WHY RAILROADS SPECIFY CREOSOTE

By Stephen Smith, P.E.

As documented in the recent report[1] for the Association of American Railroads (AAR), approximately 95 percent of all new railroad ties are preserved wood, as opposed to non-wood products of concrete, steel or plastic. Of the wooden ties purchased, 98 percent are either creosote or creosote-borate treated. Approximately 2 percent of wooden ties are copper naphthenate or copper naphthenate-borate treated. This paper explores the reasons railroads continue to specify creosote preservative treated wood for their ties.

Wood

There are several reasons railroads continue to use wooden ties to support their steel rails. In the pre- and early 1900s, wood was the only option, as well as 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 or concrete.

Experience, research and innovation have revealed new and enhanced known advantages. Wooden ties absorb some of the shock of heavy rail wheels traveling the track, thus reducing wear and tear on the rails and trains. Wood does not conduct electricity, so the ties do not interfere with electric rail monitoring. Borate dual treatment with oil-borne preservative adds preservative into the tie heartwood and thus greatly extends the service of wooden ties in high-decay regions.

Service Life

Service life of wood crossties is typically considered to average 40 years. Properly treated, wood crossties do not only fail due to deterioration from fungi and/or insects. The repeated mechanical wear caused by train loadings and rail components is exacerbated by biological deterioration. Eventually, the rail systems cut into the wood ties and the spikes can no longer anchor the rails in place. Failing ties may contribute to derailments. Wood crossties must continue to perform under extreme weather conditions, exposure to decay organisms, and mechanical impact loading from high-tonnage train cars.

There are several experimental field-test methods to evaluate performance of the preservatives that protect wood against decay and insect attack. These methods include post tests (Table 1) and 2x4-stake tests (Table 2). Also consider that the closer the sample size and the exposure are to real-life conditions, the more meaningful the results. Thus, the most reliable data of efficacy is actual rail performance of the wood crosstie. Railroads collectively have over a century of experience with creosote-treated wooded ties. In a 2007 article in *Crossties*[2] , service life of preserved wood ties was estimated to be 19 years for high humidity and a Southern wet climate exposure and high-tonnage curved track and up to 50 years for lower humidity, low tonnage, and straight tangent track.

The conclusion was that for most situations, wood crossties offered the lowest life-cycle cost. The introduction of borate dual treatment with creosote or copper naphthenate has improved service life in the high-decay regions[3].

In 1949, testing was initiated to compare many different wood preservatives' performance 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, copper naphthenate and petroleum oils. Data from this study of preservatives applicable to railroad ties is summarized in Table 1.

This test was initiated in 1949 and was, in part, designed to help determine which creosote formulations or distillation cuts would provide the best performance. Based on 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[4]. 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, as general indications of estimated service life.

Table 1 also includes a result for copper naphthenate, the other wood preservative typically used for railroad ties. Copper naphthenate in a #4 petroleum distillate carrier provides service life similar to that of creosote. No data is available regarding copper

Table 1 - Post Test Results

Mississippi Posts Test (installed 1949)
2005 American Wood Preservers' Association Proceedings

Preservative	Estimated Service Life
Coal tar creosotes:	
High residue, crystals removed	105.4
High residue, low tar acid & naph.	154
Low residue, low tar acid & naph.	53.7
Low temperature	58.2
Medium residue, low fraction 235-270	58.3
Medium residue, low naph.	67.6
Medium residue, low tar acid	66.4
Medium residue, low tar acid & naph.	66.8
Straight run, high residue	71.7
Straight run, low residue	45.7
Straight run, medium residue	54
Average of all creosotes	72.9
Average of medium residue creosotes	**62.6**
Copper naphthenate, 0.5% copper metal (by weight) in #4 aromatic residual petroleum oil	65.2
Petroleum oil, #4 aromatic residual	43
Petroleum oil, #2 distillate	7.7
Untreated controls	2.4

naphthenate in #2 petroleum distillate, which is currently the predominant carrier in use. Performance using the lighter oil may differ from that using the heavier oil.

The Forest Products Laboratory periodically publishes a summary of various wood preservative test results, the latest being the 2011 Progress Report[5]. These tests are all for ground contact exposure. 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" nominal by 18" stakes and of only creosote or copper naphthenate preservatives 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 this review, note that for railroad ties of oak, hickory or mixed hardwoods the retention of creosote is 7.0 pound per cubic foot (pcf) or refusal and for copper naphthenate it is 0.55 pcf or refusal (as copper metal). For Southern pine, retention standards are 8.0 pcf for creosote and 0.060 pcf for copper naphthenate (as copper metal)[6]. In Table 2, results with retentions close to the retention standard for crossties are highlighted with gray background for reference. Although many of the creosote tests have not yet determined the estimated service life, it appears estimated service life for these samples would be 30 or more years. Results for copper naphthenate are similar at about 26 years.

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

Performance Differences Between Preservatives

While creosote and copper naphthenate both provide good protection from decay and insect attack, there are differences between them that should be considered. Some are briefly discussed below:

Weatherability – Both petroleum oil and creosote help to seal the surface of wood ties from water penetration. It is important to consider the volatility differences between #2, #4, and #6 petroleum oil. As water penetrates and goes through cycles of saturation, freezing, and drying, wood fiber is damaged. Petroleum oil, particularly #2 distillate, evaporates within just a few years. Creosote has a high residue and is less volatile in general than #2 petroleum oil. Thus, creosote tends to protect the wood from weathering better than certain types of petroleum-based preservatives.

Lubricating Properties – The lubricating properties of preservative help to maintain the flexibility and shock absorbing qualities naturally present in wood. As wood weathers, these qualities are reduced. Both creosote and petroleum oil help to reduce the loss of these qualities.

Diluent Decay Resistance – Petroleum oil by itself evaporates or biologically decays. As shown in Table 1, posts treated ➤

Table 2 - Stake Test Results

Stake Test Results
2 x 4 Nominal x 18-inch southern pine stakes
USDA Forest Service, Forest Products Lab, 2011 Progress Report

Table	Installed (year)	Evaluated (year)	Preservative	Location	Retention* (pcf)	Removed	Avg Life (years)
4	1940	2000	Coal tar creosote	WI	1.8	100%	12.4
				MS	1.8	100%	7.7
				WI	4.3	100%	37.9
				MS	4.2	100%	17.8
				WI	8.0	29%	NYD
				MS	8.0	90%	NYD
				WI	11.8	0%	NYD
				MS	11.8	50%	NYD
			Untreated controls	WI	0	100%	2.4
				MS	0	100%	1.8
5	1941	1996	Coal tar creosote, grade 1	LA	4.6	67%	22
				FL	4.7	67%	19
				MS	4.6	100%	21.3
				LA	10	25%	26.6
				FL	10	10%	NYD
				MS	10	90%	NYD
				LA	14.5	0%	NYD
				FL	14.4	0%	NYD
				MS	14.5	0%	NYD
6	1950	1996	Coal tar creosote, diluted with toluene	MS	3.4	100%	19.1
					8.1	70%	NYD
					12.6	0%	NYD
			Control (toluene)		29.5	100%	2.2
7	1942	1992	Copper naphthenate 1%	MS	10.3(0.012)	100%	15.9
	1941			WI	10.3(0.012)	100%	25.5
	1942		Copper naphthenate 2.5%	MS	10.2(0.029)	100%	21.8
	1941			WI	9.6(0.027)	100%	34.5
	1942		Copper naphthenate 5.0%	MS	10.6(0.061)	100%	27.1
	1941			WI	10.6(0.061)	83%	28.7
	1942		Copper naphthenate 7.5%	MS	9.6(0.082)	80%	29.6
	1941			WI	9.6(0.084)	100%	35.4
	1942		Untreated controls	MS	0	100%	1.8
	1941			WI	0	100%	4.9
12	1943	1963	Copper naphthenate (0.5% Cu in naphtha solvent)	MS	13.1 (0.066)	30%	25
			Untr. Controls		0	100%	2.0

*Note that number in parentheses is retention of copper metal.
NYD - Not yet determined

only with #2 petroleum oil (used as a control sample) lasted about eight years. In comparison, posts treated with only the #4 aromatic petroleum oil (also used as a control) lasted 43 years. With the copper naphthenate added, posts lasted about 65 years; it is not clear from this test how much of that performance resulted from the #4 residual petroleum oil carrier. As cited in the 1958 Cooperative Creosote Test[7], reduction in service-life performance is also documented where creosote is mixed with a #6 petroleum oil for the AWPA P3 Creosote-Petroleum Solution. In the 1958 Post Study, posts treated with creosote mixed half and half with #6 petroleum oil had an estimated service life of about 40 years, about one-third less than for straight creosote P1/P13.

Regulation of Preservative – While creosote is regulated by EPA as a Restricted Use Pesticide and copper naphthenate is not, the way that treating plants handle preservatives and ties is basically the same. Plant operators do not wish to contaminate soil or water by employing lax procedures or using leaking equipment. At the end of life, most ties, independent of preservative, are recycled for energy recovery via cogeneration plants, heat recovery combustion systems or cement kilns. There is no practical difference in the way railroads handle used ties.

Disposal Costs – When wood crossties are removed from railroad service, most are either reused, if their condition warrants it, by a short line railroad system or in lower tonnage track, recycled for energy recovery or disposed in landfills. These options have costs but do not vary with type of preservative.

Conclusion

The railroad industry has more than a century of experience using creosote-treated railroad ties. The vast majority of ties currently purchased are creosote and creosote/borate treated wood. Experience and testing continue to support the use of creosote preservation for wood ties.

While the railroad industry has much less experience with copper naphthenate, testing results and limited experience indicate that it is also a good wood preservative that provides a service life about equal to that offered by creosote.

Railroads must weight many factors in deciding what type of ties to use to support their rails. Should they use preservative treated wood or other products such as concrete, plastic or steel? If wood, what type of preservative and with or without borate dual treatment? Many of the factors railroads need to consider are outlined above. For most cases, continued use of creosote preservative is favored.

1 Smith, S.T. (2019) 2018 Railroad Tie Survey. Journal of Transportation Technologies, 9, 276-286. https://doi.org/10.4236/jtts.2019.93017.
2 Zarembski, A. M. and Kondapalli, S. (2007) Development of Comparative Crosstie Unit Costs and Values, pp 17-18, CrossTies Jan-Feb 2007.
3 Amburgey, T. L. and Sanders, M. G. (2009) Tie Dual Treatments with TimBor and Creosote or Copper Naphthenate, 20 Years of Exposure in AWPA Hazard Zone 4. CrossTies, pp. 20-22, Nov-Dec 2009.
4 Webb, D. A., McKinney, S. A., and Pfeiffer, R. G. (2010) Assay Creosote Extraction of Selected Posts from the 1958 Cooperative Test after 50 Years of Exposure as a Ground Contact Preservative. 2010 American Wood Preservers' Association Proceedings, pp 242-248.
5 Woodward, Bessie M.; Hatfield, Cherilyn A.; Lebow, Stan T. 2011. Comparison of Wood Preservatives in Stake Tests: 2011 Progress Report. Research Note FPL-RN-02. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 120 p.
6 AWPA, 2018. 2018 AWPA Book of Standards. American Wood Protection Association, Birmingham, AL. Website: www.awpa.com.
7 Webb (2004) IBID.

COVID 19 PROTOCOLS

COVID-19 – New Administration Issues Actions For Workplace Protocols

By Monica Meyer

With the inauguration of a new president comes the assumption of changes that impact employers and workplaces. A notable issue is managing the response to the COVID-19 pandemic.

One of President Joe Biden's first actions was directing a federal workplace safety regulator to require employers to develop coronavirus protocols and enforce compliance.

Executive Orders

Biden signed at least 10 executive orders, memorandums and directives focused on tackling the pandemic, including increasing vaccination supplies, testing and personal protective equipment, as well as requiring international travelers to provide proof of a negative COVID-19 test before traveling to the United States. While an executive order was issued requiring all federal employees and visitors to wear face masks on federal property, maintain physical distancing and follow other recommended precautions, nothing has been issued to the private sector.

Families First Coronavirus Response Act (FFCRA)

The Trump administration's pandemic and economic relief package, Families First Coronavirus Response Act (FFCRA), mandated that employers with fewer than 500 employees must provide 80 hours of emergency paid sick time and 10 weeks of two-thirds pay for caring for school-aged children who were remote learning or did not have access to childcare.

FFCRA expired on Dec. 31, 2020. However, the Trump administration extended the tax credits to employers if they voluntarily continued the program until March 31, 2021. This extension did not reset the amount of time someone could use it but instead extended the deadline if employers chose to allow employees to use this time into 2021.