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## TREATED WOOD PRODUCTS, THEIR EFFECT ON THE ENVIRONMENT

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This paper gives a review of information concerning the preservative treated wood products and a cursory literature review of exposure potential to human health and the environment. Each one of the three major wood preservatives, creosote, pentachlorophenol, and the waterborne arsenicals will be discussed as well as some historical aspects of wood preservation.

Keywords: wood preservatives, environment, creosote, pentachlorophenol, arsenic

### Introduction

On September 30, 1985, the Environmental Protection Agency (EPA) concluded their 8-year study concerning the reregistration of the three major wood preservative chemicals - creosote, pentachlorophenol and its salts, and the waterborne arsenicals. These wood preservative chemicals had many uses which had included the pressure and nonpressure treatment of wood, i.e., crossties, utility poles, piling, timber, etc., groundline treatment of utility poles, brush-on application for field cuts and bolt holes, and for sapstain control of various lumber products. After EPA's careful evaluation of the risks to the public health which might occur when exposed to these wood preservative chemicals, the agency concluded that the use of these three preservative chemicals when used with certain label changes would not pose a significant risk. Part of this deliberation took into account the significant economic benefits which would result from the use of these wood preservative chemicals. The various label modifications are described in the January 10, 1986 Federal Register Notice and can be found on the labels of the three wood preservatives, thus, these specific details will not be elaborated upon. It is important to make the distinction between the registered wood preservative chemicals and the treated wood products. The wood preservative chemicals require labels for their use. However, wood, which has been treated with these chemicals are not currently regulated under EPA's pesticide regulations, i.e., treated wood is not considered a pesticide.

### Historical Aspects of Wood Preservations

The purpose of this paper is to detail some specific examples of the effect of treated wood products in the environment. However, prior to entering into this discussion, it is pertinent to give some historical information concerning the use of preservative chemicals to treat wood to increase its service life. Whether pressure or nonpressure processes are employed, the sole purpose in treating wood with wood preservatives is to protect wood from those organisms or circumstances which would destroy it. Wood destroying fungi, insects (i.e., carpenter ants and termites) and marine wood boring crustaceans use wood for food or as a place to build their tunnel shelter. Wood can also be destroyed by fire and thus it can be treated with fire retardant chemicals to reduce its tendency toward combustion.

The use of wood preservative chemicals can greatly increase the natural service life of wood. The literature indicates that the history of wood preservation began in the Eastern Mediterranean in approximately 2000 B.C. The Egyptians applied "natural oils" to wooden plows to retard the effects of moisture on the wood. During the later part of the Greek civilization in about 1000 B.C., the serviceability of wood was increased by using naturally durable timbers in conjunction with construction techniques which would keep the wood dry and away from water. Early civilization records also indicate that during the Roman Empire, it was recognized that there was a susceptibility of sapwood to "more easily rot" than the heartwood. This ob-

servation was made with the naturally durable timbers such as cedar and cypress. The Romans also recorded the use of various "oils" to preserve wood from attack by various wood boring organisms. The use of pitch, which was probably a wood rosin, was also used to protect against water.

It also is interesting to note that during the 16th and 17th centuries, the major European powers were experiencing a shortage of timber for building the naval ships. The decay of wood and attack of marine boring organisms was ravaging the wood which was used to construct these vessels. Copper sheathing was employed by the British navy to help reduce the degradation of wood by these organisms.

Thus, the interest in wood preservation as noted by Graham (1973) was a matter of national survival. In the middle 1900's, naturally durable woods were often used in an attempt to prevent attack by wood destroying organisms. The first successful preserving process was developed by Kyan in 1832. A water solution of mercuric chloride was used to soak wood, rope, and canvas to protect against cellulose-destroying organisms. Subsequently, other treating processes included the use of copper sulfate, zinc chloride, and creosote treating solutions to protect wood, until a vacuum pressure impregnation method was discovered and used by Moll in 1836.

It is important to note the comparison and the timing with regard to the use of naturally durable wood and the use of treated wood. During the late 19th century, the railroads which were involved in a vigorous construction program to link the major industrial cities within the United States were using naturally durable timbers such as black locust, cedar, chestnut, and white oak. As the supplies of naturally durable timbers decreased, the development of the wood preserving industry then occurred in the late 1800's to make use of nondurable timber species, such as red oak, maples, Douglas-fir, and the pines.

The use of wood preservative materials such as zinc chloride and creosote for treating cross-ties was well documented in the Proceedings of the American Wood-Preservers' Association (AWPA). The development of the treating industry within the United States and throughout the world has historically been based on need to protect nondurable wood from the wood destroying organisms. Ultimately, it is not possible to utilize naturally durable timbers because they simply are not available in sufficient, cost effective, quantities to meet the demand. There are isolated situations in which naturally durable import woods have been used. For example Ekki or Asobe (*Lophira alata*) is purported to be naturally durable and has been used in dock and bulkhead construction, as well as for cross-ties. Notwithstanding higher cost and long-term serviceability questions, there is substantial doubt concerning the availability to meet the demand, WEI (1987).

## Treated Wood Products

### Creosote

The use of creosote in preserving wood can be considered the oldest of the three major preservatives being used to treat wood products in the United States. The treatment of railroad cross-ties with creosote was first initiated with the Bethel full-cell pressure treatments at the Somerset, MA plant in 1865. Twelve years later, the Louisville and Nashville Railroad treating plant was built in Pascagoula, MS. As is known today, the construction of these plants is considered the beginning of the modern pressure treating industry.

The use of creosote as a preservative for both pressure and nonpressure processes has been well documented as reported in the AWPA Proceedings. It is not the intent of this paper to describe creosote or its solutions, however, it is intended to discuss the environmental effects of creosote treated wood products. Similarly, there will follow discussions concerning each of the other two major preservatives, pentachlorophenol and waterborne arsenicals.

Data indicate that naphthalene and its derivatives, along with other low-boiling constituents in creosote rapidly biodegrade in both soil and water. The compounds in creosote which are higher boiling, such as anthracene, fluoranthene, and chrysene are more slowly biodegraded than are the lower boiling compounds. The data reported in the literature do not indicate any rate for the decomposition of the various creosote constituents. There are, however, studies which have shown that a reduction in the creosote constituents in the marine environment occur expeditiously with time.

Wood products treated with creosote and its solutions of creosote/petroleum or creosote/coal tar use either pressure or nonpressure treating methods. As with the other two major preservatives, this treatment is not a separate or otherwise broadcast method for applying pesticides. The preservative chemicals are put in the wood to stay in the wood, therefore, minimizing the opportunity for environmental contamination. There are, from time to time, trace amounts of creosote that enter the soil or water environment. These small amounts occur because of the surface residual of creosote which is in the exterior pore surface of the wood.

Von Runkler, et al. (1975), in a report for EPA, stated that the evidence available indicated that the environmental hazards, posed by creosote-treated products, were minimal. They cited reports characterizing the loss of creosote constituents by vaporization from the treated wood as compared to the loss of similar PNA compounds, and in much greater quantities, that occur from pine forests.

Other researchers, including Hochman (1967) and Sweeney, et al. (1956), have reported losses of creosote

sote from small test panels exposed in marine waters. Because of the surface to volume ratio, it is probably not appropriate to compare the creosote losses from small panels and extrapolate the data to full sized timber piling.

The fact of the matter is that there are some losses of creosote from treated wood in the marine environment. Up until recently, data concerning the concentration of these creosote constituents has been somewhat limited. Wade, et al. (1987) characterized compounds which had moved into the surrounding water area. Samples of water were taken from the surface sheen, the water column, and the bottom sediment. The water samples were analyzed using two methods:

1. An acute toxicity test with sea urchin, *Areachia punctulata*.
2. High precision gas chromatography / mass spectrophotometric chemical analysis.

These analyses showed the presence of creosote components in only the water surface sheen sample. There was no identifiable creosote components found in the water column sample. There was no measurable toxicity in the water column sample as a result of the sea urchin evaluation.

As a result of this study, it is suggested that there is no identifiable impact to the marine environment in the immediate vicinity of the creosote timber piling. Thus it can be concluded that there would be minimal risk contribution from such piling regarding the consumption of fish and shell fish that would be harvested in the immediate area.

The creosote components which could have a toxic effect would be confined to the 1 nanogram layer of water. This oil sheen can be confined using an absorbant or a "boom" to restrict the creosote movement across the water.

#### Creosote and Soil

The movement or loss of creosote constituents from wood in the soil are regarded as having no adverse effect on the environment. A study conducted at Mississippi State (1975) indicated no movement of creosote, either radially or vertically from creosote treated poles. None of the major creosote components were ever isolated from soil samples collected to a depth of 6 inches or ranging from 2 to 24 inches from the pole.

Thus, it is concluded that the creosote components which may enter the soil were either oxidized or biodegraded.

Numerous other studies support this fact that creosote components are readily biodegradable. These studies include the work by Belas, et al. (1979) and Seesman, et al. (1977) which reported on the biodegradation of creosote / naphthalene treated timber

piling. Also, researchers in the United States Naval Civil Engineering Laboratory specially identified the metabolism of creosote (biodegradation) with certain marine micro-organisms. These researchers include Drisko, et al. (1962) and (1966). In considering creosote components, it is also important to consider the ubiquitous nature of these components which often are common and abundant in soil. Blumer (1961) found isomers of benzopyrene in soil samples collected in rural areas of Massachusetts and Connecticut. Also present in these samples were other polynuclear aromatic (PNA) compounds which included phenanthrene, anthracene, pyrene, chrysene, and fluorethene. The concentration of benzopyrenes ranged from 40 to 1300 microgram per kilogram. These soil samples were taken away from areas which could have been potential "pollutant" fallout areas. Conclusion was that these chemicals are indigenous to the soil and probably occur as a result of wood pyrolysis and biological degradation of plant tissue.

In conclusion, creosote treated wood products do not present an unreasonable health risk to man, animals, or have environmental effects. The amount of creosote which may migrate or be lost to the environment through vaporization is minimal and although the evidence is somewhat empirical, it does indicate there is negligible exposure.

#### Pentachlorophenol

As with the previous discussion concerning creosote, this particular section on pentachlorophenol will, for the most part, be limited to a discussion of pentachlorophenol treated wood. Wood treated with pentachlorophenol also has within it various types of "carriers" which are defined in the AWPA P9 specification. These oil type carriers are considered to be inactive as a pesticide and there will be no discussion with regard to these carrier materials.

Essentially, pentachlorophenol, hereinafter, referred to as penta, is considered to be ubiquitous in water environments. It has been suggested by some individuals that the source is treated wood products. The available evidences indicates that this would not be true.

Kozak, et al. (1979) reported the source to be from the degradation of other organic compounds and / or the chlorination of water. It also was indicated that with respect to the soil environment, presence of penta was somewhat variable and depended on several different soil characteristics, including pH, organic content, moisture content, clay mineral composition, free iron content, iron exchange capacity, and the presence of micro-organisms.

There are numerous references in the literature which focus on the fate of penta in air, water, and soil environments. However, with respect to penta

treated wood in these environments, it is often necessary to extrapolate and interpret data for these environmental exposure conditions. Thompson, et al. (1979) measured penta levels in air using different solvent systems. It was concluded that the various solvents or co-solvents and their makeup retarded the vaporization of penta from treated wood. Further interpretation of this laboratory vaporization study indicated that the potential exposure of man or animals to penta vapors did not present a significant risk. To further explain, the occasional farm animals, such as a cow or horse, which would lick penta treated wood do so in an isolated area and the amount of penta taken from the wood would be significantly below any acute toxic threshold level.

The USDA Assessment Team Report, "The Biologic and Economic Assessment of Pentachlorophenol, Inorganic Arsenicals, Creosote, Volume I: Wood Preservatives," gives numerous literature citations concerning the fate of penta in the environment, in air, water, and soil circumstances. There are also discussions concerning exposures of plants, animals, and man to pentachlorophenol treated wood. A summary of the literature concerning the persistence of penta in soil indicates that penta would be considered moderately persistent and have a realistic environmental half-life. However, the soil composition does greatly affect the persistence of penta. Penta has been identified as biodegrading into several different types of chlorophenolic chemical compounds, i.e., 2,4,5-trichlorophenol. Biodegradation of penta in soils and other environments have been reported by several researchers. The degradation parameters were 90% or complete biodegradation, with the time frame for this to occur ranging from 21 days to a high of 205 days as reported by Arsenault (1976). Available data indicates that penta from treated wood products does not represent a significant hazard to the environment. Although penta is slower in its degradation than is creosote, it is biodegraded by micro-organisms; thus, low levels of penta contamination which occur in the immediate vicinity of a treated wood structure do not represent an environmental concern.

#### Waterborne Arsenicals

In contrast to the other two preservatives discussed, creosote and pentachlorophenol, the waterborne arsenicals differ in that water is the carrier system used during the treating process. Potential exposures and the fate in the environment of the arsenicals is reasonably well documented in the literature.

The arsenical preservatives are unique as wood preservatives in that the chemicals react with the wood substrate. This reaction is termed "fixation"

because the preservative compounds in the solutions are fixed in the wood in an insoluble state. Fixation accounts for permanency of the preservative in wood.

There are three types of arsenical preservatives, Ammoniacal Copper Arsenate (ACA), Ammoniacal Copper Zinc Arsenate (ACZA), and Chromated Copper Arsenate (CCA Types A, B, and C). CCA Type C is the most balanced of the three systems in terms of arsenic, chromium, and copper content as related to preservative efficacy and leach resistance. All three components occur naturally in the earth's crust. The arsenate forms of these preservatives are very insoluble components in virtually all soils and, thus, move only by erosion.

The arsenical compounds from the treated wood occurs in three areas - air, water, and soil. Each of these will be described in a summary form separately.

With respect to air, arsenic from treated wood originates in two ways:

- When cutting the treated wood
- Air entrainment of surface deposits.

If the area of discussion is only concerned with arsenical treated wood "in place," we will limit our discussion to only the second area cited for waterborne arsenicals, which, as alluded to above, are approved by EPA for indoor use without a requirement to coat or seal the wood. The available data for airborne arsenicals primarily focuses in areas when used as wood foundation plywood structures. The use of arsenically-treated wood in the "Permanent Wood Foundation" (PWF) which was formerly known as the "All-Weather Wood Foundation" was developed almost two decades ago under industry-government cooperation. Air testing on aboveground structures such as cabins and small buildings built entirely of arsenically treated wood has shown airborne arsenic levels to be not significantly greater than background levels.

There is no data available on arsenical air samplings from wood poles, pilings, or bulkhead structures. It is not expected that the concentration of airborne arsenic would be any greater than that of background, as determined from indoor monitoring results cited above.

With respect to water sampling for preservative treated wood, it should be noted that the arsenic forms are very insoluble compounds and do not easily form solutions with water. Various researchers have conducted leachability studies from arsenically treated wood. These concentrations are no greater than what would be considered background residual levels for arsenical compounds. Several general statements can be made concerning the leachability

of waterborne arsenical preservatives, ACA, ACZA, and CCA:

- Loss of arsenic has been shown to lag behind that of copper and chrome and is related to the chromium concentration and the preservative formulation.
- Leachability of arsenic from the ammoniacal solutions tends to be greater than the CCA solutions.

Available test data indicates that the concentration of arsenic leaching from treated wood is not a significant environmental hazard. Any arsenic which may move from wood is limited to a very short distance from the treated wood product, whether it be timbers, posts, or poles.

### Conclusions

The treated wood industry has often been asked about the environmental effects of treated wood products. Our society and industry does want a clean environment and there has been a high profile level of environmental concern for treated wood products. A risk/benefit appraisal was made of treated wood products through the RPAR process, and the EPA concluded that the benefits of treated wood and the preservatives that are used to treat the wood outweigh any potential risks that may occur.

The Voluntary Consumer Awareness program arising from the EPA/Industry RPAR settlement agreement has been successfully implemented with the primary information vehicle being the Consumer Information Sheet (CIS) for all treated products. These CIS sheets detail proper use and handling techniques which should be used in conjunction with treated wood. These procedures and this program were developed to assist and give guidelines to those individuals who purchase treated wood. Copies of the CIS for each of the three preservatives are attached as an appendix to this paper.

Preservative treated wood products are not pesticides. Once their useful life has been completed, they can, under current EPA regulations, be disposed of in an ordinary land fill site. They are not considered to be hazardous waste products. There are, however, individual State regulations which may give additional guidelines for disposal of treated wood products.

A question has been asked, "What are the environmental effects of these three preservatives - creosote, pentachlorophenol, and waterborne arsenicals?" The industry is dealing with these plant operating procedures which often occur with some of the "older" treating plant facilities. As new reg-

ulations are adopted and implemented, the treating plants, to remain in compliance, will continue to put into place the procedures to use each of the preservatives within their plant operations.

However, with respect to the treated products themselves, there are some additional questions that are often asked. These questions often arise because of a perception concerning the regulations governing the preservatives and their use in the treating plants. "Do preservatives move and migrate from the treated wood and cause a significant environmental hazard?" "Do preservatives bio-accumulate to be of potential risk?" and finally, "Is there cause for concern of the general public when exposed to treating wood products?"

The answer to all of the above questions concerning treated wood is "No." Treated wood products can be safely used without any adverse effects on man, animals, or the environment. The treated wood industry has been a part of a very thorough evaluation and appraisal of the products in conjunction with EPA. As with many other chemical materials, users of treated wood products need to use good common sense use and handling practices.

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**Briefing  
for the  
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**ON THE SIGNIFICANCE OF THE ROLE CREOSOTE PLAYS IN  
RAILROAD INTERESTS OF NORTH AMERICA**

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There has probably never been a more uniquely important product to an industry than the wood crosstie has been to North American railroads. Yet, the wood crosstie and the invaluable role it has played for over 100 years could not have done it alone. Creosote, and its solutions, are the enhancers that are singularly responsible for the remarkable nature of the economic and life-cycle performance of the wood crosstie.

### A Brief History

Ever since the earliest days of the railroads in America, the wood crosstie has been the mainstay of track construction and maintenance. Even though the Louisville and Nashville Railroad had been operating a wood preservative plant since 1875, prior to 1900 less than 5% of all ties installed were treated with any preservative. And even into the century as late as 1920, when 136,000,000 ties were installed by the railroads, only 30% of the ties were treated with any process.

It was during these formative years of the wood preserving industry that numerous treatment processes were researched and tried in production. The results of the first 40 or so years of wood tie preserving proved that creosote was the key material both for preservative and weathering protection of wood crossties.

As the number of creosote treating plants steadily grew from 1920 onward, it resulted in the steady and significant reduction in the amount of wood ties purchased and installed by railroads. By 1930 only 63,000,000 ties, half of which were treated,



were installed. By the time 100% of wood ties were being treated, in the late 40's to early 50's, the number of ties installed began to reach a relatively stable state at between 25,000,000 to 28,000,000 ties.

This occurred because preservative treatment of wood ties with creosote lengthened the average useful life of these ties some 7-12 times as compared to untreated tie life. Where once railroads could only expect some 4 to 12 years life out of an untreated wood tie now, with creosote, railroads were experiencing 35, to as much as, 75 years of useful service from the same wood materials.

#### Why Does the Creosote Treated Wood Tie Work So Well?

Only within the last 20 years, has the engineering data been assembled to indicate that wood tie performance could be concisely documented. Railroads always knew wood was the best solution to track construction, but much of the science was, truly, trial and error experiential learning.

In the mid to late 1960's, several full scale research projects conducted by the Railway Tie Association, Association of American Railroads, and the railroads, helped optimize length and spacing of wood ties, as well as produced reams of data on mechanical and biological wear of the treated wood tie in track. While it had been known for a long time that creosote treatment significantly reduced biological attack on wood ties, new data emerged about how creosote protected wood ties against other

physical agents in the environment.

These other physical agents, classified under the broad term "weathering factors", include ultraviolet light, heat abrasion, and alternating/cyclical climatic conditions. It has been proven that creosote minimizes the effect of these agents on wood through its "lubricating and weathering-proofing" action.

It is in this way that creosote is such a uniquely important and reliable partner of the wood crosstie: creosote protects against biological attack, minimizes mechanical and environmental agent wear and tear on wood, achieving maximum durability at minimum cost.

### Cost Is Important

The U.S. railroad industry has not always been as successful as it has been in the last decade. In fact, had it not been for 1986 legislation that deregulated the railroads and incentivized capital investment in this highly capital intensive business, many believe that private railroad businesses would not exist in America today.

Since the 1980's, railroads have invested some \$200 billion in track and equipment. With regard to the track component of this figure, the installation of creosote treated wood crossties has accounted for approximately 40% of the investment in roadways and structures. This investment has resulted in U.S. freight

rates that are over 50% less, when adjusted for inflation, than they were in 1981. The U.S. has the lowest average freight rates per unit of output in the industrialized world. And, arguably, the superior performance and economics of the creosote treated wood crosstie is a major factor in the equation. Creosote with its nominal comparative cost to the overall price of a treated tie (approximately 10%) is, without question, the key reason that economics remain so favorable for railroad use of wood ties.

### Importance Going Forward

Railroads, and industries served by railroads, will install approximately 20,000,000 creosote treated wood ties in North America in 1998. Of that figure, 15.5 million will be installed by Class I railroads, the balance by short lines, contractors, transits, and industry (Addendum I). A recently developed forecasting model, "TieLife™", predicts growth in demand for ties by the railroad to increase until the year 2009. Class I demand alone, with a steady state economy, could reach 18,700,000 ties in 2009 (Addendum II).

This increasing demand will be met in several ways with:

- A. Solid-sawn creosote treated wood ties
- B. Engineered hybrid creosote treated wood ties
- C. Alternative materials

Alternative materials will provide only a modest portion of the ties for the railroads. Since concrete and steel ties began to appear on the scene some 20+ years ago, they have achieved approximately 6% market share. Current RTA estimates for these materials are for them to achieve 9% of the overall market by the year 2018. The reasons for this lackluster growth in the use of these materials are many, but include economic viability, performance, and maintenance costs.

Either solid sawn or engineered hybrid wood ties must be protected by creosote. No other preservative provides both biological and weathering agent protection economically. Considering the growth expected in tie demand, the lack of economically viable alternative ties and the growth in all railroading expected, both freight and passenger, creosote's importance looms even larger. Today, some 70% of the creosote used in Norther America goes to producing wood ties.

### Conclusion

Wood ties perform simple yet effective service for one of our nations most important freight, and likely in the future, people moving industries . In order to do so in a manner that allows railroads to optimize capital expenditures for roadway, structures, and equipment, and operate safely, wood ties must be available with life-cycle performance that makes economic sense. This is not possible without the availability and use of creosote wood preservative solutions.

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