

1

Introduction

1.1 Scope

This manual presents a brief description of typical practices for the design, installation, and usage of overhead utility distribution lines, providing an understanding of the basic principles, and facilitating the subsequent pursuit of the technology and issues in greater detail, as desired or appropriate. It is not, however, the intention of this document to provide or duplicate existing detailed design, construction, or installation specifications and information as presently employed by the various electric supply and communications utilities for their overhead facilities. Such information is available within the individual utilities or their representative organizations.

Although some of the information in this manual is applicable to a variety of overhead applications, including high-voltage transmission lines, the focus of the information is on the local distribution systems, closer to the customer or subscriber end of the grid. This portion of the network is typically characterized by efficient joint-use applications in which electric supply and communications facilities are in reasonably close proximity, supported on the same physical structures, but with strict rules and guidelines to help ensure reliable operation and the safety of both the public and the utility workers. These systems are characterized by significant variability between the facilities supported on each pole, and frequent changes based on customer need, and are generally not subject to the same level of physical design detail as the electrical transmission lines. Indeed, it would be neither practical nor cost-effective to perform a detailed, sophisticated structural analysis on every pole in a distribution line. In contrast, long-distance high-voltage power transmission facilities, along the same transmission line, are relative invariable and unchanging, with relatively uniform spans, and require the efforts of experienced structural engineers, often supported by the use of sophisticated software tools, to cost-effectively design reliable, safe overhead facilities.

This manual is divided into 10 sections or chapters. The background, including a description of the two general categories of construction methods relevant to outdoor utility lines, is provided in Chapter 1, including the overall characteristics and relative advantages and disadvantages represented by each category. Chapter 2 contains a description of pole structures and their physical characteristics, while Chapter 3 provides an overview of their installation, operation, and maintenance procedures. A description of the various types of suspended wires, conductors, and cables is contained in Chapter 4, and Chapter 5 discusses the methods of their installation. Chapters 6 (Strength and Loading) and 7 (Clearances) are primarily based on the rules of the National Electrical Safety Code (NESC®), which govern the physical design and construction of the overhead lines, to help ensure safe facilities for the public and utility workers. Chapter 8 explains the principles regarding wire sags (and related tensions) and provides methods for determining these values under various weather and operating conditions. Chapter 9 contains a brief description of General Order 95, which governs overhead utility lines in California, and how it compares to the NESC. Example calculations are included in Chapter 10 for estimating the physical status of pole systems subject to storm loads. Additional details and explanatory information supporting the various chapters is contained in Appendices A–E. A glossary of terms and a list of references are also provided.

1.2 Background

There are two basic modes of construction for outdoor utility lines for electric power supply and communication systems:

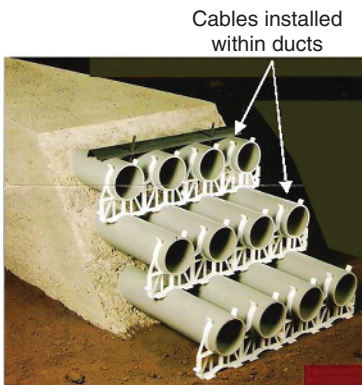
- (1) Belowground (or underground) plant consisting of an array of parallel conduit paths, spanning the distance between manholes, typically located parallel to a main thoroughfare or highway; or, for more local distribution applications, direct burial of the cables within the soil, possibly placed along a road or street, with buried service drops to the residences. Routine access to such distribution facilities is typically provided by flush-mounted handholes or above ground terminals and pedestals.
- (2) Aerial/overhead plant in which the cables are individually suspended between utility structures, including tall structures or towers for high-voltage transmission lines, spaced hundreds, or possibly thousands, of feet apart; or relatively short structures for distribution applications, typically individual poles, spaced up to a few hundred feet apart.

For both these modes of construction, the requirements and guidelines for the installation and operation of power supply and communications lines, including the shared usage of facilities (poles, underground conduit systems, trenches),

are provided in utility industry standards and documents, the most significant of which is the NESC. Both construction methods are commonly used in the industry, with an increasing amount of belowground distribution facilities being placed relative to aerial plant in more recent decades, primarily driven by regulations. For example, the large majority of new construction in local (residential) subdivisions deploys belowground facilities, in response to the demands of communities and various levels of government for a greater portion of belowground construction along roads and thoroughfares, primarily due to esthetic considerations and safety concerns. Utility pole collisions account for a significant fraction of automotive fatalities along the nation's roads and highways, for which the U.S. Federal Highway Administration, as well as the individual states, therefore provide appropriate guidelines for their usage (FHA 1993; AASHTO 2011).

A description of belowground cable applications, including conduit and duct applications, is provided in ASCE Manual of Practice No. 118 (ASCE 2009). Figure 1.1 illustrates typical belowground (underground conduit and direct-buried) construction alternatives.

The extensive conduit facilities of underground plant are generally appropriate for limited applications, such as associated with the trunk or feeder portions



Source: Courtesy of Underground Devices, Inc.



Source: Lawrence M. Slavin

Figure 1.1 Typical belowground construction.

of the traditional telecommunications network, owing to the high cost of this method of construction. However, the availability of several vacant conduits does provide flexibility, including the capability to postpone installation of expensive trunk or feeder facilities (fiber-optic, etc.) until the need arises. Such expensive underground conduit systems are also the only viable alternative in metropolitan or large urban areas where overhead lines and/or future digging are not practical options. In comparison, direct-buried plant is a lower cost method for placing individual cables belowground between any desired termination points, but lacks any flexibility with respect to future additions or replacements. While the placement of utility lines belowground, using either method of construction, avoids much of the potential damage resulting from extreme weather events, there is nonetheless greater vulnerability during incidents of flooding and accidental damage during excavation work in the area.

Although not esthetically pleasing, the ubiquitous overhead lines throughout the United States – supported by possibly as many as 200 million utility poles – provide many important benefits, and is the reason these structures and suspended lines continue to be widely used. Individual distribution poles, or even lattice transmission towers, require minimum real estate at the ground level, and allow new lines to be readily deployed in available overhead space. This includes otherwise difficult crossing applications, or where expensive belowground construction methods (e.g. directional drilling) would be required, such as at highways, railroads, and waterways. Overhead installations avoid the many possible issues encountered when attempting to perform construction beneath the surface in various or unknown belowground conditions, often in the presence of existing belowground facilities. The latter situation can be particularly hazardous, especially when power or gas lines are in the vicinity. The use of mandatory “call-before-dig” rules, and related utility locating practices, are not infallible, and unfortunate accidents may occur in spite of such precautions.

Apart from natural or man-made disasters, overhead lines are exposed to environmental stresses that are generally less severe than the persistent wet and corrosive surroundings that can be found belowground. As a result, it is often more of a challenge to design the belowground cables and/or the associated conduit/manhole facilities with sufficient resistance to those degradation forces than where the cables are placed overhead. In addition, if degradation occurs, or water penetrates the belowground plant, their repair and replacement is more difficult, expensive, and time-consuming. In general, overhead lines are inherently significantly less expensive to install and maintain than belowground facilities, as well as being characterized by greater flexibility for the addition, rearrangement, and/or replacement of the supported lines and equipment.

Figure 1.2 illustrates a typical distribution utility pole application including sharing, or joint-use, of the pole for supporting electric power supply and communications (telephone, Cable/CATV) lines.

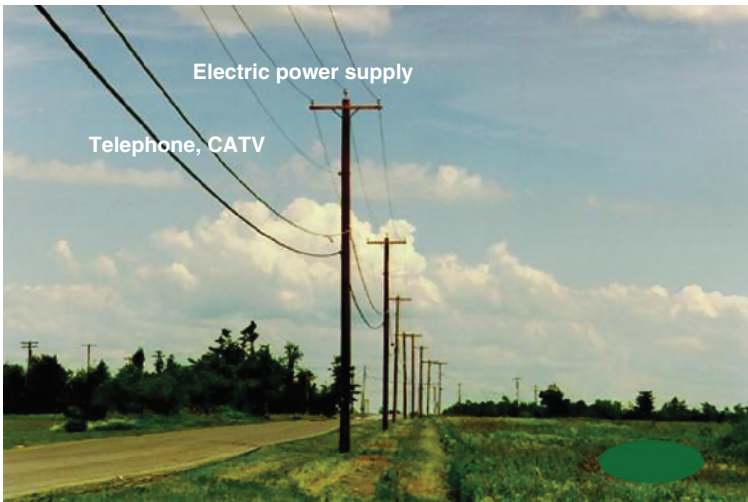


Figure 1.2 Typical joint-use utility pole application. Source: Lawrence M. Slavin.

It is recognized that the increasing deployment of wireless technologies (cellular phones, satellite TV, etc.) has greatly impacted the communications industry, resulting in lost revenue for some of the wireline-based utilities. Nonetheless, it will be a very long time, if ever, before cable-based wireline communications become replaced and discarded. Wireless technology is inherently inferior to wireline (copper, fiber, coax) technologies with respect to various characteristics and features (security, reliability, quality, information capacity, etc.), thereby inhibiting elimination of physical cables. The present major investment in new wireline facilities by the major telephone companies, wherever feasible, bears witness to this principle. Furthermore, “wireless” systems contain multiple wireline segments, such as for interconnecting towers and cell sites, and for providing backhaul communications to the necessary central offices and data centers, as well as for supplying power to the wireless facilities. Ironically, the deployment of the latest wireless technology requires denser placement of antennas than previous systems, encouraging their installation at a larger number of elevated locations, for which utility structures and poles are prime candidates. In particular, the much vaunted 5G wireless age relies on these utility poles as the required fundamental infrastructure to provide the comprehensive coverage necessary for their new services, for which the physical issues discussed in this manual should be considered. In addition, although various alternatives are being pursued for distributed, renewable energy sources for electric power, the continued use of physical cables for transporting electric power supply to homes and industries will be required for the indefinite future.

