



BEST PRACTICES FOR HANDLING CROSSTIES

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WOODEN CROSSTIES: GO FROM GOOD TO BETTER

Most railways in the United States are built on wooden crossties. Approximately 96 percent of all ties currently in track are wood. Alternative materials are available (steel, concrete and plastic), but wooden crossties have a number of advantages, including:

- A long history of proven performance.
- Well-developed technology and infrastructure for manufacture and handling.
- Cost effectiveness.
- Good service life.
- An environmentally friendly product made from a sustainable raw material that has the potential for reuse, recycling or energy generation at end-of-life.

Despite these many advantages, there are some unique challenges to using wooden crossties successfully: Wood is biodegradable and relatively variable. Preservative treatments, such as creosote and copper naphthenate, are effective at controlling biodegradation, and the robust design of the rail system helps to compensate for some relatively poor ties that may exist due to variability. However, proper handling of ties through the manufacturing and installation process can help to improve the durability, mechanical performance, and, thus, the reliability of individual ties, resulting in better track service life overall and the associated financial benefits.

This guide explains the causes of tie degradation during manufacture and presents options that will reduce these risks. Some of the suggestions given here may already be standard practice in some organizations. Others may appear to be unnecessary or impractical. However, an installed railway tie represents a significant monetary investment. We suggest that proper handling procedures will ensure that the ties perform to their best potential, resulting in very significant long-term savings.



FIGURE 1. The rot in this freshly cut tie occurred in the living tree. It should be culled.



FIGURE 2. *Stain and decay fungi have already infested these ties being processed. Rapid log processing or borate pretreatment could have reduced or prevented this problem.*

RAPID PROCESSING — THE CLOCK IS TICKING

The wood in living trees is protected by both passive (e.g., bark covering) and active features and processes (e.g., resin or gum formation). These systems are not perfect, and many standing trees are infested by insects or have rotten wood within them; insects frequently gain access through decaying branch stubs. Still, the fact that a mature hardwood tree of the type that is used for railway ties can grow for 100 years or more is a testament to the effectiveness of these protection strategies. However, when these trees are harvested and the logs are cut into cants, lumber, timber and ties, most of this protection is lost.

Many insects and fungi exist that feed on, or nest within, freshly harvested logs or sawn material. Thus, green (nonseasoned), unprotected wood such as a freshly cut crosstie is a preferred material. Furthermore, these organisms



FIGURE 3. *Dead stacking nonseasoned ties prevents drying and will quickly lead to decay and/or insect damage. Soil contact during storage or drying is also to be avoided.*

are widely distributed in the air and soil and may already be growing within the wood when the tree is cut. There is a high likelihood that they will continue to affect wood strength as long as the wood remains unprotected.

Because deterioration starts when the tree is cut and continues until the wood is chemically protected (i.e., treated),

the time between harvest and final treatment should be minimized. This procedure includes rapid processing and first-in-first-out (FIFO) handling of logs and untreated cants. Dead-stacking (which prevents drying) should be avoided and untreated inventories kept to a minimum.

FIGURE 4. Establishing good drying conditions as quickly as possible will help make the most of a tie's potential. Elevating these "German stacks" of seasoning ties on larger foundations would improve the drying of the bottom layers. Pile covers ("hack covers") would decrease the amount of water entering the piles.

UNTREATED CROSSTIES ARE LARGE PIECES OF NONSEASONED LUMBER

Professionals who process nonseasoned lumber for use in furniture, flooring and other products are well aware that the greatest risk for degradation occurs at the beginning of the drying process. They also know that it is more time-consuming to dry thick lumber successfully. These two facts of life for lumber dryers are also relevant to crosstie producers. Green, untreated crossties are like freshly sawn, very thick lumber, and, thus, it is a challenge to dry them quickly and without degradation.

In light of this challenge, the primary goal should be to initiate the drying process as quickly as possible. As the surfaces dry, the risk of new attack drops substantially. Fresh ties should be "put in the air" as quickly as possible to start the drying process. If stacking sticks (stickers) are used, they must be dry and treated with an appropriate preservative, or they may serve to inoculate new wood. As lumber dryers well know, a wet sticker will prevent drying at the area of contact between the sticker and the wood it is supporting. Dead stacking (i.e., no separation between tie faces and sides) and holding freshly cut tie inventories in railcar gondolas prevent drying and thus should be avoided.

Minimizing deterioration of tie stock is more difficult in sawmills and treating

facilities located in warm, moist regions such as the southeastern U.S. (AWPA Decay Hazard Zones [DHZ] 4 and 5) than in the cool northern states (DHZ 2 and 3) or in the relatively dry southwestern states (DHZ 1 and 2). Activities of both wood-inhabiting insects (beetles, subterranean termites) and decay fungi are greater in DHZ 4 and 5 than in other regions. This means that tie drying efforts must be more rigorous in DHZ 4 and 5: (1) Assure that rainwater does not accumulate under or between stacks in the air-dry facility; (2) Align tie stacks and spacing between them in an air-drying facility to maximize air flow; (3) Place foundations under tie stacks to aid air flow; (4) Consider stack covers to prevent rain wetting within stacks.

By contrast, air-drying facilities in dry regions (DHZ 1 and 2) must have tie stacks, and spacing between stacks, oriented to decrease air flow through the area. This is necessary to decrease tie defects such as excessive checking and splitting caused by rapid drying of the ties. In the Southeast, all German stacks or stick stacks should be off of the ground a minimum of 12 inches to allow the bottom ties in the stack to dry properly. If stacking stickers are used, they should be treated and be 1-2 inches thick. In the Southwest, the air is so dry that German stacks are not usually used. The spacing between ties within a layer can be as small as half an inch both vertically and horizontally to prevent excessive checking and splitting.



FIGURE 5. Heartwood needs protection, too! The heartwood of this bridge tie has completely rotted away because it is not possible to treat it with creosote or copper naphthenate.

Lumber producers also routinely dip freshly sawn lumber in “anti-sapstain” chemical solutions to prevent fungal attack and wood discoloration. Dipping green ties in anti-sapstain at sawmills is done on a limited basis commercially to protect the wood before the drying process begins. One procedure for decreasing deterioration of nonseasoned ties by fungi and insects is to treat them with borates (disodium octaborate tetrahydrate DOT). Borates are effective insecticides and fungicides that, unlike other wood preservatives, will diffuse through wood cell walls following the moisture gradient from the surface to the center. The use of pile covers on stacks of borate-treated air-drying ties is recommended. Generally, ties are not treated with borate at sawmills but they could be. This one step could prevent the loss of the many green ties that decay while they are being held in the sawmill yard, in railcar gondolas during transit or after delivery to the treating plant awaiting inspection and stacking. We suggest that no more than a month should pass, a shorter time during the summer months, while the green ties are in dead packs, including before or during transportation in the southeastern states. The application of a borate solution at the time ties come off of the green chain would protect the nonseasoned ties during this critical time period. It would also begin the process of water-soluble borate penetrating to the inside of the ties. Railroads could consider providing an incentive to saw millers who perform this step or to tie processors who treat before air drying, because it improves the value of otherwise similar ties.



NATURAL DURABILITY: HELPFUL, BUT NOT ENOUGH

The natural durability of the ties being dried also must be considered, especially in facilities located in Decay Hazard Zones 4 and 5. For instance, gum, red maple and other species with low natural durability will decay faster than durable species such as white oak. An efficient air-drying facility, as discussed above, is essential for successfully minimizing degrade in species with low natural durability. Insect or fungal resistance is not related to other properties such as strength or treatability. Hickory is hard and strong but not naturally durable. Beech is neither naturally durable nor easy to treat.

Only the heartwood of naturally durable species is durable; the sapwood of all wood species is susceptible. Also, as with all wood properties, natural durability is highly variable within a species — even within a single piece of wood. So, while some species deteriorate more quickly than others (e.g., gum), all species will benefit from being handled quickly and carefully.

END PLATES ARE ANTI-SPLIT DEVICES

Wood shrinks unevenly as it dries, which creates stresses that build up until the wood breaks. Thus, a certain amount of splitting is normal in dried ties. In the context of railroad crossties, a “split” is defined as a wood separation involving two or more adjacent surfaces of the tie. End plates are metal sheets with numerous pointed metal tabs (“teeth”) that are pressed into the ends of green ties. End plates can minimize end splits. While end-plating is potentially beneficial for all species, some species are less prone to end splits. Sweetgum, black gum, tupelo gum, sycamore, soft maple, beech and elm naturally have an interlocked grain that reduces end-splitting; thus, some producers don’t plate those species. However, not splitting requires being able to consistently identify and segregate wood species that may look similar but be at higher risk of end-splitting. The crosstie species most susceptible to splitting are hickory, white oak, locust, hard maple, red oak and ash.

FIGURE 6. The white fungal fruiting bodies on this tie mean that rot is well-established and strength loss has occurred. Wood weight loss as low as 2 percent caused by decay can cause as much as 30 to 50 percent strength loss.

INCISING AND CHECKS: GIVE A GOOD PRESERVATIVE ENVELOPE

Incisors are toothed drums that put shallow indentations into the faces and sides of a tie. They are cut in a pattern prescribed by AREMA (American Railway Engineering and Maintenance of Way Association). Incisions create small areas of open-end grain along the length of the tie and also help to encourage many small checks during drying. In the rail industry, “checks” are defined as wood separations that affect only one face of the tie. These develop during the drying process due to wood shrinkage. Incisions make the surface of the tie more permeable to liquids, resulting in a consistent “envelope” of preservative in the treated tie.

STACK BURN — AKA WOOD ROT OR DECAY

The decay fungi that rot wood invade the wood structure with microscopic threadlike hyphae. Thus, the beginning of the rot process is not apparent to the naked eye. As the fungus develops, it may become visible on the surface as a whitish-colored mat of mycelium (a group of hyphae) or when it produces a “fruiting body.” A mushroom is one example of a fungal fruiting body, but most decay fungi do not produce fruiting bodies on ties. Both mycelial mats and fruiting bodies are evidence of well-established fungal activity within the wood. Removing these items from the tie surface does nothing to the fungus within the wood. Wood decay

weight loss as little as 2 percent may be undetectable visually but can result in as much as 30 to 50 percent strength loss (as measured by toughness). The only way to prevent further fungal growth is to treat the wood with preservatives. Once the ties are in track, they will get wet enough for decay to continue, so preservatives are essential for long service life. If the ties were not borate-treated while green, it is essential to carry out a sterilization cycle as part of the final treatment to kill the active fungi in the wood and prevent further decay.

Stack burn refers to visible fungal activity that occurs during the tie air-drying process. As mentioned above, the presence of visible signs of a decay fungus indicates advanced rot within

the wood. Such rot greatly weakens the wood locally, even when only a small percentage of the wood’s mass in that region has been consumed by the fungi. Even with rapid processing from sawing to treatment, some stack burn will occur, but research suggests that if everything is done correctly, the strength of the tie as a whole is robust. However, the longer the time between sawing and preservative treatment, the greater the risk for stack burn that eventually will ruin the tie.



FIGURE 7. The white areas are rotten. This “stack burn” is occurring at the touch points between ties, where drying is retarded.

HOW FAST IS FAST ENOUGH?

Many factors affect how much deterioration occurs while ties are being processed prior to treatment: wood species, the length of time before drying starts, temperature, air flow and humidity during drying, and whether any pretreatments (e.g., borate) are applied. Thus, it is difficult to assign exact time frames to recommendations for rapid processing.

Cold weather (near freezing) will stop fungal activity but will not kill existing fungi. Cold temperatures will also retard drying. Warmer weather will increase rates of fungal and insect activity but can also increase the rate of drying. Humid air conditions and stagnant air slow drying rates.

Some fungi (stain and mold) can colonize and discolor lumber in a matter of days. The decay fungi that cause stack burn are slower to develop; however, if the conditions are proper, they can become well-established in a few weeks. Because ties typically air-dry for months, this time period is long enough for significant decay to occur if good drying conditions are not provided. A few weeks in a dead stacked condition where little drying occurs is certainly enough time for decay to develop.

Under proper drying conditions (German stacked or stickered), normal drying times for the Southeast are five months for mixed hardwoods and nine to 10 months for oaks and hickories. The time periods are shorter in the Southwest. But note that “air dried” ties are considered dry at 40-50 percent moisture content. At these levels of moisture content, ties are still in an ideal condition for internal decay; therefore, final creosote or copper naphthenate treatment should not be delayed (i.e., do not “overdry” the ties).



FIGURE 8. Stack burned (partially rotten) ties going into the treatment cylinder. These ties have lost some of their potential for excellent service and this loss cannot be recovered.

PROPER TREATMENT

Many proven treatment options exist, each with potential advantages. The proper choice and application of tie treatments is well-covered by the AWP (American Wood Protection Association) standards and AREMA guidelines and is beyond the scope of this guide. However, the following few general recommendations can help make the difference between a poorly treated tie that will cause problems and a properly treated tie that will provide good service for decades.

Retention

In general, treatment quality is measured in terms of the retention (how much) and penetration (how far in) of the preservatives. Preservatives must be present in sufficient concentration to kill or deter pests. This requires certain levels of retention.

Some wood species are “refractory” or difficult to penetrate with liquid preservatives. Because species vary in permeability, and because gauge retention¹ levels are often used to estimate whether ties are sufficiently treated, mixing wood species in a single charge is risky.

For example, if you have (easily treated) gum mixed with (refractory) hickory and don’t treat “to refusal,” the hickory could be undertreated. For this reason, hickory is typically treated with “oaks.”

Penetration

A common concern for treating ties is shallow penetration. If wood inside a tie is not treated, then it is susceptible to decay and insect attack as checks open up when the tie is in service, regardless of how much preservative is on the outside. Incising can help increase

penetration in the outer shell to create a uniform “envelope” of treatment in refractory species. However, regardless of species, properly drying ties prior to treatment is also critical — in wet wood the cells contain water that will block the movement of creosote or oil-borne copper naphthenate preservative liquids and prevent treatment of wood cell walls. Also, not all liquids penetrate wood equally well nor provide the same level of protection, so any substitution of alternative oils or dilutents should be carefully researched and monitored.

¹Gauge retention estimates the average amount of preservative in each tie by measuring the amount of preservative taken up by the whole load of ties. Treating “to refusal” means applying the pressure cycle for long enough that the ties will not accept any more preservative.



FIGURE 9. Stack burn weakens wood and can also interfere with treatment. Fungal activity can increase moisture content locally. Creosote failed to penetrate the areas where the fungus was established in this tie. The untreated areas are prone to decay in service.



FIGURE 10. Drilling holes in a treated tie can expose untreated wood. Whenever possible, holes, daps, etc., should be cut before pressure treatment. If drilling or fabricating must be done after treatment, preservative must be applied locally at that time. Such “field” treatments are required under AWP Standard M4, and copper naphthenate at 2 percent Cu is standardized for ground contact applications.



FIGURE 11. *Stack burn ruined this tie before it was treated. The blunt (“brash”) break of the wood in this tie is typical of the effects of fungal decay. Decay also increases permeability. The creosote treatment here shows excellent penetration. Unfortunately, the creosote preservative was applied after the damage was already done.*



FIGURE 12. *The incising of this tie will help penetration during pressure treatment.
The end plate will reduce the severity of end splits.*

DUAL TREATMENT

So-called dual treatments are becoming commonplace in the rail tie industry. These combine traditional preservatives (e.g., creosote or copper naphthenate) with a borate preservative. After treatment and assuming adequate retention, the borate component will diffuse over time throughout the entire cross-section; thus, it can protect heartwood and areas of the tie not penetrated by the other preservative. In addition, borate is a broad-spectrum biocide that will control creosote-tolerant fungi and is a corrosion inhibitor that can help reduce rust formation on spikes and the accumulation of iron in wood adjacent to spikes, which contributes to spike kill.

There are three dual treatment processes, which differ when the borate component is added to the ties. In the one-step process, the borate is mixed with the traditional preservative, and both preservatives are added to dried ties in a single pressure treatment. In the one-and-a-half-step process, the borate is also added to the dried tie, but the water-based borate and the oil-borne preservative treatments are added separately, one after the other, typically in the same cylinder. The two-step process applies borate to nonseasoned ties before air drying, typically using a (ambient pressure) dip treatment to get similar retention across all species. The borate then diffuses through the wood as the ties dry. After drying, the ties are pressure-treated with creosote or copper naphthenate.

Tests of dual treatment ties (using a two-step process) have demonstrated greatly extended service life. Because borate is inexpensive and has other benefits, dual treatments have become popular. The application of borate to the nonseasoned ties can help prevent stack burn and insect infestation during the drying process. If the ties are not chemically protected during drying, ensuring rapid drying and avoiding close stacking at sawmills or in gondolas for extended periods is even more important.



FIGURE 13. *The heartwood of this tie was not penetrated by the copper naphthenate pressure treatment. Unless a diffusible preservative (e.g., borate) is used, the heartwood will not be fully protected in service.*

QUALITY CONTROL AND ASSURANCE: YOU GET WHAT YOU INSPECT, NOT WHAT YOU EXPECT.

American hardwood species naturally provide superb raw materials for railway ties. Much research and development has been dedicated to developing excellent standards for the proper treatment of railway ties using a variety of effective technologies. However, the implementation and verification of practices that meet these standards require continuous monitoring and documentation. Examples of quality checks include:

- **Identifying species and measuring moisture content of ties before treatment.** Care must be taken to sample ties for moisture content using a sampling format that yields a representative average for the whole run. Take 20 borings near midpoint with no more than seven of them coming from ties in the stacks on the ends of the run. Species should be grouped appropriately for treatment, and wet ties should be pulled out and re-dried.
- **Ensuring sterilization cycles are performed.** These cycles kill the pests that are in the wood where preservative will not reach. As mentioned, even well-handled untreated ties contain insects and fungi. When Boultonizing green ties, the heat time is sufficiently long enough that sterilization will occur. A sterilization cycle is not necessary for ties properly dual treated using the two-step process.
- **Conducting treating cycle audits to ensure gauge readings and treating solutions are correct and sufficient.** Ask for independent assays of both treatment solutions and treated wood. There are companies that specialize in this.
- **Tracking data over time using statistical techniques such as control charts.** This will help identify abnormal variations in the systems that can lead to serious quality problems.



FIGURE 14. A dual-treated (two step) tie. The inner portion not penetrated by the creosote treatment is protected by the borate (curcumin sprayed to show boron as red).

POST-TREATMENT HANDLING — THE HARD PART IS OVER

Once ties are dried and have been preservative-treated properly, not much further protection is required. Well-prepared ties should last for decades in service, even though they may be exposed to extreme decay, termite hazards and mechanical stresses. Conversely, if ties have degraded during the manufacturing process or have been treated insufficiently, little can be done to improve their potential, and they may fail in just a few years.

CONCLUSION: MAKE THE MOST OF YOUR INVESTMENT

Wood has an excellent record as a rail tie and has a great environmental story. A key to ensuring that wood ties are cost-effective is to protect the wood through the manufacturing process. Small investments in ensuring that ties are rapidly processed and properly treated will pay off in increased service life and reliability.

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