An Evaluation of Used Wood Crossties

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Creosote has proven to be an effective preservative for sawn and peeled timber products. It has been used for well over a century for heavy-duty marine, industrial, and railroad structures, because it minimizes both weathering and decay. Wood products treated with creosote (AWPA, P1/P13) and its solutions (P2 and P3) have high durability, are flexible and cost effective, and are easily installed. Wood products treated with these creosotes typically last at least 30 years and have proven to last as long as 100 years.

Creosote continues to be the wood preservative of choice for some of the most demanding structural uses of wood, such as marine construction and railroad crossties. For example, treated wood crossties continue to be the rail transportation industry's primary track and rail support of choice; treated wood ties absorb and withstand extreme vertical and lateral loads and maintain rail gauge, surface and alignment

At the end of their service life in any heavy, medium or light duty track application, creosote treated wood products can be recycled and/or reused. Some applications include:

- Energy production in commercial power plants. Recycling used creosote treated wood as a bio-fuel conserves landfill space and offsets the need for fossil fuels.
- Depending on condition of the crosstie:
    1) Reused in Class 1 secondary track and rail yards,
    2) Sold for to short-line railroads for reuse in track ,

Objective of Study

As indicated previously the use of creosote treated wood as a fuel is one method of recycling, providing a “value added” use for a used product such as spent railroad crossties. The question has often been asked:, “How much retained creosote is within the old, no longer, serviceable wood crossties.”

This subject was initially explored by the Association of American Railroads in a comprehensive 1975 study. A selected number of used crossties were “chipped” and evaluated to determine the remaining amount of creosote retained within the crossties (percent by weight was an average of three (3) pounds per crosstie). A major focus of the 1975 AAR Study was to explore the value of the used creosote crossties for their fuel value. In addition there have been environmental considerations about the amount of creosote still remaining in used crossties.

This current project was initiated to confirm the results of the 1975 study, and add to it by answering “How much creosote remains in old used crossties that are pulled out of track some 34 years after the initial study was done?” As oak, both red and white types of the oak species and hickories, tend to dominate the wood crossties used by the railroad industry, they were selected to be a major part of the samples to be tested. Also an attempt was made to include within the test sample group, other hardwood types often creosote treated for use by the rail industry, such as the birch, elms, gums, and maples. Most importantly, it was considered a key to include enough refractory species samples in order to approximate the average wood tie condition in track at the end of service life.

Consideration was also given to the fact that softwoods such as the pine species and Douglas-fir are used by many railroads. Thus some of these wood species will be in the “mix” of crosstie wood species which have completed their useful service life.

Samples for Assay Analyses

Tangent Rail Corporation agreed to supply the test samples. The sample sections were obtained from a south central Pennsylvania contractor’s yard. Three foot sections, taken from the center, were cut using a chain-saw. Total of eleven sections were cut; these were transported to Koppers Company, Research Center in Harmarville, Pennsylvania. A band-saw was then used to cut from the center a one inch thick sample from each three foot section. With these end-sections exposed, it was then possible to do final wood species identification – in order to separate oaks, mixed hardwoods and softwoods.

Unfortunately of the eleven sample sections nine of them were oaks – two white oak and seven red oak. One other sample was southern yellow pine and the other slippery elm. Even with the wood species samples predominated by red oak (a very “treatable species), it was decided to continue the evaluation and determine the residual creosote retention on the used crossties. The crossties selected for this further evaluation were two (2) white oak, three (3) red oak, one slippery elm, and one southern yellow pine. As indicated above there were seven (7) red oak ties in the group of crossties to be used in the test. It was decided to use only three (3) red oak ties; reason being primarily the cost of performing the laboratory assay extraction test.

The age of each of these seven crossties was noted via "date nail" or from a "stamp" on the end of the tie. Ages ranged from 15 years to 78 years. This information is recorded in each of the two tables.

The one-inch center section from each three foot section was further cut in preparing the samples for assay analyses and the extraction of creosote from the treated wood. The top and bottom of the crosstie was easily determined based on the top surface being "weathered" and the bottom showing "imprints" of the rock ballast. These "top" and "bottom" surfaces of the one-inch sections were then cut into two separate samples (1) zero to ½-inch and (2) ½-inch to one-inch samples for the assay extraction test. The test procedure used to determine the amount of creosote in the wood samples was American Wood Protection Association (AWPA) Standard Test, A6-01: Method for the Determination of Oil-Type Preservatives and Water in Wood. These analyses were conducted at the Koppers Company, Harmarville Research Facility in Pittsburgh, Pennsylvania.

Results of Analyses and Conclusions

Results of these extraction tests are given in Tables 1 and 2. Water analyses for the two crosstie surfaces and the ½ inch and one inch zones are given in Table 1; while Table 2 gives the creosote retentions for the respective surfaces and zones.

The data given in Table 1 for water concentration is not of real significance other than to indicate that there was a lower amount of water concentrated on the top weathered surface compared to the surface of the crosstie next to the ballast.

Data in Table 2 gives the results of creosote penetration and retention into each crosstie. The penetration data was developed by observing creosote penetration and measuring the surface cross-sectional area in order to calculated percentage for the crosstie. As expected there was greater penetration in red oak (68%) as compared to white oak (21%); as a representative of the hardwoods group, slippery elm had 77%; with 47% creosote penetration in the pine cross-section sample. Note the pine sample had 100% penetrate in the sapwood, but no penetration in the heartwood. Several factors influenced the creosote penetration data:

- the wood species,
- the penetration gradient estimate was conservative and probably over estimated the total amount of creosote per crosstie,

When considering the retention data there were several factors that affected the amount of creosote found within the crossties:

- the wood species,
- the tie top surface had less creosote than that surface in contact with the ballast,
- and the age of the crosstie influenced residual retention.

Calculations for the total amount of creosote per tie assumed the following:

- assume three cubic feet per crosstie,
- weight of creosote per gallon being 9.1 pounds,
- creosote calculation for an overall mix of crossties that would contain – 33% each for red oak, white oak, and mixed hardwood (including pine sample).

Thus using the data from the creosote assay analyses and the above stated assumptions and with an average for all used creosotes treated crossties based on this limited number of sampling, the resulting residual retention would be 5.08 pounds or 0.56 gallons per crosstie with the percent by weight being two (2). This 2% level from the current test is 1% lower than the 3% level found in the AAR 1975 Study. Undoubtedly more samples of used crossties would have made the data more reliable, especially with regard to the mixed hardwood category.

The following conclusions can be drawn from this detailed analysis of the selected samples:

1-The ties that were measured in the 1975 AAR had been originally treated in the 1930's 40's and 50's, before modern treatment practices (and railroad cost efficiency demands) dictated that creosote retentions be "optimized". The resultant detailed study concluded that the average creosote retention in a 1975 "average used tie" was 3% by weight; while in the most recent study the average was 2% by weight.

2- This study hypothesized that as more modern and cost efficient practices became employed in the (post 1975) that lower residual creosote retentions would be resultant in the 2009 "average used tie" pulled form track.

3. This hypothesis is confirmed by two measurements, the limited samples from this study and the final report of the 1958 Creosote Cooperative Study also completed this year. After 50 years in test the southern pine creosote retained in the outer one inch was 3.4 pounds per cubic foot (pcf). This compares favorable with the 78 year old southern pine crosstie, which had 3.0 pcf.

4. If additional studies are undertaken it is strongly suggested that more crossties be obtained for evaluation especially regarding the mixed hardwood group and that the protocol established herein be followed. This is important in that to arrive at an estimate of the residual creosote in an "average tie" following its life in track, refractory species

must be included in the evaluation. Understanding the effects of age, treatability and gradients of preservative penetration are all important in evaluating this question.

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Table 1
Used Wood Crossties - Water Concentration

Code Number	Wood Species	Age of Tie (Years)	Specific Gravity	% Water Top 0-.5	Top .5-1.0	B - 0 - .5	B - .5 - 1.0
No. 1	White Oak	42	0.68	14.2	23.8	12.5	40.5
No. 3	White Oak	20	0.68	20.5	19.9	17.5	23.2
No. 2	Red Oak	42	0.63	8.5	12.9	7.4	13.2
No. 7	Red Oak	23	0.63	12	27.3	16	26.3
No. 4	Red Oak	15	0.63	10.7	26	17.9	30.1
No. 5	Slippery Elm	22	0.53	7.2	8.4	11	8.9
No. 6	Southern Pine	78	0.56	11.5	17.4	22.5	20.1

Percent water for Top surface and Bottom Surface of crosstie

Table 2

Used Wood Crosstie - Creosote Penetration and Retention Data

Code Number	Wood Species	Age of Tie (Years)	Specific Gravity	Retention -- pcf Top Surface of Tie Zero to .5"	.5 to 1.0"	Retention -- pcf Bottom Surface Tie Zero to .5"	.5" to 1.0"	Creosote Penet %	lbs. Creo per tie	33% ++ Average No. per tie group
No. 1	White Oak	42	0.68	2.5	1.9	3.71	2.52	23	1.54	1.54
No. 3	White Oak	20	0.68	1.6	1.7	3	2.5	19		
No. 2	Red Oak	42	0.63	2.1	1.8	4.4	2.45	49		
No. 7	Red Oak	23	0.63	3.6	2.1	4.7	3.9	49	5.97	5.97
No. 4	Red Oak	15	0.63	2	2.2	5	3.5	91		
No. 5	Slippery Elm	22	0.53	6.1	5.7	3.2	4.5	77	11.26	7.73
No. 6	Southern Pine	78	0.56	1.8	3.2	3.2	3.7	47	4.2	

Total Pounds of Creosote Retain in Crosstie - 5.08 Or 0.56 Gallons

Assume 3 cu. Ft. per tie
Assume 9.1 pounds per gallon of creosote

++ For the purpose of calculating to determine the amount of creosote per crosstie
Assume creosote retained being 33% each for red oak, white oak and mixed hardwoods (including pine)

Considerations Effecting the Data

* age of tie influences creosote retention
** top surface of tie has less creosote than bottom
*** wood species influences creosote penetration and retention
**** limited number of samples - only one hardwood and pine species
***** penetration gradient will have over estimated total amount of creosote per crosstie