

# Quality Control Important For Commercialization Of Borate/Creosote Dual-Treated Crossties

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Creosote-treated wooden crossties have, in general, performed well in a variety of geographic regions since the early 1900s. Increased tie life resulted from the development of new treating standards and acceptable practices promulgated by organizations such as the American Wood-Preservers' Association (AWPA), the Canadian Wood Preservation Association (CWPA) and the Canadian Standards Association (CSA), as well as the efforts of associations such as the Railway Tie Association (RTA), The Association of American Railroads (AAR), and the American Railway Engineering and Maintenance-of-Way Association (AREMA).

In spite of these efforts, however, relatively short service life of some ties continues to occur, particularly in the warm, humid areas of the southeastern U.S. that fall in AWPA Hazard Zones 4 and 5. The relatively poor performance of some refractory tie species (e.g., white oak) in these regions has prompted some railroads to separate them for use in regions with lower indices of

biodeterioration (AWPA Hazard Zones 1–3). Analysis of probable factors contributing to reduced service life of ties, assuming that ballast drainage is not an issue, indicated that (1) decay occurring in air-drying stacks and (2) the use of wood species whose heartwood is not treatable with traditional preservatives such as creosote (e.g., white oak) likely were the primary causes.

Assuming that these factors are the primary causes of the problem, the solution to achieving relatively uniform service life of wooden crossties requires their treatment prior to air-seasoning with a biocide that would penetrate the heartwood, even of refractory species. Biocides with such properties would need to be water-soluble and capable of diffusing through wood cell walls. Borates and fluorides are possible candidate biocides with such properties.

Many who have spent their entire careers drying wood prior to pressure treatment with creosote or other oil-borne formulations find the concept of treating non-seasoned stock with a water-borne biocide that continues to diffuse through wood during air-seasoning difficult to grasp. Treating plant owners and operators must understand that “diffusible” biocides, such as borates, require that a biocide “reservoir” be established in the outer wood layers so that it can continue to penetrate the material and, if drying is retarded, establish a relatively uniform retention throughout the treated stock (e.g., crossties). Diffusion treatment makes a lot of sense when treating large-sized commodities (e.g., ties and bridge timbers), where large amounts of time, energy and money are spent removing water from material so that it can be pressure impregnated.

Since penetration of “diffusible” biocides is dependent on the temperature and moisture content (MC) rather than the cellular structure of wood, both the sapwood and heartwood (even of refractory species such as white oak) can be penetrated if the initial wood MC is relatively high (near saturation) and drying is retarded during a “diffusion storage period” following treatment. Diffusion will occur in air-dried wood, but the rate of penetration will be very slow.

Diffusion will continue to occur until either the wood becomes dry or the retention of biocide reaches equilibrium (is relatively constant) throughout the treated stock. This process requires that the “reservoir” of biocide near the wood surface be sufficiently high to yield a retention that is effective against decay fungi and insects after it comes to equilibrium throughout the piece. To maximize the reservoir, incising is usually required. This “moving target” penetration is a concern of many treaters. When and how penetration and retention can be determined are questions that are often asked when discussing the use of diffusible biocides. Railroad engineers, on the other hand, are concerned that borate treatments may alter the electrical resistance of ties and thereby cause problems with signals at road crossings.

To address these concerns of treating plant owners and operators and railroad personnel, and to develop a commercially feasible procedure for producing borate/creosote dual-treated ties, a team of experts was assembled (Osmose, U.S. Borax, TASKpro, and The Crosstie Connection) to work with a cooperating treater (Seaman Timber Company) and an interested railroad (Norfolk-Southern). The methods and results of the RTA/AAR field test described below were used as a starting point to achieve “commercially viable” procedures for treating crossties by a diffusion process.

## RTA/AAR Field Test

Borates are effective biocides against both wood decay fungi and insects, have low mammalian toxicities, are corrosion inhibitors, do not adversely affect wood strength properties, and their presence at fungicidal retentions can be verified by a color test (AWPA Standard A3-05). The efficacy of borates to protect wood from insects and fungi is documented in several publications (Cockroft and Levy, 1973; Drysdale, 1994; Hamel and Robertson, 1990). As a consequence, borates were chosen for use in a field test jointly sponsored by the RTA and AAR. Ties of different species were treated with heated borate solution, bulk-stacked



One quality control step is to measure retention/penetration of borates at various stages during processing.

under a tarp for a few weeks to permit the borate to begin to diffuse through the ties, and stacked for air-drying. The dried ties then were dual-treated with creosote as the primary preservative and placed in active rail lines in different AWP Hazard Zones. These studies are documented in a progress report authored by T.L. Amburgey and S.C. Snyder dated Jan. 12, 1989, that was submitted to the 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 and in an article in *Crossties* (Jan./Feb. 2003) authored by James Gauntt.

After about 15 years in track, the Norfolk-Southern (NS) allowed track time and furnished personnel so that test ties could be removed from sections of their lines in Georgia. Basically, this test demonstrated that ties, including white oak pre-treated with borates, continued to perform well and had minimal decay and no spike kill. The results of this inspection are documented in a publication by Amburgey, Watt and Sanders, 2003 (available online from RTA); a presentation at the 2005 RTA Convention by Kitchens and Amburgey; a presentation at the 2005 AREMA Convention by Gauntt, Amburgey and Kitchens; and a presentation at the 2005 AWP Annual Convention by Gauntt.

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

- Borate retention and diffusion was greater in unseasoned than in seasoned ties.

- Borate retention 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.

- Borate retention and diffusion was greater in incised than in non-incised ties.

- 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.

- Very little borate was lost from air-dried ties during creosote treatment.

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. Results of the 15-year inspection can be summarized as follows:

- Borates had diffused through the cross-sections and, after 15 years, were present at above toxic threshold levels for decay fungi.

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

- No spike kill was observed in borate pre-treated ties, and no evidence of excessive metal corrosion was observed in tie-plate areas. Spikes were clean and essentially free of rust.

- Borate-treated ties did not negatively impact electronic signaling in the test track.

- Borate retentions were higher in the lower than in the upper half of the ties, indicating how borates move to areas of higher moisture (e.g., where decay would be most likely to occur).

- Evidence indicates that dual treatment with the primary preservative creosote reduces the rate of borate leaching from ties.

- White oak ties pre-treated with borates

are performing well on mainline track in the South.

- It may be possible to use reduced retentions of creosote if ties are properly pre-treated with borates and stored to maximize diffusion during the drying process.

- Properly borate pre-treated ties will not require a sterilization cycle during creosote dual treatment.

- Results of other phases of this study demonstrate the effectiveness of periodic supplemental treatments for protecting creosote-treated ties from decay and spike kill.

### Commercialization

In 2004, the NS placed its first order with Seaman Timber Company for commercially borate pre-treated ties that were to be dual-treated with creosote as the primary preservative. The borate formulation used was Timbor Industrial (disodium octoborate tetrahydrate or DOT) produced by U.S. Borax. From the start-up in 2004 through June 2005, 95,000 such ties were ordered by NS. Ties that have been shipped from the treating facility now are in track in AWP Hazard Zones 4 and 5. An additional 350,000 borate pre-treated ►



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ties have been ordered by NS for 2006.

At about the same time, the Canadian National (CN) ordered borate pre-treated and creosote dual-treated ties from Burke-Parsons-Bowlby and has installed approximately 40,000 to date. In 2006, CN intends to order an additional 100,000 borate pre-treated ties and 7,500 switch ties. The CN plan is to eventually use borate pre-treated ties on lines south of Memphis, Tenn.

### Commercial Production

Proper pre-treatment with borates requires that treating plant operators divide the process into four segments and that their personnel understand the importance of all four. The four segments and the parameters used at Seaman Timber Company are:

#### 1. Handling of ties and treatment with borate.

- Maintain the concentration of borate (Timbor Industrial) at 20 percent wt/wt DOT (13.5 percent B<sub>2</sub>O<sub>3</sub>) in a heated storage tank (120–150 F). If the tank temperature falls below about 85 F, borate will begin to precipitate from solution.

- Insulate the pressure retort and heat it, as well as ties to be treated, to (120 F) prior to introducing preservative. This is especially important in cold climates in winter to avoid precipitation of borate on the wood surface and to maximize the establishment of the borate reservoir in a short time.

- Deliver non-seasoned, incised ties to the treating retort.

- Introduce the heated borate solution and pressurize the retort for relatively brief periods of time (e.g., 15 minutes–one hour), depending on the treatability of the wood being used, at maximum 150 psi to yield a net gauge retention of one pound of borate per tie.

- Have a final vacuum period of five minutes at 15 inches mercury.

- Do not expose treated ties to rain wetting prior to being placed in diffusion storage.

#### 2. Diffusion Storage

- Bulk-stacked storage in a structure where drying of ties is limited is required to permit the borate reservoir at and near the surfaces to become redistributed toward the interior. Representative ties should be bored weekly to determine when borate penetration has reached a pre-determined depth (e.g., 1.5–2 inches) at a fungicidal retention (reacts

with the color test per AWP Standard A3-05) in the majority of the ties sampled so that diffusion can continue during air-seasoning. At that time (two–four weeks, depending on the wood species and MC), ties can be moved to the air-seasoning yard.

#### 3. Air-Seasoning

- Air-seasoning stacks should be constructed in a well-drained area; separated by straight, continuous alleys; placed on adequate foundations; and fitted with pile covers (as is common with hardwood lumber drying facilities). The space between rows, or stacks within rows, is dependent on the region where the drying facility is located. Evidence suggests that borate-treated ties dry in a shorter period of time (by several weeks) and more uniformly than non-treated ties.

#### 4. Dual Treatment

- Borate pre-treated ties should be dual-treated with a primary preservative such as creosote to prevent loss of borate due to leaching and to protect the wood in service from soft-rot fungi. Although borates are efficacious against basidiomycete decay fungi and insects, they do not control the growth of other groups of fungi (e.g., molds, ascomycetes). In our initial tests, the creosote retention remained the same as that used for ties not pre-treated with borate. Based on the results of the RTA/AAR field test, additional tests will be conducted using reduced retentions of creosote and/or other oil-borne formulations. This is a viable way to lessen the impact of the creosote shortage.

- The process parameters given above were developed for the Seaman Timber Company (STC) facility at Montevallo, Ala. A working treating standard has been developed for STC to assure the consistent production of a quality product. The need to adhere to strict quality control practices is essential as additional treating plant owners and operators embrace this technology. The STC facility had a retort and storage tank that previously had been used for CCA treatments. Essentially, STC put a heating jacket on the storage tank, placed heating coils in the retort, and converted an open storage building into an enclosed diffusion storage facility and they were ready to pre-treat with borates.

#### Electrical Impedance Tests

As stated earlier, some railroads have been

reluctant to use borate pre-treated ties because they fear the borates would cause signaling problems. In spite of the fact that no signaling problems were experienced in the RTA/AAR test track areas in more than 15 years, many engineers remain unconvinced that such problems will not occur. Prior to placing borate pre-treated ties in track, NS requested that our research team conduct electric impedance tests. A large-scale test with white oak ties that were either only creosote-treated (42 percent MC) or borate pre-treated and creosote dual treated (46 percent MC) was established. All ties had spiked tie plates on both ends. Impedance measurements showed that only 29 percent of the white oak ties treated with creosote without borate pre-treatment would pass the minimum 20k ohm resistance currently used as a “standard.” The test also showed that the impedance measurements of the creosote-only (16k ohm median) and the borate pre-treated (7k ohm median) ties overlapped to a significant degree. A second test with white oak ties having a lower MC than those in the first test (MC 34 percent for creosote-only and MC 39 percent for dual-treated) indicated that the creosote-only ties had a 47k ohm median and the dual-treated ties had a 52k ohm median resistance. The two tests indicate that tie MC affects their resistance as much as their borate content.

### Conclusions

Experience to date indicates that borate pre-treated ties that are dual-treated with creosote as the primary preservative have experienced essentially no biological or iron-mediated (spike kill) deterioration when exposed in AWP Hazard Zones 4 and 5. In addition, track sections containing borate pre-treated ties have experienced no unmanageable signal problems. Two Class 1 railroads, NS and CN, now are procuring borate pre-treated ties for use in their tracks in AWP Hazard Zones 4 and 5. §

#### Literature

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