Extending The Service Life Of Wooden Crossties By Using Pre- And Supplemental Preservative Treatments

15-Year Exposure Report

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In 1987, a research proposal was submitted to a Railway Tie Association (RTA) and Association of American Railroads (AAR) joint committee to sponsor research to improve the service life of wooden crossties. It was hypothesized that treating unseasoned ties with diffusible preservatives (e.g., borates) would: 1) protect ties from insects and decay fungi during air seasoning, and 2) protect the interior of ties from decay in-track by being mobilized to checks or cracks as rainwater enters them in service.

A subsequent treatment with an oil or oil-borne preservative (e.g., creosote, copper naphthenate, etc.) would prevent leaching of the borates and protect the ties from the soft-rot fungi that cannot be controlled with borates. Likely, lower retentions of creosote than usual could be used if ties were protected with borates. It was further hypothesized that pretreatment with borates (known corrosion inhibitors) would retard iron degradation of wood and the subsequent loosening of spikes (spike kill). An additional hypothesis was that borates would increase the service life of ties in-track by applying them, using a variety of delivery systems, as supplemental treatments.

These studies are documented in a progress report authored by T.L. Amburgey and S.C. Snyder and dated Jan. 12, 1989, that was submitted to AAR/RTA and in an undated AAR progress report authored by D.D. Davis and K.J. Laine. Five-year results were reported in *Technology Digest* (February 1994) and *Crossties* (July/August 1994) in manuscripts authored by Davis and Laine. Results of the 2002 inspection were summarized in a presentation by Amburgey at the RTA Annual Convention in St. Louis and in a recent article in *Crossties* (Jan/Feb 2003) authored by Jim Gauntt.

Treatment Of Ties With Borates Prior To Air Seasoning

Unseasoned and some seasoned red oak, white oak and gum (mixed hardwood) ties were treated at the Atchison, Topeka and Santa Fe (AT&SF) facility at Somerville, Texas, in late spring 1987. Ties were dip-treated for three minutes in a heated (130º F) 30 percent boric acid equivalent (BAE) solution (wt/wt) of sodium borate (TimBor, U.S. Borax) and either bulk-stacked and covered with a tarp (to prevent surface drying and thereby increase borate diffusion) or air-stacked with or without a tarp cover. After six weeks, the bulk-stacked ties were air-stacked and covers were removed from some air-stacked ties. Most ties remained air-stacked until dry and were then treated

Table 1. Borate analyses of seasoned or unseasoned ties that had been bulk-stacked under cover for six weeks following dip treatment in a heated (130º F) 30 percent BAE TimBor solution.

Species	Sample Location (inch)	Average % BAE	
		Seasoned Wood	Unseasoned Wood
White Oak	0-0.5	0.47	1.42
	0.5-1.0	0.09	0.49
Red Oak	0-0.5	0.55	1.26
	0.5-1.0	0.18	0.50

Table 2. Borate analyses of incised or non-incised unseasoned ties that were either bulk-stacked under cover or air-stacked for six weeks following dip-treatment in a heated (130º F) 30 percent BAE solution of TimBor.

Species	Sample Location (inch)	Average % BAE	
		Bulk-Stacked	Air Dried
White Oak[a]	0-0.5	1.42	0.65
	0.5-1.0	0.49	0.14
Red Oak[a]	0-0.5	1.26	0.90
	0.5-1.0	0.50	0.24
White Oak[b]	0-0.5	1.05	0.14
	0.5-1.0	0.25	0.01
Red Oak[b]	0-0.5	1.09	0.13
	0.5-1.0	0.28	0.04

a Incised – Test 1
b Non incised – Test 2

Special Consideration

Major research projects spanning three decades are immense undertakings. They involve many people and many companies. Sometimes those who begin the project are not around to see the end. Then, there are those who go the distance and those who only participate near the end. Achieving quality results depends on all of them. RTA would like to offer special thanks to all those who helped bring this new information to the marketplace, especially Terry Amburgey and Mike Sanders of Mississippi State University; Jimmy Watt of The Crosstie Connection; the Association of American Railroads' Dave Davis and Ken Laine; the RTA Research & Development and Executive Committees throughout the years; Osmose Wood Preserving Company and U.S. Borax for their analytical support this past year; Preston Painter and all the Norfolk Southern staff who helped out in the last phase of the project; and the many who supported the project along the way and gave service to this important work. Thanks to all the participants, past and present.

with creosote, but some were vapor-dried and treated with creosote at Somerville.

Results of the early phases of this study indicated the following:

1. Borate up-take and diffusion was greater in unseasoned than in seasoned ties **(Table 1)**.

2. Borate up-take and diffusion was greater in ties bulk-stacked and covered for six weeks prior to being air-stacked than in those air-stacked following treatment **(Tables 2 & 4)**.

3. Borate up-take and diffusion was greater in incised than in non-incised ties **(Table 2)**.

4. Large amounts of borate were lost from ties that were vapor-dried and treated with creosote shortly after six weeks of bulk-stacked, covered storage **(Table 3)**.

5. Very little borate was lost from air-dried ties following creosote treatment **(Table 4)**.

All borate analyses during the initial phases of this study were performed by personnel at the AT&SF chemistry laboratory.

Table 3. Borate analyses of ties before and after creosote treatment. Unseasoned ties had been dipped in heated (130º F) 30 percent BAE TimBor and bulk-stacked under cover for 6 weeks.[a]

Species	Sample Location (inch)	Average % BAE[b]	
		Before Creosote	After Creosote
White Oak	0-0.5	1.42	1.02
	0.5-1.0	0.49	0.22
Red Oak	0-0.5	1.26	1.13
	0.5-1.0	0.50	0.19
Gum	0-0.5	1.48	1.13
	0.5-1.0	0.27	0.13

aTies were vapor-dried and treated shortly after the six weeks of storage.
bToxic limit for subterranean termites is approximately 0.058% BAE (100 ppm B) and the toxic limit for decay fungi is approximately 0.025% BAE (43 ppm B).

Following air-drying, the borate-treated ties were treated with creosote at either Somerville using the regular AT&SF treatment (GBS) or Madison, Ill., (Kerr-McGee) using the regular Norfolk Southern (NS) creosote treatment (GBN) or a creosote dip treatment (GBC). The ties then were installed in-track at locations in several geographic regions.

The 15-Year inspection was at a site near Cordele, Ga., on a mainline, fully signaled track. Sample ties in each treatment group were removed from track and sectioned through the inner spike holes at both ends to check for decay, insect damage and spike kill. Samples were obtained for borate analysis between the inner spike holes from the upper surface to the center and from the lower surface to the center.

Average results of the borate analyses from ties dip-treated in creosote (GBC), pressure-treated with the regular AT&SF creosote (GBS) or pressure-treated with the

Table 4. Borate analyses before and after creosote treatment of unseasoned ties stored for six weeks in various configurations after being dipped in heated 30 percent BAE TimBor and then air-dried.

Species	Sample Location (inch)	Stacking Configuration	Average % BAE	
			Before Creosote	After Creosote
Red Oak	0-0.5	Air-stack	0.48	0.50
	0.5-1.0		0.17	0.22
	0-0.5	Bulk-stack[a]	0.85	0.86
	0.5-1.0		0.52	0.49
	0-0.5	Air-stack[a]	0.75	0.72
	0.5-1.0		0.48	0.43
White Oak	0-0.5	Air-stack	0.39	0.43
	0.5-1.0		0.17	0.18
	0-0.5	Bulk-stack[a]	0.80	0.84
	0.5-1.0		0.42	0.41
	0-0.5	Air-stack[a]	0.50	0.61
	0.5-1.0		0.37	0.39

regular NS creosote (GBN) verified color tests that indicated that borate had diffused throughout the cross-section in the pretreated ties and was present at retentions above the toxic threshold for decay fungi after 15 years in track **(Figure 1)**. All borate analyses of ties at the 2002 inspection were done by U.S. Borax. Although creosote dip-treated ties and the upper half of both GBS and GBN ties were below the toxic threshold for termites **(Figure 1)**, no termite damage was observed. Toxic thresholds for termites and decay fungi were assumed to be 0.058 percent BAE (100 ppm boron) or 0.025 percent BAE (43 ppm boron), respectively.

Results of this phase of the study can be summarized as follows:

1. Borates had diffused throughout the cross-sections and, after 15 years, were present at above toxic threshold levels for decay fungi **(Figure 1)**.

2. No decay or termite damage was observed in either the creosote dip- or pressure-treated ties.

3. No spike kill was observed.

4. The borate-treated ties did not negatively impact electronic signaling in the test track.

5. Borate retentions were higher in the lower than in the upper half of the ties.

6. Evidence indicates that the creosote overtreatment reduces the rate of borate leaching from ties (e.g., Figure 1 – GBC vs. GBS or GBN).

7. White oak ties pretreated with borates are performing well on main-line track in the South.

Supplemental Borate Treatments To Ties In Service

Supplemental preservative treatments and delivery systems were tested either on sections of track not scheduled for maintenance or where rail and tie plates were being changed. Treatments included borate rods (Pandrol) placed either in unused spike holes or in holes drilled adjacent to tie plates, fluoride rods and pads (Osmose) applied under new tie plates as rail was replaced (pads) or in holes drilled adjacent to tie plates (rods), copper-borate paste (ISK) applied under new tie plates as rail was replaced, water-borne and oil-borne copper naphthenate spray (Mooney) applied to the area near one tie plate, and borate spray (U.S. Borax) applied to the area near one tie plate. The borate spray was a heated 30 percent BAE TimBor solution applied at the rate of one quart per tie plate area. This treatment was done to determine if the application of excess dip-treating solution could be used as an effective supplemental tie treatment. All supplemental treatments were applied to one end of each tie. The other end of each tie served as a control. Characteristics of these ties are documented in the Amburgey & Snyder report (1989).

The 14-year inspection of ties given supplemental treatments was done at the Cordele and Jessup, Ga., sites. Only the borate-containing treatments were examined. As with the borate pretreated ties, ties were chosen at random from each treatment group and sectioned through the inner spike holes at each end. Comparisons of the cross-sections at the inner spikes at the treated and untreated end of each tie were used to evaluate the efficacies of the treatments. Borate color tests and analyses were taken from the area between the inner spike holes or approximately one foot toward the tie midpoints from the inner spike holes.

Results indicate that in ties with internal decay prior to the application of supplemental treatments, decay continued to progress at the untreated end. In the treated ends, however, decay, in most instances, was less than in the untreated ends. It was hypothesized that the supplemental treatments diffused through the wood and arrested the growth of decay fungi that may be present. Results of borate color tests and analyses verified that borate was present throughout the cross-sections, in most instances at levels above the toxic threshold for decay fungi **(Figure 2)**. A notable exception occurred when borate rods were placed in unused spike holes. Essentially, no borate was found in ties treated in this manner. If borate

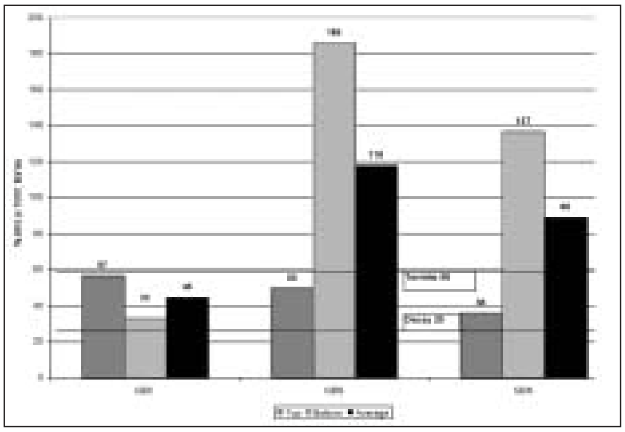

Figure 1. Borate analyses of borate-treated mixed hardwood (red and white oak, hickory and gum) ties over-treated with creosote by dip (GBC) or pressure GBS – Atchison, Topeka & Santa Fe treatment GBN – Norfolk-Southern treatment after 15 years of field exposure. Analysis zones were from the upper or lower tie surface to the center.

rods are to be used, the holes in which they are placed cannot extend through the ties. As with the borate-pretreated ties, analysis zones were from the upper and lower surfaces to the tie center.

Highest borate retentions were in ties where borate rods were placed in holes drilled on either side of tie plates **(Figure 2)**. Essentially the same results occurred at both the Cordele and Jessup test sites (Figure 2 – BR (J) & BR (C)). Analyses indicated that borate released as rods solubilized also moved toward the centers of ties (Figure 2 – BR (C) INT). Borate spray treatments indicated that this is an effective procedure for disposing of excess dip-treatment chemical that contributes toward extending the service life of older ties (Figure 2 – BSP).

Placing treated materials under tie plates as they are replaced also proved to be an effective procedure for extending the service life of ties. Although the borate paste placed under tie plates was present at below decay threshold levels for boron after 14 years, no decay or spike kill occurred in these ties **(**Figure 2 – CBP). From other studies (Amburgey & West, Amburgey & Freeman),[a] it is apparent that the toxic threshold of the CBP formulation is lower than that of either copper or boron alone. Similar results were observed in ties where fluoride pads (another diffusible material) were placed under new tie plates (inspection by Jimmy Watt). Results indicate that both of these test materials will require formulation with higher levels with borate or fluoride if 14 or more years will occur between subsequent treatments.

Discussion

Results of the tests reported above indicate that treatment of ties with borates prior to air seasoning is an effective procedure for increasing the service life of wooden crossties. Maximum borate uptake and diffusion occurred in unseasoned, incised ties that were bulk-stacked under cover for six weeks prior to air-drying. We chose to use a heated 30 percent BAE TimBor solution applied via a three-minute dip. Anyone using a TimBor solution in excess of approximately 15 percent must use a heated solution that is not permitted to cool. It may be possible to use lower concentrations of borate if longer dip times are used, ties are dip-treated on each of two successive days, or increased borate retentions are achieved by pressure rather than dip-treatment. Other borate formulations or delivery systems may be used. For instance, perhaps borate

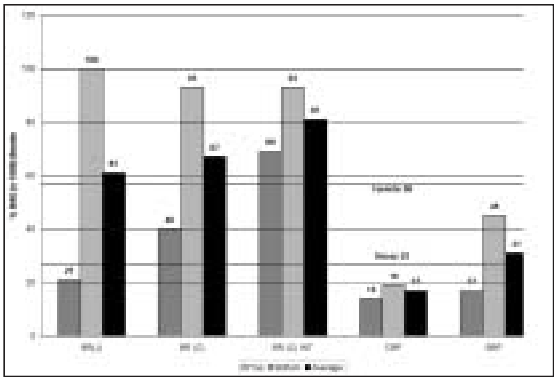

Figure 2. Borate analyses of in-track (red and white oak, hickory, and gum) ties 14 years after they had received supplemental borate treatments using borate rods (BR-J Jessup, GA), (BR-C Cordele, GA); copper-borate paste (CBP-Cordele, GA); or borate spray (BSP-Cordele, GA). Analyses were taken at the inner spike holes (BP, CBP, BSP) or one foot toward the midpoint from the inner spike holes (BR-C-INT). Analysis zones were from the upper or lower tie surface to the center.

rods (gels, pastes) could be inserted in holes drilled near the rail-bearing area and in the center of unseasoned ties. Our results indicate that the holes cannot be through-bored, and ties must be bulk-stacked for approximately six weeks prior to air-stacking. It is essential that tie surfaces do not dry too rapidly or borate diffusion will be limited. If borate rods (gels, pastes) are the delivery system of choice, the quantity of borate required for complete penetration at above toxic threshold levels must be determined (e.g., the diameter and length of rods, the concentration of diffusible preservative—borate or fluoride—in gels or pastes).

It may be possible to use reduced retentions of creosote (or other oil or oil-borne materials) if ties are properly treated with diffusible preservative and stored to maximize diffusion during the drying process. Results of these tests indicate that ties over-treated via a creosote dip retained fairly high levels of borate after 15 years in track. Perhaps a light pressure treatment with creosote would be more effective than a dip for preventing borate loss from ties. The type of over-treatment required likely would be different in ties exposed in alternative geographic regions.

Results of these tests also demonstrate the effectiveness of periodic supplemental treatments for protecting ties from decay and spike kill. Once again, alternative delivery systems may achieve equally effective or better results than those obtained in this study. However, we must ask how long a supplemental treatment should remain effective (e.g., 5, 10, 15 years). A regular schedule for applying supplemental treatments may be required to assure long-term quality of ties. Should the rail-bearing area be retreated whenever rails are replaced? What is it worth to extend the service life of ties by 5, 10, 15 years? §

[a]*Amburgey, T.L., M. West. 1989. Field tests with a groundline pole treatment. International Conference on Wood Poles and Piles, Fort Collins, Colorado, USA, October 25-27, 1989. pp. E1-E11.*

Amburgey, T.L., M.H. Freeman. 1993. Groundline treatments with a water-borne copper naphthenate-boron paste. In: Proc., 89th Annual Meeting of the American Wood-Preservers' Assoc., Newport Beach, CA. May 2-5, 1993, 89:105.

Amburgey, T.L., M.H. Freeman. 1993. Ten-year field test with a copper-borate ground line treatment for poles. International Research Group on Wood Preservation, Document No. IRG/WP93-30017.

Cooperators

Over the last 15 years, numerous people and organizations have cooperated in this study, including the following:
Railway Tie Association
Association of American Railroads
AT & SF Railway Co.
AT & SF Chemistry laboratory personnel
Norfolk Southern Railroad
U.S. Borax
U.S. Borax Analytical Laboratory personnel
Osmose Company
Pandrol Incorporated
ISK Biocides
Mooney Chemicals

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