Tie Dual Treatments with TimBor and Creosote or Copper Naphthenate

20 Years Of Exposure In AWPA Hazard Zone 4

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Introduction

In the spring of 1985, Lonnie H. Williams (USDA Forest Service, Southern Forest Experiment Station) and Terry L. Amburgey (Mississippi State University, MSU) designed a series of tests to determine the utility of borate dip-diffusion treatments in protecting a variety of wooden products.

One of these studies conducted at MSU in the summer and fall of 1985 was begun to test the hypothesis that borate dip-diffusion treatments of unseasoned crossties would protect them from decay fungi and insects during air seasoning. The study also sought to test whether the treatments would protect the interiors of "treated" ties as checks and splits develop, provided that the borate remains mobile following subsequent treatment with oil or oil-borne preservatives rather than being "fixed" in the wood. There is extensive worldwide literature attesting to the efficacies of borates for protecting wood products from decay, fungi and insects (Drysdale 1994; Barnes et al 1989; Carr 1959; Cockcroft and Levy 1973). Rather than coating the cellular surfaces of dry wood, as with conventional treatment processes, borates diffuse through the cell walls of wood that has not been dried.

It was recognized that preservative-treated crossties provide long and valuable service to the railroad industry, with an estimated service life approaching 47 years (Anon. 1975). While wood ties have performed well (Miller and Houghton, 1981), those made from refractory species (e.g., white oak) are failing after as few as seven years in AWPA hazard zones 4 and 5. Ties of refractory species often have a relatively narrow band of treated shell or sapwood surrounding a decay-susceptible heartwood core (Graham 1954, 1956; Graham and Miller 1964; Miller 1961). As long as the treated shell remains intact, these ties perform adequately. However, development of checks/splits or processes such as driving spikes or drilling holes for spikes or other hardware after preservative treatment permit moisture to enter the wood and decay fungi and/or conditions conducive to "iron sickness" (spike kill) to become established (acidic wood + ferrous metal + water = corrosion of iron and deterioration of adjacent wood).

While it has been estimated that decay accounts for only 18 to 35% of tie failures (Bescher 1977), decay fungi have a significant influence on many important wood properties and, likely, when deterioration is not readily visible in early stages of decay, mechanical tie failures are influenced by strength losses caused by decay fungi. Thus, many losses attributed to crushing, plate cut, spike kill or splits may in fact be due to decay. Treatment procedures that result in the penetration of preservatives throughout most or all of the cross sections would significantly decrease these pre-mature failures. In addition, mechanical defects may permit entry of additional decay fungi that, in turn, accelerate mechanical failures.

Once decay fungi are found in ties, the next procedure is to effect control. While control can be expensive, the benefits of prolonging tie service life can be considerable, estimated in 1985 at $5 per tie per year of extended life (Anon. 1985). This figure would be much greater today.

Methods

Unseasoned white oak, red oak and gum ties donated by Kerr-McGee, Columbus, Miss., were either placed in air-seasoning piles with no treatment or given either a single or double one-minute dip in solutions of one of four borate solutions: TimBor® (35% BAE), Am-Bor-S® (25% BAE), Am-Bor-P® (26% BAE), KM-Bor® (40% BAE). Each of these solutions contained 1% Busan 1030 as a mold inhibitor, since borates are known to have limited effect on the growth of mold and soft-rot fungi (Amburgey 1990); some ties were dipped in only Busan 1030. The TimBor®, Am-Bor-S® and KM-Bor® were heated to approximately 130F before use. Since, to our knowledge, the other borate formulations no longer are commercially available, only the TimBor® data will be presented herein.

The dipped ties were stacked and covered with polyethylene for four weeks of diffusion. The ties given a double dip were dipped for one minute on each of two consecutive days and were bulk-stacked and covered to prevent drying (aid diffusion) between dips. Following diffusion storage, ties were stacked near the untreated ties for air-drying. During air seasoning, it became apparent that the borate-Busan and Busan-only ties remained bright in color whereas the untreated ties were dark gray to black, indicating that the borates and Busan were protecting the ties from colonization by mold and sapstain fungi.

After air-seasoning, analysis of cores taken from the mid-points of treated ties confirmed that borates diffused into the ➤

Table 1. Average boric acid content of increment cores taken from the midpoint of gum, red oak and white oak crossties treated while unseasoned by dip-diffusion with TimBor® (35% BAE at 130 F).

Species	Dips (a)	Assay Zone 0 – 0.5 in. pcf (b)	%BAE	0.5 – 1.5 in. (c)pcf	%BAE	1.5 – 2.5 in. pcf	%BAE
Gum	1	0.162	0.498	0.016	0.051	0.007	0.022
	2	0.237	0.731	0.023	0.072	0.002	0.007
Red Oak	1	0.103	0.281	0.025	0.067	0.001	0.005
	2	0.203	0.551	0.023	0.038	0.002	0.004
White Oak	1	0.105	0.248	0.006	0.015	0.002	0.004
	2	0.195	0.460	0.017	0.041	0.004	0.010

a/ Number of 1-min. dips in 130F solution (on each of 2 consecutive days; bulk-stacked between dips).
b/ Pounds per cubic foot as boric acid.
c/ Percent boric acid equivalent. Calculations based on Wood Handbook (USDA Forest Service) specific gravity values: sweetgum, 0.52; southern red oak, 0.59; white oak, 0.68.

ties and that the double-dip procedure resulted in approximately twice the retention of borate as compared to the ties given a single dip (Table 1).

A portion of the borate-treated and untreated air-dried ties were treated with creosote (Kerr-McGee in Columbus, MS), copper naphthenate (Mooney Chemicals formulation in fuel oil), or remained untreated. Some borate-Busan 1009 (Buckman Laboratories) and Busan-only treated ties were not subsequently treated with creosote or copper naphthenate. All ties were placed on a washed gravel bed at the MSU Dorman Lake field exposure test site in June 1986. A spike was driven into one end of ties within each treatment group to determine the effects of treatments on iron deterioration (spike kill). After one year of exposure, a portion of the ties per species in each treatment group were inoculated with active cultures of either *Lentinus lepideus (brown-rot)* or *Trametes versicolor (white-rot)* basidiomycete decay fungi near the midpoint. Three-inch long 0.5 inch diameter wood dowels inoculated with the test fungi and grown under sterile conditions were placed in three-inch deep holes drilled near the tie midpoints.

Results

After 20 years of exposure, approximately six to eight inches of pine straw were swept from the tie surfaces prior to inspection. Sample ties from selected groups (none from those pre-treated with Am-Bor-S®, Am-Bor-P® or KM-Bor®) were removed, visually examined, segmented to check for internal decay, and sprayed with boron indicator (AWPA 2006). Following internal inspections and spraying with boron indicator, it was observed that ties given either a one- or two-minute borate dip and subsequently treated with creosote or copper naphthenate had no insect damage and little or no internal decay, even in those inoculated with *L. lepideus* and *T. versicolor*. The decay fungi in the treated dowels moved only a very short distance form the dowel before being controlled by the borates in the tie interiors. The surfaces of the borate-creosote ties looked better than those of the borate-copper naphthenate ties, presumably because the creosote provided greater protection from soft-rot fungi growing under the pine straw than did copper naphthenate. However, this difference in surface appearance had no relation to internal decay of the ties (Table 2).

The inoculated decay fungi did become established in the ties not pre-treated with borate. Most of the borate-creosote or borate-copper naphthenate ties, and some of the red oak and white oak ties given only a borate treatment, retained sufficient borate after 20 years to flash red when sprayed with indicator. This puts to rest the myth that borates leach out as rapidly as they diffuse into wood products. The coloration of the indicator indicates the presence of boron at levels equal to or greater than 0.80 kg/m3 (0.049 pcf) (AWPA 2006). Most of the TimBor–only treated ties were not serviceable. Untreated ties were essentially compost, except for portions of white-oak heartwood.

From these results, one must conclude that the test hypothesis that pre-treatment with borates will protect the interiors of ties from decay fungi and insects during air seasoning and in service is correct, if a subsequent treatment is used to prevent borate leaching and to control soft-rot fungi. In addition, the lack of spike kill in borate pre-treated ties confirms observations that borate-treated wood is not corrosive to ferrous metals. These results verify those obtained using borate-treated ties subsequently treated with creosote and exposed on active rail lines (Amburgey, Watt and Sanders 2003). §

Table 2 – Performance ratings for ties with 20 years of exposure in AWPA hazard zone four.

Treatments(a)	Species	Exterior Rating(b)	Interior Rating(b)	Loose Spikes
Untreated	Gum	0	0	All
	Red oak	0	0	All
	White oak	0	0	All
Creosote	Gum	9.8	9.4	0
	Red oak	8.6	8.5	0
	White oak	8.5	8.0	0
CuNap	Gum	6.0	8.0	0
	Red oak	6.5	4.0	1
	White oak	7.0	5.7	0
TimBor	Gum	0	0	5
	Red oak	2.0	1.1	2
	White oak	3.0	2.3	3
TimBor-Creosote	Gum	9.3	9.4	1
	Red oak	8.3	10.0	0
	White oak	8.8	9.6	0
TimBor-CuNap	Gum	8.0	9.7	0
	Red oak	7.7	10.0	0
	White oak	7.2	8.8	0

[a] Creosote , CuNap = cooper naphthenate, TimBor = borate
[b] Average AWPA rating (10 = no deterioration, 0 = failure)

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