1098

ENGINEERING NOTES

CONTAINS

INTRODUCTION

Conductors and supporting hardware combinations have been designed for predetermined mechanical loads. In order for structures and pole top assemblies to retain their designed capacities, the following construction methods must be applied.

Drill hardware mounting holes in wood poles with a bit no more than 1/16 in. larger than the diameter of the bolt to be installed. For example: Drill a hole for a 5/8 in.- diameter bolt with a number 11 bit (11/16-in. diameter).

Do not extend bolts more than 1- 1/2 in. beyond the tightened nut. Exchange bolts for the proper size rather than sawing them off.

Do not allow bolts used to mount back-to-back secondary racks to contact insulators or conductors. Saw off excess bolt flush with the nut.

Do not extend double arm all-thread bolts used on double arm construction more than 1- 1/2 in. beyond front of each arm. Leave ample room for future eyenut or dead- end installation.

Install zinc split lock washers on 3/8-in. carriage bolts, securing braces to crossarms.

Tighten all hardware so that the hardware remains tight as the pole dries. to allow for pole shrinkage. Tighten double crossarms at the center through- bolt first, then tighten the outside all-thread bolts until the space between the arms is 1/2 in. narrower than the width of the pole.

Set all dead-end and angle poles raked away from the dead- end or angle. When conductors are in place, and guys are at final tension, there should be no more than 1 ft. of rake toward the anchors. No bending or bowing of the pole is permitted.

Use the table on the following page for angle and tie limitations when framing single and double pins for both Grade B and Grade C construction.

Grade B construction shall be used for all freeway crossings, railroad crossings, navigable water crossings, and any other special applications where increased mechanical strength is required by code or engineering judgment.

Grade C construction can be used where Grade B construction is not required and is the preferred method of construction.

FRAMING, CROSSARM, ANGLE AND TIE LIMITATIONS

WIRE	TIE	GRADE C (PREFERRED)	GRADE B (CROSSINGS ON FREEWAYS, RAILROADS, AND OTHER SPECIAL APPLCIATIONS)	SPAN
ARBUTUS/OXLIP (795 PRIMARY WITH 4/0 NEUTRAL)	TIE TYPE	DEGREES	DEGREES	SPAN LENGTH
SINGLE PIN/ARM	SINGLE TOP TIE	0°	0°	< 250'
SINGLE PIN/ARM	SINGLE SIDE TIE	> 0° THROUGH 9°	> 0° THROUGH 6°	< 250'
DOUBLE PIN/ARM	DOUBLE TOP TIE	0°	0°	> 250'
DOUBLE PIN/ARM	DOUBLE SIDE TIE	> 9° THROUGH 18°	> 6° THROUGH 12°	ANY
DBL DE ON SINGLE ARM	JUMPER TIE AS NEEDED	> 18° THROUGH 30°	> 12° THROUGH 20°	N/A
DBL DE ON SEPARATE ARM	JUMPER TIE AS NEEDED	> 30°	> 20°	N/A
RAVEN/RAVEN (1/0 PRIMARY WITH 1/0 NEUTRAL)				
SINGLE PIN/ARM	SINGLE TOP TIE	0°	0°	< 300'
SINGLE PIN/ARM	SINGLE SIDE TIE	> 0° THROUGH 30°	> 0° THROUGH 20°	< 300'
DOUBLE PIN/ARM	DOUBLE TOP TIE	0°	0°	> 300'
DOUBLE PIN/ARM	DOUBLE SIDE TIE	> 0° THROUGH 30°	> 13° THROUGH 20°	> 300'
DBL DE ON SINGLE ARM	JUMPER TIE AS NEEDED	> 30° THROUGH 60°	> 20° THROUGH 40°	N/A
DBL DE ON SEPARATE ARM	JUMPER TIE AS NEEDED	> 60°	> 40°	N/A
NOTE: SPECIAL DESIGN REQUIRED FOR UNGUYED SELF-SUPPORTING ANGLE STRUCTURES > 18° FOR GRADE C AND > 12° FOR GRADE B				

1098-02 CONDUCTORS AND HARDWARE

Several types and sizes of overhead conductors exist in Austin Energy's Distribution System. The intent of the DCS is to limit the number and types of conductors used in new construction. The common overhead conductors to be used in new Construction include 795 MCM AAC 37 strand Arbutus, 4/0 AWG AAC 7 strand Oxlip, and 1/0 ACSR Raven. The common underground conductors to be used in new construction are 1000 MCM Copper XLPE and EPR, 1/0 AAC XLPE, 500MCM AAC XLPE , 350 MCM AAC XLPE, and 4/0 AWG AAC XLPE.

Wire sizes are designated in either AWG, (American Wire Gage) or kcmil (1000 circular mils). Smaller wire sizes are commonly designated in AWG, AAC, or ACSR. Aluminum Conductor is assigned a unique code word (describing one and only one conductor type) by the aluminum association. When using AWG designation, the greater the number of the wire designation, the smaller the wire is. (Initially, the number designation of the wire was taken from the number of steps required in the wire drawing process; the smaller the wire, the greater the number of steps to draw it.) The largest size designation in AWG is 0000, or 4/0. Larger than 4/0 wire sizes are commonly designated in kcmil.

A mil is defined as 1/1000 of an inch, and a circular mil is as the area contained in a circle with a 1/1000 in. diameter. It should be noted that circular area is not the same as square area. This can be understood by placing a 1-in. circle on top of a 1-in. square and observing that the circle covers less area (in square inches) than the square.

The unit of area used for circular cross- sectional area in conductors is the kcmil. (k - kilo, engineering term for 1000; cmil - circular mil). The MCM (M - roman numeral for 1000) designation for conductors used in earlier electrical system design is an obsolete term and should not be used.

The conductor types and a description of each are as follows:

- AAC (All Aluminum Conductor) is a very common type of overhead distribution conductor. It is composed entirely of aluminum wires, concentrically stranded and similar in appearance to ACSR (described below). It is usually less expensive than ACSR, but not as strong and tends to sag more under electrical and mechanical loading. It is most useful where electrical loads are heavy with short spans and low mechanical loads.
- ACSR (Aluminum Conductor Steel Reinforced) is also a very common type of overhead distribution conductor. It is a concentrically stranded conductor composed of one or more layers of aluminum wire stranded over a steel core, similar in appearance to AAC. The core may be a single wire or several strands, depending on the size. It is usually more expensive than AAC, but is stronger and sags less under electrical and mechanical loading. It is most useful where spans are long and mechanical loads are high. The steel core is not considered when calculating the area in circular mils, but it has an effect on the electrical characteristics. In general, the larger the steel core, the greater the conductivity, although the size in kcmils is the same. Because of the numerous stranding combinations of aluminum and steel wire that may be used, it is possible to vary the proportions to obtain a wide range of electrical and mechanical characteristics.

The following conductors are no longer used in Austin Energy's new construction of the overhead distribution system.

- Copper conductor was a commonly used conductor that is no longer used for new construction. It is used to repair damaged spans of copper, to avoid replacing the entire existing span with ACSR or ACC, for certain applications in underground, and in our Network system.
- Copperweld is a type of conductor in which a coating of copper is welded to the outside of a steel wire. The copper acts as a corrosion protection for the steel wire and, at the same time, increases the conductivity of the steel conductor. The steel is used for greater mechanical strength. The conductivity of Copperweld can be raised to any desired percentage, depending on the thickness of the copper layer. Copperweld was also a commonly used conductor that is no longer used for new construction. It is only used to repair damaged spans of Copperweld to avoid replacing the entire span with ACSR or ACC.

Conductor sag and tension are engineered using computer- applications. The input variables include the wire type or code word, the ruling span*, and the different loading conditions for the necessary sag and tension. The results are computed in feet and inches for initial and final sag, and in pounds for initial and final tension for every ruling span and loading condition used as an input variable. The ruling span is the span length used not only as a basis for calculating the conductor sags and tensions, but also is used in design to determine catenary curves for ground clearances, uplift, and to prepare the conductor stringing tables in the following sections.

1098-02 CONDUCTORS AND HARDWARE

In all conductors used in overhead distribution, final sags are greater than initial sags, and final tensions are smaller than initial tensions. This is particularly true for AAC. This is true because all of these conductors creep to some degree. Thermal elongation of the conductor strands due to the increase in temperature causes greater conductor sags and smaller conductor tensions.

For design purposes, the worst case is always used in calculating clearances and tensions. For clearances, the greatest sag must be used. This is either at the heaviest ice and wind loading or the highest conductor temperature, depending on the conductor and span length. For tensions, the greatest tension must be used. This is either at the heaviest ice and wind loading or the coldest conductor temperature, again depending on the conductor and span length.

Conductor sags and tensions are calculated using computer programs which reference conductor stress- strain charts supplied by conductor manufacturers. Stringing sag tables are generated for each ruling span for all conductors used at Austin Energy, which indicate the sags and tensions to be used when installing the conductors. If new conductor is being used, initial stringing sags are used. If existing conductor is being reused, either final sags or a value between initial and final should be used.

*Ruling span is defined as that span length in which, the tension in the conductor, under changes in the conductor temperature and conductor mechanical loading, will most nearly agree with the average tension in a series of spans of varying lengths between dead- ends.

1098-03 RISER INSTALLATION

A primary riser is a transition point between the overhead and underground distribution system. It is the point at which the underground conductor is terminated and attached to the overhead conductor. Special consideration should be taken when designing or constructing primary risers.

It is the responsibility of every designer or line technician to know and understand the principles of riser installations along with the hazards associated with the work. The following guidelines apply to riser installations at Austin Energy:

- Do not install primary risers on junction poles or poles with overhead apparatus such as transformers and capacitor banks.
- Install primary risers on the face of the pole away from vehicular traffic whenever possible. This will facilitate pole climbing in addition to avoiding damage in case of accidents.
- Always consider climbing space when assigning a quadrant location for a riser conduit on a pole. Quadrant assignments shall be stated on work orders in 45- degree increments. Zero degrees is located on the face of the pole closest to the front property line. Degrees increase clockwise.
- Install all riser conduits adjacent to each other on the pole to conserve climbing space. Install caps on all spare riser conduits at the base of the pole.
- Place pole riser standoff brackets so that each section of riser conduit is supported by one bracket. Place one bracket a maximum of 2- ft. below the top of the riser conduit. The utility inspector shall supply one standoff bracket to the private contractor installing the first 10- ft. portion of riser conduit.
- Install cable grips at all primary riser poles.
- Keep arrester lead lengths as short as possible.
- On secondary and primary risers, conduit shall be a minimum of 3 inches, except for Streetlight risers which can be a minimum of 2 inch conduit.

1098-04 TRANSFORMERS

A Transformer is a piece of electrical equipment used in both underground and overhead construction. In Austin Energy's Distribution System a transformer is generally used to transform higher primary voltages to lower secondary voltages. It is the point at which the primary voltage is transformed into secondary voltage. Special consideration should be taken when designing or constructing transformer stations.

It is the responsibility of every designer or line technician to know and understand the principles of transformer connections along with the hazards associated with the work. The following guidelines apply to transformer installations at Austin Energy:

- Do not install transformers on junction poles or poles with overhead apparatus such as risers, capacitor banks, air switches, and inline disconnects.
- Do not use overhead primary jumpers to change secondary phase rotation.
- Do not cross primary jumpers on the pole to connect to a specific phase illustrated.
- Transformers are purchased and delivered with a grounding strap on the center secondary lug. Remove this ground before installation if the transformer is to be installed in a bank configuration not requiring it. Serious injury or equipment damage can result otherwise.
- Install all high-leg phases at the bottom of the secondary configuration on the pole.
- Do not phase single- phase and 3- phase transformer banks together except for construction and maintenance purposes.

1098-05 SAG & TENSION INFO

This standard provides the sag and tension information for the design of overhead distribution circuits. The following assumptions were made and must be valid for the information contained herein to be accurate: All conductors are uniform along their entire length in weight and shape and shall be installed using the current construction methods. These design tables are not to be used with the "approximate ruling span" which has customarily been calculated and used by the construction crews. Only the actual ruling span as calculated by the use of the correct formula is to be used with these stringing tables. The "approximate ruling span" method of

$$S_{estimated} = \text{Average Span} + \tfrac{2}{3}\,(\text{Maximum Span} - \text{Average Span})$$

shall only be used to verify the actual ruling span used on the print. The use of this approximation may result in significantly different sags and tension creating clearance conflicts and/or overloaded structures.

The implementation of this standard will provide consistent overhead conductor installation when followed. The limits to design used herein are specific for our service area's weather history, i.e. Medium Loading district, and abide by the requirements set forth in the 2010 NESC. All conductors were analyzed in accordance with requirements in the NESC, and based upon operating temperature extremes, Aeolian vibration reduction, and maximum design tension governed by a conductor's rated breaking strength not being exceeded under weather conditions. All calculations performed were done with engineering oversight using Austin Energy's copy of ALCOA SAG10 software. Reduced neutrals should be installed to match the catenaries/sag of the larger conductor and/or maintain a minimum 12 inches of separation. In order to avoid contact with a current carrying conductor, deviations in the stringing of reduced neutrals should be allowed. If the installation of the conductors follows the stringing tables that follow, Austin Energy will be better able to ensure that clearances are maintained as prescribed by the current version of the NESC. There will also be an improvement to reliability based on the conductor's ability to support and not break during the required weather loading conditions.

Three methods of sagging in wire are provided for in the attached stringing charts. The first method involves sagging the wire using a stopwatch and the third return wave method. This method requires several iterations to create an average time to ensure that the conductor is sagged correctly by removing inherent stopwatch operation discrepancies. Another method uses the distance measurement listed in the tables. The distance, listed in feet and inches, should be measured from point of attachment of the conductor on the pole to the lowest point ("belly") of the wire span. A small degree of error is still expected in this method, but if sags are within 6 inches of the value listed during initial installation, this is acceptable per IEEE standard 524-2003. The conversion between these two methods is as listed below. However, discrepancies will be found in the tables using the formulas below due to the degree of precision between the two methods.

$$\text{Seconds} = \sqrt{(\text{Inches}/1.3417)} \quad \text{or} \quad \text{Inches} = 1.3417 \times (\text{Seconds})^2$$

The most preferred installation method is the use of a dynamometer in conjunction with the values provided in the tension row. The dynamometer or "scale" method works best at Austin Energy due to the typical use of short spans as well as allowing loads to be checked during installation. Ultimately, the installation method chosen should provide the most consistent horizontal tensions in the wire between each support as this value should be equal in every span between dead end support structures. The final sag and tension tables should be used only if the conductor has been given adequate time to experience creep elongation or has been exposed to NESC Medium Loading conditions.

Sag and Tension Tables for Bare Wire