METHODS OF APPLYING WOOD PRESERVATIVES

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METHODS OF APPLYING WOOD PRESERVATIVES

The amount of protection given by a good wood preservative depends largely upon the retention and penetration obtained. Some preservative processes are simple and inexpensive, while others are complicated, requiring expensive equipment. The protection obtained with the cheapest processes, although it will generally more than pay for the work, will not be nearly so great as that obtained with the more thorough, but also more costly methods. With any process it is important to see that the work is well done. A costly method carelessly employed may be no more effective than a less costly one properly used, and a cheap method poorly applied is not worth while.

The purpose of this report is to give brief descriptions of a variety of methods of applying wood preservatives, but complete descriptions are impractical in the limited space available. A list of references is provided at the end of the paper, however, to which the reader is referred if more detailed descriptions are desired.

Preparing Timber for Treatment

For satisfactory results with any treating process the timber must be sound and in proper condition for treatment. In a few methods, the timber is treated green and with the bark on, but usually it should be well peeled, and, for best results with the most processes, seasoned. Since preservatives will not make weak timber strong nor restore the strength of timber that has been partially destroyed by decay, only sound timber should be used. Further, except in material of small dimensions, the preservative and the heat of the treating process cannot be expected always to kill all the fungus growth in an infected or partially decayed stick, unless special care is taken to see that complete sterilization is attained. Any live fungus left in the wood may continue to grow after treatment, perhaps destroying completely the interior of the timber.

Peeling

In treating by the standing-tree method and by the various other processes in which preservatives travel lengthwise through green wood (see descriptions later in this report), the bark does not interfere with penetration and is left on the wood until after treatment. If desired, it may be left on permanently.

Peeling round or slabbed timber for treatment by other processes is necessary to enable it to season quickly enough to avoid decay and insect damage and because preservatives will not penetrate through bark satisfactorily. Strips of even the thin inner bark may prevent penetration. Patches of bark left on during treatment usually fall off in time and expose any untreated wood that may be beneath them, thus permitting decay to reach the interior of the stick. Careful peeling is especially important for wood that is to receive an inexpensive surface treatment. In the more thorough pressure processes,[1] some penetration will take place both lengthwise and tangentially in the wood and, in such treatments, small strips of bark are not quite so harmful.

Seasoning

For treatment with waterborne preservatives by certain diffusion methods and end-penetration methods, which are described later, the wood should be as green and as full of water as possible. For treatment by other methods, however, and particularly for treatment with preservative oils, seasoning before treatment is desirable. Plants treating timber by pressure processes can use artifical means of conditioning green timber (see p. 19) to make it more absorptive and thus avoid the long delay incident to air seasoning. Yet air seasoning, despite the greater time, labor, and storage space required, is the most widely used method of conditioning and is commonly the cheapest and most effective, even for pressure treatment. Kiln drying of structural timbers as a preparation for treatment is seldom used at present, but it may come into increasing use in the future.

The amount of air seasoning required will depend upon climate, the location of and protection afforded in the seasoning yard, the method of piling, the season of the year, and the size and species of the timber (13, 14).[2] A year of seasoning is commonly considered good practice for heavy timbers if conditions permit and if the timber can be kept that long under local conditions without deterioration, but the desirability of so long a drying period is not fully established. Smaller pieces season more quickly. A great deal can be accomplished even with large pieces in 3 to 6 months of good seasoning weather. The most satisfactory seasoning practice will depend upon the individual drying conditions and the preservative treatment to be used, and must be worked out by experience.

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[1] It must be recognized that all processes depend upon pressure of some kind. In this discussion the term "pressure process" is reserved for those processes that utilize hydraulic pressure produced by mechanical means.

[2] Underlined numbers in parentheses refer to publications listed as references on the last pages of this report.

Incising (12, 13)

Wood that is resistant to penetration by preservatives is sometimes incised before treatment, to facilitate deeper and more uniform penetration. To accomplish this, sawed or hewed material passes through a machine having horizontal and vertical rollers equipped with teeth that sink into the wood to a predetermined depth, usually 1/2 to 3/4 of an inch. The teeth are spaced so as to give the desired distribution of preservative with the minimum number of incisions. A machine of different design is required for incising the butts of cedar poles, but the result is similar. The effectiveness of incising depends on the fact that preservatives usually penetrate into wood much farther in a longitudinal direction than in a direction perpendicular to the faces of the stick. The incisions expose end-grain surfaces and thus permit longitudinal penetration in the incised portion. In the United States, incising is practiced chiefly on ties and timber of Douglas-fir and several other Pacific Coast and Rocky Mountain woods and on cedar poles. As the benefits of incising become better appreciated, the practice will undoubtedly be extended. It is especially effective in obtaining penetration in the heartwood areas of sawed or hewed surfaces, which are the most difficult areas to penetrate.

Cutting and Framing

All cutting, framing, and boring of holes should be done before treatment. Cutting into the wood in any way after treatment will usually expose the untreated interior of the timber and permit ready access to decay fungi or insects. It is much more practical than is commonly supposed to design wood structures so that all cutting and framing may be done before treatment. Railroads are now following the practice extensively and find it not only practical but economical (15).

Nonpressure Treatments

Brush Treatments and Spraying (10)

The simplest treatment is to apply the preservative to the wood with a brush or a spray nozzle. Creosote and similar oils, preferably hot, are used in this method. Heating is sometimes inconvenient, however, and the oil is often applied cold. In such event, creosote oil that is thoroughly liquid when cold should be selected. The oil should be flooded over the wood, rather than merely painted upon it, and care should be taken to see that every check and depression in the wood is thoroughly filled with the preservative, since any untreated wood left exposed provides ready access for fungi. At least two coats should be applied, the second one after the first has dried. This may require as much as 10 gallons of oil to 1,000 square feet of surface on rough lumber, but considerably less on surfaced lumber. The penetrations obtained will usually be less than 1/16 of an inch. Brush and spray treatments should be used only when more effective treatments cannot be employed. The additional life obtained by such treatments over that of untreated wood will be affected greatly by the conditions of service, but, for wood in contact with the ground, it may be from 1 to 3 years.

Brush treatment with solutions of water-soluble preservatives is not worth while for wood that is exposed to the weather, to soil, or to water and is less likely than creosote to be effective in protected situations.

Charring and Spraying

Service tests have demonstrated that charring alone does not significantly add to the life of fence posts. Standing poles are sometimes treated to prolong their serviceability or to arrest decay that may have started, by digging away the soil, cleaning off all decayed wood, charring the surface thoroughly and evenly, then spraying with creosote. This appears to add 3 to 5 years to the life of poles with sound interiors. A variation of the method consists in omitting the charring and mixing several gallons of creosote with the soil as it is backfilled around the pole.

Other Standing Pole Treatments

There are several other methods of treating standing poles that have begun to decay. The first step in each of these is to remove the soil from around the pole to a depth of 1 to 1-1/2 feet and to clean the pole surface thus exposed, taking especial care to remove all decayed wood and to make certain that the center of the pole is sound. The preservative is then brushed on the surface in the form of a paste, poured on as a liquid or applied by some other method. There are also patented methods whereby the preservative is injected into the pole at the ground-line zone with special tools (see p. 9). Several methods and preservatives for standing poles have been published in the Proceedings of the American Wood-Preservers' Association (4).

The Dipping Process (10)

The dipping process with creosote and similar preservatives consists simply in submerging the wood in the hot preservative for a short time, usually from a few seconds to 15 minutes, and then removing it and allowing the excess oil to drain back into the tank. The creosote temperature should be 200° F. or a little higher, and the wood should be thoroughly seasoned and dry on the surface. In cold weather a longer dipping period should be used. Wood that is covered with frost, snow, or rainwater should not be dipped, since the water on the surface will interfere with the absorption of oil.

The effectiveness of the dipping treatment is limited, and the process should not be used unless better methods are out of the question. The amount of oil absorbed will depend upon the timber and upon the length of the treating period. Ordinarily, however, it will probably be about 10 to 15 gallons per 1,000 square feet of surface. The side penetration obtained in exceptional instances may be from 1/8 to 1/4 inch, but ordinarily it will be 1/16 inch or less. The end penetration will be somewhat greater. The dipping process gives greater assurance than brushing or spraying that all surfaces and checks have been thoroughly coated with the oil and it should result in slightly greater penetrations. The increase in life of the timber, therefore, should be slightly greater, on the average, than that which ordinarily results from brush treatment. The increase will usually be more than enough to pay for the cost of treatment, but is only a partial solution of the problem of timber decay when a long life is desired under conditions favorable for rapid decay or insect attack.

A special application of the dipping process is used in the treatment of window sash, frames, doors, and other millwork (11), in which the finished products "in the white" are submerged in a special window sash preservative for not less than 3 minutes. The penetration into end surfaces of ponderosa pine sapwood is, in some cases, as much as 1 to 3 inches, and into side surfaces as much as from 1/16 to 1/8 inch. Since the exposed end surfaces at joints seem to be the most vulnerable spots in these products, good end penetration is especially advantageous. Not enough experience has accumulated to date to show fully the degree of protection obtained. Experience to date, however, seems satisfactory, and it is believed that such treatment will greatly increase the resistance of window sash and similar products to decay under normal conditions of use, but more thorough impregnation will be more reliable.

The Cold-Soaking Process (7)

The cold-soaking process is a limited-purpose treatment that has recently been used for applying creosote-fuel oil solutions, light oil solutions of pentachlorophenol, and other preservatives of similar type to well-seasoned lumber or peeled fence posts. Easily treated woods, such as sapwood pine or round pine posts containing a substantial sapwood volume, may absorb sufficient quantities of preservative and be well enough penetrated after soaking, up to a few days, to have good protection against decay and termites. Less satisfactory results can be expected, however, in woods that are more difficult to treat, including the heartwood of most species.

Cold soaking permits better treatment than can be expected from the dipping process, but the absorptions and penetrations obtained with sound wood will be generally less satisfactory than those in pressure or hot-and-cold-bath treatments. The effectiveness of the cold-soaking process can therefore be expected to be correspondingly less than that of the more thorough impregnation methods. Its advantage lies in its simplicity and moderate cost. Cold soaking, furthermore, can be used for applying oil solutions that cannot safely be heated, and for a variety of preservatives to meet various requirements as to color, cleanliness, freedom from odor, paintability, nonswelling, or other properties. The preservatives and their solvents, however, must be specially selected according to their ability to meet such requirements, since all do not have the same properties.

Domestic fuel oils, kerosene, and other similar oils containing 5 percent pentachlorophenol, or equivalent quantities of other toxic chemicals, can be applied by cold soaking. Fence posts and thick lumber should be completely immersed in the oil solution and soaked for not less than 48 hours, although shorter soaking periods of a few hours may be sufficient for thin lumber.

Except with posts of woods such as aspen and birch, which have not had a satisfactory record of performance, the cold-soaking method has not yet been in use long enough to furnish service data that may be used as a measure of its effectiveness. It is not expected, in general, to be as effective as treating by pressure or hot-and-cold-bath methods.

The Steeping Process (17)

The term "steeping" refers here to steeping or soaking in aqueous solutions of chemicals as distinct from soaking in oils. Although the process is old and has been employed in Europe for many years, its use in the United States has not been extensive. The absorptions obtained by this process vary over a wide range, and the process is not generally recommended when more reliable treatments are practical. Under certain favorable conditions, however, good results may be obtained. When mercuric chloride is used as the preservative, as is fairly common in Europe, the process is called Kyanizing, or the Kyan process. Zinc chloride, copper sulfate, and other water-soluble preservatives may also be used.

In treating by the steeping process, the timber (either green or seasoned), is simply submerged in the unheated preservative solution and allowed to soak, usually for about a week. A longer soaking period results in better absorption and penetration of the preservative, and when time is not an important factor, it is advisable to soak for 2 weeks. Keeping the solution warm or hot speeds penetration and may be helpful with preservatives that are not injured by heating. When time is limited, the timber can be removed from the solution after 2 or 3 days, and fairly good results may be expected. The penetrations obtained are likely to vary from as little as 1/16 of an inch to as much as 1 inch, depending upon the resistance of the wood being treated, the time consumed in treatment, the temperature of the solution, and the moisture content of the wood.

If the lumber to be treated has flat surfaces the solution may not easily come into contact with all parts of each piece. It is important, with all sawed material, therefore, to use stickers 1/2 inch or more in thickness between adjacent boards. With mercuric chloride or copper sulfate the tank must be made of a noncorroding material or must have special protection against corrosion, for these preservatives are corrosive to iron and steel.

A solution strength of about 1 percent is common with mercuric chloride. For zinc chloride and copper sulfate 5 percent and for sodium fluoride 3-1/2 percent solutions are recommended.

Because of the high effectiveness of mercuric chloride, a substantial increase in life may be expected when good penetrations are obtained with this preservative. The average life of Kyanized telephone poles in Germany is reported to be 6 to 8 years longer than that of untreated poles. A lower degree of effectiveness is to be expected from zinc chloride or sodium fluoride, but in one series of experiments made by the Forest Products Laboratory, posts steeped in zinc chloride have lasted more than 12 years, while similar posts, untreated, lasted a little more than 4 years.

When the steeping method is used with seasoned lumber, both the water of the solution and the dissolved preservative soak into the wood together. When green material is treated by steeping, however, much of the wood, particularly the sapwood, is already full of water. The preservative, under such conditions, enters the water-saturated wood by diffusing out of the water of the solution into the water of the wood.

End-Diffusion or "Barrel" Treatment of Posts

The end-diffusion process, sometimes referred to as the "barrel" or "trough" method, is a simple, low-cost treatment of limited protective value that can be applied to green, unpeeled fence posts. The limited results of service tests and treatment studies are not uniformly good, but on an average the treatment when carefully applied should provide an estimated life of 8 to 10 or more years to posts such as southern pine, jack pine, aspen, birch, and oak, which without treatment last only from 2 to 5 years. Zinc chloride and copper sulfate can be used, although the latter is highly corrosive to metals used in fence wire and staples.

For best results the posts should be treated within a few days after cutting of the living tree. Treatment should not be attempted during freezing weather. With zinc chloride approximately 1 pound of dry chemical should be used for each cubic foot of post. This is equivalent to 5 pounds or 1/2 gallon of 20 percent zinc chloride solution per post of average size (5-inch average diameter and 7 feet long). The butt ends of the posts are set in the treating solution until approximately 75 percent of the solution has been consumed. The posts are then reversed so that the remainder of the solution can be absorbed by the top end. Before the posts are installed they are allowed to stand for at least 4 weeks with the top ends down to allow the preservative to diffuse into the moisture in the wood.

Double-Diffusion Process

A double diffusion method of treatment developed at the Forest Products Laboratory (6) consists of successively steeping green peeled posts in solutions of chemicals that diffuse into the wood and react to deposit compounds with high resistance to leaching. For example, the posts may be steeped for several days in a 6 percent solution of copper sulfate and then for a similar period in a sodium chromate solution of slightly higher concentration, to deposit insoluble copper chromate in the wood. Other compounds, currently under study, may be deposited in wood in this manner and appear promising as wood preservatives on the basis of laboratory tests and field tests of limited duration. Specific instructions for application of the treatment can be obtained from the Forest Products Laboratory.

Other Diffusion Methods

The ability of preservatives to diffuse into the water of green or wet wood is utilized in various proprietary treating methods. In one of these, green or moisture-soaked wood is brushed with or dipped in a thick mixture of the preservative in water and then close-piled and covered tightly to prevent evaporation. After a few weeks or months the preservative becomes diffused into the sapwood to a considerable extent and to a lesser degree into the heartwood.

When the butts of standing poles that have begun to decay are treated by brushing a preservative paste on the cleaned pole surface, the water-soluble portions of the paste gradually penetrate by diffusion into the wet wood.

In another form of diffusion treatment, a special chisel or needle is forced deeply into the wood, and, as it is withdrawn, a preservative in paste or similar form is deposited in the hole. In wet wood, diffusion will cause the preservative to spread throughout the wood from the holes. If the holes are in sufficient number and properly spaced, the entire sapwood ring of a pole at the ground line may be treated in this manner.

The methods described in the three foregoing paragraphs undoubtedly give some protection to the wood, and under certain conditions, their use may be distinctly practical. The extent of their advantages and limitations, however, is not yet fully known.

An old diffusion method of treating fence posts or small poles consisted of boring several downward slanting holes into the wood near the ground line, filling them with a mixture of arsenic, mercuric chloride, and common salt, and then plugging the holes with corks or wooden plugs. Diffusion of preservative took place mainly in a vertical direction above and below the holes. A considerable degree of success is claimed by some users of the method, but other users have been unsuccessful. It does not seem sufficiently certain of success to be recommended. When enough holes are bored to insure complete penetration, the pole or post may be seriously weakened.

A diffusion treatment developed in Canada and still in the experimental stage at present, consists in boring holes close together longitudinally into the butts of green poles or posts, near the circumference, filling alternate holes with copper sulfate paste and sodium arsenite paste, and closing the holes with corks or tight-fitting plugs. The poles or posts are treated and set as soon as possible after cutting, and the bark is left on up to the ground line. Evaporation of moisture from the above-ground part draws preservative up the sapwood from the holes, and diffusion of copper and arsenic salts into contact with each other permits the formation of compounds resistant to loss by leaching. Further experience may show this method to be very useful where the wood above ground does not need treatment.

Preservative bandages, consisting of a broad strip of quilted cloth or similar material saturated or coated with a water-soluble preservative, have been used to some extent, particularly in Europe. The bandage is wrapped tightly around a post or pole at the ground-line area, and the moisture in the soil and wood causes the preservative to diffuse into the wood. Bandages may also be inserted between timbers or between timber and other materials, where they make contact in the joints of a structure. The method may be useful sometimes, but it does not appear to offer much promise of extensive use.

Some woods, especially the pines, appear to be more receptive to treatment by diffusion methods than others. Since good penetration and distribution of the preservative is an essential requirement for good treatment, woods that show poor or erratic penetrations are not so desirable for treatment by these methods as woods that permit a more thorough diffusion of the preservative.

Hot-and-Cold-Bath Process (10)

The hot-and-cold-bath treatment with coal-tar creosote and other oil preservatives is the most effective of the nonpressure processes, and the thoroughness of the treatment obtainable most nearly approaches that of the pressure processes. The treatment consists in heating the wood in the preservative in an open tank for several hours, and then quickly submerging it in cold preservative and allowing it to remain several hours more. This may be accomplished by transferring the wood at the proper time from a hot tank to a cold one or by draining the hot preservative from a single tank and quickly filling it with cold. The same result can also be accomplished, although more slowly, by shutting off the heat at the proper time and allowing the wood and the hot preservative to cool together.

The principle involved is the same in each case. During the hot bath, the heating causes the air in the wood to expand and some to be forced out. When the cooling takes place, whether it is sudden or slow, the air in the wood contracts, and a partial vacuum is thus created that results in the forcing of liquid into the wood by the pressure of the atmosphere. Little absorption of preservative takes place during the hot bath, except in a few woods that are exceptionally easy to treat.

The chief use of the hot-and-cold-bath process has been in treating the butts of fence posts and of poles for telegraph, telephone, and power lines. The process is also useful for lumber or timbers for other purposes when circumstances do not permit the more effective pressure treatments. Coal-tar creosote is the preservative ordinarily chosen because it is the most suitable preservative for posts and poles, but water solutions, such as zinc chloride solution, may also be employed, if the solution is kept at uniform strength. Other water-soluble preservatives that are not adversely affected by heating may also be used in this treatment. Petroleum oils containing preservatives such as pentachlorophenol and copper naphthenate can be used in the hot-and-cold-bath method provided that the oils used in the treating solution are properly selected so that they can be heated safely and without objectionable sludging at the temperatures required during the treatment.

With coal-tar creosote, hot-bath temperatures up to 230° F. may be employed, but usually a temperature of 210° to 220° F. is sufficient. In the commercial treatment of cedar poles, temperatures of about 230° F. are specified. If the temperature is too high, a considerable percentage of the oil may be lost by evaporation, especially if a creosote with a relatively low boiling range is used. In the cold bath the desired temperature is usually approximately 100° F. This temperature keeps the oil fluid but much cooler than the hot bath. If the oil is found not sufficiently fluid at 100° F., however, the temperature of the cold bath should be increased.

The length of both baths must be governed by the ease with which the timber takes treatment and by the demand for speed. With well-seasoned timber that is moderately easy to treat, a hot bath of 2 or 3 hours and a cold bath of like duration will probably be sufficient, but much longer periods are required with resistant woods. In using coal-tar creosote, the object is to obtain as deep penetration as possible, but with a minimum amount of oil. If the penetration is not sufficient, either the hot or the cold bath should be lengthened. If the penetration is satisfactory, but too much oil is absorbed, the cold bath should be shortened. The best combination of treating conditions in any instance will vary with the character and the condition of the timber and must be learned by trial. The penetration cannot always be controlled at will by manipulating the treating conditions, however, for some woods are highly resistant to treatment and at best may permit a depth of only 1/8 inch or less, especially in heartwood faces. The sapwood of most species is less resistant to penetration than the heartwood; hence, penetrations of 1/4 to 1 inch are often obtained in sapwood.

In the hot-and-cold-bath treatment of posts of some woods such as southern yellow pine, particularly those containing mold infection, blue stain, and incipient decay, preservative retentions are often found to be excessively high. One method of reducing preservative retentions is to employ a final heating or "expansion" bath with the creosote at 200° to 220° F. for an hour or two and to remove the wood while the oil is hot. This expands the oil and air in the wood, and some of the oil is thus recovered. The expansion bath also leaves the wood cleaner than when it is removed directly from cold oil. Another means for reducing preservative retentions is to use water, zinc chloride solution, or steam as a heating medium prior to the cold bath in creosote. It is important in such a case that water absorbed during the heating will not prevent good penetration and adequate retention of the preservative. Diluting the preservative with nontoxic materials such as light fuel oil and kerosene to compensate for excessive preservative retentions cannot be done without involving some risk of reducing the protective value of the preservative. Creosote-petroleum solutions have recognized value in the treatment of railroad ties, but the petroleum oils in such a case have been of the heavy residual, rather than of the low-viscosity, distillate-fuel type.

Hot-and-Cold Bath for Preservatives That Should Not be Heated

Certain preservatives in water solution cannot safely be heated to high temperatures because, at such temperatures, reactions may take place that precipitate some of the preservative out of solution or otherwise reduce the value of the solution. Such solutions are not practical for use in the hot bath. This difficulty has been solved in some open-tank plants by heating the wood with steam instead of in the preservative. This is accomplished by covering the tank with canvas or other material after the wood is in place and then applying steam at atmospheric pressure a few hours. At the conclusion of the steaming period, cold preservative solution is pumped into the tank and absorption takes place as the wood cools.[3]

Preservatives consisting of toxic chemicals in volatile organic solvents cannot safely be heated in open tanks because the solvent would be lost by evaporation and considerable danger of fire or explosion would be involved. Steaming would be unsuitable because it wets the surface of the wood, and this would interfere with the penetration of preservative oils. The obstacle is sometimes overcome by heating the wood in a dry kiln or hotbox and then immersing it quickly in cold preservative. A kiln-heating process for this purpose, in which the humidity in the kiln is controlled during the heating process, is covered by U. S. Patent 1, 991, 811 issued in 1935.

Vacuum Process

An adaptation of the hot-and-cold-bath method, referred to as the "vacuum process," has recently had some commercial use in the treatment of lumber and millwork. This treatment uses a preliminary vacuum instead of the heating bath in the hot-and-cold-bath process. Good penetration of the preservative can be obtained by the vacuum process in woods that are not resistant to treatment. Efforts to obtain deep penetration, however, may result in excessively high retentions of the preservative. This would not be a serious objection, however, in the case of waterborne preservatives, the retentions of which can be controlled by varying the concentration of the treating solution. Experiments at the Forest Products Laboratory have shown that with oilborne preservatives a combination of a short vacuum treatment followed by cold soaking for several hours will help to reduce preservative retentions without seriously reducing the depth of penetration.

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[3] See U. S. Patent 2, 235, 822 to A. D. Boardman, March 1941.

Boucherie or Sap-Displacement Methods (12)

A French patent (11,061) was issued in 1838 to Dr. Boucherie, covering a method of treating trees by attaching a container of preservative solution to the tree in such a way that the evaporation of moisture from the foliage drew the preservative solution into the sapwood of the tree. Many patents on variations of this method have been issued since the time of Boucherie. A British patent (1369) by Boucherie in 1855 covered the method of treating poles by forming a tight chamber over one end and leading preservative solution into this chamber from an overhead tank. The hydrostatic pressure of the column of liquid gradually forced the preservative through the wood and caused the natural sap to flow from the opposite end. This method was used in Europe for many years for treating poles with copper sulfate and is still in use there to some extent with that and other waterborne preservatives.

Variations of the Boucherie hydrostatic method have been in use in a small way in the United States but have not been a commercial success. In principle they are exactly the same as the Boucherie method of 1855. The variations are mainly in the details of forming the pressure chamber at the end of the pole (or pile), in the method of applying pressure, and in the preservative used. The old method of applying hydrostatic pressure from an overhead open tank of solution is still in use to some extent. In some methods, however, the solution is held in a high-pressure closed tank, and pressure is applied by forcing compressed air into this tank above the solution. This permits the use of pressures higher than can be obtained conveniently from an open overhead tank and thus shortens the treating period.

It is practicable by these Boucherie methods to get complete sapwood penetration in round timbers, and the methods may be used for the treatment of any green round timbers for which waterborne preservatives are acceptable. The methods do not appear to be generally competitive with commercial pressure treatments, but may sometimes be economical for treating timber at the place of cutting or be used to avoid high transportation costs, high equipment costs, and long seasoning periods, or for the treatment of timber upon which it is desired to retain the bark.

Modern Tree Treatments (8)

The U. S. Bureau of Entomology and Plant Quarantine, Washington, D. C., has revived and improved the Boucherie method of applying water solutions of preservative to standing trees or freshly felled trees with the branches on. Detailed instructions for treating by these methods can be obtained from that Bureau. Briefly, the processes are as follows:

In treating the standing trees, the bark is shaved away near the butt, and a deep groove is made around the tree in the sapwood by a saw or chisel. If made by a saw, the groove may be covered tightly with a rubber band and preservative from a container led into the space thus made. If a clean saw kerf is made and all the air is forced out as the preservative enters the groove, the preservative will be drawn up rapidly by the tree and can thus be made to penetrate the sapwood completely. Practically no penetration takes place in the heartwood. If the groove or cuts in the sapwood are made with an ax or chisel, a watertight, collarlike container of rubberized fabric or coated crepe paper can be formed around the tree below the groove and extending several inches above it. Preservative solution is poured into this container, from which it is absorbed by the sapwood of the tree.

Freshly felled trees, with the leaves and branches still on, may be treated by shaving the bark to make a smooth surface at the butt end, slipping one end of a tire inner tube over the end, binding it tightly in place, pouring the required amount of preservative solution into the container thus formed, and fastening up the loose end of the tube so that the solution will all be absorbed by the tree, and in a few days it will be thoroughly distributed through the sapwood.

For trees that are not too heavy to be lifted, a still simpler method, called "stepping," is to stand them in a container into which the required amount of preservative has been placed. The preservative will then be drawn into the sapwood by the evaporation of moisture from the leaves, as in the other methods described.

These methods of treatment are especially suitable for the prevention of decay and insect attack in material to be used with the bark on in log cabins, rustic furniture, and rustic structures of various kinds. They do not work with oil preservatives, but are suitable for the application of selected water-soluble preservatives, such as zinc chloride and copper sulfate, that will flow freely through the wood. Some chemicals tend to precipitate out of solution promptly when entering the wood, and their use by this method is likely to be unsuccessful.

Tire-Tube Post Treatments (18)

This modification of the Boucherie method is convenient for treating freshly cut fence posts with bark on with zinc chloride or other preservatives in water solution. It consists in placing the post on supports in such a way that the large end is 1 or 2 feet higher than the small end. The large end is then peeled or shaved to a smooth surface for a distance of 4 to 6 inches, a section of tire inner tube is slipped on and bound tightly in place, and the free end of the tube is fastened so it will hold preservative solution without spilling. A measured amount of preservative solution is then poured into the tube and begins to flow through the post, pushing the natural sap of the tree out through the small end of the post. When all of the solution has flowed into the post, treatment is complete, although the preservative continues to spread out more uniformly through the wood for some days afterwards. If the posts are thoroughly green and the ends are freshly trimmed off, the treatment may require only a day or less. The method will not work with partly seasoned timber nor with preservative oils. Detailed instructions for treating by this method may be obtained from the Forest Products Laboratory. The treatment is more likely to be successful with pines than with other woods. It should not be used on woods with thin sapwood. Many hardwoods do not treat well by this method.

Pressure Processes (3, 12, 13)

The commercial treatment of wood is most often accomplished by surrounding the wood with preservative in high-pressure apparatus and applying pressure to the preservative. A number of pressure processes differ from one another in a few details, but the general principle is the same in all. The wood, placed on steel cars, is run into a long steel cylinder, which is then closed and filled with preservative. Pressure then forces preservative into the wood until it has absorbed the desired amount and a relatively deep penetration is obtained. Two principal types of pressure treatment, the full-cell, or Bethell, and the empty cell, are in common use.

Full-Cell Process

The full-cell or Bethell creosoting process is widely used when the retention of a maximum quantity of preservative is desired. For timbers exposed to marine borers it is standard. The steps in this process are essentially as follows:

(1) After the charge of timber has been sealed in the treating cylinder, a preliminary vacuum is applied for 1/2 hour or more to remove the air from the cylinder and as much as possible from the wood.

(2) The preservative, previously heated to about the desired treating temperature, is admitted to the cylinder without the admission of air.

(3) After the cylinder has been filled, pressure is applied until the required absorption of oil is obtained.

(4) When the pressure period has been completed, the preservative is withdrawn from the cylinder.

(5) A short final vacuum is usually applied immediately afterward to free the charge from dripping.

When the timber is steamed before treatment, the preservative is admitted at the end of the vacuum period that follows steaming. When the material has received preliminary treatment by the Boulton, or boiling-under-vacuum process, the cylinder can be filled and the pressure applied as soon as the conditioning period has been completed.

Empty-Cell Process

The object of empty-cell treatment is to obtain deep penetration with a relatively low net retention of preservative. For treatment with oil preservatives, the empty-cell process should always be used when it will result in the desired absorption. Two empty-cell treatments are commonly employed, both of which make use of the expansive force of compressed air to drive out part of the preservative absorbed during the pressure period.

Rueping Process

The Rueping empty-cell process has been widely used for many years, both in Europe and in the United States. The following general procedure is employed:

(1) Air under pressure is forced into the treating cylinder, which contains the charge of timber. The air penetrates some species easily, requiring but a few minutes application of pressure. In the treatment of the more resistant species common practice is to maintain air pressure from 1/2 hour to 1 hour before admitting the preservative, but the

necessity for long air-pressure periods does not seem fully established. The air pressures employed generally range between 25 and 100 pounds per square inch, depending on the net retention of preservative desired and the resistance of the wood.

(2) Following the application of preliminary air pressure, the preservative is admitted to the cylinder. During the filling process the air in the treating cylinder either interchanges with preservative at the same pressure in an equalizing or "Rueping tank," or it is gradually allowed to escape from the treating cylinder as the preservative is pumped in, at a rate that keeps the pressure within the cylinder constant. When the treating cylinder has become filled with preservative, the treating pressure is raised to a higher point and continued until the point of refusal is reached or until the gross absorption is sufficient to leave the required net retention of preservative in the wood after the completion of the treatment.

(3) At the end of the pressure period the preservative is drained from the cylinder and a final vacuum removes the surplus preservative from the wood. The amount recovered may be from 20 to 60 percent of the gross amount injected.

Lowry Process

The chief difference between the Lowry and the Rueping process is that the Rueping process employs initial air pressures above atmospheric, while in the Lowry process the preservative is admitted to the cylinder without either an initial air pressure or a vacuum, and the air originally in the wood at atmosphere pressure is imprisoned during the filling period. After the cylinder has become filled with the preservative, pressure is applied, and the remainder of the treatment is the same as described for the Rueping treatment.

The Lowry process has the advantage that the equipment for the full-cell process can be used without other accessories, while the Rueping process usually requires additional equipment, such as an air compressor and an extra cylinder or Rueping tank for the preservative or a suitable pump to force the preservative into the cylinder against the air pressure. Both processes, however, have advantages, and both are widely and successfully used.

Conditioning Green Timber for Pressure Treatment (12, 13)

When green timber is to be treated under pressure, either of two commonly used methods for conditioning may be selected. One is the steaming-and-vacuum process, which is employed mainly for southern yellow pine, and the other is the Boulton or boiling-under-vacuum process, which is used for Douglas-fir and to some extent for hardwoods. In the steaming process the green material is steamed in the treating cylinder for several hours, usually at 20 pounds gage pressure (259° F.), and when the steaming has been completed a vacuum is immediately applied. During the steaming period the outer part of the wood is heated to a temperature approaching that of the steam, and the subsequent vacuum lowers the boiling point so much that part of the water is evaporated or is forced out of the wood by the steam produced when the vacuum is applied. The steaming and vacuum periods employed depend upon the size, species, and moisture content of the material. The steaming method usually reduces the moisture content of green wood somewhat and assists greatly in getting the preservative to penetrate, but it does not dry the wood to the seasoned condition.

In the Boulton, or boiling-under-vacuum, method of partial seasoning, the timber is heated in the preservative oil under vacuum at temperatures usually about 180° to 210° F. This temperature range, lower than that of the steaming process, is a considerable advantage in treating woods that are especially susceptible to injury from high temperatures. The Boulton method removes more water from green wood than the steaming-and-vacuum method, but, with the exception of timber of small dimensions, leaves it with a high average moisture content.

A third method of conditioning known as "vapor drying" (19) has been patented and has recently come into commercial use for the seasoning of railroad ties, poles, and other products. The green or partially seasoned wood is seasoned by subjecting it in the treating cylinder to the vapors produced by boiling an organic chemical such as xylene and removing the mixed vapors of water and the chemical from the drying chamber. A small quantity of the chemical remains in the wood and the balance is recovered and reused. The wood is treated by standard pressure methods after the seasoning has been completed.

Seasoning by vapor drying is claimed to be particularly advantageous in the case of hardwoods, such as the oaks and tupelos (gums), that are not adaptable to steam conditioning, air season slowly with considerable checking, and under unfavorable climatic conditions often begin to decay during the slow process of air seasoning. Ties of these woods, when not already partially air seasoned, have been seasoned by vapor drying within a period of 12 hours and without the development of large seasoning checks and splits common to air-seasoned ties. Some loss in compressive strength perpendicular to the grain has been reported in vapor-dried oak, but it is possible that this loss will be compensated for by abovementioned advantages claimed for the process.

Pressure Treatment with Water-Soluble Salts

The pressure treatment of wood with preservatives in water solution is usually by the full-cell process. The steps are substantially identical with those of the full-cell process for oils or Bethell process previously described. The only essential differences are in the preservative used and the temperatures employed. Waterborne preservatives are generally applied at temperatures from 100° to 160° F., whereas oils are applied at higher temperatures. Empty-cell treatments are occasionally used with water-soluble preservatives when an oil treatment is to be given immediately afterward, or when it is desired to minimize the increase in weight by using a smaller amount and a higher concentration of solution than is required in full-cell treatment.

Treating Pressures and Preservative Temperatures

The pressures used in the full-cell and Lowry treatments vary from about 100 to 200 pounds per square inch, depending on the species and the ease with which the wood takes the treatment, but they are most commonly about 150 to 175 pounds per square inch. Pressures applied in the Rueping treatment are usually between 150 and 200 pounds per square inch, depending more or less on the preliminary air pressure employed. Many woods are sensitive to high treating pressures, especially when hot. With these woods, pressures of 100 to 125 pounds are safer than higher pressures.

Specifications of the American Wood-Preservers' Association commonly require that the temperature of preservative oils during the pressure period shall not be more than 210° F. and shall average at least 180° F. Since high temperatures are much more effective than low temperatures in treating resistant wood, better results are obtained by using average temperatures between 190° and 200° F. This applies to both preservative oils and to water solutions that are not injured by high temperatures. With a number of waterborne preservatives, however, especially those containing chromium salts, temperatures above 150° F. should not be used because they cause partial precipitation of the preservative.

Absorption and Penetration (12, 13)

The amount of oil usually injected into structural timbers for land use varies from about 8 to 16 pounds per cubic foot. Piling to be used in salt water in which marine borers are active should be treated practically to refusal, which may mean 20 pounds per cubic foot or even more for southern yellow pine having thick sapwood, and 14 to 16 pounds per cubic foot for Douglas-fir. For railway ties, absorptions of 6 to 8 pounds per cubic foot are common; for pressure-treated poles, 8 to 12 pounds, and for fence posts, 6 pounds. The absorptions should be increased for material of smaller cross section, to obtain a treatment as effective as that in the larger sizes, because of the greater proportion of surface area to volume in the smaller sizes. More than twice as much absorption per cubic foot may be required in the very small sizes to obtain a penetration as good as that in large timbers. For unusually large timbers the absorption per cubic foot may have to be reduced.

Penetrations vary widely, even in pressure-treated material. In most species, heartwood is more difficult to penetrate than sapwood. There are also great differences between species in the degree to which the wood may be penetrated; the red heartwood of beech and the heartwood of white oak, sweetgum, and mountain-region Douglas-fir, for example, is exceptionally resistant to penetration by commercial treating processes, even when incised. Penetrations in unincised heart faces of these species may occasionally be as deep as 1/4 inch, but usually are less and often are not more than 1/16 inch. Long experience has shown that even these slight penetrations have value, although deeper penetrations are highly desirable. The heartwood of coast-region Douglas-fir, southern yellow pine, and various hardwoods, while highly resistant, can be made to take penetrations of 1/4 to 1/2 inch on the average and sometimes considerably more. Incising is beneficial for most of these species. The white heartwood of beech and the heartwood of the red oaks, black tupelo, and ponderosa pine can be penetrated deeply. It should be the ideal in all pressure treatments to have the sapwood completely penetrated. This can usually be accomplished in small sizes with most woods; with skillful treatment it can often be obtained in piling, ties, and structural timbers. It is not always practical, however, for the operator to insure complete penetration of sapwood in every piece when treating large pieces of round material having thick sapwood, such as poles and piling. The lower the absorption the greater the difficulty of obtaining complete penetration of sapwood.

Specifications (1, 3, 9)

Specifications covering many of the details of treatment by various pressure processes and by the hot-and-cold-bath process have been prepared by the American Wood-Preservers' Association (3). These specifications, although far from perfect, are very helpful and are used to a considerable extent by various public and private agencies in ordering treated material. They are rather broad in some respects, allowing the purchaser some latitude in specifying the details of his individual requirements. The purchaser should exercise great care, however, to avoid limiting the operator of the treating plant so closely that he cannot do a good treating job, and to avoid requiring treating conditions so severe that they will damage the wood. Federal Specification TT-W-571c(9) recommends treatment practices for use on United States Government orders for pressure-treated material.

Specifications covering treatment have also been prepared by the American Railway Engineering Association (1) and the American Association of State Highway Officials. In the main, the requirements of these specifications are similar to those of the American Wood-Preservers' Association.

Handling Timber After Treatment

Treated timber should be handled with sufficient care to avoid breaking through the treated shell. The use of pikes, cant hooks, picks, tongs, or other pointed tools that dig deeply into the wood should be prohibited. Spikes or dogs may be driven into piling near the point and near the butt when needed for forming log booms, but they should never be driven into the part of the pile that will be exposed in service. Handling heavy loads of lumber or sawed timber in rope or cable slings may crush the corners or edges of the outside pieces. Breakage or deep abrasions may also result from throwing the material or dropping it any considerable distance. When damage has resulted through carelessness or otherwise, the exposed places should be retreated as thoroughly as conditions permit.

Field Treatment of Cut Surfaces

Although cutting wood after treatment is highly undesirable, it cannot always be avoided. When cutting is necessary, the damage may be partly overcome in timber for land or fresh-water use by thoroughly brushing the cut surfaces with coal-tar creosote. Two coats of hot oil should be given if practicable, but cold application will be better than none. Brush coating cut surfaces, however, gives little protection against marine borers. A special device is available for applying pressure treatment to bolt holes bored after treatment. For wood treated with water-soluble preservatives, where the use of creosote is not practicable, a strong solution of the preservative in use may be substituted.

For treating the end surfaces of piles where they are cut off after driving, at least two generous coats of creosote should be applied with great care and thoroughness. A coat of asphalt or similar material may well be applied over the creosote, followed by some protective sheet material, such as metal, roofing felt, or saturated fabric, fitted over the pile head and brought down the sides far enough to protect against damage to the top treatment and the entrance of storm water.

Seasoning After Treatment

Timber treated with creosote and other oils may be used immediately after treatment, if desired, but a period of seasoning may help to dry the oily surfaces and make the timber a little less unpleasant to handle.

With waterborne preservatives, seasoning after treatment is important for the timbers that are to be used in buildings, or in any other place where shrinkage after placement in the structure would be undesirable. Injecting water-borne preservatives puts large amounts of water into the wood, and considerable shrinkage is to be expected as subsequent seasoning takes place. For best results, the wood should be dried to approximately the moisture content it will ultimately reach in service.

With certain proprietary, waterborne preservatives, seasoning after treatment is recommended for all material, in order to complete the chemical reactions that are intended to take place within the wood and, thus, to increase the resistance of the preservative to leaching by water.

Inspection (3)

Grade and Quality

Inspection of the timber for quality and grade before treatment is desirable. Grade-marked lumber and timber can be specified and obtained in many instances. Such material is graded at the mills and is usually dependable without additional inspection. When inspection previous to treatment is impractical, the purchaser can usually inspect for quality and grade after treatment; if this is to be done, however, it should be made clear in the purchase order.

Absorption

There is no practical way to obtain a correct determination of absorption by sampling timber after treatment, without destroying most of the timber, because of the variation in absorption between the individual pieces in a charge and the nonuniform distribution of preservative throughout the length of each piece. The purchaser, therefore, must either accept the statements or affidavit of the treating-plant operator or have an inspector at the treating plant to observe the treatments and insure compliance with the specifications. Railroad companies and other corporations that purchase large quantities of treated timber usually maintain their own inspection services. Commercial inspection and consulting service is available for purchasers able to pay an inspection fee, but not using enough treated timber to justify inspectors of their own. Care should be taken to choose experienced, competent, and reliable inspectors.

Penetration

Penetration measurements should be made at the treating plant, if inspection service is provided, but can be made by the purchaser at any time after the timber has been treated. They give about the best single measure of the thoroughness of treatment. Rejection of treated timber for insufficient penetration is hardly enforceable, however, unless there has been previous agreement with the plant operator on minimum and average penetration requirements. The specifications of the American Wood-Preservers' Association usually contain definite requirements as to penetration (3).

The depth of penetration of creosote and other dark-colored preservatives can be determined directly by observing a boring removed by an increment borer. The boring should usually be taken at about midlength of the piece, or at least several feet from the end of the piece, in order to avoid the unrepresentative end portion that is completely treated by end penetration. In poles and posts, the boring should be made near the point where the ground line will be when the pole or post is in service. Since the preservative oil has a tendency to creep over cut surfaces, the observation should be made promptly. Holes made for penetration measurements should be tightly filled with a thoroughly treated wooden plug.

The penetration of preservatives that are practically colorless must be determined by chemical dips or sprays that show the penetration by color reactions. For example, the penetration of zinc chloride is determined by spraying a cross section or boring of the wood with a solution containing potassium ferrycyanide, potassium iodide, and starch, whereby the treated area of the wood turns blue (3).

Other chemical mixtures have been developed by the promoters of proprietary preservatives for disclosing the penetration of their respective preservatives. Several of these are now included in the specification of the American Wood-Preservers' Association (3).

Effect of Treatment on Strength (12, 13, 16)

Coal-tar creosote, water-gas tar, wood-tar creosote, creosote-tar solutions, and creosote-petroleum solutions are practically inert to wood and have no chemical influence upon it that would affect its strength. Concentrated solutions of zinc chloride will attack wood, but the 2 to 5 percent solutions commonly used in preservative treatment are not harmful. If absorptions of zinc chloride of several pounds per cubic foot are used, or if the treated timber is to be used under unusually low humidities or high temperatures, the zinc chloride may seriously reduce the strength of the wood.

Although wood preservatives are not harmful in themselves, the treatment necessary in injecting them into the wood may result in considerable loss of strength to the wood. The strength of green wood conditioned for the injection of preservatives by steaming or by boiling-under-vacuum may be seriously reduced if extreme temperatures or heating periods are employed. Consequently, care should be used to keep the temperature as low and the duration of the treatment as short as is consistent with satisfactory absorption and penetration of the preservative. A temperature of 259° F. (about 20 pounds gage pressure) is sufficiently high for steam conditioning. No advantage is known to result from higher pressures, and the resulting higher temperatures are much more likely to damage the wood. The maximum temperature employed in the boiling-under-vacuum process is usually less than 220° F. Absence of scorching, checking, and collapse is not proof that there has been no reduction in strength. The effect of temperature is apparently influenced by such factors as species of wood, size and moisture condition of the timbers treated, and the length of the heating period.

The use of treating pressures greater than 175 pounds for injecting preservatives into wood that is soft from long heating is likely to cause severe end checking and collapse. Considerably higher pressures can be used if the wood has been heated for a short time only, or not at all. Woods of low density are more subject to injury from high pressures than woods of high density. It has not been definitely established that collapsed wood is seriously weakened, but both collapse and checking are undesirable and should be avoided.

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References 8, 9, 10, 13, and 14 may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at the prices stated (stamps not accepted).

References 7, 11, 17, 18, and 19 may be obtained free from the Forest Products Laboratory, Madison, Wis.