THE tie GUIDE

HANDBOOK FOR COMMERCIAL TIMBERS USED BY THE CROSSTIE INDUSTRY

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TABLE OF CONTENTS

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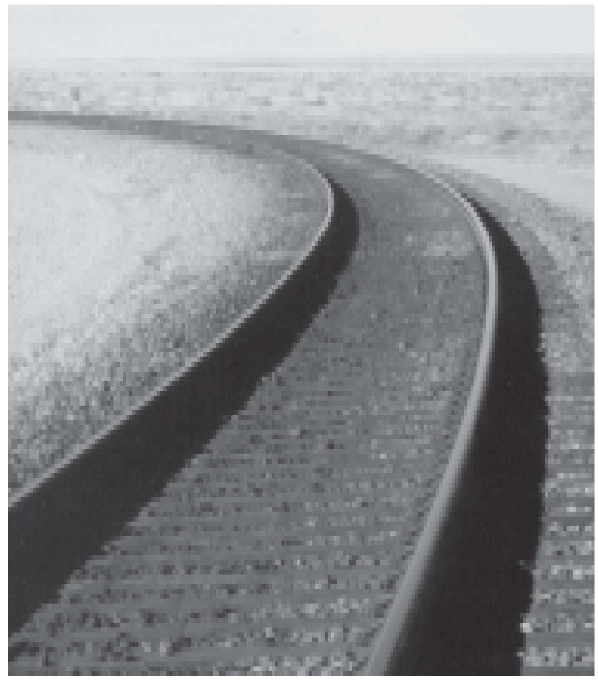
INTRODUCTION



The wood crosstie has served the American railroad industry since its earliest days when wood ties were used as a foundation for the rail in the track structure. The dependability and service life of this wood component has been exemplary. The information provided in this booklet will provide the reader with a description of the identification, treatment and ultimate use of wood in the engineered crosstie system.

Wood is the only structural building material that is renewable. As a timber crop which can be cut and harvested on a rotation basis, wood sawn for crossties, has served the railroad industry over a century.

With the use of wood preservatives, the durability and service life of wood is significantly enhanced. This booklet brings together wood technology principles with a focus on the practical application for “the tie grader in the yard” as her performs his duties of classifying oaks, mixed hardwoods and softwoods that will be treated with a creosote preservative solution and subsequently installed in a railroad track.

The task is to develop a common thread illustrating the development and ultimate performance of the treated wood crosstie. It should be noted that within this booklet there are some practical applications given along with certain technical details outlined in the wood crosstie engineering section. The Railway Tie Association Performance Standard found in the engineered wood crosstie section of this manual describes specific strength property characteristics and load traffic environment applications for the various types of wood tie material.

This booklet intended for use in the classroom as well as a practical guide. The Railway Tie Association, as part of its primary mission, sponsors seminars in the practical identification and grading of wood crossties and on the engineering principals behind tie performance. This manual will be an instructional component in these seminars.

THE TREATMENT OF WOOD CROSSTIES

Wood is a cellulosic material which can be adversely affected by decay fungi, insects, and marine borers. The use of chemical preservatives (organic and/or inorganic) must be used to protect wood from attack from these organisms.

The degree of protection obtained is dependent upon the type of preservative used and achievement of proper penetration and retention of the chemicals. As will be discussed in later chapters, there is a difference in the treatability of wood species. There is also a difference in the treatability of the sapwood and the heartwood portion of the tree.

With respect to wood crossties, the American Wood Preservers' Association Use Category System- UC4 **(previously referred to as Standard C-6)** for crossties and switch ties, gives the general requirements for preservative treatment by pressure processes. In addition, described within the Standard are the processing, conditioning, treatments, results of treatment (quality control), and storage of treated crosstie materials.

The processing and treatment of wood crossties are somewhat unique.
This product, as used by the American railroad industry, has historically been treated with a creosote solution meeting the requirements of AWPA Standard P2. There are also occasions when other timber products such as bridge material will be treated using the AWPA Standard P1/P13 meeting the requirements for coal tar.

A heavy petroleum oil that meets AWPA P4 Standard has also been used for blending with creosote. This creosote/petroleum solution has been used extensively for many years to reduce the cost of the preservation solution. Its use, however, has been in the Western and Rocky Mountain states and Canada which are areas that have climatic conditions which are less conducive to wood deterioration from fungi and insects. Organisms that attack wood - fungi and termites - are not as active at ***low*** temperature and humidity levels found in many areas of these geographic regions.

THE TREATMENT OF WOOD CROSSTIES

Creosote and its solutions are the preservatives most widely used. Crossties are typically pressure treated using the empty-cell method (Lowry or Rueping Process). The specified creosote net retention is usually between six and ten pounds per cubic foot (pcf).

Prior to treatment, wood crossties must be properly conditioned in order to achieve the desired preservative penetration and retention. The various conditioning methods and processing procedures are described in the ***AWPA** Book of Standards.* A current copy of the AWPA Standards is readily available to anyone who is involved in the procurement, treatment, and use of wood crossties and may be obtained at nominal costs from either the AWPA or RTA. (Note that a copy of the AWPA UC4 is included in the appendix.)

The treatment results are described as the retention of preservative and penetration of preservative. The accepted method for retention of preservative is based on the readings of work tank gauges or scales. Penetration of preservative is determined by boring a representative sample number of crossties within a charge of material. Individual railroad customers typically add more specific requirements to the AWPA UC4 Use Category, thus creating a railroad "specific use" standard.

For additional reference materials for the treatment of wood crossties, one should consult the specifications for the treatment of crossties as described in **AREMA** (American Railway Engineering and Maintance-of-Way Association). These specifications also cover the preservative treatment of crossties and switchties.

TECHNICAL ASPECTS AND A LESSON IN WOOD

Wood varies significantly with regard to its structure. The hardwood species differ from the softwoods. In addition, within each of these groups there are also differences between the wood species. To be even more specific there are differences within the same tree, because the heartwood usually contains substances not found in the sapwood. These differences have an influence on the permeability of liquids, such as wood preservatives, into the structure of wood.

The hardwood timbers or broadleaf trees, such as the hickories, oaks and maples, have a cellular structure that serve as sap conductors. These cells, which are positioned end to end, are commonly known as pores or vessels, which from somewhat contiuious passages within the wood. The mechanical support is provided by fibers that surround the vessels.

TECHNICAL ASPECTS AND A LESSON IN WOOD

The softwood timbers or needle bearing trees know as conifers – such as Douglas-fir, the pines, hemlocks and true firs – do not have the specialized sap-conducting cells that are found in hardwoods, but instead have elongated cells called tracheids or fibers, which have a closed end. These fibers also serve as the mechanical support and to conduct the sap.

The terminology hardwood and softwood is often misleading, because there are some softwoods that are actually harder than some hardwoods from a structural standpoint. For instance yellow poplar, although a broadleaf tree and termed a hardwood, is actually lower in specific gravity, less dense and softer than Douglas-fir, which is classified as a softwood.

Hardwoods are classified based on pore size and distribution within a growth ring (annual ring). The hardwood timbers, such as beech, birch, the gums and maples, in which the pores are somewhat uniform in size and distribution, are called "diffuse-porous" woods. While those woods which have alternate layers of small and large pores, such as ash, hickory and oak, are termed ring-porous woods. Those woods that exhibit cellular structure in between diffuse- and ring-porous woods are classified as semi-ringed-porous (or semi-diffuse-porous). Black walnut and persimmon are semi-ringed-porous woods. The primary cause for the difference in the penetration of preservatives in both hardwoods and softwoods is the difference in the amount of heartwood and sapwood. Young trees are usually all sapwood. As a tree grows older the heart-wood volume increases in the center of the tree as the sapwood layers continue to be formed.

The sapwood is the "living" portion of the wood, which transmits fluids and nutrients between the roots and leaves of the tree. The heartwood, which often is darker in color than the sapwood, no longer transmits fluids; it is inactive.

The pores of the heartwood are "blocked" or partially closed with various pith-like growths called tyloses, or with gum-like materials; while in the conifers the vessel openings become partially or totally occluded and thus resistant to the passage of liquids.

With most wood species the change from sapwood to heartwood increases the resistance to preservative penetration. However, there are exceptions; for example, both the sapwood and heartwood of eastern hemlock are resistant to the penetration of liquids. In addition, there are some woods, such as red oak, that are relatively easily penetrated by liquids.

TECHNICAL ASPECTS AND A LESSON IN WOOD

The general rule is that the treatability of heartwood is more difficult than sapwood. Reference Table 1 lists four groups of woods, rating the degree of penetration difficulty for the various wood species.

Pith-like growths known as tyloses, develop in the heartwood of some hardwoods. With regard to commercial timbers used for crossties, tyloses are commonly found in black locust and the white oaks. The influence of tyloses on the penetration of preservatives into the heartwood is easily illustrated by comparing penetration in the white oak group and the red oaks.

By using Table 1, it would be generally concluded that all white oaks are difficult to penetrate with preservative; similarly all red oaks can easily be treated. There are some exceptions to this “rule.” For example, chestnut oak (Quercus montana) is a white oak that has few tyloses and thus the heartwood is treatable. While the red oak known as black jack or jack oak (Q. marilandica) has pores that are closed by tyloses impending the penetration of liquids.

Penetration of liquid preservative can occur in wood in a three directions;

– longitudinally, which is the direction the length of the tree trunk;
– radially, which is in the direction of the radius through the center of tree;
– tangetially, which is in the direction of the annual rings.

With few exceptions, practically all species are most easily penetrated longitudinally. This can be illustrated by visualizing the wood fibers or vessels as a “bundle of straws.” These vessels or “straws” vary in length, with the ends closed. “Holes” or pits occur between the vessels, which allow for passage of liquids from one vessel to another. However, the fact remains that liquids move more easily longitudinally within the vessel rather than radially or tangentially between the vessels.

Even though considerable research was used to develop the process over many decades, in practice, the preservative treatment of wood using pressure methods is not necessarily an exact science. This occurs due to the variability of wood itself from within a given species and between the various wood species. Exploring the numerous reference books cited in the Appendix will confirm that there is an “art and science” to wood treatment.

TABLE 1
TREATABILITY WITH CREOSOTE FOR CROSSTIES

Heartwood least difficult to penetrate-MOST TREATABLE (#1)

Softwoods

- Ponderosa Pine (Pinus ponderosa)
- Redwood (Sequoia sempervirens)

Hardwoods

- American basswood (Tilia americana)
- Black tupelo/ black gum (Nyssa sylvatica)
- Green ash (Fraxinus pennsylvanica)
- River birch (Betula nigra) • Red oaks (Quercus spp.)
- Slippery elm (Ulmus rubra) • Sweet birch (Betula lenta)
- Water tupelo (Nyssa aquatica) • White ash (Fraxinus americana)

Heartwood moderately difficult to penetrate-MODERATELY TREATABLE (#2)

Softwoods

- Baldcypress (Taxodium distichum)
- Douglas fir, coastal (Pseudotsuga menziesii)
- Eastern white pine (Pinus strobus)
- Jack pine (P. banksiana)
- Longleaf pine (P. palustris)
- Red pine (P. resinosa)
- Shortleaf pine (P. echinata)
- Sugar pine (P. lambertiana)
- Western hemlock (Tsuga heterophylla)
- Loblolly pine (Pinus taeda)

Hardwoods

- Chestnut oak (Quercus prinus)
- Cottonwood (Populus spp.)
- Bigtooth aspen (P. grandidentata)
- Mockernut hickory (Carya tomentosa)
- Silver maple (Acer saccharinum)
- Sugar maple (A. saccharum)
- Yellow birch (Betula lutea)

Heartwood difficult to penetrate-DIFFICULT TO TREAT (#3)

Softwoods

- Eastern hemlock (Tsuga canadensis)
- Engelmann spruce (Picea engelmann)
- Grand fir (Abies grandis)
- Lodgepole pine (Pinus contorta)
- Noble fir (Abies procera)
- Western larch (Larix occidentalis)
- White fir (Abies concolor)

Hardwoods

- American sycamore (Platanus occidentalis)
- Hackberry (Celtis occidentalis)
- Rock elm (Ulmus thomasi)
- Yellow poplar (Liriodendron tulipifera)

Heartwood very difficult to penetrate-MOST DIFFICULT TO TREAT(#4)

Softwoods

- Douglas fir, intermountain (Pseudotsuga menziesii)
- Northern white cedar (Thuja occidentalis)
- Tamarack (Larix laricina)
- Western red cedar (Thuja plicata)

Hardwoods

- American beech (red heartwood) (Fagus grandifolia)
- Black locust (Robinia pseudoacacia)
- Blackjack oak (Quercus marilandica)
- Sweet gum (redgum) (Liquidambar styraciflua)
- White Oaks (Quercus spp.)

THE TREATMENT OF WOOD CROSSTIES

Wood preservation began in earnest during the second half of the nineteenth century. The first commercial treating plant was built in Lowell, Massachusetts in 1848. The treating process utilized a water-borne solution of the inorganic salt mercuric chloride as the wood preservative. This wood preservative solution was also referred to as the Kyanizing Process. The primary use of this treatment was on wood crossties for installation on several eastern railroads.

In addition, there were two other inorganic chemical compounds- copper sulfate and zinc chloride- used as waterborne treatments to preserve wood. Subsequently, it was determined that these waterborne mixtures of salt solutions readily leached out of the wood when placed in exterior exposure conditions where there was “free running” water.

In order to improve the effectiveness of these waterborne inorganic chemical compounds, the wood was first treated with zinc chloride followed by a treatment with creosote. In 1906 J.B. Card patented a one step impregnation process with a mixture of zinc chloride and creosote. The mixture of zinc chloride/creosote for the treatment of crossties reached a peak in the middle 1920’s with the subsequent treatment process being abandoned in 1934.

The first full cell creosote treating plant was built in 1865 in Somerset, Massachusetts. However, there is more significance attached to the plant that was erected in 1875 in West Pascagoula, Mississippi. This plant was built by the Louisville and Nashville Railroad for the treatment of the various wood materials including crossties that were to be used within the railroad system. It is generally considered that this marked the initial development of the modern pressure wood treating plants.

The full cell process was also know as the Bethell Process and was used almost exclusively for all of those early treatments. Because it was not always possible to satisfactorily treat unseasoned timbers (“green” crossties with high moisture) the Boulton Process was patented in the United States in 1881. This conditioning method (Boulton Process), or boiling under vacuum, removed free water from the wood cells, which then allowed creosote to be impregnated into the wood.

The full cell process placed the maximum amount of preservative into the wood. Thus, for economic reasons two new empty cell processes were developed. These empty cell processes were named for the two individuals who developed and patented them-Max Rueping in 1902 and C.B. Lowry in 1906.

A BRIEF HISTORY OF WOOD PRESERVATION

The Rueping and Lowry Processes (empty cell) provide for coating the wood cell with creosote and thus, results in a significantly smaller retention of preservative than that which would have been retained with the Bethell Process. This empty cell process, with certain modifications is the primary treatment used today for wood crossties.

With additional focus on providing an economical treating solution for creosote treated crossties, such materials as coal tar, water-gas tar and petroleum were mixed with creosote. These diluents were added to reduce the overall preservative cost of the mixture without significantly reducing its effectiveness. Water-gas tar is no longer available and the creosote preservative manufacturers have minimized the addition of coal tar. The use of heavy petroleum still continues and is mixed with creosote for use by several railroads in arid climates west of the Mississippi. Creosote/petroleum mixtures are exclusively used by the Canadian railroads for treatment of wood crossties.

The use of creosote and its solutions reached a peak in 1929 when 203 plants reported treatment of approximately 360 million cubic feet of wood which included 60 million crossties. Creosote continued to be the dominant treatment until shortages of the preservative occurred during World War II.

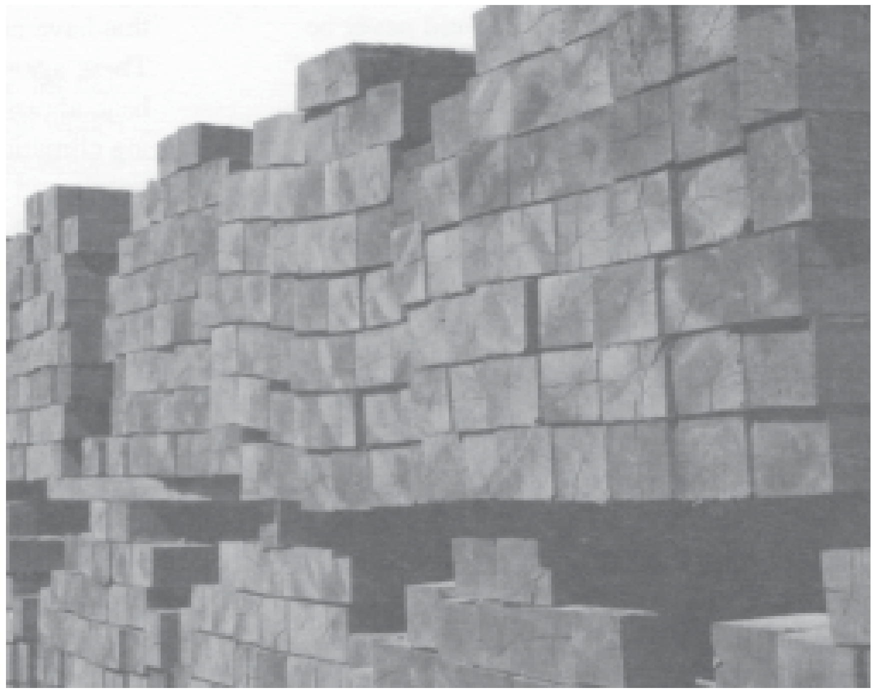
During the early 1950s pentachlorophenol (5-9% concentration) in a carrier-oil began to be used for the treatment of utility poles. In the decade of the 1960s, significantly more leach resistant waterborne preservative solutions of copper chrome arsenate (CCA), ammoniacal copper arsenate (ACA) and a formulation revised to include zinc (ACZA), along with several other copper containing preservative formulations were developed. These waterborne preservatives have had a significant impact in the increased volume of pressure treated lumber produced for use in the consumer markets.

That being said, both the railroad and wood treating industries will continue to look for potential new developments for preserving the wood crosstie. Beside creosote and its solutions, two oilborne preservatives – pentachlorophenol and copper naphthenate are allowed for use in UC4 AWPA Specifications for the treatment of crossties and switch ties. In recent years there has been research in the use of borates, both as a pre-treatment and remedial treatment to improve the service life of the wood crossties. The application would be in the southern climate high decay zones.

However, creosote and its solutions continue to be the preservative of choice in the treatment of wood that is used by the railroads. The treatment of the wood crosstie with creosote and its solutions not only protects the wood from decay organisms and insects, such as termites, that will attack and destroy the wood, it also provides the wood with a degree of weatherability.

Creosote does not readily mix with water. In fact when wood is treated with creosote, the water will be repelled. In addition, the service life of the treated wood crosstie is estimated to be over 30 years. With the creosote treated wood crosstie having been used since the 1880’s - well over 100 years - it is not difficult to understand the reluctance of railroads to part company with such a reliable partner.

WHY SHOULD WOOD BE TREATED WITH A PRESERVATIVE?



Wood always been a preeminent material for construction. And rightly so, as within North America, as well as other parts of the world, there exists an abundant timber resource. And, wood is a construction material that is renewable. With such a valuable resource as wood, it is possible to see why the wood preserving industry was developed - that is, to conserve and extend the useful service life of this resource.

Many wood products, and notably crossties, along with other wood materials used by the railroad industry, are manufactured from trees that can be grown within a reasonable period of time. For economic and durability reasons, it is important to extend the service life of wood products. This is the primary objective for the use of preservative materials in the treatment of wood products. By extending the service life of wood, the ultimate cost of the product is significantly decreased and provides for permanence in construction.

The crosstie industry is a prime example demonstrating the benefits of the preservative treatment of wood. During the early part of this century, the average service life of untreated crossties was approximately five and a half (5 1/2) years. Subsequently, the treatment with creosote extended that service life to an estimated average life in excess of thirty (30) years.

To illustrate further a comparison can be made between treated and untreated red and white oak crossties. Red oak and white oak are considered to have similar structural strength properties. When used untreated white oak will exhibit an average service life of twelve (12) years. Thus, the service life of this naturally decay-resistant white oak material is more than double that of red oak. However, the service life is maximized when creosote is impregnated into either of these two oak wood groups.

WHY SHOULD WOOD BE TREATED WITH A PRESERVATIVE?

The conclusion should never be drawn that “naturally durable woods” will give acceptable service life as a crosstie or as other components of wood construction. It ***can*** be concluded that wood preservatives increases life of timber products by as much as five (5) to eight (8) times.

To give the maximum durability, wood preservatives must penetrate the wood to enough depth to inhibit attack from various wood destroying organisms that include decay fungi, insects (i.e. termites) and marine borers. With respect to crossties, decay fungi and termites are usually the organisms of concern. When properly treated with a preservative such as creosote, deterioration due to these organisms is essentially eliminated.

It is also important to note that there are physical agents that come under the broad classification of ***weatherability***, that have effects on the wood structure. These agents include ultraviolet light, heat, abrasion, and exposure to alternating climatic conditions. These physical agents and their effect on wood can be minimized when the crosstie has been treated with creosote or an oil-type preservative.

Achieving maximum durability and thus increasing the service life of the wood crosstie material, requires preservative treatment. Historically, the performance of creosote and its solutions has been exemplary. The use of this preservative makes the wood crosstie a durable and economical timber product, produced from a renewable timber resource. This unmatched performance is why wood remains the predominant choice by the railroads for building and maintaining the rail track structure.

SUMMARY OF THE COMMERCIAL TIMBERS USED AS CROSSTIE MATERIAL

Many wood species are used for railroad crossties. The most common woods used are the oaks and what is known as the mixed hardwoods, which include the gums, maples, birches, and hickories. Several softwood species such as Douglas fir, hemlocks, true firs and several pine species are also utilized as crosstie material. The relative suitability and use of the various wood species for the crossties depends on their strength characteristics.

The most important strength properties considered for wood as a crosstie material are:

- bending strength
- end-hardness, which is strength in compression parallel to grain; thus indicating the resistance to lateral thrust and spike pull-out
- side hardness, which is compression perpendicular to the grain; thus indicating resistance to plate-cutting

For the purpose of this chapter on the “Summary of the Commercial Timbers Used as Crosstie Material” all of the wood species recognized by the **AREMA** and **RTA** will be grouped into seven categories for Solid Sawn Wood of Crossties. The next chapter on the Engineered Crosstie System gives the material and strength characteristics according to the seven wood species groups listed as follows:

- Oaks
- Northern Mixed Hardwoods
- Southern Mixed Hardwoods
- Southern Yellow Pine
- Eastern Softwoods
- Western Softwoods
- Douglas-Firs

The information given for the various wood species used for crosstie materials must be separated according to treatability, performance and strength characteristics. Typically the density, of specific gravity, indicates the strength characteristics of a wood species (Figure 1).

THE OAKS

Each of the seven solid sawn wood crosstie groups is made up of numerous wood species. For example, the oaks can be separated into two groups, red and white. There are twelve (12) wood species listed for the red oaks; and ten (10) for the white oaks. Common names and scientific names are given for each species.

Within North America, crosstie from red and white oaks are primarily produced from those states and provinces of the Atlantic coastal region, Southern and Appalachian Mountain regions and the central lake state areas (note Table 2 and Figure 1 which highlights geographic locations for the various wood species). There are two exceptions for the oaks; *California black oak* (red oak group) and *Oregon oak* (white oak group).

FIGURE 1

Specific Gravity at 12% MC

Gymnosperms	Sp. Gr.	Angiosperms
	1.0	
	0.95	
	0.90	
	0.85	
	0.80	
	0.75	Shagbark Hickory
	0.70	Black Locust White Oak
	0.65	Beech, Red Oak Yellow Birch
	0.60	White Ash
Southern Yellow Pine Tamarack	0.55	Black Walnut Red Gum
Douglas Fir	0.50	Black Cherry
Western Hemlock	0.45	Sassafras Chestnut Catalpa
Eastern Spruce Redwood	0.40	Yellow Poplar Butternut Basswood
Eastern Pine Western Red Cedar	0.35	Cottonwood
	0.30	

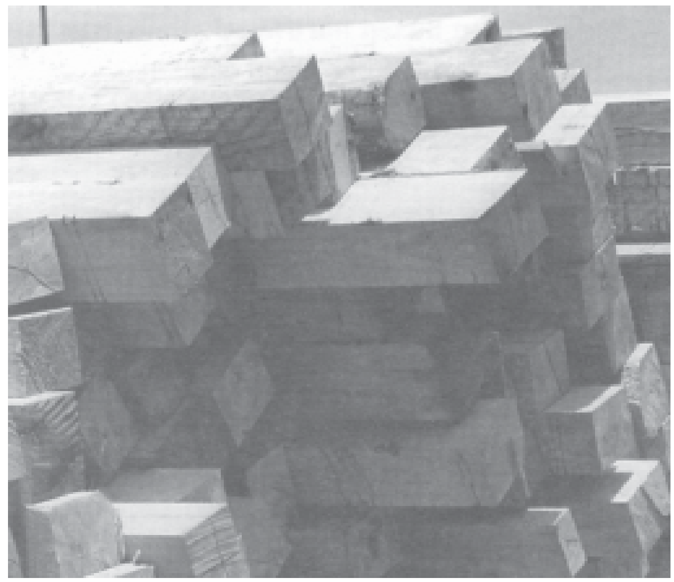
SUMMARY OF THE COMMERCIAL TIMBERS USED AS CROSSTIE MATERIAL

For the most part, the separation of the red and the white oak groups indicates their relative treatability; the red oaks are easily treated, while the white oaks are difficult to treat due to the presence of tyloses. There are two exceptions to this; in the red oak group, *blackjack oak* has tyloses, thus is difficult to treat; *while chestnut oak*, in the white oak group, does not have tyloses and is easily treated.

The sapwood of both red and white oak groups is white in color, between one and two inches in thickness and is easily treated. The heartwood of the red oak group is generally considered to be reddish brown. The wood rays are generally broad and conspicuous. The heartwood of the white oaks is usually grayish brown and the wood rays are less noticeable. With the two exceptions previously referred to, the presence of tyloses is a distiguishable characteristic between the red and white oaks.

Even though the heartwood of the white oaks is difficult to penetrate with preservatives, it has moderately satisfactory decay resistance. It is important to properly condition white oak ties with “an envelope” of preservative in their exterior surfaces.

The ***Oaks*** as a group are often specified by the railroad industry for crossties because of their hardness, durability, and excellent service life.



NORTHERN & SOUTHERN MIXED HARDWOODS

This is the second and third groups of commercial timbers used by the wood treating industry to produce railroad crossties. With respect to volume treated when combined together, these two groups represent the second largest amount of wood used as crosstie material. As previously indicated, it is predominately the gums, maple, birches and hickories that make up the total mixed hardwood group of woods.

As indicated by the section following this descriptive summary of the various woods used for crossties, there are thirty-four (34) wood species that make up the **northern mixed hardwood** group (Table 3); while there are twenty one (21) different wood species listed in the **southern mixed hardwood** group (Table 4). It should be

SUMMARY OF THE COMMERCIAL TIMBERS USED AS CROSSTIE MATERIAL

noted that because of the regions in which the various species grow, there is "overlap" between the mixed hardwood groups. For example both the hickories and maples will be found growing in northern and southern localities - red maple in Pennsylvania and Georgia.

The treatability of the two mixed hardwood groups is given along with the region from within North America that they are harvested in Figure 1 and Tables 3 and 4. The treatability of the mixed hardwoods varies from easy to very difficult. The gums - with exception of sweetgum - and birches are the most treatable; while both the hickories and maples are considered moderately treatable. Both hackberry and sycamore are somewhat more difficult to treat; while the most difficult to treat of the mixed hardwood groups is beech, black locust, catalpa, mulberry and sweetgum.

In even the most difficult woods to treat, the "outer" sapwood can be readily treated, thus creating an "envelope" of preservative to provide protection to the crosstie. It should be noted that an asterisk (*) is given for several woods - black cherry, black walnut, honey locust, osage orange, etc. There is no scientific data available on the treatability of the heartwood of these wood species. Generally it has been considered that the "dark colored" heartwood of these woods will not be penetrated by liquid preservatives and if sapwood is present it will be treated. Of course the real question is, "How many black cherry and black walnut ties find their way into the treating cylinder in the future?"

The wood species that makeup the **northern and southern mixed hardwood** groups have given excellent service performances as railway crosstie material. This is important because the forest resource constantly changes and the utilization of all appropriate wood species allows railroads to improve the overall economics for the wood crosstie. The Canadian railroads for example have had excellent service life from hard maple; while several railroads in the United States have had more than satisfactory service from the gums.

SOUTHERN YELLOW PINES

There are five (5) species that make up this group of woods. The wood from the various species is quite similar in appearance. The heartwood begins to form when the tree is about twenty (20) years old. The treatability (heartwood) and geographic location are given in Table 5. Generally the sapwood, which is easily treated, makes up the greater portion (volume) of the timbers that are produced.

In order to obtain heavy, structurally strong wood from the southern pines, it is necessary to specify "high density" material. The visual characteristics (i.e., growth rings per inch) are sited in the specifications for the structural material. Dense southern pine has been used extensively by many railroads for bridge ties and timbers with very satisfactory service performance. However,

REGION LOCATOR FOR COMMERCIAL TIMBERS USED AS A CROSSTIE MATERIAL

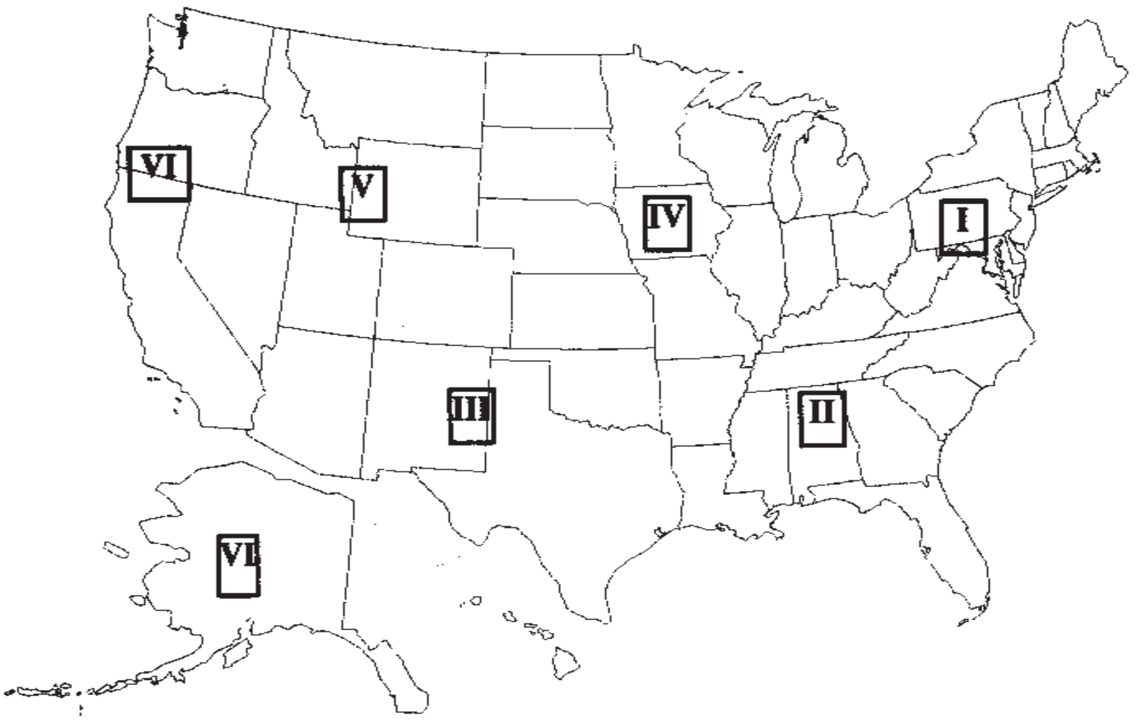


TABLE 2

OAKS

Commercial Name for Timber (Species)	Location	Treatability
Red Oaks		
• Black Oak *(Quercus velutina)*	I,II,IV	1
• Blackjack Oak *(Q. marilandica)*	II,III	4
• California Black Oak *(Q. kelloggii)*	VI	1
• Northern Pin Oak *(Q. ellipsoidalis)*	IV	1
• Northern Red Oak *(Q. rubra)*	I,II,IV	1
• Pin Oak *(Q. palustis)*	I,IV	1
• Scarlet Oak *(Q. coccinea)*	I,II,IV	1
• Shingle Oak *(Q. imbricaria)*	I,III,IV	1
• Shumard Oak *(Q. shumardii)*	II,III,IV	1
• Southern Red Oak *(Q. falcata)*	I,II	1
• Water Oak *(Q. nigra)*	II,III	1
• Willow Oak *(Q. phellos)*	II,III	1
White Oaks		
• Bur Oak *(Q. macrocarpa)*	I,III,IV	4
• Chestnut Oak *(Q. primus)*	I,IV	2
• Chinquapin Oak *(Q. muehlenbergii)*	I,II,III,IV	4
• Live Oak *(Q. virginiana)*	II	4
• Oregon Oak *(Q. garryana)*	VI	4
• Overcup Oak *(Q. lyrata)*	II	4
• White Oak *(Q. alba)*	I,II,IV	4
• Post Oak *(Q. stellata)*	I,II,III	4
• Swamp Chestnut Oak *(Q. michauxii)*	II	4
• Swamp White Oak *(Q. bicolor)*	I,IV	4

TABLE 3

NORTHERN MIXED HARDWOODS

Commercial Name for Timber (Species)	Location	Treatability
• White Elm *(Ulmus americana)*	I,II,III,IV	1
• Slippery Elm *(U. rubra)*	I,II,III,IV	1
• Hackberry *(Celtis occidentalis)*	I,IV	3
• Black Locust *(Robinia pseudoacacia)*	I,II,III	4
• Red Mulberry *(Morus rubra)*	I,II,III,IV	4
• Hardy Catalpa *(Catalpa speciosa)*	I	4
• Honey Locust *(Gleditsia triacanthos)*	II,III,IV	*
• White Ash *(Fraxinus americana)*	I,II,III,IV	1
• Sassafras *(Sassafras albidum)*	I,II,IV	*
• Persimmon *(Diospyros virginiana)*	I,II,IV	2
Hickory		
• Shagbark *(Carya ovata)*	I,II,IV	2
• Shellbark *(C. laciniosa)*	I,IV	2
• Pignut *(C. glabra)*	I,II,IV	2
• Mockernut *(C. tomentosa)*	I,II,IV	2
• Bitternut *(C. cordiformis)*	I,II,IV	2
• Pecan *(C. illinoensis)*	II,III,IV	2
• Sycamore *(Platanus occidentalis)*	I,II,III,IV	3
• Beech *(Fagus grandifolia)*	I,II,IV	4
Maple		
• Sugar *(Acer saccharum)*	I,IV	2
• Silver *(A. saccharinum)*	I,II,IV	2
• Black *(A. nigrum)*	I,IV	2
• Red *(A. rubrum)*	I,II,IV	2
• Boxelder *(A. negundo)*	I,II,III,IV,V	2
• Black Cherry *(Prunus serotina)*	I,II,III,IV	*
• Black Walnut *(Juglans nigra)*	I,II,III,IV	*
• Butternut *(Juglans cinerea)*	I,III,IV	*
• Yellow Birches *(Betula alleghaniensis)*	I,IV	1
• Sweet Birch *(Betula lenta)*	I,II	1
• River Birch *(Betula nigra)*	I,II,IV	1
• Cottonwood *(Populus deltoides)*	II,III,IV	1
• Black Gum *(Nyssa sylvatica)*	I,II,IV	1
• Red or Sweet Gum *(Liquidambar styraciflua)*	I,II,III	4
• Yellow Poplar *(Liriodendron tulipifera)*	I,II,IV	3
• Basswood *(Tilia americana)*	I,IV	1

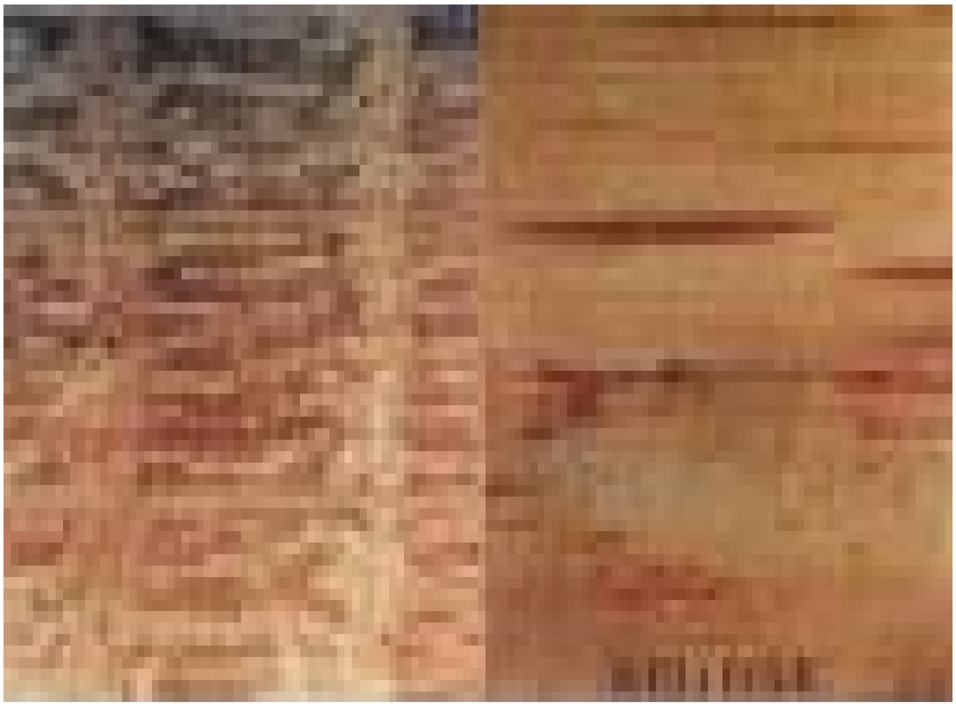
TABLE 4

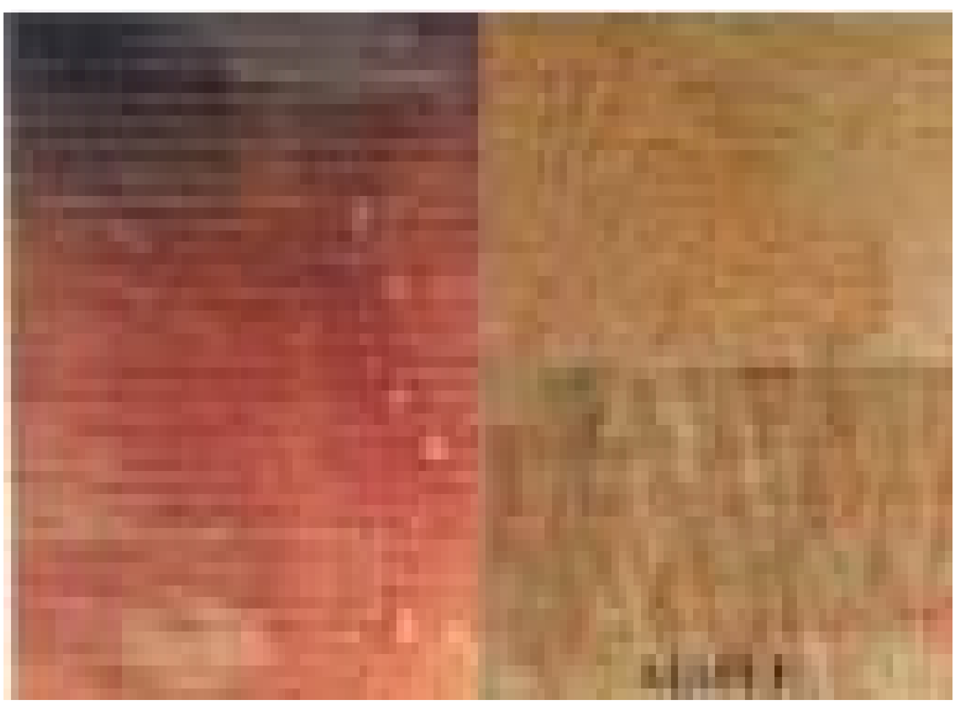
SOUTHERN MIXED HARDWOODS

Commercial Name for Timber (Species)	Location	Treatability
• Cork Elm *(Ulmus alata)*	II	3
• Osage Orange *(Maclura pomifera)*	III	*
• Coffeetree *(Gymnocladus dioicus)*	I,II,IV	*
• Persimmon *(Diospyros virginiana)*	I,II,IV	*
Hickory		
• Shagbark *(Carya avata)*	I,II,IV	2
• Pignut *(C. glavbra)*	I,II,IV	2
• Mockernut *(C. tomentosa)*	I,II,IV	2
• Bitternut *(C. cordiformis)*	I,II,IV	2
• Pecan *(C. illinoensis)*	I,III,IV	2
• Nutmeg *(C. myristicaeformis)*	II	*
• Water *(C. aquatica)*	I,III	*
Maple		
• Silver *(Acer saccharimum)*	I,II,IV	2
• Red (A. rubrum)	I,II,IV	2
• Boxelder (A. negundo)	I,II,III,IV,V	2
• Black Cherry *(Prumus serotina)*	I,II,III,IV	*
• Black Walnut *(Juglans nigra)*	I,II,III,IV	*
• Butternut *(Juglans cinerea)*	I,III,IV	*
• River Birch *(Betula nigra)*	I,II,IV	1
Guns		
• Black Gum *(Nyssa sylvatica)*	I,II,IV	1
• Red or Sweet Gum (Liquidambar styracifua)	I,II,III	4
• Water Tupelo (Nyssa aquatica)	II	1

Footnote * - as indicated no reference could be found for these wood species and the treatability of the heartwood

EXAMPLE HARDWOOD SPECIES SECTIONS





Source: Mississippi State University

SUMMARY OF THE COMMERCIAL TIMBERS USED AS CROSSTIE MATERIAL

consideration must be given to the fact that the southern pines are for the most part lower in density than the oaks and mixed hardwoods and thus will not resist “plate-cutting” to the same degree. This is the reason that for higher density “mainline” track the more dense woods are specified.

EASTERN AND WESTERN SOFTWOODS

The fifth and sixth groups of woods that are used for crossties are made up of several species from the eastern and western regions of North America. There are six (6) woods from the eastern region and thirteen (13) species from the western area. Location of growth and treatability information are given in Tables 6 and 7 for the respective two groups of softwoods.

Of the eastern softwoods, white cedars, fir, hemlock, spruces and tamarack have very limited actual use for crossties in a mainline track. There is undoubtedly some use of eastern softwoods in those regions near the local harvest area. Timbers would be used for the construction of secondary track and bridge timbers. All of the eastern softwoods are considered difficult to treat with preservatives such as creosote. Even the sapwood of eastern hemlock is difficult to treat and with this species incising is necessary, not only to assist in drying the crosstie, but to improve the penetration of preservatives.

DOUGLAS-FIR

The final timber used for wood crossties is Douglas-fir. It is the only species with the data for growth location and treatability given in Table 8. There are however, two types of Douglas-fir - Coastal and Intermountain. The coastal variety is considered moderately treatable; while the intermountain type is most difficult to treat. Treatment with creosote of Douglas-fir requires incising ties and timbers for acceptable preservative penetration.

This wood species is one that is referred to as having “thin-sapwood”; usually not more than one-inch in thickness, but in second-growth trees of commercial size the sapwood may be as much as three-inches. The range of Douglas-fir extends from the Rocky Mountains to the Pacific coast and from Mexico to central British Columbia. Considerable quantities of this wood species finds its way into railroad crossties for use in track primarily in Canada and the western United States. Douglas-fir timber has also been used extensively for bridge timbers.

TABLE 5

SOUTHERN YELLOW PINES

Commercial Name for Timber (Species)	Location	Treatability
Shortleaf Pine *(Pinus echinata)*	II,III	2
Loblolly Pine *(P. taeda)*	II,III	2
Longleaf Pine *(P. palustris)*	II,III	2
Slash Pine *(P. elliottii)*	II,III	2
Virginia Pine *(P. virginiana)*	II,III	2

TABLE 6

EASTERN SOFTWOODS

Commercial Name for Timber (Species)	Location	Treatability
Eastern Spruces *(Picea spp.)*	I,II,IV	3
Tamarack *(Larix laricina)*	I,II,IV	3
Eastern Hemlock *(Tsuga canadensis)*	I,II,IV	3
Balsam Fir *(Abies balsamea)*	I,II,IV	3
Northern White Cedar *(Thuja occidentalis)*	I,II,IV	3
Atlantic White Cedar *(Chamaecyparis thyoides)*	I,II,IV	3

TABLE 7

WESTERN SOFTWOODS

Commercial Name for Timber (Species)	Location	Treatability
Western White Pine *(Pinus monticola)*	III,V,VI,VII	*
Limber Pine *(P. flexilis)*	III,V,VI,VII	*
Jeffery Pine *(P. jeffreyi)*	III,V,VI,VII	*
Lodgepole Pine *(P. contortai)*	III,V,VI,VII	3
Ponderosa Pine *(P. ponderosa)*	III,V,VI,VII	1
Engelmann Spruce *(Picea engelmannii)*	III,V,VI,VII	3
Western Larch *(Larix occidentalis)*	III,V,VI,VII	3
Port Orford Ceder *(Chamaecyparis lawsoniana)*	III,V,VI,VII	*
White Fir *(Abies concolor)*	III,V,VI,VII	3
Grand Fir *(Abies grandis)*	III,V,VI,VII	3
Redwood *(Sequoia sempervirens)*	III,V,VI,VII	1
Western Hemlock *(Tsuga heterophylla)*	III,V,VI,VII	2
Western redceder *(Thuja plicata)*	III,V,VI,VII	4

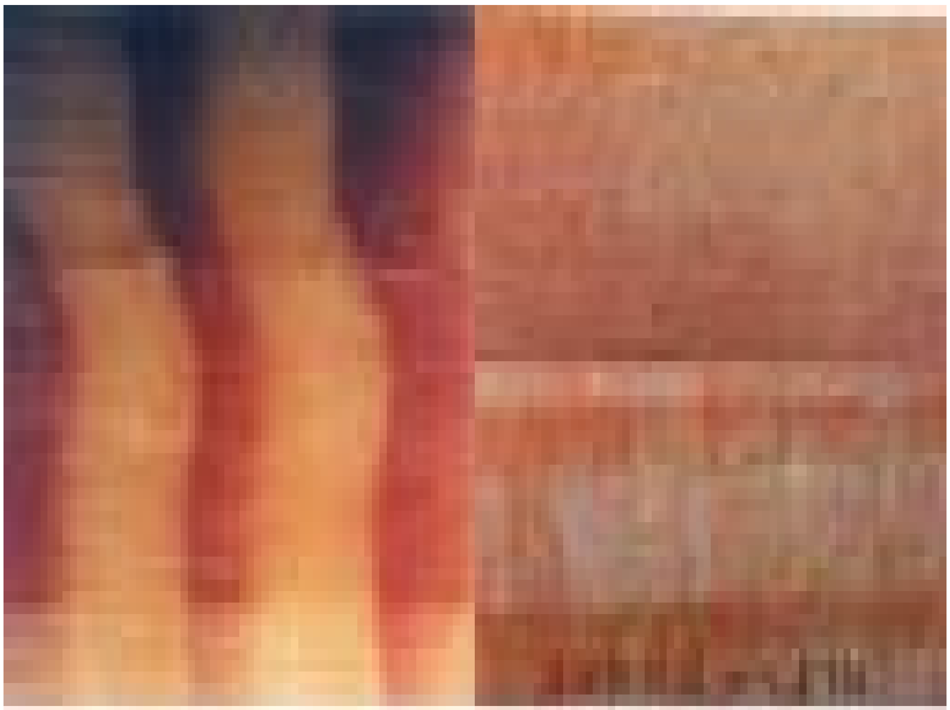
Footnote * - as indicated no reference could be found for these wood species and the treatability of the heartwood

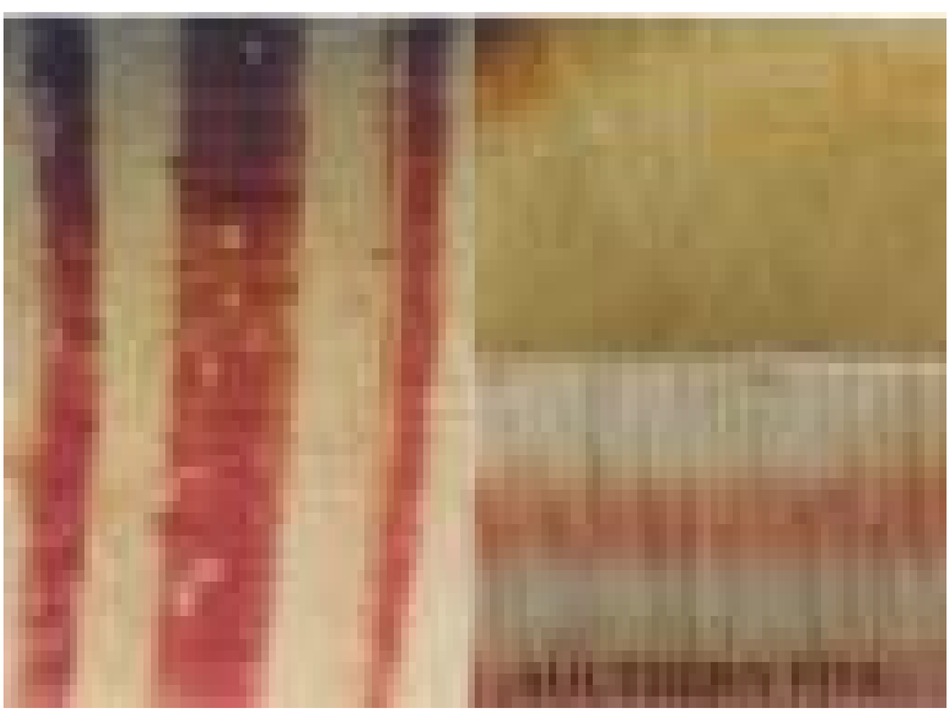
TABLE 8

DOUGLAS FIR

Commercial Name for Timber (Species)	Location	Treatability
Coastal *(Pseudotsuga menzeisii)*	VI	2
Intermountain *(Pseudotsuga menzeisii)*	VI	4

EXAMPLE SOFTWOOD SPECIES SECTIONS





Source: Mississippi State University

THE ENGINEERED WOOD CROSSTIE

In an earlier section of this booklet, "Why Should Wood Be Treated With Preservative?", the statement was brought forward that wood is the only construction material that is a renewable resource. History books and various literature citations make numerous references to wood as a long standing material of construction. To illustrate a few examples concerning the importance of wood in the development of this country, a few brief statements are offered.

* The average early frontier log cabins required about 80 logs, as well as smaller timbers. Wood roof shakes and wood pegs were used to hold the structure together.

* During the first part of the 18th century settlers in the Conestoga Valley of Pennsylvania built a wagon almost completely of wood. The Conestoga wagons transported freight supplies throughout the eastern part of the country.

* Boats, bridges and roads were made of wood. The "wooden plank" road ran between New York and Newark over wet marshland. During the 19th century two thousand miles of wood roads were built in the states of New York, Michigan, Wisconsin and other Midwestern states had extensive systems. In some states, such as Alabama, plank roads delayed the coming of the railroads.

* Wood was the predominate material of construction even into the first part of the 20th century. Because wood was plentiful and the vast timber resource seemed unending, the production and preservative treatment of crossties for the railroad industry became well established. The hand hewn-tie and subsequently the sawn-tie were produced according to standard cross-sectional dimensions (inches) - 6x7, 7x7, 7x8 and 7x9. Length of the wood crosstie depended on that specified by the railroad; eventually moving to an acceptable standard length of either eight and one half or nine feet.

The wood crosstie thus has specific physical dimensions with specific measurements. In addition, the specifications for timber crossties as quoted from the American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway Engineering, Section 3.1.1.2.1 General Quality:

> ***"Except as hereinafter provided, all ties shall be free from any defects that may impair their strength or durability as crossties, such as decay, large splits, large shakes, slanting grain, or large or numerous holes or knots."***

THE ENGINEERED WOOD CROSSTIE

To further emphasize the importance placed on physical characteristics a quote from the same AREMA Manual is taken from Section 3.2.1.2.2 Resistance to Wear:

"When so ordered, ties from needle leaved trees shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have six or more rings of annual growth."

The point of this dialogue is that wood is a very important structural material, and when used solely for crossties, historically, the physical characteristics have been the most important consideration.

The wood crosstie is now thought of as the ***Engineered Wood Crosstie*** with its own set of specifications based on structural strength test data. Given in Table 9 are the strength characteristics for the seven types of solid sawn woods that are used in the production of crossties:

— Oaks
— Northern Mixed Hardwoods
— Southern Mixed Hardwoods
— Southern Yellow Pine
— Eastern Softwoods
— Western Softwoods
— Douglas-Fir

This new specification for timber ties is under development by The Railway Tie Association (RTA), in cooperation with AREMA, to provide data to the engineer who desires to use the data in the structural design of the "rail track system". In addition, the RTA will be working in cooperation with those manufacturing facilities to provide structural strength information for ***Composite Wood Materials.***

Two examples of ***Composite Wood Materials*** would be glue laminated lumber and parallel strand lumber laminated products. Currently one example of a commercial material is Trus-Joist's Parallam ®. These fabricated products can be made from several different wood species and engineered to meet specific strength characteristics.

THE tie GUIDE
HANDBOOK FOR COMMERCIAL TIMBERS USED BY THE CROSSTIE INDUSTRY

THE ENGINEERED WOOD CROSSTIE

Material and Strength Properties		Solid Sawn Tie Type: 1 Oak	2 North Mixed Hardwoods	3 South Mixed Hardwoods	4 Southern Pine	5 Western Softwoods	6 Eastern Softwoods	7 Douglas Fir	Engineered Hybrid Wood: 8 Laminated W. Products	9 Parallel Strand Lumber
Based on		Southern Red Oak	White Birch	Silver Maple	Shortleaf Pine	Ponderosa Pine	Eastern Hemlock	Coastal Douglas Fir	(1)	(2)
Dimensions	Nominal									
Length (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Width (in)	9	9	9	9	9	9	9	9	9	9
Depth (in)	7	7	7	7	7	7	7	7	7	7
Density (pcf)		58.6	55.1	48.1	51.6	41.9	41.9	48.9		
Weight (lbs)		218	205	179	192	156	156	182		
Moment of Inertia (in⁴)		257	257	257	257	257	257	257		
Section Modulus (in³) RS+=RS-=C+=C-		73.5	73.5	73.5	73.5	73.5	73.5	73.5		
Modulus of Elasticity (MOE) 1.00E+10⁶ psi	-40F	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
	+72F	1.06	1.09	0.86	1.28	0.93	0.97	1.44		
	+140F	1.06	1.09	0.86	1.28	0.93	0.97	1.44		
Modulus of Rupture (MOR)psi	-40F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(3)	
	+72F	6570	6291	5499	7173	4977	5985	7353		
	+140F	6570	6291	5499	7173	4977	5985	7353		
Rail Seat Compression Test psi		524	273	366	357	279	350	387		
Material Surface Hardness Test Janka Ball		792	536	541	419	301	369	469		
Static Bending Strength (in-Kips) Theoretical (based on MOR and I/c)		483	462	404	527	366	440	540		
Flexibility (deflection in inches) ("Stiffness-Load/Deflection) Theoretical, based on 60" spacing applied load (Kips) of 10		0.165	0.160	0.202	0.136	0.189	0.179	0.122		
Lateral resistance characteristics Single tie lateral push test Load at 0.25" deflection (approx. peak)		1960	1900	1778	1839	1672	1672	1793		

(1) [illegible]

(2) [illegible]

(3) [illegible]

MATERIAL PROPERTIES OF SOLID SAWN WOOD CROSSTIE MATERIALS

Wood is an extremely versatile and effective material for use as a railroad track crosstie. However, the key properties of wood will vary with the wood species. In order to allow for the potential use of a broad range of types, the wood tie properties presented in this section have been divided into seven (7) categories of wood as given in Table 10.

For each category a representative wood species was used. The material properties given to Table 9 represent a "minimum" value for each category (useless otherwise noted). This is to allow for the use of these material properties in "design" calculations. The value are based on a collection of material properely data, to include both handbook sample data and full tie test data (with adjustment to compensate for the differences).
An explanation for the wood properely values given to Table 9 are as follows:

- * Dimensions are based on the AREMA specification that allows a 1/4-inch reduction in width and depth.
- * Volume is calculated based on dimensions.
- * Density is based on 40% moisture content (as determined from the oven-dry volume). Seven (7) lbs./cu.ft. of creosote was added to the density and the total reduced by 10% to account for variations in values in the material property table and in the treatment process.
- * Weight is the density multiplied by the volume.
- * Moment of inertia is calculated based on the defined dimensions and rectangular cross-section.
- * Section modulus was calculated from dimensions and rectangular cross-section.
- * Modulus of Elasticity (MOE) is based on "green" values plus 10% of the difference between the green and the dry values (to account for the fact that the outside of the tie is drier than the interior of the tie). Ninety percent (90%) of the calculated value is taken to determine a "minimum" value for design purposes.
- * Modulus of Rupture (MOR) is based on "green" values plus 10% of the difference between the green and the dry values (to account for the fact that the outside of the tie is drier than the interior of the tie). Ninety percent (90%) of the calculated value is taken to determine a "minimum" value for design purposes.
- * Rail Seat Compression Test is based on "green" values plus 10% of the difference between the green and dry values (to account for the fact that the outside of the tie is drier than the interior of the tie) and based on handbook data for Compression Perpendicular to the

MATERIAL PROPERTIES OF SOLID SAWN WOOD CROSSTIE MATERIALS

Grain. Ninety percent (90%) of the calculated value is taken to determine a "minimum" value for design purposes.

* Material Surface Hardness Test is based on "green" values plus 10% of the difference between the green and the dry values (to account for the fact that the outside of the tie is drier than the interior of the tie) and based on handbook data for Hardness Perpendicular to the Grain. Ninety percent of the calculated value is taken to determine a "minimum" value for design purposes.
* Static Bending Strength is a theoretical calculation based on the MOR and the section modulus.
* Flexibility (which is a more appropriate term than stiffness-load deflection) is a theoretical calculation based on a applied load of 10,000 lbs. And a sixty (60) inch support spacing.
* Lateral resistance values are based on field tests taken by US Department of Transportation, Volpe Transportation Systems Center, using single tie push tests. Results are based on "minimum" value for consolidated track. To account for differences in density (weight), 50% lateral resistance was varied linearly as a function of the weight of the ties, using mixed hardwoods as the base reference. To account for the non-weight related component of lateral resistance (due to side and end effects that do not change with weight) only 50% of the lateral resistance was varied with weight, with the remaining 50% held constant.

TABLE 10

Crosstie Category	Wood Species
Oak	Southern red oak
Northern Mixed Hardwoods	White birch
Southern Mixed Hardwoods	Silver maple
Southern Pine	Shortleaf pine
Western Softwoods	Ponderosa pine
Eastern Softwoods	Eastern hemlock
Douglas-fir	Coastal Douglas-fir

THE ABOVE WOOD SPECIES WERE USED TO CALCULATE THE CATEGORY VALUES FOR STRENGTH PROPERTIES IN TABLE 9

HYBRID ENGINEERED WOOD CROSSTIE MATERIALS

The solid sawn creosote treated wood crosstie, which was discussed earlier in this section, has an average service life of well over thirty five (35) years. To this present day, it continues to be the major track component that binds the steel rails together. These solid sawn treated wood crossties will undoubtedly continue as the preferred material of choice by the railroads.

In the early part of this century the crosstie material used by the railroads progressed form an untreated hand-hewn tie to the creosote treated solid sawn tie. So it may be fitting that as we move into a new century, there are new progressions in the field of wood technology occurring. The Railway Tie Association, through its Research and Development Committee, continues to take a leadership role in coordinating significant research projects in this area. These include the evaluation of: under-utilized wood species, dowel-laminated wood, glue-laminated wood, parallel oriented wood fiber and fiber reinforced laminated wood for use as crosstie material.

For lack of a better term, all of these materials should be called “hybrid” wood products. They bring together structural adhesives, polymeric fibers, and wood in various combinations to provide an engineered wood structurally suitable for use as crosstie, switch tie and bridge timber materials. These new products may provide advantages over the existing materials for crosstie. It is a fact that some of these hybrid products are already in use by the railroads in widely varying applications.

Given in Table 10 are structural data for the solid sawn and engineered wood products. It must, however, be recognized that because these are “engineered” wood products – i.e., glue-laminated timbers, etc. – the strength characteristics can be “adjusted” by varying the density, wood species and the orientation/ use of wood materials. Because of this it is not possible to provide structural test data for all the variations. However, one can assume that the goal is to “engineer in” strength properties that will be greater that solid sawn products, while keeping economics under consideration.

Wood is a renewable resource but the larger old growth timber, once abundant, is increasing less accessible to harvest. Second-growth and third-growth trees that are currently harvested are typically smaller in diameter. While the majority of crossties produced will remain solid sawn material for the foreseeable future, the changes occurring in managing the resource will require increasing utilization of alternative species and engineered hybrid wood products. As the demand for crosstie continues, it is realistic to expect that the engineered hybrid wood crosstie has a significant future.

APPENDIX

SPECIFICATIONS FOR TIMBER CROSSTIES

(Latest Revision as of January 2003)

These specifications were arrived at by a joint committee of the Railway Tie Association and the American Railway Engineering and Maintenance of Way Association, and are identical to Chapter 30 of the AREMA Manual for Railway Engineering. This publication does not include numerous other requirements of AREMA specifications.

AREMA Manual Chapter 30 is a multi-page work covering many additional practices regarding crossties and switch ties, including adzing, boring, trimming, branding, application of anti-splitting devices, log storage, air seasoning, treatment, and care after preservative treatment. It is available from AREMA Publications Department, 8201 Corporate Drive, Suite 1125, Landover, MD 20785, for $125 (non-member price is $150) for the individual Chapter 30 or $425 (non-member price is $650) for the complete Manual. Prices are subject to change without notice.

3.1.1 SPECIFICATIONS FOR TIMBER CROSSTIES

NOTE: It is recommended for West Coast species that W.C.L.B. Grading Rules apply.

3.1.1 MATERIAL

3.1.1.1 Kinds of Wood*

Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for crossties will be accepted:

Ashes	Gums	Oaks
Beech	Hackberries	Pines
Birches	Hemlocks	Poplars
Catalpas	Hickories	Redwoods
Cherries	Larches	Sassafras
Douglas fir	Locusts	Spruces
Elms	Maples	Sycamores
Firs (true)	Mulberries	Walnuts

*Each railway will specify only the kind of wood it desires to use.
Others will not be accepted unless specially ordered.

3.1.1.2 PHYSICAL REQUIREMENTS

3.1.1.2.1 General Quality

Except as hereinafter provided, all ties shall be free from any defects that may impair their strength or durability as crossties, such as decay, large splits, large shakes, slanting grain, or large or numerous holes or knots.

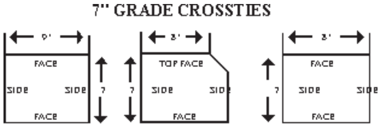
3.1.1.2.2 Resistance to Wear

When so ordered, ties from needle-leaved trees shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have six or more rings of annual growth.

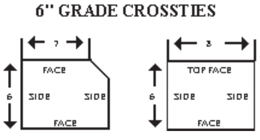
3.1.1.3 DESIGN

Size Categories for 7" & 6" Crossties 1" of Wane Allowed —— 20% Square 7" x 8" Allowed

7" GRADE CROSSTIES



6" GRADE CROSSTIES



3.1.1.3.1 Dimensions

Ties shall be 8'-0", 8'-6", or 9'-0" long as specified by the customer. Thickness, width, and length specified are minimum dimensions for green ties. Dry or treated ties may be 1/4" thinner or narrower than the specified sizes. Ties exceeding these dimensions by more than 1" shall be rejected. The grade of each tie shall be determined at the point of most wane on the top face of the tie within the rail-bearing areas. The rail-bearing areas are those sections between 20" and 40" from the center of the tie. The top of the tie shall be the narrowest face and/or the horizontal face farthest from the heart or pith center.

All rail-bearing areas shall measure as follows: 7" grade crossties shall be 7" x 9" in cross section with a maximum of 1" of wane in the top rail-bearing areas. A maximum of 20% of the ties in any given quantity may be square-sawn 7" x 8" in cross section with no wane in the rail-bearing areas. A 6" grade tie shall be 6" x 8" in cross section with a maximum of 1" of wane permitted in the top rail-bearing areas. For both 6" and 7" grade ties, wane shall be permitted on the bottom face so long as it does not exceed 1" at any given point.

3.1.1.4 INSPECTION

3.1.1.4.1 Place

Ties will be inspected at suitable points as specified in the purchase agreement of the railway.

3.1.1.4.2 Manner

Inspectors will make a reasonably close examination of the top, bottom, sides and ends of each tie. Each tie will be judged independently, without regard to the decisions on others in the same lot. Rafted or boomed ties too muddled for ready examination will be rejected. Ties handled by hoists will be turned over as inspected, at the expense of the producer.

3.1.1.4.3 Decay

Decay is the disintegration of the wood substance due to the action of wood destroying fungi. "Blue stain" is not decay and is permissible in any wood.

3.1.1.4.4 Holes

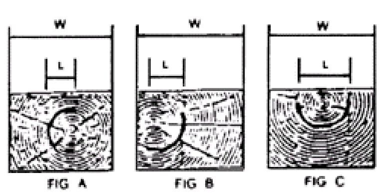
A large hole is one more than 1/2" in diameter and 3" deep within, or more than 1/4 the width of the surface on which it appears and 3" deep outside, the sections of the tie between 20" and 40" from its middle. Numerous holes are any number equaling a large hole in damaging effect. Such holes may be caused in manufacture or otherwise.

3.1.1.4.5 Knots

Within the rail-bearing areas, a large knot is one having an average diameter more than 1/3 the width of the surface on which it appears, but such a knot will be allowed if it is located outside the rail-bearing areas. Numerous knots are any number equaling a large knot in damaging effect.

3.1.1.4.6 Shake

A shake is a separation along the grain, most of which occurs between the rings of annual growth.



The procedure illustrated in the above diagrams shall be used in determining the length of a shake. One which is not more than 1/3 the width of the tie will be allowed, provided it does not extend nearer than 1" to any surface.

3.1.1.4.7 Split

A split is a separation of the wood extending from one surface to an opposite or adjacent surface. Do not count the end as a surface when measuring the length of a split. In unseasoned crossties, a split no more than 1/8" wide and/or 4" long is acceptable. In a seasoned crosstie, a split no more than 1/4" wide and/or longer than the width of the face across which it occurs is acceptable. In seasoned crossties, a split exceeding the limit is acceptable, provided split limitations and anti-splitting devices are approved by the buyer and properly applied.

3.1.1.4.8 Checks

A check is a separation of the wood due to seasoning which appears on one surface only. Do not count the end as a surface. Ties with continuous checks whose depth in a fully seasoned and/or treated tie is greater than 1/4 the thickness and longer than 1/2 the length of the tie will be rejected.

3.1.1.4.9 Slope of Grain

Except in woods with interlocking grain, a slant in grain in excess of 1 in 15 will not be permitted.

3.1.1.4.10 Bark Seams

A bark seam or pocket is a patch of bark partially or wholly enclosed in the wood. Bark seams will be allowed provided they are not more than 2" below the surface and/or 10" long.

3.1.1.4.11 Manufacturing Defects

All ties must be straight, square-sawn, cut square at the ends, have top and bottom parallel, and have bark entirely removed. Any ties which do not meet the following characteristics of good manufacture will be rejected:

a. A tie will be considered straight when a straight line from a point on one end to a corresponding point on the other end is no more than 1-1/2" from the surface at all points.
b. A tie is not well-sawn when its surfaces are cut into with score marks more than 1/2" deep, or when its surfaces are not even.
c. The top and bottom of a tie will be considered parallel if any difference at the sides or ends does not exceed 1/8".
d. For proper seating of nail plates, tie ends must be flat, and will be considered square with a sloped end of up to 1/2", which equals a 1 in 20 cant.

SPECIFICATIONS FOR TIMBER SWITCH TIES

(Latest Revision as of January 2003)

These specifications were arrived at by a joint committee of the Railway Tie Association and the American Railway Engineering and Maintenance of Way Association, and are identical to Chapter 30 of the AREMA Manual for Railway Engineering.

AREMA Manual Chapter 30 is a multi-page work covering many additional practices regarding crossties and switch ties, including adzing, boring, trimming, branding, application of anti-splitting devices, log storage, air seasoning, treatment, and care after preservative treatment. It is available from AREMA Publications Department, 8201 Corporate Drive, Suite 1125, Landover, MD 20785, for $125 (non-member price is $150) for the individual Chapter 30 or $425 (non-member price is $650) for the complete Manual. Prices are subject to change without notice.

3.2.1 SPECIFICATIONS FOR TIMBER SWITCH TIES

NOTE: It is recommended for West Coast species that W.C.L.B. Grading Rules apply.

3.2.1.1 MATERIAL

3.2.1.1.1 Kinds of Wood

Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for switch ties will be accepted:

Ashes	Firs (true)	Maples
Beech	Gums	Oaks
Birches	Hemlocks	Pines
Cherries	Hickories	Redwood
Douglas Fir	Larches	Spruces
Elms	Locusts	Walnuts

Others will not be accepted unless specially ordered.

3.2.1.2 PHYSICAL REQUIREMENTS

3.2.1.2.1 General Quality

Except as hereinafter provided, all ties shall be free from any defects that may impair their strength or durability as switch ties, such as decay, large splits, large shakes, slanting grain, or large or numerous holes or knots.

3.2.1.2.2 Resistance to Wear

When so ordered, ties from needle-leaved trees shall be of compact wood throughout the top fourth of the tie, where any inch of any radius from the pith shall have 6 or more rings of annual growth.

3.2.1.3 DESIGN

3.2.1.3.1 Dimensions

All unseasoned or green switch ties shall measure in cross section a minimum of 7" in side thickness and 9" in face width. A maximum of 1" of wane is allowed on the top or bottom faces within the rail-bearing area, which is defined as the section between 12" from each end of the tie. Seasoned or treated switch ties may be 1/4" under the specified dimensions for thickness and width, or not more than 1" over the specified dimensions. Lengths and length tolerances shall be specified by the customer.

All thickness and face width dimensions apply to the rail-bearing area. All determinations of face width shall be made on the top of the switch tie, which is the narrowest horizontal face. If both horizontal faces are of equal width, the top shall be that face with the narrowest or no heartwood.

3.2.1.4 INSPECTION

3.2.1.4.1 Place

Ties shall be inspected at suitable points as specified in the purchase agreement of the railway.

3.2.1.4.2 Manner

Inspectors will make a reasonably close examination of the top, bottom, sides and ends of each tie. Each tie will be judged independently, without regard for the decisions on others in the same lot. Ties too muddied for ready examination will be rejected. Ties handled by hoists will be turned over as inspected, at the expense of the producer.

3.2.1.4.3 Decay

Decay is the disintegration of the wood substance due to the action of wood destroying fungi. "Blue stain" is not decay and is permissible in any wood.

3.2.1.4.4 Holes

A large hole is one more than 1/2" in diameter and 3" deep within, or more than 1/4 the width of the surface on which it appears and 3" deep outside, the section of the tie between 12" from each end of the tie. Numerous holes are any number equaling a large hole in damaging effect. Such holes may be caused in manufacture or otherwise.

3.2.1.4.5 Knots

A large knot is one whose average diameter exceeds 1/4 the width of the surface on which it appears; but such a knot may be allowed if it occurs outside the section between 12" from each end of the tie. Numerous knots are any number equaling a large knot in damaging effect.

3.2.1.4.6 Shake

One which is not more than 1/3 the width of the tie will be allowed. The procedure and diagrams shown in 3.1.1.4.6 for crossties shall also apply to switch ties for measuring the length of a shake.

3.2.1.4.7 Split

A split is a separation of the wood extending from one surface to an opposite or adjacent surface. Do not count the end as a surface when measuring the length of a split.

In unseasoned or green switch ties, a split no more than 1/8" wide and/or 5" long is acceptable. In a seasoned or treated switch tie, a split no more than 1/4" wide and/or longer than the width of the face across which it occurs is acceptable. A split exceeding the limit is acceptable, provided split limitations and anti-splitting devices are approved by the buyer and properly applied.

3.2.1.4.8 Checks

A check is a separation of the wood due to seasoning which appears on one surface only. Do not count the end as a surface when measuring the length of a check. Ties with continuous checks whose depth in a fully seasoned and/or treated tie is greater than 1/4 the thickness and longer than 1/2 the length of the tie will be rejected.

3.2.1.4.9 Slope of Grain

Except in woods with interlocking grain, a slope of grain in excess of 1 in 15 will not be permitted.

3.2.1.4.10 Bark Seams

A bark seam or pocket is a patch of bark partially or wholly enclosed in the wood. Bark seams will be allowed provided they are not more than 2" below the surface and/or 10" long.

3.2.1.4.11 Manufacturing Defects

All ties must be straight, square-sawn, cut square at the ends, have top and bottom parallel, and have bark entirely removed. Any ties which do not meet the following characteristics of good manufacture will be rejected:

a. A tie will be considered straight when a straight line from a point on one end to a corresponding point on the other end is no more than 2" from the surface at all points.

b. A tie is not well-sawn when its surfaces are cut into with score marks more than 1/2" deep, or when its surfaces are not even.

c. The top and bottom of a tie will be considered parallel if any difference at the sides or ends does not exceed 1/4".

d. For proper seating of nail plates, tie ends must be flat, and will be considered square with a sloped end of up to 1/2", which equals a 1 in 20 cant.

3.2.1.5 DELIVERY

3.2.1.5.1 On Railway Premises

Ties shall be delivered and stacked as specified in the purchase agreement of the railway. If ties are to be inspected, they must be placed so that all ties are accessible to the inspector.

3.2.1.5.2 Risk, Rejection

All ties are at the owners risk until accepted. All rejected ties shall be removed within one month after inspection.

3.2.1.5.3 Species Groups for Seasoning and Treating

Switch ties shall be grouped as shown below for air-seasoning or artificial seasoning and subsequent preservative treatment. Only the kinds of wood named in a group may be processed together.

Group Ta	Group Tb	
Black Locust	Douglas Fir	Redwood
Honey Locust	Firs (True)	Spruces
Red Oaks	Hemlocks	
White Oaks	Larches	
Black Walnut	Pines	

Group Tc	Group Td	
Gums	Ashes	Elms
	Beech	Hard Maples
	Birches	Hickory
	Cherries	Soft Maples
	White Walnut	

3.2.1.6 SHIPMENT

Ties forwarded in cars or vessels shall be separated therein according to the above groups, and also according to the above sets or lengths if inspected before loading, or as may be stipulated in the contract or order for them.

SPECIFICATIONS FOR TIMBER INDUSTRIAL GRADE CROSSTIES

(Latest Revision as of January 2003)

These specifications were arrived at by a joint committee of the Railway Tie Association and the American Railway Engineering and Maintenance of Way Association, and are identical to Chapter 30 of the AREMA Manual for Railway Engineering.

AREMA Manual Chapter 30 is a multi-page work covering many additional practices regarding crossties and switch ties, including adzing, boring, trimming, branding, application of anti-splitting devices, log storage, air seasoning, treatment, and care after preservative treatment. It is available from AREMA Publications Department, 8201 Corporate Drive, Suite 1125, Landover, MD 20785, for $125 (non-member price is $150) for the individual Chapter 30 or $425 (non-member price is $650) for the complete Manual. Prices are subject to change without notice.

3.9.1 SPECIFICATIONS FOR TIMBER INDUSTRIAL GRADE CROSSTIES

3.9.1.1 Material

3.9.1.1.1 Kinds of Wood

Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for crossties will be accepted:

Ashes	Gums	Oaks
Beech	Hackberries	Pines
Birches	Hemlocks	Poplars
Catalpas	Hickories	Redwoods
Cherries	Larches	Sassafras
Douglas Fir	Locusts	Spruces
Elms	Maples	Sycamores
Firs (true)	Mulberries	Walnuts

3.9.1.2 General

All procedures regarding quality, manufacture, inspection, shipment, and delivery will comply fully with those specified for grade crossties in Part 1, General Considerations unless excepted by information contained in this part.

3.9.1.3 Classification and Design

The following sizes, lengths, minimum faces and tolerances are allowed:

Grade	Dimensions	Minimum Faces Allowed
6" IG	6"x 8" x 8’0"/8’6"	6" face on top or bottom
7" IG	7"x 8" x 8’0"/8’6"	6" face on top or bottom
7" IG	7"x 9" x 8’0"/8’6"	6" face on top or bottom

The above minimum face requirements apply to the rail-bearing areas, which are the areas between 20" and 40" from the middle of the industrial grade crossties. Outside the rail-bearing areas, wane will be limited to half the face width on the top or bottom of the tie. The grade of each tie shall be determined at the point of most wane, on the top or bottom, within the rail-bearing areas. (The top is defined as the horizontal face farthest from the heartwood or pith center).

Dry or treated ties may be 1" narrower or 1/2" thinner than the specified sizes. Thickness and width may not vary more than 1" from end to end. The tie body may be out of square by no more than 1" throughout the length. Tie length may vary from +1" to -3" for the length specified.

3.9.1.4 DEFINITION OF DEFECTS

3.9.1.4.1 Wane

Wane is defined as bark or the lack of wood (see 3.9.1.3 for allowance).

3.9.1.4.2 Decay

A decayed knot greater than 3/4" in diameter will be rejected within the rail-bearing area. Also, slight incipient decay may be allowed if the tie, as a whole, is basically of good quality. Decay is allowed outside the rail-bearing area if the decayed area does not exceed 2" in diameter. Ties with decay up to 2" in diameter appearing in both ends of the tie will be rejected.

3.9.1.4.3 Holes

Ties having holes on any surface within the rail-bearing areas that are greater than 1/2" in diameter or greater than 3" deep will be rejected. Holes on any surface outside the rail-bearing areas which are greater than 3" in diameter or deeper than 4" will be rejected.

3.9.1.4.4 Knots

A knot greater than 3" in diameter within the rail-bearing area will not be permitted.

3.9.1.4.5 Shakes

Seasoned or treated ties with shakes having a length on the cross-section greater than 5" or extending to within 1" of any surface shall be rejected. Length measurements shall be made using 3.1.1.4.6 as a guide.

3.9.1.4.6 Splits

A split is a separation of wood extending from one surface to an opposite or adjacent surface – not counting the ends as a surface. A seasoned or treated tie with a split greater than 1/2" wide or 11" long will be rejected with or without a nail plate.

3.9.1.4.7 Checks

A check is a separation of wood due to seasoning which appears on the surface only – not counting the end as a surface. Season checks greater than 2" deep or 3/4" wide shall be rejected as industrial grade ties.

3.9.1.4.8 Cross or Spiral Grain

Except in species with interlocking grain, ties having cross, slant, or spiral grain greater than 2" in 15" of length will be rejected.

3.9.1.4.9 Bark Seams

Bark seams will not be acceptable if more than 2" deep or more than 10" long anywhere in the tie.

3.9.1.4.10 Manufacturing Defects

All ties must be straight and have top and bottom parallel. Any ties which do not meet the following characteristics of good manufacture will be rejected:

a. A tie will be considered straight when a straight line from a point on one end to a corresponding point on the other end is no more than 2" from the surface at all points.

b. The top and bottom of a tie will be considered parallel if any difference at the sides or ends does not exceed 1".

c. A tie is not well-sawn when its surfaces are cut with score marks more than 1" deep.

d. For proper seating of nail plates, tie ends must be flat, and will be considered square with a sloped end of up to 1/2", which equals a 1 in 20 cant.

AMERICAN WOOD-PRESERVERS' ASSOCIATION PRESERVATIVE STANDARDS, P1/P13, P2, P3 AND P4

PAGES 39-42

AMERICAN WOOD-PRESERVERS' ASSOCIATION PRESERVATIVE COMMODITY STANDARD UC4 "USER SPECIFICATION FOR TREATED WOOD" and T1-05 "PROCESSING AND TREATMENT STANDARD"

PAGES 43-45

AMERICAN WOOD-PRESERVERS' ASSOCIATION STANDARD

(This Standard is promulgated according to a consensus procedure and is under the jurisdiction of AWPA Subcommittee P-3)

P1/P13-01

STANDARD FOR CREOSOTE PRESERVATIVE

Note: AWPA Standard P1/P13-01 consists of one page.

1. The creosote shall be a distillate derived entirely from tar produced by the carbonization of bituminous coal.
2. The new material and the material in use in treating solutions shall conform to the following detailed requirements.

	New Material		Material In Use	
	Not Less Than	Not More Than	Not Less Than	Not More Than
2.1 Water, % by Volume	––	1.5	––	3.0
2.2 Matter Insoluble in Xylene, % by wt.	––	0.5	––	1.5
2.3 Specific Gravity at 38^{O} C Compared to water at 15.5^{O} C:				
Whole Creosote	1.070	––	1.070	––
Fraction 235-315^{O} C	1.028	––	1.028	––
Fraction 315-355^{O} C	1.100	––	1.100	––
2.4 Distillation: The distillate, % by wt. on a water free basis, shall be within the following limits:				
Up to 210^{O} C	––	2.0	––	2.0
Up to 235^{O} C	––	12.0	––	12.0
Up to 270^{O} C	10.0	40.0	10.0	40.0
Up to 315^{O} C	40.0	65.0	40.0	65.0
Up to 355^{O} C	65.0	77.0	65.0	77.0

3.0 Tests to establish conformance with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A1.)

Standard P1/P13-95 was reaffirmed in 2000 and 2001 with minor editorial corrections.
The title was amended in 1999, 2000 and 2001.

AMERICAN WOOD-PRESERVERS' ASSOCIATION STANDARD

(This Standard is promulgated according to a consensus procedure and is under the jurisdiction of AWPA Subcommittee P-3)

P2-01

STANDARD FOR CREOSOTE SOLUTION

1. The material shall be a pure coal tar product derived entirely from tar produced by the carbonization of bituminous coal. It may either be a coal tar distillate or a solution of coal tar in coal tar distillate.
2. The new material and the material in use in treating operations shall conform to the following detailed requirements.

	New Material		Material In Use	
	Not Less Than	Not More Than	Not Less Than	Not More Than
2.1 Water, % by Volume	—	1.5	—	3.0
2.2 Matter Insoluble in Xylene, % by wt.	—	3.5	—	4.5
2.3 Specific Gravity at 38^{O} C Compared to water at 15.5^{O} C:				
Whole Creosote	1.080	1.130	1.080	1.130
Fraction 235-315^{O} C	1.025	—	1.025	—
Fraction 315-355^{O} C	1.085	—	1.085	—
2.4 Distillation: The distillate, % by wt. on a water free basis, shall be within the following limits:				
Up to 210^{O} C	—	5.0	—	5.0
Up to 235^{O} C	—	25.0	—	25.0
Up to 315^{O} C	32.0	—	32.0	—
Up to 355^{O} C	52.0	—	52.0	—

3.0 Tests to establish conformance with the foregoing requirements shall be made in accordance with the standard methods of the American Wood-Preservers' Association. (See Standard A1.)

Proceedings: 1917, 1918, 1921, 1923, 1933,1935, 1936, 1941, 1942, 1947, 1953, 1954, 1957, 1958, 1968, 1985, 1989, 1995, 1998 and 2001.

Standard P2 was reaffirmed in 1995 with minor editorial correction; and amended in 1998 to remove, without prejudice due to lack of use and obsolescence, a coke residue requirement, and reaffirmed with minor editorial corrections in 2001.

AMERICAN WOOD-PRESERVERS' ASSOCIATION STANDARD

(This Standard is promulgated according to a consensus procedure and is under the jurisdiction of AWPA Subcommittee P-3)

P3-01

STANDARD FOR CREOSOTE-PETROLEUM SOLUTION

Note: AWPA Standard P3-01 consists of one page.

1. Creosote-Petroleum Solution (CPS) shall consist solely of specified proportions of Creosote conforming to AWPA Standard P1/P13 and of Petroleum Oil conforming to AWPA Standard P4.

1.1. No Creosote-Petroleum Solution shall contain less than 50 percent by volume of such Creosote, nor more than 50 percent by volume of such Petroleum Oil.

2. The test to establish conformance with the foregoing requirements shall be made in accordance with American Wood-Preservers' Association Standard A22.

4, Due to the limited accuracy of this test, the purchaser may wish to obtain the materials separately and have them blended under his supervision.

Standard P3 was reaffirmed in 2000 and in 2001 with a change in format.

AMERICAN WOOD-PRESERVERS' ASSOCIATION
STANDARD

(This Standard is promulgated according to a consensus procedure and is under the jurisdiction of AWPA Subcommittee P-3)

P4-03

STANDARD FOR PETROLEUM OIL FOR BLENDING WITH CREOSOTE

1. Petroleum oil for blending with creosote (Standard P1/P13) shall conform to the following requirements:

		Not Less Than	Not More Than
1.1	Specific Gravity[1,2] at 15.5°C/15.5°C (60°F/60°F) (not greater than 15.9° A.P.I.) ASTM Standard D 287	0.96	
1.2	Water & Sediment, % by volume ASTM Standard D 96		1.0
1.3	Flash Point[3] . Flash point as determined by the Pensky-Martens closed tester. ASTM Standard D 93	79°C	
1.4	Viscosity[4] . The viscosity shall be expressed as Kinematic vs. cST at 99°C (210°F) by ASTM Standard D 445	4.2	10.2

[1]To convert the specific gravity of Group 0 petroleum oils at 15.5°C/15.5°C (60°F/60°F) to specific gravity at 38°C/15.5°C subtract 0.0140. Group 0 oils have a specific gravity not less than 0.9665 at 15.5°C/15.5°C (60°F/60°F). The conversion for specific gravity of Group 1 oil is made by subtracting 0.0162 and Group 1 oil has a specific gravity not less than 0.8504 and not over 0.9664 at 15.5°C/15.5°C (60°F/60°F)

[2]Petroleum oil with a lower specific gravity may be used provided experience or testing shows that it may be blended in creosote without the formation of excessive sludge.

[3]In the interest of plant and worker safety, petroleum oil shall have a minimum flash point of 79°C (174°F) by TCC (D 56).

[4]Petroleum oils with a higher viscosity may be used provided the penetration requirements are met. The purchaser may specify the viscosity best suited to his/her requirements, allowing the supplier a tolerance of plus or minus 10% of the value specified (Equivalent vs. SUS at 99°C (210°F) shall be 40 min. to 60 max. by ASTM D 88).

[5]Each of the foregoing determinations shall be made in accordance with the ASTM method currently in effect. The ASTM Standards referred to herein may be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428 (www.astm.org).

COMMODITY SPECIFICATION C

CROSSTIES AND SWITCHTIES

(This Commodity Specification is promulgated pursuant to a consensus procedure and is under the jurisdiction of AWPA Subcommittee T-3)

1. **INTRODUCTION:** Commodity Specification C covers preservative pressure treatment of crossties and switchties. It includes general requirements, minimum preservative penetration and retention requirements for its Use Category, special requirements and special information .

1.1 The preservative retentions and penetrations assigned to the Use Category in Commodity Specification C are minimum retentions and penetration depths for the commodity, preservative and species treated. They have been found to be satisfactory for their Use Category.

1.2 The requirements for preservative penetration and retention assigned to any Use Category for any combinations of preservatives or species are equally important for any product to be acceptable under this Standard, all the listed requirements including preservative penetration and retention must be met.

2. **GENERAL REQUIREMENTS:** Commodity Specification C is to be used in conjunction with AWPA Standard T1, Use Category System: Processing and Treatment Standard.

2.1 Refer to Section 4 of the Use Category Standard for preservatives listed in this Commodity Specification.

2.2 Marking. Ties shall be branded with identifying information, year of production, and any additional information which may be specified by the purchaser. The brands shall be sufficiently deep so that all characters are plainly legible after treatment. This brand is to establish identification, traceability and ownership of the products.

2.3 Product Quality. Crossties and switchties shall conform to the physical requirements of the specifications under which they have been purchased. Material shall be processed in such a manner as to prevent damage and degrade.

2.4 Cleanliness. Crossties and switchties shall be supplied reasonably free of exudate and surface deposits.

2.5 Conditioning. Crossties and switchties shall be suitably seasoned or conditioned prior to treatment.

2.6 Machining. Crossties and switchties should be manufactured in their final form prior to treatment to eliminate any necessity for subsequent cutting or boring of the treated wood.

2.7 Incising. Incising is required for Cypress, Coastal Douglas-fir, Western Hemlock, Western Larch, Intermountain Douglas-fir, Jack Pine, Lodgepole Pine and Red Pine. Incising is optional for Oak and Hickory, Mixed Hardwoods, Southern Pine and Ponderosa Pine.

2.8 Sampling and Testing. A borer core shall be taken from 20 ties well distributed throughout the charge. If 80% of the cores meet the penetration requirement shown in the Commodity Specification C penetration table for the species treated, the charge shall be accepted. Except for Oak, if the average penetration of the 20, 75 mm (3.0-in.) borings meet the penetration requirement, the charge shall be accepted. Specific instructions or the calculation of percentage of rings penetrated in Oak are given in Standard M2, Paragraph
5.3.2.

Retention in ties shall be determined by gauge. Users requiring retention results by assay should refer to Commodity Specification A.

3.0 PRESERVATIVE RETENTION SPECIFICATIONS (Crossties and Switchties) – UC4A, UC4B, UC4C

Retentions in English (pcf) units

Retentions in English (pcf) units

Use Category System (UC4A, UC4B and UC4C)	Retention Specification by Gauge (pcf).			
	Creosote		Pentachlorophenol	Cu Naphthenate
Species	**CR**	**CR-S, CR-PS**	**PCP-A, PCP-C**	**CuN**
Oak and Hickory	7.0 or Refusal	7.0 or Refusal	0.35 or Refusal	0.055 or Refusal
Mixed Hardwoods	7.0	7.0	0.35	0.06
Southern and Ponderosa Pine	8.0	8.0	0.4	0.06
Coastal Douglas-fir, Western Hemlock, Western Larch	8.0 or Refusal	8.0	0.4	0.06
Intermountain Douglas-fir	Refusal	Refusal	Refusal	---
Jack, Red & Lodgepole Pine	6.0	7.0	---	---

Retentions in metric (kg/m^3) units

Use Category System (UC4A, UC4B and UC4C)	Retention Specification by Gauge (kg/m^3).			
	Creosote		Pentachlorophenol	Cu Naphthenate
Species	**CR**	**CR-S, CR-PS**	**PCP-A, PCP-C**	**Cu**
Oak and Hickory	112 or Refusal	112 or Refusal	5.6 or Refusal	0.88 or Refusal
Mixed Hardwoods	112	112	5.6	0.96
Southern and Ponderosa Pine	128	128	6.4	0.96
Coastal Douglas-fir, Western Hemlock, Western Larch	128 or Refusal	128	6.4	0.96
Intermountain Douglas-fir	Refusal	Refusal	Refusal	---
Jack, Red & Lodgepole Pine	96 (6.0)	112	---	---

8.3 CROSSTIES AND SWITCHTIES

(AWPA Subcommittee T-3))

8.3.1 Seasoning. Where circumstances or climatic conditions permit, ties may be air seasoned. Air seasoning procedures are given in AWPA Standard M1. The maximum moisture content shall not be more than:

Species	Seasoning (Months)	Oven Dry moisture Content (%)
Locust, Oak, Black Walnut	9-14	50
Douglas-fir, Western Larch	5-10	20
Gum-Black, Tupelo, Sweet	4-7	40
Southern Pine	3-6	30
Hickory, all other hardwoods	4-10	40

The moisture content of air-seasoned ties are to be obtained from 50 mm (2 in.) borings taken midway between the ends midway across the edge-face, and halfway up the stack. Kiln-drying is permitted in such a manner that causes no serious damage. Boulton drying is permitted for all species. Where permitted, steam conditioning temperature shall not exceed 115^{O}C (240^{O}F). Total duration shall not exceed 17 hours for Southern and Ponderosa Pine and 3 hours for Red Pine, Jack Pine, and Lodgepole Pine. Steam conditioning is not permitted for other species.

8.3.2 Pressure Limitations. Minimum pressure is 850 kPa (125 psig) for the refusal treatments. Maximum pressures shall not exceed:
1750 kPa (250 psig) for Oak, Hickory, and mixed hardwoods

1400 kPa (200 psig) for Southern Pine, Ponderosa Pine 1200 kPa (175 psig) for jack, red and Lodgepole pine. 1050 kPa (150 psig) for Coastal Douglas-fir, Intermountain Douglas-fir, Western hemlock, Western Larch

8.3.3 Minimum Preservative Concentrations The minimum preservative concentration for pentachlorophenol for refusal treatment shall be 5% wt/wt. The minimum preservative concentration for copper naphthenate for refusal treatment shall be 0.8% wt/wt copper as metal.

8.3.4 Expansion Baths. Expansion baths for recovery of preservative and retarding bleeding are permitted on all tie species as long as temperatures do not exceed those listed in Section 8.3.1

8.3.5 Retention Testing. The net retention in any charge shall not be less than 90 percent of the retention specified, but the retention of 5 consecutive charges shall be at least 100 percent. When a contract comprises less than 5 charges, the net retention in any charge shall not be less than 95 percent of that specified. The retention of preservative solution retained shall be calculated after correcting the volume of preservative to 40^{O}C (100^{O}F) for creosote using factors in AWPA Standard F1 and to 16^{O}C (60^{O}F) for pentachlorophenol using factors in AWPA Standard F2.

8.3.6 Penetration Requirements. A borer core shall be taken from the center of 20 ties in each charge. If 80 percent of the borings meet the penetration requirements, the charge shall be accepted. For Oak, if the average penetration of twenty 75mm (3 in) borings meets the penetration requirements, the charge shall be accepted.

8.3.6 Minimum Preservative Penetration Requirements For Crossties And Switchties

Species	Minimum Preservative Penetration Specification (Depth into Wood Expressed as)	
	mm And / Or % of Sapwood (a)	Inches And / Or % of Sapwood (a)
Oak Hickory	White Oak, 95% of Sapwood Red Oak, 65% of Annual Rings. (c)	
Mixed Hardwoods	1.5 inches or 75% (a)	38 mm or 75% (a)
Southern Pine Ponderosa Pine	2.5 inches or 85%	63 mm or 85%
Coastal Douglas-fir Western Hemlock Western Larch Fir	0.5 inches and 90% (b)	13 mm and 90% (b)
Intermountain Douglas-fir	0.5 inches and 90% (b)	13 mm and 90% (b)
Jack Pine Red Pine Lodgepole Pine	0.5 inches and 90% (b)	13 mm and 90% (b)

Footnotes: Penetration Tables

(a) Wherever depth "or" percent of sapwood penetration is specified, it shall be interpreted to mean whichever is less.
(b) Wherever depth "and" percent of sapwood penetration is specified, it shall be interpreted to mean whichever is greater.
(c) For Red Oak, the penetration must average a minimum of 65% on 20 - 75 mm (3.0 in.) cores.

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CONDITIONING & TREATMENT OF WOOD CROSSTIES

Wood is a cellulose material which can be adversely affected by decay fungi, insects, and marine borers. For all non-durable wood species and the sapwood of all woods, the use of chemical preservatives must be applied to protect wood from attack from these organisms.

The degree of protection given to the wood depends upon the type of preservative used and proper penetration and retention of the preservative. In addition, there is a difference in the treatability of the various wood species. Also there is a difference in the treatability of the sapwood and the heartwood portion of the various wood species.

With respect to wood crossties, the American Wood Preservers' Association (AWPA) Commidity Standard UC4 for crossties and switch ties, gives the general require-ments for preservative treatment by pressure processes. In addition, the Standard describes processing, conditioning, treatment, results of treatment (quality control), and storage of treated crosstie materials.

It is the intention of this booklet to provide a general overview of the conditioning and treatment of wood crossties. It is recognized that there are other treated wood materials which are used by the railroad transportation industry. These would include poles, piling, and other lumber products. In generic terminology when there is a discussion concerning wood crossties, there will be some overlap with switch tie and timber product materials.

PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT

If there is one process in the treatment of wood products that is more important than any other, it is the preparation and conditioning of wood prior to treatment. It is necessary to remove most of the free-water from within the wood cells. This must be accomplished in order to put the wood preservative within those cells. When all the free-water has been removed from within the wood cells then it is said that the *fiber saturation point* has been reached. With most wood species it is thirty (30) percent moisture based on the oven-dry weight of the wood. It is below the *fiber saturation point* that wood begins to shrink and develops checks and splits. This occurs most notably in large timbers such as crossties.

The removal of water can be accomplished in four ways:

- Kiln Drying
- Air Seasoning
- Boulton Drying
- Steam Conditioning

Kiln Drying

With respect to practical applications within the crosstie industry, the process of **kiln drying** is not used to remove water from large timbers (six to eight inch cross-section). To date, it has not been found to be economical to process materials such as crossties and other large timbers in this manner.

Air Seasoning

This drying process is the preferred method for conditioning wood crossties prior to treatment. It is the general practice to segregate the wood according to species and the size of the timber. For practical purposes, the species separation is into two groups - the oaks and mixed hardwoods (refer to the first section of this book for a more thorough discussion). In addition, some railroads for use purposes ask that treating companies segregate the red and white oaks, and possibly other species.

Climatic conditions significantly influences air seasoning. In some parts of the Southeast where the temperature and humidity are relatively high during a large part of the year, it can be difficult to air season crossties and timbers. It is

PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT

imperative in these locations that air seasoning be carefully monitored under these conditions to avoid premature or incipient decay. Within the treating industry this is often termed “stack-burn”. There are certain wood species such as hackberry, because of its high sugar content, that should be pretreated with a preservative chemical to prevent this surface decay/ stack-burn potential.

As with any of the conditioning/seasoning processes for removal of moisture from wood, there are both advantages and disadvantages. The air-seasoning process is the preferred method because it is the most economical. The extra time in the treating cylinder for either the Boultonizing or steam-conditioning is considered expensive in contrast. On the other hand, a major shortcoming of the air-seasoning process is the inventory cost of the accumulated, untreated crossties and timbers. Depending on the climate, regional location and the wood species, the required air-seasoning time can range from four to twelve months and in some instances, even longer than twelve months (see RTA Research Compendium, Volume I, Tab 21).

PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT

Boulton Conditioning Method

In dry or more arid regions of the country, rapid drying of the timber can cause severe checking and splitting. The conditioning procedure best suited for water removal in these regions is the **Boulton process**. In addition, a significant advantage for the Boulton drying procedure is that material can be processed rapidly from the "green" condition.

It speeds up the drying process. As currently used in the industry, the Boulton process can be described as follows:

> *The green/wet wood materials are placed in the treating cylinder which is then filled with hot creosote. It is important to completely cover the timbers with the creosote and that the equipment have sufficient void space for the collection of moisture vapor. The creosote is heated under vacuum to draw the*

> *moisture vapor out of the wood cells. It is important 1) to know the moisture content of the wood prior to treatment and 2) that all wood within the treating cylinder be uniform in moisture content.*
>
> *The treating operator must be able to measure the amount of water that has been removed from the charge of wood material. In addition there will be a volatile portion of the*

PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT

creosote which will condense along with the water.

These should be separated from the water with the volatile materials returned to the creosote work tank.

Once the Boulton conditioning process has been completed, the pressure treatment of the wood with creosote can then proceed. This process will be described in a later section of the paper. It is generally considered that the total Boulton processing time will be between six and ten hours. The variability in the time for conditioning will be wood species and temperature dependent. For example, there can be a variation between the time required for Douglas fir and the oaks. Also, a charge of crossties to be Boultonized in January in Ontario, Canada will necessarily be longer as compared to a charge of material to be Boultonized in July in a location such as central Texas.

There are advantages and disadvantages in using the Boulton process in conditioning wood. Major advantages are listed as follows:

- Crossties and timbers can effectively be conditioned/seasoned in a much shorter time as compared to air seasoning. This results in a significantly reduced total time to process and creosote treat the wood products.
- As compared to the steam conditioning method, the Boulton process uses a significantly milder temperature with a minimum effect on wood strength properties.
- Again when compared to the steaming process, a lower moisture content level within the wood can be achieved

The chief disadvantages of the Boulton process are that it is only suitable for creosote and other oil preservatives; it often costs more than air seasoning; and it heats the wood more slowly than the

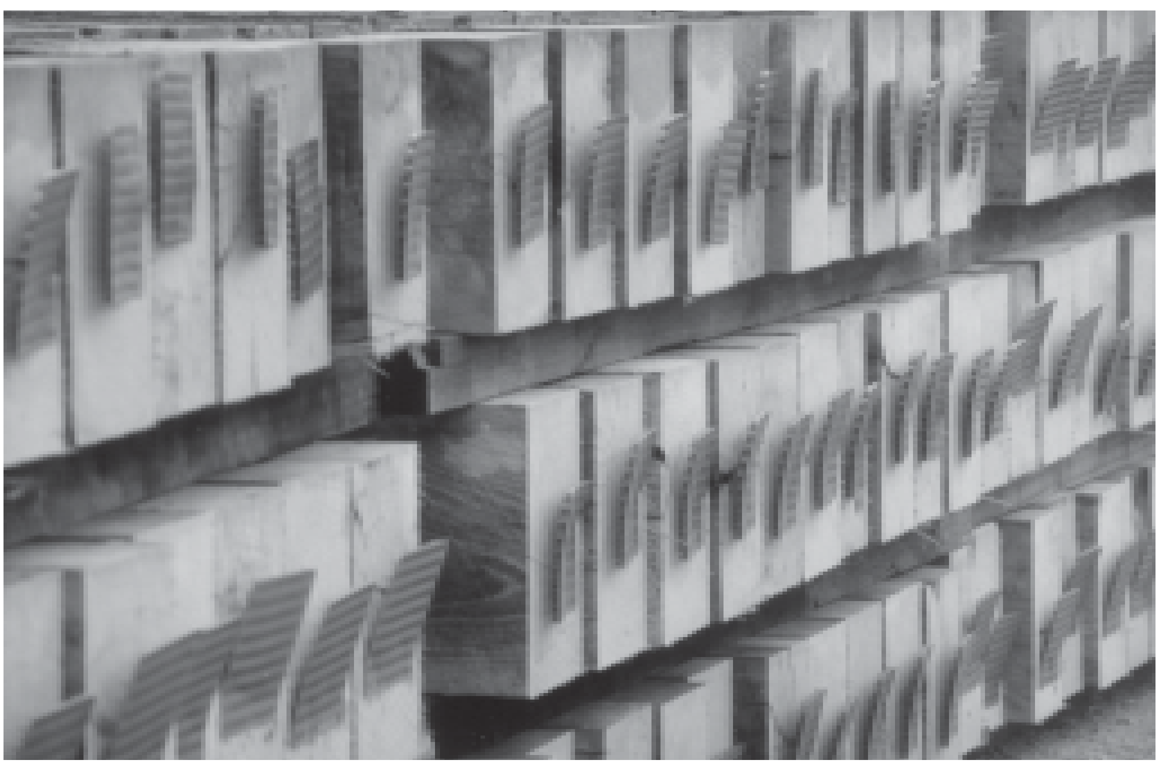
PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT

steaming process.

The Steam Conditioning Method

The final conditioning process for removing water from wood prior to treatment is known as the **steam conditioning** process. In applying the steam conditioning process, as currently used in the industry, it can be described as follows:

> *A charge of green pine material is placed in the cylinder and steamed for several hours. The total time for steaming is dependent on the size of the timbers. At the conclusion of the steaming period, a vacuum is applied to remove the moisture vapor from the wood. It is important to note that the steaming time is dependent upon 1) temperature of the wood 2) cross-sectional dimensions of the wood and 3) wood density.*
>
> *It is important for the vacuum to be applied as soon as possible after the steaming cycle has been completed. When the temperature of the wood surface is lowered significantly, the average amount of water removed during the vacuum will be lower than if the vacuum had been applied immediately after the steaming cycle.*



PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT

Often a common practice within the treating industry is to apply the steam in one cylinder and remove the charge from the cylinder; and then continue with the vacuum and creosote pressure treating process in a second cylinder. This practice is not the most efficient because the maximum amount of water vapor cannot be removed.

The common practice of steaming southern pine timbers (assuming twenty pounds gauge pressure) will effectively condition a charge of material in a time period of ten to fourteen hours. This includes both the steaming and vacuum periods of the conditioning cycle. As with the Boulton cycle, these times will vary 1) with the temperature of the wood and 2) pine species and its density.

Currently within the industry this process is generally used only with southern pine timbers and to a lesser extent for other pines. The primary reason for using steam conditioning is that the air-seasoning process of this wood cannot be effectively performed without some decay occurring in the southern climate areas. There are advantages and disadvantages to the steaming process. The principal advantages of the steaming process are:

- Steam heats faster than any other heating mediums
- Easily applied and usually does not require any special equipment in the treating cylinder
- The temperature can be easily controlled

The disadvantages are as follows:

- Only a limited amount of moisture

PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT

can be removed in the steaming/vacuum cycle

- It is often necessary to use higher temperatures than are used, for example, in the Boulton process (note that the AWPA Standards have maximum times and temperatures that can be used in the steaming process).

Mechanical Preparation

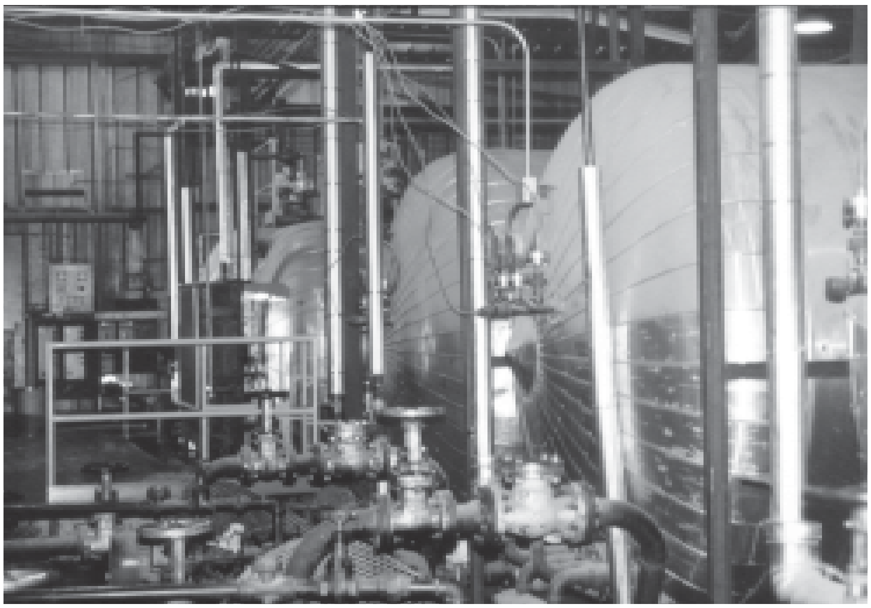
The first part of this paper has focused on the methods for removal of moisture from wood crossties and timbers in order to condition them prior to creosote treatment. However, it is necessary to take a "step-back" and note several mechanical procedures that need to be implemented before the condition-ing processes are initiated.

It is assumed that the crossties and timbers that will be conditioned and subsequently treated have been inspected for or by the customer, who has purchased the material. An inspection "in-the-white" is important to eliminated those pieces which have defects. There are a number of defects that will cause a cross-tie, for example, to be culled. These include ring-shake, wane, large knots, incipient decay and excessive splits and checks. There are three mechanical procedures usually performed on crossties and timbers; they are listed as follows:

- antichecking devices
- framing, adzing and boring
- incising

Historically, antichecking irons commonly known as S-iron and C-iron were used to reduce severe end-splitting in crossties and switch ties. Today a product known as an *end-plate* is also in widespread use. It is generally believed that end plates are effective in reducing the amount of end-splits. End-plates are

PREPARATION OF CROSSTIES AND TIMBERS FOR TREATMENT



generally inserted on those crossties that are judged by an inspector to have the potential to split at the end.

Whenever practical, all framing, adzing and boring of crossties and timbers should be done before the pressure treating process. Cutting into the timber after treatment can expose untreated wood. As a normal practice the standard 7x9 inch crosstie will not be cut or drilled; however, there can often be considerable framing, etc., that will be performed on bridge crossties and timbers. It is important to have all this work done prior to treatment.

The incising of crossties and timbers has been a common practice for those wood species that are resistant to penetration of liquid preservatives. In particular, the Rocky Mountain and western species, such as Douglas fir, have been passed through a machine equipped with cutting teeth projecting from the rollers. This is what is referred to as the incising process.

The primary benefit of incising woods that are difficult to treat is to cut through the fiber and expose end-grain to allow preservative penetration of the wood. There is an additional benefit. By incising crossties and large timbers in the original green state, it is possible to achieve a more uniform drying/conditioning of the wood. The use of incising minimizes severe checks and splits that often occur in large timbers. This is why most ties today are incised whether or not they are resistant to liquid preservative penetration.

EFFECT OF WOOD STRUCTURE ON TREATMENT

Wood varies greatly in its structure. The hardwoods differ from the softwoods and within these groups the individual species are different. It is not the intent of this publication to provide a wood technology lesson, however it is of importance to note some of the wood structural differences that effect the treatability of various wood species.

Listed as follows are some of the wood characteristics that could possibly influence preservative treatment:

- Within a specific wood species it is generally accepted that the sapwood is more easily treated than the heartwood. The heartwood may contain gums, resins, extractive and pigment materials. Because of these materials, the heartwood is a darker color.
- Wood density does not significantly influence the treatability of a wood species. There are too many other considerations such as open pores in red oak, tyloses found in white oak, the presence of resin in the heartwood of various softwoods.
- The longitudinal wood cells in softwoods (termed tracheids or fibers that have closed ends) and hardwoods which have open cells stacked end to end and known as vessels. One could think of the longitudinal wood cells as being a "bundle of straws". The softwood fibers have bordered pits in the cell walls and these allow liquids to pass readily between the cells. Hardwoods do not have this type of cell structure. The penetrability of the liquid preservative depends to a great extent on the open or closed condition of the longitudinal cells.
- The directional structure differences within a cross-section of wood influence the penetration of liquids. Along with the previously mentioned longitudinal fiber direction of wood cells, would be the tangential direction flowing around with the wood growth rings and third the radial direction across the growth rings and parallel to the wood rays. The most easily penetrated fibers are those in the longitudinal direction.

MOISTURE CONTENT AND ITS EFFECT ON TREATMENT

At the beginning of the paper, a definition for the *fiber saturation point* was given as approximately thirty (30)% moisture content. This is an important definition to keep in mind. For example, when trees are freshly cut, the green moisture content for Douglas fir sapwood is 115%; the heartwood is 37%. The sapwood of white oak has a moisture content of 78% and the heartwood is 64%.

The water within the cells of the wood completely fills the void space in the cell. This is known as *free water*. The cell walls remain saturated with water; thus, the term *fiber saturation.* As this moisture is removed from the wood fibers, shrinkage of the wood will occur. It is important to control this moisture loss in order to minimize the checking and splitting of wood. This fact was illustrated in the previous sec-tions in the discussion of Conditioning Processes and the use of *incising* in the mechanical preparation of crossties and timbers.

The presence of moisture in wood can be a determining factor for treatability. If the wood has not been conditioned and the cells are full of water there is no place for the preservative to enter the wood. Large timbers, such as crossties and switch ties, do not have to have their moisture content reduced to fiber saturation point when the treatment will be creosote or an oilborne preservative. Satisfactory penetration and retention of preservative can be achieved with a moisture content in the range of 40 to 45%.

Consideration needs to be given to the fact that when treating with creosote the wood can be ***too dry***. With the emphasis today on clean and dry treated products,

MOISTURE CONTENT AND ITS EFFECT ON TREATMENT

laminated bridge timbers that have a moisture content of 15% can be significantly over treated. There are procedures that can be used to minimize this over treatment. These will be discussed in the section dealing with treatment processes.

The moisture content of the wood product is an important piece of information that needs to be known by the treating operator before the charge of material is to be treated. The following is just a couple of examples:

- For green crossties that are to be Boultonized, how much water needs to be removed?
- For air-dried timbers that are to be treated with creosote, has sufficient moisture been removed to allow for proper penetration of the preservative?
- What is the moisture content of pine timbers? Do they need to be steam conditioned? It is important to remember that the process known as ***treatment to refusal*** can only be used with refractory wood species such as Douglas fir and white oak.

WOOD PRESERVATIVE AND THE PRESSURE PROCESSES

The processing and treatment of wood crossties, switch ties and timbers are somewhat unique. This product as used by the North American railroad industry has historically been treated with a creosote solution meeting the requirements of AWPA Standard P2. There are also occasions when ties and other timber products such as bridge materials will be treated using the AWPA Standard P1/P13 .

In addition, another creosote preservative blend material has been used by the industry to treat crossties and timbers. In those regions of North America that have an arid climate or in northern zones where the potential decay and insect attack are less, a heavy petroleum oil that meets AWPA P4 Standard has been used with creosote. This creosote/petroleum solution has been used extensively for many years to reduce the cost of the preservation solution. Its use has been primarily in the western United States and Canada in which conditions of use are less conducive to wood deterioration.

Creosote and its solutions are the preservatives most widely used. The crossties are pressure treated using the empty cell method (Lowry or Rueping Process). The specified creosote net retention is usually between six and ten pounds per cubic foot (pcf).

As previously discussed prior to treatment the wood crossties and timbers must be properly conditioned in order to achieve the desired preservative penetration and retention. As reference, it should be noted that the various conditioning methods and processing procedures are described in the *AWPA Book of Standards*. A recent copy of the AWPA Standards should be readily available to anyone who is involved in the treatment and use of wood crossties.

Before initiating a discussion on the pressure treatment process it should be noted that many of the railroad customers specify and many of the treating plants that produce crossties use a sterilization cycle just prior to pressure treatment. To achieve sterilization laboratory studies have shown that the heating conditions required to kill wood-destroying fungi require both a specific temperature and duration of time. The results also

WOOD PRESERVATIVE AND THE PRESSURE PROCESSES

indicate that it is not practical to sterilize wood at temperatures below 150 degrees F. The following table shows the temperature/times to attain sterilization in wood:

Temperature (F)	***Time (minutes)***
150	75
170	30
180	20
200	10
212	5

However, it must be taken into consideration that the temperature required is an internal one not an external temperature. Thus the center of a 7 x 9 crosstie, or any other large sawn timber, must reach that desired temperature. Given as follows are a few examples:

Size of Timber (inches)	***Time (hours) to Reach Temperature of 150º F ****
4 x 4	1 ¼
6 x 6	3
6 x 8	4
7 x 9	5
8 x 10	6 ½
10 x 10	8 ½

*** Note that inital wood temperature was 60 degrees F. with the external heat source being 200 degrees F.**

The pressure treatment process is briefly outlined as follows:

- Properly condition the wood to be treated (procedures described previously),
- Determine the pressure process to be used either Full or Empty Cell,
- At conclusion of the pressure process, initiate post conditioning procedures; i.e., final vacuum and possibly steaming,
- Make the determination if the wood has been properly treated using inspection procedures for penetration and retention of the preservative.

A more detailed description of the pressure treating process will now be given.

THE TREATMENT PROCESSES

Because the vast majority of railroad crossties, switch ties and timbers are treated only with creosote and its solutions, the procedures used for pressure treating with this preservative will be the only one discussed. As previously indicated, there are two pressure processes that can be used in the treatment of crossties and timbers with creosote. These two principal types are the full cell (Bethell) and the empty cell (Lowry and Rueping). The most commonly used is the empty cell process. For the purposes of this booklet, a somewhat limited practical application for these two pressure treating processes will be described. Additional information can be obtained by the reader on this subject from reference books.

The major difference between the full-cell and the empty cell processes is that a preliminary vacuum is applied to the treating cylinder during the initial phase of the full cell process while with the empty cell process, air pressure is applied instead of a vacuum. That initial air pressure can be atmospheric pressure as defined by the Lowry process. The Rueping process is the most commonly used. Air pressure is forced into the treating cylinder before the preservative is admitted. The air pressure is then maintained while the cylinder is filled with preservative. Thus the wood cells will contain air under pressure and preservative under pressure as well.

Depending upon the desired preservative retention level and the wood species, the initial air pressure may vary between 20 and 60 psi. The ultimate objective is to vary the retention level based on the amount of the preservative "*kick-back*" from the wood cells during the final post-conditioning vacuum cycle. Upon release of the pressure, the preservative is being forced out of the wood by the

THE TREATMENT PROCESSES

expanding air. The amount of recovered preservative will be greater when the initial air pressure is higher.

A good example would be the treatment of southern pine.

- With the full-cell process and the application of a vacuum, 25 pcf creosote will be retained.
- With the Lowry process and atmospheric initial pressure, the retention level could be 20 pcf.
- With the Rueping process and an initial air pressure of 10 psi, the creosote retention could be 16 pcf.
- With an initial air pressure of 30 psi, the creosote retention level could be 12 pcf.
- With the initial air pressure being 60 psi, the creosote retention level could be 8 pcf.

The above is strictly a theoretical example to show the effect the vacuum and initial air pressure can have on the preservative retention level. It is important for any treating plant operator to be aware of these differences and effects of vacuum and the amounts of air pressure.

The Pressure Period

Once the creosote preservative has been admitted into the cylinder and the initial air pressure or vacuum has been maintained during the creosote filling process, the charge of material is then put under pressure. The pressure period may vary depending upon the wood product that is being treated. AWPA UC4 gives recommended maximum and minimum levels of pressure depending upon the wood species. There is a similar recommendation for the maximum and minimum temperature level for the creosote during the pressure period.

The pressure period can also vary depending upon the conditioning cycle which was used to make the wood ready for treatment. In addition to the wood species, the size of timber can effect the length of the pressure period. For example, kiln dried southern pine 6x6 inch timbers will have a shorter pressure period as compared to Boultonized oak switch ties. This assumes that both products have approximately the same creosote retention level. Once again, it is important that the treating operator have knowledge of the products that are being treated and the operation of his own plant facility.

Post Conditioning Processes

Once the pressure period is completed, the final post conditioning process is one that focuses in several areas to (1) recovery of preservative and (2) environmental considerations have become important issues and it is imperative surface

THE TREATMENT PROCESSES

deposits and bleeding creosote wood products be minimized. The post conditioning processes are as follows:

- Temperature considerations of the preservative as the pressure periods is completed,
- Expansion bath to assist in the recovery of the creosote preservative,
- Vacuum cycles to recover preservative,
- Possible use of steaming improves surface appearance of the treated wood material.

There are four post conditioning procedures listed above. The first and the third processes are the most important and must be used in every treating cycle. A brief description of each of the above processes follows:

Temperature considerations — within two hours of completion of the pressure period, the temperature of the creosote treating solution should reach its peak. That temperature normally should be between 190 and 200 degrees Fahrenheit.

Expansion bath — this is a procedure that is often used with Douglas fir timbers. As the pressure within the cylinder is released and the creosote remains in the cylinder with the charge of timber still submerged, the temperature of the preservative is raised approximately 10 degrees Fahrenheit. A vacuum is applied during this period which assists in removing the air and some creosote from the wood.

Vacuum cycles — once the creosote has been drained from the cylinder, it is imperative that at least one vacuum cycle (minimum 22 inches Hg) be applied to the charge of material. The duration of this vacuum cycle will be dependent upon the material (species and size) that has been treated. For optimum surface cleanliness, it is recommended that following the first vacuum cycle and "breaking" back to atmospheric pressure, that a second vacuum cycle be applied. The duration of this second cycle will be based upon the treating operator's experience.

Steaming cycle — the use of steam in the post conditioning part of the treating cycle is definitely optional. Treating plants do not favor the use of steam because it accumulates waste water that needs to be processed. However, steaming between the two vacuum cycles is an extremely effective way of expanding the air which remains in the treated timber which is ultimately removed with the second vacuum cycle. The steam that is applied should not be "live" steam. The steam should originate from water that has been put into the cylinder to cover the coils and thus, generates steam from the boiling of the water (closed steaming operation).

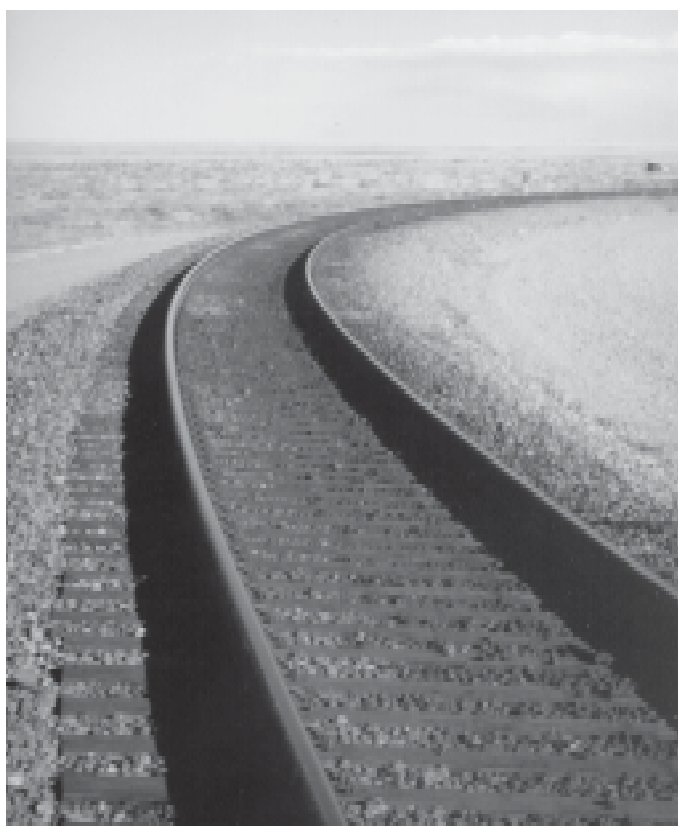
STANDARDS AND SPECIFICATIONS FOR TREATMENT

Standards and specifications are an extremely important segment of any industry. They are the guide by which products are produced. They allow the consumer, who purchases and uses the product, to have confidence that what has been purchased will perform to expectations that the producer has advertised to the purchaser.

The wood treating and railroad transportation industries are no different. There are essentially three (3) sets of specifications and standards that govern the industry:

- **The AREMA specifications for timber crossties, switch ties and industrial grade crossties were jointly developed by the Railway Tie Association (RTA) and the American Railway Engineering and Maintenance-of-Way Association (AREMA). These set of specifications pertain to the untreated (white material) prior to its treatment with preservative. Within these specifications are given the physical requirements, inspection criteria and the definition of defects.**
- **The second set of standards which is important to the wood treating industry pertains to the type of creosote that is used in treatment of crossties and timbers. These American Wood-Preservers' Standards (AWPA) are listed as follows:**
  - P1/P13, Standard for Creosote Preservative
  - P2, Standard for Creosote Solution
  - P3, Standard for Creosote - Petroleum Solution
  - P4, Standard for Petroleum Oil for Blending with Creosote
- **The final Standard that is important to the wood treating and railway transportation industries is that which brings together the treatment of "white stock material" and the creosote preservative used in the pressure process for the treatment of crossties and timbers. This is the AWPA UC4, the Standard for Treatment of Crossties and Switch ties - Preservative Treatment by Pressure Processes.**

The above stated Standards and Specifications can all be found in the Appendix section of this ***Tie Guide***, published in 2005 by the Railway Tie Association (RTA).



QUESTIONS AND ANSWERS

NOTE: These questions apply to both sections of the Tie Guide. A review of each section is necessary to answer all questions.

(circle the one correct answer)

- **Which American Wood -Preservers' Association (AWPA) Standard pertains to the treatment of crossties and switch ties?**

  Standard UC2 UC3 UC4 UC5

- **What is the fiber saturation point of wood?**

  Moisture Content of 20% 25% 30% 34%

- **When treating a Boulton charge of hardwood crossties, what would be an acceptable moisture content at which the ties could be treated?**

  Moisture Content of 25% 32% 35% 42%

- **Which of the four conditioning processes is the least used by the treating industry for removing moisture from crossties and timbers?**

  Kiln Drying *Air Seasoning*

  Boulton Drying *Steam Conditioning*

- **Below what moisture content does wood start to shrink?**

  Moisture Content of 20% 30% 35% 38%

QUESTIONS AND ANSWERS

- **Wood being a cellulosic material, what primary mechanism causes the deterioration of the wood crosstie?**

  Termites   Carpenter ants   Fungi   Mechanical Damage

- **What is the primary creosote treating solution used to impregnate wood crossties?**

  P1/P13   P2   P3   P4

- **Which set of Standards are the ones used primarily by the wood treating industry?**

  American Wood-Preservers' Association (AWPA)

  Railway Tie Association (RTA)

  American Standard for Testing Materials (ASTM)

  American Railway Engineering and Maintenance-of-Way Association (AREMA)

- **The first commercial wood treating plant was built in which location?**

  West Pascagoula, Mississippi   Somerset, Massachusetts

  Lowell, Massachusetts   Louisville, Kentucky

- **The full cell pressure treating process is often referred to as ...**

  Boulton Process   Rueping Process   Lowry Process   Bethell Process

QUESTIONS AND ANSWERS

- **In the early 1900's, J. B. Card added which material to creosote for the treatment of crossties?**

  sodium chloride pentachlorophenol zinc chloride copper sulfate

- **Which of these hardwood species is one that is not often used as crosstie material?**

  red oak red maple hickory basswood

- **Which of these softwood species is one that is not often used as crosstie material?**

  southern yellow pine Douglas fir Western hemlock Eastern white pine

- **Which of these white oak species does not have tyloses?**

  Oregon oak chestnut oak post oak swamp white oak

- **Which of these softwood species has been used predominately as timber bridge material?**

  tamarack southern yellow pine eastern hemlock Ponderosa pine

- **Which of the western softwood species is considered a timber to be of significant used in the railway transportation industry?**

  Western Hemlock Port Orford Cedar Redwood Douglas fir

QUESTIONS AND ANSWERS

- **During the wood treating process which of the following mediums is the most efficient?**

  electric heat *steam heat* *Boulton heat* *liquid heat transfer*

- **End-plates are used for what primary reason?**

  reduce abrasion on the end of crosstie

  hold large knots "in-place"

  reduce ring-shake

  reduce end-splitting

- **What is the primary reason that incising is beneficial when applied to a crosstie that is green and in the "white"?**

  more uniform drying *help preservative penetration*

  reduce moisture lose *prevent decay*

- **Which of these wood characteristics influence treatment with liquid preservative; thus assist in the penetration of the preservative?**

  wood density *tyloses*

  heartwood cells *longitudinal wood cells*

QUESTIONS AND ANSWERS

- **In recent years there has evolved an emphasis on "clean and dry" treated wood products. Of the following techniques used in a treating cycle, which would have the most effect on wood surface cleanliness?**

  pressure cycle   temperature   steam   vacuum

- **What information is probably the most important for a treating operator to know about the charge of wood that is going to be treated?**

  wood species   desired preservative retention

  moisture content   type of treating cycle to be used

- **When adjusting the treating cycle in order to have an effect on raising or lowering the preservative retention level, which of the following techniques will be most influential?**

  temperature   initial air pressure   vacuum   steam pressure

- **At the conclusion of the pressure cycle when treating with creosote at what temperature is it most desirable to have the charge of crossties?**

  Degrees Fahrenheit —   150   175   195   225

- **The final vacuum cycle used to remove excess air and creosote from a charge of crosstie, it is imperative that what level of vacuum be achieved?**

  Inches of Mercury (Hg) —   10   18   22   30

QUESTIONS AND ANSWERS

QUESTIONS EITHER ARE TRUE OR FALSE — circle the correct one

- **The most important Standards writing organization for the treating industry is the American Standards for Testing Materials (ASTM)**

  True *False*

- **The service life of wood products is significantly enhanced when pressure treated with a preservative solution.**

  True *False*

- **In the Western and Rocky Mountain states and in Canada, it is possible to use a heavy petroleum oil that meets AWPA P4 Standard treat wood and achieve satisfactory service life for crosstie material.**

  True *False*

- **Decay organisms that attack untreated wood - fungi and termites - are highly active at low humidity and low temperature.**

  True *False*

- **The heartwood of a tree is generally more easily treated with preservative than is the sapwood.**

  True *False*

QUESTIONS AND ANSWERS

- **Of the hardwood (oak) species, one of the most easily treated is red oak.**

  True *False*

- **One of the most important factors in the treatment of wood is its moisture content.**

  True *False*

- **Some of the "free-water" needs to be removed from within the wood cell in order to treat wood.**

  True *False*

- **Climate conditions in a specific region of North America can influence the air-seasoning of crossties and switch ties.**

  True *False*

- **When considering the conditioning processes, the most efficient means of heating a charge of timber is by using Boulton Process.**

  True *False*

- **The mechanical procedure known as incising performed on crossties is an excellent procedure to encourage uniform air-drying of the wood material.**

  True *False*

QUESTIONS AND ANSWERS

- **The heartwood of most white oak species is difficult to treat because of the presence of tyloses.**

  True *False*

- **Creosote-petroleum solutions are often used to treat crossties in Western arid regions of the United States**

  True *False*

- **Creosote attained its dominant use as preservative treatment for crossties and timbers just following World War I and during the early 1920's.**

  True *False*

- **Creosote has been used for well over 100 years in the treatment of wood products and it still remains the preferred preservative of choice for the treatment of crossties.**

  True *False*

- **The mixed hardwoods are primarily made up of the following wood species: beech, cherry, black locust, sassafras and catalpa.**

  True *False*

QUESTIONS AND ANSWERS

- **One of the heaviest and most dense wood species used for crossties is beech.**

  True *False*

- **Premature or incipient decay in crossties can be caused by the Boulton conditioning process.**

  True *False*

- **When steam conditioning a charge of southern yellow pine timber, an acceptable and efficient practice is to apply the steam in one cylinder; remove the charge and place in a second cylinder in order to complete the vacuum cycle and creosote pressure process.**

  True *False*

- **The most common type of anti-checking device is known as the S-iron.**

  True *False*

- **Wood density does not significantly influence the treatability of a wood species.**

  True *False*

- **The liquid preservative moves through wood cells most easily across the growth rings of the wood.**

  True *False*

QUESTIONS AND ANSWERS

- **The term *"treatment to refusal"* should only be used when a refractory wood species such as Douglas fir or white oak are the charge of material that is to be treated.**

  True *False*

- **The Hybrid Engineered Wood Crosstie is a highly refined structural material that does not need to be treated with preservative.**

  True *False*

- **As second and third growth timber - typically smaller in diameter - that are currently being harvested reach the market, it is reasonable to expect the hybrid engineered wood products will have a future in the transportation industry.**

  True *False*

ABOUT THE AUTHORS

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