Unique Operational Characteristics of Creosote, Pentachlorophenol, and Chromated Copper Arsenate as Wood Pole and Cross-Arm Preservatives

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1. Introduction

The existing electrical transmission and distribution system in the United States is primarily supported by wood poles. These poles also support much of the communication infrastructure (telephone and cable) of the county. This infrastructure is an integral part of the backbone of our economy, lifestyle, and national security.

Estimates of the current number of poles in the system range as high as 130 million (American Wood Preservers Association (AWPA, 2005). On an annual basis, approximately 1 to 2 million poles (USWAG, 2004) are added to the system as additional capacity is required and older poles are replaced. The vast majority of these wood poles are treated with one of following three preservatives:

- Creosote
- Pentachlorophenol (penta)
- Chromated copper arsenate (CCA)

For many utilities – especially many smaller utilities, including rural cooperatives – the investment in treated wood poles comprises the largest portion of a utility’s capital costs. Thus, the selection of what type of treated wood pole to use in a particular utility system is an issue of paramount attention and deliberation. While the relative percentage of each of the above preservatives used in utility treated wood transmission and distribution structures varies, each preservative plays a unique and critical role in the overall ability of utilities to provide reliable and cost-effective electrical service to the public.

As discussed below, each preservative has unique characteristics that are evaluated by utilities in determining which preservative is best suited for use in a particular region of the country. These decisions are based on a variety of factors, including the physical and performance characteristics of the preservative, the location of the service area, and the associated environmental, climatic and developmental (urban versus rural) characteristics of the service area. In circumstances where one preservative may serve as effectively as another in any particular setting (e.g., the use of penta- or creosote-treated wood poles in hot, dry climates), other variables such as costs, supply and worker acceptability (e.g., utility linemen may prefer working with one treated wood pole over another) are important factors in selecting the type of treated wood used in a particular setting.

In short, there is not a one-to-one “substitutability” between the above preservatives; rather, each preservative is selected for use by utilities depending on a variety of unique preservative characteristics and the individual needs of each utility. This technical brief presents a number of practical and relevant facts, scenarios, and conditions illustrating this point.
2. Technical/Operational Specifics

2.1 CCA – Circumstances Where The Use of CCA-Treated Poles Is Specified Over the Use of Penta- or Creosote-Treated Wood Poles

CCA-treated poles are specified for locations where a dry, residue-free surface is required (United States Department of Agriculture, Forest Service (USDA) (Lebow and Tippie, 2001)), and/or odors are not acceptable, including, for example, in urban areas where sidewalks are common and poles are set through the sidewalk into the ground. In this setting, CCA-treated poles are frequently specified as the best choice because penta- or creosote-treated poles sometimes “bleed.” Bleeding causes oily staining at the base of a pole. Use of CCA is also specified frequently for residential areas, where contact with the wood surface is more likely than in rural areas and where staining/odors may be a concern.

In areas with high soil moisture, where the water table is high, or water is perched at a shallow depth, CCA-treated poles are specified over penta- or creosote-treated poles because the CCA preservatives are “fixed,” or chemically bonded within the wood (Lebow and Tippie, 2001). Proper fixation minimizes the risk of leaching. Long-term subsurface saturation is less likely to deplete the CCA preservatives, shortening service life, and increasing the risk of early pole failure and unplanned electrical outages.

CCA-treated poles are also specified in areas that experience occasional freshwater flooding, because the CCA is fixed and thus helps ensure a longer service life. Further, in these “flooding” environments, creosote and penta poles may cause an unacceptable sheen in the water (Lebow and Tippie, 2001).

2.2 Penta – Circumstances Where The Use of Penta-Treated Poles Is Specified Over the Use of CCA- or Creosote-Treated Wood Poles

Penta treatment is the preferred option over CCA- and creosote-treated wood for use in utility cross-arms for a number of reasons. First, southern pine cross-arms treated with CCA have poor dimensional stability because of wide growth rings (due to fast plantation growth conditions) and the “dryness” of CCA-treated wood (compared to Douglas-fir treated with penta or creosote). When these fundamental characteristics are combined with the fact that cross-arms are constantly exposed to direct sunshine, differential drying and shrinking occurs. The differential stresses cause severe twisting and warping of cross-arms, a physical action that strains electrical wires. The strains are often severe enough to cause unplanned
electrical outages. This type of failure risk is plainly unacceptable from an operational perspective.

The dimensional stability issue is addressed by utilities by specifying one of two solutions, as follow:

- Cross-arms are manufactured using dimensionally stable Douglas-fir treated with penta.
- Cross-arms are manufactured with southern pine but treated with penta instead of CCA. The oil carrier for penta prevents exaggerated warping of cross-arms by preventing extreme drying of the wood.

The AWPA has standardized the use of CCA with Douglas-fir sawn cross-arms and poles, but explicitly cautions that Douglas-fir is “extremely difficult” to adequately treat with CCA (AWPA, 2004). This is the case because Douglas-fir consists primarily of heartwood which is laden with extractives. The extractives block the wood pores, and water based preservatives (such as CCA) have difficulty penetrating to an adequate depth. The USDA has confirmed the practical difficulties of treating Douglas-fir with CCA (Lebow and Tippie, 2001).

Penetration and retention specifications for Douglas-fir are more readily achieved with penta and creosote, because both preservatives can be heated for use during pressure-treatment. The heated solution helps dissolve extractives in the heartwood, allowing better penetration. From an aesthetic and operational perspective, however, creosote is rarely requested by utilities for treatment of cross-arms because, over time, there may be drippage onto wires, insulators, or electrical equipment located below the cross-arms on the same pole.

Penta-treated poles may have greater flex (due to oil content) than CCA-treated poles, which are dry and stiffer. Creosote may be specified in areas prone to impact loads such as ice and/or wind.

Penta has several additional attributes that cannot be matched by CCA, as follow:

- Penta is oil-borne. The oil repels rain and moisture from the pole surface. Moisture is one of the requirements for any type of decay. Reduced moisture will contribute to reduced decay.
- The oil keeps the pole “soft.” This enhances penetration of gaffs, making penta-treated poles among the easiest for linemen to climb.
- The oil reduces checking and splitting. This minimizes physical avenues that would otherwise allow easy access for insects and fungi to interior pole locations where preservatives may not have penetrated.
Penta-treated poles impart some corrosion resistance to metal hardware because of the presence of the carrier oil. In contrast, CCA-treated poles require galvanized or stainless steel hardware because CCA enhances corrosion of unprotected metal. Therefore, CCA and creosote cannot substitute for penta in cross-arms manufactured from Douglas-fir or southern pine. Only penta is suitable for this use. Furthermore, in western states, Douglas-fir is the primary species used for utility poles. As described above, adequate treatment of Douglas-fir with CCA is “extremely difficult.”

### 2.3 Creosote – Circumstances Where the Use of Creosote-Treated Poles Is Specified Over the Use of Penta- or CCA-Treated Wood Poles

From an operational and functional perspective, one of the highest-valued uses of creosote-treated wood poles is along coastal areas. Penta-treated poles cannot be used in these environments because salt spray and salt water will hydrolyze the penta, reducing its effectiveness. Penta-treated piles are never recommended for marine (saltwater) use because of this effect. Creosote-treated poles also repel salt water better than CCA. Use of creosote-treated poles in this environment ensures the reliable and cost-effective delivery of electricity to the public.

From an operational perspective, creosote-treated wood poles (along with penta-treated wood poles) are also specified for use by utilities in hot and dry environments, such as utility service areas in southwest Texas, and parts of Arizona and California. Creosote and penta are better choices as preservatives in these environments over CCA because the carrier oils keep the wood “lubricated” and “soft.” As such, there is less splitting/cracking/checking than typically occurs with CCA poles in this environment.

Creosote-treated wood poles are often specified in areas of high alkaline soils. In these environments, penta can be converted to sodium penta, which has higher water solubility than creosote. In settings with alkaline soils and the potential for high soil moisture or a high water table, the effectiveness of penta will be reduced, increasing the risk of early failure and unplanned outages. Thus, in these environments, creosote-treated wood is specified for use by many utilities.

Creosote-treated poles may have greater flex (due to the “oil” content) than CCA-treated poles, which are dry and more stiff. Creosote may be specified in areas prone to impact loads such as ice and/or wind.

In coastal settings, where poles may experience occasional flooding, creosote poles are more effective at preventing marine borer damage (Lebow and Tippie, 2001).
3. Summary

While all of the three preservatives discussed above are designed to prevent decay, the preservatives are not always interchangeable, because decay is not a function of identical decay-causing organisms or environments. In fact, decay-causing conditions and organisms vary depending on the type of wood that is used and the environment the wood is used in. As a result, the three different wood-preservative formulations have evolved to specifically target a variety of organisms, settings, and wood types.

If all wood preservatives worked equally well under all conditions, the only consideration in choosing a preservative would be cost, and utility consumers would have already sorted through the choices and settled on a single preservative. Clearly, since utilities continue to specify all three preservatives, this is not the case.

Other salient and important factors can also influence the choice of the “best” preservative. For example, in areas where labor organizations have an influence on preservative choice, penta and creosote may be more common than CCA – poles treated with creosote or penta are perceived as being easier to climb, and specifying their use for climbing ease (“safety” reasons) is an important factor in selecting a certain type of treated wood.

The above discussion underscores the fact that there is not a “one-to-one” substitutability between the three main wood preservatives – penta, creosote, CCA – for purposes of use in electric utility poles and cross-arms. Each preservative has unique characteristics that are evaluated by utilities in determining which preservative is best for use in a particular region of the country. These decisions are based on a variety of factors, including the physical and operational characteristics of the preservative, the location of the service area and the associated environmental, climatic and developmental (urban versus rural) characteristics of the service area. In those circumstances where one preservative may serve as effectively as another in any particular setting (e.g., the use of penta- or creosote-treated wood poles in hot, dry climates), other variables such as costs, supply and worker acceptability (e.g., utility linemen may prefer working with one treated wood pole over another) are important factors in selecting the type of treated wood used in a particular setting.
References


