Distribution Line Design - Volume 3: Structural Guying

An Online Continuing Education Course for Engineers

Course Number: E-3069

Credit: 3 Hours / 3 PDH / 3 CPD

Distribution Line Design – Volume 3: Structural Guying

Lee Layton, P.E.

Introduction

This course is the third volume in a series of three courses on the design of electric distribution pole lines. This volume explains how guys and anchors are installed at distribution line deadends, line angles and at points of unbalanced conductor tensions.

The first volume in this series discussed how to determine: The loads applied to un-guyed wood distribution poles, a pole's strength requirements to sustain applied loads, maximum horizontal spans based on pole strengths, crossarm vertical loads, and crossarm horizontal loads. The second course in this series presented the methodology and equations required to calculate distribution line ruling spans and conductor sags and tensions.

Unbalanced conductor tensions occur where the conductor size is changed or where there is an appreciable change in the ruling span. A guy assembly needs to be designed to hold the entire horizontal component of the load being applied on the structure in the opposite direction of the guy assembly. A wood pole is used as a strut and supports the vertical components of all loads on the pole including the vertical forces due to the tension contributed by the guy.

While a pole may have sufficient strength to withstand side strain of angles up to five degrees for small conductors, it is usually advisable to install a guy and anchor to prevent the pole from leaning.

This course describes several typical distribution guy and anchor assemblies and their permitted loads and holding power, respectively. The course also discusses the component parts of guy assemblies and their strengths. Installation guidelines are provided for guy and anchor assemblies.

Within this course is the derivation of the equations required to calculate: loading moments, guy resisting forces for several guying situations, guy loads, minimum guy leads, and required pole class to support vertical loads. Example problems using these equations are also presented.

The course references rules and presents selected strength and overload factors required by the 2012 Edition of the National Electrical Safety Code (NESC) for certain guy calculations. At the time this course was written, the 2012 Edition was the latest edition of the NESC. Periodically the NESC is updated and revised. Users of this course should use the rules and data, as may be revised and renumbered, from the most recent edition of the NESC.

Chapter 1: Guying Components

Selection of the proper type of anchor assembly depends upon the soil conditions where the anchor is to be installed. Many utility systems standardize on one or two sizes of anchors of the types most suitable for the soil conditions found in their service areas. The surface area and holding power of the anchor assemblies for distribution line construction are shown in Table 1.

Table 1 Typical Distribution Anchor Assemblies		
Anchor Type	**Minimum Area (square inches)**	**Designated Maximum Holding Power (lbs) ***
Expanding	**90**	**6,000**
	100	**8,000**
	120	**10,000**
	135	**12,000**
Screw (Power Installed)	**90**	**6,000**
	100	**8,000**
	120	**10,000**
	135	**12,000**
Plate	**90**	**6,000**
	100	**8,000**
	120	**10,000**
	135	**12,000**
Swamp	**Helix Diameter (inches)**	
	10	**6,000**
	12	**8,000**
	15	**10,000**
Service	**Anchor Type**	
	Expanding	**2,500**
	Screw	**2,500**
* Note: The "designated maximum holding power" assumes the use of the proper anchor rod type and diameter and proper installation in Class 5 soils.		

Expanding anchors are the most commonly used anchors on rural distribution lines. Screw (power installed) anchors are most commonly used when loose soils are known to be prevalent near the ground line with firmer soil underneath. Likewise, swamp anchors are needed to penetrate firm soil under swamps and wetlands. Plate anchors are most commonly used when heavy conductors are installed on rural distribution lines. Service anchors are usually used to guy service drops and secondary conductors.

Example of a Screw Anchor

Rock anchors are to be installed and used where solid rock is encountered. Only one guy is to be attached to a rock anchor. Where more than one guy is required, separate anchors are to be installed for each guy at a minimum of two feet apart and, where practical, in a direct line with the conductors. The holding power of rock type anchors is highly variable and depends on type of rock, installation procedures and the grout used.

Anchor Strength Requirements

Table 261-1 of the NESC specifies strength factors (equal to 1.0 for both Grade B and Grade C construction) with which the established holding power of anchors are to be multiplied. Rule 264 of the NESC requires that an anchor and rod assembly have an ultimate strength not less than that of the guys attached to it.

Soil Classifications

Table 2 defines the commonly accepted soil classes and their descriptions.

Table 2 Soil Classifications	
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
3	Dense clayed sand, sand, gravel; very stiff to 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; loess; soft-firm clays; varied clays; fill
8	Peat; organic silts; inundated silts; fly ash

Guy Wires

Table 3 illustrates the most common sizes and types of stranded guy wire used for guying conductors on distribution lines. The last column of the table shows the maximum load permitted on a guy wire which is 90 percent of its rated breaking strength per the strength factors (for both Grade B and Grade C construction) specified in Table 261-1 of the 2012 Edition of the NESC. Guy wires and guy assemblies need to be able to hold all of the horizontal forces (loads) acting on the pole multiplied by the appropriate overload factors found in Section 25 of the NESC.

Table 3 Guy Wire Strength Data			
Type Strand	**Size**	**Breaking Strength (lbs)**	**Permitted Load (0.9 * RBS) (lbs)**
Siemens Martin Steel	1/4 in	3,150	2,835
	3/8 in	6,950	6,255
	7/16 in	9,350	8,415
High Strength Steel	1/4 in	4,750	4,275
	3/8 in	10,800	9,720
	7/16 in	14,500	13,050
Aluminum Clad Steel	6 M	[illegible]	5,400
	[illegible]	[illegible]	7,200
	[illegible]	[illegible]	9,000
	[illegible]	[illegible]	11,250

Guy Assemblies and

Typical distribution guying [illegible] ware to connect the guy wire to the pole. Fo[illegible] wires and the pole attachment hardware s[illegible] ware as the guying assembly. Table 4 pr[illegible] ltiple downguys consist of two or more guy a[illegible] or more anchors as may be needed. The last t[illegible] permitted loads allowed on each guy as[illegible] ulated strengths of the assemblies, multiplied [illegible] required in the NESC. All wind and conductor tension loads a[illegible] guy assemblies need to be multiplied by the appropriate overload factors as found in the NESC.