RTA TieReport #11

Benefits of Dual Treatment (Borate + Creosote) Ties

INTRODUCTION

Recent RTA and railroad sponsored studies have shown that the treatment of conventional wood crossties with both Borate and Creosote can significantly extend tie life in high wood decay areas as compared to ties treated only with creosote. This is especially true in regions where moisture and environmental conditions are a primary factor leading to wood tie failure.

In order to examine the effects of the dual treatment (Borate and Creosote) on tie life, as a function of climate conditions, a system-wide average U.S. tie life for creosote-only ties was calculated based on a five-year history of existing ties and tie installations. Using the actual number of ties installed in U.S. Class 1 track in each of the last five years and dividing that number into the number of wood ties gives the approximate tie life, as shown in Table 1. The resulting average nationwide tie life for wood ties is 35.2 years for creosote-only treated wood ties.

Table 1: Five-Year History of Ties and Installations

Year	2006	2007	2008	2009	2010
Track Miles	162,056	161,114	160,734	160,781	160,781
Ties*	526,557,342	523,496,566	522,261,858	522,414,572	522,414,572
Wood Ties**	500,229,474	497,321,738	496,148,766	496,293,844	496,293,844
Ties Installed in 2010	14,017,000	13,464,000	14,401,000	14,463,000	14,292,000
Tie Life (years)	35.7	36.9	34.5	34.3	34.7
5-yr Average Tie Life	**35.2**				

** based on 3,249 ties per mile*
*** based on U.S. ties being 95% wood and 5% concrete and other tie material*

CREOSOTE-ONLY TIE LIVES BY CLIMATE ZONE

As noted above, tie life varies significantly with climatic conditions. In order to reflect the range of climatic conditions, the United States has been divided into five Climate Zones as shown in Figure1. These zones represent the severity of wood decay, where Zone 1 has the lowest rate and Zone 5 has the most severe rate. Given equal tonnages and curvature, conventional creosote-only tie lives will be significantly lower in Zone 5 than in Zone 1 due to environmentally caused wood tie decay.

For the analysis of the effect of dual-treatment of ties, it is necessary to determine the distribution of ties in each of the five zones. The resulting distribution by decay Zone is presented in Table 2.

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Figure 1: Five Wood Decay Zones in the United States

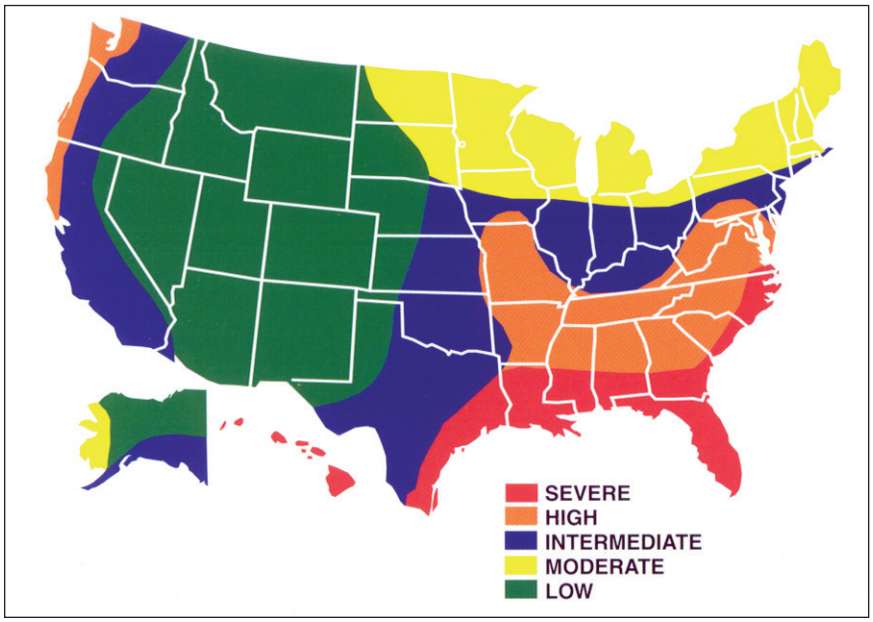

Table 2: U.S. Mileage and Tie Count by Zone

		Distribution of Route Miles By Zone				
	All US	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
U.S. Route Miles	139,679	27,195	28,702	39,278	30,263	14,241
Dist. (%)	100%	19.5%	20.5%	28.1%	21.7%	10.2%
U.S. Track Miles	212,365	41,347	43,638	59,717	46,011	21,652
Percentage Wood	94.8%	90%	90%	98%	98%	98%
Wood Ties	654,131,564	120,911,350	127,610,939	190,153,628	146,510,350	68,945,298

As Table 2 shows, 10.2% of all ties (miles) are found in Zone 5 and 31.9% of all ties are found in Zones 4 and 5, the two most environmentally severe regions of the U.S. Overall, of the 654 billion wood ties in the U.S., 215 billion lie in Zones 4 and 5. Adding Zone 3, we find that 60% of all U.S. ties lie on one of the three most severe zones, with a total of 405.5 billion wood ties.

Using this data together with tonnage and curvature data for the United States (see Reference 1), and using ZETA-TECH's *TieLife* model [4, 6], the average new tie life for creosote-only treated ties can be calculated based on key track, traffic and environmental factors as tie material, annual tonnage, curvature, and climate zone. Using the calculated tie lives for each zone [1] together with the percentage distributions of track miles by Climate Zone from Table 2, a system average new tie life for creosote-only treated ties can be calculated. This is shown below in Table 3. Note that the weighted average value is 35.2 years, matching Table 1.

Table 3: U.S. Average New Creosote-Only Tie Life and Summary by Climate Zone

Climate Zone	Average New Creosote-Only Tie Life (years)	Distribution (%)
1	43.3	19.5%
2	39.9	20.5%
3	35.9	28.1%
4	30.7	21.7%
5	18.1	10.2%
System-wide U.S. Average	**35.2**	100%

RANGE OF CREOSOTE-ONLY TIE LIVES

Noting that wood ties do not all fail at the same time, but rather fail around a distribution curve (the Forest Products failure distribution curve [2, 7]), the range of actual tie life around the "average" life presented in Table 3 can be determined. This curve, which is a skewed "normal" distribution, shows that a significant number of ties fail earlier than average and likewise a significant number of ties have a life greater than average. Noting that 95% of all ties will fail within two standard deviations (i.e. $\pm 2\sigma$) of the calculated new average tie life, the range of new tie life can be calculated as a function of Climate Zone as presented in Table 4.

Table 4: Tie-Life Range by Climate Zone for 95% of all Ties in Each Zone

Climate Zone	Average New Creosote-Only Tie Life (years)	Range of Tie Lives for 95% of the Ties (years)
1	43.3	20.21 to 60.95
2	39.9	18.62 to 56.17
3	35.9	16.75 to 50.54
4	30.7	14.33 to 43.22
5	18.1	8.45 to 25.48
U.S. System-wide	**35.2**	**16.43 to 49.55**

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TIE LIFE EXTENSION WITH DUAL TREATMENT (BORATE + CREOSOTE)

As noted in Reference 1, the use of a dual-treatment process, with a Borate treatment in addition to the conventional creosote treatment, will reduce the rate of tie decay in the environmentally severe zones. This extension is greatest for those species of ties that are more difficult to treat with creosote, such as those shown in Table 5.

Table 5: Treatability of Ties by Species and Distribution in U.S. Railroads

Group Number	Treatability	Percentage of U.S. Ties	Includes the Following Species
1	Most Difficult	40.0%	White Oak, Hickory/Pecan (20%), Sweet Gum (80%), Black Locust, Mulberry, Hardy Catalpa, Beech, Poplar (Large Heart)
2	Moderate Difficulty	17.5%	Red Oak (25%), Hickory/Pecan (80%), Sweet Gum (20%), Persimmon, Sassafras, Osage Orange, Birch, Honey Locust, Some Maples (Large Heart), Sycamore, Butternut, Kentucky Coffeetree, Boxelder
3	Relatively Easy	24.5%	Red Oak (45%), Black Gum/Tupelo Gum (20%), Ash, Basswood, Cork Elm, Some Maples, Hackberry
4	Easy	18.0%	Red Oak (30%), Black Gum/Tupelo Gum (80%), Elm

Based on dual-treatment studies that have been performed [8-13], the Railway Tie Association has been able to make determinations as to how much the borate treatment will lengthen the tie lives for each of the four treatability categories of ties (Table 5) for Climate Zones 3, 4, and 5. These life extension factors, shown below in Table 6, reflect only the environmental life extension and do not reflect the influence of mechanical degradation (primarily tonnage and curvature effects). Life extension factors of 1.0 are used for Climate Zones 1 and 2 since it is assumed that dual-treatment will not be used for ties in these zones where mechanical degradation tends to be the dominant failure mode.

Table 6: Environmental Life Extension Factors by Treatability Group and Climate Zone[1]

		Life Extension Factors for Dual Treatment		
Treatability Group	**Distribution**	**Climate Zone 5**	**Climate Zone 4**	**Climate Zone 3**
1	40.0%	2.83	2.50	1.67
2	17.5%	2.33	1.92	1.48
3	24.5%	1.55	1.36	1.18
4	18.0%	1.18	1.14	1.05
Weighted Average	100%	2.13	1.87	1.41

Using these extension factors, the extended life of the dual-treated ties are calculated and presented in Table 7 for average dual-treated tie life.

1 *Tie life extension data and projections are provided by the Railway Tie Association based upon the 1987 AAR/RTA/MSU research on ties dual treated at the Atchison, Topeka and Santa Fe Railroad wood preserving plant in Somerville, TX.*

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Table 7: Average New Tie Life for U.S. Ties – Creosote Only and Dual Treated

	Tie Life (years)		
Climate Zone	**Creosote Only**	**Dual Treated**	**Percent Increase from Dual Treatment**
1	43.3	43.3	Not dual treated
2	39.9	39.9	Not dual treated
3	35.9	39.9	11.1%
4	30.7	39.9	30.0%
5	18.1	38.6	113.3%
US System-wide	**35.2**	**40.4**	**14.8%**

As shown in Table 7, dual treatment of all wood ties in the U.S. would extend the system average tie life (all zones / all U.S.) from 35.2 years to 40.4 years. This amounts to a 14.8% extension of U.S. average wood tie life by the use of dual treatment in Zones 3, 4, and 5. The life extension is even more pronounced when looking only at Zones 4 and 5. In Zone 4, the average tie life increases from 30.7 years to 39.9 years, or a 30.0% life extension. In Zone 5, the average tie life increases from 18.1 years to 38.6 years, amounting to a 113.3% extension of life (i.e. more than doubling the life of a Zone 5 wood tie).

ECONOMIC IMPACT OF DUAL-TREATED TIES

Using the above life extension of the dual-treated wood ties, the economic impact of this using dual-treated ties can be calculated. For these calculations, the installed cost of a creosote-only tie is taken to be $110.00. Assuming a steady-state replacement rate, the annual replacement rate and costs for creosote-only ties are shown in Table 8.

Table 8: Replacement Rate and Costs for Creosote-only Ties in the U.S.

	Zone 5	Zone 4	Zone 3
Total Wood Ties	68,945,298	146,510,350	190,153,628
Creosote-Only Tie Life (years)*	18.0	30.0	35.0
Replacement Ties Per Year	3,830,294	4,883,678	5,432,961
Cost Per Year at $110.00 Per Tie	$421,332,375	$537,204,616	$597,625,687

As part of this economic analysis (for a more detailed explanation of the analysis approach refer to reference 1), three different interest rates were used: 3.0%, 6.0%, and 10.0% with the 6.0% case begin considered the most appropriate value under current economic conditions. The rates are used to adjust future expenditures and savings into "today's dollars," i.e. to calculate a Net Present Value.

The cases were also examined with regard to the difference in price between a creosote-only tie and a dual-treated tie. The installed cost of a creosote-only tie is taken to be $110 throughout. The three cases of dual-treated tie cost are as follows: $115.00, $112.50, and $110.00. While it is generally expected that the cost of a dual-treated tie will be higher than the creosote-only cost, it is noted that by making small reductions to the amount of creosote used in a dual-treatment tie, the cost differential can be minimized, potentially even to being of equal cost.

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The resulting NPV economic analysis was then applied for each of the three Zones.

For Zone 5, the economic results are summarized as shown in Table 9 for a full system and table 10 on a per tie basis. Positive benefit indicates that the life cycle costs associated with the dual-treated ties is lower (better) than that of the creosote-only treated ties.

Table 9: Zone 5 Economic Analysis of Dual-Treated Ties (All Ties in Zone)

Zone 5 All ties	Creo $110, Dual $115			Creo $110, Dual $112.5			Creo $110, Dual $110		
	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%
Benefit in 65 years	$3,354	$1,322	$406	$3,541	$1,443	$488	$3,729	$1,563	$571

**Note: All costs expressed in millions of dollars*

Table 10: Zone 5 Economic Analysis of Dual-Treated Ties (Per Tie)

Zone 5 Costs per tie	Creo $110, Dual $115			Creo $110, Dual $112.5			Creo $110, Dual $110		
	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%
Benefit in 65 years	$48.64	$19.18	$5.88	$51.37	$20.93	$7.08	$54.09	$22.67	$8.28

As shown in Tables 9 and 10, use of dual-treated ties in Zone 5 is economically advantageous for all three interest rates and all three dual-treatment costs. Looking at the 65-year time horizon and the $115-cost, dual treatment will produce a gain of $400 million to $3.35 billion, depending on interest rate (a $1.3 billion gain for the 6% rate). If the cost of the dual-treated ties can be reduced to $112.50 or $110, this 65-year gain (at 6% interest) climbs from $1.3 billion to $1.44 and $1.56 billion, respectively. Again, note that all amounts are expressed in "today's dollars" (in actual dollars saved, the benefit over 65 years is $9.6 billion). For the 65-year time horizon and the 6% interest rate, these correspond to benefits of $19.18, $20.93, and $22.67 per tie (based on a base cost of $110 per tie) for each of the three dual treatment costs.

Tables 11 and 12 show the economic results for Zone 4. For this Zone, an economic benefit (positive NPV) is obtained for dual treatment for all cases of 3% and 6% interest and for all cases where the dual-treated cost is $112.50 or $110.00. Only in the case of 10% interest and a $115 cost per dual-treated tie is the economic benefit negative. Thus for the 65-year time horizon and the 6% interest rate, these correspond to benefits of $0.99, $2.27, and $3.54 per tie (based on a base cost of $110 per tie) for each of the three dual treatment costs in the study.

Table 11: Zone 4 Economic Analysis of Dual-Treated Ties (All Ties in Zone)

Zone 4 All ties	Creo $110, Dual $115			Creo $110, Dual $112.5			Creo $110, Dual $110		
	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%
Benefit in 65 years	$883	$145	-$102	$1,196	$332	$17	$1,509	$519	$134

**Note: All costs expressed in millions of dollars*

Table 12: Zone 4 Economic Analysis of Dual-Treated Ties (Per Tie)

Zone 4 Costs per tie	Creo $110, Dual $115			Creo $110, Dual $112.5			Creo $110, Dual $110		
	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%
Benefit in 65 years	$6.03	$0.99	-$0.69	$8.16	$2.27	$0.12	$10.30	$3.54	$0.93

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Applying the same methodology to Zone 3 generates the results shown in Tables 13 on a per tie basis. Here, however, the economic benefit of dual treatment is a little more mixed. There is a clear benefit (positive NPV) for all tie costs for the 3% case and for all interest rates when the dual-treatment tie cost is $110. For a cost of $112.50, however, the benefit comes only for the 3% and 6% cases, and for the $115 cost it is only for the 3% interest rate. Thus, for the 65-year time horizon and the 6% interest rate, these correspond to benefits of $0.30 ($112.50 cost case) and $1.43 per tie ($110 cost case), based on a base cost of $110 per tie, for each of the noted dual treatment costs in the study.[2]

Table 13: Zone 3 Economic Analysis of Dual-Treated Ties (Per Tie)

Zone 3 Costs per tie	Creo $110, Dual $115			Creo $110, Dual $112.5			Creo $110, Dual $110		
	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%	3.0%	6.0%	10.0%
Benefit in 65 years	$0.80	-$0.83	-$1.09	$2.72	$0.30	-$0.38	$4.65	$1.43	$0.32

In reviewing the results from the economic analysis, it is clear that there is a substantial economic benefit to dual treated ties in Zone 5. There is also a substantial benefit in Zone 4, provided that the interest rate is below 10% or the cost differential between creosote only and dual treatment is less then $5 per tie. The benefit in Zone 3 is more tenuous and would require either a long-term low interest rate (near 3%) or a minimal difference in tie treatment costs.

SUMMARY AND CONCLUSIONS

This analysis looked at the extension in tie life that can be achieved through the use of dual treatment with both creosote and borate. The analysis segments the wood crossties in the United States into five Climate Zones, according to the Wood Decay Deterioration Map. Using the RTA developed life extension factors, the overall effect on tie life was found for each Wood Decay zone and for the United States as a whole.

As expected, the largest effect was found in Zone 5 where environmental wood decay is the most severe. In this zone, average new tie life is found to increase from 18.1 years to 38.6 years. In Zone 4, dual treatment results in an extension from 30.7 to 39.9 years. In Zone 3 the extension is from 35.9 to 39.9 years. Overall, if dual treatment were applied to all ties in Zones 3, 4, and 5, the aggregate increase in U.S. wood tie life in all five zones would be from a system average of 35.2 years to 40.4 years. This is an increase in tie life of 14.8% for all wood ties throughout the U.S.

With these increases in tie life, the net economic benefit of dual treatment was determined for Zones 3, 4, and 5. Economic benefit analysis shows that there is a substantial gain in Zone 5 for all cases. A significant gain is also found in Zone 4 provided the interest rate is less than 10% or the dual-treatment installed cost is below $115.00. In Zone 3, the net benefit is more mixed. A positive benefit is obtained for a very low interest rate (3%) or a minimum difference in treatment cost. For other combinations, the benefit may be negative or very small.

Overall, the study demonstrated the significant extension of wood tie life that can be achieved through dual treatment with creosote and borate for high-decay climatic zones. Overall wood tie life can be extended by 14.8% in the U.S. with system average tie life increasing from 35.2 years to 40.4 years. The use of dual-treatment ties in Zones 4 and 5 can lead to a net present economic benefit on the order of one to five billion dollars over the next 65 years. Expressed in actual dollars (not "today's dollars"), this would be a benefit of 13 to 15 billion dollars.

2 As noted, there was no benefit associated with the $115 dual treated tie cost.

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