

WOOD PRESERVATIVES

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WOOD PRESERVATIVES

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REQUIREMENTS

Wood preservatives are chemicals that, when injected into wood, make it unpalatable or uninhabitable to wood-destroying organisms. For protection against decay fungi and most insects, preservatives must either be toxic to these organisms or inhibit their development. Protection against powder-post beetles can be accomplished by any film that covers the surface of the wood so that the insects cannot deposit their eggs in the pores. There may also be some chemicals that are repellent to insects rather than poisonous. For general use, however, a preservative must have a high toxicity. It must also be chemically stable and permanent so that it will remain in the wood for many years, have good penetrating properties, be safe to handle, harmless to wood and metal, readily available, and reasonably cheap. Additional requirements for special uses may include cleanliness, paintability, freedom from odor or color, fire resistance, moisture repellence, freedom from the tendency to cause swelling, or various combinations of these properties.

Considerable emphasis is often given to the question of the safety of a preservative. Wood preservatives by their very nature are toxic materials and are therefore harmful to human beings and domestic animals if taken internally in substantial quantity. Preservatives should, however, be of such character that only ordinary precautions are required to avoid harm to those who handle them around wood-preserving operations. They must be harmless to those who come in contact with the wood after it has been treated.

A number of these properties can be tested in the Laboratory and, within a period of 3 to 6 months, it can be determined whether the material being tested is sufficiently toxic and sufficiently promising in other respects to receive favorable consideration. There is no acceptable laboratory test for permanence, however, and so far as all-around effectiveness is concerned, no substitute for long-time exposure tests under actual use conditions. It is necessary, therefore, to continue observations on a new

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preservative for several years in use before its effectiveness can be evaluated with confidence or safely compared with that of older materials. This fact is seldom recognized by the promoters of new preservatives.

There are many materials that are capable of extending the life of wood. Naturally some are more effective than others;² all possess certain disadvantages that limit their use, as well as advantages that make them especially suitable for specific purposes. With few if any exceptions, these preservatives fall into two general classes: oil-type preservatives, like creosote and petroleum solutions of toxic chemicals, which are relatively insoluble in water and of low volatility; and the waterborne salts that are injected into wood in the form of water solutions.

COAL-TAR CREOSOTE

Coal-tar creosote is a black or brownish oil made by distilling coal tar. The first fractions collected in tar distillation are the light oils, the residue is pitch, and in between is the portion that is saved for wood-preserving purposes. The character of the tar used, the method of distillation, and the temperature range in which the creosote fraction is collected, all influence the character of the creosote oil. The character of the various coal-tar creosotes available, therefore, may vary to a considerable extent. Small differences in character, however, do not prevent creosotes from giving good service, and satisfactory results in preventing decay may be expected, as a general rule, from any coal-tar creosote that complies with or closely approaches the requirements of standard specifications.

Coal-tar creosote is the most important and most generally useful wood preservative. Its advantages are (1) its high toxicity to wood-destroying organisms, (2) its relative insolubility in water and its low volatility, which impart to it a great degree of permanence under the most varied use conditions, (3) its ease of application, (4) the ease with which its depth of penetration can be determined, (5) its oily nature which retards moisture changes and thereby provides some protection against weathering of the wood, and (6) its general availability and relatively low cost when purchased in wholesale quantities.

Although for general outdoor service in structural timbers there is, as yet, no better preservative than coal-tar creosote, for some special purposes it has certain properties that are disadvantageous. Without question, freshly creosoted timber can be ignited easily and will burn readily, producing a dense smoke. After the timber has seasoned some months, however, the more volatile parts of the oil disappear from near the surface and the creosoted wood usually is but little, if any, easier to ignite than untreated wood. On the other hand, after untreated wood has started to decay, often within a few years, it is easier to ignite than timber that

²The effectiveness of preservative treatment, of course, depends on the amount of preservative absorbed and the depth of penetration, as well as on the preservative used, and the importance of this fact must not be overlooked.

has been kept sound by creosote treatment. The extent to which creosoted wood should be regarded as a fire hazard has never been satisfactorily determined. The only recommendation that can be made in this respect is that some preservative other than creosote should be used in places where fire hazard is considered of utmost importance, unless the treated wood is covered with a fireproof coating of some kind, or other protection is provided.

The odor of creosoted wood is unpleasant to some persons and may be considered objectionable in dwellings. Foodstuffs that are sensitive to odors should not be stored near creosoted wood. Workmen sometimes object to the use of creosoted wood because it soils their clothes and because it burns the skin of the face and hands of some individuals, causing an injury similar to sunburn. There need be no fear, however, that creosoted timber has a serious effect on the health of workmen handling or working near it, or on the health of the occupants of buildings in which creosote-treated material has been used. Creosoted wood can very often be used in sills and foundation timbers, floor sleepers embedded in or resting on concrete, and even subflooring, with little danger of the odor becoming objectionable.

The color of creosote and the fact that wood treated with it usually cannot be painted satisfactorily make it unsuitable for finish lumber or other material where appearance and paint receptivity are of major importance.

Creosote Specifications

A number of specifications prepared by different organizations are available for creosote oils of different kinds. Although the oil obtained under most of these specifications will probably be sufficiently effective in preventing decay, the rules of some organizations are needlessly difficult to meet and others are needlessly loose. Specification TT-W-556a for coal-tar creosote, adopted for use by the United States Government, will generally prove satisfactory and, under normal conditions, can be met without difficulty by most creosote producers. The requirements of this specification vary somewhat from those of the American Wood-Preservers' Association Standard Pl for coal-tar creosote. AWPA Standard Pl requires the specific gravity of the fraction between 235° and 315° C. to be not less than 1.025 and the fraction between 315° and 355° C. to be not less than 1.085 at 38° C. compared with water at 15.5° C. The requirements of Specification TT-W-556a are as follows:

Coal-tar creosote shall have the following properties:

The creosote shall be a distillate of coal-gas tar or coke-oven tar³ and shall comply with the following requirements:

	: Method	: For pressure	: For treating ties,
	: of	: treatment of:	: lumber, piles, posts,
	: analy-	: poles or for:	: and miscellaneous
	: sis,	: mixing with	: structural timber or for
	: AWP	: petroleum	: butt treating poles
	: Standard:	-----	-----
	: No.	: Not	: Not
	:	: more	: less
	:	: than	: than
	-----	-----	-----
Water, percent by volume	:	: 3	: 3
Material insoluble in benzol, percent by weight ⁴	: A1	: 0.5	: 0.5
Coke residue, percent by weight:	: A1	: 2	: 2
Specific gravity at 38° C. compared with water at 15.5° C.	: A1	: 1.03	: 1.03
Distillate shall be within the following limits (percent by weight, water-free basis)	: A1	:	:
Up to 210° C.	:	: 5	: 5
Up to 235° C.	:	: 25	: 25
Up to 355° C. ⁵	:	: 75	: 65
	:	:	:

³owing to the complexity of the chemical composition and physical properties of coal-tar creosote, and to the fact that some of the same compounds and properties which characterize coal-tar creosote are found in certain petroleum derivatives, the determination of the purity of creosote is difficult. When there is not certain assurance that the oil is a pure product, certain tests will aid in arriving at an opinion as to its coal-tar origin. If the sample does not comply with at least one of the following tests, it is undoubtedly not a pure coal-tar creosote:

A. Fraction distilling between 210° and 235° C. is usually solid or contains some solids when cooled to 25° C.

B. All of the fractions up to 315° C. contain tar acid in varying amounts, usually at least 1 percent, calculated on the amount of the fraction tested (26b).

C. The specific gravity of the fraction between 235° and 315° C. is usually not lower than 1.025 and specific gravity of the fraction between 315° and 355° is usually not lower than 1.085 at 38° C. compared with water at 15.5° C. However, some pure coal-tar distillates fall slightly below these limits.

^{4,5}See footnotes on page 5.

A list of producers and dealers in coal-tar creosote can be obtained, upon request, from the Forest Products Laboratory, Madison, Wisconsin.

OTHER WOOD-PRESERVING OILS

Crystal-free Coal-tar Creosote

The term, "crystal-free," applies to a coal-tar creosote from which some of the crystal-forming materials have been removed so that the oil will flow freely at ordinary temperatures and will not deposit crystals in its container. These oils are more convenient to handle than ordinary creosotes, but their general properties and effectiveness are similar. Federal specifications are available.

Anthracene Oils

Anthracene oils (carbolineums) are coal-tar distillates of higher specific gravity and higher boiling range than ordinary coal-tar creosotes, but their general properties and preservative effectiveness are similar to those of coal-tar creosote. They are usually sold under proprietary or trade names. Federal specifications are available for anthracene oils. Other things being equal, high-boiling distillates are advantageous to use in open-tank treatments that involve heating, since losses through evaporation are likely to be less than with low-boiling oils.

Wood-tar Creosote

Wood-tar creosotes are made by distilling wood tar. Just how they compare in effectiveness with coal-tar creosote has not been established, but it is certain that when of good quality and properly injected they are highly effective. Wood-tar creosotes are not extensively used for the commercial preservation of wood because they have not been produced in sufficiently large quantities of satisfactory and uniform quality and at a price to attract the attention of large consumers.

⁴Samples of creosote taken from working tanks may show an increase in matter insoluble in benzol due to treating operations. Such increase is permissible if it does not exceed the specification limit by 1 percent and if it can be shown that the original fresh creosote was of specified quality.

⁵Samples of creosote taken from working tanks may show a decrease in distillate up to 355° C., due to treating operations. Such decrease is permissible if the minimum does not fall below the specification limit by 2 percent and if it can be shown that the original fresh creosote was of specified quality.

Tar

Coal tars have seldom been used alone (except occasionally in treating railway ties) for preserving wood, because it is usually difficult to obtain good penetration with them, they leave a dirtier wood surface, and the tars are less poisonous to wood-destroying fungi than the creosotes. Service tests have demonstrated that surface coatings of tar are of little value, but when good retentions and deep penetrations are obtained, it is reasonable to expect a satisfactory degree of effectiveness from treatment with coal tar.

Water-gas tar has been used less extensively than coal tar, but, in certain cases where fence posts have been thoroughly impregnated with it, the results have been excellent. Wood tar also probably has value, but little information is available about it.

Creosote Solutions

For the past 40 years, coal tar and petroleum oil have been mixed with coal-tar creosote, in various proportions, as a means of lowering preservative costs. These creosote solutions have had a satisfactory record of performance, mostly when used in the treatment of crossties.

Federal Specification No. TT-W-566a, "Creosote-coal-tar Solution," places no limit on the quantities of coal-tar creosote and coal tar present in the solution, but the solution must meet definite requirements as to physical and chemical composition. American Wood-Preservers' Association Standard P2 for "Creosote coal-tar solutions" includes four solutions that must contain, respectively, not less than 80, 70, 60, or 50 percent by volume of coal-tar distillate, and that must also meet requirements as to physical and chemical properties. Federal Specification No. TT-W-568 and American Wood-Preservers' Association Standard P3 stipulate that creosote-petroleum solution shall contain not less than 50 percent by volume of coal-tar creosote.

Creosote solutions, besides costing less than straight creosote, also tend to reduce weathering and checking of the treated wood. The solutions may have a greater tendency to accumulate on the surface of the treated wood (bleed) and may penetrate the wood with greater difficulty, particularly since they generally are higher in viscosity than straight creosote. Higher temperatures and pressures during treatment can often be used to advantage, however, to improve penetration when solutions of high viscosity are used.

Since petroleum oil and coal tar are less toxic than straight creosote, creosote solutions are also less toxic. However, experience has shown that creosote-petroleum solutions, as covered in the above-mentioned specifications, provide a high degree of protection to ties and other products. The toxicity of a creosote-petroleum solution is generally less, proportionately, than the percentage of creosote in the solution. It is believed by some that creosotes of high toxicity are therefore desirable for use in creosote-petroleum solutions.

Since 1945, whenever it has become necessary to extend creosote supplies by adding various petroleum oils, particularly in pole treatment, some preservative users have fortified the petroleum oils in the solutions with such toxic materials as pentachlorophenol and copper naphthenate in an effort to avoid reducing the preservative effectiveness of the solution.

Creosote-petroleum solutions for which performance records have been favorable have generally contained petroleum oils of the comparatively heavy, high-boiling, and high-viscosity residuum types. The protective qualities of solutions containing lighter distillate fuel oils have not been adequately demonstrated.

Petroleum Solutions of Pentachlorophenol and Copper Naphthenate

Petroleum oils fortified with chlorinated phenols, principally pentachlorophenol, and copper naphthenate have come into fairly wide use as wood preservatives during the last few years in the United States. These preservatives were first sold as proprietary materials, primarily for surface applications. The chlorinated phenols in volatile light-colored solvents such as mineral spirits were first used for window sash and millwork that required a clean, nonswelling, and paintable treatment. Pentachlorophenol solutions were first used for the large-scale treatment of poles and lumber in 1941. In 1945 and 1946, following World War II, pentachlorophenol and copper naphthenate solutions came into large-scale use in this industry because of the current shortage of coal-tar creosote. The petroleum oil used in these solutions varies from the Diesel-oil type to the heavier types ordinarily used in creosote-petroleum solutions.

Large-scale users, such as the telephone companies and the Rural Electrification Administration, have developed specifications covering the formulation and use of pentachlorophenol and copper naphthenate solutions. Federal Specification TT-W-570 covers pentachlorophenol, and the American Wood-Preservers' Association Standard P8 covers both pentachlorophenol and copper naphthenate. Federal Specification TT-W-571 recommends retention of solutions of these preservatives for various use requirements. This specification recommends that pentachlorophenol treating solutions be required to contain 5 percent of this chemical while that containing copper naphthenate be required to have a copper metal concentration of not less than 0.5 percent.

The American Wood-Preservers' Association Standard P9 covers two petroleum oils suitable for use in pentachlorophenol and copper naphthenate solutions. Attention is called to the fact that the performance of these preservatives is influenced by the character of the petroleum oil in the treating solution, and that best results are obtained with fairly heavy oils of low volatility.⁶

⁶-Petroleum oils that remain in the wood in substantial quantities after treatment are likely to interfere with painting. When painting after treatment is essential, the user is cautioned either to make his own painting tests or to require the supplier of the preservative or treatment to furnish painting instructions and evidence of satisfactory performance with respect to paintability.

Service and field tests on wood treated with petroleum oils containing 5 percent of pentachlorophenol or copper naphthenate equivalent to 0.5 percent or more of copper metal show that these preservatives provide a high degree of protection against decay fungi and termites when the wood is properly treated. It is too early to predict their ultimate protective properties in comparison with coal-tar creosote. They are known, however, to provide much less protection than creosote against marine borers. Navy tests have shown that wood well impregnated with copper naphthenate solution resists marine-borer attack for limited periods. In other tests, southern yellow pines heavily impregnated with No. 2 fuel oil containing 5 percent of pentachlorophenol solution were severely riddled by borers in from 1 to 2 years.

Pentachlorophenol does not appreciably alter the natural color of the wood, but copper naphthenate gives it a green color. The properties of the wood treated with petroleum oils containing these preservatives, with respect to cleanliness, paintability, color, odor, and combustibility, are dependent largely upon the properties of the petroleum oil used. Pentachlorophenol in the dry form and in solutions irritates the skin of workers, but with careful handling and the use of suitable protective clothing it is possible to avoid harmful effects. The use of "bloom" preventives, such as ester gum, is required in pentachlorophenol solutions with volatile solvents to prevent the formation of crystals of the preservative on the surface of the wood after treatment.

WATERBORNE PRESERVATIVES

Wood preservatives such as zinc chloride, chromated zinc chloride, Wolman salt (Tanalith), Celcure (acid cupric chromate), zinc meta arsenite, and Chemonite (ammoniacal copper arsenite) are injected into the wood as water solutions. These preservatives are included either in the Federal wood-preservative specifications or in Standards of the American Wood-Preservers' Association, or in both specifications. They are employed principally in the treatment of wood for uses where it will not be in contact with the ground or water and where the treated wood requires painting. As a general rule, they are less resistant to leaching and do not perform so satisfactorily as do the preservative oils under conditions favorable to leaching. The leaching resistance of some of these preservatives has been developed to the extent that good performance can be expected in ground contact or in otherwise wet installations, but they are still not considered equal in effectiveness to creosote when used under such conditions. On the other hand, waterborne preservatives are generally preferable to creosote for indoor use. They can give indefinitely long life where not subject to leaching.

Waterborne preservatives leave the wood surface comparatively clean, paintable, and free from objectionable odor. Since water is added during treatment, the wood must be dried after treatment to the moisture content required for use. Zinc chloride and chromated zinc chloride are frequently used as fire retardants for wood, but at retentions somewhat higher than those used only for wood-preserving purposes.

With the exception of zinc chloride, the waterborne preservatives must be used at lower treating temperatures, preferably not over 120° F., because of their instability at the higher temperatures used with preservative oils. This may involve some difficulty when higher temperatures are needed to obtain good treating results in woods such as Douglas-fir.

Zinc Chloride and Chromated Zinc Chloride

Zinc chloride and chromated zinc chloride are covered, respectively, in Federal Specifications Nos. TT-W-576a and TT-W-551. The latter is included in American Wood-Preservers' Association Standard P5. Until 10 years ago, zinc chloride was the most extensively used waterborne preservative in the United States. Its principal advantages are its low cost, cleanness, and lack of fire hazard. Zinc chloride solutions were at one time used in mixture with creosote for the treatment of crossties and construction timbers, but this use has been discontinued as the zinc chloride does not give so satisfactory performance as some of the other extenders for creosote already mentioned. Since 1938 there has been a gradual displacement of zinc chloride by chromated zinc chloride and other waterborne preservatives.

Chromated zinc chloride was developed and promoted about 1934. According to the above-mentioned specifications, it must contain not less than 77.5 percent of zinc chloride and not less than 17.5 percent of sodium dichromate dihydrate. The chromated zinc chloride is claimed to have greater resistance to leaching than plain zinc chloride. This claim is supported by the results of some field tests but not by others.

Newly developed proprietary forms of chromated zinc chloride are copperized chromated zinc chloride and chromated zinc chloride (FR).¹ Copperized chromated zinc chloride is included in American Wood-Preservers' Association Standard P5 and contains approximately 73 percent zinc chloride, 20 percent sodium dichromate dihydrate, and 7 percent cupric chloride dihydrate. This preservative has been used for only a limited time, but in laboratory and accelerated field tests it is reported to have shown better permanence than chromated zinc chloride. These tests indicate that the two preservatives compare favorably in other properties. Chromated zinc chloride (FR) is included in American Wood-Preservers' Association Standard P10 and contains 80 percent chromated zinc chloride, 10 percent boric acid, and 10 percent ammonium sulfate. Retentions of from 1-1/2 to 3 pounds per cubic foot of wood provide combined protection against fire, decay, and insect attack.

Wolman Salt (Tanalith)

Wolman salt (Tanalith) is covered by U. S. Patent No. 1,957,873 (1934). Its approximate composition, according to Federal Specification TT-W-573 and American Wood-Preservers' Association Standard P5, is 25 percent sodium

¹(FR) for fire retardant.

fluoride, 25 percent disodium hydrogen arsenate, 37-1/2 percent sodium chromate, and 12-1/2 percent dinitrophenol. Service records on various types of wood structures treated with this preservative, and not used in contact with the ground or water, show performance to be generally favorable.

Celcure (Acid Copper Chromate)

Celcure is covered by U. S. Patents Nos. 1,684,222 (1926) and 2,041,655 (1936). It contains, according to Federal Specification TT-W-546 and American Wood-Preservers' Association Standard P5, approximately equal quantities of copper sulfate and sodium dichromate and a sufficient quantity of free acetic acid or chromic acid to maintain the preservatives in solution under operating conditions. Tests on stakes and posts exposed to decay and termite attack indicate that wood well impregnated with Celcure can give good service. Marine-borer tests by the Forest Products Laboratory and the U. S. Navy have shown that wood thoroughly impregnated with at least 1 pound of Celcure per cubic foot has some resistance to attack. The protection against marine borers furnished by this preservative, however, is much less than that provided by the standard treatment with creosote.

Zinc Meta Arsenite (ZMA)

Zinc meta arsenite is covered by U. S. Patents Nos. 1,659,135 (1928) and 1,984,254 (1934). Federal Specification No. TT-W-581 requires the zinc meta arsenite in treating solutions to be composed approximately of 60 parts of arsenious acid and 40 parts of zinc oxide, with sufficient acetic acid to keep the preservative in solution under operating conditions. Zinc meta arsenite has been in use for nearly 25 years, but recently its use has been very limited. Service records on treated crossties, poles, and posts show that this preservative provides considerable protection when applied under careful supervision.

Chemonite (Ammoniacal Copper Arsenite)

Chemonite was developed about 1925, is covered by U. S. Patent No. 2,149,284 (1939), and has been in commercial use for about 20 years. According to Federal Specification No. TT-W-549, the components in a typical Chemonite treating solution are 1.84 parts of copper hydroxide, 1.3 parts of arsenic trioxide, 2.8 parts of ammonia, and 0.05 part of acetic acid, with water sufficient to make 100 parts of solution. The solution strength is adjusted as necessary according to the retention of dry chemicals desired in the treated wood. The net retention of preservative is calculated as pounds of copper oxide plus arsenic trioxide in the proportion of 1.5 to 1.3 parts. Chemonite is included in American Wood-Preservers' Association Standard P5, the requirements of which differ slightly from those of the Federal specification.

Service records on Chemonite-treated structures show that this preservative provides good protection against decay and termites. Chemonite

adds to the life of untreated wood exposed to attack by marine borers, but it cannot be recommended as a substitute for creosote when long service is required or when the treated structure is to be used in heavily-infested waters.

Greensalt (or Erdalith) (Chromated Copper Arsenate)

Greensalt (or Erdalith) (chromated copper arsenate) was developed in India under the name of Ascu and is covered by U. S. Patent No. 2,106,978 (1938). It has been used in the United States since 1938 to a limited extent for the treatment of poles, posts, and lumber. American Wood-Preservers' Association Standard P5 stipulates that Greensalt contain 56 percent of potassium dichromate, 33 percent of copper sulfate, and 11 percent of arsenic pentoxide. Service data, on poles, posts, and stakes treated with this preservative and installed in the United States, show good protection against decay and termites over a period of 12 years or less. Favorable records for a somewhat longer period are available outside the United States.

Boliden Salt (Chromated Zinc Arsenate)

Boliden salt (chromated zinc arsenate) was developed in Sweden and has been used there since 1936 for the commercial treatment of various wood products. It has been used commercially in the United States since 1951 and is covered by U. S. Patent No. 2,139,747 (1938). American Wood-Preservers' Association Standard P5 stipulates that Boliden salt contain approximately 20 percent of arsenic acid, 21 percent of sodium arsenate, 16 percent of sodium dichromate, and 43 percent of zinc sulfate. Test data on stakes installed in Sweden in 1936, in South Africa in 1937, and in the United States and Panama Canal Zone in 1940 show that Boliden salt, in retentions of 0.5 pound per cubic foot or higher, provides good protection against decay and against termites.

PAINTS AND VARNISHES

The paints, varnishes, enamels, tars, asphalt, and similar materials commonly used for interior and exterior coatings do not effectively protect wood against decay, marine borers, and most insects and would not need mention here except for the fact that it is sometimes erroneously stated that they have value as preservatives. These materials, as a rule, are nontoxic. Furthermore they are almost invariably applied to only the faces or the faces and edges of the boards to be protected, leaving the hidden parts uncoated. Decay fungi, termites, and other destroyers ordinarily attack the hidden surfaces first and are not deterred by any coatings applied to exposed surfaces. When conditions are favorable for their growth, fungi readily penetrate through ordinary paint films.

WATER-REPELLENT PRESERVATIVES

Water-repellent preservatives and related products for treatment of wood by superficial methods such as brief dipping, brushing, or spraying do not penetrate deeply enough to afford adequate preservation against decay when the wood is used in contact with the ground or other source of prolonged dampness. Those that contain good preservatives are useful, however, for wood used above ground where it is dry most of the time, but may at times become damp enough for fungi to thrive, particularly where rain water may penetrate into joints. Such superficial preservatives are especially useful where it is important that the exposed surfaces be kept painted or otherwise finished for decoration, for such preservatives may be so made that they do not interfere with decorative coating. The water-repellent preservatives and related products are discussed in Forest Products Laboratory Reports No. 919, "Preservative Treatment of Window Sash and Other Millwork," and No. 1495, "A Survey of the Properties of Commercial Water Repellents and Related Products;" and in an article entitled "Water-repellent Preservatives for Wood," by F. L. Browne, reprints of which are available at the Forest Products Laboratory.

Treating Specifications

The Standards of the American Wood-Preservers' Association,⁸ Federal Specification TT-W-571,⁹ and treating specifications of other users of treated wood include requirements on the retention and penetration of preservatives for various uses. These specifications should be consulted by those interested in recognized standards of good treatment. Forest Products Laboratory Report No. 154, "Methods of Applying Wood Preservatives," contains useful information on this subject.

⁸American Wood-Preservers' Association Manual of Recommended Practice (revised annually), American Wood-Preservers' Association, 839 Seventeenth Street, N.W., Washington 6, D. C.

⁹Copies obtainable at 5 cents each (cash) from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.