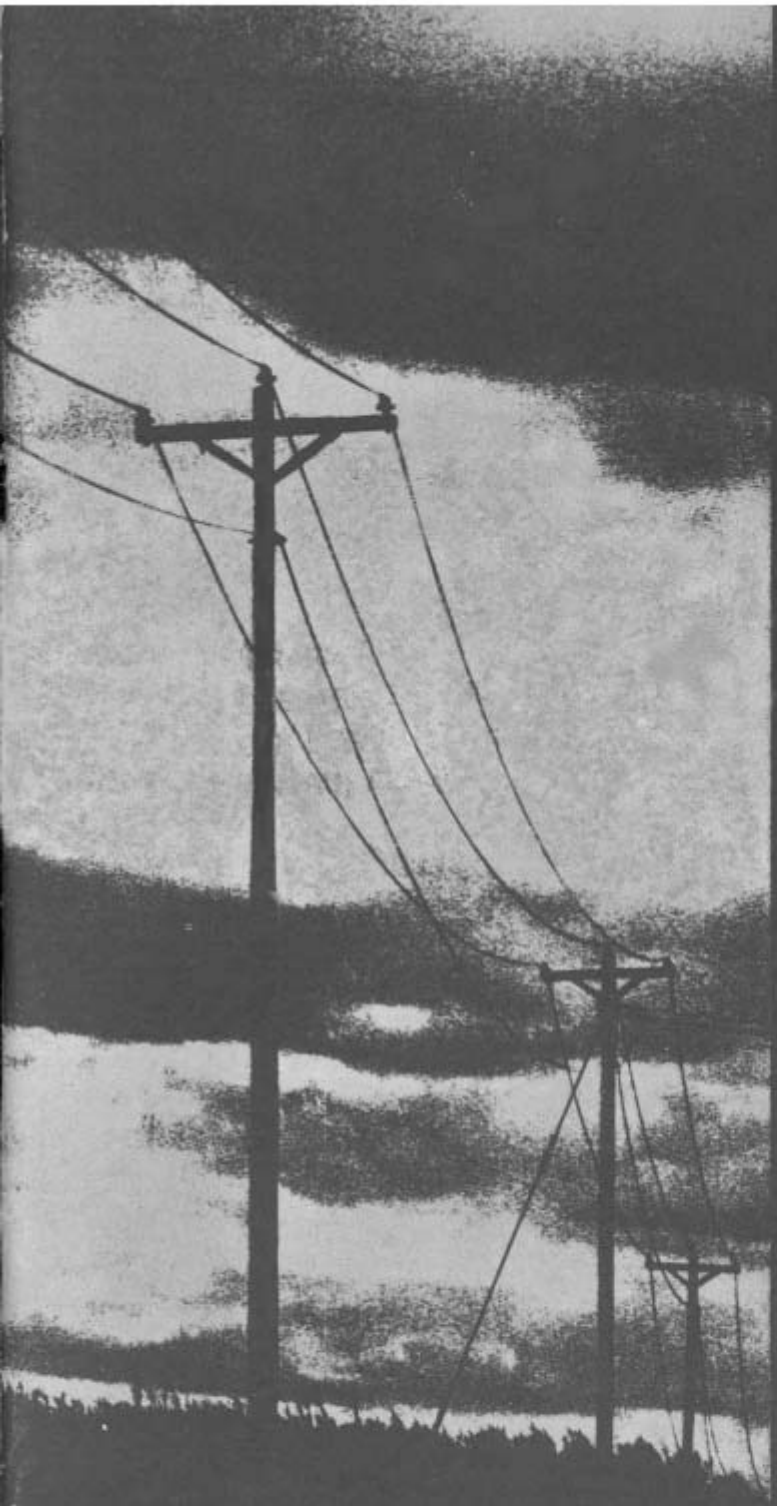


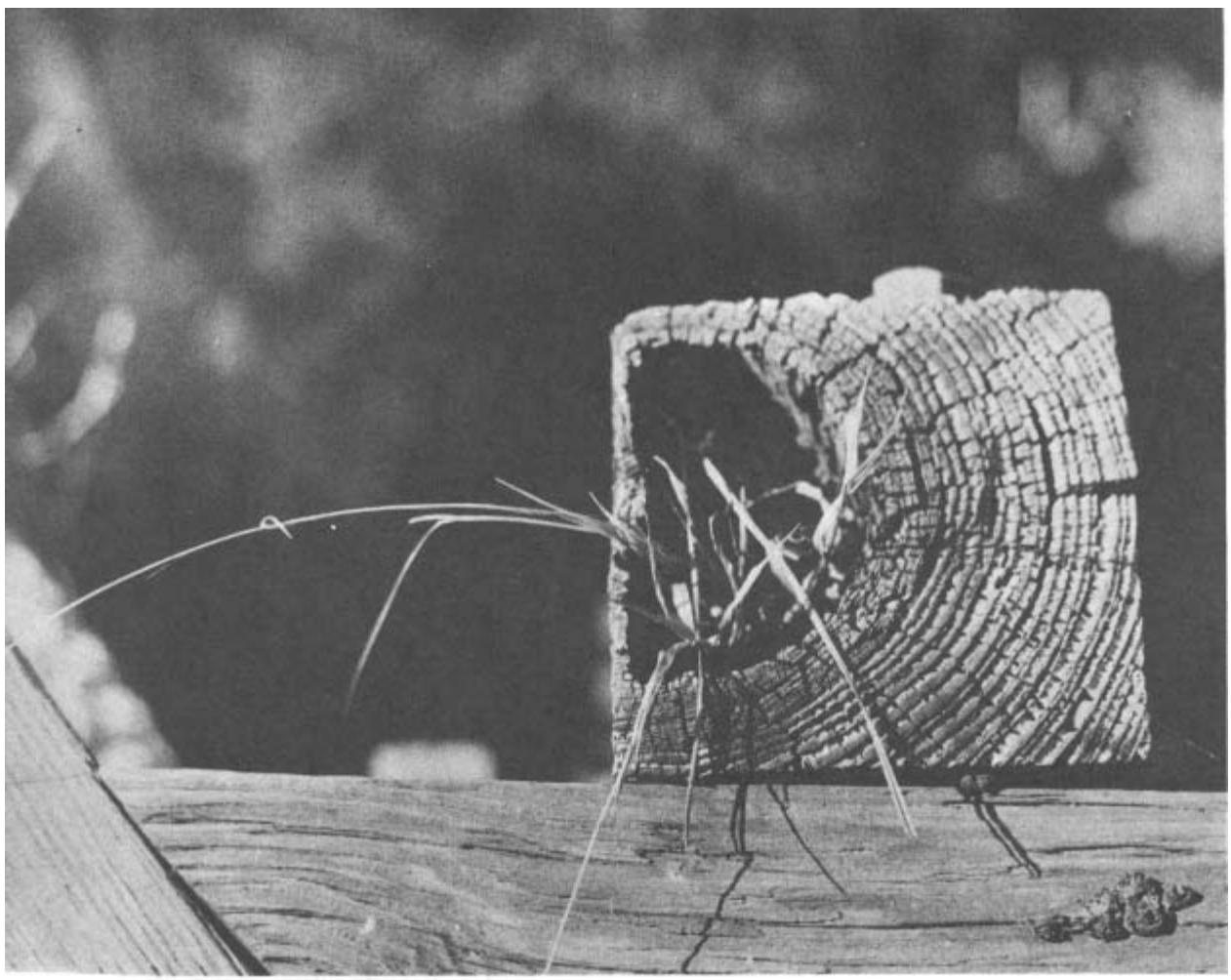
SELECTION, PRODUCTION, PROCUREMENT AND USE OF PRESERVATIVE-TREATED WOOD,

SUPPLEMENTING FEDERAL SPECIFICATION TT-W-571

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FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WIS.



This southern pine bridge timber suffered heartwood decay. Because heartwood does not usually "treat" as easily as does the surrounding sapwood, the wide treated sapwood band on the right and the thin treated border of heartwood on the left have outlasted the untreated exposed heartwood core.

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PREFACE

This report has been prepared to supplement Federal Specification TT-W-571 "Wood Preservation: Treating Practices." Developed for the General Services Administration by the U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, the Specification is used by Federal agencies, State agencies, and private users in procuring preservative-treated wood.

The economical and practical procurement of treated wood demands a knowledge of wood deterioration and means of protection. The U.S. Forest Products Laboratory, the nation's center for wood utilization research, has studied preservatives and their effects on wood for nearly three-quarters of a century. This report has been compiled to assist in the selection and procurement of treated wood products. It elucidates the technical details of the Specifications: the causes of wood deterioration, the nature and variety of preservatives, the advantages and disadvantages of different types of preservatives, and preservative treatment procedures for all uses and situations.

Single copies of Federal Specification TT-W-571 are available from the General Services Administration Regional Offices in Boston, New York, Washington, D.C., Atlanta, Chicago, Fort Worth, Denver, San Francisco, Los Angeles, Seattle, and Kansas City, Mo.

SELECTION, PRODUCTION, PROCUREMENT AND USE OF PRESERVATIVE-TREATED WOOD, SUPPLEMENTING FEDERAL SPECIFICATION TT-W-571

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INTRODUCTION

Scope of Wood Preservation

In modern usage, the term "wood preservation" denotes the treatment of wood with chemicals to impart resistance to living organisms that destroy wood. It is an important branch of the broader subject of wood protection. The latter may involve the use of chemicals to impart resistance to other destructive agents such as fire or surface weathering. Protection against mechanical wear may be obtained in a multitude of ways such as by the use of rugs on floors, steel treads on the decks of wooden bridges, or steel tie plates on railroad crossties. The design and maintenance of buildings influence the deterioration of wooden members.

Because this discussion is concerned primarily with chemical treatments of wood to prevent its destruction by living organisms, the nonpreservative aspects of wood protection will receive only casual mention. This paper has the same limitation on subject matter as Federal Specification TT-W-571, to which it may be considered supplemental.

The space available here does not permit a detailed discussion of the complex subject of wood preservation. The Forest Products Laboratory has been studying wood preservation problems and treatments for nearly 75 years. As the nation's center for wood utilization research, the Laboratory has set up preservative evaluation test plots around the country to provide service life information on tens of thousands of samples of all types of wood components and at least 50 different preservative types. A user of treated wood who desires advice on the use of any preservative or treated product may find it advantageous to consult the Laboratory. Another source of information on less technical aspects of the major wood preservatives is the American Wood Preservers' institute.[3]/

Organisms that Destroy Wood

On the basis of total damage done, fungi are by far the most important of the living enemies of wood. They are low forms of plant life that use wood as food and, by lowering its strength, render it unfit for its intended use. The condition of such wood is commonly spoken of as "rotten" or "decayed."

Fungi are found in ail parts of the world that are habitable by man. Many kinds of wood-destroying fungi have been identified by specialists. The fungi differ widely in many

1/ Baechler is a research chemist retired from the Forest Products Laboratory.
2/ Maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin.
3/ American Wood Preservers' Institute, McLean, Va.



A preservative evaluation plot provides for testing performance of treated wood under actual conditions of use. This exposure site shows some of the 11,000 stakes the Forest Products Laboratory currently has under test around the country.

(M 84 749 F)

characteristics including details of practical significance such as the conditions under which they grow most readily, their ability to attack different species of wood, and their resistance to specific chemicals.

Typical wood-destroying fungi *(brown-rot* and *white-rot)* decay damp wood but are unable to grow In wood saturated with water. Other wood destroyers grow near the surface of very wet wood. Their attack is often very slow and is called *soft-rot.* Other microorganisms cause little damage, although some molds produce an unsightly surface and some fungi stain interior sapwood without affecting strength appreciably. Some bacteria and mold fungi increase the porosity of wood and, thereby, increase its susceptibility to wetting by rain.

Next to fungi in importance as wood destroyers are certain insects, especially *termites.* While not as widespread as fungi, termites destroy tremendous quantities of wood in tropical and subtropical regions and may be found even in some temperate climates. The conditions under which they thrive are generally also favorable for fungi. Most chemicals that protect wood against decay are also more or less effective against termites. in those areas with temperate climates where there are no drywood termites, the selection of a preservative treatment is generally made from the standpoint of protection against decay. in many tropical areas, the termite hazard is often considered the more important factor.

Some damage to untreated wood is due to invasion by several other kinds of insects, notably powder-post beetles and carpenter ants.

Most coastal waters are infested with wood-attacking animals collectively known as *marine borers.* They present a special problem in wood preservation in that many chemicals that prevent attack by fungi and Insects are not effective against marine borers.

Woodpeckers occasionally damage treated poles. Some pole users have resorted to means of protection in addition to treatment with chemicals - for example, wrapping the upper parts with wire cloth.

Some mammals gnaw wood under special conditions. The aggregate damage caused in this way is small.

Because decay produced by fungi is the most widespread form of wood deterioration, protection against decay may be assumed throughout this publication to be the primary objective of wood preservation.

SELECTION

Factors in Deciding Whether Preservative Treatment is Advisable

In addition to a suitable food such as wood, the essential requirements of fungi are: (1) Adequate moisture (the amount varies with the species of the fungus), (2) a favorable temperature, and (3) at least a small supply of oxygen. Further information is needed on the requirements of other wood-destroying agents such as termites and marine borers. These requirements determine the factors that must be considered in deciding to use a preservative treatment.

Moisture Conditions

The water present in a tree when cut is generally removed partially or completely by drying before the wood is put into use. If the wood is well dried, it will remain immune to decay so long as there is no opportunity for it to absorb water. For this reason, one is inclined to consider moisture conditions first of all when attempting to assess the decay hazard of a given situation.

The presence or absence of *contact with soil* is a key factor. Wood in contact with soil may be expected to absorb sufficient moisture to promote decay. This is true even in areas of low rainfall, although decay is generally slower there than in areas of high rainfall. Not only does soil act as a reservoir of water, but it nearly always contains decay fungi and certain nutriments they require. Soil thus acts as a constant source of infection. The practical result is that most species of wood will decay when used in contact with soil. Generally, when wood for such use is treated to recognized standards, the treatment will extend the service life to many times that of untreated wood.

Exposure to rainfall in above-ground uses is another condition of use under which wood may absorb sufficient moisture to support the growth of fungi. in use above ground, the decay hazard is much more variable and more difficult to assess than where there is contact with soil. The absorption of water by wood requires some time. in areas of low-to-moderate rainfall with good drying weather between rains, rainwater on the surface of wood may evaporate before the wood has absorbed sufficient water for fungi to start growing. Where rains are frequent with short intervening drying periods, wood may be sufficiently moist much of the time for decay to proceed. in such climate, wood exposed to the weather may have a satisfactory service life only if it is given a preservative treatment.



The supporting members of this wooden patio sit directly on the ground. The treated wood is expected to last in excess of 50 years in Wisconsin's temperate climate.
(Courtesy, Forest Products Laboratory)

Only broad generalizations are possible regarding the relative decay hazard In different parts of a given building. Experience has shown that in low-to-moderate rainfall areas, horizontal members such as siding generally require no treatment. On the other hand, it is often advisable, even In those areas, to use treated wood in porches, outdoor stairways, and railings. It is difficult to avoid opportunities for water trapping in such structures. The probable need for treatment increases generally with increase In annual rainfall and average temperature. Practical experience in the area often is a good guide.

It is commonly accepted that wood used indoors will remain too dry to decay provided that the building is designed and maintained to exclude rainwater and avoid plumbing leaks.

While the weight of experience with wooden buildings seems to support this broad generalization, there are some important exceptions to it. When decay of wood occurs indoors it generally can be traced to the absorption of liquid water formed by the condensation of moisture in the air.

Wood items used above ground but requiring pressure treatment are: (1) Framing lumber in floors and walls of shower rooms: (2) framing, sheathing, trim, and doors in cold-storage rooms: (3) wood used in and around swimming pools, especially the roofs: (4) wood used wherever opportunities for condensation are not counteracted by adequate ventilation such as cold areas of some buildings, roofs of recreation halls, and other rooms that occasionally hold large gatherings of people who not only contribute to the condensation problem but are exposed to the hazard of failure in structural wood members: (5) buildings used in "wet" industries (laundries, papermilis, etc.) and in factories such as textile mills in which the air is purposely held at a high relative humidity (The increased use of air conditioning in residences, offices, factories, and public buildings has multiplied the number of situations in which condensed moisture induces decay.): and (6) wood members subjected to rainwater splash.

In some cases, this hazard can be minimized by practices that either avoid localized condensation or promote the evaporation of condensed moisture. Such measures are not always adequate, in which case the most reliable way to avoid the cost of replacing decayed wood is the initial use of treated wood.

Temperature

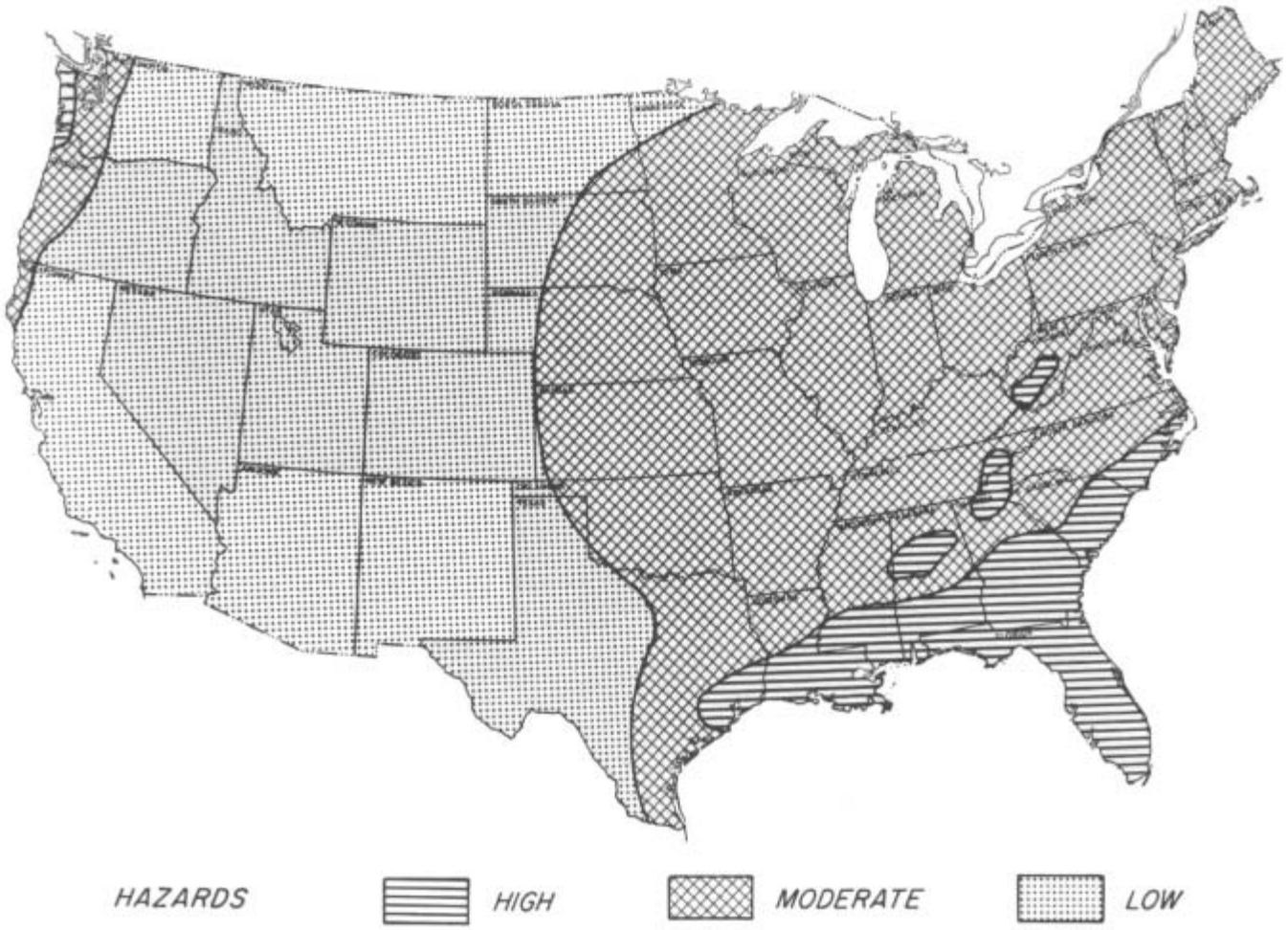
Temperature also plays an important role in the decay hazard in a given situation. Although there is no practical way of preventing decay of wood in use by controlling the surrounding temperature, the temperature of use conditions does have a bearing on the question of whether any treatment is needed and, if so, the level of protection required. Wood used out of doors in the arctic regions often gives good service without preservative treatment even though it is subject to some decay during the warmer months. As average temperatures increase, the length of the growing season increases for ail plant life including wood-destroying fungi. The rate at which preservatives are lost from wood by the combined effects of leaching and evaporation also increases. With an increase in average temperature is an increase in the probability that preservative treatment of wood is economical and also that an increased retention of preservative is advisable. In 1971, a formula to yield an index of the relative potential of a climate to promote decay in off-the-ground wood structures was published by T. C. Scheffer (6).[4]/

The steaming of pine poles and the Boulton drying (heating the wood in preservative under vacuum) of Douglas-fir poles prior to pressure impregnation are believed to have a beneficial sterilizing effect and thus prevent or retard the further development of incipient decay that may start during the period between felling and treatment. Similarly, when a long pressure period is used to treat crossties of species in which deep penetration is impossible, the sterilizing effect of the hot oil may go deeper than the preservative. These details of treatment are included in American Wood-Preservers' Association (AWPA) Standard C6 (1). AWPA Standards are adequately cross referenced in Federal Specification TT-W-571.

Oxygen Requirements

Wood-destroying fungi require a small amount of oxygen for their growth, and where oxygen is excluded wood does not decay. Thus, foundation pilings driven below the water table require no treatment if they are to be used in an area where the water table cannot drop even after several years of severe drought. Posts and poles set in the ground decay most rapidly just below ground level where there is an adequate supply of oxygen plus moisture. As a preservative is depleted by leaching or evaporation or both, decay tends to start in this area even though some other part of the piece – for example, the upper part of a pole – may have lost more preservative. Accordingly, when supplementary treatments are applied to standing poles that are starting to decay, the treatment is generally confined to

4/ Underlined numbers in parentheses refer to Literature Cited at the end of this report.



The potential of climate in promoting wood decay above ground, as indexed and mapped by Scheffer (6), may aid in deciding whether or not preservative treatment is advisable, and, if so, to what degree.

(M 145 493)

the surface from just above the groundline to 1-1/2 to 2 feet below.

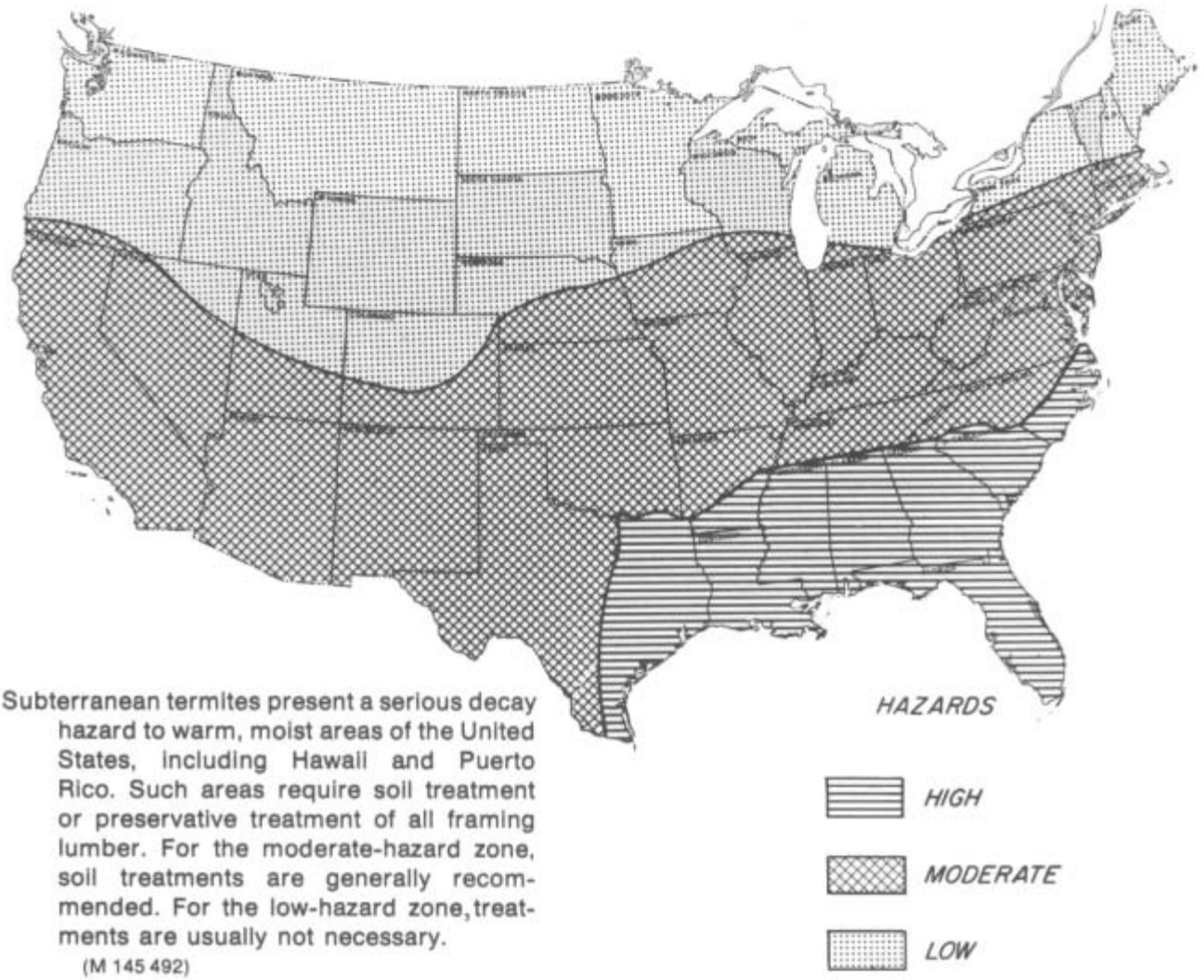
While the dissolved oxygen in seawater is generally ample for the minimum requirements of marine borers, it is sometimes reduced below this level by organic pollutants.

Termites

The protection of wood against termites involves some special considerations even though all of the standard preservatives now being used commercially are effective against termites as well as decay.

It is practical to consider the many species of termites as either subterranean or nonsubterranean. Subterranean termites avoid open air except during their brief swarming periods. They maintain their colonies in the ground and most species gain access to wood either by direct contact of the wood with the ground or through earthen tubes which they build to reach wood above ground. These tubes may extend over treated wood (or masonry) in the substructure in order to reach untreated wood above the foundation. Subterranean termites can often be controlled by chemical treatment of the soil around and under a structure.

Nonsubterranean termites do not require any contact or connection with the soil. They are widespread in the tropics but are found in only limited areas in this country. Attack by species found in the United States can be



Subterranean termites present a serious decay hazard to warm, moist areas of the United States, including Hawaii and Puerto Rico. Such areas require soil treatment or preservative treatment of all framing lumber. For the moderate-hazard zone, soil treatments are generally recommended. For the low-hazard zone, treatments are usually not necessary.
(M 145 492)

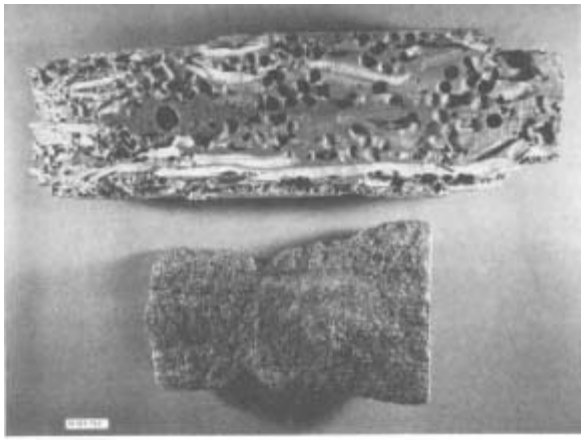
prevented by treatment of the wood with normal retentions of preservatives selected for this use. All surfaces of the wood cut after treatment must be given in-place treatment.

Marine Borers

Marine borers live in saline or brackish waters. Many kinds occur throughout the world. The most important ones fail into two broad groups based on their general structure and their method of attacking wood: Mollusks are distantly related to oysters and clams; crustaceans are distantly related to lobsters and crabs.

Of the wood-boring mollusks, *Teredo* and *Bankia* are most widely distributed. They look like worms and are frequently called *shipworms.* They enter the wood in the form of larvae which make very small entrance holes in the surface. Once within the wood they increase greatly in site, subsisting mainly on aquatic micro-organisms which they obtain with a pair of siphons extending through the wood surface. They are extremely destructive of untreated wood. During their most active season they may destroy a small piece of lumber within a month. *Pholads,* such as *Martesia,* look like small clams and are known as piddocks. They also enter wood as young individuals by boring small entrance holes. They do considerable damage to wood in tropical and semitropical harbors.

Of the crustacean borers, *Limnoria* (also called gribbles) are the most widespread and destructive. Unlike the wood-boring mollusks,



Teredo and *Bankia* (upper) and Limnoria (lower) borers weaken wood severely and make it subject to erosion. Wood treated with proper preservatives will resist attack by these marine borers.
(M 139 752)

they are small free-swimming animals that do not become imprisoned in the wood. They form shallow galleries near the surface of the wood and, while the effect may seem superficial at the start, the honeycombed texture that is formed is subject to erosion by the action of waves and debris.

Protection of wood against decay can be discussed conveniently as a single subject even though there are wide differences between the many fungi to be combatted. On the other hand, protection against marine borers involves several problems, some of which have been solved satisfactorily while others remain to plague students of wood preservation. The wood-boring mollusks, during their larval stage, are extremely susceptible to creosote. Treatment with creosote has been found by long experience to give good protection to piling in harbors infested only with teredine borers (shipworms). Unfortunately, *Limnoria* possess considerable resistance to creosote. This is especially true of *Limnoria tripunctata,* which is found in warmer harbors. Treatments more effective than creosote alone have been developed and are in use, but some problems in their use remain to be solved by research now in progress. This is discussed In "Exposure Conditions."

Cost Factors

Most users of wood products are interested in wood preservation as a means of reducing the annual cost of maintaining wooden structures. The economic aspects of the subject are quite involved, and have undergone extensive study. Some of the mathematical formulae that have been developed are applied by large users of treated wood, such as railroad and public utility companies. This discussion will be limited to a few basic principles for deciding whether treated wood should be specified and, if so, what level of protection is justified by the value of the product, the cost of replacing it, and the anticipated service life.

The cost of treating wood is the sum of separate items, some of which are readily recognized – for example, the delivered and storage cost of the preservative, the transportation of the wood from the growing area to the treating plant, processing costs such as labor and power, and capital costs such as plant overhead and inventory costs on material held for seasoning prior to treatment.

The cost of replacing a wood product includes the costs of materials, transportation, and the labor required for the relacement. In addition, there may be hidden costs such as the loss of revenue from a utility line that is temporarily out of service. The relationship between material costs and labor costs varies greatly; on small repair jobs, labor costs tend to be much higher than material costs. This is often overlooked in judging the benefits of preservative treat ment.

Voluminous service data have been collected and published in AWPA annual proceedings and elsewhere on some wood items such as crossties, poles, and posts. These enable one to estimate the annual costs of the treated versus the untreated items. Such data on other wood items are quite meager. Helpful information on some questions along this line may be available at the Forest Products Laboratory.

Naturally Durable Species

The advantages and disadvantages of naturally durable wood are not strictly a branch of wood preservation, but are related to it. During the growth of trees, some materials that are not part of the wood cell wall are deposited within the wood; because they

can be extracted with solvents, they are called *extractives.* In some species, the extractives in the heartwood are toxic to fungi and insects and so the wood is referred to as “naturally durable.”

The amount of extractives varies from species to species, from tree to tree of the same species, and also from different parts of the same tree. This explains the variability in decay resistance that has been found in heartwood boards of the same species.

The heartwoods from old-growth redwood and western redcedar constitute the chief sources of softwood lumber with natural decay resistance.

Douglas-fir heartwood is moderately decay resistant. The absorption of water by the wood is slow, so that when it is used above ground in low-to-moderate rainfall areas where rapid drying conditions prevail between rains, untreated Dougias-fir heartwood may perform well. On the other hand, untreated Douglas-fir heartwood has been found to be unsatisfactory for waterfront structures, Including decking. Preservative-treated lumber should be specified for such use.

The situations in which untreated lumber of decay-resistant species gives good service are found most commonly in above-ground members of buildings in areas of low-to-moderate decay hazard. Examples are porch

When wood is to be used In contact with ground or water, preservative treatment is more reliable than dependence on natural durability.

The natural durability of heartwood Is also a controlling factor in the service life to be expected from treated poles of species that have thin sapwood which usually does not give satisfactory penetration of preservative. Many cedar poles with treatment confined to a narrow sapwood band have been used, especially in the northern part of the United States, and on the average have given excellent service.

Types of Preservatives

For purposes of discussion, it is convenient to separate commercial preservatives into two groups: Oil-type and waterborne. Each group possesses characteristic advantages and disadvantages.

Oil-type Preservatives

The oil-type preservatives fall into two main classes: (1) Coal-tar creosote and solutions of creosote with coal tar or petroleum oils, and (2) solutions of a preservative chemical dissolved in a suitable nonaqueous carrier. In a high percentage of such solutions, pentachlorophenol is the preservative chemical. The carrier is often, although not always, an oil, derived in processing crude petroleum. Such carriers vary greatly in volatility, with the choice depending upon the need for cleanliness of the treated product. The performance of the treated wood and the cleanliness of the surface are influenced by the nature of the carrier. Where paintability is desired, the carrier may consist of a volatile solvent. In some treatments of specialty products that may come close to or into contact with foodstuffs, copper-8-quinolinolate is the only preservative recognized in Federal Specification TT-W-571. Tributyitinoxide (TBTO) is a relatively new preservative in the continental United States: until now it has been used principally in tropical and subtropical areas in which dry-wood termites are very active. it is now recommended that an EPA-registered insecticide be added to the TBTO preservative.

Waterborne Preservatives

In treatments with waterborne preservatives, the chemicals are dissolved in water alone or in water containing either ammonia or acidic compounds that hold the preservative chemicals in solution. Some chemical changes may take place within the wood and if they result in compounds that are very low in solubility, the preservative is designated as *leach-resistant.* Waterborne preservatives which do not form insoluble compounds are assumed to be *leachable.*

Leach-resistant.–Of the waterborne preservatives in commercial use, five formuiations comprise mixtures that undergo changes In the treated wood whereby relatively insoluble materials are deposited: (1) *Acid copper chromate* (ACC) is a mixture of copper sulfate and sodium dichromate with some additional chromic acid. The chromium compounds react chemically with wood substance with a resulting decrease in acidity; this permits the deposition of Insoluble copper chromate. *Chromated copper arsenate* (CCA) mixtures contain copper and arsenic compounds and also hexavalent chromium compounds that solubilize other ingredients of the treating solution but are later reduced by the wood with a resulting deposition of insoluble copper-chromium-arsenate complexes of indefinite chemical composition; (2) *CCA Type I* contains the highest percentage of chromium, (3) *CCA Type II* is highest in arsenic; and (4) *CCA Type III* is intermediate in the ratio of chromium to arsenic; (5) *Ammoniacal copper arsenate* (ACA) treating solution may be thought of as a mixture of copper hydroxide plus arsenic acid dissolved in dilute ammonium hydroxide. In modern practice, other compounds of copper and arsenic are generally used. After treatment, evaporation of the ammonia accompanied by oxidative changes results in the deposition of insoluble copper arsenate in the wood.

Leachable.–Federal Specification TT-W-571 covers two waterborne preservatives subject to leaching from wood: (1) *Chromated zinc chloride* (CZC), a mixture of zinc chloride and sodium dichromate, and (2) *fluor-chrome-arsenate-phenol* mixtures (FCAP) consisting of sodium fluoride, sodium chromate or sodium dichromate, and sodium arsenate, plus either dinitrophenol or sodium pentachiorophenate. These preservatives are used mainly for treating lumber intended for use where leaching conditions are not severe.

Oil-type vs Waterborne

At one time it was accepted that only oil-type preservatives were suitable for treating wood to be used in ground contact or other situations where leaching conditions prevailed. With the development of waterborne formulations that deposit leach-resistant compounds in the wood, this principle is no longer valid.

Oil-type preservatives are lost by exudation followed by washing from the surface and also by evaporation. The loss of creosote by evaporation from treated wood may be minimized by the use of creosote having a high percentage of the higher-boiling-point constituents. The loss can also be compensated for by the injection of high initial retentions. The relative permanence of creosote in wood is demonstrated by the fact that some creosoted utility poles used in England have been found to be sound after a century of use.

Service records this old are, of course, lacking for the leach-resistant waterborne preservatives, the commercial use of which started during the late 1930's. The same is true of pentachlorophenol solutions, first used commercially in the 1940's. However, the analyses of treated specimens removed after many years of exposure to damp soil have shown insignificant losses, indicating that properly applied pentachlorophenol solutions and leach-resistant waterborne preservatives have a very high order of permanence.

It has been mentioned that in addition to affording protection against decay and insects, creosote and solutions of pentachlorophenol In heavy petroleum oils also retard weathering and checking. This explains their wide use for treating products that have no exacting cleanliness requirements.

The advantages of waterborne preservatives stem mainly from their cleanliness, paintability of the treated wood, and freedom from odor. This is especially important in the treatment of sawn wood for many uses and also has a bearing on the acceptability of treated poles and posts for some uses. This subject will be discussed further in later pages.

Methods of Application

The two main features of a preservative treatment are the preservative used and the method of applying it. The results will also be affected by the treatability of the species selected (table 1).

Table 1 .–Treatability of heartwood of various species

Group 1 .–Heartwood least difficult to penetrate

Softwoods	Hardwoods
Bristlecone pine *(Pinus aristata).*	American basswood *(Tilla americana).*
Pinyon pine *(P. edulis).*	Beech (white heartwood) *(Fagus grandifolia).*
Redwood *(Sequoia sempervirens).*	Black tupelo (blackgum) *(Nyssa sylvatica).*
	Green ash *(Fraxinus pennsylvanica* var. *lanceolata).*
	Pin cherry *(Prunus pensylvanica).*
	River birch *(Betula nigra).*
	Red oaks *(Quercus spp.).*
	Slippery elm *(Ulmus fulva).*
	Sweet birch *(Betula lenta).*
	Water tupelo *(Nyssa aquatica).*
	White ash *(Fraxinus americana).*

Group 2.–Heartwood moderately difficult to penetrate

Softwoods	Hardwoods
Baldcypress *(Taxodium distichum).*	Bigtooth aspen *(Populus grandidentata).*
California red fir *(Abies magnifica).*	Black willow *(Salix nigra).*
Douglas-fir (coast) *(Pseudotsuga menziesii* var. *menziesii).*	Chestnut oak *(Quercus montana).*
	Cottonwood *(Populus spp.).*
Eastern white pine *(Pinus strobus).*	Mockernut hickory *(Carya tomentosa).*
Jack pine *(P. banksiana).*	Silver maple *(Acer saccharinum).*
Loblolly pine *(P.* taeda).	Sugar maple *(A. saccharum).*
Longleaf pine *(P. palustris).*	Yellow birch *(Betula lutea).*
Ponderosa pine *(P. ponderosa).*	
Red pine *(P. resinosa).*	
Shortleaf pine *(P. echinata).*	
Sugar pine *(P. lambertiana).*	
Western hemlock *(Tsuga heterophylla).*	

Group 3.–Heartwood difficult to penetrate

Softwoods	Hardwoods
Eastern hemlock *(Tsuga canadensis).*	American sycamore *(Platanus occidentalis).*
Engelmann spruce *(Picea engelmannii).*	Hackberry *(Celtis occidentalis).*
Grand fir *(Abies grandis).*	Rock elm *(Ulmus thomasi).*
Lodgepole pine *(Pinus contorta* var. *latifolia).*	Yellow-poplar *(Liriodendron tulipifera).*
Noble fir *(Abies procera).*	
Sitka spruce *(Picea sitchensis).*	
Western larch *(Larix occidentalis).*	
White fir *(Abies concolor).*	
White spruce *(Picea glauca).*	

Group 4.–Heartwood very difficult to penetrate

Softwoods	Hardwoods
Alpine fir *(Abies lasiocarpa).*	American beech (red heartwood) *(Fagus grandifolia).*
Corkbark fir *(A. lasiocarpa* var. *arizonica).*	American chestnut *(Castanea dentata).*
Douglas-fir (Rocky Mountain) *(Pseudotsuga menziesii* var. *glauca).*	Black locust *(Robinia pseudoacacia).*
Northern white-cedar *(Thuja occidentalis).*	Blackjack oak *(Quercus marilandica).*
Tamarack *(Larix laricina).*	Sweetgum (redgum) *(Liquidambar styraciflua).*
Western redcedar *(Thuja plicata).*	White oaks *(Quercus spp.).*

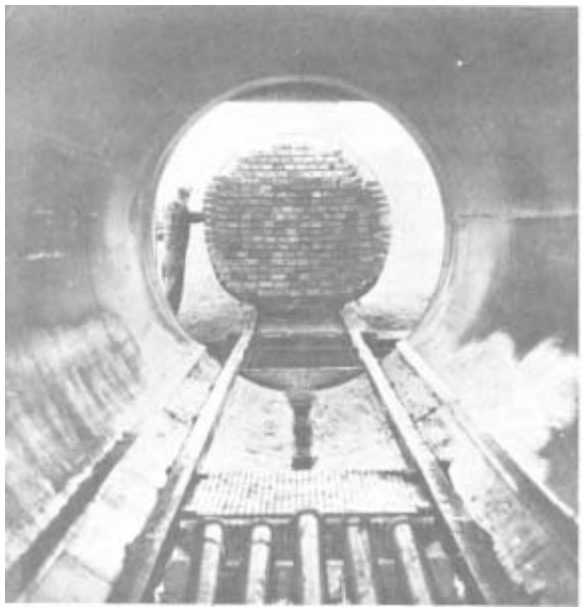
Furthermore, the wood must always be sound at time of treatment; no preservative will restore strength that has been lost by decay.

A countless number of methods have been tried in efforts to protect wood from its natural enemies. A fairly large number have been more or less successful in the attainment of this objective but – often for economic reasons – have found little or no use. This discussion will focus attention on the methods that are now being used commercially to produce the treated wood available on the market. A few comments will concern supplementary treatments that may be applied to treated wood that has begun to decay and also to simple, onsite methods that may be practical for the wood user.

In the wood-preserving industry, treating methods are arbitrarily divided into two classes, *pressure* and *nonpressure.* The essential features of a pressure method are that wood is surrounded by liquid preservative in a closed vessel and hydrostatic pressure is applied to force the liquid into the wood. All other methods are called nonpressure, even though the movement of liquid into wood is caused by some form of pressure.

Pressure Methods

Pressure methods dominate the commercial treatment of wood. They offer several advantages. In many species, deeper and more uniform preservative penetrations may be obtained by pressure as compared with nonpressure methods. When very high retentions are desired, they are more likely to be obtainable by pressure methods. When relatively low retentions are adequate, they are subject



A charge of decking on trams is about to enter a pressure treating cylinder.
(M 113 859)

to better control with pressure methods. With a few exceptions to be noted later, the purchaser should specify pressure treatment of a suitable species when maximum protection is needed.

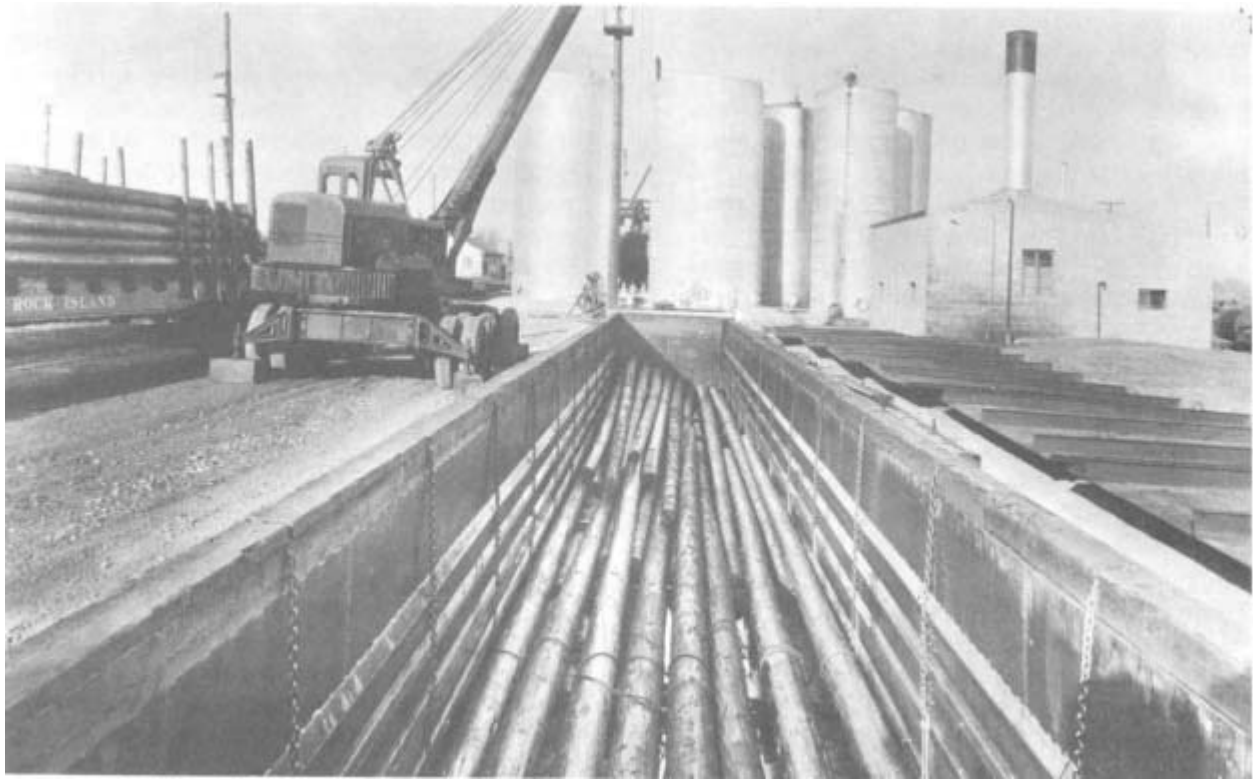
Pressure methods may be used for either *full-cell* or *empty-cell* treatments. In full-cell treatments, the wood is first subjected to a vacuum, which is maintained while the cylinder is being filled, so that the wood retains as much as possible of the liquid injected. In treatments with oil preservatives, full-cell methods are used for products such as marine piling which require the highest retentions that may be obtained. Full-cell methods are also generally used in treatments with waterborne preservatives.

Two empty-cell methods are used, namely the *Rueping* and the *Lowry* processes. In the Rueping process, air is first injected into the treating cylinder containing only the wood. The intensity of air pressure depends upon the judgment of the operator who takes into consideration the character of the wood, especially the species and moisture content. The cylinder is then filled with preservative in such a way that the injected air is trapped in the wood. A higher pressure is then applied, forcing preservative into the wood and further compressing the imprisoned air. When the desired absorption has been obtained, the pressure on the preservative is released and, as it falls, the compressed air in the wood expands and forces out a considerable amount of preservative. After the pressure has fallen to atmospheric, a vacuum is applied to accelerate the recovery of preservative. The amount of preservative injected initially is called the gross *absorption;* the preservative recovered is called the *kickback;* and the amount of preservative remaining in the wood is designated as the *retention.* In the Lowry process, the cylinder is filled under atmospheric pressure.

Empty-cell methods are used when the objective is as deep penetration as possible with a limited amount of preservative. Such methods are nearly always used in treatments of poles and lumber with oil-type preservatives and are also used in treatments of crossties of the more readily treatable species. Final steaming or an expansion bath is often used to promote surface cleanliness.

Nonpressure Methods

In the United States, the *thermal process,* also called the hot-and-cold process, is the most important nonpressure process for treating wood to be used in ground contact. It is the only nonpressure process covered by specifications of the American Wood-Preservers' Association and, by reference, Federal Specification TT-W-571. It consists of immersing wood successively in baths of hot and relatively cool liquid preservatives. Immersion in the hot bath expands the air in the outer zones of the wood, whereby some air and water vapor are expelled. The cold bath then causes the remaining air and water vapor to contract, thus forming a partial vacuum within the wood. Atmospheric pressure forces liquid into the wood in an amount sufficient to satisfy the vacuum. The most important application of this method lies in the treatment of poles of several species. Approximately half of the poles treated by the thermal process are of western redcedar, a species with a thin sapwood and a naturally durable heartwood. Some poles of several other western species–e.g., Douglas-fir, western larch, and lodgepole pine – are also treated in this manner. Either creosote or pentachlorophenol solutions can be used.



Huge vats are required to hold poles in immersion-type thermal treating processes.
(M 130 272)
(Courtesy, Bell Lumber & Pole Co.)

Modern specifications call for some incising of some species of poles. Incising is puncturing of the lateral surfaces of wood to obtain deeper and more uniform preservative penetration. Sometimes incising is confined to the groundline area of the poles, but full-length incising is also practiced.

An alternate to the hot-and-cold technique is the *vacuum process* whereby a partial vacuum in wood is created by placing the dried wood in a tightly covered tank and mechanically evacuating the air. After the vacuum has been held for a proper period of time, the tank is filled with liquid preservative, and air at atmospheric pressure is admitted. This causes liquid to move into the wood to satisfy the partial vacuum. Frequently a final vacuum is applied in order to recover excess preservative. This method finds some use in the treatment of lumber and millwork of easily treated species. The preservative most commonly used is pentachlorophenol plus a water-repellent material dissolved in a light petroleum solvent.

When seasoned wood is immersed for extended periods In cold, oil-type preservatives *(cold-soak process),* it tends to absorb oil by capillary movement into air spaces. The amount of oil absorbed and the depth of penetration are extremely variable. As a rule they are insufficient to give good protection to wood used in ground contact. The most favorable conditions prevail when an easily penetrated wood such as pine sapwood is thoroughly air-dried so that considerable checking has developed. Absorptions may vary from amounts that are too low to give good protection to amounts that are excessive from a cost standpoint. The method has been promoted with mediocre success as a means of treating fenceposts on farms.

Although short immersion in oil-type preservatives *(dip-treatment process)* yields even poorer results, it is used much more extensively than longtime immersion. The protection afforded is adequate for certain

wood products used under very mild decay conditions. Window sash and frames and millwork are the outstanding examples of products that have been treated successfully by this process. Although penetration into the sides is quite superficial, penetration into the ends of absorbent wood such as pine sapwood is appreciable. This is the area of the most iikely absorption of water that may form occasionally due to condensation of moisture in the air. Pentachlorophenol dissolved in low-boiling-point solvents is the standard preservative used; it is commonly supplemented by water-repellent additives which improve the performance. The method has proven its value by many years of experience with the treated products used under very miid decay conditions and, therefore, is used extensively in the millwork industry. The U.S. Commercial Standard CS 262-63, "Water-Repellent Preservative, Nonpressure Treatment for Millwork" (7), describes this type of treatment.

It should be noted that these good results have been obtained only under miid decay conditions and on products that can be completely machined before treatment so that there is no occasion for cutting away the more heavily treated end grain. Similar results cannot be expected from treatments of lumber that may be end-trimmed before installation. The preservative and solvent for the dip-treatment process is prescribed in Federal Specification TT-W-572.

Brushing or *spraying* the surface of wood with a liquid preservative results in limited absorption. However, it is useful in protecting cut surfaces of treated wood, especially exposed end grain which absorbs more preservative than does side grain. Preservatives in *paste* or *grease form* are also used for this purpose and have an advantage over liquids in that a greater amount is held on the surface. Pastes are also widely used in groundline treatments of standing poles.

When dry wood is immersed in an aqueous solution of a preservative chemical, there is a rapid absorption of solution by the outer layers. This causes swelling which has the effect of closing the inner passages and rapidly retarding the rate of absorption of liquid. Subsequent uptake of liquid is surprisingly slow.

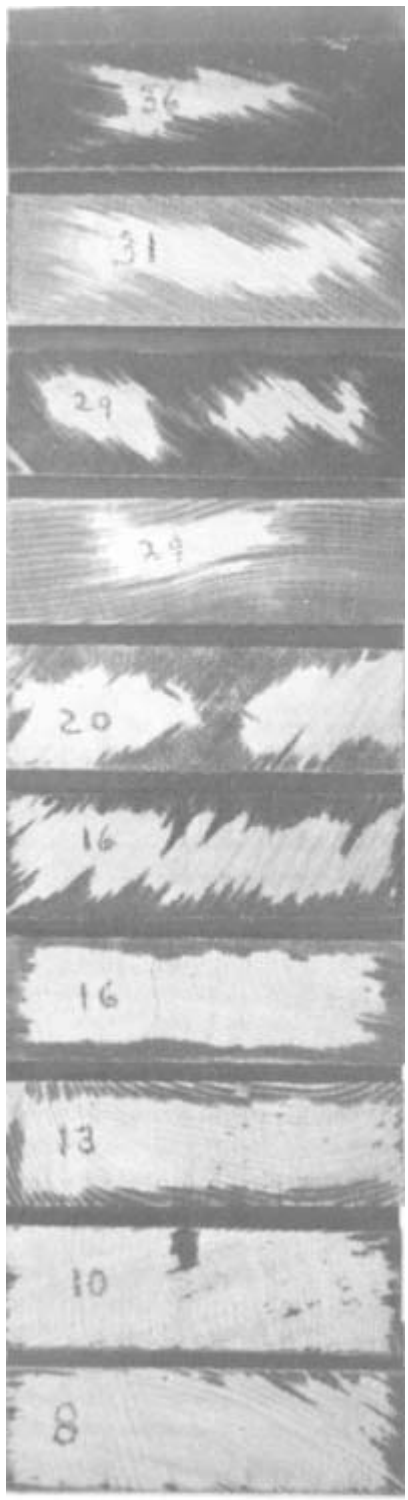
When green or partially seasoned wood is held in contact with a solution of a water-soluble chemical, the individual molecules of the dissolved chemical have a decided tendency to move into the liquid water present in the wood. This spontaneous movement of a dissolved chemical independent of the solvent is called *diffusion.* There are a number of ways in which this phenomenon has been utilized to introduce preservative chemicals into wood. For example, green wood has been soaked in, or dipped in, or brushed or sprayed with various solutions and pastes. The chemicals applied by this method tend to leach out if the wood is used in wet places.

A modification of the one-stage diffusion process is the method called *double-diffusion* in which wood is treated successively with two chemicals that react with each other within the wood to deposit a preservative compound that is highly resistant to leaching. The results on some species, especially pines and several other conifers, have been excellent, comparing favorably with results obtained by pressure methods. A set of 100 southern pine posts, treated by double-diffusion and installed in a test site of high decay and termite hazard in southern Mississippi, showed 11 percent loss after 34 years as compared with an average life of 3.3 years for untreated posts. The method has not as yet been widely promoted. At present, double-diffusion-treated wood is available in only a few areas in the United States.

Treatability of Various Species

Regardless of the method of treatment used, treatment results may vary greatly within species, and from one Species of wood to another (table 1). With pressure methods, the sapwood of most species can be impregnated much more readily than heartwood. it is in the treatability of the heartwood that one finds the widest differences between species. In a few species – for example, most of the red oaks – even the heartwood takes treatment readily by pressure methods, whereas in a few species even the sapwood is difficult to penetrate.

Many species have heartwood of intermediate treatability. In a few commercially important species, the heartwood is practically impenetrable by commercial treating processes. incising the wood before treatment improves results greatly in some species but not in others.



The degree to which wood will accept treatment varies from species to species and within species as illustrated by these cross sections of redwood.

(M 113 484)

In the selection of species acceptable for a given product, the strength properties are practically always of prime Importance; but when the item is to be used where treatment is necessary, the treatability is also a controlling factor. In Tables I, II, and Ill of Federal Specification TT-W-571, the acceptable species for each product are those which will take treatment, are most commonly treated, and are, therefore, available on the market in treated form. When incising prior to treatment is necessary for satisfactory penetration, it is designated as a requirement of the specification.

Other Factors in Selecting a Preservative

The primary requirement of a wood preservative is that it prevent destruction by living organisms. Other properties affect the acceptability of a treatment for a given product; if they are overlooked, the investment in treating may not be returned.

Cleanliness

The importance of cleanliness depends greatly upon the intended end use of the treated wood. A very clean surface on the treated lumber in stadium seating is essential: at the other extreme, an oily or tarry deposit on the surface of railway crossties is considered by the railroad industry to be a virtue. By protecting against weathering as well as decay, it increases the service life of crossties. Between these extremes are products for which the importance of cleanliness depends upon the location in which the product is used. in a highway bridge, a structural member that will be used unpainted would have no exacting requirements on cleanliness, but a handrail should be treated only with a preservative that leaves a clean surface. Similarly, an exudate on the surface of a treated pole may cause little trouble in a lightly populated area, but would be objectionable if the pole were used where occasional contact by people could be expected.

Heavy oil-type preservatives tend to creep along nails and may stain materials such as finish lumber, plywood, insulation board, or plaster in contact with the treated wood. Asphalt shingles may be softened around the heads of nails driven into such wood. Such

problems can be avoided by the use of wood treated with waterborne preservatives.

In most cases where the cleanliness of a product is highly important and a definite decay hazard exists, the preservative chosen should be either a waterborne preservative or pentachlorophenol dissolved in a volatile carrier. Exceptions exist in the use of TBTO and copper-8-quinolinolate.

Paintability

As a general rule, wood treated with either creosote, creosote-containing solutions, or pentachlorophenol dissolved in a heavy petroleum solvent, cannot be painted satisfactorily.

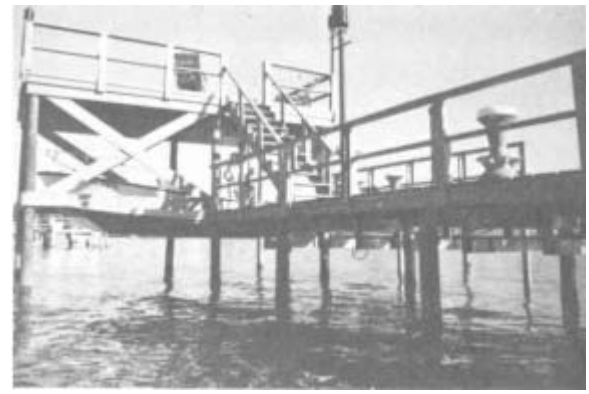
Difficulties may be encountered in painting wood that is pressure treated with pentachlorophenol in a light petroleum solvent. AWPA P9 solvents types B and D are least likely to cause painting problems.

Resinous wood treated with a volatile solvent may have a surface deposit that interferes with painting. This may be removed by sanding, or washed off with a suitable solvent. A better procedure, and one that should be specified by the purchaser, consists of steaming the wood to set the resin. A minimum temperature of at least 165° or 170° F solidifies the resins and reduces the possibility of it bleeding through the paint flim. When such wood is purchased and painting is contemplated, the supplier should be required to designate a type or brand of paint that will give satisfactory results.

Generally, painting problems tend to decrease with decrease in retention of preservative. However, even in a charge that is pressure-treated to minimum average retentions as required by Federal Specification TT-W-571, the more receptive pieces will retain enough preservative to interfere with painting. Allowing the wood to dry before painting is helpful but is of limited practicability because of the time required. The buyer should advise the supplier if painting is contemplated.

For a mild decay hazard, a water-repellent pentachlorophenol solution in an oil carrier can afford adequate protection even at the low retentions obtained by dipping, brushing, or spraying. Such treated surfaces generally may be painted satisfactorily.

Wood treated with a waterborne preservative should be properly seasoned after treatment (to 19 pct moisture content or less) and may require light brushing or sanding to provide a paintable surface.



The choice of a preservative treatment is often limited by the need or desire for a clean surface or a paint coating over the treated wood of a structure such as this dock. Yet another part of the same structure may demand a high-powered preservative treatment that can't be disguised.

(Courtesy, Koppers Co.)

Gluability

Deposits on the surface of treated wood present problems in gluing as well as in painting. Such problems are more likely to be caused by treatments with oil-type preservatives than with waterborne preservatives. Basic principles in all gluing of treated wood are that the wood should be surfaced before gluing and that the glue must be selected to be compatible with the preservative and with the exposure conditions.

Wood treated with very high retentions of creosote or pentachlorophenol in a heavy solvent is practically nongluable. Wood treated with low retentions of these preservatives, allowed to dry, and surfaced just before gluing may be glued with fair success.

Wood treated with low retentions of pentachlorophenol in a light petroleum solvent may be somewhat more adaptable to gluing than creosoted wood but, here again, surfacing just before gluing is essential. The presence of a water-repellent material intensifies interference with gluing. Even for wood

containing the low retentions of these materials as are obtained in dip treatments, surfacing before gluing is essential.

Wood treated with waterborne preservatives and *organic* fire retardants has been glued successfully, but not all glues are compatible with a given treatment and must be selected accordingly. Consultation with both the manufacturer of the glue and the wood treater is recommended. Before wood treated with a waterborne preservative can be glued satisfactorily, it must be brought to a moisture content suitable both for the intended use and for the making of good glue joints. *Inorganic* fire-retardant formulations cause serious troubles in structural gluing but not in the application of solvent-based contact or construction adhesives.

Odor

Some treated wood has an odor characteristic of the preservative. This is seldom very objectionable when the wood is used outdoors but may be troublesome in indoor exposure.

Freshly creosoted wood has a fairly strong odor which tends to disappear in time. Wood treated with creosote at retentions of up to 8 pounds per cubic foot and air seasoned to dry the surface has been used for sills and floor joists, and in many cases the slight odor has not been considered objectionable. The interiors of some buildings such as factories or warehouses are so well ventilated that the odor of wood treated with moderate retentions of oil-type preservatives is barely noticeable. On the other hand, even a relatively mild odor may be undesirable in residences or offices, or in storage rooms that are kept closed for extended periods. As a general rule, it is advisable to avoid the use of any preservative that has an appreciable odor if the wood is to be pressure treated and then used indoors. Exceptions to this rule (as have been cited in “Oil-type Preservatives”) may arise, but careful consideration should be given to service conditions before departing from the rule. The waterborne preservatives, being odorless, are preferable for such situations. This is especially true when the treated wood is used in proximity to foods, such as dairy products, that are prone to absorb odors.

Corrosiveness to Metal Fastenings

The metals commonly used on fasteners are compatible with wood that is dried before use and remains dry. The corrosion (rusting) of common iron fasteners causes practically no trouble in wood that is used indoors. Even in exteriors where occasional wetting followed by drying is encountered, the rusting of common wire nails is generally not a serious problem. As the moisture content increases, the rate of corrosion increases whether the wood is treated or untreated. Along with the obvious loss in the strength of the nail, a deterioration of surrounding wood occurs due to a chemical degradation that is catalyzed by iron salts. The enlargement of the nail hole not only contributes to the loosening of the nail but also leads to the entrapment of water, accelerating further corrosion. The iron salts resulting from corrosion spread to surrounding wood, producing a stain that is objectionable on products such as siding.

Some species of wood contain acidic extractives that accelerate corrosion. For this reason, iron nails have long been supplanted by copper nails in the construction of redwood cooling towers. Galvanized nails and nails of nonferrous metals are commonly used In siding of species that contain acidic extractives – for example, redwood and the cedars.

Whereas the heavy oil-type preservatives are likely to retard corrosion of metals, some waterborne preservatives are not. This is particularly true when the treated wood containing metal fasteners is used under moist conditions. In wood treated with nonleaching waterborne preservatives, the effect on the rate of corrosion is not pronounced in aboveground exposures; but if the same wood is used where it may remain damp for extended periods, fastenings should be made of a corrosion-resistant metal such as copper, stainless steel, or silicon bronze. The need is greatest for nails driven into horizontal surfaces such as bridge decking. Corrosion-resistant fastenings should be used in wood foundations because of the need for very long service life.

The inorganic fire-retardant salt formulations present a special problem. These salts in wood will absorb moisture from the air whenever the relative humidity exceeds 75 to

85 percent, and at 90 percent R.H. the wood may become quite wet. Under frequent or long-time exposure to these humidity conditions, corrosion of hardware can be expected. There are formulations of organic fire retardants on the market that will not absorb excessive moisture from the air. They should be specified when high relative humidities are anticipated.

Protection against Weathering and Mechanical Wear

The term "weathering" designates the roughening and distortion of wood exposed to the weather. The most important factor is believed to be the swelling and shrinking that accompanies changes in moisture content, but it is now known that chemical changes induced by ultraviolet rays in sunlight also contribute to the deterioration. The waterborne preservatives that contain copper and chromium salts have been found to absorb ultraviolet rays and thus provide protection against this form of deterloration. The conventional method of combatting weathering is the covering of the exposed surface with paint, varnish, or other material that retards moisture changes. Some of the preservative materials used primarily to prevent biological attack have a decided effect on the rate of weathering.

Oil-type preservatives retard abrupt changes in the moisture content of the outer layers of wood exposed to the weather and thus suppress the development of surface checks. While wood treated with substantial amounts of the heavy oil-type preservatives cannot be painted satisfactorily, It is fairly well protected against weathering. When appearance is secondary to cost, the costs of initial application and subsequent maintenance of a paint film can be avoided.

For products that are commonly used unpainted – for example, railway bridges – protection against weathering is an added benefit of treatment with an oil-type preservative. By retarding weathering, oil-type preservatives promote the mechanical life of crossties, bridge decking, and factory flooring. However, their chief contribution to the service life rests on the prevention of decay.

Under some conditions, waterborne preservatives seem to stimulate the development of checks in unpainted wood. At one time, many crossties were treated with zinc chloride. in semiarid regions, checking was very severe and physical breakdown rather than decay was the principal reason for removals. On horizontal surfaces such as bridge decks, nail holes that have been enlarged by vibration and wear constitute points of entry for water. Asphaltic material covering rows of nails illustrates a practice that may increase the serviceability of treated wood.



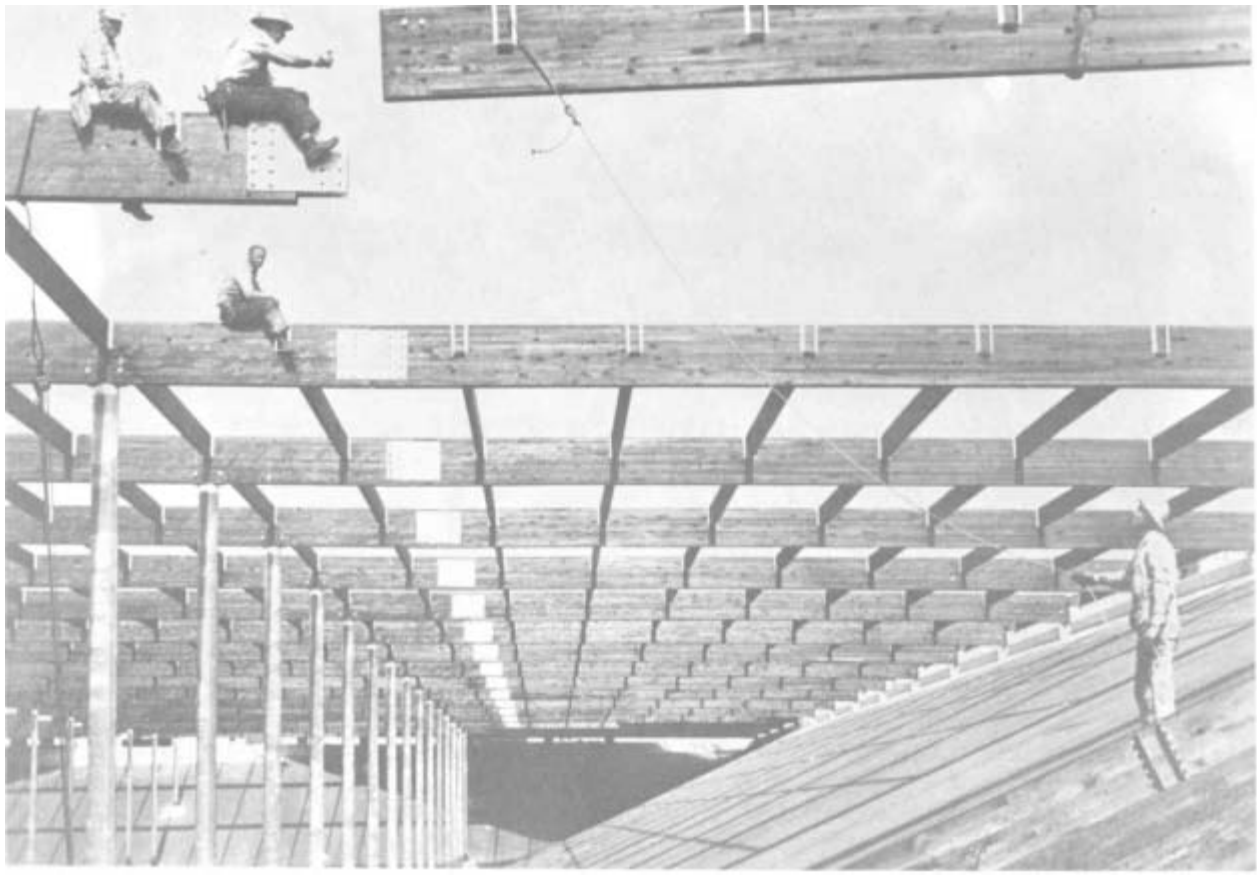
For several reasons, oil-type preservatives are best for railroad crossties. Not only do the oil types prevent biological attack, but by retarding changes in moisture content, they prolong the mechanical life.

(Courtesy, Koppers Co.)

Environment

All wood preservatives now in use have some degree of toxicity to living protoplasm. The use of treated wood is therefore attended by some risk of harmful effects on humans, livestock, wildlife, and growing crops and other vegetative life. Conditions of use must be considered in selecting a treatment. Despite the extensive use of treated wood for more than a century, harmful effects on humans and animals have been rare.

At one time, treated wood was occasionally used in the construction of reservoirs to hold drinking water, and no harmful effects were observed. Similarly, creosoted staves were sometimes used in the construc-



These pressure-treated laminated wood beams provide the supports for a roof over a 22-million-gallon reservoir near Pinole, Calif. Treatments vary for special uses, such as this one in contact with a supply of drinking water.

(M 120 972)

(Courtesy of American Wood Preservers' Institute)

tion of fiumes for transporting water for municipal use. Here again no serious effects of the creosote were reported. The amount of creosote picked up by the water during its brief contact with the staves was generally too small to affect the flavor. A drawback to the practice was found when the water was chlorinated, whereby the action of chlorine on phenolic constituents of the creosote produced chlorinated phenols having a very strong and objectionable taste and odor.

The low solubilities in water of oil-type preservatives minimize their hazards as stomach poisons. Furthermore, their tastes appear to be unattractive to farm animals. A minor health hazard of creosoted wood lies in its irritating effect on skin and the suspected carcinogenicity of some of its minor constituents. Individuals vary greatly in their sensitivity to this effect, but it is more likely to be noticed at treating plants. After the wood is treated, objections from the user are more likely to stem from the odor than from its irritating effects. An exception is the objection to installing small pieces that must be handled individually, such as the creosote-treated slats in cooling towers.

Like creosote, pentachlorophenol is irritating to the skin and individuals vary in their susceptibility to it. Workers whose jobs involve handling the treated wood should wear solvent-resistant gloves. Protective ointments



This 4,000-foot-long, 80-inch water pipe was built in the 1930's of Douglas-fir treated with a preservative salt.
(Courtesy, Forest Service)

are also available for application before exposure. The same precautions should be observed in the application of groundilne treatments, as most of the materials used commercially contain pentachlorophenol. In low retentions such as in dip-treated millwork, pentachlorophenol is essentially free from irritating effects on people exposed to the wood. In the machining of large quantities of wood treated with pentachlorophenol in a volatile carrier, some provisions should be made for removing the dust from the atmosphere.

The use of pentachlorophenol-treated wood in farm structures such as pole buildings should be limited to the vertical poles and the lower skirt board only. Pentachlorophenol-treated wood should not be used where it can contact food or feed.

Numerous cases have been reported of injury to growing plants that came into contact with wood pressure-treated with either creosote or pentachlorophenol solutions. Although some plants may show little effect, wood treated with those preservatives finds little or no use around greenhouses. For the same reason, the oil-type preservatives are usually considered unsuitable for treating wooden stakes and trellises used to support growing plants.

Because thay are essentially nonvolatile, waterborne preservatives do not emit toxic vapors. Some types may be lost from wood by leaching with water. Accordingly, any health hazard a waterborne preservative may present depends upon the solubility of the final products deposited in the wood and the opportunities for leaching. Wood treated with one of the leachable waterborne preservatives may be used safely where there is little or no likelihood of leaching. This situation is illustrated by the floor joists and subflooring of most buildings. Ammoniacal copper arsenate and chromated copper arsenate have such low solubilities that they may be used safely under a wide range of conditions.

Up to the present, only one preservative has been used on a scale greater than experimental for treating wood products that in normal use come into contact with foods. This exception to the general rule is copper-8-quinolinolate. It has been used to a considerable extent in dip treatments of wooden boxes and baskets used in harvesting fruits and vegetables. Beneficial results in the suppression of molds and retardation of decay have been reported. The sponsor has reported that chemical analyses of the wood have shown only negligible amounts of chemical in the form of surface deposits.

Strength

The oil-type preservatives undergo no chemical reaction with wood that might affect its strength. Any loss in strength accompanying treatment with such preservative is

due mainly to the effect of temperatures employed. In some cases, a harmful effect may be traced to excessive pressures.

The treatment specifications of the American Wood-Preservers' Association (some parts of which, by reference, become part of Federal Specification TT-W-571) contain limitations on the temperatures and the durations of these temperatures to which various wood products may be subjected during pretreatment conditioning and impregnation.

When wet wood is steamed prior to treatment, a chemical reaction between water and wood substance (especially the cellulosic constituents) occurs; this causes a measurable loss in strength. In southern pines, the loss in strength is tolerable and is allowed for in the design values for poles and piles. in many other species, the loss in strength is not tolerable. This is why the pretreatment steaming of unseasoned Douglas-fir poles is not permitted. The method commonly used to condition Douglas-fir products—namely,heating in oil under partial vacuum–has a smaller effect on strength than does steaming. This strength loss likewise is allowed for.

All of the waterborne preservatives undergo at least some slight chemical reactions with wood whereby some losses in strength properties may occur. The rates of these reactions increase with temperature. To avoid serious strength losses, specifications limit temperatures used in treating wood – especially with the chromium-containing preservatives – and also in drying the wood after treatment.

There is a considerable difference in the degree to which different strength properties of wood are affected by the presence of waterborne preservatives. Unless excessive temperatures are employed in treating and after-treatment drying, the loss in strength parallel with the grain is small and has no practical effect on the performance of building poles, foundation pilings, and other wood products used as columns. Likewise, the loss in bending strength is not great enough to affect the serviceability of wood members used as beams. The strength property that is most seriously affected by the presence of waterborne preservatives is *resistance* to impact (toughness). This strength property Is very important in certain products such as highway guardrail posts and fender piling.

Flammability

From the standpoint of the flammability of the treated product, waterborne preservatives have an advantage over oil-type preservatives. As with all other differences between oil-type and waterborne preservatives, the importance of this difference varies with the product and conditions of use.

Wood freshly treated with oil-type preservatives is easier to ignite than is untreated wood. The oil on the surface burns freely, producing objectionable smoke. This may be the deciding factor in the choice between the two main classes of preservatives wherever the fire hazard must be given primary consideration. Thus, oil-type preservatives are excluded from use in mines.

Except under wind conditions that favor combustion, large timbers and poles that have been creosoted and dried do not ordinarily continue to burn for long periods when ignited by grass fires or the burning of small amounts of, other combustible materials. As is well known, the size of the cross section of a piece of wood greatly affects its ease of ignition. Structures containing much thin lumber present a much greater fire hazard than structures in which the wood is mainly In the form of heavy timbers.

Cost and Availability

Very often the cost of the preservative constitutes a small percentage of the total in-place cost of a piece of treated wood. For this reason, factors other than cost tend to dominate the selection of a preservative for a specific use. Frequently, when several preservatives are suitable for a given situation, selection between them is based on cost and availability. Not all preservatives are available in all areas.

The unit-delivered cost of treated wood includes transportation costs. Because of differences in the latter item, two preservatives at recommended retentions may be competitive in cost in one area but not in another and it may be difficult to justify the selection of the more costly treatment.

Creosote and pentachlorophenol-petroleum solutions are widely available. Many

treating plants carry in stock one, but not both, of the creosote-containing solutions that are used in the treatment of crossties. The use of a specific waterborne preservative may be precluded in a given area because of the transportation costs from the nearest plant that carries that preservative in stock.

Factors in Specifying Degree of Treatment

The tables in Federal Specification TT-W-571 may list several levels of retention of a given preservative for treating a given product. The purchaser must decide whether adequate protection can be expected from a low retention in the recommended range or whether circumstances indicate that a high retention is logical. The decision requires consideration of a number of factors.

Organisms to be Combatted

Of the organisms that may be encountered in land use, fungi and termites are often controlled by the minimum retentions listed in the tables. In other cases, higher retentions are advisable because of one or more factors to be mentioned.

The hazard of marine-borer attack in coastal waters varies greatly. In the colder harbors of the United States, teredine borers constitute the sole hazard of borer attack. They are quite susceptible to coal-tar creosote [5]/ so that retentions and penetrations of creosote that protect against decay will generally also prevent destruction of wood by teredine borers. Ammoniacal copper arsenate and chromated copper arsenate will also give protection against Teredo but the retentions required are higher than those used for wood exposed to the soil.

Most of the warm-water harbors are infested with *Limnoria* which are very difficult to combat. (See "Severe exposure conditions.")

Exposure Conditions

The loss of preservative by leaching with water takes place slowly when wood is exposed to damp soil. The loss is more rapid under exposure to stagnant water and reaches a maximum in moving water such as the tidal currents prevailing in the ocean. Loss of preservative by leaching as well as by evaporation increases with increase in temperature. This is one reason why retentions that are adequate in cool climates need to be increased in warm climates.

The size of a piece of wood has a bearing on the rate at which preservative will be lost from it. Because the ratio of surface to volume increases with decrease in cross section, small wooden pieces need higher initial retentions than do large pieces in order to obtain the same degree of protection. This is counterbalanced to some extent by the fact that a unit volume of wood tends to cost more in large sizes than in small sizes.

Severe exposure conditions.–Perhaps the most difficult problem in wood preservation is the protection of wood exposed in *warm coastal waters.* This is due to the presence of marine borers that are resistant to the commonly used preservatives. *Limnoria tripunctata* has done much damage to wood containing the maximum amounts of creosote that can be injected. In some harbors the salinity, biological oxygen demand (B.O.D.), the temperature of the water, as well as the presence of toxic pollutants, and perhaps other factors not clearly understood, are unfavorable to the activity of this organism, whereby fairly good protection is provided by high retentions of properly selected creosote. The type of creosote considered most suitable for this purpose is designated as *marine-grade* creosote. Protection against *Teredo* is also provided by this treatment.

The effectiveness of such creosote in combating *Limnoria* may be sharply reduced by the presence of a layer of fuel oil on the surface of the water around the piling. When this situation exists, the portion of the piling that has been in contact with the fuel oil should be given some form of mechanical protection. A number of methods that may be used for this purpose have been described in the literature on wood preservation. One recommended method comprises covering the vulnerable portion of the piling with a double plastic wrapping consisting of a layer of polyethylene covered with a layer of polyvinyl chloride.

5/ In discussing protection against marine borers, the term "creosote" is used to Include creosote-coal-tar solutions.



The endless salt-water and fresh-water shorelines of the United States require millions of feet of pilings in dock structures. Selected preservatives protect against destruction by marine borers and fungi, and resist leaching by salt water.
(M 136 477-7)

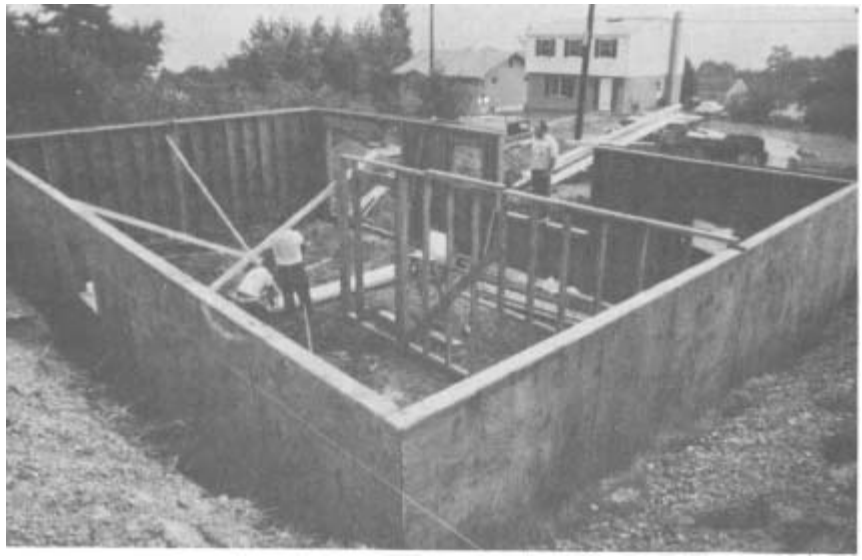
Two of the waterborne preservatives, ammoniacal copper arsenate (ACA) and chromated copper arsenate (CCA), are more effective than creosote in preventing *Limnoria* attack. The minimum retentions that will control *Limnoria* are considerably higher than those required to control fungi and termites. The high retentions also repel *Teredo* but, according to tests on small specimens, *Pholads* are quite resistant to these chemicals.

When the water is infested by both *Limnoria* and *Pholads,* the wood should be treated with one of the waterborne preservatives mentioned above and then impregnated with a high retention of creosote. This procedure is designated in specifications as the *dual treatment.* Because of its effect on impact strength, steaming between the two stages of the treatment should be held to the minimum necessary to meet requirements on retentions of creosote.

Research on this difficult problem is still in progress. Up to the present, the dual treatment has given the best results of those that have been subjected to extensive tests. It is of course more expensive than a single treatment with either of the components, but the added cost is believed to be justified by the high annual cost of maintaining marine structures in warm-water harbors. Because of the time required for seasoning between stages, a longer-than-normal lead time must be allowed by the purchaser.

Treated wood foundations. –Another situation in which requirements on quality are very exacting occurs when treated lumber and plywood are used as foundation material in buildings. Only those preservatives that are highly effective, leach-resistant, clean, and free of odor are recommended for this use: (1) ACA, and (2) CCA, Types I, II, and III. The retentions are listed in Table III of Federal Specification TT-W-571.

It is further required that lumber (including laminates) for use in *building foundations* be no thicker than 2 inches. Each charge must be assayed by an independent inspection agency. Except for southern pine and ponderosa pine, all softwood lumber species must be incised on four sides to a minimum



An all-wood foundation is entirely practical when the wood is treated to conform with specifications. Wood foundations allow for better insulation for energy conservation, and for quicker construction in any weather in any climate, with less expensive equipment.
(Courtesy, Koppers Co.)

depth of 0.4 inches prior to treatment. Southern pine and ponderosa pine lumber should not contain more than 20 percent heartwood.

Additional requirements are that plywood for use in building foundations should be of exterior grade. Southern pine plywood for use in building foundations should contain no heartwood faces.

Round building poles and posts should be treated with one of the preservatives recommended in Table II of TT-W-571. The highest retentions for these products as listed in Table II should be specified. According to Federal Specification TT-W-571, penetration in each piece 10 inches or less in diameter must be at least one-half of the radius. In each piece more than 10 inches in diameter, penetration must be at least 2.5 Inches. In all cases, 90 percent of the sapwood should be penetrated. Mechanical means to obtain the required penetration, such as incising or through-boring, should be permitted. Increment borings to determine penetration should be taken from the incised area. Borings for assay should be taken from the approximate midpoint, but not from the incised area. Each charge should be assayed.

Structural Importance

The structural Importance of a wood item is another factor to consider in specifying preservative treatment. The failure of a structural member of a bridge may have more serious consequences than the failure of a similar piece of lumber with a less critical function. In the former case the increased cost of a high retention is easlly justified.

The purchaser of treated wood must be alert to the possible hazard to human life that may result from the decay of wood In outdoor stairways, upper-level porches, handrails on bridges, and other places. It is obvious that initial cost should be subordinate to the safety factor in specifying retentions in wood intended for such uses.

Initial Cost vs. Replacement Cost

Not only the initial cost but also the cost of replacing a wood product must be considered in deciding upon the quality of treatment to specify. Closely related to the accessibility of a piece of wood to be replaced is the ease of inspecting it. Sometimes pressure treatment is advisable even though the decay hazard is indefinite – for example, wood resting on con-



Even the grandest of structures are not immune to decay. The expense of repairing or replacing decayed wood is often Increased by technical difficulties, historical value, lost time, and danger to users.

(M 107 F)

crete slabs or supported by a low masonry foundation. Fenceposts, utility poles, and crossties are examples of wood products that are easy to inspect so serious decay need not go unnoticed. Considering their sizes, they are relatively easy to install. Replacement of an individual piece can be accomplished without damage to adjacent sound wood.

The foregoing is not true for wood used in many structures such as bridges and buildings where wood is generally difficult to inspect and costly to replace. In such cases, the absolute service life of each piece in a charge – as distinct from the average service life – is highly important. High uniformity requires a retention above that needed for high average quality. Also, greater care is needed in the selection of raw stock to be treated.

PRODUCTION DETAILS THAT AFFECT QUALITY

Wood Selection and Preparation

Some species of wood are so difficult to impregnate that a high percentage of pieces in a charge are poorly penetrated and comprise a poor risk for the ultimate user. Other more refractory species are designated as being impossible to treat. The species that are acceptable for the treatment of various wood products are covered in Federal Specification TT-W-571 and in AWPA Standards.

Within each species considered acceptable, selection must be made on the basis of properties that are significant for a given item – for example, deviation from straightness in poles and piling, rate of growth (which in a general way indicates strength), and number, sizes, and distribution of knots. It is the responsibility of the producer of treated round products to select material having sufficient sapwood thickness to permit obtaining the retention and penetration specified.

After the wood has been selected, it must be prepared for treatment. Generally the first step consists of *peeling* – removal of the bark which hinders the seasoning necessary prior to treatment and which also interferes with the penetration of the preservative. Peeling is an essential step in the preparation of round material for treatment. It seldom is needed for lumber but occasionally is needed for crossties sawn from small trees.

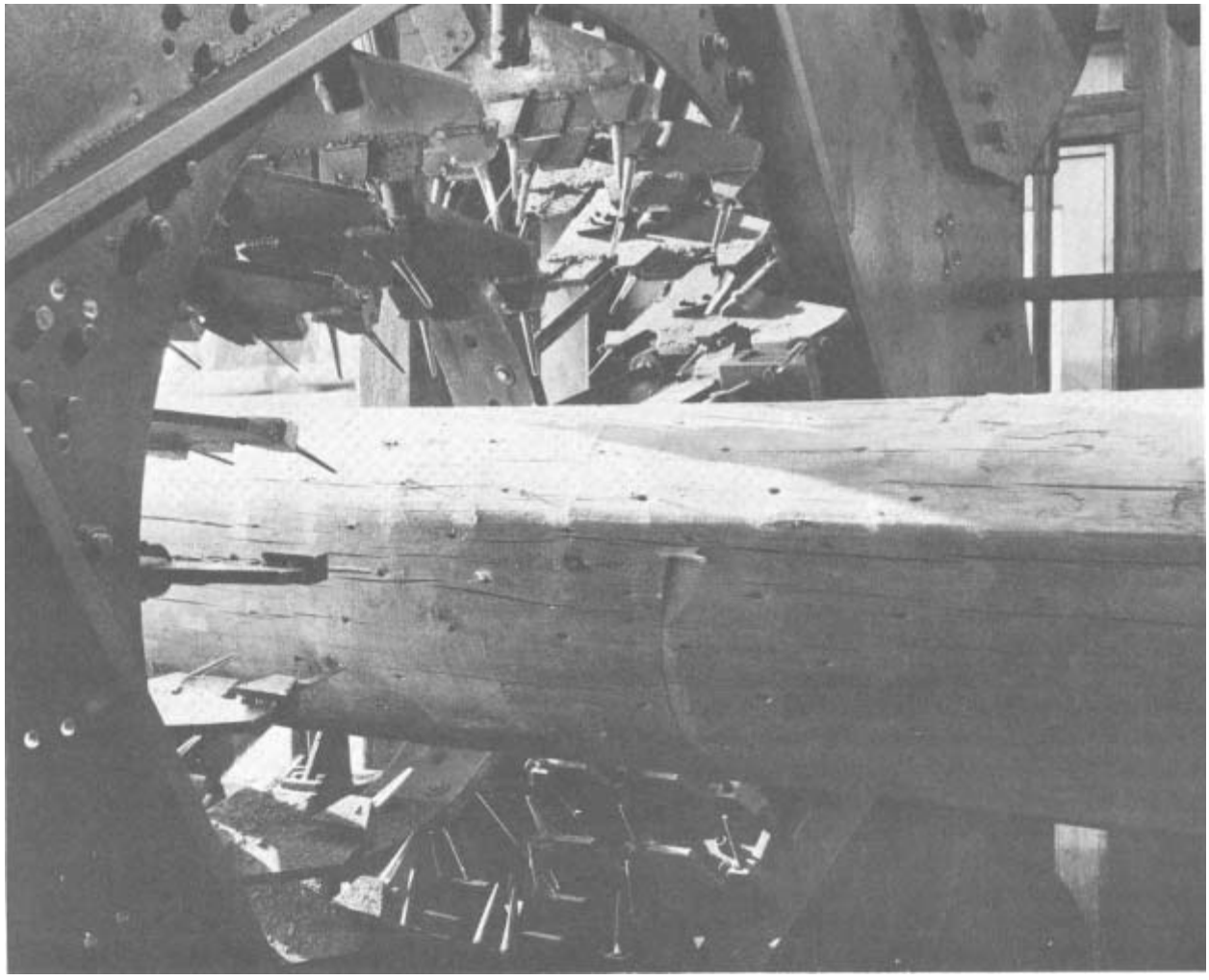
The preservative penetration obtained in hard-to-treat species can be increased significantly by *incising* the wood before treatment. The incisions made in sawed material are commonly 1/4 to 3/4 inch long and deep, and about 1/8 inch wide. The value of incising is confined to species that are resistant to side penetration but which accept treatment fairly well along the grain. lncising is used extensively on sawed Douglas-fir products and on poles of thin sapwood species. It is an essential step in the preparation of such products for treatment. It is true that it may have an adverse effect on appearance, a fact often stressed out of proportion to its importance. Whenever the lumber of such species as Douglas-fir, western larch, western hemlock, redwood, and pines that contain much heartwood is to be used where a high quality of treatment is indicated – either by the decay hazard anticipated or by the structural importance or cost of the product – incising should be specifled and unincised material should not be accepted as an alternate in blds.

Pretreatment Seasoning and Posttreatment Drying

The presence of free water in wood is necessary in treatments made by diffusion. In all other methods, water in wood hinders impregnation with preservatives. The most common method of removing excess water is by proper stacking of the green wood out of doors and allowing sufficient time for evaporation to take place. The time required varies widely depending upon the weather and the nature of the wood product. Thus, small pine poles may be *air seasoned* for a month or less while large pine poles often are air seasoned for several months. Oak ties are commonly seasoned for a year or even longer.

Air seasoning prior to treatment involves two hazards – decay and checking. Wood piled for air seasoning in warm humid climates is susceptible to decay, especially during weather that is not favorable for evaporation. For this reason, southern pine poles need to be inspected periodically during air seasoning and may require some pretreatment to prevent decay.

Air seasoning is least important in round products of thick-sapwood species. It is often dispensed with in the treatment of southern pine poles when low to moderate retentions are specified. In southern and ponderosa pine poles, the depth of the sapwood typically exceeds the deepest check that develops in drying. Internal decay rarely is found in southern pine poles treated to meet modern specifications. When decay develops it is almost invariably in the outer zone of the groundline area. In some treatment processes, poles are subjected to steaming in the cylinder at temperatures and time periods that are con-



The punctures in this wood, produced by a pole incisor, allow greater penetration of preservative into wood. Greater penetration always adds to the service life of treated wood.
(M 141 288)
(Courtesy, J. H. Baxter Co.)

trolled to avoid undue damage to the strength of the wood. *Steaming* followed by a vacuum removes only small amounts of water but, for reasons not clearly understood, it improves the distribution of preservative. The sterilizing effect is considered an additional benefit because incipient decay often develops during the air seasoning of pine poles. Although treated poles of thick-sapwood species seldom develop internal decay, poles of thin-sapwood species sometimes show internal decay associated with checking through the treated zone.

In contrast to the development of decay, checking is most serious under conditions that promote rapid drying. It may be minimized by methods of stacking that retard drying and also by the application of end coatings. For crossties, most railroads use steel doweling to reduce serious end checking. Other anti-checking devices applied to the ends of crossties are also used.

Kiln-drying is next to air seasoning in importance as a method of pretreatment seasoning. This practice, unheard of during the early days of wood preservation, has become quite



Stacks of railroad ties undergo pretreatment air seasoning in open yards, a practice that has been in existence for years.
(Courtesy, Forest Service)

common.

The *vapor-drying* method was developed as a means of avoiding decay and the development of deep checks during drying. The vapor of a low-boiling organic liquid, such as xylol or a petroleum distillate, is passed over the green wood carrying water vapor with it. Not only is the development of large checks avoided but the treated timber appears to remain free from serious checking indefinitely after being put into service.

All sawn material should be dried before treatment if it is to be treated with an oil-type preservative and used in buildings or other places where high moisture content or shrinkage after installation would be objectionable. When sawn material is to be treated with a waterborne preservative, it should be suitably conditioned before treatment. If such treatment is with a permanent-type chromium-containing preservative, such as chromated copper arsenate, the moisture content as determined with a resistance-type moisture meter prior to treatment should not be more than 25 percent. The moisture content should be measured at a depth equivalent to the required penetration, up to a maximum of 1.5 inches. Unless otherwise specified, lumber 2 inches or less in thickness and plywood treated with a waterborne preservative should be dried, after treatment, to a moisture content of 19 percent or less.

PROCUREMENT AND USE

Inspection and Quality Assurance

Treated wood is procured under diverse arrangements between buyers and sellers. During the past several decades a number of fundamental changes have been adopted in procurement practices – the assay of treated wood being the most significant. Differences in procurement practices have evolved through U.S. history.

Historical Review

Before the middle of the 19th century only small amounts of wood were treated annually in the United States. A rapid growth in wood preservation began during the second half of the century when a number of railroad companies built plants for pressure treating their crossties, piling, and bridge timbers. Because the producer was also the ultimate user, there was no need for specifications covering the final product. Specifications were gradually developed to govern the purchase of the raw materials, namely the wood products and the preservatives.

With a gradual increase in the percentage of treated ties in track came a dramatic increase in average service life. This naturally led to a gradual decrease in the number of ties needed annually for replacement. An overcapacity of facilities for treating crossties could be foreseen before it had actually taken place.

During this period the market for other treated wood products, especially utility poles, was growing rapidly. Naturally durable cedar and chestnut poles had supplied the pole market but, as the ravages of the chestnut blight and diminishing supplies of cedar created shortages in those species, industry was compelled to use nondurable species. Preservative treatment was the obvious answer.

Some commercial wood-treating companies that entered the business of treating poles for sale to utility companies found that they could purchase, at a favorable price, semi-idle plants from railroad companies. Often the transaction involved a long-term contract for supplying the railroad with all or part of its needs for treated wood. This led to a rather unique arrangement between the producer and user of treated wood.

Under this arrangement, the treating company suppiled treating services only. The ultimate user (the railroad company) purchased the wood and transported it to the treating plant where it was stacked for air seasoning. Often a supply of preservative, owned by the railroad, was also kept in stock at the plant. The treatment was supervised by a representative of the railroad company. The retention of preservative in a charge was calculated from the initial and final volumes of preservative in a working tank, as shown by gages, and the known volume of wood.

Although this system is still used to some extent, much treated wood is today being produced and sold under a system similar to that prevailing in the manufacture of many other products. The treating company purchases wood and preservative and sells the treated wood on the open market. Sometimes the wood is treated and held in stock awaiting sale. In such case the treater usually guarantees that the treatment was conducted according to some designated industry specification. The product maybe stamped or branded to show compliance. Large orders are generally produced under a contract that is negotiated before the raw material is purchased. The contract invariably stipulates the specification under which the treatment is to be made. The properties of the final product as demonstrated by test methods approved by the industry may also be specified.

Inspection

The inspection of treated wood is rendered difficult by the complexity of the factors that determine the quality most desired by the user – namely, the ability to withstand agents of deterioration and thus give long service. A thorough discussion of this involved subject is beyond the scope of this publication; a number of highlights will be pointed out.

In-plant inspection.–Inspections may be classified on the basis of the interests of

whoever employs the inspector. This may be either the producer, the ultimate user, or a middleman. All commercial wood-treating companies maintain some form of quality control and inspect their products with more or less thoroughness. Federal Specification TT-W-571 deciares that, "unless otherwise specified, the supplier is responsible for the performance of all inspection requirements.'' A Government agency may at its discretion accept the findings of the producer regarding the various properties of his product. However, this specification also deciares that, "the Government reserves the right to perform and/or retain services for any of the inspections set forth. . . ." It further states that, "Tests to verify the accuracy of inspection reports furnished by the supplier shall be made either by the purchaser, or by commercial inspection companies retained by the purchaser. The purchaser may elect to employ the services and accept the brand of an independent quality-control agency."

Inspection by the producer forms the basis for a tentative acceptance of a charge or lot of treated wood. Verification of the inspection may be dispensed with, or it may be conducted according to any one of the several procedures selected by the purchaser.

Broadly speaking, plant inspection is the most practical procedure for large products such as piling which can be handled only with special equipment. Plant inspection offers several other advantages. The wood may be inspected prior to treatment when it is possible to detect the early stages of decay. The temperatures used during preconditioning and impregnation may be observed. In treatment of marine piling, it is easy to obtain a sample of the creosote for a check on its quality.

Destination inspection. –Two distinctly different types of destination inspection should be recognized: (1) A tentative inspection such as the determination of penetration can be conducted by a person who has limited training and has available only very simple equipment, and (2) a thorough inspection requires the facilities of a chemical laboratory and the services of personnel qualified to determine retentions by the assay of borings and – in products such as marine piling – to determine the quality of the creosote in the wood.

It is practically impossible to obtain a representative sample of a lot of piling at many places where they may be received.

Inspectors

In view of the complexity of the factors that determine the quality of treated wood, the responsibility for inspection should be delegated only to those who have a thorough knowledge of wood preservation and experience in the inspection of this specific product. Any Government agency that procures large quantities of treated wood should include on its staff an individual in a supervisory capacity who is competent to supervise inspection.

Methods to be used in the inspection of treated wood are covered in Standard M2 (4) of the American Wood-Preservers' Association. The judgment of the inspector is required wherever recommendations of a general nature are given.

Inspection of treated wood by the user of considerable quantities or by his delegated agency is practical and is recommended. Unfortunately, the cost of an inspection by the purchaser may be prohibitive when applied to a small purchase. The user of small quantities may find it more practical to purchase material bearing the mark or brand of a quality-control agency or the brand of the producer of the treated wood. Whenever an agency of the Federal Government purchases small quantities, it should require that the treated wood conform to Federal Specification TT-W-571. As was pointed out, a simple test of the treated wood at destination to determine the preservative penetration can be very helpful in partially verifying conformance to the Federal Specification. *When a contractor uses treated wood in building a structure for a Government agency, the contractor is the supplier responsible for the quality.*

Quality Assurance

Penetration. –The one essential quality of treated wood that can be measured with simpie equipment is penetration. Borings from a number of pieces in a shipment give a good preliminary indication of the quality of treatment. It is therefore strongly recommended that, whenever possible, observations of

penetration be made on a number of pieces (usually no fewer than 20) selected at random from each shipment received at destination. The presence or absence of the mark of a quality control agency (evidence of inspection and conformance to specification) should also be noted. When the wood contains such a mark and the penetration observed conforms to the specification, the shipment may be accepted.

In checking penetration, borings should be taken far enough from ends to avoid the effect of end penetration. In wood that has been incised, borings should be taken between incisions. When wood contains an oil-type preservative, observations should be made promptly to avoid the misleading effect of creep. A boring that is smudged should be split lengthwise and the penetration measured on the cut face. Penetrations of dark-colored preservatives are easily recognized but the detection of light-colored preservatives requires stains described in AWPA Standard A3 (2). Holes formed by increment borers should be plugged with treated wooden plugs. Because of variability between individual pieces treated in the same charge, the results on a few pieces may be misleading. At least 20 pieces from a lot or charge should be checked for penetration. For additional information on sampling procedure, refer to AWPA Standard M2 (4).

When the penetration observed casts doubt on the quailty of the treatment, a thorough Inspection by either the Government, a quailty control agency, or an independent inspection agency should be made and any nonconforming shipment should be rejected. Such inspection should be made within 30 days of delivery.

Under such policy, thorough inspection at destination would not be regarded as a tool for routine acceptance but rather as a tool to be used in special cases in which preliminary examination strongly indicates the need for *rejection.*

Retention. –The purchaser of treated wood must familiarize himself with the present system of expressing retentions of preservatives in treated wood. It has always been and continues to be based on the weight of preservative (in pounds) retained by a standard volume of wood (1 cubic foot). However, in the case of most products there has been a radical departure during recent years from the original system which comprised retention on the basis of the entire piece of wood. Formerly, the entire volume of wood in a charge was calculated and the weight of preservative retained was determined either by gain in weight of the wood or (more commonly) by



Increment borings can be taken with an electric drill-type borer. Depth of penetration is recorded as soon as possible after treatment, and borings are often preserved for future reference. Bore holes are immediately plugged with treated dowels to prevent infection.
(Courtesy, Forest Service)

decrease in the amount of preservative in a working tank. An average retention in pounds of preservative per cublc foot of wood was then calculated. This system is still used for a few products, notably crossties. In the case of most other products, retentions are based on the analysis of a composite sample of borings of specified length taken from a number of pieces in the charge. The length of each boring taken for analysis Is *not a fixed standard for all products.* It varies, depending upon the species and the kind of product treated. For example, a retention value of 12 pounds per cublc foot of creosote in Dougias-fir poles designates that *0.25- to 1-inch* portions of a composite sample of borings upon assay show 12 pounds per cubic foot of creosote: a retention value of 12 pounds per cubic foot of creosote in southern pine poles designates that the assay of the *0.5- to 2.0-inch* portions of a composite sample of borings show 12 pounds per cubic foot of creosote.

In sawn as well as in round products, the retention values refer to the amounts of preservative found in the specified zones. The assay zones specified were selected originally on the basis of the typical sapwood depth and treatability of acceptable species. For some products, such as southern pine piling, retentions by assay are fairly close to the average retention in the entire piece. For other products, such as Dougias-fir poles, assay retentions are considerably higher than the average retention in all of the wood in the charge.

The retention requirements based on assay that appear in modern specifications were selected by one or the other of two methods, either by the assay of borings from wood that had given good service, or more often, by taking gage or gain-in-weight average retentions as had been recorded originally for wood that had performed acceptably in service tests and converting them to appropriate values for assay retentions.

Warping and checking of lumber that has been treated with a waterborne preservative and then dried may also be observed in a preliminary inspection. Material should be rejected if either distortion or checking is serious enough to render it unfit for the intended service. Acceptable tolerances should be described in the requests for bids.

Marking Treated Products

Branding with hot metal dies has been more or less a standard practice for identifying creosoted and pentachlorophenol-treated piles, poles, and crossties. Metal tags are also used. The information to be included in the brand is the prerogative of the purchaser but is limited by space. This practice is generally unsuitable for marking oil-treated lumber but a completely satisfactory alternate method remains to be found. Wood treated with waterborne preservatives may be ink stamped.

Sawn material less than 2 inches thick or plywood treated with an oil-type preservative may be bundled, with tags being attached to the bundles. in lieu of tags, when such material is treated with a waterborne preservative, the required information may be dye stamped on the outer pieces of a bundle.

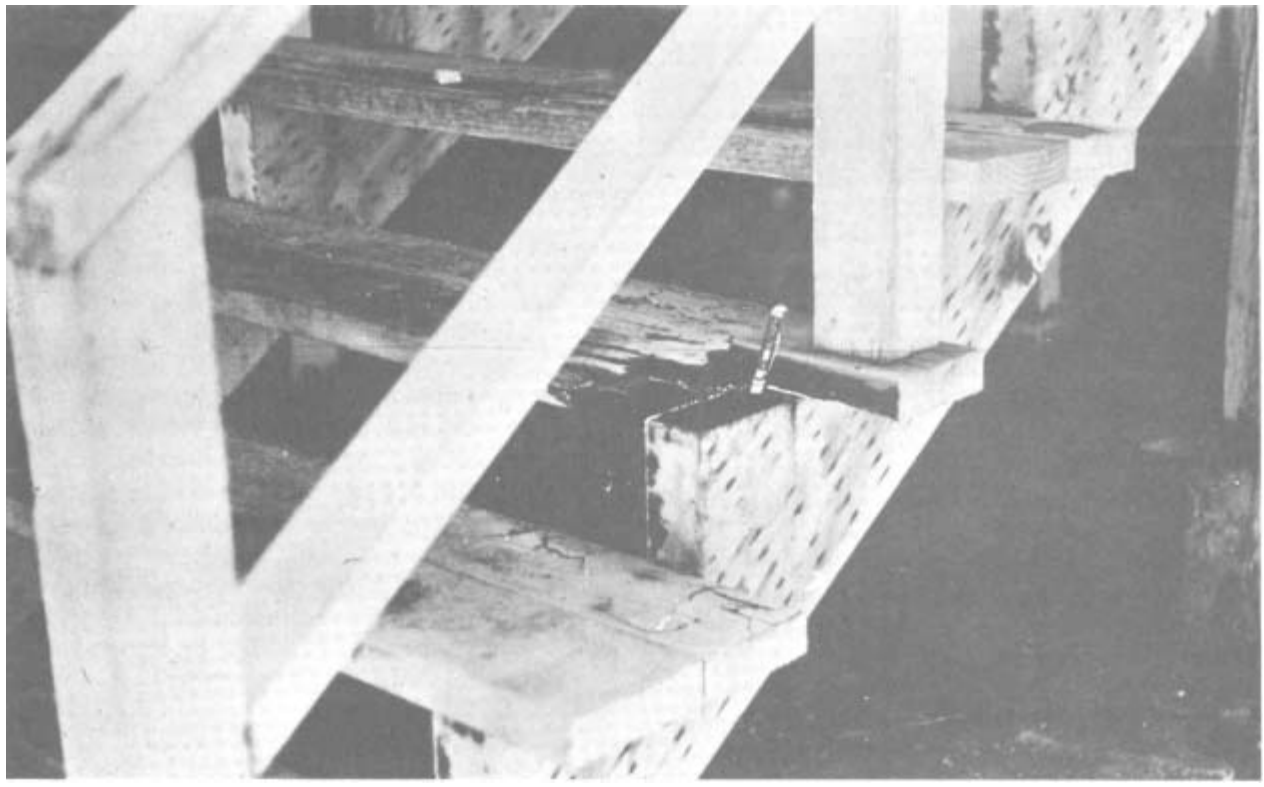
The places where different products should be branded or marked and also the items of information that should be given are outlined in Federal Specification TT-W-571.

Care in Processing and Use

Like other building materials, treated wood undergoes gradual deterioration in normal use and may be rapidly damaged if used improperly. AWPA Standard C1 (3) contains provisions against treating conditions that seriously lower the strength of wood. AWPA Standard M4 (5) outlines recommended practices in the care of preservative-treated products. It deals mainly with practices to be followed by the treating plant operator and also refers to field treatment that may be necessary during installation of the treated wood. A few additional precautions to be observed by Government purchasing agents have been recommended in foregoing pages.

Machining and Cutting

The serviceability of treated wood is impaired through cutting and damage to the treated surface. For this reason it has long been standard practice to conduct certain manufacturing operations prior to the treat-



Increased penetration resulting from incising can be negated if treated material is cut, and untreated areas are exposed. The penknife blade is sunk into an area that should have been field-treated when the stairs were constructed.
(M 111 561)

ment. This includes the adzing and boring of crossties, the roofing, gaining, and boring of poles, and the framing and boring of crossarms. It is often possible to frame and bore structural timbers before treatment; this desirable practice is not always observed. It calls for cooperation between the designing engineer and purchasing agent.

When cutting or damage to the surface of treated wood cannot be avoided, the instructions given in AWPA Standard M4 (5) should generally be followed. Cut surfaces of wood treated with oil-type or oil-borne preservatives should be given at least two brush applications of either creosote or a solution of at least 5 percent pentachlorophenol in a suitable solvent, or one heavy application of a grease or suitably bodied preservative composition containing at least 10 percent pentachlorophenol. The choice should be based upon cleanliness requirements. Cut surfaces of wood treated with a waterborne preservative should be given at least one application of a 5 percent solution of the preservative used in the treatment.

Storage

The service life of wood treated with oil-type preservatives may be affected adversely by conditions of storage prior to instailation. Creosoted and some pentachlorophenol-treated woods suffer a gradual loss of preservative on exposure to air. Therefore it is good practice to avoid undue delay in the instailation of wood items treated with oil-type preservatives. If creosoted wood is held in stock for more than 3 months, it should be reassayed before being accepted and installed. If a long (more than 3 months) storage time is anticipated, waterborne preservatives are recommended.

Treated lumber should be stored under cover whenever possible, especially for

protection against the sun.

When poles of thick-sapwood species treated with oil-type preservatives are stored for a long time, they should be reassayed before being accepted. The longtime storage of treated poles of thin-sapwood species, such as Dougias-fir, should be avoided. Horizontal storage is conducive to the development of checks on the upper side. Such checks may extend into the untreated Interior and trap water, thereby creating conditions that favor decay. Poles showing checks beyond the treated zone should be rejected.

Installation

The Installation of treated wood requires vigilance to avoid damage to the treated outer zone. Because heavy pieces need to be handled mechanically, they are subject to damage by the parts of equipment that come into contact with the wood – for example, chains, cables, and the teeth and clams of lift trucks. The corners of large sawn material, such as laminated timbers, are especially vulnerable to such damage. When acceptable treated wood has been delivered, it Is the responsibility of the contractor to handle it properly.

When treated poles are installed, a material that can be well tamped around the pole should be used, especially in contact with the groundline area. It should be borne in mind that air promotes the development of fungi. Loose material containing large rocks and miscellaneous debris is not proper backfill material.

The user of treated wood may effect substantial savings in annual maintenance costs by periodic inspection and the use of supplementary treatments if the onset of decay is detected. Such treatments have found their most successful use in the application of preservative pastes or greases to the groundline area of poles that have started to decay. A number of formulations have been compared in field tests. The latest information on the subject may be obtained from the Forest Products Laboratory. Encouraging results have been obtained by internal treatment with volatile pesticides[6]/

6/ Detailed information on this process is available from the Forest Research Laboratory, Oregon State University, Corvallis, Oregon.



Proper treating, sound design, careful handling, and good construction techniques enable structures like this laminated bridge support system to function beautifully with no decay problems.
(M 138 863)

Supplementary Treatments

A situation unfavorable to poles in use develops occasionally when, due to a change in grade line, the groundline of a pole is raised to a portion that has been exposed above ground for a number of years to loss of oil-type preservatives by evaporation. In such case, a Supplementary treatment to the new groundline area should add many years to the life of the pole.

Increasing the life of decaying timber structures by use of supplementary treatments is more difficult to achieve. An onsite treatment of an old structure may not be worth the cost. Flooding with preservative may not get it deep enough to reach infections that have developed. Paint films tend to act as barriers. When the decay is mainly in the joints and is detected in the early stages, flooding the joint with a solution of pentachlorophenol may be worth the time required. The application of a grease-type preservative to horizontal members that have checked badly may be helpful. Frequently, it is more logical to replace the decaying members with properly treated wood.

The service life of treated wood products may be shortened drastically when mechanical abrasion of the heavily treated outer layers exposes untreated wood to the elements. This often contributes to the early failures of fender piling. Another example is bridge decking, where wear and decay often proceed simultaneously. In such cases mechanical protection serves to retard decay.

Procurement Data Requirements

Ordering Data in Procurement Documents

Certain data and information should be covered in procurement documents:

1. Title, number, and date of specification under which the treated wood is purchased
2. Moisture content required at acceptance
3. Condition of surface following treatment
4. Treatment other than normally required
5. information required in branding or marking
6. End use

Stipulations for Bid Invitations

Various detailed requirements must be specified in Invitations for bids:

1. Quantity of wood product
2. Form of wood product
3. Species of wood product
4. Grade, if applicable
5. Fabrication of wood
6. Preservative specified
7. Retention of preservative
8. Penetration of preservative, if other than standard
9. Treatment specification to be complied with
10. Special requirements, when applicable:
    a. Cleanliness
    b. Paintability
    c. Gluability
    d. Water repellancy
    e. Drying after treatment with waterborne preservative and freedom from excessive distortion and checking

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NOTICE

Pesticides can be injurious to humans, domestic animals, desirable plants, and fish and other wildlife - if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the handling of preservative-treated wood.

Only those preservatives registered by the U.S. Environmental Protection Agency have been recommended in this publication and then only for uses as permitted in the registration. The list of registered preservatives varies from time to time; prospective users, therefore, should get current information on registration status from the Environmental Protection Agency, 401 M Street N.W., Washington, D.C.

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