Coal Tar Distillate (Creosote)—The First and Still Great Choice to Preserve Utility Poles

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Abstract

Creosote, a coal tar distillate product, has been used to preserve wooden utility poles for well over 100 years. Such use began in the late 1800s and continues to this day. Creosote's efficacy in protecting wood from decay, termite attach, and general weathering has been demonstrated by actual performance of poles in utility service and in documented field and laboratory testing. The American Wood Protection Association has standardized and long recognized the efficacy of creosote preservation. With production of pentachlorophenol ending after 2022, preservation may easily convert to creosote preservative. Creosote preservative also is an environmentally sound choice in that used poles can be used as fuel and otherwise, creosote degrades biologically. Wood is sustainable as new trees are grown to replace poles while the poles are sequestered carbon. Utility service life of creosote preserved wooden poles typically lasts for 70 to over 100 years with inspection and maintenance. Utilities can expect new creosote preserved poles to last into the next century.

Background

Coal tar distillate (of which creosote is a product) is a dark brown liquid that is produced by thermal distillation of coal tar. Coal tar is a biproduct of producing coke for steel production from coal via a pyrolytic process in "coke ovens" (Fig. 1) where the coal is heated to over 1,000°C in an oxygen-limited condition (Ametek 2022). The tar is distilled into lower-, medium-, and high-boiling-point fractions. Creosote wood preservative, as standardized by the American Wood Protection Association (AWPA), is derived from the medium-boiling-point fraction in the range of 210°C to 355°C (American Wood Protection Association [AWPA] 2021). Creosote is coal tar distillate meeting specific fractional proportions as defined by the AWPA.

Production of coal tar distillate is not a chemical creation process, but a process to separate the chemicals that originated from the ancient biomass that resisted decay so that they remained in coal. The qualities that prevented decay over millennia are those that protect wood treated with creosote (Henry and Webb 1974a). This fraction of coal tar distillate, standardized as creosote, is a complex mixture of many (hundreds of) identifiable chemicals that are primarily hydrocarbons. Approximately 40 to 60 percent of creosote is composed of two- to six-ring polycyclic aromatic hydrocarbons (PAHs; Creosote Council 2011). Creosote use as a wood preservative became commercially practical with the

Figure 1.—Coke discharging from oven.

process patents for the Bethel full-cell treatment process in 1838, the Rueping empty-cell treatment process in 1902, and the Lowry empty-cell treatment improvement in 1906 (Creosote Council 2022).

During the 1800s, coal tar was available in abundance as a byproduct from both coke ovens and town gas plants. It was used as a liquid fuel, as a road or roofing sealer, and as coal tar distillation feedstock.

Wooden utility pole preservation with creosote was first commercially applied in 1897 when the Atlantic Telephone and Telegraph Company installed 10,000 poles between Washington, D.C. and Norfolk, Virginia. Inspection after 30 years of service found that most poles were still in good condition. Although the line was out of service, a follow-up inspection in 1979 (83 years after installation) found that 38 poles were still in place and another 49 were in a storage yard and still in serviceable condition. Many poles had been removed over the years because of realignment changes rather than because of decay.

Formation of the Rural Electrification Administration in 1935 accelerated installation of electric utility infrastructure. By the end of World War II, 8.1 million wooden poles were being produced annually (Wolfe and Kluge 2005). Creosote remained the primary wood preservative through approximately 1955, at which time the market was transitioning to pentachlorophenol and waterborne treatments (Henry and Webb 1974b). Creosote-treated wooden poles were the accepted material as the United States was electrified during the first half of the 20th century.

Creosote is utilized as the preservative for approximately 16 percent of the wooden poles being installed in 1997 in the United States (Smith 2011). The market is changing. Pentachlorophenol, at approximately 40 percent market share, will not be produced after 2022. In addition to its proven history of long service life, creosote is the only carbon-based preservative, meaning that it offers the advantage of being clean burning if used poles are reused for energy production or, if not used as fuel, is biodegradable.

Creosote-preserved wood utility poles are preferred by some utilities, including Texas Electric Cooperative. While also providing long service life and protection from decay and insect attack, in severe climate exposures such as Texas, creosote offers some advantages over other preservatives by better resisting desiccation and being more resistant to wildfires.

Creosote-preserved wood performance

The paper “Creosote Utility Poles—An 83-Year Case Study” documents both the long history of creosote preservation of poles and the long service life enabled by such treatment (Henry and Webb 1974). Creosote-preserved wood utility poles of both square and round cross-sections were installed between Washington, D.C. and Norfolk, Virginia in 1897 by the Atlantic Telephone and Telegraph Company. Eighty-three years later, in 1979, poles were last inspected. At that time, 38 poles were still in service and another 49 poles that had been removed for various reasons other than decay were in storage. All but two of these poles were still serviceable. Further, extraction of samples from two representative poles showed approximately 12 lb of creosote/CF still meeting today’s treatment standards.

Although no small sample tests are more relevant than actual performance, numerous reports cover significant testing of smaller creosote-preserved wood samples. Two important sets of test results, for posts and stakes, are discussed below. Note that in these, only the results relevant to creosote are presented, as the intent is to show that creosote offers long-term service life to products rather than to compare its performance with that of other accepted preservatives.

In 1949, testing was initiated to compare the performance of many different wood preservatives in protecting southern pine fence posts of 4- to 5-inch diameters. The test included 25 posts of each preservative. Preservatives included creosote of many grades and types. Data from this study applicable to creosote-preserved utility poles are summarized in Table 1. This shows that treatment with creosote very substantially extends the service life from just a couple of years to 60 or more years.

This test was initiated in 1949 and was, in part, designed to help determine which coal tar distillate (creosote) formulations or distillation cuts would provide the best performance. On the basis of results such as these and a similar test, the 1958 Cooperative Test, the AWPA standards for creosote were changed in 1978 to include less of the low-temperature distillate and more of the medium residue material (Webb et al. 2010). So, in Table 1, the line “Average of medium residue creosotes” best represents current AWPA Standard P1/P13 and P2 creosotes in use with an estimated service life of approximately 63 years. By observation of the various creosote results, one can also see the wide range of variability in results such tests yield. Thus, results should not be accepted as precise, but rather general indications of estimated service life.

The Forest Products Laboratory periodically publishes a summary of various wood preservative test results, the latest being the 2011 Progress Report (Woodward et al. 2011). Tests only for ground contact exposure are considered. In

Table 1.—Mississippi posts test (installed 1949).[a]

Preservative	Estimated service life (years)
Coal tar creosotes	
High residue, crystals removed	105.4
High residue, low tar acid and naphthalene	154.0
Low residue, low tar acid and naphthalene	53.7
Low temperature	58.2
Medium residue, low fraction 235–270	58.3
Medium residue, low naphthalene	67.6
Medium residue, low tar acid	66.4
Medium residue, low tar acid and naphthalene	66.8
Straight run, high residue	71.7
Straight run, low residue	45.7
Straight run, medium residue	54.0
Average of all creosotes	72.9
Average of medium residue creosotes	62.6
Petroleum oil, no. 4 aromatic residual	43.0
Petroleum oil, no. 2 distillate	7.7
Untreated controls	2.4

[a] Adapted from Freeman et al. (2005).

the applicable tests, the stakes are driven into the soil in locations of high decay and insect (termite) hazard. Various test results are summarized in many different tables, each representing separate tests.

In Table 2, Progress Report results of tests using only 2- by 4-inch nominal by 18-inch stakes and of only creosote preservative are summarized. It is noteworthy that even with about 50 years of exposure, some estimates of service life could not yet be made (shown as NYD) because some stakes had not yet failed. Since one purpose of the tests is to determine the optimum preservative retention for given applications, various retentions are tested together. For southern pine, retention standards are 8.0 lb/CF for creosote (AWPA 2018). Although many of the creosote tests have not yet determined the estimated service life, it appears that estimated service life for these samples would be 30 or more years. Typically, larger members, such as poles, provide longer service life than these small samples.

The conclusion from review of the summarized information in the tables is that creosote provides good protection of wood in ground contact at the retentions specified by AWPA.

Creosote-preserved utility poles today

Use of creosote to preserve utility poles has gradually declined in the last 60 years. Although now only about 14% of poles are creosote preserved, many creosote-preserved wooden utility poles remain in service. In a 2019 report by Osmose, fractions of poles of preservative types by decay region were presented. At this time, the proportion of poles in service treated with creosote ranged by U.S. regions from approximately 25 to 50 percent (Osmose Utility Services 2019). Thus, creosote-preserved utility poles remain as a vital part of the utility infrastructure in the United States (Fig. 2).

Creosote-preserved wooden utility poles have and will continue to provide excellent long-term performance of 60 to 100 years with appropriate inspections and maintenance.

Table 2.—Stake test results.[a,b]

Table	Installed (year)	Evaluated (year)	Preservative	Location	Retention (lb/CF)	Removed (%)	Avg. life (yr)
4	1940	2000	Coal tar creosote	Wisconsin	8.0	29	NYD[c]
				Mississippi	8.0	90	NYD
5	1941	1996	Coal tar creosote, grade 1	Louisiana	10	25	26.6
				Florida	10	10	NYD
				Mississippi	10	90	NYD
6	1950	1996	Coal tar creosote, diluted with toluene	Mississippi	3.4	100	19.1
					8.1	70	NYD
					12.6	0	NYD
			Control (toluene)		29.5	100	2.2

[a] 2 × 4-inch nominal × 18-inch southern pine stakes.
[b] Adapted from Woodward et al. (2011).
[c] NYD = not yet done.

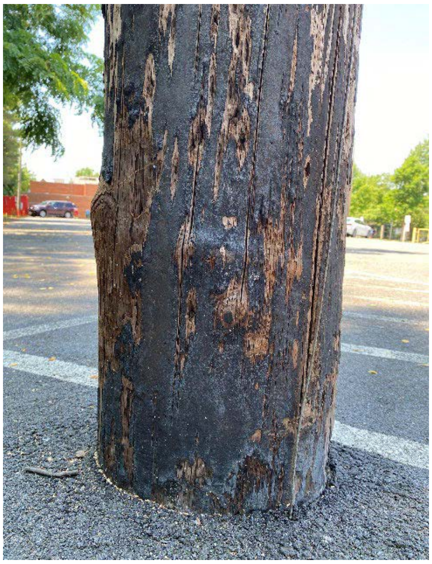

Figure 2.—Approximately 75-year-old creosote-treated pole in parking lot in Vienna, Virginia.

Creosote treatment of poles is widely available in the United States and the many plants transitioning away from pentachlorophenol can shift to creosote treatment with little investment. Availability is further enhanced with creosote treatment because it can be used for southern pine and Douglas fir. Creosote-preserved poles remain climbable by linemen because creosote seals and lubricates the wood fiber so that flexibility in the wood surface is retained. Current treatment practice and standards assure that the surface of poles has only minimal residue of creosote and is much cleaner than in past decades.

The environmental issues favor creosote over other preservative systems; however, the issues are also complicated. Creosote largely consists of PAHs, some of which are regulated as human carcinogens and environmental pollutants. These PAHs do naturally break down to elemental components, especially when in low concentrations. The larger-molecular-weight PAHs may take years to degrade. For poles in utility service, creosote was only detected in the soil within a small radius of about 8 inches from the pole surface (North American Wood Pole Council 2020). Adhesion to soil particles and biodegradation limit further migration. It is also important to understand that PAHs are naturally occurring. "PAHs have been found in 2,000-year-old glacial ice in Sweden. Typically, naturally occurring background levels of PAHs are low, in the neighborhood of 10 to 100 parts per billion (by weight) in soils and sediments (North American Wood Pole Council 2020)."

PAHs do burn and provide useful heat value when creosote-preserved wood is combusted or pyrolyzed, yielding carbon dioxide and water vapor as combustion products. Thus, when used creosote-preserved utility poles are recycled by combustion or pyrolysis, the energy contained in the wood and creosote is beneficially used and offsets fossil fuel, thereby reducing emissions of greenhouse gases. Further, if pyrolyzed, some of the carbon in the wood may be sequestered in biochar used as admixture to improve soil.

Utilities should also recognize the advantages of wood over man-made materials such as steel, concrete, and synthetics. Originally, back in the pre- and early 1900s, wood was the only option, being readily available in North America, economical, and flexible. The introduction of wood preservation and recovery coke ovens, which made creosote widely available, added long service life to the advantages of wood over steel, concrete, and synthetic materials.

Wood is truly sustainable. Trees grown for poles typically grow in less time than the poles provide in service. United States forested land continues to grow more wood than is harvested, ensuring a supply for the future (Ince and McKeever 2011). In doing so, trees remove carbon dioxide from the air and, by photosynthesis, convert it into wood and oxygen. Thus, using wooden instead of other types of poles reduces global warming (Bolin and Smith 2011).

Experience, research, and innovation have revealed new and enhanced known advantages. Wooden poles are flexible enough to absorb some of the shock of wind and seismic loads. Wood does not conduct electricity, so the linemen are less likely to face electric shock. Inspections and maintenance treatments, such as with borates, greatly extend the service of wooden poles.

The infrastructure of wooden poles and crossarms maintained by U.S. utilities is carbon that was removed from the atmosphere as the trees grew and is sequestered for the many decades of service. "This wood is estimated to contain 27 million tons of carbon (25 metric tonnes of carbon). It represents approximately 90 million metric tonnes of CO2 removed from the environment and stored in the wood poles and crossarms while in use (Smith 2020)." This is equivalent to carbon dioxide from driving a typical gasoline-powered vehicle approximately 220 billion miles (U.S. Environmental Protection Agency 2020).

Conclusion

With a history of well over 100 years of in-service performance, coal tar distillate creosote is proven as an effective wood preservative for utility poles in North America. Today, creosote is still an environmentally sound and effective preservative for wood products in long-term infrastructure-type uses, such as utility poles. Preservative treatment standards of the AWPA continue to assure that products will be properly treated and provide performance over many decades. Utilities installing creosote-preserved wooden poles can reasonably expect them to continue their performance into the next century.

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