	2.173	2.72	3992	2.42	4500*
32	0.5	0	0	1.745	3.18	2750	2.71	3219
–20	0	0	0	0.804	1.27	3161	0.97	4149
0	0	0	0	0.804	1.75	2298	1.24	3234
30	0	0	0	0.804	2.58	1559	1.90	2121
60	0	0	0	0.804	3.35	1201	2.69	1493
90	0	0	0	0.804	4.03	1000	3.44	1170
120	0	0	0	0.804	4.62	871	4.10	982
167	0	0	0	0.804	5.45	740	5.00	807

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1862	**1656**	**1492**	**1362**	**1256**	**1169**	**1096**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
1.36	**100**	0.54	0.61	0.67	0.74	0.80	0.86	0.92
1.65	**110**	0.65	0.74	0.81	0.89	0.97	1.04	1.11
1.96	**120**	0.78	0.87	0.97	1.06	1.15	1.24	1.32
2.30	**130**	0.91	1.03	1.14	1.25	1.35	1.45	1.55
2.67	**140**	1.06	1.19	1.32	1.45	1.57	1.69	1.80
3.07	**150**	1.22	1.37	1.51	1.66	1.80	1.94	2.06
3.49	**160**	1.38	1.56	1.72	1.89	2.05	2.20	2.35
3.94	**170**	1.56	1.76	1.94	2.13	2.31	2.49	2.65
4.41	**180**	1.75	1.97	2.18	2.39	2.59	2.79	2.97
4.92	**190**	1.95	2.19	2.43	2.66	2.89	3.10	3.31
5.45	**200**	2.16	2.43	2.69	2.95	3.20	3.44	3.67
6.01	**210**	2.38	2.68	2.97	3.25	3.53	3.79	4.05
6.59	**220**	2.61	2.94	3.25	3.57	3.87	4.16	4.44
7.21	**230**	2.86	3.21	3.56	3.90	4.23	4.55	4.85
7.85	**240**	3.11	3.50	3.87	4.25	4.61	4.95	5.28
8.52	**250**	3.38	3.80	4.20	4.61	5.00	5.38	5.73
9.21	**260**	3.65	4.11	4.55	4.99	5.41	5.81	6.20
9.93	**270**	3.94	4.43	4.90	5.38	5.83	6.27	6.69
10.68	**280**	4.23	4.76	5.27	5.78	6.27	6.74	7.19
11.46	**290**	4.54	5.11	5.66	6.20	6.73	7.23	7.72
12.26	**300**	4.86	5.47	6.05	6.64	7.20	7.74	8.26

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

TABLE B.89: Heavy Loading, 795 ACSR, Ruling Span = 250 Feet

Conductor: COOT	795 kcmil	36/1 Stranding ACSR
Area = 0.6417 sq in.	Weight = 0.804 lb/ft	
Diameter = 1.04 in.	RTS = 16,800 lb	
Design data from Sag10 Chart No. 1-898	Ice = 56 lb/ft^3	

Design Points

Creep IS a Factor					Final		Initial	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	2.173	4.22	4028	3.78	4500*
32	0.5	0	0	1.745	4.73	2886	4.13	3304
–20	0	0	0	0.804	2.47	2542	1.79	3506
0	0	0	0	0.804	3.12	2016	2.28	2758
30	0	0	0	0.804	4.05	1551	3.18	1979
60	0	0	0	0.804	4.89	1285	4.08	1539
90	0	0	0	0.804	5.64	1115	4.91	1281
120	0	0	0	0.804	6.32	996	5.66	1113
167	0	0	0	0.804	7.28	866	6.69	942

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1802	**1658**	**1538**	**1438**	**1353**	**1279**	**1216**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
2.62	**150**	1.26	1.36	1.47	1.57	1.67	1.77	1.86
2.98	**160**	1.43	1.55	1.67	1.79	1.90	2.01	2.12
3.37	**170**	1.61	1.75	1.89	2.02	2.15	2.27	2.39
3.77	**180**	1.81	1.96	2.12	2.27	2.41	2.55	2.68
4.20	**190**	2.02	2.19	2.36	2.52	2.69	2.84	2.99
4.66	**200**	2.23	2.43	2.61	2.80	2.98	3.14	3.31
5.14	**210**	2.46	2.67	2.88	3.08	3.28	3.46	3.65
5.64	**220**	2.70	2.93	3.16	3.38	3.60	3.80	4.00
6.16	**230**	2.95	3.21	3.45	3.70	3.94	4.16	4.38
6.71	**240**	3.22	3.49	3.76	4.03	4.29	4.53	4.76
7.28	**250**	3.49	3.79	4.08	4.37	4.65	4.91	5.17
7.87	**260**	3.77	4.10	4.41	4.73	5.03	5.31	5.59
8.49	**270**	4.07	4.42	4.76	5.10	5.42	5.73	6.03
9.13	**280**	4.38	4.75	5.12	5.48	5.83	6.16	6.49
9.80	**290**	4.70	5.10	5.49	5.88	6.26	6.61	6.96
10.48	**300**	5.03	5.46	5.88	6.29	6.70	7.07	7.44
11.19	**310**	5.37	5.83	6.27	6.72	7.15	7.55	7.95
11.93	**320**	5.72	6.21	6.68	7.16	7.62	8.04	8.47
12.68	**330**	6.08	6.60	7.11	7.61	8.10	8.56	9.01
13.47	**340**	6.46	7.01	7.55	8.08	8.60	9.08	9.56
14.27	**350**	6.84	7.43	8.00	8.57	9.11	9.62	10.13

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

B

TABLE B.90: Heavy Loading, 795 ACSR, Ruling Span = 300 Feet								
Conductor: COOT			795 kcmil		36/1 Stranding ACSR			
Area = 0.6417 sq in.			Weight = 0.804 lb/ft					
Diameter = 1.04 in.			RTS = 16,800 lb					
Design data from Sag10 Chart No. 1-898			Ice = 56 lb/ft^3					
Design Points								
Creep IS a Factor					**Final**		**Initial**	
Temp (°F)	**Ice (in.)**	**Wind (psf)**	**K (lb/ft)**	**Weight (lb/ft)**	**Sag (ft)**	**Tension (lb)**	**Sag (ft)**	**Tension (lb)**
0	0.5	4	0.3	2.173	6.00	4078	5.44	4500*
32	0.5	0	0	1.745	6.56	2999	5.84	3367
–20	0	0	0	0.804	4.11	2200	3.09	2933
0	0	0	0	0.804	4.83	1876	3.76	2409
30	0	0	0	0.804	5.82	1558	4.79	1888
60	0	0	0	0.804	6.71	1351	5.77	1570
90	0	0	0	0.804	7.52	1206	6.66	1361
120	0	0	0	0.804	8.26	1098	7.47	1214
167	0	0	0	0.804	9.33	974	8.61	1054

*Design Condition.

Largest Final Sag[1] (ft)	Stringing Span (ft)	Initial Stringing Table (decimal ft)						
		Tension (lb)						
		1764	**1659**	**1569**	**1490**	**1421**	**1360**	**1305**
		Temperature (°F)						
		40	**50**	**60**	**70**	**80**	**90**	**100**
4.15	**200**	2.28	2.42	2.56	2.70	2.83	2.96	3.08
4.57	**210**	2.51	2.67	2.83	2.97	3.12	3.26	3.40
5.02	**220**	2.76	2.93	3.10	3.26	3.43	3.58	3.73
5.48	**230**	3.02	3.20	3.39	3.57	3.74	3.91	4.07
5.97	**240**	3.28	3.49	3.69	3.88	4.08	4.26	4.44
6.48	**250**	3.56	3.78	4.01	4.22	4.42	4.63	4.81
7.01	**260**	3.85	4.09	4.33	4.56	4.78	5.00	5.21
7.56	**270**	4.16	4.41	4.67	4.92	5.16	5.39	5.61
8.13	**280**	4.47	4.75	5.03	5.29	5.55	5.80	6.04
8.72	**290**	4.79	5.09	5.39	5.67	5.95	6.22	6.48
9.33	**300**	5.13	5.45	5.77	6.07	6.37	6.66	6.93
9.96	**310**	5.48	5.82	6.16	6.48	6.80	7.11	7.40
10.62	**320**	5.84	6.20	6.56	6.91	7.25	7.58	7.88
11.29	**330**	6.21	6.59	6.98	7.34	7.71	8.06	8.39
11.98	**340**	6.59	7.00	7.41	7.80	8.18	8.55	8.90
12.70	**350**	6.98	7.42	7.85	8.26	8.67	9.07	9.43
13.44	**360**	7.39	7.85	8.31	8.74	9.17	9.59	9.98
14.19	**370**	7.80	8.29	8.78	9.23	9.69	10.13	10.54
14.97	**380**	8.23	8.74	9.26	9.74	10.22	10.69	11.12
15.77	**390**	8.67	9.21	9.75	10.26	10.77	11.26	11.71
16.59	**400**	9.12	9.69	10.26	10.79	11.32	11.84	12.32

[1] Largest final sag is defined by 2023 *NESC* Rule 232A.

C

Horizontal Pull and Total Guy Load at Angles for 30- to 55-Foot Poles Using Grade C Construction

Tables begin on next page.

C

TABLE C.1: Light Loading District: Single Phase—4 ACSR Primary and Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.1928
Neutral = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.1928
Pole = 55'/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	837	1181	1507	1876	1013	1428	1823	2268
4	931	1313	1676	2086	1106	1560	1991	2478
6	1025	1445	1844	2295	1200	1692	2159	2687
8	1118	1576	2012	2504	1293	1823	2328	2897
10	1211	1708	2180	2713	1386	1955	2496	3106
12	1304	1839	2348	2922	1480	2086	2663	3314
14	1397	1970	2515	3130	1573	2217	2831	3522
16	1490	2101	2682	3338	1665	2348	2997	3730
18	1583	2231	2849	3545	1758	2479	3164	3938
20	1675	2362	3015	3752	1850	2609	3330	4144
22	1767	2491	3180	3958	1942	2738	3496	4350
24	1859	2621	3345	4163	2034	2868	3661	4556
26	1950	2749	3510	4368	2125	2996	3825	4760
28	2041	2878	3674	4572	2216	3125	3989	4964
30	2132	3005	3837	4775	2307	3252	4152	5167
32	2222	3133	3999	4977	2397	3380	4314	5369
34	2311	3259	4161	5178	2487	3506	4476	5570
36	2401	3385	4321	5377	2576	3632	4637	5770
38	2489	3510	4481	5576	2665	3757	4796	5969
40	2578	3634	4640	5774	2753	3881	4955	6166
42	2665	3758	4797	5970	2840	4005	5113	6363
44	2752	3881	4954	6165	2928	4128	5270	6558
46	2839	4003	5110	6359	3014	4250	5425	6751

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.2: Light Loading District: Single Phase—2 ACSR Primary and Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 2 ACSR 6/1 Neutral = (1) 2 ACSR 6/1 Pole = 55'/1 NWC Bending Moment (ft-lb) = 10,060	Design Tension (lb) = 1425 Design Tension (lb) = 1425 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.2370 Wind Load (lb/ft) = 0.2370 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	917	1293	1651	2054	1133	1597	2039	2537
4	1030	1452	1854	2307	1245	1756	2242	2790
6	1143	1612	2057	2560	1358	1915	2445	3043
8	1256	1771	2260	2813	1471	2074	2648	3295
10	1368	1930	2463	3065	1584	2233	2851	3548
12	1481	2088	2666	3317	1696	2392	3053	3800
14	1593	2246	2868	3569	1809	2550	3255	4051
16	1705	2404	3069	3820	1921	2708	3457	4302
18	1817	2562	3271	4070	2032	2866	3658	4552
20	1928	2719	3471	4320	2144	3023	3859	4802
22	2040	2876	3671	4569	2255	3179	4059	5051
24	2150	3032	3871	4817	2366	3336	4258	5299
26	2261	3187	4069	5064	2476	3491	4457	5546
28	2370	3342	4267	5310	2586	3646	4655	5792
30	2480	3497	4464	5555	2695	3800	4851	6037
32	2589	3650	4660	5799	2804	3954	5047	6281
34	2697	3803	4855	6042	2912	4107	5242	6524
36	2805	3955	5049	6283	3020	4259	5436	6765
38	2912	4106	5242	6523	3127	4410	5629	7005
40	3019	4256	5433	6762	3234	4560	5821	7244
42	3124	4405	5624	6999	3340	4709	6012	7481
44	3230	4554	5813	7234	3445	4857	6201	7717
46	3334	4701	6001	7468	3549	5005	6389	7950

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.3: Light Loading District: Single Phase—1/0 ACSR Primary and Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 1/0 ACSR 6/1 Neutral = (1) 1/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,600	Design Tension (lb) = 2190 Design Tension (lb) = 2190 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.2985 Wind Load (lb/ft) = 0.2985 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1062	1497	1911	2378	1333	1879	2399	2986
4	1235	1742	2223	2767	1507	2124	2712	3375
6	1409	1986	2536	3156	1680	2369	3024	3763
8	1582	2231	2848	3544	1853	2613	3336	4151
10	1755	2475	3159	3932	2026	2857	3648	4539
12	1928	2719	3471	4319	2199	3101	3959	4926
14	2101	2962	3781	4705	2372	3344	4269	5313
16	2273	3205	4091	5091	2544	3587	4579	5699
18	2445	3447	4400	5476	2716	3829	4888	6083
20	2616	3688	4709	5859	2887	4071	5197	6467
22	2787	3929	5016	6242	3058	4312	5504	6850
24	2957	4169	5322	6623	3228	4551	5810	7231
26	3126	4408	5627	7003	3398	4791	6116	7611
28	3295	4646	5931	7381	3566	5029	6420	7989
30	3463	4883	6234	7758	3735	5266	6722	8365
32	3631	5119	6535	8133	3902	5502	7023	8740
34	3797	5354	6835	8506	4068	5736	7323	9113
36	3963	5588	7133	8877	4234	5970	7621	9484
38	4127	5820	7429	9246	4399	6202	7918	9853
40	4291	6051	7724	9612	4562	6433	8212	10,220
42	4454	6280	8017	9977	4725	6662	8505	10,584
44	4615	6508	8308	10,339	4887	6890	8796	10,946
46	4776	6734	8597	10,698	5047	7116	9085	11,306

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.4: Light Loading District: Three Phase—4 ACSR Primary and Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 4 ACSR 7/1 Neutral = (1) 4 ACSR 7/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,600	Design Tension (lb) = 1180 Design Tension (lb) = 1180 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.1928 Wind Load (lb/ft) = 0.1928 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1194	1683	2149	2674	1544	2177	2780	3459
4	1381	1947	2486	3093	1731	2441	3116	3878
6	1568	2211	2822	3512	1918	2705	3453	4297
8	1755	2474	3158	3931	2105	2968	3789	4715
10	1941	2737	3494	4348	2292	3231	4125	5133
12	2128	3000	3830	4766	2478	3494	4460	5551
14	2313	3262	4164	5182	2664	3756	4795	5967
16	2499	3524	4498	5598	2849	4018	5129	6383
18	2684	3785	4831	6012	3034	4279	5462	6797
20	2869	4045	5164	6426	3219	4539	5794	7211
22	3053	4304	5495	6838	3403	4798	6126	7623
24	3236	4563	5825	7249	3586	5057	6456	8034
26	3419	4820	6154	7658	3769	5315	6785	8443
28	3601	5077	6481	8066	3951	5571	7112	8851
30	3782	5333	6807	8472	4132	5827	7438	9256
32	3962	5587	7132	8875	4313	6081	7763	9660
34	4142	5840	7455	9277	4492	6334	8086	10,062
36	4320	6091	7776	9677	4671	6586	8407	10,462
38	4498	6342	8096	10,075	4848	6836	8726	10,860
40	4674	6590	8413	10,470	5024	7084	9044	11,255
42	4849	6838	8729	10,863	5200	7332	9360	11,647
44	5023	7083	9042	11,253	5374	7577	9673	12,037
46	5196	7327	9353	11,640	5547	7821	9984	12,425

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.5: Light Loading District: Three Phase—2 ACSR Primary and Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 2 ACSR 6/1 Neutral = (1) 2 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,060	Design Tension (lb) = 1425 Design Tension (lb) = 1425 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.2370 Wind Load (lb/ft) = 0.2370 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1353	1908	2436	3031	1784	2515	3211	3996
4	1579	2227	2842	3537	2010	2834	3618	4502
6	1805	2545	3249	4043	2236	3152	4024	5008
8	2030	2863	3655	4548	2461	3470	4430	5513
10	2256	3181	4060	5053	2687	3788	4836	6018
12	2481	3498	4465	5557	2911	4105	5241	6522
14	2705	3814	4870	6060	3136	4422	5645	7025
16	2929	4130	5273	6562	3360	4738	6048	7527
18	3153	4446	5675	7062	3584	5053	6450	8027
20	3376	4760	6076	7562	3806	5367	6852	8527
22	3598	5073	6476	8059	4029	5680	7252	9024
24	3819	5385	6875	8556	4250	5993	7650	9520
26	4040	5697	7272	9050	4471	6304	8047	10,015
28	4260	6006	7668	9542	4691	6614	8443	10,507
30	4479	6315	8062	10,032	4909	6922	8837	10,997
32	4696	6622	8454	10,520	5127	7229	9229	11,485
34	4913	6927	8844	11,005	5344	7535	9619	11,970
36	5129	7231	9232	11,488	5559	7839	10,007	12,453
38	5343	7534	9617	11,968	5774	8141	10,393	12,933
40	5556	7834	10,001	12,445	5987	8441	10,776	13,410
42	5768	8132	10,382	12,920	6198	8740	11,157	13,884
44	5978	8429	10,760	13,391	6409	9036	11,536	14,355
46	6187	8723	11,136	13,858	6617	9331	11,911	14,823

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.6: Light Loading District: Three Phase—1/0 ACSR Primary and 2 ACSR Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 1/0 ACSR 6/1	Design Tension (lb) = 2190	Wind Load (lb/ft) = 0.2985
Neutral = (1) 2 ACSR 6/1	Design Tension (lb) = 1425	Wind Load (lb/ft) = 0.2370
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 10,060	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1570	2214	2826	3517	2084	2939	3752	4669
4	1887	2660	3396	4226	2401	3386	4322	5379
6	2204	3107	3966	4936	2718	3832	4893	6088
8	2520	3553	4536	5645	3034	4279	5462	6797
10	2836	3999	5105	6352	3350	4724	6031	7505
12	3151	4444	5673	7059	3666	5169	6599	8212
14	3466	4888	6240	7765	3981	5613	7166	8917
16	3781	5331	6805	8469	4295	6056	7731	9621
18	4094	5773	7370	9171	4609	6498	8296	10,324
20	4407	6214	7932	9871	4921	6939	8859	11,024
22	4719	6653	8493	10,570	5233	7379	9420	11,722
24	5029	7091	9052	11,265	5544	7817	9979	12,418
26	5339	7527	9610	11,959	5853	8253	10,536	13,111
28	5647	7962	10,164	12,649	6161	8688	11,091	13,802
30	5954	8395	10,717	13,336	6468	9120	11,643	14,489
32	6259	8826	11,267	14,021	6774	9551	12,193	15,173
34	6563	9254	11,814	14,702	7078	9980	12,740	15,854
36	6865	9680	12,358	15,379	7380	10,406	13,284	16,531
38	7166	10,104	12,899	16,052	7681	10,830	13,825	17,205
40	7465	10,526	13,437	16,721	7979	11,251	14,363	17,874
42	7762	10,944	13,971	17,387	8276	11,670	14,897	18,539
44	8057	11,360	14,502	18,047	8571	12,086	15,428	19,200
46	8350	11,773	15,029	18,703	8864	12,498	15,956	19,856

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.7: Light Loading District: Three Phase—3/0 ACSR Primary and 1/0 ACSR Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 3/0 ACSR 6/1 Neutral = (1) 1/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,060	Design Tension (lb) = 3310 Design Tension (lb) = 2190 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.3765 Wind Load (lb/ft) = 0.2985 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1935	2728	3483	4334	2584	3643	4651	5787
4	2415	3405	4347	5410	3064	4320	5515	6863
6	2895	4082	5212	6486	3544	4997	6379	7939
8	3375	4759	6075	7560	4024	5674	7243	9013
10	3854	5434	6937	8633	4503	6349	8105	10,086
12	4332	6109	7798	9705	4981	7023	8966	11,158
14	4810	6782	8658	10,774	5459	7697	9826	12,227
16	5286	7454	9515	11,841	5935	8368	10,683	13,295
18	5762	8124	10,371	12,906	6410	9039	11,539	14,359
20	6235	8792	11,224	13,967	6884	9707	12,392	15,421
22	6708	9458	12,074	15,026	7357	10,373	13,242	16,479
24	7179	10,122	12,922	16,081	7828	11,037	14,090	17,534
26	7648	10,784	13,766	17,132	8297	11,699	14,934	18,585
28	8115	11,443	14,608	18,178	8764	12,357	15,775	19,632
30	8581	12,099	15,445	19,220	9229	13,013	16,613	20,674
32	9044	12,751	16,278	20,258	9692	13,666	17,446	21,711
34	9504	13,401	17,108	21,290	10,153	14,316	18,276	22,743
36	9963	14,047	17,933	22,316	10,611	14,962	19,101	23,770
38	10,418	14,690	18,753	23,337	11,067	15,605	19,921	24,790
40	10,871	15,329	19,568	24,352	11,520	16,243	20,736	25,805
42	11,321	15,963	20,379	25,360	11,970	16,878	21,546	26,813
44	11,769	16,594	21,183	26,362	12,417	17,508	22,351	27,815
46	12,213	17,220	21,983	27,356	12,861	18,134	23,150	28,809

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.8: Light Loading District: Three Phase—4/0 ACSR Primary and 1/0 ACSR Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 4/0 ACSR 6/1 Neutral = (1) 1/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,060	Design Tension (lb) = 4000 Design Tension (lb) = 2190 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.4223 Wind Load (lb/ft) = 0.2985 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2111	2976	3799	4728	2822	3979	5079	6321
4	2673	3769	4811	5988	3384	4772	6092	7581
6	3235	4561	5823	7247	3946	5564	7103	8840
8	3797	5353	6834	8505	4508	6356	8114	10,098
10	4358	6144	7844	9761	5069	7147	9124	11,354
12	4918	6934	8852	11,015	5629	7937	10,132	12,609
14	5477	7722	9858	12,267	6188	8725	11,138	13,861
16	6034	8508	10,862	13,517	6746	9511	12,142	15,110
18	6591	9293	11,863	14,763	7302	10,296	13,144	16,357
20	7146	10,075	12,862	16,006	7857	11,078	14,142	17,600
22	7699	10,855	13,858	17,246	8410	11,858	15,138	18,839
24	8250	11,633	14,850	18,480	8961	12,636	16,131	20,074
26	8800	12,407	15,839	19,711	9511	13,410	17,119	21,304
28	9347	13,179	16,824	20,936	10,058	14,182	18,104	22,529
30	9891	13,947	17,804	22,156	10,603	14,950	19,085	23,750
32	10,433	14,711	18,780	23,371	11,145	15,714	20,060	24,964
34	10,973	15,472	19,751	24,579	11,684	16,475	21,031	26,172
36	11,509	16,228	20,717	25,781	12,221	17,231	21,997	27,374
38	12,043	16,981	21,677	26,976	12,754	17,983	22,958	28,569
40	12,573	17,728	22,632	28,164	13,285	18,731	23,912	29,757
42	13,100	18,471	23,581	29,345	13,812	19,474	24,861	30,938
44	13,624	19,210	24,523	30,517	14,335	20,212	25,803	32,110
46	14,144	19,942	25,458	31,682	14,855	20,945	26,739	33,275

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.9: Light Loading District: Three Phase—336.4 ACSR Primary and 4/0 ACSR Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 336.4 ACSR 18/1	Design Tension (lb) = 4000	Wind Load (lb/ft) = 0.5130
Neutral = (1) 4/0 ACSR 6/1	Design Tension (lb) = 4000	Wind Load (lb/ft) = 0.4223
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 10,060	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2452	3458	4414	5493	3343	4714	6018	7489
4	3086	4352	5555	6913	3977	5608	7159	8909
6	3720	5245	6696	8333	4611	6502	8300	10,329
8	4353	6138	7836	9751	5244	7395	9440	11,747
10	4986	7030	8974	11,168	5877	8286	10,578	13,164
12	5617	7920	10,111	12,582	6508	9177	11,715	14,579
14	6247	8809	11,245	13,994	7139	10,065	12,849	15,990
16	6876	9696	12,378	15,403	7768	10,952	13,982	17,399
18	7504	10,580	13,507	16,809	8395	11,837	15,111	18,805
20	8130	11,463	14,633	18,210	9021	12,719	16,237	20,206
22	8753	12,342	15,756	19,607	9644	13,599	17,360	21,603
24	9375	13,219	16,875	21,000	10,266	14,475	18,479	22,996
26	9994	14,092	17,990	22,387	10,885	15,348	19,594	24,383
28	10,611	14,962	19,100	23,769	11,502	16,218	20,704	25,765
30	11,225	15,828	20,206	25,145	12,116	17,084	21,810	27,141
32	11,837	16,690	21,306	26,514	12,728	17,946	22,910	28,510
34	12,445	17,547	22,401	27,877	13,336	18,804	24,005	29,873
36	13,050	18,400	23,490	29,232	13,941	19,657	25,094	31,228
38	13,651	19,249	24,573	30,579	14,543	20,505	26,177	32,575
40	14,249	20,092	25,649	31,919	15,141	21,348	27,253	33,915
42	14,844	20,930	26,719	33,250	15,735	22,186	28,323	35,246
44	15,434	21,762	27,781	34,572	16,325	23,018	29,385	36,568
46	16,020	22,588	28,836	35,885	16,911	23,845	30,440	37,881

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.10: Light Loading District: Three Phase—477 ACSR Primary and 4/0 ACSR Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 477 ACSR 18/1	Design Tension (lb) = 4000	Wind Load (lb/ft) = 0.6105
Neutral = (1) 4 ACSR 6/1	Design Tension (lb) = 4000	Wind Load (lb/ft) = 0.4223
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 10,060	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2652	3739	4773	5939	3676	5182	6616	8233
4	3286	4633	5914	7360	4310	6077	7757	9654
6	3919	5526	7055	8780	4943	6970	8898	11073
8	4553	6419	8195	10,198	5577	7863	10,038	12,492
10	5185	7311	9333	11,615	6209	8755	11,176	13,908
12	5817	8201	10,470	13,029	6841	9645	12,313	15,323
14	6447	9090	11,604	14,441	7471	10,534	13,448	16,735
16	7076	9977	12,736	15,850	8100	11,421	14,580	18,144
18	7703	10,862	13,866	17,255	8727	12,305	15,709	19,549
20	8329	11,744	14,992	18,657	9353	13,188	16,835	20,950
22	8953	12,623	16,115	20,054	9977	14,067	17,958	22,348
24	9574	13,500	17,234	21,446	10,598	14,944	19,077	23,740
26	10,194	14,373	18,349	22,834	11,218	15,817	20,192	25,128
28	10,810	15,243	19,459	24,215	11,834	16,687	21,302	26,509
30	11,425	16,109	20,564	25,591	12,449	17,553	22,408	27,885
32	12,036	16,971	21,665	26,961	13,060	18,415	23,508	29,254
34	12,644	17,828	22,760	28,323	13,668	19,272	24,603	30,617
36	13,249	18,681	23,849	29,678	14,273	20,125	25,692	31,972
38	13,851	19,530	24,932	31,026	14,875	20,974	26,775	33,320
40	14,449	20,373	26,008	32,365	15,473	21,817	27,851	34,659
42	15,043	21,211	27,077	33,696	16,067	22,655	28,921	35,990
44	15,633	22,043	28,140	35,019	16,657	23,487	29,983	37,312
46	16,219	22,869	29,195	36,331	17,243	24,313	31,038	38,625

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.11: Light Loading District: Three Phase—556 ACSR Primary and 336 ACSR Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 556 ACSR 18/1 Neutral = (1) 336 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,060	Design Tension (lb) = 4500 Design Tension (lb) = 3500 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.6593 Wind Load (lb/ft) = 0.5130 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2287	3224	4116	5123	3136	4421	5644	7024
4	2961	4175	5329	6632	3809	5371	6857	8533
6	3634	5124	6541	8140	4483	6321	8069	10,042
8	4307	6073	7752	9647	5156	7269	9280	11,549
10	4979	7020	8962	11,152	5828	8217	10,490	13,054
12	5650	7966	10,169	12,655	6499	9163	11,697	14,557
14	6319	8910	11,375	14,155	7168	10,107	12,903	16,057
16	6988	9853	12,578	15,652	7836	11,049	14,106	17,554
18	7654	10,793	13,778	17,146	8503	11,989	15,306	19,047
20	8319	11,730	14,974	18,635	9168	12,927	16,502	20,536
22	8982	12,664	16,167	20,119	9831	13,861	17,695	22,021
24	9642	13,596	17,356	21,599	10,491	14,792	18,884	23,500
26	10,300	14,524	18,541	23,073	11,149	15,720	20,069	24,974
28	10,956	15,448	19,720	24,541	11,805	16,644	21,248	26,442
30	11,608	16,368	20,895	26,003	12,457	17,565	22,423	27,904
32	12,258	17,284	22,064	27,458	13,107	18,480	23,592	29,359
34	12,904	18,195	23,227	28,905	13,753	19,392	24,755	30,807
36	13,547	19,101	24,385	30,345	14,396	20,298	25,912	32,247
38	14,186	20,002	25,535	31,777	15,035	21,199	27,063	33,678
40	14,822	20,898	26,679	33,200	15,670	22,095	28,207	35,102
42	15,453	21,789	27,815	34,614	16,302	22,985	29,343	36,516
44	16,080	22,673	28,944	36,019	16,929	23,870	30,472	37,921
46	16,703	23,551	30,065	37,414	17,552	24,748	31,593	39,315

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.12: Light Loading District: Three Phase—740 AAAC Primary and 336 ACSR Neutral

Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 740 AAAC 37 Neutral = (1) 336 ACSR 18/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,060	Design Tension (lb) = 4500 Design Tension (lb) = 3000 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.7433 Wind Load (lb/ft) = 0.5130 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2382	3358	4287	5335	3316	4676	5969	7428
4	3036	4280	5464	6800	3970	5598	7146	8893
6	3689	5202	6640	8264	4624	6520	8323	10,357
8	4342	6122	7816	9726	5277	7440	9498	11,820
10	4994	7042	8990	11,187	5929	8360	10,672	13,281
12	5645	7960	10,162	12,646	6580	9278	11,844	14,740
14	6295	8877	11,332	14,102	7230	10,195	13,014	16,196
16	6944	9791	12,499	15,555	7879	11,109	14,182	17,648
18	7591	10,703	13,664	17,004	8526	12,021	15,346	19,098
20	8236	11,613	14,825	18,449	9171	12,931	16,508	20,543
22	8880	12,520	15,983	19,890	9814	13,838	17,666	21,984
24	9521	13,424	17,137	21,326	10,455	14,742	18,820	23,420
26	10,159	14,325	18,287	22,757	11,094	15,643	19,969	24,851
28	10,795	15,222	19,432	24,182	11,730	16,540	21,114	26,276
30	11,429	16,115	20,572	25,601	12,364	17,433	22,254	27,694
32	12,059	17,004	21,707	27,013	12,994	18,321	23,389	29,106
34	12,687	17,888	22,836	28,418	13,621	19,206	24,518	30,512
36	13,310	18,768	23,959	29,815	14,245	20,086	25,641	31,909
38	13,931	19,643	25,076	31,205	14,866	20,960	26,758	33,299
40	14,548	20,512	26,186	32,586	15,482	21,830	27,868	34,680
42	15,160	21,376	27,289	33,959	16,095	22,694	28,971	36,053
44	15,769	22,234	28,384	35,323	16,704	23,552	30,067	37,416
46	16,373	23,087	29,472	36,676	17,308	24,404	31,155	38,770

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.13: Light Loading District: Three Phase—795 ACSR Primary and 336 ACSR Neutral		
Light Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 795 ACSR 18/1 Neutral = (1) 336 ACSR 18/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 10,060	Design Tension (lb) = 4500 Design Tension (lb) = 2600 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.7800 Wind Load (lb/ft) = 0.5130 Wind LF = 2.2 Guy Attachment Height (ft) = 46

	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
		Total Guy Load (lb)				Total Guy Load (lb)		
Line Angle (degrees)	**Horizontal Pull (lb)**	**1-to-1 Guy Lead**	**2-to-3 Guy Lead**	**1-to-2 Guy Lead**	**Horizontal Pull (lb)**	**1-to-1 Guy Lead**	**2-to-3 Guy Lead**	**1-to-2 Guy Lead**
2	2416	3406	4348	5411	3388	4777	6098	7589
4	3054	4306	5497	6841	4026	5677	7247	9018
6	3692	5205	6645	8269	4664	6576	8395	10,447
8	4329	6104	7792	9696	5301	7474	9542	11,874
10	4965	7001	8937	11,122	5937	8372	10,687	13,300
12	5601	7897	10,081	12,545	6573	9268	11,831	14,723
14	6235	8791	11,223	13,966	7207	10,162	12,973	16,144
16	6868	9683	12,362	15,384	7840	11,054	14,112	17,561
18	7499	10,574	13,498	16,798	8471	11,944	15,248	18,975
20	8129	11,461	14,631	18,208	9101	12,832	16,381	20,386
22	8756	12,346	15,761	19,614	9728	13,717	17,511	21,792
24	9382	13,228	16,887	21,015	10,354	14,599	18,637	23,193
26	10,005	14,107	18,009	22,411	10,977	15,478	19,759	24,589
28	10,626	14,982	19,126	23,802	11,598	16,353	20,876	25,979
30	11,244	15,854	20,239	25,186	12,216	17,224	21,989	27,364
32	11,859	16,721	21,346	26,564	12,831	18,092	23,096	28,741
34	12,471	17,584	22,448	27,935	13,443	18,955	24,198	30,112
36	13,080	18,442	23,543	29,298	14,052	19,813	25,293	31,476
38	13,685	19,296	24,633	30,654	14,657	20,667	26,383	32,832
40	14,287	20,144	25,716	32,002	15,259	21,515	27,466	34,180
42	14,885	20,987	26,792	33,342	15,857	22,358	28,542	35,519
44	15,479	21,825	27,862	34,672	16,451	23,196	29,611	36,850
46	16,068	22,656	28,923	35,993	17,041	24,027	30,673	38,171

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.14: Medium Loading District: Single Phase—4 ACSR Primary and Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.2523
Neutral = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.2523
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	651	918	1172	1459	881	1242	1585	1972
4	745	1050	1341	1668	974	1373	1753	2182
6	838	1182	1509	1878	1068	1505	1922	2391
8	932	1314	1677	2087	1161	1637	2090	2601
10	1025	1445	1845	2296	1254	1769	2258	2810
12	1118	1577	2013	2505	1347	1900	2425	3018
14	1211	1708	2180	2713	1440	2031	2593	3226
16	1304	1838	2347	2921	1533	2162	2760	3434
18	1396	1969	2514	3128	1626	2292	2926	3642
20	1489	2099	2680	3335	1718	2422	3092	3848
22	1581	2229	2845	3541	1810	2552	3258	4054
24	1672	2358	3010	3746	1902	2681	3423	4260
26	1764	2487	3175	3951	1993	2810	3587	4464
28	1855	2615	3339	4155	2084	2938	3751	4668
30	1945	2743	3502	4358	2175	3066	3914	4871
32	2036	2870	3664	4560	2265	3193	4077	5073
34	2125	2997	3825	4760	2354	3320	4238	5274
36	2214	3122	3986	4960	2444	3446	4399	5474
38	2303	3248	4146	5159	2532	3571	4558	5673
40	2391	3372	4305	5357	2621	3695	4717	5870
42	2479	3495	4462	5553	2708	3819	4875	6067
44	2566	3618	4619	5748	2795	3941	5032	6262
46	2653	3740	4775	5942	2882	4063	5187	6455

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.15: Medium Loading District: Single Phase—2 ACSR Primary and Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 2 ACSR 6/1 Neutral = (1) 2 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 1425 Design Tension (lb) = 1425 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.2720 Wind Load (lb/ft) = 0.2720 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	698	984	1256	1563	945	1332	1701	2116
4	811	1143	1459	1816	1058	1491	1904	2369
6	923	1302	1662	2068	1171	1651	2107	2622
8	1036	1461	1865	2321	1283	1810	2310	2875
10	1149	1620	2068	2573	1396	1968	2513	3127
12	1261	1778	2270	2825	1509	2127	2715	3379
14	1374	1937	2473	3077	1621	2285	2917	3631
16	1486	2095	2674	3328	1733	2443	3119	3882
18	1597	2252	2875	3578	1845	2601	3320	4132
20	1709	2409	3076	3828	1956	2758	3521	4381
22	1820	2566	3276	4077	2067	2915	3721	4630
24	1931	2722	3475	4325	2178	3071	3920	4878
26	2041	2878	3674	4572	2288	3226	4119	5126
28	2151	3033	3872	4818	2398	3381	4317	5372
30	2260	3187	4069	5063	2507	3536	4513	5617
32	2369	3341	4265	5307	2616	3689	4709	5861
34	2478	3493	4460	5550	2725	3842	4904	6103
36	2585	3645	4654	5791	2832	3994	5098	6345
38	2692	3796	4846	6031	2940	4145	5291	6585
40	2799	3947	5038	6270	3046	4295	5483	6823
42	2905	4096	5229	6507	3152	4444	5674	7060
44	3010	4244	5418	6742	3257	4593	5863	7296
46	3114	4391	5606	6976	3362	4740	6051	7530

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.16: Medium Loading District: Single Phase—1/0 ACSR Primary and Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 1/0 ACSR 6/1 Neutral = (1) 1/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 2190 Design Tension (lb) = 2190 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.2993 Wind Load (lb/ft) = 0.2993 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	795	1122	1432	1782	1067	1505	1921	2391
4	969	1366	1744	2171	1241	1750	2234	2780
6	1143	1611	2057	2559	1415	1994	2546	3169
8	1316	1855	2369	2948	1588	2239	2858	3557
10	1489	2100	2680	3335	1761	2483	3170	3945
12	1662	2343	2991	3723	1934	2727	3481	4332
14	1834	2587	3302	4109	2106	2970	3791	4718
16	2007	2829	3612	4495	2279	3213	4101	5104
18	2178	3071	3921	4879	2450	3455	4411	5489
20	2350	3313	4229	5263	2622	3696	4719	5872
22	2520	3554	4537	5646	2792	3937	5026	6255
24	2691	3794	4843	6027	2963	4177	5333	6636
26	2860	4033	5148	6407	3132	4416	5638	7016
28	3029	4271	5452	6785	3301	4654	5942	7394
30	3197	4508	5755	7161	3469	4891	6244	7771
32	3364	4744	6056	7536	3636	5127	6546	8146
34	3531	4979	6356	7909	3803	5362	6845	8519
36	3697	5212	6654	8280	3969	5596	7143	8890
38	3861	5444	6950	8649	4133	5828	7440	9258
40	4025	5675	7245	9016	4297	6059	7734	9625
42	4188	5905	7538	9380	4460	6288	8027	9990
44	4349	6132	7829	9742	4621	6516	8318	10,351
46	4510	6359	8117	10,102	4782	6742	8607	10,711

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.17: Medium Loading District: Three Phase—4 ACSR Primary and Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.2523
Neutral = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.2523
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1089	1535	1960	2439	1547	2182	2785	3466
4	1276	1799	2297	2858	1734	2445	3122	3885
6	1463	2063	2633	3277	1921	2709	3458	4304
8	1650	2326	2969	3695	2108	2972	3795	4722
10	1836	2589	3305	4113	2295	3236	4130	5140
12	2022	2852	3640	4530	2481	3498	4466	5557
14	2208	3114	3975	4947	2667	3760	4800	5974
16	2394	3375	4309	5362	2852	4022	5134	6389
18	2579	3636	4642	5777	3038	4283	5468	6804
20	2764	3897	4974	6190	3222	4543	5800	7218
22	2948	4156	5306	6603	3406	4803	6131	7630
24	3131	4415	5636	7013	3590	5061	6461	8040
26	3314	4672	5965	7423	3772	5319	6790	8450
28	3496	4929	6292	7830	3954	5575	7118	8857
30	3677	5184	6618	8236	4135	5831	7444	9263
32	3857	5439	6943	8640	4316	6085	7768	9667
34	4037	5692	7266	9042	4495	6338	8091	10,069
36	4215	5943	7587	9442	4674	6590	8413	10,469
38	4393	6194	7907	9839	4851	6840	8732	10,866
40	4569	6442	8224	10,234	5027	7089	9049	11,262
42	4744	6689	8540	10,627	5203	7336	9365	11,654
44	4918	6935	8853	11,017	5377	7581	9678	12,044
46	5091	7179	9164	11,404	5550	7825	9990	12,432

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.18: Medium Loading District: Three Phase—2 ACSR Primary and Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 2 ACSR 6/1	Design Tension (lb) = 1425	Wind Load (lb/ft) = 0.2720
Neutral = (1) 2 ACSR 6/1	Design Tension (lb) = 1425	Wind Load (lb/ft) = 0.2720
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1181	1666	2126	2646	1676	2363	3016	3753
4	1407	1984	2533	3152	1902	2681	3423	4260
6	1633	2303	2939	3658	2127	3000	3829	4765
8	1859	2621	3345	4163	2353	3318	4235	5271
10	2084	2938	3751	4668	2578	3635	4641	5775
12	2309	3255	4156	5172	2803	3952	5046	6279
14	2533	3572	4560	5675	3028	4269	5450	6782
16	2757	3888	4963	6177	3252	4585	5853	7284
18	2981	4203	5366	6677	3475	4900	6256	7785
20	3204	4517	5767	7177	3698	5214	6657	8284
22	3426	4831	6167	7674	3920	5528	7057	8782
24	3648	5143	6566	8171	4142	5840	7455	9278
26	3868	5454	6963	8665	4363	6151	7853	9772
28	4088	5764	7358	9157	4582	6461	8248	10,264
30	4307	6073	7752	9647	4801	6770	8642	10,754
32	4525	6380	8144	10,135	5019	7077	9034	11,242
34	4741	6685	8534	10,620	5236	7382	9424	11,728
36	4957	6989	8922	11,103	5451	7686	9812	12,210
38	5171	7291	9308	11,583	5665	7988	10,198	12,691
40	5384	7592	9691	12,060	5878	8289	10,581	13,168
42	5596	7890	10,072	12,535	6090	8587	10,962	13,642
44	5806	8187	10,451	13,006	6300	8884	11,341	14,113
46	6015	8481	10,827	13,473	6509	9178	11,717	14,581

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.19: Medium Loading District: Three Phase—1/0 ACSR Primary and 2 ACSR Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 1/0 ACSR 6/1 Neutral = (1) 2 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 2190 Design Tension (lb) = 1425 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.2993 Wind Load (lb/ft) = 0.2720 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1328	1873	2391	2975	1860	2622	3347	4166
4	1645	2319	2961	3685	2177	3069	3918	4875
6	1962	2766	3531	4394	2493	3515	4488	5585
8	2278	3212	4101	5103	2810	3962	5057	6294
10	2594	3658	4669	5811	3126	4407	5626	7001
12	2910	4103	5237	6518	3441	4852	6194	7708
14	3225	4547	5804	7223	3756	5296	6761	8414
16	3539	4990	6370	7927	4070	5739	7327	9118
18	3852	5432	6934	8629	4384	6181	7891	9820
20	4165	5873	7497	9330	4697	6622	8454	10,520
22	4477	6312	8058	10,028	5008	7062	9015	11,219
24	4787	6750	8617	10,724	5319	7500	9574	11,914
26	5097	7187	9174	11,417	5628	7936	10,131	12,608
28	5405	7621	9729	12,107	5937	8371	10,686	13,298
30	5712	8054	10,282	12,795	6243	8803	11,238	13,985
32	6017	8485	10,831	13,479	6549	9234	11,788	14,670
34	6321	8913	11,378	14,160	6853	9663	12,335	15,350
36	6624	9339	11,923	14,837	7155	10,089	12,879	16,028
38	6924	9763	12,464	15,510	7456	10,513	13,421	16,701
40	7223	10,185	13,002	16,180	7755	10,934	13,958	17,370
42	7520	10,603	13,536	16,845	8052	11,353	14,493	18,035
44	7815	11,019	14,067	17,505	8346	11,769	15,024	18,696
46	8108	11,432	14,594	18,162	8639	12,181	15,551	19,352

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.20: Medium Loading District: Three Phase—3/0 ACSR Primary and 1/0 ACSR Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 3/0 ACSR 6/1	Design Tension (lb) = 3310	Wind Load (lb/ft) = 0.3340
Neutral = (1) 1/0 ACSR 6/1	Design Tension (lb) = 2190	Wind Load (lb/ft) = 0.2993
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1581	2230	2846	3542	2172	3063	3910	4866
4	2062	2907	3711	4618	2653	3741	4775	5942
6	2542	3584	4575	5693	3133	4417	5639	7018
8	3021	4260	5438	6768	3613	5094	6503	8092
10	3500	4936	6301	7841	4092	5769	7365	9165
12	3979	5610	7162	8912	4570	6444	8226	10,237
14	4456	6283	8021	9982	5047	7117	9085	11,306
16	4933	6955	8879	11,049	5524	7789	9943	12,373
18	5408	7625	9734	12,114	5999	8459	10,798	13,438
20	5882	8293	10,587	13,175	6473	9127	11,652	14,500
22	6354	8960	11,438	14,234	6946	9793	12,502	15,558
24	6825	9624	12,285	15,289	7416	10,457	13,350	16,613
26	7294	10,285	13,130	16,339	7886	11,119	14,194	17,664
28	7762	10,944	13,971	17,386	8353	11,778	15,035	18,710
30	8227	11,600	14,808	18,428	8818	12,434	15,873	19,753
32	8690	12,253	15,642	19,465	9281	13,086	16,706	20,790
34	9151	12,902	16,471	20,498	9742	13,736	17,536	21,822
36	9609	13,549	17,296	21,524	10,200	14,382	18,360	22,849
38	10,065	14,191	18,116	22,545	10,656	15,025	19,181	23,869
40	10,518	14,830	18,932	23,560	11,109	15,664	19,996	24,884
42	10,968	15,465	19,742	24,568	11,559	16,298	20,806	25,892
44	11,415	16,095	20,547	25,569	12,006	16,929	21,611	26,894
46	11,859	16,721	21,346	26,564	12,450	17,555	22,410	27,888

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.21: Medium Loading District: Three Phase—4/0 ACSR Primary and 1/0 ACSR Neutral								
Medium Loading District Primary = (3) 4/0 ACSR 6/1 Neutral = (1) 1/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471			Poles: 30 to 55 ft Design Tension (lb) = 4000 Design Tension (lb) = 2190 Tension LF = 1.1 Wire Height (ft) = 47.5			Grade C Construction Wind Load (lb/ft) = 0.3543 Wind Load (lb/ft) = 0.2993 Wind LF = 2.2 Guy Attachment Height (ft) = 46		
	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
		Total Guy Load (lb)				Total Guy Load (lb)		
Line Angle (degrees)	Horizontal Pull (lb)	1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead	Horizontal Pull (lb)	1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1705	2404	3069	3819	2324	3276	4183	5205
4	2267	3197	4081	5079	2886	4069	5195	6465
6	2829	3989	5093	6338	3448	4862	6207	7724
8	3391	4781	6104	7596	4010	5654	7218	8982
10	3952	5572	7113	8852	4571	6445	8227	10,238
12	4512	6362	8121	10,106	5131	7234	9235	11,493
14	5071	7150	9127	11,359	5690	8022	10,241	12,745
16	5629	7936	10,131	12,608	6247	8809	11,245	13,994
18	6185	8721	11,133	13,854	6804	9594	12,247	15,241
20	6740	9503	12,132	15,097	7359	10,376	13,246	16,484
22	7293	10,283	13,128	16,337	7912	11,156	14,242	17,723
24	7844	11,061	14,120	17,572	8463	11,933	15,234	18,958
26	8394	11,835	15,109	18,802	9013	12,708	16,223	20,188
28	8941	12,607	16,093	20,027	9560	13,479	17,207	21,414
30	9485	13,375	17,074	21,247	10,104	14,247	18,188	22,634
32	10,028	14,139	18,050	22,462	10,647	15,012	19,164	23,848
34	10,567	14,900	19,021	23,670	11,186	15,772	20,135	25,057
36	11,104	15,656	19,987	24,872	11,723	16,529	21,101	26,259
38	11,637	16,408	20,947	26,067	12,256	17,281	22,061	27,454
40	12,168	17,156	21,902	27,255	12,786	18,029	23,016	28,642
42	12,695	17,899	22,850	28,436	13,313	18,772	23,964	29,822
44	13,218	18,637	23,792	29,608	13,837	19,510	24,906	30,995
46	13,738	19,370	24,728	30,773	14,357	20,243	25,842	32,159
NOTE: This table is based on the 2023 edition of the *NESC*.								

TABLE C.22: Medium Loading District: Three Phase—336.4 ACSR Primary and 4/0 ACSR Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 336.4 ACSR 18/1	Design Tension (lb) = 4000	Wind Load (lb/ft) = 0.3947
Neutral = (1) 4/0 ACSR 6/1	Design Tension (lb) = 4000	Wind Load (lb/ft) = 0.3543
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1897	2674	3414	4248	2596	3660	4672	5814
4	2531	3568	4555	5669	3230	4554	5814	7235
6	3165	4462	5696	7089	3864	5448	6954	8654
8	3798	5355	6836	8507	4497	6340	8094	10,073
10	4430	6247	7974	9924	5129	7232	9233	11,489
12	5062	7137	9111	11,338	5761	8122	10,369	12,904
14	5692	8026	10,246	12,750	6391	9011	11,504	14,316
16	6321	8913	11,378	14,159	7020	9898	12,636	15,725
18	6948	9797	12,507	15,564	7647	10,783	13,765	17,130
20	7574	10,679	13,633	16,966	8273	11,665	14,891	18,531
22	8198	11,559	14,756	18,363	8897	12,544	16,014	19,929
24	8819	12,435	15,875	19,756	9518	13,421	17,133	21,321
26	9439	13,309	16,990	21,143	10,138	14,294	18,248	22,709
28	10,056	14,178	18,100	22,525	10,755	15,164	19,358	24,090
30	10,670	15,044	19,206	23,900	11,369	16,030	20,464	25,466
32	11,281	15,906	20,306	25,270	11,980	16,892	21,564	26,835
34	11,889	16,764	21,401	26,632	12,588	17,750	22,659	28,198
36	12,494	17,617	22,490	27,987	13,193	18,603	23,748	29,553
38	13,096	18,465	23,573	29,335	13,795	19,451	24,831	30,901
40	13,694	19,309	24,649	30,674	14,393	20,294	25,907	32,240
42	14,288	20,146	25,719	32,006	14,987	21,132	26,977	33,571
44	14,878	20,979	26,781	33,328	15,577	21,964	28,039	34,893
46	15,465	21,805	27,836	34,641	16,163	22,791	29,094	36,206

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.23: Medium Loading District: Three Phase—477 ACSR Primary and 4/0 ACSR Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 477 ACSR 18/1 Neutral = (1) 4/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4000 Design Tension (lb) = 4000 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.4380 Wind Load (lb/ft) = 0.3543 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1985	2799	3573	4447	2743	3868	4938	6145
4	2619	3693	4715	5867	3377	4762	6079	7565
6	3253	4587	5856	7287	4011	5656	7220	8985
8	3886	5480	6995	8705	4644	6548	8360	10,403
10	4519	6371	8134	10,122	5277	7440	9498	11,820
12	5150	7262	9270	11,536	5908	8331	10,635	13,234
14	5780	8151	10,405	12,948	6538	9219	11,769	14,646
16	6409	9037	11,537	14,357	7167	10,106	12,901	16,055
18	7037	9922	12,666	15,763	7795	10,991	14,031	17,460
20	7663	10,804	13,793	17,164	8421	11,873	15,157	18,862
22	8286	11,684	14,915	18,561	9044	12,752	16,280	20,259
24	8908	12,560	16,034	19,954	9666	13,629	17,399	21,652
26	9527	13,433	17,149	21,341	10,285	14,502	18,514	23,039
28	10,144	14,303	18,259	22,723	10,902	15,372	19,624	24,421
30	10,758	15,169	19,365	24,099	11,516	16,238	20,729	25,797
32	11,370	16,031	20,465	25,468	12,128	17,100	21,830	27,166
34	11,978	16,889	21,560	26,830	12,736	17,958	22,925	28,528
36	12,583	17,742	22,649	28,186	13,341	18,811	24,014	29,884
38	13,185	18,590	23,732	29,533	13,942	19,659	25,096	31,231
40	13,783	19,433	24,809	30,873	14,540	20,502	26,173	32,571
42	14,377	20,271	25,878	32,204	15,135	21,340	27,242	33,902
44	14,967	21,103	26,941	33,526	15,725	22,172	28,305	35,224
46	15,553	21,930	27,995	34,839	16,311	22,999	29,360	36,537

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.24: Medium Loading District: Three Phase—556 ACSR Primary and 336 ACSR Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 556 ACSR 18/1	Design Tension (lb) = 4500	Wind Load (lb/ft) = 0.4597
Neutral = (1) 336 ACSR 18/1	Design Tension (lb) = 3500	Wind Load (lb/ft) = 0.3947
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1694	2388	3049	3794	2298	3240	4137	5148
4	2368	3338	4262	5303	2972	4191	5350	6657
6	3041	4288	5474	6812	3645	5140	6562	8166
8	3714	5236	6685	8319	4318	6089	7773	9673
10	4386	6184	7894	9824	4990	7036	8982	11,178
12	5057	7130	9102	11,327	5661	7982	10,190	12,681
14	5726	8074	10,307	12,827	6331	8926	11,395	14,181
16	6395	9016	11,510	14,324	6999	9869	12,598	15,678
18	7061	9956	12,710	15,817	7666	10,809	13,798	17,171
20	7726	10,894	13,907	17,306	8330	11,746	14,995	18,660
22	8389	11,828	15,100	18,791	8993	12,680	16,188	20,145
24	9049	12,759	16,289	20,270	9654	13,612	17,377	21,624
26	9707	13,687	17,473	21,744	10,312	14,540	18,561	23,098
28	10,363	14,611	18,653	23,212	10,967	15,464	19,741	24,566
30	11,015	15,531	19,827	24,674	11,620	16,384	20,915	26,028
32	11,665	16,447	20,997	26,129	12,269	17,300	22,085	27,483
34	12,311	17,359	22,160	27,577	12,915	18,211	23,248	28,931
36	12,954	18,265	23,317	29,017	13,558	19,117	24,405	30,371
38	13,593	19,166	24,467	30,448	14,197	20,018	25,555	31,802
40	14,228	20,062	25,611	31,872	14,833	20,914	26,699	33,226
42	14,860	20,952	26,748	33,286	15,464	21,805	27,836	34,640
44	15,487	21,837	27,876	34,691	16,091	22,689	28,964	36,045
46	16,110	22,715	28,997	36,086	16,714	23,567	30,085	37,439

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.25: Medium Loading District: Three Phase—740 AAAC Primary and 336 ACSR Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 740 AAAC 37 Neutral = (1) 336 ACSR 18/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4500 Design Tension (lb) = 3000 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.4970 Wind Load (lb/ft) = 0.3947 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1725	2432	3105	3863	2367	3338	4261	5303
4	2379	3354	4282	5328	3021	4260	5438	6768
6	3032	4276	5458	6792	3675	5182	6615	8232
8	3685	5196	6634	8255	4328	6102	7790	9694
10	4338	6116	7808	9716	4980	7022	8964	11,155
12	4989	7034	8980	11,175	5631	7940	10,136	12,614
14	5639	7951	10150	12,631	6281	8857	11,306	14,070
16	6287	8865	11,317	14,084	6930	9771	12,474	15,523
18	6934	9777	12,482	15,533	7577	10,683	13,638	16,972
20	7580	10,687	13,643	16,978	8222	11,593	14,800	18,418
22	8223	11,594	14,801	18,419	8,865	12,500	15,958	19,858
24	8864	12,498	15,955	19,855	9,506	13,404	17,112	21,294
26	9503	13,399	17,105	21,286	10,145	14,305	18,261	22,725
28	10,139	14,296	18,250	22,711	10,781	15,202	19,406	24,150
30	10,772	15,189	19,390	24,129	11,415	16,095	20,546	25,569
32	11,403	16,078	20,525	25,542	12,045	16,984	21,681	26,981
34	12,030	16,962	21,654	26,947	12,672	17,868	22,810	28,386
36	12,654	17,842	22,777	28,344	13,296	18,748	23,933	29,784
38	13,274	18,716	23,893	29,734	13,917	19,622	25,050	31,173
40	13,891	19,586	25,003	31,115	14,533	20,492	26,160	32,555
42	14,504	20,450	26,106	32,488	15,146	21,356	27,263	33,927
44	15,112	21,308	27,202	33,851	15,755	22,214	28,359	35,291
46	15,717	22,160	28,290	35,205	16,359	23,066	29,447	36,645

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.26: Medium Loading District: Three Phase—795 ACSR Primary and 336 ACSR Neutral

Medium Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 795 ACSR 36/1	Design Tension (lb) = 4500	Wind Load (lb/ft) = 0.5133
Neutral = (1) 336 ACSR 18/1	Design Tension (lb) = 2600	Wind Load (lb/ft) = 0.3947
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1731	2441	3116	3878	2390	3370	4303	5354
4	2369	3341	4265	5307	3028	4270	5451	6784
6	3007	4240	5413	6736	3666	5169	6599	8212
8	3644	5138	6559	8163	4303	6068	7746	9640
10	4281	6036	7705	9588	4940	6965	8892	11,065
12	4916	6931	8849	11,012	5575	7861	10,035	12,488
14	5550	7826	9990	12,432	6209	8755	11,177	13,909
16	6183	8718	11,130	13,850	6842	9648	12,316	15,327
18	6814	9608	12,266	15,264	7474	10,538	13,453	16,741
20	7444	10,496	13,399	16,675	8103	11,426	14,586	18,151
22	8072	11,381	14,529	18,080	8731	12,311	15,716	19,557
24	8697	12,263	15,655	19,482	9356	13,193	16,842	20,958
26	9320	13,142	16,777	20,878	9980	14,071	17,963	22,354
28	9941	14,017	17,894	22,268	10,600	14,946	19,081	23,745
30	10,559	14,888	19,006	23,652	11,218	15,818	20,193	25,129
32	11,174	15,756	20,114	25,030	11,833	16,685	21,300	26,507
34	11,786	16,619	21,215	26,401	12,446	17,548	22,402	27,878
36	12,395	17,477	22,311	27,765	13,054	18,407	23,498	29,242
38	13,000	18,331	23,401	29,121	13,660	19,260	24,587	30,598
40	13,602	19,179	24,484	30,469	14,261	20,109	25,671	31,946
42	14,200	20,022	25,560	31,808	14,859	20,952	26,747	33,285
44	14,794	20,860	26,629	33,139	15,453	21,789	27,816	34,615
46	15,384	21,691	27,691	34,460	16,043	22,621	28,877	35,936

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.27: Heavy Loading District: Single Phase—4 ACSR Primary and Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.4190
Neutral = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.4190
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	879	1239	1581	1968	1259	1776	2267	2821
4	972	1371	1750	2177	1353	1907	2435	3030
6	1066	1502	1918	2387	1446	2039	2603	3240
8	1159	1634	2086	2596	1540	2171	2771	3449
10	1252	1766	2254	2805	1633	2302	2939	3658
12	1345	1897	2422	3014	1726	2434	3107	3866
14	1438	2028	2589	3222	1819	2565	3274	4075
16	1531	2159	2756	3430	1912	2696	3441	4283
18	1624	2289	2923	3637	2004	2826	3608	4490
20	1716	2419	3089	3844	2097	2956	3774	4697
22	1808	2549	3254	4050	2189	3086	3940	4903
24	1900	2678	3419	4255	2280	3215	4105	5108
26	1991	2807	3584	4460	2372	3344	4269	5313
28	2082	2936	3748	4664	2463	3472	4433	5516
30	2173	3063	3911	4867	2553	3600	4596	5719
32	2263	3190	4073	5068	2643	3727	4758	5921
34	2352	3317	4234	5269	2733	3854	4920	6122
36	2442	3443	4395	5469	2822	3980	5080	6322
38	2530	3568	4555	5668	2911	4105	5240	6521
40	2619	3692	4714	5866	2999	4229	5399	6719
42	2706	3816	4871	6062	3087	4353	5557	6915
44	2793	3939	5028	6257	3174	4475	5713	7110
46	2880	4060	5184	6451	3261	4597	5869	7304

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.28: Heavy Loading District: Single Phase—2 ACSR Primary and Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 2 ACSR 6/1 Neutral = (1) 2 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 1425 Design Tension (lb) = 1425 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.4387 Wind Load (lb/ft) = 0.4387 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	925	1304	1665	2072	1323	1866	2382	2964
4	1038	1463	1868	2325	1436	2025	2586	3218
6	1151	1622	2071	2577	1549	2184	2789	3470
8	1263	1781	2274	2830	1662	2344	2992	3723
10	1376	1940	2477	3082	1775	2502	3195	3975
12	1489	2099	2679	3334	1887	2661	3397	4227
14	1601	2257	2882	3586	1999	2819	3599	4479
16	1713	2415	3083	3837	2112	2977	3801	4730
18	1825	2573	3284	4087	2223	3135	4002	4980
20	1936	2730	3485	4337	2335	3292	4202	5230
22	2047	2887	3685	4586	2446	3449	4402	5479
24	2158	3043	3884	4834	2557	3605	4602	5727
26	2268	3198	4083	5081	2667	3760	4800	5974
28	2378	3353	4281	5327	2777	3915	4998	6220
30	2488	3507	4478	5572	2886	4069	5195	6465
32	2596	3661	4674	5816	2995	4223	5391	6709
34	2705	3814	4869	6059	3103	4376	5586	6952
36	2813	3966	5063	6300	3211	4528	5780	7193
38	2920	4117	5255	6540	3318	4679	5973	7433
40	3026	4267	5447	6779	3425	4829	6165	7672
42	3132	4416	5638	7016	3531	4978	6355	7909
44	3237	4564	5827	7251	3636	5127	6544	8144
46	3342	4712	6015	7485	3740	5274	6732	8378

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.29: Heavy Loading District: Single Phase—1/0 ACSR Primary and Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (1) 1/0 ACSR 6/1	Design Tension (lb) = 2190	Wind Load (lb/ft) = 0.4660
Neutral = (1) 1/0 ACSR 6/1	Design Tension (lb) = 2190	Wind Load (lb/ft) = 0.4660
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1023	1442	1841	2291	1446	2039	2603	3239
4	1196	1687	2153	2680	1620	2284	2915	3628
6	1370	1931	2466	3068	1793	2528	3228	4017
8	1543	2176	2778	3457	1967	2773	3540	4405
10	1716	2420	3089	3844	2140	3017	3851	4793
12	1889	2664	3400	4232	2313	3261	4163	5180
14	2062	2907	3711	4618	2485	3504	4473	5567
16	2234	3150	4021	5004	2657	3747	4783	5952
18	2406	3392	4330	5388	2829	3989	5092	6337
20	2577	3633	4638	5772	3000	4230	5401	6721
22	2748	3874	4946	6155	3171	4471	5708	7103
24	2918	4114	5252	6536	3341	4711	6014	7484
26	3087	4353	5557	6916	3511	4950	6319	7864
28	3256	4591	5861	7294	3680	5188	6623	8242
30	3424	4828	6164	7670	3848	5425	6926	8619
32	3592	5064	6465	8045	4015	5661	7227	8994
34	3758	5299	6765	8418	4182	5896	7527	9367
36	3924	5533	7063	8789	4347	6130	7825	9738
38	4088	5765	7359	9158	4512	6362	8121	10,107
40	4252	5996	7654	9525	4676	6593	8416	10,473
42	4415	6225	7947	9889	4838	6822	8709	10,838
44	4576	6453	8238	10,251	5000	7050	9000	11,200
46	4737	6679	8526	10,611	5160	7276	9289	11,559

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.30: Heavy Loading District: Three Phase—4 ACSR Primary and Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.4190
Neutral = (1) 4 ACSR 7/1	Design Tension (lb) = 1180	Wind Load (lb/ft) = 0.4190
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1543	2176	2778	3457	2305	3250	4148	5162
4	1730	2440	3114	3876	2492	3513	4485	5582
6	1917	2703	3451	4295	2679	3777	4822	6000
8	2104	2967	3787	4713	2866	4040	5158	6419
10	2291	3230	4123	5131	3052	4303	5494	6837
12	2477	3492	4458	5548	3238	4566	5829	7254
14	2663	3755	4793	5965	3424	4828	6164	7670
16	2848	4016	5127	6380	3610	5090	6498	8086
18	3033	4277	5460	6795	3795	5351	6831	8501
20	3218	4537	5792	7208	3980	5611	7163	8914
22	3402	4797	6124	7621	4164	5871	7494	9326
24	3585	5055	6454	8031	4347	6129	7824	9737
26	3768	5313	6783	8441	4530	6387	8153	10,146
28	3950	5570	7110	8848	4712	6643	8481	10,554
30	4131	5825	7436	9254	4893	6899	8807	10,960
32	4312	6079	7761	9658	5073	7153	9132	11,364
34	4491	6332	8084	10,060	5253	7406	9455	11,766
36	4670	6584	8405	10,460	5431	7658	9776	12,165
38	4847	6834	8725	10,857	5608	7908	10,095	12,563
40	5023	7083	9042	11,252	5785	8157	10,413	12,958
42	5199	7330	9358	11,645	5960	8404	10,728	13,351
44	5373	7576	9671	12,035	6134	8649	11,042	13,741
46	5546	7819	9982	12,422	6307	8893	11,353	14,128

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.31: Heavy Loading District: Three Phase—2 ACSR Primary and Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 2 ACSR 6/1 Neutral = (1) 2 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 1425 Design Tension (lb) = 1425 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.4387 Wind Load (lb/ft) = 0.4387 Wind LF = 2.2 Guy Attachment Height (ft) = 46

	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
		Total Guy Load (lb)				Total Guy Load (lb)		
Line Angle (degrees)	Horizontal Pull (lb)	1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead	Horizontal Pull (lb)	1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1636	2306	2944	3664	2433	3431	4379	5450
4	1862	2625	3351	4170	2659	3749	4786	5956
6	2087	2943	3757	4676	2885	4067	5193	6462
8	2313	3261	4163	5181	3110	4386	5599	6967
10	2538	3579	4569	5686	3336	4703	6004	7472
12	2763	3896	4974	6190	3561	5020	6409	7976
14	2988	4213	5378	6693	3785	5337	6813	8479
16	3212	4529	5781	7195	4009	5653	7217	8981
18	3435	4844	6184	7695	4233	5968	7619	9481
20	3658	5158	6585	8195	4456	6282	8020	9981
22	3881	5472	6985	8692	4678	6596	8420	10,478
24	4102	5784	7384	9188	4899	6908	8819	10,974
26	4323	6095	7781	9683	5120	7219	9216	11,469
28	4542	6405	8176	10,175	5340	7529	9611	11,961
30	4761	6713	8570	10,665	5558	7837	10,005	12,451
32	4979	7020	8962	11,153	5776	8145	10,397	12,939
34	5196	7326	9352	11,638	5993	8450	10,787	13,424
36	5411	7630	9740	12,121	6208	8754	11,175	13,907
38	5626	7932	10,126	12,601	6423	9056	11,561	14,387
40	5839	8232	10,509	13,078	6636	9357	11,945	14,864
42	6050	8531	10,890	13,553	6848	9655	12,326	15,338
44	6261	8827	11,269	14,024	7058	9952	12,704	15,809
46	6469	9122	11,645	14,491	7267	10,246	13,080	16,277

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.32: Heavy Loading District: Three Phase—1/0 ACSR Primary and 2 ACSR Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 1/0 ACSR 6/1	Design Tension (lb) = 2190	Wind Load (lb/ft) = 0.4660
Neutral = (1) 2 ACSR 6/1	Design Tension (lb) = 1425	Wind Load (lb/ft) = 0.4387
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	1783	2513	3209	3993	2617	3690	4711	5862
4	2099	2960	3779	4703	2934	4137	5281	6572
6	2416	3407	4349	5412	3251	4583	5851	7281
8	2733	3853	4919	6121	3567	5030	6421	7990
10	3049	4298	5487	6829	3883	5475	6989	8698
12	3364	4743	6055	7536	4199	5920	7557	9405
14	3679	5187	6622	8241	4514	6364	8124	10,110
16	3993	5631	7188	8945	4828	6807	8690	10,814
18	4307	6073	7752	9647	5141	7249	9254	11,517
20	4619	6513	8315	10,348	5454	7690	9817	12,217
22	4931	6953	8876	11,046	5766	8130	10,378	12,915
24	5242	7391	9435	11,742	6076	8568	10,937	13,611
26	5551	7827	9992	12,435	6386	9004	11,494	14,304
28	5860	8262	10,547	13,125	6694	9439	12,049	14,995
30	6166	8695	11,100	13,813	7001	9871	12,602	15,682
32	6472	9125	11,649	14,497	7306	10,302	13,151	16,366
34	6776	9554	12,196	15,178	7610	10,731	13,699	17,047
36	7078	9980	12,741	15,855	7913	11,157	14,243	17,724
38	7379	10,404	13,282	16,528	8213	11,581	14,784	18,398
40	7678	10,825	13,820	17,198	8512	12,002	15,322	19,067
42	7974	11,244	14,354	17,863	8809	12,421	15,856	19,732
44	8269	11,660	14,885	18,523	9104	12,836	16,387	20,393
46	8562	12,073	15,412	19,179	9397	13,249	16,914	21,049

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.33: Heavy Loading District: Three Phase—3/0 ACSR Primary and 1/0 ACSR Neutral		
Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 3/0 ACSR 6/1 Neutral = (1) 1/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 3310 Design Tension (lb) = 2190 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.5007 Wind Load (lb/ft) = 0.4660 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2036	2870	3664	4560	2930	4131	5274	6563
4	2516	3548	4529	5636	3410	4808	6138	7639
6	2996	4225	5393	6711	3890	5485	7003	8714
8	3476	4901	6256	7786	4370	6162	7866	9789
10	3955	5576	7119	8859	4849	6,837	8728	10,862
12	4433	6251	7980	9930	5327	7512	9589	11,933
14	4911	6924	8839	11,000	5805	8185	10,449	13,003
16	5387	7596	9697	12,067	6281	8857	11,306	14,070
18	5862	8266	10,552	13,132	6757	9527	12,162	15,135
20	6336	8934	11,405	14,193	7230	10,195	13,015	16,196
22	6809	9600	12,256	15,252	7703	10,861	13,865	17,255
24	7280	10,264	13,103	16,306	8174	11,525	14,713	18,309
26	7749	10,926	13,948	17,357	8643	12,187	15,557	19,360
28	8216	11,585	14,789	18,404	9110	12,846	16,399	20,407
30	8681	12,241	15,626	19,446	9576	13,501	17,236	21,449
32	9144	12,894	16,460	20,483	10,039	14,154	18,069	22,486
34	9605	13,543	17,289	21,516	10,499	14,804	18,899	23,519
36	10,063	14,189	18,114	22,542	10,958	15,450	19,724	24,545
38	10,519	14,832	18,934	23,563	11,413	16,093	20,544	25,566
40	10,972	15,471	19,750	24,578	11,866	16,732	21,359	26,581
42	11,422	16,105	20,560	25,586	12,316	17,366	22,170	27,589
44	11,869	16,736	21,365	26,587	12,764	17,997	22,974	28,590
46	12,313	17,362	22,164	27,582	13,208	18,623	23,774	29,585

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.34: Heavy Loading District: Three Phase—4/0 ACSR Primary and 1/0 ACSR Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 4/0 ACSR 6/1 Neutral = (1) 1/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4000 Design Tension (lb) = 2190 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.5210 Wind Load (lb/ft) = 0.4660 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2159	3045	3887	4837	3081	4344	5546	6902
4	2722	3838	4899	6097	3644	5137	6558	8162
6	3284	4630	5911	7356	4206	5930	7570	9421
8	3845	5422	6922	8613	4767	6722	8581	10,678
10	4406	6213	7931	9870	5328	7513	9591	11,935
12	4966	7002	8939	11,124	5888	8302	10,599	13,189
14	5525	7791	9945	12,376	6447	9090	11,605	14,441
16	6083	8577	10,949	13,626	7005	9877	12,609	15,691
18	6639	9362	11,951	14,872	7561	10,661	13,610	16,937
20	7194	10,144	12,950	16,115	8116	11,444	14,609	18,180
22	7748	10,924	13,946	17,355	8669	12,224	15,605	19,420
24	8299	11,701	14,938	18,589	9221	13,001	16,597	20,654
26	8848	12,476	15,927	19,820	9770	13,776	17,586	21,885
28	9395	13,247	16,911	21,045	10,317	14,547	18,571	23,110
30	9940	14,015	17,892	22,265	10,862	15,315	19,551	24,330
32	10,482	14,780	18,868	23,480	11,404	16,080	20,527	25,545
34	11,022	15,540	19,839	24,688	11,943	16,840	21,498	26,753
36	11,558	16,297	20,805	25,890	12,480	17,597	22,464	27,955
38	12,092	17,049	21,765	27,085	13,014	18,349	23,424	29,150
40	12,622	17,797	22,720	28,273	13,544	19,097	24,379	30,338
42	13,149	18,540	23,668	29,454	14,071	19,840	25,328	31,519
44	13,672	19,278	24,610	30,626	14,594	20,578	26,270	32,691
46	14,192	20,011	25,546	31,791	15,114	21,311	27,205	33,856

NOTE: This table is based on the 2023 edition of the *NESC*.

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TABLE C.35: Heavy Loading District: Three Phase—336.4 ACSR Primary and 4/0 ACSR Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 336.4 ACSR 18/1 Neutral = (1) 4/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4000 Design Tension (lb) = 4000 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.5613 Wind Load (lb/ft) = 0.5210 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2351	3315	4232	5266	3353	4727	6035	7510
4	2985	4209	5373	6686	3987	5621	7176	8930
6	3619	5103	6514	8106	4621	6515	8317	10,350
8	4252	5995	7654	9525	5254	7408	9457	11,769
10	4884	6887	8792	10,941	5886	8300	10,595	13,185
12	5516	7777	9929	12,356	6518	9190	11,732	14,600
14	6146	8666	11,063	13,767	7148	10,079	12,866	16,012
16	6775	9553	12,195	15,176	7777	10,965	13,999	17,420
18	7403	10,438	13,325	16,582	8404	11,850	15,128	18,826
20	8028	11,320	14,451	17,983	9030	12,732	16,254	20,227
22	8652	12,199	15,574	19,381	9654	13,612	17,377	21,625
24	9274	13,076	16,693	20,773	10,275	14,488	18,496	23,017
26	9893	13,949	17,807	22,160	10,895	15,362	19,611	24,404
28	10,510	14,819	18,918	23,542	11,512	16,231	20,721	25,786
30	11,124	15,685	20,023	24,918	12,126	17,097	21,826	27,162
32	11,735	16,547	21,124	26,287	12,737	17,959	22,927	28,531
34	12,344	17,404	22,218	27,650	13,345	18,817	24,022	29,894
36	12,949	18,258	23,308	29,005	13,950	19,670	25,111	31,249
38	13,550	19,106	24,390	30,352	14,552	20,518	26,194	32,596
40	14,148	19,949	25,467	31,692	15,150	21,361	27,270	33,936
42	14,742	20,787	26,536	33,023	15,744	22,199	28,340	35,267
44	15,333	21,619	27,599	34,345	16,334	23,032	29,402	36,589
46	15,919	22,445	28,654	35,658	16,921	23,858	30,457	37,902

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.36: Heavy Loading District: Three Phase—477 ACSR Primary and 4/0 ACSR Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 477 ACSR 18/1 Neutral = (1) 4/0 ACSR 6/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4000 Design Tension (lb) = 4000 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.6047 Wind Load (lb/ft) = 0.5210 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 100 to 300 Ft				For Spans of 301 to 500 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2440	3440	4391	5465	3501	4936	6301	7841
4	3074	4334	5533	6885	4135	5830	7442	9262
6	3708	5228	6674	8305	4768	6724	8583	10,681
8	4341	6120	7813	9723	5402	7616	9723	12,100
10	4973	7012	8952	11,140	6034	8508	10,861	13,516
12	5605	7903	10,088	12,554	6666	9398	11,998	14,931
14	6235	8791	11,223	13,966	7296	10,287	13,133	16,343
16	6864	9678	12,355	15,375	7925	11,174	14,265	17,752
18	7491	10,563	13,484	16,781	8552	12,059	15,394	19,157
20	8117	11,445	14,611	18,182	9178	12,941	16,520	20,559
22	8741	12,324	15,733	19,579	9802	13,820	17,643	21,956
24	9362	13,201	16,852	20,972	10,423	14,697	18,762	23,348
26	9982	14,074	17,967	22,359	11,043	15,570	19,877	24,736
28	10,599	14,944	19,077	23,741	11,660	16,440	20,987	26,117
30	11,213	15,810	20,183	25,117	12,274	17,306	22,093	27,493
32	11,824	16,672	21,283	26,486	12,885	18,168	23,193	28,862
34	12,432	17,530	22,378	27,848	13,493	19,026	24,288	30,225
36	13,037	18,383	23,467	29,204	14,098	19,879	25,377	31,580
38	13,639	19,231	24,550	30,551	14,700	20,727	26,460	32,928
40	14,237	20,074	25,626	31,891	15,298	21,570	27,536	34,267
42	14,831	20,912	26,696	33,222	15,892	22,408	28,606	35,598
44	15,421	21,744	27,758	34,544	16,482	23,240	29,668	36,920
46	16,007	22,571	28,813	35,857	17,068	24,066	30,723	38,233

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.37: Heavy Loading District: Three Phase—556 ACSR Primary and 336 ACSR Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 556 ACSR 18/1 Neutral = (1) 336 ACSR 18/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4500 Design Tension (lb) = 3500 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.6263 Wind Load (lb/ft) = 0.5613 Wind LF = 2.2 Guy Attachment Height (ft) = 46

	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
		Total Guy Load (lb)				Total Guy Load (lb)		
Line Angle (degrees)	**Horizontal Pull (lb)**	**1-to-1 Guy Lead**	**2-to-3 Guy Lead**	**1-to-2 Guy Lead**	**Horizontal Pull (lb)**	**1-to-1 Guy Lead**	**2-to-3 Guy Lead**	**1-to-2 Guy Lead**
2	1997	2815	3594	4472	2828	3988	5091	6335
4	2670	3765	4807	5982	3502	4938	6303	7844
6	3344	4715	6019	7490	4175	5887	7515	9353
8	4016	5663	7230	8997	4848	6836	8726	10,860
10	4688	6611	8439	10,502	5520	7783	9936	12,365
12	5359	7557	9647	12,005	6191	8729	11,144	13,868
14	6029	8501	10,852	13,505	6861	9673	12,349	15,368
16	6697	9443	12,055	15,002	7529	10,616	13,552	16,865
18	7364	10,383	13,255	16,495	8195	11,556	14,752	18,358
20	8029	11,321	14,452	17,984	8860	12,493	15,948	19,847
22	8691	12,255	15,645	19,469	9523	13,427	17,141	21,332
24	9352	13,186	16,834	20,948	10,184	14,359	18,330	22,811
26	10,010	14,114	18,018	22,422	10,842	15,287	19,515	24,285
28	10,665	15,038	19,198	23,891	11,497	16,211	20,695	25,753
30	11,318	15,958	20,372	25,352	12,150	17,131	21,869	27,215
32	11,968	16,874	21,542	26,807	12,799	18,047	23,038	28,670
34	12,614	17,785	22,705	28,255	13,445	18,958	24,202	30,118
36	13,257	18,692	23,862	29,695	14,088	19,864	25,359	31,557
38	13,896	19,593	25,012	31,127	14,727	20,766	26,509	32,989
40	14,531	20,489	26,156	32,550	15,363	21,661	27,653	34,413
42	15,163	21,379	27,293	33,964	15,994	22,552	28,789	35,827
44	15,790	22,263	28,421	35,369	16,621	23,436	29,918	37,231
46	16,412	23,141	29,542	36,764	17,244	24,314	31,039	38,626

NOTE: This table is based on the 2023 edition of the *NESC*.

TABLE C.38: Heavy Loading District: Three Phase—740 AAAC Primary and 336 ACSR Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 740 AAAC 37	Design Tension (lb) = 4500	Wind Load (lb/ft) = 0.6637
Neutral = (1) 336 ACSR 18/1	Design Tension (lb) = 3000	Wind Load (lb/ft) = 0.5613
Pole = 55′/1 NWC	Tension LF = 1.1	Wind LF = 2.2
Bending Moment (ft-lb) = 4471	Wire Height (ft) = 47.5	Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2028	2859	3650	4542	2897	4085	5215	6490
4	2682	3781	4827	6007	3551	5008	6393	7955
6	3335	4703	6003	7471	4205	5929	7569	9419
8	3988	5623	7179	8934	4858	6850	8744	10,882
10	4640	6543	8353	10,395	5510	7769	9918	12,343
12	5292	7461	9525	11,853	6161	8688	11,090	13,801
14	5942	8378	10,695	13,309	6811	9604	12,260	15,257
16	6590	9292	11,862	14,762	7460	10,519	13,428	16,710
18	7237	10,205	13,027	16,211	8107	11,431	14,593	18,160
20	7882	11,114	14,188	17,657	8752	12,341	15,754	19,605
22	8526	12,021	15,346	19,098	9395	13,248	16,912	21,046
24	9167	12,925	16,500	20,534	10,037	14,152	18,066	22,482
26	9806	13,826	17,650	21,964	10,675	15,052	19,215	23,913
28	10,442	14,723	18,795	23,389	11,311	15,949	20,361	25,338
30	11,075	15,616	19,935	24,808	11,945	16,842	21,501	26,756
32	11,705	16,505	21,070	26,220	12,575	17,731	22,635	28,168
34	12,333	17,389	22,199	27,625	13,202	18,615	23,764	29,573
36	12,957	18,269	23,322	29,023	13,826	19,495	24,887	30,971
38	13,577	19,144	24,439	30,412	14,447	20,370	26,004	32,361
40	14,194	20,013	25,549	31,794	15,063	21,239	27,114	33,742
42	14,806	20,877	26,652	33,166	15,676	22,103	28,217	35,115
44	15,415	21,735	27,747	34,530	16,285	22,962	29,313	36,478
46	16,020	22,588	28,835	35,884	16,889	23,814	30,401	37,832

NOTE: This table is based on the 2023 edition of the *NESC*.

C

TABLE C.39: Heavy Loading District: Three Phase—795 ACSR Primary and 336 ACSR Neutral

Heavy Loading District	Poles: 30 to 55 ft	Grade C Construction
Primary = (3) 795 ACSR 36/1 Neutral = (1) 336 ACSR 18/1 Pole = 55′/1 NWC Bending Moment (ft-lb) = 4471	Design Tension (lb) = 4500 Design Tension (lb) = 2600 Tension LF = 1.1 Wire Height (ft) = 47.5	Wind Load (lb/ft) = 0.6800 Wind Load (lb/ft) = 0.5613 Wind LF = 2.2 Guy Attachment Height (ft) = 46

Line Angle (degrees)	For Spans of 50 to 200 Ft				For Spans of 201 to 350 Ft			
	Horizontal Pull (lb)	Total Guy Load (lb)			Horizontal Pull (lb)	Total Guy Load (lb)		
		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead		1-to-1 Guy Lead	2-to-3 Guy Lead	1-to-2 Guy Lead
2	2034	2868	3661	4556	2920	4118	5257	6542
4	2672	3768	4810	5986	3559	5018	6405	7971
6	3310	4667	5958	7414	4196	5917	7553	9400
8	3947	5565	7105	8841	4833	6815	8700	10,827
10	4583	6463	8250	10,267	5470	7713	9846	12,253
12	5219	7359	9394	11,690	6105	8608	10,989	13,676
14	5853	8253	10,536	13,111	6740	9503	12,131	15,097
16	6486	9145	11,675	14,529	7372	10,395	13,270	16,514
18	7117	10,035	12,811	15,943	8004	11,285	14,407	17,928
20	7747	10,923	13,944	17,353	8633	12,173	15,540	19,339
22	8375	11,808	15,074	18,759	9261	13,058	16,670	20,745
24	9000	12,690	16,200	20,160	9887	13,940	17,796	22,146
26	9623	13,569	17,322	21,556	10,510	14,819	18,918	23,542
28	10,244	14,444	18,439	22,947	11,130	15,694	20,035	24,932
30	10,862	15,315	19,552	24,331	11,748	16,565	21,147	26,317
32	11,477	16,183	20,659	25,709	12,364	17,433	22,254	27,694
34	12,089	17,046	21,761	27,080	12,976	18,296	23,356	29,065
36	12,698	17,904	22,856	28,444	13,584	19,154	24,452	30,429
38	13,303	18,758	23,946	29,800	14,190	20,008	25,542	31,785
40	13,905	19,606	25,029	31,147	14,792	20,856	26,625	33,133
42	14,503	20,449	26,105	32,487	15,389	21,699	27,701	34,472
44	15,097	21,287	27,175	33,817	15,983	22,537	28,770	35,803
46	15,687	22,118	28,236	35,138	16,573	23,368	29,832	37,124

NOTE: This table is based on the 2023 edition of the *NESC*.

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RUS publications are available from various sources. For information, contact the U.S. Department of Agriculture, Rural Utilities Service, Washington, DC 20250.

Assembly Unit Numbers and Standard Format, Bulletin 1728F-800
Checking Sag in a Conductor by the Return Wave Method, Bulletin 1726C-115
Design Guide for Rural Substations, Bulletin 1724E-300
Design Manual for High Voltage Transmission Lines, Bulletin 1724E-200
Electric Distribution Line Guys and Anchors, Bulletin 1724E-153
Electric System Construction Policies and Procedures, 7 C.F.R. Part 1726
Electric System Operation and Maintenance, Bulletin 1730-1
List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers, Information Publication 202-1
Mechanical Design Manual for Overhead Distribution Lines, Bulletin 160-2
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Specifications and Drawings for 24.9/14.4 kV Line Construction, Bulletin 1728F-803
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AAAC. All-aluminum alloy conductors.

ACSR. Aluminum conductor, steel-reinforced.

ADSS. All-dielectric self-supporting fiber optic cable often attached to distribution poles.

Aeolian Vibration. Conductor vibration caused by the wind blowing perpendicular to the conductor.

Anchor. A device that provides a solid point in the earth for attachment of guy wires. *See* RUS Specification F1.6, F1.8, etc.

Angle Structure. Any structure that is not a straight-line structure. Examples are A3, C3, etc.

ANSI. American National Standards Institute.

Average Guy Attachment. The average of the heights of the guy attachments from grade. *See* **Figure 7.6**.

Average Guy Lead. The average of the distance, in feet, of the anchors from the pole. *See* **Figure 7.6**.

Backspan. The span of conductor immediately behind the pole at which the stakers are presently located.

Bending Moment. A moment of force that causes a pole to bend at groundline.

Bisecting an Angle. Dividing an angle into two equal parts. *See* **Figure 2.8**.

Birthmark, Pole. The pole brand that contains the pole treatment company and the date that the pole was treated; commonly referred to as the birthmark.

Buckarm Construction. Deadends using crossarm construction as opposed to deadends using vertical construction.

Cantilever Loading. Loading produced on a beam or member supported at only one end.

Catenary Curve. The curve shape assumed by a completely flexible conductor when suspended between two rigid supports.

Chain, Surveyor's. A metal measuring tape usually made of steel in 100- or 200-foot increments.

Change Order. Generally refers to a staking sheet where the specified construction has been changed because of field conditions.

Circuit. An electrical single-phase, vee-phase, or three-phase set of conductors that carry electricity from one point to another.

Circumference. The distance around a circular object such as a ball or circle.

Clearances. Generally the distance between an energized conductor and any object such as the ground or a building.

Communication Circuits. Generally cable TV or telephone circuits on the same pole line as the electric circuits.

Conductor. Either aluminum, aluminum alloy, or copper wire that carries electricity.

Conductor Tension, Reduced. A construction method whereby the conductor is not tightened to its design strength, thus resulting in increased sag or a slack span.

Conductor, Ultimate Strength. The maximum tensile strength of a conductor above which, if force is applied, the conductor will break.

Deadend. When the conductors are terminated abruptly on the last structure of the line; commonly referred to as deadend structure.

Deflection Angle. *See* **Line Angle**.

Double Deadend. Structure where the conductor is deadended in both directions (source and load) such as a C8, C4-1, or A6.

glossary

Double Down Guy. Two down guys specified as one assembly. *See* RUS Specification E2.1G.

Earth Resistivity. Electrical resistance of the soil itself when used as part of an electrical circuit.

Easement. A right to land owned by another that entitles its holder to a specific, limited use.

Elevation. The height to which something is raised above normally flat ground.

Encroachment Permits. A permit to place electric utility facilities on public rights-of-way.

Fault. A short circuit caused by a phase wire touching another phase wire or a phase wire touching the neutral or ground.

Fiber Strength. The strength of the fibers in wood poles or in wooden crossarms.

Final Sag. The sag of a conductor that has been subjected to wind and ice loading over a period of years. *See also* **Unloaded Conductor Tension**.

Framing, Pole. The position in which, or the way that, pole line hardware, equipment, or assemblies are attached to the pole.

GPS. Global Positioning System, a satellite-based navigation system.

Grading the Line. Selecting the height of the pole so that the finished line will not produce uplift or excessive downstrain because of changes in topography or increased clearances because of crossings.

Ground Fault. When the primary falls into the neutral or comes into contact with the ground, a ground fault or ground short circuit is said to have occurred.

Guy Attachment. Hardware that is bolted to the pole and has the guy wire attached to it. *See* RUS Specification E1.1.

Guy Factor. A force multiplier derived from the geometric relationship of the length of the guy lead to the height of the guy attachment.

Guy Lead. The horizontal length as measured from the bottom of the pole along the groundline to the anchor location.

Guy Wire. A wire used to provide additional support to poles or structures by means of attachment to an anchor. *See* RUS Specifications E1.1, E1.1L, and E1.2.

Horizontal. Parallel to or in the same plane as the horizon.

Horizontal Pull. Forces acting in the horizontal plane.

Hot Line Work. Operating and maintaining an energized distribution line.

Ice Loading. The additional weight put on the conductor caused by ice. *See NESC* Section 250 and Table 250-1.

IEEE. Institute of Electrical and Electronics Engineers.

Incline Span. A span where the poles are at different elevations, such as up a hill or down into a valley.

Initial Sag. Sag achieved in the conductor upon initial installation before the conductor carries any load, is heated by direct sunlight, or undergoes loading due to wind and/or ice.

Insulation. Any material that prevents the flow of electricity. In power systems or in distribution systems, the insulation generally consists of porcelain insulators and isolation, via air space.

Insulator Link. A fiberglass insulating rod used to electrically insulate ground guys from phase-associated hardware such as through bolts on a suspension insulator. *See* RUS Specification E1.5.

glossary

Joint Use. Both communications and electric power conductors attached to the same pole structure.

Junction Pole. *See* **Tap Line**.

kV. Kilovolts or 1,000 volts.

kVA. One thousand volt amperes.

Large Conductors. Any conductor having a breaking strength of more than 4500 lb.

Line Angle. Deflection angle created by a change in the direction of the line.

Line Configuration. Whether the primary line has single-phase, vee-phase, or three-phase construction.

Line Conversion. The act of changing out the wire to a larger wire size, increasing the distribution voltage, or converting a single-phase line to a vee- or three-phase line.

Line Extension. The act of extending distribution line, either single-phase, vee-phase, or three-phase, via the construction work order process.

List of Materials. A short reference to REA Bulletin 43-5, which became RUS Bulletin 1728C-100 but has now been renamed RUS Informational Publication 202-1, which provides approved materials for use by RUS borrowers; also refers to materials required to construct a particular project.

Load Factor (LF). A safety factor that combines the load and strength factors of the *National Electrical Safety Code*.

Longitudinal Strength. The strength of a structure in the same direction as the conductors that it supports.

Make-Ready Construction. The examination of existing construction and making it ready for the attachment of other utility lines, communication conductors, or cable TV.

Material Pick List. The list of specific material developed from the construction units that are contained on the work order.

Maximum Conductor Temperature. The maximum temperature at which a conductor is expected to operate during its life span.

Moment. A force applied through a distance.

Multigrounded Neutrals. Construction where the neutral is grounded with a driven ground rod at each transformer station and other locations along the line.

NESC. *National Electrical Safety Code* (ANSI C2).

Neutral. Conductor that is effectively grounded throughout its length.

NWC. Northern White Cedar.

Open Point. The point in the circuit that is opened by a set of switches or by the removal of jumper wires and through which electricity will not flow.

Open Supply Line. Bare wire construction.

Parabolic Curve. Something bowl-shaped, such as a microwave reflector. Similar to the Catenary Curve shown in **Figure 4.3**.

Perpendicular. Two lines are said to be perpendicular when they cross at 90° angles.

Phases. The primary current-carrying conductors of RUS construction.

Pi. The Greek symbol (π) denoting the ratio of the circumference of a circle to its diameter.

Plan and Profile. A type of graph showing an overhead view and a side view of distribution or transmission line construction.

Pole Band, Guy Attachment. A metal strap that wraps around a pole for attaching a guy wire. *See* RUS Specification E1.3L.

glossary

Pole Buckling. When a pole bows or breaks due to the vertical down weight caused by transformers and other vertical downward forces such as guys.

Pole Butt. The big end of a treated utility pole.

Pole Setting Depth. Generally 10% of the pole length plus 2 feet.

Pole-Top Assemblies. The hardware, including crossarms and insulators, required to attach conductors to a pole. They are shown in detail in the appropriate RUS specifications bulletin.

Post-Type Insulators. Similar in use to pin-type insulators, but differ in appearance. Post-type or line post insulators are single porcelain insulators with multiple petticoats or skirts.

Primary. Reference to high-voltage conductors. Primary lines are the phase wires or conductors.

PSF. Pounds per square foot. Units used to describe wind pressure.

Quarter Point of Span. A point in the span at a distance from a pole equal to 25% of the span's total length. The quarter point of a 100-foot span is 25 feet from the pole.

Radial Thickness of Ice. Referred to in the *NESC* in the definition of loading districts. A conductor with a radial thickness of ice equal to ½ inch has ½ inch of ice covering the conductor. So, a conductor with a diameter of ¾ inch with ½ inch of ice will have an overall diameter of 1¾ inches.

Range Rod. An instrument used in land surveying; a painted rod marked with alternating 1-foot orange and white bands.

Right Angle. Ninety-degree angle.

Right-of-Way. A strip of land dedicated for public use that may include roads and utility facilities. The land could be owned by the utility, or the utility could have rights to the property through easements.

Rodman. An assistant to a surveyor who typically holds the range rod.

RTS. Rated Tensile Strength, a measurement of the force required to break something (such as wire). Also referred to as Rated Breaking Strength (RBS).

Rule of Thumb. A simplified rule used for applying complicated ideas. Typically, rules of thumb only apply to a narrow range of parameters. Many exceptions will exist. Refer to Section 4 for a **comparison of Rule of Thumb 4.1 to Equation 4.1**.

Ruling Span. May be considered as an assumed "design span" that ensures the best average tension throughout a line section of unequal span lengths between guyed deadends.

RUS. Rural Utilities Service. The U.S. Government agency that works with the electric cooperatives.

RUS Designation. The number and abbreviated name assigned by RUS to each cooperative in the country that is typically not the formal name of the cooperative. This designation is used on the staking sheets. Example: Georgia 103 Coweta.

RUS Spec. Book. The collection of RUS specifications and drawings used for construction of distribution lines. They include RUS Standard D801 Specifications and Drawings for 34.5/19.9-kV Line Construction, RUS Standard D803 Specifications and Drawings for 24.9/14.4-kV Line Construction, and RUS Standard D804 Specifications and Drawings for 12.47/7.2-kV Line Construction.

Safety Factor (SF). *See* **Load Factor** (LF).

Sag Tables. Tables that show the amount of sag in feet and the tension in pounds for a specified span length under specified loading conditions. *See* **Appendix B**, Sag and Tension Tables

Sag Template. A catenary curve-shaped plastic template typically used in the design of transmission lines. Its shape is based on its corresponding sag tables. *See* **Figure 4.3**.

glossary

Secondaries. Description of low-voltage conductors (480 volts or less).

Sectionalizing. Procedure used to provide overcurrent protection to a distribution system.

Sectionalizing Device. Devices used to sectionalize a line or clear a downline fault. They include fuses, reclosers, sectionalizers, and switches.

Self-Protecting Transformer. A transformer with an internal breaker used to clear faults. The internal breaker is used in place of an external fuse.

Service Line. Secondary conductors that terminate at the consumer's weatherhead.

Services. *See* Service Line.

Short Guy Leads. Guy leads that have less than a 1-to-1 ratio. Guy leads shorter than 1-to-2 should not be used with standard distribution structures.

Side Guys. Guys installed on either side of a tangent pole to increase its transverse strength. Sometimes referred to as storm guys.

Sine. Trigonometric function of an angle in a right triangle that is equal to the ratio of the length of the side opposite the angle to the length of the hypotenuse.

Soil Classification. A designation used to describe the composition of a particular soil into which an anchor will be placed. *See* **Table 7.4**.

Span Length. The linear distance between two adjacent poles supporting a conductor.

Staking Package. A collection of tables and data used by the staking technician in the field. The package should contain sag and design tables, staking tables, pole strength tables, pole-top assembly strength tables, line-angle guying tables, deadend guying tables, and staking sheets.

Staking Sheet. A form used to convey the information required to construct or convert a distribution line.

Straight Line Pole. A pole supporting conductors with no line angle. *See* also Tangent Structure.

Strain Insulators. A rod usually made of fiberglass with metal fasteners on each end. It is typically used on guys to provide insulation and clearance of grounded parts from energized conductors.

Stringing Sag Tables. These tables differ from sag tables in that they show sag in either inches or feet for several temperatures and span lengths that may occur for a given ruling span. *See* **Table 4.5** for an example.

Structure. The complete assembly used to support distribution or transmission conductors. Includes the pole, pole-top assembly, and guys and anchors.

Suspension Insulators. Sometimes referred to as deadend bells or may be a string of insulators that hangs down vertically from a crossarm. The length of a string of suspension insulators is dictated by the insulation level required.

Tangent Structure. A pole supporting conductors with no line angle. *See* also Straight Line Pole.

Tap Line. A line emanating from the main line, i.e., extensions of the main line of the circuit. A concern when calculating the bending moment on a pole. Also referred to as a tap.

Territorial Agreement. An agreement between adjacent electric utilities that defines the service territory line. Provisions in the agreement may include joint-use construction considerations.

Three-Phase. Description of the voltage relationship among the three primary conductors used in modern electric power systems. The three phases are 120° out of phase with each other and are at different voltage potentials when referred to one another.

glossary

Torque. A force that produces a twisting or turning action. An engine provides torque to a drive shaft.

Total Guy Load. The load on a guy that is defined as the resultant vector of the horizontal and vertical load on a guy. The resulting force on a guy or total guy load is a function of the length of the guy lead and the amount of horizontal load on a structure to be held by the guy. The shorter the guy lead, the higher the total guy load.

Transformer. A device used on electric power systems to convert high voltage to low voltage by means of windings on a magnetic core.

Transit. A surveyor's instrument that has a telescope mounted on a turntable. Used to accurately measure angles and establish straight lines.

Transverse Loading, Wind. Loading applied to conductors or structures by wind blowing at a right angle to the axis of the body. *See* **Figure 5.4**.

Transverse Loading, Wire Tension. Loading applied to pins or structures by wire tension acting at right angles to the pins or structures. A tap off the main line produces a transverse loading on a pole. An angle in the line produces tensions that have force vectors acting at right angles to the pins and structures.

Two-Way-Feed. An open point in the line where two different sources meet.

Ultimate Holding Power Rating, Anchor. The maximum rating in pounds that an anchor can hold without moving.

Ultimate Resisting Moment. The strength of a wood pole to resist a force applied at a right angle to the pole that can be calculated based on the dimensions of the pole and the fiber strength.

Unloaded Conductor Tension. Also known as final unloaded conductor tension. After a conductor has been subjected to wind and ice loads over a period of years, it achieves an inelastic stretch. When this condition is reached, the tension at a temperature of 0°F/-17°C for heavy loading, 15°F/-9°C for medium loading, and 30°F/-1°C for light loading without ice or wind is known as the unloaded conductor tension. *See also* **Final Sag**.

Uplift. Upward pull of conductors on a structure. During cold weather, conductors will contract and approach their minimum sag values. This may cause the conductors to pull up on a pole that is at a lower elevation than the adjoining poles. *See* **Figure 2.1**.

Urban Construction. Construction in areas of extremely high consumer density where pole spans are very short. Typically found in commercial areas and residential subdivisions of towns and cities.

Vertical Clearance. The clearance beneath a conductor measured in a vertical line to the ground.

Voltage. The electric potential or potential difference expressed in volts. Sometimes described using water pressure as a model of electric voltage.

Weatherhead. A rounded cap, typically on mast pipe, meant to keep water out of electric service pipes; it is often owned by the electric utility customer. The weatherhead is typically the transition point of ownership between the electric utility and customer.

Weight Span. The distance of the iced span, supported by a crossarm, in feet from the low point in the conductor sag in the span ahead to the low point in the sag in the back span. *See* **Figure 6.1**.

glossary

Wind Displacement. Used in the *NESC* to describe an adjusted position of a conductor as a result of wind blowing the conductor. Sometimes referred to as conductor blowout.

Wind Pressure. The pressure, measured in pounds per square foot, exerted by the wind on objects such as conductors and poles.

Wind Span. The average of the two spans adjacent to a given distribution structure. *See* **Figure 5.3**.

Working Space. The space required by the *NESC* to allow a lineworker to work on a structure. *See NESC* Rule 237.

Wrapped Guy Attachment. Type of guy attachment where the guy wire is wrapped around the pole and clamped. *See* RUS Specification E1.2.

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