PRESERVATION OF TIMBER BY THE STEEPING PROCESS

Information Reviewed and Reaffirmed November 1959

Original report dated October 1954

No. 621

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

PRESERVATION OF TIMBER BY THE STEEPING PROCESS

Forest Products Laboratory,[1] Forest Service
U. S. Department of Agriculture

Timber is often used in building construction, for fence posts, or for other purposes under conditions that favor decay and attack by insects. To make this timber more durable, a preservative treatment of some kind is desirable. Commercial pressure treatment, however, is often impracticable because of the small amount of timber requiring treatment, the distance from the treating plant, or the cost of treatment. In these cases, the timber should be treated by simple, inexpensive, nonpressure methods.

Several nonpressure methods[2] for treating with straight coal-tar creosote or creosote solutions are available, and in many cases, these preservatives are to be recommended. When these preservatives are impractical to use, however, because of their cost, their odor, or color, or because material so treated cannot be readily painted, some other preservative, such as zinc chloride, will often be suitable. In such cases, the steeping process may sometimes be used to advantage.

Timber treated by the steeping process will not usually be as durable as timber treated by impregnation under pressure or by the hot-and-cold-bath process, because the absorption and penetration of the preservative is generally less with the steeping process than with the other processes. As a rule, however, steeping under selected conditions may be expected to increase the life of the timber materially.

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[1]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2]A description of preservatives and methods suitable for treating fence posts is given in USDA Farmers' Bulletin No. 2049. A copy of this bulletin may be had free on request to the Forest Products Laboratory, Madison 5, Wis.

In general, the steeping process is suitable only for water-soluble preservatives, such as zinc chloride, chromated zinc chloride, mercuric chloride, and sodium fluoride.

Zinc Chloride Preservatives

Zinc chloride and chromated zinc chloride have been used in the United States for the preservation of timber. Chromated zinc chloride is intended as an improvement over straight zinc chloride. Although it has not yet been demonstrated to be superior to the straight zinc chloride for application by the steeping method, the chromated form should be suitable for use in this process.

In 1953, about 3 million pounds of these chemicals were consumed by the various timber-treating companies in the United States, most of it for the treatment of lumber and miscellaneous material by pressure processes. Although zinc chloride preservatives are comparatively cheap, the price varies somewhat and can best be determined by securing quotations from manufacturers or dealers on the amount desired. While zinc chloride is poisonous if taken internally, only ordinary care need be exercised when using it to avoid danger to the health of workmen.

Zinc chloride is suitable for use by the steeping method either in the granulated form or in concentrated solution. The granulated form consists of dry, white grains or small pieces that dissolve readily in water. Chromated zinc chloride is generally sold only in the granulated form. These compounds must be shipped in airtight containers because they quickly take up moisture when exposed to the air, and the grains stick together or even melt in the absorbed water. When using granules, therefore, it is desirable to mix the entire contents of the container with water at one time, whenever practicable. If any unused granules must be left in the container, it should be tightly closed as quickly as possible.

Concentrated solution is the most convenient form of straight zinc chloride for small users. Various manufacturers ship the solution in different strengths, usually about 48 to 72 percent. The purchaser should know what strength of solution is being furnished so that he may know how much water to add to make the proper treating solution, as well as what the zinc chloride part of the solution is costing him. The solution form is usually the cheapest to buy, except where there is a long freight haul. Since the solution is generally about half water, the freight cost will be higher than on an equal amount of zinc chloride shipped in the dry form.

American Wood-Preservers' Association Standard P5-53, covering zinc chloride for wood preserving purposes, requires that the zinc chloride shall not contain more than 0.2 percent iron and aluminum and at least 94 percent zinc chloride. Concentrated zinc chloride solution shall contain at least 50 percent chloride of zinc. To meet the requirements of this association, chromated zinc chloride in dry form must contain not less than 77.5 percent zinc chloride and not less than 17.5 percent sodium dichromate dihydrate.

For use in the steeping treatment, the treating solution of either chemical should have a strength of at least 5 percent.

If the zinc chloride preservatives have been purchased in granulated form, and are reasonably pure, a solution of approximately 5 percent strength can be made by mixing in the proportion of 5 pounds of the solid chemical to 95 pounds of water. If the zinc chloride is 95 percent pure, about 5-1/4 pounds will be required for 95 pounds of water. Since it is not practical to measure quantities of solid preservative it should be weighed and, even with water, weighing is generally more accurate than measuring. However, when it is inconvenient to weigh the water, it may be measured. A gallon of water at a temperature of about 60° F. weighs about 8-1/3 pounds. For 5-1/4 pounds of 95 percent pure zinc chloride, therefore, about 11-1/4 gallons of water are required to make a solution of about 5 percent strength.

If the zinc chloride has been purchased in concentrated solution the amount of water required will depend upon the concentration. Table 1 shows the approximate proportions of concentrated solution and water required for the different strengths of zinc chloride solution commonly available, to produce a treating solution of 5 percent strength.

Table 1.

Strength of concentrated solution	Approximate amount of water to be added to 10 pounds of concentrated solution to make a 5 percent treating solution	
Percent	Pounds	Gallons
48-1/2	87	10-1/2
50	90	10-3/4
70	130	15-1/2
72	134	16

Mercuric Chloride (Corrosive Sublimate)

This salt is sold in the form either of white powder or crystals. It is a dangerous poison that must be handled with great care. It should never be left where children or animals can get at it, and workmen should especially avoid getting it into the mouth or eyes or in contact with the skin. For many years mercuric chloride has been used as a wood preservative quite extensively in Europe but it has been used only in comparatively small quantities in the United States.

Its price is rather high; the commercial grade suitable for wood preservation may cost from 10 to 20 times as much per pound as zinc chloride. Its greater effectiveness permits the economy of a 1 percent solution instead of a 5 percent solution, but the first cost remains as high as 2-1/2 to 4 times that of zinc chloride. It has given excellent results, however, and experiments by the Forest Products Laboratory indicate that for fence posts treated by steeping, mercuric chloride is more effective than zinc chloride. When mercuric chloride is used in steeping, which is most common, the process is called the Kyan process, or Kyanizing, after the inventor.

A 1 percent mercuric chloride solution is generally used for steeping treatments; that is, in the proportion of 1 pound of mercuric chloride to 99 pounds of water, which is about equal to adding 14 ounces of the dry chemical to each 10 gallons of cold water.

Sodium Fluoride

This salt is sold in the form of a very finely ground white powder that may be obtained 95 percent pure. Although poisonous if taken internally, ordinary care in using it will avoid danger to life or health of workmen. Since sodium fluoride may easily be mistaken for harmless chemicals, it should never be left where such a mistake could be made. Sodium fluoride has not been used alone as a wood preservative on any large scale, but a number of experiments made in this country and in Europe have indicated it will give good service. Its price per pound is usually higher than that of zinc chloride, and the evidence so far available shows it to perform about the same as zinc chloride.

A solution of about 3-1/2 percent should be used in the steeping process; that is, about 3-3/4 pounds of sodium fluoride of 95 percent purity should be dissolved in 98 pounds of water, which is about equal to adding 3 pounds and 3 ounces of 95 percent sodium fluoride to each 10 gallons of cold water.

Other Preservatives

Copper sulfate, in a 5 percent solution, is a preservative suitable for application by the steeping method, but it is highly corrosive to iron and steel and cannot be used in tanks of these metals. Copper sulfate in the treated wood will corrode staples and fencing wire.

Method of Treatment

Apparatus Required

About the only apparatus required in the steeping process is a means for handling the timber if it is large and a vat or tank long enough to hold the largest sticks to be treated. The larger the vat, of course, the more timber it will hold; hence, the amount of timber and the time available for treatment should be considered in determining the vat size. The vat should be deep enough to permit complete submergence of the timber during the entire treating period. For mercuric chloride and copper sulfate solution, the vat must be made of wood or concrete or some other nonmetallic material. Metal tanks cannot be used because these chemicals will rapidly corrode the tanks unless they are especially protected. For zinc chloride, chromated zinc chloride, sodium fluoride, and practically all other preservatives, the treating tanks may be made partly or wholly of metal, since these preservatives do not corrode metal seriously.

Some means must be provided for keeping the timber completely submerged during treatment, otherwise part of it will remain above the surface of the treating solution. The submergence may be accomplished with suitable weights, retaining frames, covers, or equivalent devices.

If a large amount of timber is to be treated, it may be convenient to have separate tanks in which the preservative can be mixed and stored until it is needed. A hydrometer should also be available so that the strength of the treating solution can be determined.

Preparing the Timber for Treatment

To get the best results, only absolutely sound timber free from all outer and inner bark should be used. Inner bark may seriously interfere with the penetration of preservative in some species, and care should be taken to remove it. While both seasoned and green material are treatable by the steeping process, common practice has been to season the material before it is treated. The double-diffusion process developed by the Forest Products Laboratory is considered to be more effective for the treatment of green timber than the steeping method. A Forest Products Laboratory report No. 1955, "How to Treat Fence Posts by Double Diffusion," can be obtained without charge upon request.

The timber should be cut to final dimensions, and all boring and framing should be done before treatment, if possible. Cutting the timber after treatment may expose untreated wood and thus offer an opportunity for decay or insects to enter. If it is necessary to cut into the timber after treatment, all faces exposed by the cutting should be brush coated, preferably with two coats of hot coal-tar creosote or with two coats of a strong solution of the preservative used in the treatment.

Treating

In treating by the steeping process, the timber is simply submerged in the preservative solution and allowed to soak, usually for about a week. A longer soaking period would result in better absorption and penetration of the preservative, and, when time is not an important factor, it is advisable to soak for 2 weeks or longer. When time is very limited the timber can be removed from the solution after 2 or 3 days, with fairly good results, but the longer soaking periods are recommended.

If the timber to be treated has flat surfaces, the solution may not easily come into contact with all parts of each piece. With all sawed material, therefore, it is important to use stickers between adjacent timbers. The stickers should be at least 1/2 inch and preferably more in thickness.

Controlling the Strength of the Solution

Many factors may influence the strength of preservative solutions; therefore, it is important that the solutions be checked at intervals to be certain that they are being maintained at about the desired strengths. If the treating tanks are not protected from rain, the solution may be weakened. On the other hand, the solutions may be strengthened by the evaporation of water during hot, dry weather, especially if the tanks are not protected from the direct rays of the sun. When green material is treated, the absorption of preservatives occurs partly by absorption of the treating solution, but mainly by diffusion of chemical from the water of the solution into the water that is naturally in the wood. Diffusion, therefore, reduces the strength of the treating solution.

The most accurate method of determining the strengths of treating solutions is by chemical analysis. A much simpler but less reliable method is by specific gravity, which can be determined with a hydrometer. The approximate strength of a solution can then be obtained from tables giving the relationship between specific gravity and solution.

When wood is steeped in water solutions, some of the water soluble extractives it contains may be taken up by the solution. The quantity of extractives dissolved from the wood will vary with such factors as the species of wood, the amount of heartwood and sapwood, and the temperature of the treating solution. A large amount of extractives in a treating solution may materially affect the accuracy of the specific gravity method of determining the strength of the solution. Occasionally, therefore, it is advisable to have the solution analyzed, especially if the solution is to be reused. By comparing the strength values obtained by the two methods, an operator can determine what effect, if any, extractives are having on the strength values obtained by the specific gravity method. If the values are found to be in reasonably close agreement, no further chemical analyses need be made.

The approximate relationship between specific gravity and solution strength for the preservatives and strengths suggested for the steeping treatment are shown in table 2.

Steeping treatments are ordinarily made with unheated preservative solutions. Better results can be obtained for a given steeping period, however, if the treating solution is heated. Preservatives containing chromates should not be heated to a temperature above 140° F., since higher temperatures may break down the chemicals.

Table 2.--Approximate relationship between specific gravity and strength for various water solutions

Preservative	Approximate strength of solution	Specific gravity at 60° F.
	Percent	
Zinc chloride.........	4	1.037
	5	1.047
	6	1.056
Sodium fluoride.......	3	1.030
	3-1/2	1.035
	4	1.040
Mercuric chloride.....	0.8	1.005
	1.0	1.007
	1.2	1.009

Seasoning After Treatment

Whether or not the timber should be seasoned after treatment depends on how it is to be used. If it is to be placed where dampness or subsequent shrinkage of material would be objectionable, it should be thoroughly air-dried in open piles. This can be determined by periodically weighing a few pieces taken from various parts of the pile. When, during good seasoning weather, the check pieces show little or no weight loss between weighings, the timber may be regarded as being dry. The timber should be kiln-dried, if a moisture content lower than that ordinarily obtainable in air seasoning is required. If the timber is to be placed in contact with the ground, seasoning after treatment is generally not important.

Cost of Treatment

The cost of treatment by steeping will, of course, vary with the amount and size of the timber, the capacity of the apparatus used, the delivered cost of the preservative, the cost of labor, and other factors.

The approximate cost of the preservative actually retained by posts treated by the Forest Service ranges between 2 cents and 25 cents per post (based upon 1954 prices). This wide variation is due to such factors as species of wood treated, size of posts, length of steeping period, delivered cost of preservative, and solution strength. These figures do not include labor and equipment charges (both of which are generally low per unit volume in the steeping treatment) nor the cost of surplus preservative needed to keep the wood covered during treatment. The cost of this last item per unit volume of material is dependent upon the size and shape of the treating tanks and the quantity of material to be treated.

Effectiveness of the Treatment

The life of timber treated by steeping will depend chiefly upon the species of wood treated, the thoroughness of the treatment, and the conditions under which the timber is subsequently used. If the timber is used in building construction under conditions favorable to decay, but not in contact with the ground and not subject to the leaching action of water, a comparatively long life may be expected. If the treated timber is used in contact with ground that is continuously damp, or ground that is alternately wet and dry, the life will, as a rule, be much shorter than in more favorable locations. Even under such adverse conditions, however, the treated wood usually outlasts untreated wood long enough to justify the cost of treatment. It will not perform as well under adverse conditions, however, as wood pressure-treated with standard preservatives, such as coal-tar creosote.

The service tests made to date by the Forest Service with the steeping process have been confined to fence posts. A few posts were treated green, but most of them were air-dried before treatment. Air-dried posts treated by the steeping process are in service at Halsey, Nebr.; Miles City, Mont.; Madison and Verona (near Madison), Wis.; and Saucier, Miss. Posts of 5 species treated green have been in service since 1947 at Saucier, Miss. The records of the treatments and the serviceability of the several installations of posts will be found in table 3.

At Halsey and Saucier, both decay and termites are active; at the other locations, decay is the principal deteriorating factor. It may be noted that in the five places the posts are under test, untreated posts or stubs of each species are in service for comparison with the treated posts. While cross sectional measurements were sometimes not shown for the untreated posts and stubs, they are in all cases comparable in size to the treated posts of the same species.

In all species, except Western redcedar, the treated posts are giving longer life than the untreated posts or stubs. The effectiveness of the treatments, however, is not uniform for the different species and test locations.

The results of the service tests so far indicate that the steeping process will improve the life of posts of most species, but not to the extent that can be expected from pressure treatment with standard preservative oils. The steeping process is of questionable value for treating decay-resistant woods, such as Western redcedar, and for treating posts of hardwoods for installation under severe climatic conditions, such as those existing in the Gulf Coast area.

Lists of manufacturers of and dealers in zinc chloride preservatives, mercuric chloride (corrosive sublimate), and sodium fluoride may be obtained on request from the Forest Products Laboratory, Madison 5, Wisconsin.

Table 3.--Treatment and service data on posts treated by the steeping process

Species[1]	Type of post	Average diameter or width of face	Preservative	Approximate steeping period	Average retention of dry salt	Average concentration of solution	Average side penetration in Sapwood	Average side penetration in Heartwood	Posts in test	Where set	Date set	Years of service	Posts unserviceable or replaced	Average life
Treatment data									Service data					
		Inches		Days	Lb. per cu. ft.	Percent	Inches	Inches	No.				Percent	Years
Ash, green	Round	3.4	Sodium fluoride	7	0.22	3.46	0.23	--	25	Halsey, Nebr.	1925	29	68.0	[2]28
Ash, green	Round	3.4	Zinc chloride	7	0.26	3.42	.13	--	25	Halsey, Nebr.	1925	29	60.0	[2]29
Ash, green	Round	--	Untreated	--	--	--	--	--	10	Halsey, Nebr.	1925	25	100.0	18.7
Ash, green	Round	3.8	Sodium fluoride	6-7	0.28	3.18	.29	--	19	Miles City, Mont.	1926	17	100.0	13.1
Ash, green	Round	3.4	Zinc chloride	6-7	0.46	6.13	.14+	--	10	Miles City, Mont.	1926	17	100.0	13.1
Ash, green	Round	3.4	Zinc chloride	3-4	0.31	6.10	.18+	--	10	Miles City, Mont.	1926	17	100.0	12.3
Ash, green	Round	--	Untreated	--	--	--	--	--	12	Miles City, Mont.	1926	15	100.0	8.6
Cottonwood	Square	4.2	Sodium fluoride	7	0.42	3.18	.36	--	25	Halsey, Nebr.	1925	14	100.0	8.4
Cottonwood	Square	4.2	Zinc chloride	7	0.38	3.26	.27	--	24	Halsey, Nebr.	1925	29	87.6	[2]24
Cottonwood	Square	4.2	Untreated	--	--	--	--	--	10	Halsey, Nebr.	1925	7	100.0	5.8
Cottonwood	Round	5.3	Sodium fluoride	6-7	0.28	3.09	.80	--	10	Miles City, Mont.	1926	17	100.0	9.4
Cottonwood	Round	5.6	Sodium fluoride	3-4	0.17	3.31	.23	--	13	Miles City, Mont.	1926	15	100.0	7.8
Cottonwood	Round	5.1	Zinc chloride	6-7	0.67	6.07	.24	--	6	Miles City, Mont.	1926	17	100.0	13.1
Cottonwood	Round	5.1	Zinc chloride	3-4	0.48	6.03	.14	--	19	Miles City, Mont.	1926	17	100.0	13.5
Cottonwood	Round	--	Untreated	--	--	--	--	--	7	Miles City, Mont.	1926	15	100.0	6.5
Douglas-fir	Round	5.3	Mercuric chloride	7	0.03	0.96	.08	--	19	Madison, Wis.	1926	27	--	--
Douglas-fir	Round	5.8	Sodium fluoride	7	0.14	3.68	.07	--	25	Madison, Wis.	1926	27	52.0	[2]29
Douglas-fir	Round	5.9	Zinc chloride	7	0.11	3.53	.09	--	23	Madison, Wis.	1926	27	47.8	[2]29
Douglas-fir	Round	--	Untreated	--	--	--	--	--	24	Madison, Wis.	1926	27	91.7	[2]21
Larch, western	Round	5.3	Mercuric chloride	7	0.04	0.96	.08	--	21	Madison, Wis.	1926	27	--	[2]--
Larch, western	Round	5.8	Sodium fluoride	7	0.13	3.68	.08	--	22	Madison, Wis.	1926	27	40.8	[2]30
Larch, western	Round	--	Untreated	--	--	--	--	--	23	Madison, Wis.	1926	27	91.3	[2]21
Oak, red*	Round	4.1	Zinc chloride	7	2.4	10	.18	--	25	Saucier, Miss.	1947	6	68.0	[2]6
Oak, red	Round	4.1	Untreated	--	--	--	--	--	25	Saucier, Miss.	1947	6	92.0	[2]5
Pine, jack	Square	4.0	Sodium fluoride	21	0.37	3.80	.48	--	7	Madison, Wis.	1926	15	100.0	15.0
Pine, red (Norway)	Square	4.0	Sodium fluoride	22	0.44	3.79	.44	--	6	Madison, Wis.	1926	15	100.0	12.5
Pine, jack and red (Norway)	Square stubs	--	Untreated	--	--	--	--	--	10	Madison, Wis.	1926	15	100.0	4.3
Pine, jack	Round	2.8	Sodium fluoride	7	0.46	3.27	.74	--	25	Halsey, Nebr.	1925	27	100.0	16.5
Pine, jack	Round	2.8	Zinc chloride	7	0.51	3.41	.71	--	25	Halsey, Nebr.	1925	29	100.0	16.1
Pine, jack	Round	--	Untreated	--	--	--	--	--	10	Halsey, Nebr.	1925	14	100.0	5.7
Pine, lodgepole	Round	6.3	Sodium fluoride	3-4	0.095	2.81	.29	--	36	Miles City, Mont.	1926	17	100.0	13.5
Pine, lodgepole	Round	6.0	Zinc chloride	6-7	0.35	5.17	.52	--	51	Miles City, Mont.	1926	17	62.7	[2]16
Pine, lodgepole	Round	6.0	Zinc chloride	3-4	0.28	5.47	.42	--	17	Miles City, Mont.	1926	17	100.0	15.0
Pine, lodgepole	Round	--	Untreated	--	--	--	--	--	20	Miles City, Mont.	1926	17	100.0	9.4

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Table 3.--Treatment and service data on posts treated by the steeping process (continued)

Species[1]	Type of post	Average diameter or width of face	Preservative	Approximate steeping period	Average retention of dry salt	Average concentration of solution	Average side penetration in- Sapwood	Average side penetration in- Heartwood	Posts in test	Where set	Date set	Years of service	Posts unserviceable or replaced	Average life
		Inches		Days	Lb. per cu. ft.	Percent	Inches	Inches	No.				Percent	Years
Pine, ponderosa	Round	2.6	Sodium fluoride	7	0.33	3.27	.89	--	25	Halsey, Nebr.	1925	29	96.0	[2]22
Pine, ponderosa	Round	2.7	Zinc chloride	7	0.38-0.46	3.44	1.04	--	24	Halsey, Nebr.	1925	29	95.1	[2]22
Pine, ponderosa	Round	--	Untreated	--	--	--	--	--	10	Halsey, Nebr.	1925	10	100.0	6.3
Pine, ponderosa	Split	--	Sodium fluoride	6-7	0.27	3.18	.73	.20	20	Miles City, Mont.	1926	17	100.0	15.3
Pine, ponderosa	Split	--	Zinc chloride	6-7	0.49	5.34	.77	.27	18	Miles City, Mont.	1926	17	100.0	15.1
Pine, ponderosa	Split	--	Untreated	--	--	--	--	--	6	Miles City, Mont.	1926	17	100.0	8.3
Pine, ponderosa	Round	5.3	Sodium fluoride	6-7	0.25	2.83	1.04	--	33	Miles City, Mont.	1926	17	97.0	[2]12.0
Pine, ponderosa	Round	5.5	Sodium fluoride	3-4	0.24	3.03	.81	--	17	Miles City, Mont.	1926	17	100.0	9.9
Pine, ponderosa	Round	5.2	Zinc chloride	6-7	0.75	6.08	.78	--	6	Miles City, Mont.	1926	17	83.3	[2]15
Pine, ponderosa	Round	6.4	Zinc chloride	3-4	0.48	5.74	.59	--	40	Miles City, Mont.	1926	17	67.5	[2]16
Pine, ponderosa	Round	--	Untreated	--	--	--	--	--	23	Miles City, Mont.	1926	15	100.0	8.6
Pine, red (Norway)	Square	4.0	Sodium fluoride	21-23	0.06	0.91	good	slight	33	Verona, Wis.	1925	20	100.0	13.7
Pine, red (Norway)	Square	4.0	Zinc chloride	18-23	0.31	3.30	good	slight	31	Verona, Wis.	1925	19	100.0	14.7
Pine, red (Norway)	Square stubs	4.0	Untreated	--	--	--	--	--	50	Verona, Wis.	1925	19	100.0	10.0
Pine, scotch	Round	2.6	Sodium fluoride	7	0.42	3.18	.59	--	25	Halsey, Nebr.	1925	24	100.0	11.2
Pine, scotch	Round	2.6	Zinc chloride	7	0.34-0.49	3.40	.61	--	23	Halsey, Nebr.	1925	19	100.0	12.3
Pine, scotch	Round	--	Untreated	--	--	--	--	--	12	Halsey, Nebr.	1925	11	100.0	6.3
Pine, slash*	Round	4.1	Zinc chloride	7	2.5	10	.46	--	25	Saucier, Miss.	1947	6	--	--
Pine, slash	Round	4.1	Untreated	--	--	--	--	--	25	Saucier, Miss.	1947	5	100.0	2.2
Pine, southern yellow	Round	3.5	Mercuric chloride	8-25	0.09	48-1.0	.27	--	100	Saucier, Miss.	1937	17	28.0	[2]21
Pine, southern yellow	Round	--	Untreated	--	--	--	--	--	98	Saucier, Miss.	1937	4-6	100.0	3.2
Redcedar, western	Split	--	Sodium fluoride	6-7	0.14	3.21	.07	.05	19	Miles City, Mont.	1926	17	52.6	[2]18
Redcedar, western	Split	--	Sodium fluoride	3-4	0.11	2.32	.10	.08	18	Miles City, Mont.	1926	17	5.5	--
Redcedar, western	Split	--	Zinc chloride	6-7	0.34	6.20	.06	.05	24	Miles City, Mont.	1926	17	37.5	[2]20
Redcedar, western	Split	--	Zinc chloride	3-4	0.25	6.18	.13	.03	24	Miles City, Mont.	1926	17	4.2	--
Redcedar, western	Split	--	Untreated	--	--	--	--	--	42	Miles City, Mont.	1926	17	38.1	[2]20
Redcedar, western	Split	--	Untreated	--	--	--	--	--	20	Halsey, Nebr.	1925	29	75.0	[2]26
Sweetbay*	Round	4.2	Zinc chloride	7	1.6	10	.24	--	25	Saucier, Miss.	1947	6	72.0	[2]6
Sweetbay	Round	4.2	Untreated	--	--	--	--	--	25	Saucier, Miss.	1947	3	100.0	1.6
Sweetgum*	Round	3.7	Zinc chloride	7	2.0	10	.42	--	25	Saucier, Miss.	1947	6	52.0	[2]6
Sweetgum	Round	3.7	Untreated	--	--	--	--	--	25	Saucier, Miss.	1947	2	100.0	1.6
Tupelo, water*	Round	3.8	Zinc chloride	7	1.5	10	.19	--	25	Saucier, Miss.	1947	6	88.0	[2]5
Tupelo, water	Round	3.8	Untreated	--	--	--	--	--	25	Saucier, Miss.	1947	3	100.0	2.1
Willow	Round	2.8	Sodium fluoride	7	0.51	3.44	.28	--	24	Halsey, Nebr.	1925	12	100.0	6.0
Willow	Round	2.8	Zinc chloride	7	0.52	3.40	.23	--	25	Halsey, Nebr.	1925	25	100.0	11.7
Willow	Round	--	Untreated	--	--	--	--	--	10	Halsey, Nebr.	1925	9	100.0	4.1

[1]All posts were air-seasoned before treatment except where asterisk (*) follows the name of the species.

[2]Estimated life on the basis of failures to date.