Selection and Use of Preservative Treated Wood

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Caution

The pesticides—wood preservatives, mildewcides, and fungicides—described in this report were registered for the uses described at the time the report was prepared. Registrations of pesticides are under constant review by the Environmental Protection Agency. Therefore, consult a responsible State agency on the current status of any pesticide. Use only pesticides that bear a Federal registration number and carry directions for home and garden use.

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the label. Avoid inhalation of vapors and sprays; wear protective clothing and equipment if these precautions are specified on the label.

If your hands become contaminated with a pesticide, do not eat, drink, or smoke until you have washed. If you swallow a pesticide or if it gets in your eyes, follow the first aid treatment given on the label and get prompt medical attention. If a pesticide gets onto your skin or clothing, remove the clothing immediately and wash skin thoroughly.

Store pesticides in their original containers out of the reach of children and pets, under lock and key. Follow recommended practices of the disposal of surplus pesticides and containers. Preservative treated wood or finished wood should never be burned, either for heat or for disposal. Toxic fumes and ashes may be released. Dispose of the material using procedures approved by your appropriate state agency (usually through ordinary trash collection or burial).

Acknowledgement

Portions of the material and photos used in this publication were excerpted from a U.S. Navy Document titled "Wood Protection". The reference is Wood Protection NAVFAC MO-312. May 1990. Naval Facilities Engineering Command, 200 Stovall St., Alexandria, VA 22332-2300. Wood Protection was prepared by Daniel Cassens, Professor of Wood Products, Purdue University, and Rodney De Groot, Research Plant Pathologist, U.S. Forest Products Laboratory with funding from the U.S. Navy.
Disclaimer

The mention of trade names or commercial products in this publication does not constitute endorsement or recommendation for use.

WARNING: This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and Federal agencies before they can be recommended.
Reader's Summary

For centuries wood has been one of our most common and easiest to use construction materials. It is used practically everywhere; in housing and agricultural buildings, as posts, utility and telephone poles, railroad ties, wharves, piling, and many others. Wood is also a renewable material. Although we have consumed tremendous volumes of wood for centuries, the United States is growing more wood volume than what is being harvested.

Wood is a biological material and as such it is subject to decay, insect, and marine borer attack. These agents are nature’s way of recycling wood in the natural ecosystem. Without nature’s recycling system, we would literally be buried by wood and other cellulose-based materials, such as grass, leaves and agricultural field residues. However, when wood is used in a more or less permanent application, it must be protected from biological degradation. Destruction can be prevented by any number of methods or combinations of methods. This book is written for homeowners, contractors, building supply clerks, architects and others who use or recommend wood products. This summary will briefly review the major causes of biological deterioration of wood and how it can be prevented.

Agents of Biological Deterioration

Wood decay, or wood rot, is one of the major causes of wood deterioration. Decay is caused by certain classes of fungi which use moist or wet wood as a food source. As decay develops, the wood is literally dissolved away, rapidly loses its strength, and most commonly becomes brown and crumbly (brown rot); or it may develop into a white, soft, fibrous mass (white rot). Dry wood does not decay. The term "dry rot" is a misnomer in that the wood was actually wet when it decayed and then subsequently dried out. Thus, it is sometimes termed "dry rotted".
Decay fungi are spread by tiny spores which are equivalent to seeds. These spores are everywhere in the air and soil around us. There is no avoiding them. When a spore comes in contact with a moist piece of wood, it may germinate and develop microscopic hyphae which can quickly spread through the wood, using it for food.

Wood decay fungi have four basic requirements in order to destroy wood. These are: a food source or the wood itself; moisture; warm temperatures; and oxygen. Eliminating any one of these four requirements will stop the decay fungi. Normally, wood does not decay because it is kept dry as in houses, or the wood is made a non-food source by treating it with a preservative. Similarly, wood buried deep underground or submerged in water undergoes very little decay because of limited oxygen.

Insects represent the second major biological category of organisms which destroy wood. Some insects use the wood as a food source while a few use it for shelter. Termites are probably the most commonly thought of insect which use wood as a food source. The common subterranean termite actually nests in a moist area, usually the soil, and moves to the wood and consumes it as a food source. These termites may build shelter tubes over unpenetratable surfaces in order to reach the wood and not expose themselves to predators and the drying effect of the air. Numerous other wood boring insects also use wood as a food source. These include other types of termites, powder post beetles and old-house borers.

Carpenter ants and carpenter bees are examples of insects which use wood for shelter. Carpenter ants prefer damp and partially decayed wood. They simply gnaw the wood away in order to create cavities for themselves. When carpenter ants and decay occur together, serious damage can result. Carpenter bees which look like bumblebees simply bore into soft textured wood located under eaves or similarly protected locations and lay eggs in the tunnel created. Damage is normally limited to the 1/2-inch round entrance holes and tunnels within the wood.

Marine borers represent the third general class of biological organisms which can destroy wood. There are many different types of marine borers. Their natural ranges, the manner in which they destroy wood, and control measures all vary greatly. Marine borers, regardless of
type, are serious pests if present in significant numbers. Wood used in all United States' coastal and brackish waters is subject to at least some marine borer damage. The number of different species of marine borers and the severity of attack is more pronounced in warmer waters. Some marine borers are tolerant of certain wood preservatives.

One group of marine borers, generally called the shipworms, is probably the most fascinating. The young larvae enter the wood by boring a hole less than 1/16 inch in diameter. After metamorphosis, the shipworms continue to grow and bore in the wood. They can never leave it, but their offspring can. One group of shipworms can enlarge to about a 7/8 inch diameter and grow to 5 or 6 feet in length.

Gribbles represent another common group of marine borers. Gribbles bore holes about 1/16 inch in diameter and seldom go more than about 1/2 inch below the surface of the wood. However, there may be 300 to 400 organisms per square inch. As the wood is honeycombed, it is broken away by the mechanical action of the waves and the borers continue to destroy the wood, usually most rapidly in the intertidal zone. In piling, a typical hourglass shape results.

**Control of Wood Destroying Organisms**

Wood destroying organisms or their effects can be controlled by a number of different methods or combination of methods. These methods include construction techniques to keep wood dry, insecticides, and the use of naturally durable wood or preservative treated wood.

Where wood can be kept dry to prevent decay and away from the soil to prevent subterranean termite attack, the chances for deterioration are greatly reduced. Traditional house designs are in part the result of designers' and builders' wishes to keep wood dry and off the ground. Masonry materials are generally used for the foundation and the lowest wood members are usually at least 8 inches from the soil line. This technique keeps the wood from soaking up water from the soil and forces termites to build shelter tubes (and, thus, announce their presence) in order to reach the wood above. Roof overhangs and gutters help divert water away from the house. Traditional siding and caps over windows and doors are all constructed
in an overlapping fashion so any wind-driven water is shed downwards. Adequate ventilation in attics and crawl spaces is also provided. When attention is paid to design features and to construction detailing that keeps wood dry, centuries of good performance can be expected.

There are many uses for wood where it cannot be kept dry. These include applications such as decks, fence posts and fence boards, utility and telephone poles, railroad ties, landscape timbers, marine structures, and numerous others. In these cases, wood treated with preservatives or naturally durable wood species should be specified.

Before the science of wood preservation was developed, woods with naturally durable heartwood were commonly available and used. These woods are species like black locust, white oak, cypress and cedar in the eastern United States and redwood and all cedars in the west. The heartwood, or dark central part of these trees as compared to the white outer sapwood, is naturally impregnated with extractives which impart some resistance to decay and insects. The natural resistance varies greatly and is less in the younger trees which are available today. It is probably best not to use this material where a high potential for decay or insect attack exists. Today it is much more common to use materials which are treated with a wood preservative.

Wood preservation is a complicated science which is not always exact due to the biological nature of the materials and organisms involved. From an industrial aspect, there are numerous standards and regulations which have been prescribed. An understanding of preservatives and preservative treated wood will facilitate more intelligent selection, specification, purchasing, and installation of the proper materials.

Depending on how wood preservatives are applied, several different levels of protection can be achieved. Treatments such as brush, spraying and dipping are superficial and do not deeply penetrate the wood, nor can the wood normally absorb large amounts of preservative. Therefore these treatments offer a minimal amount of protection and are generally used for above ground applications where a high decay hazard does not exist, for remedial treatment, or field treatment where treated wood has been cut.
Commercial preservative-treating processes use various combinations of vacuum and pressure to assure that adequate quantities of the preservative are forced deeply into the wood. To insure long-term performance, the correct preservative for a particular application must first be specified. An adequate amount of preservative must then be impregnated into the wood. This is called retention, and minimum retention levels are always specified in treating standards. In addition, the treatment should penetrate the wood as deeply as can be reasonably achieved. Penetration levels are also specified in treating standards.

Essentially, the treating process forms a protective shell of wood containing preservative around an inner core of untreated material. This shell must not be broken by sawing, boring, machining, or from checks due to seasoning because the core of untreated wood will then be subject to attack by biological agents. Larger members will have substantially more untreated core than smaller ones for any given species. If the shell is broken, the exposed wood should be liberally treated by brushing or soaking with a preservative. Smaller dimension lumber and plywood when properly treated to existing standards, should not present a serious problem.

For wood products such as lumber, plywood, and posts available in retail yards, waterborne preservatives are most commonly used. Water is used as a carrier for the solution which is forced into the wood. The water subsequently moves out of the wood leaving the preservative behind. The preservative changes its chemical form and it becomes fixed in the wood and highly leach resistant. These preservatives are also referred to as CCA (chromated copper arsenate) which is used commonly in the eastern and central United States on southern pine and ACZA (ammoniacal copper zinc arsenate) used on Douglas-fir in the west. ACQ (ammoniacal copper quaternary ammonium compound) is a newer waterborne preservative which has recently been introduced. Wood treated with the waterborne preservatives should have a residue free surface. It is odor free and, when dry, the treated wood can be stained or painted. Wood treated with the waterborne preservatives is commonly used wherever resistance to decay and insects is needed. These uses include decks, sill plates, outdoor steps, landscape timbers, posts and fence boards, posts in pole barns, wharves, and many other applications. If moisture is present when standard ferrous fasteners are used with waterborne preservatives, corrosion can occur. Therefore, hot dipped galvanized fasteners are used above ground and stainless steel fasteners are used in more severe applications.
such as soil contact.

Pentachlorophenol (penta) and creosote are probably the most common of the older, traditional, oil-based preservatives and most of the wood treated with these preservatives ends up in commercial applications. For example, pentachlorophenol is commonly specified for treating poles, whereas creosote is specified for treating railroad ties and marine structures. Because these preservatives are oil-based and have a characteristic odor, they are generally not suitable for use where aesthetics is important or skin contact is likely. After aging for many years, however, the surface residue and odor can become less of a problem. Another oil-based preservative called copper naphthenate is also gaining acceptance in the pole market.

As mentioned, numerous standards and regulations exist in the wood treating industry. The standards are developed and maintained by the American Wood Preservers' Association (AWPA) and the preservatives themselves are regulated by the U.S. Environmental Protection Agency (EPA). The American Lumber Standard Committee (ALSC) is the industry group which certifies that wood products are treated according to accepted standards. Products which meet these standards are marked with ink stamps, tags or brands which indicate the treating company, the preservative, and other important information. For preservative treated lumber obtained at lumber yards, producers will normally supply a limited warranty. Wood products which are not marked with the above information may not be treated according to industry standards for the particular end use under consideration.

It is important to recognize that the preservatives CCA, ACZA, pentachlorophenol and creosote, are restricted-use pesticides based on EPA regulations. That is, they are only available to individuals who have received special training concerning the safe application and handling of restricted-use pesticides. However, wood products treated with these preservatives are not restricted and they are available to anyone. The EPA has published Consumer Information Sheets which provide information on the safe use, handling, and disposal of the material. These sheets are available from the distributor of the material. Be sure to obtain your copy and read it carefully.
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Chapter 1. Introduction

Durability

Wood, because of its abundance, has always been a common building material in North America. Uses include shelter, farm and factory buildings, ships and docks, railroads, fences, and many others. The colonist and early settlers quickly learned that each species has unique characteristics that make it particularly suitable for certain uses. For example, the heartwood of black locust, white oak, cypress and cedars is noted for being naturally durable or resistant to decay and insects. As a result, these species and some others were used where a high potential for decay or insect attack existed. The practice of using naturally durable woods where needed continued to about the end of the 1800's. At this time virgin old growth durable timber was being depleted in many sections of the country. The industrial revolution and particularly the railroads and utilities created a need for large quantities of timber products which would have long life expectancies when used in conditions which favored decay and insect attack. In response, the science of wood preservation was developed. That is, preservatives are injected into more plentiful, non-durable wood to make the material resist decay and insect attack.

Timber Availability

It makes good sense to use wood as a construction material. Trees are a renewable resource and when the colonists cut virgin timber and the land was not developed, new stands soon began to grow and mature. This timber is harvested on a periodic basis much like any other agricultural crop. With proper management, this resource can be both utilized and maintained. For example, in 1991 the national net timber growth exceeded the volume harvested by one third as compared to the 1920's when the harvest was double the growth.¹

Environmental Acceptability

In addition to being renewable, wood is one of the most environmentally acceptable materials which can be
used. From raw material extraction to finished product, the energy input is 70 times higher for a ton of aluminum than for a ton of lumber, and 17, 3.1 and 3 times higher for steel, brick and concrete block than for wood. Wood is also an excellent insulator when compared to other construction materials. For an equivalent thickness, solid wood is 4 times more efficient as an insulator than cinder block, 6 times more efficient than brick, 15 times more efficient than concrete and 1,770 times more efficient than aluminum. Finally, healthy, fast-growing forests managed by scientific silvicultural methods for long-term yield absorb carbon dioxide from the atmosphere and provide a net oxygen gain thus reducing the greenhouse effect.

**Treated Wood Saves Material**

In some respects, the wood which is available today is different from the old growth material. Tree diameters are smaller and the amount of heartwood is less. Therefore, when the material is used in a high decay or insect hazard application, in most cases, it should be treated with a wood preservative. The proper use of wood preservatives insures maximum longevity of the material. Two important benefits result. First, if the wood does not have to be replaced less timber needs to be cut. It has been estimated that treating wood saves 226 million merchantable trees annually. Second, replacement of deteriorated wood is costly in terms of the wood used and the labor required in replacement, as well as any general disruption which results.

**Health Issues**

Wood preservatives are chemicals and like all substances, when not properly handled and applied, certain environmental and health hazards exist. Available wood preservatives are regulated by the U.S. Environmental Protection Agency. Some preservatives are available "over the counter" to the general consumer while the sale of others is restricted to certified applicators. The restricted-use applies to the chemical preservative and not to treated wood products. Wood products treated
with restricted-use pesticides or preservatives are available to the general public. It is important to read all labels and to follow proper use, handling, and disposal recommendations. Preservative treated wood should be used only where conditions warrant it. Safe use of wood preservatives and treated wood products is addressed in Chapter 11.

This publication will first provide background information on wood as a construction material as well as biological deterioration. Then, the methods used to protect wood, the types of preservatives, treatment processes and properties of treated wood will be addressed. How buyers can specify treated wood products and be assured of receiving a quality product will be addressed. Finally, safe handling and environmental concerns with treated wood products will be discussed. Emphasis will be placed on the softwood species since they are the most common commercial species which are treated with preservatives. Some information on hardwoods will also be provided when appropriate.

Chapter 2. Wood as a Construction Material

Lumber, heavy timbers, poles, piles and many other wood products are derived from trees. Trees are biological organisms which we see and enjoy every day, but we seldom consider the complexity and variability of the wood produced by them. An understanding of some of the basic characteristics and properties that make wood a complex and variable material can help in making sound decisions in specifying, treating, and, finally, using the many different wood products. In addition, a better understanding of wood characteristics can also help solve problems when they arise in current applications.

Softwoods and Hardwoods

Softwoods are by far the most common wood material which is treated with preservatives.

Softwoods are trees such as the
pines, spruces, larch, true firs, hemlock, redwood, yew, cypress, Douglas-fir and cedars which have needles or scale-like leaves and, except for cypress and larch, maintain these needles throughout the year. They are also called evergreens. Because they bear scaly cones to produce seeds, they are sometimes called conifers. Softwoods are most commonly used for construction lumber, heavy timbers, poles and piles where functionality, not appearance, is important.

Softwoods for construction purposes are specified by "species groups". For example, if "Southern Pine" is specified, the shipment may contain any of the major species, namely loblolly, longleaf, shortleaf or slash pine. Another group is called "Mixed Southern Pine" which may contain any of the ten southern pine species. For western species, larch can be mixed in with Douglas-fir and sold as the species group "Douglas-Fir-Larch" or "Douglas-Fir-Larch (North)". Or it may be sold by itself and be designated "Douglas Fir-South". "Hem-Fir" is another mixed group composed of western hemlock and several species of true firs. These species groupings are made on strength characteristics and the availability of the species within a producing region.

Hardwoods are trees such as the oaks, maples, hickories, gums and many others which have broad deciduous leaves. Their leaves change color in the fall and drop to the ground--at least in temperate climates. Hardwoods are often used for railroad ties, heavy timbers, pallets, and for interior applications. Hardwoods used for crossties are always treated but, other than this application, the availability of preservative treated hardwoods is limited.

The terms "hardwood" and "softwood" do not directly describe the hardness or softness of the wood. Instead, they refer to the leaf form or mode of seed production for trees from which the wood is cut. The terms are especially confusing because some true hardwoods such as basswood have softer or lighter
wood than common softwoods such as southern pine. Softwoods are also very strong for their weight in comparison to the hardwoods.

**Sapwood and Heartwood**

The wood formed immediately inside the bark of a tree is called sapwood. Sapwood is light in color and contains living cells that transport water from the roots to the branches and leaves at the top of the tree. Heartwood is formed in the central part of the tree stem, as those water conducting cells in the sapwood die. Due to an accumulation of various materials, extractives, pitch, oil, and other extraneous substances, the heartwood is often darker than the sapwood. It is these materials which impart natural decay resistance to some species.

The relative thickness of sapwood and heartwood in stems of various tree species is an important characteristic. Heartwood of most tree species is difficult to treat with preservatives, but the sapwood of nearly all species accepts preservatives. Southern pine poles and lumber readily accept preservatives because these trees and lumber are mostly sapwood (Fig. 2-1). By contrast, poles and lumber cut from mature Douglas-fir trees contains a high proportion of impermeable heartwood that is difficult to treat. Considering the hardwoods, the heartwood of red oak is permeable whereas that of white oak is some of the most impermeable wood. Thus, red oak is preferred for railroad ties. It is this type of variability, that shapes the grouping of wood products by species into standards for wood preservative treatments.

Very few, if any, differences exist in the mechanical properties of sapwood and heartwood. Heartwood of some species may have a slightly higher weight per unit volume than sapwood due to the presence of significant amounts of extractives.

**Natural Durability**

In the past, old growth naturally durable woods such as cedars, cypress, redwood, chestnut and some others were available and commonly
used where biological deterioration could occur. Table 2-1 ranks the more common species for natural heartwood durability and Table 2-2 rates several wood species commonly imported into the United States. It is the extractives, pitch, oil and other extraneous substances deposited in the heartwood which impart resistance to decay and insects, thus making certain species more durable than others. Where the extractives do not have a toxic or repellent effect, the heartwood is no more resistant than the sapwood. Now, the demand for naturally durable woods exceeds potential supply, or they are too expensive for general construction purposes. Furthermore, second growth heartwood may be less durable than scarcer old growth material. As a result, wood properly treated with preservatives is more commonly utilized than are the naturally durable species.

**Earlywood and Latewood**

The growth increments in softwood species, such as southern pine and Douglas-fir, are composed of two distinct parts. Earlywood (sometimes called springwood) is that portion of the growth increment which is formed during the first part of the growing season or usually in the spring. Earlywood cells are relatively large in diameter, thin-walled and lighter colored. Latewood (sometimes called summerwood) is formed after the earlywood (Fig. 2-1). The latewood cells are smaller, thick-walled and darker. As a result, latewood is denser and stronger than earlywood.

The growth rate or width of the growth increment, and the percent of latewood which it contains, are important factors in the grading of southern pine lumber where mechanical properties are of concern. For example, a grade called Dense Southern Pine is defined as averaging, one end or the other, not less than six annual rings per inch, and one-third or more of each annual ring is latewood. Pieces averaging not less than four annual rings per inch with one-half latewood are also classified as dense. Fast growth southern pine may have only two or three growth increments per inch and a relatively small
percentage of latewood in each ring. The mechanical properties of fast
growth southern pine are less than those for the material with a high
percentage of latewood. As a result, the fast growth material is placed in a
lower grade for lumber used in structural applications.

The latewood in softwoods is more easily penetrated with wood
preservatives than earlywood but the retention is less due to a decreased
void volume. Wide bands of latewood also make species such as southern
pine and Douglas-fir more prone to peeling and flaking when painted.

Grain Patterns (Planes or Surfaces)

Visible characteristics, shrinkage and mechanical properties of wood are
defined in terms of the three planes or surfaces in which wood can be cut
from a log (Fig. 2-1). In reality, however, very few boards are
perfectly cut on one of these planes. The saw cut usually ends up at some
angle between the radial and tangential planes.

End grain (cross section) is the surface exposed when wood is cut
across the width of a log or board. The end grain reveals the annual rings.
Because the end grain is porous it absorbs or loses moisture much more
easily than side grain (radial or tangential). The end grain is also
more easily treated with preservatives.

The radial surface is exposed when a log is cut longitudinally from its very
center or pith to the bark (along the radius). In the hardwood industry,
lumber cut this way is known as quartersawn lumber. Some softwood
species, such as southern pine and Douglas-fir, are quartered to expose a
vertical grain pattern, and are used for flooring because of the high resistance
to wear and the wood's tendency not to cup. It is also the preferred
material for preservative treated southern pine shakes and decking.
This lumber is sometimes referred to as edge-grained or vertical-grained
(Fig. 2-2).

The tangential surface is exposed when a board is cut parallel to the
bark and tangent to the log diameter.
The lumber is called flat-grained
(softwoods) or plainsawn
(hardwoods). This is the most
common way of producing lumber
today. A characteristic U or V-shaped
grain pattern (Fig. 2-2) results in the
softwoods with distinct earlywood
and latewood bands, such as southern
pine and Douglas-fir, and the coarse
grained hardwoods such as oak.

**Moisture Content Levels**

Because the amount of water in wood
(moisture content) affects wood
treatability, strength, durability and
dimensional stability, wood moisture
content is often referenced in
specifications.

The moisture content of wood is the
ratio of the weight of water in the
wood to the weight of the wood
when it is oven-dry. The following
formula is used to calculate the
moisture content of wood. Wood is
considered oven dry when it is heated
to 103 ±2°C and approximately
constant weight is achieved.

\[
\text{Moisture Content (\%) } = \frac{\text{Initial weight} - \text{Oven-dry weight}}{\text{Oven-dry weight}} \times 100
\]

Wood cut from a green log often
contains as much or more than its
oven-dry weight in the form of sap or
water, hence its moisture content may
be more than 100 percent. The cell
walls in green wood are fully
saturated and swollen, and the cell
cavities are partially to completely
filled with water. The water in wood
cell cavities is called free water.

After the wood has dried to about 30
percent moisture content, it is at the
fiber saturation point. In this state,
the cell cavities are emptied of free
water, but the cell walls are still
saturated with bound water and, thus,
still in their weakest condition. At
moisture contents above the fiber
saturation point, wood can be
attacked by decay fungi. *Note:*
*Because the moisture content of
wood is variable and changes with
environmental conditions, any wood
with a moisture content of 20 percent
or more is considered subject to
decay.*

Since wood is a hygroscopic material,
FIG. 2-1

Cross Section

Sapwood

Heartwood

Pith

Outer dead bark

Inner living bark

Earlywood

Latewood

Radial surface

Tangential surface
the amount of bound water which the wood holds depends on the relative humidity. That is, it responds to changes in atmospheric humidity and loses water as the relative humidity drops, regaining water as the relative humidity increases. For a given relative humidity level, a balance is eventually reached at which the wood is no longer gaining or losing moisture. When this balance of moisture exchange is established, the amount of bound water eventually contained in a piece of wood is called the equilibrium moisture content of the wood.

Shrinking and Swelling

Wood shrinks and swells due to the loss or gain of bound water from the cell walls. The amount of movement depends on the amount of water gained or lost, the orientation of the wood cells and the species (Table 2-3). The percent shrinkage from green to any given moisture content can be calculated by dividing the total shrinkage provided in the table by 30 and multiplying by the moisture content at less than 30 percent. This movement can be significant and it can create structural and aesthetic problems.

To minimize problems (shrinking, swelling, checking and warping) due to changing moisture contents, wood should be dried to its anticipated service equilibrium moisture content before installation. Table 2-4 shows the recommended moisture content values for various wood items at the time of their installation.

Shrinkage of normal wood in the longitudinal direction is about 0.1 percent and considered insignificant.

Tangential shrinkage in wood is generally 1.5 to 2 times that of the radial shrinkage. Since radial and tangential shrinkage is not equal, and because most boards contain some combination of the two grain patterns, warping will result if green lumber is allowed to dry without restraint. Warping includes cup, bow, twist, as well as diamonding, and crook (Fig. 2-3). Round products such as poles, piles and posts and large sawn timbers, develop surface checks and
deep cracks for the same reason. Checks or cracks that penetrate the preservative shell on treated products provide entryways for decay fungi and insects. These products are ideally dried before treating so the preservative will penetrate any openings which develop. In many commercial processes, poles, railroad ties and large timbers are put in treating cylinders and steamed or boultenized (heated in oil) prior to treatment. This process dries the wood to acceptable limits.

Abnormal Wood

In both hardwoods and softwoods, depending on age and location in the tree, some wood is found which is not representative for that species. This wood is called abnormal wood. Its strength properties are significantly lower than that of normal wood; therefore, the amount of abnormal wood in a structural product is usually limited. Longitudinal shrinkage characteristics are also much higher than for normal wood.

Juvenile wood is one type of abnormal wood that is formed near the center or pith of the tree, and is prevalent in the softwoods or conifers. It also occurs in the hardwoods. Juvenile wood is characterized by wide growth rings with shorter, thin-walled cells, and fewer latewood cells, thus resulting in a lower density and reduced strength values. There is also a tendency towards greater spiral grain which lowers the wood's mechanical properties. The shrinkage characteristics of juvenile wood are also different from those of normal wood, thus increasing warp problems. When drying, the wood often checks across the grain (Fig. 2-4) and it can be difficult to treat. The change from juvenile wood to normal wood is gradual, thus making identification of juvenile wood difficult.

Reaction wood is an abnormal wood that forms in leaning or bent trees and it is an attempt by the tree to straighten itself out. In softwoods, reaction wood is called compression wood. It is formed on the lower side of leaning trees. The part of the growth ring with reaction wood is usually wider than the rest of the ring.
and has a high proportion of latewood. As a result, the tree develops an eccentrically shaped stem, and the pith is not centered. Compression wood, especially the latewood, is usually duller and more lifeless in appearance (Fig. 2-4). It presents serious problems in wood manufacturing since it is much lower in strength than normal wood of the same density and it may fail with a brash break. Also, unlike normal wood, it tends to shrink excessively in the longitudinal direction causing cross grain checking. Compression wood can be the cause of cross grain breaks and subsequent breaking away of the wood surface (Fig. 2-5). It is sometimes the cause of structural failures in critical applications, such as ladders. The softwood lumber grading rules restrict the extent of compression wood in lumber. Specifications and standards for wood poles usually require that the outer one inch of all poles be free from compression wood visible on either end.

In hardwood trees, reaction wood is called tension wood and forms predominately toward the upper side of the leaning tree. Tension wood is usually not as easy to detect as compression wood. It may form irregularly around the entire stem and, as a result, there is less tendency for the pith to be off center. It may have a silvery appearance. At other times it cannot be visually detected. When machined, a fuzzy or woolly surface may result, particularly in green wood. Stain is sometimes absorbed irregularly by tension wood during the finishing process, leaving a blotchy appearance. Warping is also a problem with tension wood due to abnormal longitudinal shrinkage and during drying, collapse often results. The strength properties of tension wood are generally less than for normal wood.

**Treatability**

Treatability describes the ease with which preservatives can be forced into the wood under pressure. With the exception of hemlock and true fir, the sapwood of all species is easily treated. However, as with the many other wood characteristics, heartwood
treatability varies with the different wood species (Table 2-5). Significant variability may also occur within a given species. Douglas-fir heartwood is a good example. The heartwood of coastal Douglas-fir is relatively permeable, Cascade Mountain sources are moderately impermeable and intermountain sources are impermeable or refractory.

Lastly, the treatability of wood varies with grain direction. The penetration ratio of end grain to side grain for the preservative oils is approximately 15 to 1 and 20 to 1 for the waterborne preservatives.6

**Mechanical Properties**

Mechanical, or strength properties, refer to those characteristics which architects or engineers use in the design of a structure (utility line, wharf, bridge, house, etc.). These properties, called allowable design values for lumber, are available in pounds per square inch (psi).7 A complicating factor arises with wood because it has different strength values across the grain as compared to along the grain. Most species are four to five times as strong in compression along the grain as they are across the grain. It is also important to recognize which mechanical properties should be considered since a wood which is relatively strong with respect to one strength property may be weaker in a different property when compared to another species.

Stiffness is an important property of wood members that should not sag. The Modulus of Elasticity (MOE or E) is a measure of stiffness or rigidity. Allowable design values are keyed to an average MOE value without reduction for property variability because stiffness is most important from an appearance standpoint and not from the point of life safety. That is, the member, if not properly designed, could sag or otherwise deflect without physically hurting someone.

The Modulus of Rupture (MOR) is the measure of the ability of a beam to support an applied load. Since the modulus of rupture represents the
point at which a beam will fail, it is considered a life endangering property and the allowable design values are substantially reduced from those given for small clear wood specimens.

Compression strength is a measure of the resistance of wood to being crushed. A common example of where compression strength along the grain is utilized occurs in studs in house walls. The studs, usually 2x4’s, hold up the roof with any snow or wind loads that may arise and are loaded in compression parallel to the grain.

Tensile strength is basically the opposite of compression strength. In this case, the load is applied in such a way that the wood member is being pulled from end to end (tension parallel to the grain). An example is the bottom chord or member of a single roof truss. As the two rafters of the truss are forced downward by wind or snow loads, the bottom horizontal member is put into tension as it holds the ends of the rafters in place.

The shear strength of a member parallel to the grain is a measure of the ability of wood to resist the slipping of one part along another. Shear failure is important in beam design. Shear strength, like modulus of rupture, is a life endangering property. Consequently, substantial differences exist between the allowable design values, and those for small clear wood specimens.

Side hardness relates to the ability of wood to resist denting. One example includes flooring.

Toughness is a measure of the amount of work expended in breaking a small specimen by impact bending. This property is important when impact loads are applied. Toughness is reduced by the early stages of decay and even stain fungi.

Figure 2-1. Section of mature southern pine tree showing gross wood structure.

Figure 2-2. Earlywood (light colored) and latewood (dark colored) bands in both edge (left) and flat grain (right)
samples of southern pine.

Figure 2-3. Various types of warp.

Figure 2-4. Juvenile wood with cross grain checking (top arrows) and compression wood (bottom arrow) in ponderosa pine.

Figure 2-5. “Shelling” from compression wood in a southern pine utility pole.
FIG. 2-3

- BOW
- POINT OF GREATEST DEFLECTION
- CROOK
- RISE OF FOURTH CORNER
- TWIST

- OVAL
- DIAMOND
- CUP

POINT OF GREATEST DEFLECTION
FIG. 2-4

COMPRESSION WOOD

JUVENILE WOOD

Labels will be improved.
Table 2-1. Natural decay resistance of the heartwood of several domestic species.¹

<table>
<thead>
<tr>
<th>Resistant or very resistant</th>
<th>Moderately resistant</th>
<th>Slightly or nonresistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baldcypress</td>
<td>Bald cypress</td>
<td>Alder</td>
</tr>
<tr>
<td>(old growth)</td>
<td>(young growth)</td>
<td>Ashes</td>
</tr>
<tr>
<td>Catalpa</td>
<td>Douglas-fir</td>
<td>Aspens</td>
</tr>
<tr>
<td>Cedars</td>
<td>Honeylocust</td>
<td>Basswood</td>
</tr>
<tr>
<td>Cherry, black</td>
<td>Larch, western</td>
<td>Beech</td>
</tr>
<tr>
<td>Chestnut</td>
<td>Oak, swamp chestnut</td>
<td>Birches</td>
</tr>
<tr>
<td>Cypress, Arizona</td>
<td>Pine, eastern white</td>
<td>Buckeye</td>
</tr>
<tr>
<td>Junipers</td>
<td>Southern Pine:</td>
<td>Butternut</td>
</tr>
<tr>
<td>Locust, black</td>
<td>Longleaf</td>
<td>Cottonwood</td>
</tr>
<tr>
<td>Mesquite</td>
<td>Slash</td>
<td>Elms</td>
</tr>
<tr>
<td>Mulberry, red</td>
<td>Tamarack</td>
<td>Hackberry</td>
</tr>
<tr>
<td>Oak:</td>
<td></td>
<td>Hemlocks</td>
</tr>
<tr>
<td>Bur</td>
<td></td>
<td>Hickories</td>
</tr>
<tr>
<td>Chestnut</td>
<td></td>
<td>Magnolia</td>
</tr>
<tr>
<td>Gambel</td>
<td></td>
<td>Maples</td>
</tr>
<tr>
<td>Oregon white</td>
<td></td>
<td>Oak (red and black species)</td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td>Pines (other than longleaf, slash, and eastern white)</td>
</tr>
<tr>
<td>White</td>
<td></td>
<td>Poplars</td>
</tr>
<tr>
<td>Osage-orange</td>
<td></td>
<td>Spruces</td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
<td>Sweetgum</td>
</tr>
<tr>
<td>Sassafras</td>
<td></td>
<td>True firs (western and eastern)</td>
</tr>
<tr>
<td>Walnut, black</td>
<td></td>
<td>Willows</td>
</tr>
<tr>
<td>Yew, Pacific</td>
<td></td>
<td>Yellow-poplar</td>
</tr>
</tbody>
</table>

¹ These woods have exceptionally high decay resistance.
Table 2-2. Natural decay resistance of the heartwood of several imported species.

<table>
<thead>
<tr>
<th>Resistant or very resistant</th>
<th>Moderately resistant</th>
<th>Slightly or nonresistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angelique</td>
<td>Andiroba*</td>
<td>Balsa</td>
</tr>
<tr>
<td>Apamate</td>
<td>Apitong*</td>
<td>Banak</td>
</tr>
<tr>
<td>Brazilian rosewood</td>
<td>Avodire</td>
<td>Cativo</td>
</tr>
<tr>
<td>Caribbean pine</td>
<td>Capirona</td>
<td>Ceiba</td>
</tr>
<tr>
<td>Courbaril</td>
<td>European walnut</td>
<td>Jelutong</td>
</tr>
<tr>
<td>Encino</td>
<td>Gola</td>
<td>Limba</td>
</tr>
<tr>
<td>Goncalo alves</td>
<td>Khaya</td>
<td>Lupuna</td>
</tr>
<tr>
<td>Greenheart</td>
<td>Laurel</td>
<td>Mahogany, Philippine:</td>
</tr>
<tr>
<td>Guijo</td>
<td>Mahogany, Philippine:</td>
<td></td>
</tr>
<tr>
<td>Iroko</td>
<td>Almon</td>
<td>Mayapis</td>
</tr>
<tr>
<td>Jarrah</td>
<td>Bagtikan</td>
<td>White lauan</td>
</tr>
<tr>
<td>Kapur</td>
<td>Red lauan</td>
<td>Obeche</td>
</tr>
<tr>
<td>Karri</td>
<td>Tanguile</td>
<td>Parana pine</td>
</tr>
<tr>
<td>Kokrodua (Afromosia)</td>
<td>Ocote pine</td>
<td>Ramin</td>
</tr>
<tr>
<td>Lapacho</td>
<td>Palosapis</td>
<td>Sande</td>
</tr>
<tr>
<td>Lignumvitae</td>
<td>Sapele</td>
<td>Virola</td>
</tr>
<tr>
<td>Mahogany, American Meranti*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peroba de campos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primavera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Maria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spanish-cedar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teak</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* More than 1 species included, some of which may vary in resistance from that indicated.
Table 2-3. Shrinkage values from green to oven-dry moisture content for selected domestic species.¹

<table>
<thead>
<tr>
<th></th>
<th>Shrinkage from green to oven-dry moisture content³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Radial</td>
</tr>
<tr>
<td></td>
<td>--  Percent --</td>
</tr>
<tr>
<td><strong>Hardwoods:</strong></td>
<td></td>
</tr>
<tr>
<td>Oak (Northern Red)</td>
<td>4.0</td>
</tr>
<tr>
<td>Oak (White)</td>
<td>5.6</td>
</tr>
<tr>
<td>Sweetgum</td>
<td>5.3</td>
</tr>
<tr>
<td>Yellow-Poplar</td>
<td>4.6</td>
</tr>
<tr>
<td><strong>Softwoods:</strong></td>
<td></td>
</tr>
<tr>
<td>Douglas-fir</td>
<td></td>
</tr>
<tr>
<td>Coast type</td>
<td>4.8</td>
</tr>
<tr>
<td>Interior North</td>
<td>3.8</td>
</tr>
<tr>
<td>Interior West</td>
<td>4.8</td>
</tr>
<tr>
<td>Fir</td>
<td></td>
</tr>
<tr>
<td>Pacific silver</td>
<td>4.4</td>
</tr>
<tr>
<td>White</td>
<td>3.3</td>
</tr>
<tr>
<td>Western Hemlock</td>
<td>4.2</td>
</tr>
<tr>
<td>Pine</td>
<td></td>
</tr>
<tr>
<td>Eastern White</td>
<td>2.1</td>
</tr>
<tr>
<td>Southern</td>
<td>5.0</td>
</tr>
</tbody>
</table>

¹Expressed as a percentage of the green dimension.

²Coast Douglas-fir is defined as Douglas-fir growing in the States of Oregon and Washington west of the summit of the Cascade Mountains. Interior West includes the State of California and all counties in Oregon and Washington east of but adjacent to the Cascade summit. Interior North includes the remainder of Oregon and Washington and the States of Idaho, Montana, and Wyoming.

³Average of four major species.
Table 2-4. Recommended moisture content values for wood at time of installation.

<table>
<thead>
<tr>
<th>Interior:</th>
<th>Most areas of United States</th>
<th>Moisture content for dry southwestern areas</th>
<th>Damp, warm coastal areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Range -- Percent --</td>
<td>Average Range -- Percent --</td>
<td>Average Range -- Percent --</td>
</tr>
<tr>
<td>Woodwork, flooring, furniture, wood trim, laminated timbers, coldpress plywood</td>
<td>8  6-10</td>
<td>6  4-9</td>
<td>11  8-13</td>
</tr>
<tr>
<td>Exterior:</td>
<td>12  9-14</td>
<td>9  7-12</td>
<td>12  9-14</td>
</tr>
<tr>
<td>Siding, wood trim, framing, sheathing, laminated timbers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2-5. Classification of American woods with respect to heartwood penetrability

#### Softwoods

**Group 1. Heartwood Easily Penetrated**

<table>
<thead>
<tr>
<th>Bristlecone pine</th>
<th>Basswood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinon pine</td>
<td>Beech (white heartwood)</td>
</tr>
<tr>
<td>Ponderosa pine*</td>
<td>Black gum</td>
</tr>
</tbody>
</table>

#### Hardwoods

<table>
<thead>
<tr>
<th>Black gum</th>
<th>Green ash</th>
<th>Pin cherry</th>
<th>River birch</th>
<th>Red oaks</th>
<th>Slippery elm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet birch</td>
<td>Tupelo gum</td>
<td>White ash</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Group 2. Heartwood Moderately Difficult to Penetrate**

<table>
<thead>
<tr>
<th>Douglas-fir (Pacific-coast type)</th>
<th>Black willow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jack pine</td>
<td>Chestnut oak</td>
</tr>
<tr>
<td>Lobolly pine*</td>
<td>Cottonwood</td>
</tr>
<tr>
<td>Longleaf pine*</td>
<td>Largetooth aspen</td>
</tr>
<tr>
<td>Norway pine</td>
<td>Mockernut hickory</td>
</tr>
<tr>
<td>Shortleaf pine*</td>
<td>Silver maple</td>
</tr>
<tr>
<td>Western hemlock</td>
<td>Sugar maple</td>
</tr>
<tr>
<td></td>
<td>Yellow birch</td>
</tr>
</tbody>
</table>

**Group 3. Heartwood Difficult to Penetrate**

| Eastern hemlock                  | Hackberry |
|                                  | Rock elm  |
| Engelmann spruce                 | Sycamore  |
| Lowland white fir                |           |
| Lodgepole pine                   |           |
| Noble fir                        |           |
| Sitka spruce                     |           |
| Western larch                    |           |
| White fir                        |           |
| White spruce                     |           |

**Group 4. Heartwood Very Difficult to Penetrate**

| Alpine fir                       | Beech (red heartwood) |
| Corkbark fir                     | Black locust          |
| Douglas-fir (intermountain type) | Chestnut              |
| Northern white cedar             | Redgum                |
| Tamarack                         | White oaks (except chestnut oak) |
| Western redcedar                 |                        |

* More recent experience indicates that the heartwood is variable in penetrability and these species may be more difficult to penetrate than indicated.

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Chapter 3. Biological Deterioration of Wood

Wood preservatives are used to prevent damage by fungi, bacteria, insects, marine borers and other agents described here. An understanding of these organisms and their damage will contribute to improved wood procurement, construction, or rehabilitation practices. The various characteristics are summarized for fungi and bacteria in Table 3-1, for termites and carpenter ants in Table 3-2, for wood boring insects in Table 3-3 and for marine borers in Table 3-4. The correct identification and effective treatment of these numerous pests can require specialized expertise and experience. Licensed Pest Control Operators (PCO's) are individuals who have this specialized knowledge.

Fungi Causing Wood Rot

Wood decay, commonly called rotting, is the fungal decomposition of woody material. Fungi are non-green, flowerless, one cell to thread-like organisms that use wood and other plant materials as a food source. The thread-like structures, visible only with a microscope, are called hyphae (Fig. 3-1). Initially, individual hyphae develop from germinating spores and spread throughout the wood. The hyphae secrete enzymes which attack the wood cells, and finally cause the wood to disintegrate. In its early or incipient stage, wood decay is difficult to detect even though serious strength loss in the wood may have already occurred. Toughness is the mechanical property most sensitive to decay. It is a measure of wood's resistance to impact bending. A decrease of as much as one-third to one-half of the normal toughness value may occur even before any weight loss is detected.

Advanced decay is readily detected. Wood with appreciable decay will break brashly (abruptly) across the grain, whereas sound wood splinters at the break. Brashness, reflecting reduced toughness, can be detected by breaking small pieces by hand, or by lifting pieces of wood from the surface by means of a pointed
tool--the "pick test" (Fig. 3-2). The wood should be wet, otherwise it may break brashly even if sound. Brashness also is characteristic of compression wood (as discussed in Chapter 2), and test results should be interpreted appropriately.

**Fungi Requirements**

Fungi have four requirements for growth: food; oxygen; favorable temperature; and moisture.

**Food** - Since fungi are non-green plants, they cannot utilize sunlight to synthesize food materials. They require an already synthesized food source such as wood. Mold fungi generally feed on material located on the wood surface while sapstain fungi utilize food substances stored in the wood cells. The decay fungi utilize the wood cells themselves or the material which holds the cells together (lignin) thus causing serious weight and strength losses. Wood preservatives protect wood by making it non usable as a food source.

**Air** - All wood decaying fungi need a source of oxygen. Wood stored under water or deep in the soil does not readily decay because of the lack of oxygen. Only very slow and superficial degradation by soft rot fungi and bacteria may occur under these conditions.

**Temperature** - The best temperature for most wood decay fungi to develop is 75-90°F. Decay continues at a reduced rate at temperatures below 50°F and slightly above 90°F. It is dormant near 32°F and 100°F. Fungi may be killed by sterilization treatments. Sterilization temperatures and duration periods depend on the size of the wood material as well as the fungal species.

**Moisture** - For fungi to destroy wood, free water must be present in the cell cavities. Free water is usually found when the wood moisture content is 25 to 30 percent or higher. Thus, one effective way to control wood decay is to keep the moisture content of wood below 20 percent. Twenty percent is a commonly cited figure since wood moisture contents change with environmental conditions. Even
within the same wood member, moisture contents may vary depending on the immediate surroundings. Lumber properly installed in buildings has a moisture content of 8 to 15 percent, while that cut from freshly harvested trees may have a moisture content of well over 100 percent, based on the oven-dry weight of the wood. Wood in soil contact almost always has a moisture content of 20 percent or more.

The amount of moisture available and temperature are affected by geographic location. Figure 3-3 is a map which shows the relative decay potential for different parts of the United States. The southeastern United States and the coastal northwest have the highest potential for decay while the dry southwest has the least.

**Brown Rot**

Brown rot (Fig. 3-4) is the predominant type of decay in softwoods used above ground. Brown rot fungi remove the carbohydrates or cellulose, leaving a modified lignin residue. In the early stages of decay, the wood surface lacks luster and appears dull or dead. The strength properties of wood attacked by brown rot fungi decrease rapidly even in the early stages of decay. As decay progresses, the wood acquires an abnormal brown color, often as if it had been charred. Cross grain cracking, collapse or crumbling, and abnormal shrinkage finally result.

Dry rot is an erroneous term commonly used to describe well decomposed, brown-rotted wood. It is applied to wood which is both rotten and relatively dry, thus dry rotted. Actually, the wood was wet when it decayed and subsequently dried out. A few fungi can transport water to wood which would otherwise be dry and thereby cause its decay.

**White Rot**

White rot fungi preferentially remove lignin or both lignin and cellulose together. The white rot fungi (Fig. 3-5) are important in hardwoods used above ground. In the early stages of decay, the wood color tends to turn
an off-white, sometimes making the wood appear bleached. Black zone lines may develop in the light areas. Unless severely degraded, the wood does not crack across the grain and develop abnormal shrinkage or collapse as with the brown rots. A white fibrous mass may result. The strength properties decrease gradually with the exception of toughness.

Molds and Sapstains

Mold and sapstain fungi are two additional types of fungal damage that are important. Molds (Fig. 3-6) discolor the surface of wood by turning it different shades of green, black and occasionally orange or other light colors. Although the fungal hyphae do penetrate into the wood, the surface discoloration can generally be planed or even brushed off. Strength other than toughness is not seriously affected by molds, but absorptivity may be increased markedly. Some molds can develop on air-dried wood with a moisture content in the 20 percent range if the relative humidity is 90 percent or more.

Sapstain fungi cause a (Fig. 3-7) blue to black, gray or brown darkening of the sapwood. The dark color is due to the deep penetration of large masses of fungal hyphae. Some sapstains may produce relatively bright colors such as red, purple, and yellow. In warm weather the sapwood of some species can discolor in less than a week. It is generally agreed that sapstains do not seriously reduce wood strength except for toughness. Therefore, the wood should not be used where it will receive significant repeated jars, jolts or blows. However, it should be recognized that decay could easily accompany intense sapstain and thus affect other strength properties.

Two good methods to control molds and sapstains are to dry the wood product to below 20 percent or by treating it with an approved fungicide.

Soft Rot

Soft rot fungi (Fig. 3-8) affect wood exposed to very wet conditions such as that used in cooling towers and in
hardwoods preservatively treated with waterborne preservatives.

The surface of wood that has soft rot can be scraped off with a fingernail. The wood is darkened, dull brown to blue-gray. When dry the surface may appear as though it had been lightly charred, and there will be profuse fine cracking and fissuring both with and across the grain. When probing with a sharp object, the degraded wood will be comparatively shallow and the transition between it and the underlying firm wood will be abrupt.

The soft rot fungi have been shown as a group to be able to better tolerate certain extremes of the environment such as higher temperatures, more alkaline conditions, preservative chemicals, and ability to grow with restricted oxygen. Oil-type preservatives may provide better protection to hardwoods exposed to soft rot fungi in very wet environments.

Bacteria

Bacteria are minute, one-cell organisms that can slowly deteriorate untreated or poorly treated wood products such as piles or wood slats in cooling towers that are completely saturated or submerged in water for many years. Upon drying, the outer, degraded area develops a cross-checking that is particularly pronounced on the tangential face. The sapwood of all wood species appears susceptible; the heartwood less so. The earlywood may be decomposed more rapidly than the latewood.

Insects

Insects are the second major category of biological organisms which damage and destroy wood products. Because the damage caused by insects is usually more easily observed than the insects themselves, emphasis in this section will be placed on identifying damage. Two forms of insects, the immature and the adult form, may be involved in creating the damage. The adult form of the insect is present for only a portion of the year. Immature forms may be observed during other times. Thus, correct identification
based on the insect is often difficult. The important characteristics for termites and carpenter ants are summarized in Table 3-2 and for wood boring insects in Table 3-3.

Wood destroying insects require three conditions to complete their life cycle. These are (1) a source from which the infestation can spread, (2) susceptible wood, and, (3) suitable conditions of temperature and humidity. If any of these three conditions are eliminated insect activity ends. Insects are often selective in what they will attack. Moist conditions that support fungal decay in wood often encourage insect infestations.

**Subterranean Termites**

Subterranean termites refer to both native and imported species which have specific requirements for moisture. The insects maintain their nests in the ground or in very close contact with other sources of moisture. Subterranean termites range throughout much of the United States (Fig. 3-9).

Native subterranean termites are small-to-medium sized insects that live in social groups or colonies. These individuals will be found in different stages of metamorphosis (egg, nymph or adult) and different casts (reproductive, workers, and soldiers). Both winged and wingless adults occur in any one colony.

A termite colony is initiated with two primary reproductives or swarmers. The swarmers are light tan to black in color with four equal-sized wings, three pairs of legs, one pair of antennae and a pair of large eyes on the head, and are about 1/3 to 1/2 inch long. These primary reproductives are released by a mature colony of termites during daylight hours in the spring and early summer for most parts of the country. In the desert southwest and southern California, the swarms occur more commonly on summer nights, shortly after the first rain. Thousands of swarmers may emerge from numerous colonies at any one time, thus allowing intermixing of individuals from many populations. Termites are relatively weak fliers and their wings
break off easily. The presence of large numbers of wings from these swarvers is an indication that a colony is close by. The female attracts a nearby male and the two then search for a suitable nesting site. The first eggs are laid within a week to several weeks after mating and development of the colony is very slow for several years.

The usual first sign of a subterranean termite infestation is the appearance of the swarvers, or discovery of the discarded wings, usually on a window sill or other lighted area. Another common sign is the presence of shelter tubes (Fig. 3-10) constructed over foundation walls or piers, in crevices between structural members or on infested wood. When active infestations or shelter tubes are damaged, termite workers and soldiers will promptly appear (Fig. 3-11). Shelter tubes are used as a means for the termites to move from their nest in the soil to wood located above ground. These shelter tubes are made from particles of soil or wood and bits of debris held together with fecal material. The tubes do not conduct moisture, but rather serve to protect the termites from enemies and allow them to return to the soil.

The only other visible sign of an infestation is the presence of dark spots or blister-like areas on flooring, trim or framing members. These areas are easily crushed with a knife or screwdriver. In cases of severe damage, a wood member might be partially collapsed at bearing points or otherwise failed. Internal damage can sometimes be determined by probing the wood with a sharp instrument or by pounding with a hammer to detect hollow areas.

When termite-damaged wood is broken open, several characteristic features can be observed (Fig. 3-12). First, termites tend to eat the soft earlywood and leave behind the hard latewood. A thin outer shell is left around the entire wood member. Some cavities may contain substantial quantities of soil mixed with chewed wood. The gallery walls of the damaged wood and shelter tubes will have a pale, spotted appearance resembling dried oatmeal. The
appearance is produced by the plastering of soft fecal material on the surface. There are no fecal pellets in subterranean termite galleries.

Several methods may be used to prevent and control subterranean termites. Treatment of the soil under and around the foundation with an approved insecticide is probably the most important step which can be taken to protect buildings. Good design and construction practices should also be followed. Untreated wood should be at least eight inches from the soil line and definitely not placed in contact with the soil. Earth-filled porches, flower planters, etc., should not be attached directly to the house. Wood debris should not be left or buried under or near the house. Pressure treatment of the wood with preservatives is another method of control. This simply makes the wood inedible for the insects. Therefore, termites are usually not a problem in preservative treated poles, piles, railroad ties, heavy timbers and lumber unless they gain access through the protective preservative shell.

Where termites are a serious problem (Fig. 3-13), a yearly inspection should be carried out. Heavy damage from native subterranean termites is not likely to occur for the first five years after a house is constructed. When termites are found there is no reason for making hurried decisions. Substantial additional damage will not occur if treatment follows within six months.

Other Termite Species

There are three additional termite species which deserve mention, especially because of their significance in certain regions of the country.

Formosan Subterranean Termites. The Formosan subterranean termite has spread from the Far East to Hawaii, numerous other Pacific islands, California, Texas and to locations in the southeastern United States. It is expected to spread within its current range. Formosan termites multiply quickly and can cause serious damage in less time than the native species. If found,
treatment within a few months is suggested. Although numerous differences exist between the Formosan termite and the damage they cause as compared to the native species, the control measures given for the native subterranean species also apply.

**Drywood Termites.** Drywood termites occur in warm, humid climates ranging throughout the very southern United States from the east to west coast (Fig. 3-9). In southern California and Arizona, southern Florida, the Pacific area and the Caribbean, new houses may be infected within five years of their construction. They utilize the moisture within the wood they eat and do not need a source of water to live. These insects may colonize and damage smaller wooden articles such as furniture and packing materials, therefore, they can be important pests in wood items returning from the tropics.

Drywood termites tend to work just under the surface of the wood, leaving a very thin veneer-like layer. Wood damaged by drywood termites has broad pockets or chambers connected by tunnels which cut across the grain without regard for earlywood or latewood (Fig. 3-14). The galleries are perfectly smooth and have no surface deposits. Some fecal pellets may be stored in portions of the galleries; the galleries are closed off by partitions made of fecal pellets stuck together with a secretion.

Piles of fecal pellets are usually the first sign of a drywood termite infestation. The pellets are hard, elongate, less than 1/25 inch in length, with rounded ends, six flattened or concavely depressed sides and light gray to very dark brown in color. The pellets are eliminated from the galleries in the wood through round kick holes. The holes are closed with a secretion and pellets when not being used. Probing wood with a sharp instrument or pounding the surface may reveal hidden damage.

The methods available to prevent drywood termite attack are not as practical nor as economical as those
to prevent subterranean termites. First, any wood product or other cellulose-based material should be carefully examined before it is used or placed in a new or existing structure. Potential outdoor sources of infestation such as stored lumber, firewood, dead branches, etc. should be examined or removed. The use of desiccating dust application and the use of preservative-treated lumber is effective in prevention. The use of fumigants is also effective for items in transit, but for houses, it is expensive and needs to be repeated in areas of severe regional infestation.

Dampwood Termites. Dampwood termites locate their colonies in damp and sometimes decaying wood and are of economic significance only on the Pacific Coast. Soil contact is not required if the wood is damp. Since these termites require the presence of damp wood, the same measures used to keep wood dry and prevent decay will control them.

Carpenter Ants

Carpenter ants are like termites because they live in colonies composed of several casts. There are winged and unwinged queens, winged males, and several sizes of unwinged workers. However, carpenter ants, like all ants, have a very narrow waist and wings of two different sizes, the front ones much larger than the hind ones. Adult termites do not have a restricted waist and do have equal-sized wings. Ants and termites are compared in Figure 3-15. The adults of those species found nesting in houses are predominantly black; however, some may be partially reddish-brown to yellowish.

Carpenter ants burrow into the wood to make nests and, unlike termites, do not use it for food. Most species prefer to nest in moist hardwoods and softwoods that have begun to decay. The galleries extend both along the grain of the wood and around the
annual rings. The softer earlywood tends to be removed first. The harder-grained latewood is penetrated at frequent intervals, so that, unlike galleries made by subterranean termites, there is complete access (across annual rings) between the galleries (Fig. 3-16). Once a nest is established, it can be extended into the sound wood. The surfaces of ant galleries are smooth and perfectly clean. This contrasts with galleries of subterranean termites in which walls are rough due to the coating of fecal materials.

Carpenter ants can also nest in houses without attacking timbers. They simply use existing cavities, including wall voids, hollow flush panel doors, termite galleries in wood, etc. Carpenter ants are generally more of a nuisance when found in the house foraging for food and water.

In addition to the presence of large ants, other indications of an infestation are piles or scattered bits of very fibrous and sawdust-like frass which the ants have removed from the wood. If the pieces are from decayed wood, they tend to be darker and more square ended. The frass will contain fragments of ants and other insects mixed with the wood fibers. The frass is expelled from cracks and crevices, or from slit-like openings called windows made by the ants. These "windows" are the only external evidence of attack by carpenter ants. The frass is quite often found in basements, dark closets, attics, under porches, and other out-of-the-way places. Faint rustling and even gnawing sounds can be heard in the wood or cavity when the ants are active.

Good building practices that keep wood dry will contribute to a reduced risk of attack by carpenter ants. These practices include adequate clearance between wood and soil, good drainage and ventilation, proper roof flashing, tight exterior wood joints, etc. If the wood cannot be kept dry, such as that on some porches, decks, columns, etc., it should be pressure treated with an appropriate preservative. Chemical treatment of soil under and around a foundation to prevent subterranean
termites may not prevent attack by carpenter ants.

If the good building practices discussed above have been followed and carpenter ants are still present, the nests should be treated with residual contact insecticide applied as a dust or spray. The infested wood can be bored, the pesticide injected and the holes plugged. The approaches and areas surrounding the nest should also be treated. Treating the areas where the ants are seen is seldom effective, since many ants never leave the nest. For treating indoors, pesticides specifically registered for that purpose must be selected. Poison baits may be available.

**Powder Post Beetles**

The term "powder post" describes a group of beetles that convert the inner portion of infested wood to a powdery or pelleted mass. The thin outer shell on the surface of infested wood often shows numerous small holes through which the beetles exited. These exit holes aid in the recognition and identification of beetle attack.

Damage is probably heaviest in warm, humid climates but can occur throughout the world. Table 3-3 summarizes the major characteristics of these important wood boring beetles as well as other less serious pests which may be mistaken for them. A detailed discussion for each group is provided below.

**Anobiid Beetles.** Anobiids, sometimes referred to as death watch beetles or furniture beetles, are found on recently seasoned and older hardwoods or softwoods throughout the United States. Sapwood, particularly that close to the bark, is preferred. Unheated buildings or houses built with crawl spaces over damp ground, as often occurs in the southeastern United States, are particularly susceptible, but houses are usually ten or more years old before damage becomes obvious.

It is very difficult to detect an anobiid infestation. During and after emergence, a bright and light-colored powdery frass and tiny pellets will be found streaming from the exit holes or
accumulating underneath infested wood. The frass in the galleries is loosely packed and does not tend to fall freely from the wood unless the wood has dried out considerably since the attack occurred. The exit holes are round and vary in diameter from 1/16 to 1/8 inch (Fig. 3-17). When anobiid infestations die out naturally, the frass becomes yellowed and partially caked on the surface.

In most old, heavy infestations there are very tiny round exit holes, about 1/32 inch in diameter, scattered over the infested surface. These are emergence holes of parasitic wasps, the larvae of which feed on the beetle larvae.

**Lyctid Beetles.** Lyctid beetles, which are also commonly called powder post beetles, attack the sapwood of hardwoods. They probably cause more damage to hardwoods than any other group of beetles and are also an important pest of imported hardwood products. Hardwoods with large pores such as oak, hickory, and ash are the most susceptible, but other species such as walnut, pecan, poplar, sweetgum and cherry can also become infected. The greatest activity of the beetles occurs when the wood moisture content is between 10 and 20 percent, but beetle activity can occur when the moisture content ranges from 8 to 32 percent.

Infested wood does not show any external evidence of attack until the first generation of adult beetles emerge. The circular emergence holes and longitudinal galleries are 1/32 to 1/16 inch in diameter (Fig. 3-18). Small piles of flour-like wood or frass can be found on or under the wood. The frass is loosely packed and a slight jarring of the wood will make the frass sift from the holes. With severe infestations, the sapwood may be completely converted to frass held in by a very thin veneer of surface wood with beetle exit holes. With heavy infestations, parasitic wasps, which make circular holes larger than those of the beetle, may be seen.

Control procedures for anobiid and lyctid beetles are based on three approaches: 1) eliminate or reduce the beetle population; 2) use a
chemical treatment to protect susceptible wood or use naturally durable wood, if available; and 3) control environmental conditions in the wood to retard development of the beetles or larvae.

The use of good building design will also help control beetles. Good ventilation in crawl spaces and attics, and good drainage and proper clearance between wood and soil will help to reduce the equilibrium moisture content of wood in buildings; this creates conditions less favorable for beetle development. Before sawn wood is purchased or placed into service, it should be inspected. If an active infestation is suspected, the wood should be heat sterilized before leaving the manufacturing plant.

Pressure treatment with preservatives will prevent beetle attack. Diffusion treatments with boron also protect wood from attack by beetles. Brushing or spraying wood with residual insecticides can also be used for control.

Fumigation quickly and completely controls infestations of wood-boring beetles whether the wood is in storage or service. In addition to acting rapidly, fumigants are useful when an infestation is very extensive, or is in building locations that make other control procedures impractical. Because of the current uncertainty over the availability and use of residual insecticides, and the large turnover in home ownership requiring certification that structures are insect-free, fumigation has recently become a more common control procedure. Sulfuryl fluoride is the fumigant widely used for the control of wood-boring beetles in houses. Fumigation is an expensive process, and it offers no residual protection from reinfestation. In addition, it is necessary for the residents to leave the premises for one or more days.

Other Wood Boring Beetles

There are several additional groups of wood-boring beetles of which two will be discussed. These are the long-horned beetles, or round-headed wood borers, and the old-house borers. Collectively, both groups are called
Cerambycids.

**Long-horned Beetles.** The long-horned beetles derive their name from the mature beetle having antennae longer than half their body length. The larvae are described as round-headed wood borers, presumably due to the circular emergence holes (Fig. 3-19). This group should be recognized because they may emerge after the wood is put into service or their damage may be mistaken as evidence of an active infestation of the powder post beetles.

Damage from long-horned beetles usually occurs in fire, disease or insect-killed timber which is being salvaged. The borers damage the wood before it is processed, and the activity ceases when the wood is dried. Many species feed just under the bark before moving into the sapwood, and sometimes the heartwood. As beetles emerge, they make slightly oval to nearly round exit holds ranging from 1/8 to 3/8 inch or more in diameter. Most of the beetles emerge before the wood is over one and one-half years old. If the damage occurred in the log, the galleries in the sawn lumber may appear oval to elongate depending on how the saw intersected the galleries. The texture of the frass varies from rather fine and meal-like in some species to very coarse and almost excelsior-like in other species (Fig. 3-19). Since the beetles are in the wood only a limited time and do not reinfest the wood, serious structural damage usually does not result.

**Old-house Borers.** The old-house borer is a round headed borer which, unlike most of the others in this family, is capable of reinfesting wood in use. It probably ranks next to the termites as a pest of buildings in the eastern United States. The heaviest infestations occur along the Atlantic seaboard, particularly the mid Atlantic states. It is found in old and new construction, seasoned and relatively unseasoned softwood lumber, but not hardwoods.

The adult beetle is 5/8 to 1 inch long, slightly flattened, brownish in color with many gray hairs on its head and the forepart of the body. The borers
are up to 1 1/4 inches long. The adult lays its eggs in cracks and crevices in the wood. The larvae hatch in about two weeks. The larvae crawl over the surface of the wood and eventually bore their way into the sapwood. The larvae generally take two to five years to develop and, in particularly dry wood, they may take 12 to 15 years. A moisture content range of 15 to 25 percent encourages rapid development.

Early infestations are almost impossible to detect since there are no external signs. The larvae, when boring in the wood, make a rhythmic ticking or rasping sound much like that of a mouse gnawing. The borers tunnel very closely to the surface but seldom break through. The surface may bulge out due to packed frass. After the adults have emerged, there may be small piles of frass beneath or on top of the infested wood. The frass, which is loosely packed in the tunnels, is composed of very fine powder. The exit holes are oval and 1/4 to 3/8 inch in diameter. Serious damage can develop where enough humidity or moisture exists for reinfestations to occur.

**Carpenter Bees**

Carpenter bees are found throughout the United States and are similar in appearance to bumblebees and are more of a nuisance than a serious problem. The only external evidence of attack is the entry holes made by the females. The original entry hole is perfectly round and approximately 1/2 inch in diameter. The tunnel turns abruptly at a right angle after being extended approximately the length of the bee's body across the grain of the wood. The tunnel is extended with the grain from 4 to 6 inches in a new site and is smooth walled (Fig. 3-20) when repeatedly used by succeeding generations, it may ultimately reach 6 to 10 feet in length. Frass accumulates on surfaces below the site of activity. Frass is usually the color of freshly sawed wood, and varies with the species of wood under attack.

Carpenter bees usually choose wood that is soft and easy to bore such as redwood, cypress, cedar, white pine,
and southern pine. Bare unpainted wood is preferred; lightly painted or stained wood is also subject to attack. They also will tunnel wood that has been lightly pressure-treated for above ground use with waterborne preservatives.

Damage from carpenter bees can be prevented by keeping wood surfaces well painted. Interior unpainted surfaces should be protected by keeping windows and doors closed or screened during the spring and early summer when the bees are looking for a nesting site. Wood pressure-treated with organic preservatives, such as pentachlorophenol, or with high retentions of waterborne preservatives, is resistant to carpenter bee attack. Even surface coatings of organic preservatives are helpful.

Five to 10 percent carbaryl (Sevin) dust, or any insecticide labeled for bee control, applied into the entry holes will kill bees which come into contact with the residue. Several days after treatment, the holes should be plugged with short lengths of dowel rod or with plastic wood. Plugging the holes without applying insecticide can lead to the production of new holes next to the plugs when bees inside attempt to emerge, or nesting females seek re-entry into galleries in use.

**Marine Borers**

There are three categories of marine borers which damage wood in salt or brackish water. The first, and probably the most fascinating, are wood-boring shipworms. Most native shipworms belong to the genera *Teredo* or *Bankia* within the family Teredinidae. A second category is the *Pholads* or rock-boring piddocks of the family Pholadidae and most of which belong to the genus *Martesia*. Pholads, as they are commonly called, resemble clams. The last category is the crustaceans. These include the gribbles, genus *Limnoria*, in the family Limnoridae and the pillbugs, genus *Sphaeroma*, in the family Sphaeromatidae. The different types of marine borers are compared in Table 3-4.

Marine borers vary greatly in their
distribution (Fig. 3-21) and ability to destroy wood. They are generally more destructive in tropical and subtropical waters. Their population can rise and fall depending on any number of factors such as salinity changes due to floods or other causes, water temperature, and dissolved oxygen content. There is some indication that marine borer populations increase as pollution levels decline. Because of this variation, it is always best to consult local authorities for exact identification and before initiating control procedures.

**Shipworms**

Shipworms have a worm-like appearance and they are notorious for causing extensive damage to wooden ships and other wooden waterfront structures. They are found in all coastal waters of the United States and some are capable of withstanding broad changes in salinity, thus they can also be found in the upper reaches of many estuaries. Boring is done by the mechanical rasping action of a pair of shell-hardened valves equipped with fine serrations on the head of the animal. The wood is partially digested to supplement the food furnished by other organisms. The posterior of the body has two siphons which extend into the water. The incumbent siphon draws in water containing microscopic organisms for food, and dissolved oxygen for respiration. The excurrent siphon expels waste and reproductive products.

Entrance holes about 1/16 inch or less in diameter are bored into the surface of the wood by the young larva. Thus, it is difficult to detect their presence or extent of damage from the surface of the wood. Attack is frequently concentrated at the mud line. The larvae enter the wood at right angles to the grain and then burrow with the wood grain in the longitudinal direction, following a very irregular course, turning to avoid unfavorable sections such as knots. Once inside the wood, the larvae develop worm-like bodies rapidly and remain imprisoned in the wood for life. The wood may become completely honeycombed (Fig. 3-22). Adults of
the genus *Teredo* may be one to two feet in length and one-half inch in diameter while those of the genus *Bankia* may be 5-6 feet in length and 7/8 inch in diameter. The wall of the hole is lined with a shell-like (calcareous) deposit. When the animal's siphons are withdrawn from the water into the hole, the opening is plugged with small calcareous pellets.

Shipworms are deterred by preservative treatments of 20 to 25 pounds of marine-grade creosote meeting the American Wood Preservers' Association (AWPA) Standard P1/P13-91 or creosote-coal tar meeting AWPA Standard P2-90 per cubic foot of wood, or 2.5 pounds of chromated copper arsenate (CCA) per cubic foot of wood.

**Pholads**

Pholads resemble clams in that they have a pear-shaped body, which is entirely encased within the bivalve shell even in adult form. These borers do not exceed over two and one-half inches in length by one inch in diameter and become imprisoned within the wood. Pholads are found from South Carolina southward and become economically destructive in Florida and other tropical and subtropical waters. They cause serious damage in Hawaii and Mexico.

Pholads can bore in wood, clay, soft rock, shells, plastic and even poorer grades of concrete. The surface entrance hole is about 1/4 inch in diameter. The bore holes may be two to two and one-half inches deep and up to one inch in diameter. Thus, most of the damage is close to the wood surface. The diameter of the hole increases as the organism develops and increases in size.

Pholad attacks can be precluded by treating with 20 to 25 pounds of marine-grade creosote or creosote-coal tar per cubic foot of wood or a dual treatment consisting of 1.0 to 1.5 pounds of CCA per cubic foot of wood followed by drying and then treatment with 20 pounds creosote or creosote-coal tar per cubic foot of wood.
Gribbles

Gribbles, are serious marine pests that can cause extensive damage. However, their damage is generally visible and, thus, not as spectacular as the shipworms. One species, *Limnoria tripunctata*, found in temperate and subtropical regions, is tolerant of creosote in subtropical waters. The other two species, *L. lignorum*, found worldwide in cool to temperate climates, and *L. quadripunctata*, found in temperate waters of the Pacific coast, are not creosote tolerant. Gribbles are active along the entire coastal area of the United States. Their activity is accelerated in warm tropical waters where breeding occurs year round as compared to colder regions.

Gribbles bore holes about one-sixteenth inch in diameter and seldom go more than one-half inch below the wood surface, and may run obliquely for one inch or more. Earlywood is preferred. Wood is normally heavily infested and may contain 300 to 400 animals per square inch, and the surface of the wood will be severely honeycombed. The remaining thin wood partitions are broken away by wave or other mechanical action and new wood is exposed to further attack. The attack is usually concentrated between half tide and low tide levels, or at mud line where the eroding action is the greatest. A distinctive hourglass shape (Fig. 3-23) results.

The method used to prevent *Limnoria* attack depends on which of the three species are present. This, in turn, depends somewhat on climatic conditions. *L. tripunctata*, which is destructive on the Pacific coast from San Francisco southward, on the Atlantic coast from North Carolina southward, and on the gulf coast, is tolerant of creosote in these regions. This species may be extending its range northward, and it has been shown that a population explosion can occur if the water temperature increases slightly.

Two preservative treatments are recommended to control gribbles. One is a dual treatment which consists of treating pilings with 1.0 to
1.5 pounds of CCA per cubic foot of wood; drying the wood; and then treating with 20 pounds of marine-grade creosote or creosote-coal tar per cubic foot of wood. An alternative treatment is to use 2.5 pounds of CCA per cubic foot of wood. Treatments for the other two species (L. lignorum and L. quadripunctata) found in temperate or cold waters consists of using 20 to 25 pounds of marine-grade creosote or creosote-coal tar per cubic foot of wood or 2.5 pounds of CCA per cubic foot of wood.

**Pillbugs**

Pillbugs, technically known as *Sphaeroma*, are similar to *Limnoria*, except they are longer and stouter reaching a length of 3/8 to 1/2 inch long and 1/4 inch wide. Their burrows are typically 1/4 inch in diameter, generally perpendicular to the timber surface, and usually go to a depth of about three times the diameter (Fig. 3-24). Softer species of wood are preferred. Heavily attacked wood surfaces are often honeycombed. The wood is used for shelter and probably not ingested.

Wood boring species of *Sphaeroma* are usually found in brackish waters along the south Atlantic and gulf coast and, to a lesser extent, on the west coast from San Francisco southward. They are most common in Florida estuaries, but their occurrence is spotty and unpredictable. They seem to be particularly tolerant of CCA. Creosote seems to resist attack better but with time becomes susceptible. Dual treatment with CCA and creosote is the preferred method of protection against this borer.

Figure 3-1. Thread-like structures in wood cells called hyphae.

Figure 3-2. When wet wood is probed with a pick or comparable tool, it tends to lift out as a long sliver or it breaks by splintering if sound (left), but if decayed even slightly, it tends to lift in short lengths and to break abruptly, without splintering (right).

Figure 3-3. AWPA map which shows the relative decay hazard for different
regions in the United States.

Figure 3-4. Early stage of brown rot showing discoloration on side grain (top right) and end grain (top left) of the same board and across grain cracking and collapsed wood associated with advanced brown rot (bottom).

Figure 3-5. Discoloration from white rot on end grain, characterized by mottling and dark zone lines (arrows) bordering the abnormally light-colored areas (top) and side grain of the same board (bottom).

Figure 3-6. Surface mold on sweetgum veneer.

Figure 3-7. Sapstain in a cross section of pine.

Figure 3-8. Typical surface checking of soft-rotted wood when dry.

Figure 3-9. Range map for subterranean (a) and drywood (b) termites.

Figure 3-10. Subterranean termite shelter tubes on the interior foundation wall of a crawl space type house.

Figure 3-11. Subterranean termite workers.

Figure 3-12. Termite damaged wood showing the insects' preference for the softer earlywood and accumulation of soil and/or fecal material in the galleries.

Figure 3-13. Hazard regions for subterranean termites.

Figure 3-14. Drywood termite damage showing round "kick holes" and the very thin veneer-like layer left after excavating without regard for earlywood or latewood.

Figure 3-15. Major differences between ants and termites include waist and wing size. The ant has a restricted waist.

Figure 3-16. Carpenter ant damage to Douglas-fir showing preference for earlywood and removal of some latewood to allow access between galleries.
Figure 3-17. Anobiid damage showing insect exit holes. Zone lines indicating the wood is also partially decayed are evident on the end grain.

Figure 3-18. Ash shovel handle damaged by lyctid beetles.

Figure 3-19. Long-horned beetle or round-headed wood borer damage to ash showing the tightly packed, rather coarse frass in the galleries (top) and the circular exit hole (bottom).

Figure 3-20. Carpenter bee damage in redwood showing a single entry hole (from inside) at the top center and individual cells (right).

Figure 3-21. Distribution of marine borers in the United States. Solid lines indicate areas in which the designated marine borers are a hazard to wood that has not been treated with an appropriate preservative. The borers may be found beyond these ranges, but they have not been reported as causing problems. Dashed lines indicate areas in which sporadic attack is probable. Dotted lines demarcate transition areas where problems with designated borers are unlikely but could occur.

Figure 3-22. Damage from shipworms.

Figure 3-23. Extensive damage to a creosoted fender pile from marine borers, commonly known as gribbles (Limnoria).

Figure 3-24. Sphaeroma and associated damage.
Figure 3-1. Thread-like structures in wood cells called hyphae.
Deterioration Zones

1 = Low  2 = Moderate  3 = Intermediate  
4 = High  5 = Severe
**SUBTERRANEAN TERMITES**

**Mode of life:** The termites which usually have their workings associated to some degree with soil are referred to as subterranean termites. We have already discussed
Table 3-1. Comparison of characteristics of brown rot, white rot, molds, sapstains, soft rot, and bacteria infected wood.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Brown Rot</th>
<th>White Rot</th>
<th>Mold</th>
<th>Sapstain</th>
<th>Soft Rot</th>
<th>Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferred host</td>
<td>Softwoods</td>
<td>Hardwoods</td>
<td>Surface of both sapwood and heartwood for</td>
<td>Sapwood of both softwoods and hardwoods</td>
<td>Softwoods and hardwoods</td>
<td>Sapwood and earlywood more susceptible than heartwood and latewood</td>
</tr>
<tr>
<td>Color</td>
<td>Initially lacks luster and appears dead; then abnormal brown color develops</td>
<td>Initially off-white, sometimes with black zone lines</td>
<td>Black, green, orange or other shades</td>
<td>Blue to black, gray or brown, some red, purple or yellow</td>
<td>Darkened, dull brown to blue gray</td>
<td>Brownish, inner zones have been noted to be greenish</td>
</tr>
<tr>
<td>Surface characteristics</td>
<td>Cross grain checking, collapse or crumbling, and abnormal shrinkage</td>
<td>Nearly normal until advanced stages; white fibrous mass results</td>
<td>Can be brushed or planed from surface; shallow staining may result in hardwoods</td>
<td>Discolored blue to black even when when planed</td>
<td>Softened on surface; fine cracking and fissuring both with and across the grain when dry</td>
<td>Softened on surface; cross checking develops when dry</td>
</tr>
<tr>
<td>Strength</td>
<td>Significant, rapid reduction in many properties</td>
<td>Gradual reduction except for toughness which is rapidly reduced</td>
<td>No serious effect except toughness reduced</td>
<td>Only toughness reduced</td>
<td>Significant in thin members</td>
<td>Significant reductions in many properties with prolonged exposure</td>
</tr>
<tr>
<td>Other</td>
<td>Can occur on air-dried wood when relative humidity exceeds 90 percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Attacks surface of saturated wood</td>
</tr>
</tbody>
</table>
Table 3-2. Comparison of characteristics for termites and carpenter ants.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Subterranean Termites</th>
<th>Formosan</th>
<th>Drywood Termites</th>
<th>Dampwood Termites*</th>
<th>Carpenter Ants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wood used for</strong></td>
<td>Food</td>
<td>Food</td>
<td>Food</td>
<td>Food</td>
<td>Shelter</td>
</tr>
<tr>
<td><strong>Moisture source</strong></td>
<td>Soil or other</td>
<td>Soil or other</td>
<td>No soil or moisture supply required</td>
<td>Damp or decayed wood preferred; will extend to dry, sound wood</td>
<td></td>
</tr>
<tr>
<td>or other conditions</td>
<td>consistent supply of moisture required</td>
<td>of moisture required</td>
<td>of moisture required</td>
<td>of moisture required</td>
<td></td>
</tr>
<tr>
<td><strong>Damage characterization</strong></td>
<td>Shelter tubes present; earlywood preferred; with pale, spotted appearance like dried oatmeal on gallery walls</td>
<td>Shelter tubes present; earlywood preferred; with pale, spotted appearance like dried oatmeal on gallery walls</td>
<td>Piles of fecal pellets eliminated from kickholes in wood; infested wood with very thin surface; broad pockets with no regard for earlywood or latewood; galleries smooth without deposits</td>
<td>Damage in sound wood is similar to subterranean damage. Piles of fecal pellets eliminated from kickholes in wood; infested wood with very thin surface; broad pockets with no regard for earlywood or latewood; galleries smooth without deposits</td>
<td>Galleries follow earlywood but will cut through latewood; gallery walls smooth and perfectly clean; &quot;windows&quot; or slit-like openings sometimes present on wood surface; sawdust-like frass and other debris present below windows</td>
</tr>
<tr>
<td><strong>Insect description</strong></td>
<td>Swampers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Swarmers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size (length)</td>
<td>Up to 1/3 - 1/2 inch</td>
<td>Up to 5/8 inch</td>
<td>1/2 - 5/8 inch</td>
<td>Up to 1 inch</td>
<td>Up to 3/4 inch</td>
</tr>
<tr>
<td>Color</td>
<td>Light tan to black</td>
<td>Yellow brown, larger than native subterranean</td>
<td>Slightly larger and lighter than native subterranean</td>
<td>Yellowish brown to dark brown</td>
<td>Predominately black to yellowish</td>
</tr>
<tr>
<td><strong>Wings</strong></td>
<td>Four equal sized; two prominent longitudinal veins at front edge</td>
<td>Like subterranean but with hairy wings</td>
<td>Several distinct longitudinal veins with many cross veins</td>
<td>Veins predominately on front edge of wings, more numerous than subterranean</td>
<td>Two pair, unequal size</td>
</tr>
<tr>
<td><strong>Soldiers</strong></td>
<td>Oblong, rectangular head</td>
<td>Oval-shaped head, exuded whitish, sticky substance</td>
<td></td>
<td>Very large, dark, rectangular head with large jaws</td>
<td></td>
</tr>
<tr>
<td><strong>Waist</strong></td>
<td>Not constricted</td>
<td>Not constricted</td>
<td>Not constricted</td>
<td>Not constricted</td>
<td>Very narrow, constricted</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Present in areas of TX, LA, SC and probably other southern coastal states; places carton in walls</td>
<td>Will attack small wooden articles such as furniture</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Dampwood termites vary depending on species. This description is given for the Pacific coast species, the only one of economic importance.
Table 3-3. Summary table of exit/entry hole size, type and condition of wood attacked, appearance of frass and potential for reinfestation for wood boring beetles and carpenter bees.

<table>
<thead>
<tr>
<th>Insect Type</th>
<th>Shape and size (inches) of exit/entry hole</th>
<th>Wood Type</th>
<th>Condition of Wood Attacked</th>
<th>Appearance of Frass in Tunnels</th>
<th>Reinfest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anobii beetles</td>
<td>Round 1/16-1/8</td>
<td>Softwoods &amp; hardwoods</td>
<td>Seasoned</td>
<td>Fine powder and pellets, loosely packed (pellets may be absent and frass tightly packed in some hardwoods)</td>
<td>Yes</td>
</tr>
<tr>
<td>Lycoidal beetles</td>
<td>Round 1/32-1/16</td>
<td>Hardwoods</td>
<td>Newly seasoned</td>
<td>Fine, flour-like, loosely packed</td>
<td>Yes</td>
</tr>
<tr>
<td>Long-horned beetles (round-headed borers)</td>
<td>Round-oval 1/8-3/8</td>
<td>Softwoods &amp; hardwoods</td>
<td>Unseasoned logs and lumber</td>
<td>Coarse to fibrous, mostly absent</td>
<td>No</td>
</tr>
<tr>
<td>Old house borers</td>
<td>Oval 1/4-3/8</td>
<td>Softwoods</td>
<td>Seasoning to seasoned</td>
<td>Very fine powder &amp; tiny pellets, tightly packed</td>
<td>Yes</td>
</tr>
<tr>
<td>Carpenter bees</td>
<td>Round 1/2</td>
<td>Softwoods</td>
<td>Seasoned</td>
<td>None present</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 3-4. Comparison of characteristics for marine borers.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Teredo (Shipworms)</th>
<th>Bankia (Shipworms)</th>
<th>Martesia (Pholads)</th>
<th>Limnoria (Gribbles)</th>
<th>Sphaeroma (Pillbugs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Worm-like</td>
<td>See Teredo</td>
<td>Clam-like</td>
<td>Louse-like</td>
<td>See Limnoria</td>
</tr>
<tr>
<td><strong>Maximum borer size</strong></td>
<td>Length 1-2 ft., diameter 1/2 in.</td>
<td>Length 5-6 ft., diameter 7/8 in.</td>
<td>Length 2 1/2 in., diameter 1 in.</td>
<td>Length 1/8-1/4 in., 1/3 as wide</td>
<td>Length 3/8-1/2 in., width 1/4 in.</td>
</tr>
<tr>
<td><strong>Damage</strong></td>
<td>Entrance hole 1 1/16&quot; or less in diameter; surface damage minimal; subsurface severely honeycombed; holes lined with calcareous deposits</td>
<td>See Teredo</td>
<td>Entrance hole 1/4&quot; diameter; damage close to surface; 2-2 1/2 in. deep and 1 in. in diameter</td>
<td>Surface severely honeycombed, early-wood preferred; holes 1/16 in. diameter by 1/2 in. deep; wave action erodes surface</td>
<td>Burrows typically 1/4 in. in diameter and about 3 times as deep, and perpendicular to the surface.</td>
</tr>
<tr>
<td><strong>Area commonly attacked</strong></td>
<td>Mud line</td>
<td>See Teredo</td>
<td>--</td>
<td>Between half and low tide, mud line; hourglass shape develops in piles</td>
<td>See Limnoria</td>
</tr>
</tbody>
</table>
Chapter 4. Protection of Wood

Degree of Protection Needed

The amount and type of "protection" needed for wood subject to attack by decay, insects, or marine borers will vary depending on several factors. Factors which should be considered are exposure of the wood and geographic location, permanency or expected service life, structural and non-structural applications, and replacement costs. The type of protection which can be provided includes using proper construction practices, use of naturally durable wood, and use of preservative treated wood.

Geographic Location and Exposure

The four requirements of decay, food source, moisture, moderate temperature, and oxygen were discussed in Chapter 3. The higher the decay hazard as shown in Figure 3-3, the more protection needed.

Figure 3-13 showed the hazard regions for subterranean termites. The hazard is most severe in the southeastern United States.

Another critical issue in determining the type of protection needed is whether the wood will be in contact with the soil, such as posts, or above ground, such as fence boards or deck boards. One of the most severe uses for wood is in contact with the soil. In this application, the conditions for decay and termite attack are the most favorable for the greatest lengths of time. Wood used above ground does not have the usual constant source of moisture and it is usually exposed so that any insect attack is visible. As a result, the amount of preservative which is impregnated into the wood is sometimes decreased for lumber used above ground. However, since it is uncertain exactly how a piece of lumber will be used at the time of treatment, many companies will simply treat all lumber with adequate preservative for it to be used in soil contact. Such lumber is very satisfactory for use above ground.
buildings. These structures should be designed to keep the wood dry and, thus, free from decay. Subterranean termites are best controlled by the use of an insecticide applied to the soil. In order to keep wood dry in these structures, three basic premises must be strictly adhered to. First, all wood in or near the foundation, unless treated with a preservative, must be an adequate distance from the soil line to prevent it from becoming excessively wet. Second, starting from the roof line down, the structure must be made in such a way that any water which falls on the roof or blows against the side of the structure will run down and away. The third concern is to promptly dispose of any moisture which accumulates in the crawl space and water vapor which is generated in the living quarters. Figure 4-1 shows a basic house with good construction practices which help to minimize moisture accumulation.

Wide roof overhangs provide some protection from sun and rain to at least the upper portions of the structure. When a four-foot-wide overhang is provided, approximately two-thirds of a conventional one-story sidewall is protected from exposure to full sunlight. Any wood used for siding, sheathing, or plates should be at least 8 inches above the outside groundline unless pressure treated with a wood preservative.

Metal flashings under shingles at roof edges prevent water from entering the roof decking and sidewalls, particularly on roofs with a low slope that are located in areas of high rainfall. Metal flashings in roof valleys, junctions of roofs and walls, along dormers and siding material changes, and around chimneys, as well as drip caps over window and door frames, help prevent water from entering the house. Adequate and properly maintained gutters and properly hung downspouts prevent overflow and subsequent wetting of house eaves and sides and resulting "rainwater splash" of the siding near the ground level.

Adequate insulation and ventilation of attics and crawl spaces prevents moisture condensation and resulting
high moisture contents in the remainder of the house.

Exhaust fans should be used to remove moisture from high-humidity areas such as washrooms with showers or baths, kitchen areas, and appliances such as clothes dryers. Be sure the fans are vented to the outside of the house. Clothes dryers should never be vented to the inside living quarters or to the crawl space, basement, or attic. Plumbing should be well maintained.

If the house is built on a crawl space, a clearance of at least 18 inches between the soil and the floor joists is required, while wood girders must clear the soil by 12 inches. Any standing water in the crawl space must be eliminated. The ground should be covered with a 4- to 6-mil thick polyethylene sheet or soil cover to prevent moisture movement from the soil upward. The crawl space should be adequately ventilated and the vents kept open except in the coldest weather.

Proper installation of vapor barriers (vapor retarders), where appropriate, will help minimize condensation in walls and ceilings. Recent research has shown that vapor retarders should be installed without air leaks around electrical receptacles, pipes, etc. Traditionally, recommendations for vapor retarders (4- to 6-mil thick polyethylene sheets) have been based on climate. Three different climate zones are recognized in the United States, based on winter design temperatures (Fig. 4-2). Zone I includes areas with design temperatures below -20°F; zone II, between 0°F and -20°F; and zone III, >0°F, with the exception of areas with extremely warm and humid summers.

Vapor retarders are traditionally recommended for installation on the warm side of all exterior walls in zones I and II, and in zone III when the wall is insulated beyond R-4. Ceiling vapor retarders have traditionally been recommended for zone I only, but they are now recommended for zone II as well. These recommendations conform with current interim guidelines from the American Society
Humid climates deserve special attention (Fig. 4-3). Where dwellings are constantly air conditioned, warm moist air can move from the outside and condense on the cooler inside portion of outside walls. This situation is the reverse of cold weather condensation experienced in northern climates, but the same principle applies. In general, exterior surfaces of the building should be airtight and higher in vapor resistance than interior surfaces. That is, vapor retarders should be used on the outside of exterior walls. Any water that does enter the outside surface of the structure can flow to the inside where it can be removed by the air-conditioning system instead of accumulating in the floor, wall, or roof construction. The amount of condensation that is likely to occur is difficult to generalize and depends on local conditions. Therefore, successful, trouble-free local practices should be followed.

**Natural Durability**

As indicated earlier, the heartwood of some wood species is naturally durable or resistant to decay and insect attack. Table 2-1 rates many of the common domestic species by their decay resistance and Table 2-2 rates several wood species commonly imported into the United States. It should be noted that the only naturally durable native softwood species commonly available in construction lumber grades at retail lumber yards are the heartwood of cedars and redwood.

Although the heartwood of redwood, cedars and cypress has developed a reputation for natural durability, some caution needs to be exercised. This experience was developed with old growth wood and very little of this material is available today. One scientific study on redwood\textsuperscript{12} and a second on cypress\textsuperscript{13} have both demonstrated that second growth heartwood is not as durable as that of old growth. Both of these studies and a third study on western redcedar\textsuperscript{14} have demonstrated that the natural decay resistance of these species increases with increasing heartwood.
diameter. Thus, small diameter second growth timber has less durability. Of even more significance, these studies all demonstrate that the natural decay resistance of timber is highly variable and cannot be controlled. Thus, it is best to apply the limited quantities of these species to decorative purposes or above ground applications where the decay hazard is only moderate.

Of the naturally durable hardwood species, white oak is the most readily available in lumber form. Certain other species such as black locust and osage-orange are used for fence posts. When dealing with the hardwoods, the lower grades are sometimes sold for farm or other rough construction purposes. This material is generally affordable, but it is usually not dried and rough cut, and thus not uniform. The heavier species are difficult to nail and saw as compared to the standard softwoods. Despite this, at least some of this material continues to be consumed on a local use basis.

To provide maximum protection, preservatives are used to protect wood. Numerous preservative treatment methods and standards exist. These are the subject of discussion in the next chapter.

Figure 4-1. Good construction practices prevent excessive buildup of moisture in wood members. Maintaining the correct moisture contents in wood increases its service life and decreases the risk of wood decay and insect attack.

Figure 4-2. The three different climate zones in the United States.

Figure 4-3. Humid climates in the continental United States follow the coastal belt of the Gulf of Mexico and South Atlantic coastal areas. They deserve special attention concerning the placement of vapor retarders.

Chapter 5. Types of Preservatives

Wood preservatives must be effective
At least 18-inch roof overhang at eaves and gables
Roof ridge straight
Shingles cover all roof decking
Attic vents
Exhaust fans
Gutters tight and free of debris
Drip caps
Ground sloped away from house
Porch sloped away from house
Porch below wood members
Porch separated from foundation
Dowspouts intact
Planter separated from foundation
More than 18-inch crawl space
Vents for crawl space
No peeling paint, caulking maintained
Planters separated from foundation
Paint, caulk maintained

FIG. 4-1
against wood-destroying organisms, yet safe from an environmental and health standpoint for the end use intended. Numerous chemicals or chemical combinations have been used as preservatives in the past and many more have been proposed. The popularity of the different preservatives has changed depending on long term use experience and the preservative's effect on the different properties of the wood. In the last fifteen years, or so, emphasis has been on the effect of the preservative on the environment and on any humans, animals, or marine life that come in contact with it. As a result, there are many newer products entering the market and the availability of certain traditional preservatives previously available over the counter is now limited. In this section, those preservatives which are available to consumers at retail outlets will first be discussed. A discussion of preservatives which are most often applied in commercial operations will then follow.

Over-the-Counter Preservatives

Over-the-counter preservatives are those materials which are available to the general public as compared to restricted-use pesticides, which require certification of the user. Over-the-counter preservatives are most often applied by brush, spray or dip treatment. Application methods and techniques are discussed in Chapter 6.

Water repellents applied by brushing, dipping or spraying have been shown through research to be effective in reducing deterioration of wood from fungal activity in above ground applications. Since they help wood repel water, they will also reduce checking and warping. Water repellents are mixtures of wax, resin, drying oil, and a solvent. Water-repellent preservatives are simply water repellents with a preservative added. Both water repellents and water-repellent preservatives have been used as a natural finish and as a wood stabilizer before painting. These materials are readily available to the general consumer and are often used to treat wood decks. Water repellents and water-repellent preservatives are designed to protect only the surface
of the wood and they must be renewed frequently, sometimes annually. They should not be confused with materials (preservatives) intended to provide more long-term protection against biological agents. Some of these preservatives which are available over the counter, as well as some which are used in commercial pressure treating, also have a water repellent added. The objective is to reduce checking and warping while the preservative controls biological activity. Be sure to read the label or product information sheet carefully to be certain that the material selected will perform as needed. Some information on the more common over-the-counter formulations containing preservatives are as follows.

Copper naphthenate is a greenish-colored preservative which imparts the same color to the wood. However, the wood may turn brown after several months of exposure. Copper-naphthenate-based preservatives have typically been oil-based but a water-based formulation is now available. For brushing and other superficial methods, a copper content of one to two percent (approximately 10 to 20 percent copper naphthenate) is usually required. This preservative is also used for pressure treating and additional information is provided in that section.

Zinc naphthenate is similar to copper naphthenate. It is less effective in preventing decay and mildew. It is lighter colored and does not impart the characteristic green color of copper naphthenate.

IPBC or Polyphase, technically known as 3-iodo-2-propynyl butyl carbamate, is a wood preservative which is marketed by retail stores in water-repellent preservative formulations. It is intended for above ground applications only. Some formulations can be painted and no odor remains after drying.

Copper-8-quinolinolate is green in color, odorless, is toxic to a wide range of wood destroying organisms and has a low toxicity to humans and
animals. It is permitted by the U.S. Food and Drug Administration for treatment of wood used in food handling. Examples include commercial refrigeration units, fruit and vegetable baskets and boxes, mushroom trays, greenhouse flats, water tanks and others. It has also been used on non wood materials such as webbing, cordage, cloth, leather and plastics.

TBTO or tributyltin oxide, technically known as bis (tri-N-butyltin) oxide, is a colorless to slightly yellow organotin liquid soluble in many organic solvents but insoluble in water. TBTO is not effective against decay when used in soil contact and it is only recommended for above ground use such as millwork. It has been used as a marine antifoulant, but its use has been virtually eliminated because of environmental impact.

Borates, at least in the United States, are one of the newest preservatives to become available. They are derived from the mineral sodium borate; this mineral is the same material used in laundry additives. The preservative is effective against decay, termites, beetles, and carpenter ants when used in above ground applications. Borate preservatives are odorless, do not corrode ferrous metal fasteners, and they can be finished with paint or other coatings. The preservative remains in place as long as it is not exposed to liquid water or does not come into prolonged contact with the soil. Borate solutions can be sprayed, brushed, or injected.

In green wood or wood which has become wet from exposure, borates will diffuse into the wood. Thus, in existing structures, this preservative will diffuse into those areas which are wet and most susceptible to decay. Since the preservative diffuses into the wood, it also has the potential for treating large timbers or other wood members which are not easily pressure treated. The material has also been used to treat hardwood pallets where a bright appearance and absence of insects is important. It should be remembered that this preservative is leachable.

Borates have been made available to
the pest control industry and in some cases directly to the consumer. Since borates have received approval by AWPA as a preservative for wood not in contact with ground or liquid water, the number of commercial users and companies marketing the product is expected to increase.

**Commerically Applied Preservatives**

Many of the currently used preservatives for pressure treatment of wood have been available for many years. As a result, actual use data on long term durability is available. Table 5-1 presents fence posts test data on four of the six preservatives presented in this section. Some of these preservatives have extended the service life of wood posts by at least 10 fold when compared to the untreated posts.

Preservatives which are applied by commercial pressure treating operations can be placed in two classifications; oil type preservatives and the waterborne preservatives. The traditional oil type preservatives are creosote, pentachlorophenol (often called penta), and, more recently, copper naphthenate. The traditional waterborne preservatives are chromated copper arsenate (CCA), ammoniacal copper zinc arsenate (ACZA), and more recently ammoniacal copper quaternary ammonium compound or ammoniacal copper quat (ACQ). With the exception of copper naphthenate and ACQ, the preservatives themselves are all restricted-use pesticides. That is, they can only be purchased and applied by individuals who have received specific training on the safe handling and use of pesticides. However, the wood which is treated is not restricted and it is available for general consumer use. Information on the safe use, handling, and disposal of the wood is given in Chapter 11.

**Oil Type Preservatives**

Creosote, or coal-tar creosote, is the one preservative which has persisted since the earliest days of preservative treatments. In the United States it was first used for marine pilings in 1889 and, by the 1920's, it became
the treatment of choice for the railroad industry and continues to be so. Creosote is also commonly used on heavy timbers and poles.

Creosote is distilled from coal-tar. Coal-tar is a by-product derived when coke is produced by the high temperature carbonization of bituminous coal in sealed airtight ovens. Creosote is effective against most biological organisms that attack wood. It imparts a dark brown to black color and has a characteristic odor. It is permanent due to its low volatility and low insolubility in water. The odor and oily dark surfaces of the treated wood may be objectionable in some applications and freshly creosoted wood may ignite easily. Creosoted material cannot be painted and it should not be used indoors or where human contact is likely. In November of 1986, creosote became a restricted-use pesticide and it is available only to certified applicators. For use and handling precautions, refer to the Consumer Information Sheet provided by the U.S. Environmental Protection Agency (EPA) in Chapter 11.

Pentachlorophenol has been widely used for both pressure and non-pressure preservative treatment of wood. In heavy oils, common applications included poles of all kinds, posts, timbers, and lumber. In this form, the material leaves an oily residue on the surface which cannot be painted. Odor, except for that of the oil carrier, is not a problem. When light oils are used as a solvent for pentachlorophenol, the treated wood is typically much lighter in color than creosoted material.

Pentachlorophenol is effective against many terrestrial wood destroying organisms such as mold, stain, decay fungi, and insects. However, it is not used in salt water due to leaching. It should not be applied indoors or where human, plant, or animal contact is likely.

Pentachlorophenol in a 5 percent solution of light petroleum solvents such as mineral spirits and similar solvents has also been used for treating exterior millwork since the solvent evaporates and leaves a clean, paintable surface.
Pentachlorophenol was one of the most common preservatives for commercial pressure treatment as well as residential and agricultural use until oil prices escalated in the early 1970’s. It became a restricted-use pesticide in November of 1986. During the same time period, use of the waterborne preservatives which leave an oil free and paintable surface increased markedly. As a result, pentachlorophenol has lost its popularity for certain products. It is found in many older installations and still used in substantial quantities for treatment of utility poles and crossarms. It is commonly used as a standard by which to compare the effectiveness of other or newer preservatives. For use and handling precautions, refer to the Consumer Information Sheet provided by EPA in Chapter 11.

Copper naphthenate’s toxicity to wood destroying fungi and insects has been known for close to a century and the preservative has had commercial use since the 1940’s. It is a mixture of naphthenic acids, usually obtained as by-products in petroleum refining, and copper salts. Use of this preservative for poles as well as other applications where protection against decay and insects is needed has increased as a replacement for pentachlorophenol.

Copper naphthenate is a dark green liquid. The color of the treated wood may vary from olive to dark green when treated at ambient temperatures. Green colored wood with several months exposure may weather to a brown. If heat is used in the treating process, the wood may vary from light brown to chocolate. The material is non corrosive and when applied to wood, it is mostly leach resistant.  

Copper naphthenate is not a restricted-use pesticide and it does not require special handling or exposure under the Resource Conservation and Recovery Act (RCRA). Although the material is not a restricted-use pesticide, it should be handled as any industrial pesticide. Handling precautions are similar to those for wood treated with oil- based and waterborne preservatives.
sure to obtain current detailed information from the supplier.

**Waterborne Preservatives**

Lumber and many other types of wood products including posts, poles and some marine pilings are commonly treated with one of several waterborne preservatives. The resulting wood product is usually somewhat green or brownish in appearance, no odor results, the surface can be free of excess preservative, and the wood when dry can be painted.

The more common waterborne preservatives include chromated copper arsenate (CCA), ammoniacal copper zinc arsenate (ACZA), and ammoniacal copper quaternary ammonium compound (ACQ). There are three different forms of CCA, all of which have performed well against decay and insect attack. Type C is the most common form of CCA currently being used. In addition, high retention of 2.5 pounds per cubic foot of CCA will provide good resistance to the marine borers Limnoria and Teredo.

Ammoniacal copper zinc arsenate, or ACZA, is used almost exclusively on the west coast for the treatment of Douglas-fir. The chemical makeup of this particular preservative improves its penetration of refractory Douglas-fir heartwood. Wood treated with ACZA is similar in performance and characteristics to that treated with CCA.

Ammoniacal copper quaternary ammonium compound, or ACQ, is the newest of the waterborne preservatives to become available. It is being promoted on the basis that, unlike CCA and ACZA, it does not contain any arsenic or chromium and, thus, is more environmentally acceptable. It is not now a restricted-use pesticide. The treated wood is reported to be as resistant to decay, termites and insects as that treated with CCA. The wood weathers to a permanent brown tone. The treatment is suitable for a number of different wood species including southern pine and Douglas-fir.
Properties of Treated Wood

Shrinkage can be an important factor when using wood treated with the waterborne preservatives. When the wood is treated, it is injected with large quantities of water which carries the preservative chemical with it. The water swells the wood to near its original green dimensions. Thereafter, lumber may seem dry on the surface, but be quite wet in the interior. If the wood is installed while it is still wet and allowed to air dry as in an exposed deck, it will shrink about three to five percent. This dimensional change can amount to about 1/4 inch on a nominal six inch wide board. Thus, if the spacing between boards or the dry dimension of the structure is critical, the amount of shrinkage should be considered when using undried wood (Fig. 5-1).

Warping and twisting as wet wood dries is also common. Thus, the wood should be firmly attached in place so it will remain flat or it should be air dried under restraint. The use of spiral or ring-shanked nails will help hold the pieces in place.

Corrosion of metals used in contact with wood treated with the oil-type preservatives is usually not a problem. Heavy oils tend to coat the surface of the fasteners. In wharf and shoreline bulkhead construction where metals are exposed to salt water, hot dip galvanized steel is usually recommended. Corrosion of metal fasteners within the wood is inhibited in these applications because the holes are most often drilled prior to pressure impregnation of the preservative.

Corrosion of metal fasteners can occur due to the presence of small quantities of soluble copper ions in the waterborne preservatives. Under conditions of low moisture content, corrosion will be negligible. When the moisture content of the treated wood approaches 20 percent, corrosion can occur. It has been shown that in above ground applications hot dip galvanized steel is acceptable to use for fasteners. Where moisture is commonly present, as in soil contact, stainless steel is most often recommended as the appropriate fastener. In applications where
structural integrity or where life endangering situations could develop, stainless steel is also preferred.

The strength characteristics of wood treated with the waterborne preservatives is another factor which should be considered. Early in the commercial development of CCA it was noted that some material seemed to have reduced mechanical properties and brash breaks were not uncommon. A brash break, as compared to a splintery break, generally indicates reduced mechanical properties. After substantial research, it was determined that if treated wood was dried at temperatures below about 160°F strength reductions were limited to about 5 to 10 percent. Existing standards are being modified to reflect these new findings. However, at this time very little lumber is kiln dried after treatment. Higher grade lumber is affected more than lower grade lumber. In summary, the use of waterborne salts can reduce the mechanical properties of wood. However, if moderate temperatures are used in drying, the reductions are minimized and probably not a significant factor except in the most critical applications.

Figure 5-1. Tongue-and-groove lumber treated with a waterborne preservative and not dried before installation was used for this deck. The tongue-and-groove boards were laid tight against each other. Note the shrinking and warping which can occur.
Table 5-1. Some examples of expected service life for southern pine posts in soil contact and pressure treated with different preservatives. The posts were installed in southern Mississippi in an area with a high decay hazard rating and abundant termite populations. Because treatments and retentions varied considerably, these data do not represent a comparison of preservatives. Rather, they are intended to show the large increase in service life that can be achieved with a number of different preservatives.

<table>
<thead>
<tr>
<th>Preservative</th>
<th>Retention (pcf)</th>
<th>Estimated service life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromated copper arsenate* (CCA) - Type C</td>
<td>0.41</td>
<td>26 + bc</td>
</tr>
<tr>
<td>Coal-tar creosote*</td>
<td>5.6</td>
<td>46</td>
</tr>
<tr>
<td>Copper-8-Quinolinolate (1.0% in petroleum oil)</td>
<td>8.1</td>
<td>26 + bc</td>
</tr>
<tr>
<td>Copper naphthenate (0.5% in petroleum oil)</td>
<td>6.3</td>
<td>50</td>
</tr>
<tr>
<td>Pentachlorophenol* (0.5% in petroleum oil)</td>
<td></td>
<td>3.3</td>
</tr>
<tr>
<td>No preservative treatment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Restricted-use pesticide.
bcTest still in progress.
*aNo failures as of 1990.
Chapter 6. Preservative Treatment Processes

Preservative treatment processes can be divided into two broad categories. The first category consists of superficial non-pressure treatments including brushing, spraying, dipping or soaking. With a few exceptions, these methods are most often applied on site and offer minimal protection. Vacuum, diffusion, and hot and cold bath treatments can improve penetration somewhat over the strictly non-pressure methods. Pressure treating processes involve different combinations of vacuum and pressure and are done in commercial installations. These treatments are capable of offering the maximum protection available.

Requirements for an Effective Wood Preservative

The degree of protection offered by a particular preservative and treatment process is dependent upon the fulfillment of four basic requirements. These are the toxicity and permanence of the preservative to potential biological agents, the amount of preservative impregnated into the wood (also called retention) and, finally, the degree of penetration of the preservative into the wood.

Toxicity refers to how effective a preservative is in deterring decay fungi, wood destroying insects, and marine borers. Some preservatives, or particular formulations or mixtures of preservatives, are more effective than others. AWPA standards define applicable preservatives.

Permanence is also required for an effective preservative. The preservative must be resistant to leaching and volatilization, as well as chemical and biological breakdown.

Retention is the term used in wood preservation which specifies the amount of preservative which must be impregnated into a specified volume of wood in order to meet standards and to assure that the product will repel the numerous biological agents. Some preservatives are more toxic than others while some biological
organisms are more tolerant than others. Therefore, the recommended retention can vary depending on the preservative and end use intended. Retention levels, usually expressed as pounds per cubic foot, are set by AWPA standards and should be strictly adhered to.

Penetration of the preservative into the wood is the fourth major requirement for effectiveness. As wood is pressure treated, the preservative penetrates from the ends and sides of the piece. The end grain is relatively easily penetrated while the sides are more difficult. Some species such as southern pine are easily treated because the wood is predominately sapwood while others like Douglas-fir, which is predominately heartwood, are very difficult to penetrate. Even using the best pressure treating technology, it is very difficult to penetrate most woods by more than a few inches. As a result, the interior is not treated in timbers, poles and other large members. The outer treated wood forms a protective shell around the untreated interior. This protective shell must not be broken or the interior of the member could be attacked. Penetration levels, generally expressed in inches, are likewise set by AWPA standards and should be strictly adhered to. Where these standards call for incising of refractory or difficult to treat species, this should not be waived.

**Non-Pressure Treatments**

Brushing, spraying, dipping or soaking are all non-pressure processes which, with the exception of soaking in certain situations, only provide superficial protection to wood. The preservative does not penetrate deeply into the wood and the treatments are not intended to protect the wood from sustained exposure to degrading organisms. These treatments should only be used for above ground applications where the decay hazard is relatively small or for field treatment if exposed surfaces where pressure treated wood is cut. Some preservatives and their solutions can pose a health hazard to the applicator as well as resulting in environmental damage. Therefore,
read and follow all label directions and exercise caution when working with these materials.

Brush treatment is probably the simplest of all treatment methods. The preservative solution is simply flooded onto the surface and brushed out. Brush treatment is preferred to roller or spray application because the movement of the brush helps introduce preservative into the microfissures of the wood. Checks and other openings should be saturated to the point of refusal. A second or even third treatment after the first has been absorbed will improve the effectiveness. Wood should be well dried before treatment or it will not accept preservatives applied in this manner.

When preservatives are sprayed, they can become airborne and, thus, present a potential hazard to the applicator and to the environment. Within factories, these concerns can be addressed through engineering design and maintenance of operating equipment. When preservatives are to be applied outdoors by this method, a coarse spray should be used and the operator should wear protective clothing and respiratory equipment. Special precautions should be taken to avoid spray drift.

Dip treatment involves the immersion of wood materials into a tank of preservative until the wood absorbs the appropriate amount of solution or until it refuses to accept additional preservative. This method is used commercially to treat millwork with a water-repellent preservative. A three minute submersion of easily penetrated millwork which will be used above ground has been shown to give substantial protection against moisture absorption and subsequent decay (Fig. 6-1).

The National Wood Window and Door Association (NWWDA) maintains a standard for the non-pressure treatment of wood. The standard requires that the normal shrinking and swelling of wood be reduced by at least 60 percent when exterior millwork is treated with a water-repellent preservative. The surface of the wood must be left clean, dry and
paintable. NWWDNA requires a soaking period of 15 seconds when individual parts or units are dip treated and 3 minutes for batches or bundles of exterior millwork. Preservatives included in water-repellent formulations must be effective in preventing decay. In 1994 this standard will be rewritten. AWPA is in the process of establishing standards for non-pressure treatments.

Cold soaking is simply the soaking of bark-free dried wood in an unheated oil-based preservative such as creosote or pentachlorophenol. Cold soaking well dried, permeable woods, such as the sapwood of pine, for two days to one week may result in absorption of four to six pounds of preservative per cubic foot of wood. Thus, with little equipment costs and effort, reasonable protection against decay and insects can be achieved, especially for small, round products such as fence posts.

**Other Treatments**

For vacuum treatment, the air in a chamber is exhausted with a vacuum pump and the preservative is introduced. After the preservative enters the chamber and the vacuum is released, air at atmospheric pressure increases penetration.

The hot and cold bath is also known as the open-tank treatment, the boiling-and-cooling method, or the thermal process. Creosote and other oils are commonly used with this process since large quantities are not lost through heating and evaporation in open tanks. However, water-soluble salts have also been used effectively. The process is used for butt, as well as for full length, treatment of air-dried, bark-free poles. Butt treatment protects the most vulnerable part of the pole. The process is capable of treating the non-durable sapwood portion. As a result, it has been used in those sections of the country with a low decay hazard rating and where cedar poles with naturally durable heartwood are used. It has also been used on fence posts, lumber, and other timber products, particularly where small quantities are treated.
Material that is to be treated by the hot and cold bath method, must be thoroughly dried. Dry wood is first immersed in a hot bath of preservative for about six hours. The temperature of creosote or pentachlorophenol for the hot bath should not exceed 230°F. The hot bath expands the air in the cell lumens and forces a portion of it out of the wood. The hot bath is followed by a cold or cooling bath. In the case of the cold bath, the hot preservative is replaced with a preservative at a lower temperature. With a cooling bath treatment, the hot preservative is left in the treating tank and simply allowed to cool. As the wood cools, air and vapor in the outer cell lumens contract forming a partial vacuum and atmospheric pressure forces the preservative into the wood.

The cold bath temperature is usually between the point at which solids form in the preservative and 150°F. It normally lasts two hours or more. A final expansion bath of hot preservative oil may be applied at the end of the treating process.

Diffusion is a method of treating green wood where the chemical preservative moves from an area of high concentration (the chemical at the surface) to an area of lower concentration (inside the wood) over extended time periods. This method has been used to a limited extent in wood treating for years. One successful and continuing application is the remedial treatment of poles at groundline (Fig. 6-2). In this case, the soil is removed from the groundline area, preservative is applied to the pole (after all decayed wood, etc., has been cut away) and it is then covered with a protective wrapping. The hole is back filled. Active ingredients slowly diffuse into the high moisture content wood to suppress growth of decay fungi and to resist insect attack.

With the introduction of borates as preservatives into the United States' market, the use of the diffusion process may expand into other areas. Borates readily diffuse into wet wood. However, when exposed to liquid water, they will diffuse back out. That is, they are not permanently locked into the wood. Applications will be effective in locations where
wood has become wet or subject to insect attack, but where it is not exposed to the rain or other free moisture sources. Examples might include wood in crawl spaces or cabin logs. Recent research has shown that borates are effective preservatives, not toxic to humans and on green or wet wood they can be effectively applied by diffusion.

Double diffusion is similar to diffusion except two different chemical solutions are used. In this process the green wood is first soaked in one chemical solution such as sodium fluoride and then in a second solution such as copper sulfate. The chemicals then combine to form a leach-resistant compound, copper fluoride. Copper sulfate and sodium chromate with sodium arsenate may also be used. The double diffusion method can be an effective method of wood preservation and, unlike pressure treating, requires very little capital equipment. EPA guidelines must be followed for all stages of use and disposal of the treating chemicals.

In commercial pressure treating there are three general areas of processing which must be addressed. These are the preparation of the material before treatment, the preservative treatment itself and, finally, any conditioning which must be done after the treatment process is finished. Each of these three areas can vary substantially depending on the type of product (i.e. lumber, poles, piles, timbers, etc.) being processed, the intended end use and the preservative being used. The following is a general description of the processes.

**Pre-Treatment Processing**

Bark on wood prevents it from drying, blocks the penetration of preservative into the wood, and also encourages wood boring and decay organisms to develop. Therefore, all bark must be removed, especially from round products. For poles and posts, shaving machines are normally used. In the spring of the year when growth first begins, bark is more easily peeled and hand equipment is sometimes used on small quantities.

**Pressure Processes**
Next, the wood must be dried before treatment to obtain satisfactory penetration and retention of preservatives. Air drying is the simplest method. Wood is stacked with adequate room for air to circulate around each piece, thus allowing water to evaporate. Wood products are also dried in kilns. Dry kilns are simply large ovens used to accelerate the drying of wood without producing excessive defects. The temperature, humidity and air velocity in the kilns are controlled.

Another method for drying wood to be pressure treated is steam conditioning. Wood in a treating cylinder is subjected to live steam at 220-245°F for one to twenty hours followed by a vacuum. Moisture is removed during the vacuum period. Unfortunately, steaming can also reduce wood strength. Therefore, the maximum allowable steaming times and temperatures are defined in AWPA standards.

Vapor drying is yet another method which is used in the wood treating industry. This method exploits the principle that the energy lost in the condensation of hot organic vapors on wood can be used to evaporate water from wood in a treating cylinder. The drying agent, an organic compound, is pumped into the cylinder and heated, water from the wood and the organic vapors are transferred to a condenser where they are separated and the drying agent is recycled.

Boultonizing is a drying method also accomplished in a treating cylinder by heating wood in creosote or an oil type preservative while subjecting it to a vacuum. Water will boil at less than 212°F because the wood is under vacuum. Therefore, this process uses temperatures below those required in the steaming and vacuum process.

After drying certain species and products may be incised. Incising is the production of small slits or holes in the surface of wood products to facilitate deeper and more uniform penetration of preservative by creating more end grain surface area (Fig. 6-3). It is commonly used on those species such as Douglas fir which do not
readily accept preservatives. Incising requirements for different species and commodities are given in AWPA standards.

Finally, all machining and cutting such as boring or framing of pole tops, etc., should be done prior to preservative treatment to reduce exposure of untreated portions of wood to decay fungi, insects, and marine borers.

**Treating Processes**

Pressure treating processes are the most commonly employed method to obtain deep penetration of wood preservatives. These treatments are done in retorts, or closed cylinders, where penetration and retention can be controlled. These cylinders are usually four to ten feet in diameter and up to 180 feet long (Fig. 6-4). Preservative storage and measuring tanks, pressure and vacuum pumps, steam boilers, measuring and recording instruments, and other equipment are usually located adjacent to the cylinder.

Pressure processes can be divided into two categories. These are the full cell process and the empty cell process. A general description of each process is given below.

The full-cell process is also called the Bethell process and was patented in 1838. This process is designed to force as much preservative into the wood as possible. The cell lumens, or voids, are loaded with preservative, resulting in a high retention. This process is commonly used with creosote treatments for marine piling where high retentions are required and with the waterborne preservatives. With oilborne treatments or creosote, the full-cell process forces so much preservative into the wood that some of it may bleed onto the surface after the treated wood products are installed. Therefore, with these preservatives, this process should only be used where the additional retention is needed. The modified full-cell process is a relatively recent development intended to accelerate post-treatment conditioning of wood products that have been treated with waterborne preservatives.
The empty cell process impregnates and coats the cell walls with preservative. The cell lumens are not filled. This is accomplished by using a slight initial pressure within the wood product to force excess preservative out of the wood at the end of the treating cycle. This process provides the deepest penetration with low retention of preservative. The Reuping and Lowry processes are the two empty cell processes commonly employed.

Exact specifications for both full and empty cell processes are given by AWPA. Substantial operator experience and judgment is required to obtain the specified results with any of these processes.

**Post Treatment**

After the wood has been pressure treated with a preservative, there are two additional steps which can be taken depending on end-use requirements. These are cleaning or steaming the surface to remove any excess preservative and fixing the waterborne preservative to increase its leach resistance. Both cleaning and fixing may be done in the treating cylinder. In order to decrease processing time in the treating cylinder, kilns may be used to dry the wood to a specified moisture content.

The cleaning process is important. With oil-based preservatives it removes excess preservative which improves appearance and facilitates handling. With the waterborne preservatives which are commonly used where human exposure is likely, surface cleaning will reduce the amount of chemical on the surface (see section on safety and environmental issues).

The redrying of those wood products, treated with waterborne preservatives is important for two reasons. First, dry wood is lighter and stronger and it will not shrink, warp or check as severely as will wood installed when it is wet. However, most standard lumber treated with the waterborne preservatives is not dried before shipment and the material should be installed understanding that shrinkage is likely. Secondly, and more
importantly, the fixation process for chromium-containing preservatives is completed as wood is heated and dries either in the atmosphere or in kilns. During fixation, hexavalent chromium converts to its trivalent form and a leach resistant (fixed) complex is formed. The fixation period is extended by cool temperatures. The fixation process can also be completed before the wood is removed from the treating cylinder. AWPA Standard C1 permits hot water or steam to be injected into the cylinder to accelerate the fixation process so long as the temperature does not exceed those set in the treating standards.

Figure 6-1. Contrast between dip-treated (A) and untreated (B) steps after 5 years of exposure near Gulfport, Mississippi. On-site dip treatment consisted of immersing the precut lumber 3 minutes in a light oil solution of 5 percent pentachlorophenol and water repellent. Pentachlorophenol is now a restricted-use pesticide but other preservatives are available.

Figure 6-2. Remedial treatment of a pole at groundline using the diffusion principle.

Figure 6-3. Incising improves the treatability of refractory woods such as Douglas-fir.

Figure 6-4. Typical treating cylinder with charge ready for processing.

Chapter 7. Standards, Quality Assurance and Specifying Preservative Treated Wood Products

The extent to which the "quality" of preservative treated wood products needs to be monitored is directly related to the project being constructed. Minimal concern will probably exist when a dozen "landscape timbers" are being purchased in order to construct a raised rose bed or where a few boards are being purchased for a wood deck constructed a few inches above ground level. On the other hand, maximum concern will be expressed
Figure 6-2. Remedial treatment of a pole at groundline using the diffusion principle.
and all precautions taken if a utility company is constructing a high voltage cross country transmission line using large wood poles or a new wharf is being installed in salt or brackish water.

In establishing quality specifications, there are two general areas where concern should be concentrated. The first is the condition and grade of the wood material itself. Lumber and panels should be of the grade and quality as specified or as represented. Poles, piles and heavy timbers should be inspected prior to treatment to determine if any defects which could cause structural weakening are present and that the material is of the quality needed. The next level of concern is whether the material has been properly treated with the preservative as specified or represented.

In this section, we will first discuss what a consumer of small quantities of treated wood products should look for in making a purchase. Then we will detail what an architect, contractor, specifier, or purchasing agent, for example, can do to provide maximum assurance that all standards and specifications have been closely followed and a quality treated product delivered.

**Purchases for Residential and Agricultural Applications**

When purchasing small quantities of preservative treated material, such as lumber or small timbers from local lumber yards or other sources, the material should be examined to determine if the grade (appearance) of the lumber itself is acceptable for the intended end use. Some yards will carry a higher grade than others. The grade is normally stamped on each piece (Fig. 7-1). Price is usually directly related to grade. Some material will also contain more bark edges or wane than others. Bark edges may be objectionable if appearance is important. For the lumber grade mark to be valid after treatment, the lumber must adhere to the grade requirements and the moisture content of the grade as represented.
Since heartwood does not accept preservative treatment well, its presence in southern pine as well as other pine species should be limited in critical members and in areas of high degradation hazard. Some heartwood is nearly always present, but some shipments will have a higher percentage (Fig. 7-2). Pieces wider than about six inches will also tend to have more heartwood. If possible, those pieces which do contain heartwood should be placed where exposure to biological agents is less severe. Douglas-fir, on the other hand, is almost all heartwood and different treating specifications and preservatives apply to it.

The next concern is the preservative treatment itself. Each piece should be stamped with a quality mark (Fig. 7-3) or contain a tag (Fig. 7-4).

The American Lumber Standard Committee (ALSC) accredits agencies which use the stamp or tag described above. This represents the industry’s method of monitoring itself and providing consumers at the retail level with a quality product. In essence, the system has established applicable quality control standards and accredited independent inspection agencies to monitor subscribing treating facilities and determine if they are in compliance. This ALSC quality control overview is preferable to simple treating plant certificates or other claims of conformance made by the producer without inspection by an independent agency. If the treated wood products do not carry the stamp or tag and if the supplier is not willing to provide documentation that the appropriate AWPA standards were followed, there is no assurance of the quality of the product. For some applications such as decks, an ink stamp on each piece of lumber is aesthetically objectionable. Therefore, end tags are used by some suppliers.

**Purchases for Commercial Installations**

To provide maximum assurance that a quality product is being received, it is necessary to (1) determine if the type and quality of the wood material itself is suitable for the end use intended, and (2) to make certain that the wood
preservative and the preservative treatment process are in accordance with applicable standards. Each step of the process must follow set procedures and be appropriately documented. Independent inspection agencies are often retained to assure that the material, preservative and treatment specifications are strictly adhered to.

**Material Specifications**

Wood is a biological material and as such is naturally variable. The variability is related to a large number of factors which can include species, growth rate, age, genetic makeup, mechanical damage such as cross breaks, and natural defects such as knots, shake, etc. Some of these defects such as cross breaks in poles and piles can be detected only after the bark has been removed and before the product is treated. These products are often inspected before preservative treatment. The industry refers to this as inspection "in the white". Existing material specifications have been developed which will group (or grade) wood products with known structural properties and engineering design values.

For complete material standard specifications for different products, the following sources should be referenced:


Treatment Specifications

The proper choice and application of preservative for the intended end use is critical to the successful performance of the treated product. AWPA standards require different preservative retentions for different use environments. Substitution of materials properly treated for one environment into another environment may contribute to early failure or unacceptable aesthetic qualities. Marine exposures, for example, require much heavier retentions of preservatives than are required for use in ground contact. Marine exposures may also utilize preservatives such as creosote that are not acceptable for indoor use. Recommended retentions and applicable AWPA standards by product and preservative for southern, ponderosa and red pines are summarized in Table 7-1, while Douglas-fir, western hemlock, and the species group hem-fir are summarized in Table 7-2. For complete details users should refer to the actual standards. Note that some preservatives are restricted to certain species. Also, other less common species are given in AWPA standards. These standards address chemicals, process requirements, and performance requirements for preservative pressure-treated wood products. Acceptable preservatives and carriers are identified and defined. The standards also define the amount of each type of preservative and the depth of penetration required by commodity and species. Processing parameters such as temperature are also defined. For some commodities, such as poles, the preservative penetration and retention within a given assay zone will vary with species. Sampling protocols for inspecting treated wood products and methods for care and handling
products after treatment are also addressed.

Although AWPA standards are generally accepted by treated wood producers and purchasers, all wood is not necessarily treated according to these specifications. If AWPA standards are not followed, purchasers should be certain that they understand the technical aspects of wood preservation and that the specifications as written will provide a product which meets or exceeds long term performance expectations. Inspection must be conducted to determine if the specifications are being carried out.

"Treatment to refusal" is a terminology still used in standards for pressure treatment of a few very difficult-to-treat woods such as white oak. When this terminology is used in a procurement specification for pressure-treated products, it does not require a minimum amount of preservative (retention) nor does it require a minimum depth of treatment (penetration). Whenever the minimum retention and penetration are listed in standards for pressure-treated wood products, this terminology, "treatment to refusal," should not be used. Instead, cite the standard as published. Use of the terminology, "treatment to refusal," could allow acceptance of poorly treated products that would not otherwise meet standard requirements.

NWWDA specifies acceptable preservatives and the degree of water repellency required for non pressure treatments. AWPA is currently working on standards for non-pressure treatment.

Additional specifications on wood preservation by pressure treatment as well as water repellents have been published by the U.S. General Services Administration. These have not been updated for several years and it is more appropriate to reference current industry standards.

**Inspection Procedures**

Inspection to determine if the
material, the preservative and the treatment process comply with applicable standards and procurement contracts can be done at several different times and locations. Pre-treatment inspections are made of materials after the bark has been removed, but before treatment. These inspections, especially for large members such as poles and piling, are normally done at the treating plant just before treatment.

Whether the treating plant complies with processing parameters as specified in procurement contracts can only be determined at the plant. For example, gauges and charts are examined during and after treatment and a sample of the preservative is taken to verify that the treatment process is being performed in compliance with requirements of the procurement contract.

The material can also be inspected at destination regardless of whether it was inspected at the plant or not. However, for large products such as poles, piles and timbers, specialized handling equipment may be required.

Although some inspection programs require examination of every piece of treated material, most inspections are done by sampling. Sampling is utilized primarily to reduce inspection costs. The frequency and intensity of sampling is often defined in treating standards, but the purchaser has the option of requiring more rigorous sampling. Although commercial wood-treating companies maintain some form of quality control through internal inspections, additional independent inspection both at the plant site and at destination reduce the risk of accepting nonconforming items.

Inspection of wood products both before, during, and after treatment requires experienced individuals with specialized knowledge and equipment. Increment borings may be made to determine retention and penetration. Therefore, the process is normally completed by an independent agency. These agencies are accredited by ALSC and a current list is available from the committee. Some large routine buyers such as utility companies may employ their own
inspectors. Independent inspectors may be retained by the supplier or by the purchaser.

**Documentation**

All treated piling, building poles, lumber, timbers and plywood should have a mark or stamp on each piece which indicates that it was inspected before treatment. Brands, stamps, or tags which indicate that the product was inspected after treatment and that it complies with the appropriate AWPA standards should also be present. Common symbols for wood species and preservatives which may be used on all commodities treated in accordance with AWPA specifications are given in Table 7-3. An inspection report or certificate of an independent inspection agency certifies that the items comply with the appropriate AWPA standards. Reports or certificates should show actual test results for penetration and retention of preservative. Certificates from the treating plants themselves are of dubious value. Millwork, inspected and approved by NWWDA, should bear a "Quality Certified" brand (Fig. 7-5) as proof of inspection.

**Spot Checking of Different Commodities**

**Poles.** There are two types of poles, round building poles and power poles.

To check for evidence of inspection prior to treatment, look on the tip (top) end of the poles for a brand that identifies the inspection agency and the inspector (Fig. 7-6). Upon inspection "in the white", poles which meet material standards are hammer stamped on the tip end. This is the only stamp that is ever put on the tip end.

To determine the type of treatment and preservative retention level check the brand applied by the supplier. Following preservative treatment, poles are branded on the face side of the pole 10 feet from the extreme butt for poles 50 feet or shorter and 14 feet from the extreme butt for poles over 50 feet long. These brands contain the following information:

1. Supplier's Name
Power poles are often treated in accordance with AWPA Standard C4 and may be inspected under Power Pole Standard REA DT-5C. To determine that power poles have been inspected, check for a hammer mark of an approved inspector/agency on the butt end of each pole (See Fig. 7-6).

Building poles are treated in accordance with AWPA Standard C23. In shipments which are under the ALSC accreditation program, look for the quality mark of the accredited agency as evidence that building poles were inspected.

**Piles.** There are three types of piles: marine, general (usually called "land and fresh water"), and foundation. Marine piles are exposed in salt or brackish water; general piles are used in fresh water or in soil, but not capped with concrete; and foundation piles are entirely embedded in the ground and capped with concrete.

To determine if piling was inspected prior to treatment, check for the inspector's hammer brand on the tip end of the piling just as with poles.

To determine the type of preservative that was used and the retention to which the piling was treated, check the brand at points 5 feet and 10 feet from the butt end of the pile. These brands show:

1. Supplier's Brand
2. Plant Designation
3. Year of Treatment
4. Species of Timber and Preservative Treatment
5. Retention(s)
6. Length

The symbols used for preservatives and wood species are shown in Table 7-3.

The treatment of piles is addressed in AWPA commodity Standards C3, C14, and C18.
For those piles procured with the services of the inspection program offered by ALSC, check the piles for the quality mark of an ALSC accredited agency. To determine the intended use of piling inspected under the ALSC program, read the letter symbols for the respective AWPA standard (Tables 7-1 and 7-2).

**Lumber, Timbers and Plywood.** The material should be inspected prior to treatment and be stamped to certify that it meets specific requirements for the grade represented.

As mentioned previously, each piece of pressure treated lumber, timber, or plywood should bear a quality mark or stamp that will evidence independent inspection of the wood after it was preservatively treated. When checking materials that have been inspected by agencies approved by ALSC, it is important to recognize that there are a number of stamps or marks for lumber, timber and plywood. The stamp or mark provides information on both the preservative used and the intended use environment for the treated wood. By careful reading of these marks (Fig. 7-3 and Tables 7-1 and 7-2) the person receiving the shipment can determine whether the materials received are appropriate for the planned use.

AWPA Standard C2 addresses the general aspects of treating lumber and timbers; other, more focused standards address specific commodities. Plywood is covered by AWPA Standard C9. The requirements for treated materials used specifically in marine environments are addressed in AWPA Standards C2, C3, and C18.

Figure 7-1. Shows a typical lumber grade stamp as approved by ALSC and its interpretation for Douglas-fir lumber. (Courtesy of ALSC).

a - The trademark indicates agency quality supervision.
b - Mill Identification - firm name, brand or assigned mill number.
c - Grade Designation - grade name, number or abbreviation.
d - Species Identification - indicates species individually or in combination.
e - Condition of Seasoning at time of surfacing:
   S-Dry - 19% max. moisture content
   MC 15 - 15% max. moisture content
   S-GRN - over 19% moisture content (unseasoned)

Figure 7-2. Heartwood in treated southern pine lumber.

Figure 7-3. Typical quality mark for lumber preservative treated to conform to the ALSC accreditation program. (Courtesy of ALSC)

1 - The identifying symbol, logo or name of the accredited agency.
2 - The applicable American Wood Preservers' Association (AWPA) commodity standard.
3 - The year of treatment if required by AWPA standard.
4 - The preservative used, which may be abbreviated.
5 - The preservative retention.
6 - The exposure category (e.g. Above Ground, Ground Contact, etc.).
7 - The plant name and location; or plant name and number; or plant number.
8 - If applicable, moisture content after treatment. (KDAT is kiln dried after treatment.)
9 - If applicable, length, and/or class.

Figure 7-4. A quantity of waterborne preservative treated lumber showing end tags.

Figure 7-5. "Quality Certified" brand that indicates compliance with water-repellent preservative treatment standards of NWWDA.

Figure 7-6. Examples of hammer marks used on poles.
Figure 7-1. Shows a typical lumber grade stamp as approved by ALSC and its interpretation for Douglas-fir lumber. (Courtesy of ALSC).

- The trademark indicates agency quality supervision.
- Mill Identification - firm name, brand or assigned mill number.
- Grade Designation - grade name, number or abbreviation.
- Species Identification - indicates species individually or in combination.
- Condition of Seasoning at time of surfacing:
  - S-Dry - 19% max. moisture content
  - MC15 - 15% max. moisture content
  - S-GRN - over 19% moisture content (unseasoned)
Figure 7-2. Heartwood in treated southern pine lumber.

NOT AVAILABLE
Figure 7-3. Typical quality mark for lumber preservative treated to conform to the ALSC accreditation program. (Courtesy of ALSC)

```
ABC 1
XXX 7

19-19 3
GROUND CONTACT 6

0.40 5

AWPA ___ STDS 2
PRESERVATIVE 4
KDAT 8
X-XX 9

1 - The identifying symbol, logo or name of the accredited agency.
2 - The applicable American Wood Preservers' Association (AWPA) commodity standard.
3 - The year of treatment if required by AWPA standard.
4 - The preservative used, which may be abbreviated.
5 - The preservative retention.
6 - The exposure category (e.g. Above Ground, Ground Contact, etc.).
7 - The plant name and location; or plant name and number; or plant number.
8 - If applicable, moisture content after treatment. (KDAT is kiln dried after treatment.)
9 - If applicable, length, and/or class.
```
Figure 7-6. Examples of hammer marks used on poles.

IN PREPARATION
Table 7-1. Recommended retentions and applicable AWPA standards for southern, ponderosa and red pine by product and preservative based on AWPA standards.18.a

<table>
<thead>
<tr>
<th>USE</th>
<th>AWPA Standard(s)</th>
<th>ACQb</th>
<th>ACZa</th>
<th>CCA</th>
<th>Creosote Petroleumc</th>
<th>Creosote Solutionsd,e</th>
<th>Pentachlorophenolef</th>
<th>Copper Naphthenateg</th>
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<tr>
<td><strong>LUMBER, TIMBER &amp; PLYWOOD</strong></td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Above ground</td>
<td>C2/C9</td>
<td>.25</td>
<td>.25</td>
<td>.25</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>.40</td>
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<td>C2/C9</td>
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<td>.40</td>
<td>.40</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>.50</td>
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<tr>
<td>Ponderosa wood foundations</td>
<td>C2</td>
<td>NR</td>
<td>.60</td>
<td>.60</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Salt water use</td>
<td>C2/C9</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>25</td>
<td>NR</td>
<td>25</td>
<td>NR</td>
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<td>C3</td>
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<tr>
<td>Teredo only</td>
<td>C18</td>
<td>NR</td>
<td>2.5h</td>
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<td>NR</td>
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<td>Pholads only</td>
<td>C18</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
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<td>Limnoria tripunctata only</td>
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<tr>
<td>Sphaeroma teredans or for both pholads and Limnoria tripunctata use a dual treatment</td>
<td></td>
<td></td>
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<td>-</td>
<td>-</td>
<td>20</td>
<td>20</td>
<td>-</td>
<td>NR</td>
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<tr>
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<td>Normal</td>
<td>C4</td>
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<td>7.5</td>
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<td>.38</td>
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<td>Severe service conditions (high incidence of decay and termite attack)</td>
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<td>NR</td>
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<td>Fence</td>
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<tr>
<td>Round, half-round, and quarter-round</td>
<td>C5</td>
<td>.40</td>
<td>.40</td>
<td>.40</td>
<td>8</td>
<td>8</td>
<td>8</td>
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<tr>
<td>Sawn four sides</td>
<td>C2</td>
<td>.40</td>
<td>.40</td>
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<tr>
<td>Round, half-round, and quarter-round</td>
<td>C14</td>
<td>NR</td>
<td>.40</td>
<td>.40</td>
<td>8</td>
<td>8</td>
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<td>.40</td>
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<tr>
<td>Sawn four sides</td>
<td>C14</td>
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<td>Guardrail and Spacer Blocks</td>
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<td>Round</td>
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<td>.50</td>
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<td>12</td>
<td>.60</td>
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</table>

Retention Assay of Treated Wood -- lbs/cu.ft.
AWPA Standards detail plant operating procedures for pressure treatment of wood. These standards include minimum vacuum, pressure, penetration requirements, maximum steaming and temperature allowances. AWPA also details retention and assay zone requirements for each commodity, preservative and wood species. AWPA standards make it unnecessary for specifications to include detailed requirements on penetration and allowable processes. Generally, it is desirable to specify the preservative desired, the intended application, necessary retention and to reference appropriate AWPA standards. AWPA standard C-1 applies to each of the treating processes and all types of material.

These preservatives have only recently been added to the AWPA Standards. Hence, the 8 wood species and commodities approved for treatment with them are limited and subject to change.

Not recommended where cleanliness and freedom from odor are necessary.

When these preservatives are specified, the creosote shall conform to AWPA Standard P1 and the creosote solutions shall conform to Standard P2.

Pentachlorophenol in suitable solvents or waterborne preservatives can provide a clean, paintable, odorless, dry surface. When one or more of these features is required, the processor should be so advised when the order is placed.

When the lumber and plywood parts have been treated in accordance with AWPA C-22 standard and the foundation is fabricated and constructed in accordance with National Forest Products Association Technical Report No.7, the foundation should have a life equal to or greater than the rest of the structure.

NR -- Not Recommended.

The assay retentions are based on two assay zones - 0 to 0.50 inch and 0.50 to 2.0 inches.

Note: Needs updating based on 1993 AWPA Standards when available.
Table 7-2. Recommended retentions and applicable AWPA standards for western species by product and preservative based on AWPA standards.\textsuperscript{a,9}

<table>
<thead>
<tr>
<th>USE</th>
<th>AWPA Standard(s)</th>
<th>ACZA</th>
<th>CCA\textsuperscript{b}</th>
<th>Creosote</th>
<th>Pentachlorophenol</th>
<th>Copper Naphthenate</th>
</tr>
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<tr>
<td>LUMBER, TIMBER &amp; PLYWOOD</td>
<td></td>
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<tr>
<td>Above ground use</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber, Timber</td>
<td>C2</td>
<td>.25</td>
<td>.25</td>
<td>8</td>
<td>.40</td>
<td>.04</td>
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<td>Plywood</td>
<td>C9</td>
<td>.25</td>
<td>.25</td>
<td>8</td>
<td>.40</td>
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<tr>
<td>Ground contact or fresh water use</td>
<td></td>
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<td>Lumber, Timber</td>
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<td>.40</td>
<td>.40</td>
<td>10</td>
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<td>.04</td>
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<td>10</td>
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</tr>
<tr>
<td>Marine Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of water not subject to splash</td>
<td>C2/C18</td>
<td>.40</td>
<td>.40</td>
<td>10</td>
<td>.50</td>
<td>NL</td>
</tr>
<tr>
<td>Out of water and subject to splash</td>
<td>C2/C18</td>
<td>.60</td>
<td>.60</td>
<td>12</td>
<td>.60</td>
<td>NL</td>
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<tr>
<td>In salt water</td>
<td></td>
<td></td>
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<tr>
<td>Single treatment</td>
<td>C2/C18</td>
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<td>2.50</td>
<td>25</td>
<td>NR</td>
<td>NL</td>
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<tr>
<td>Dual treatment</td>
<td>C2/C18</td>
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<td>1.50</td>
<td>20</td>
<td>NR</td>
<td>NL</td>
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<td>Bridges-important structural members</td>
<td>C2/C14</td>
<td>.60</td>
<td>.60</td>
<td>12</td>
<td>.60</td>
<td>.075</td>
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<td>Permanent Wood Foundations: Kilndried after treatment</td>
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<tr>
<td>Lumber</td>
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<td>.60</td>
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<td>NR</td>
<td>NL</td>
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<tr>
<td>GLUED LAMINATED BEAMS (treatment after lamination)</td>
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<td>Above ground use</td>
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<td>NL</td>
<td>NL</td>
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<tr>
<td>Ground or fresh water contact</td>
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<td>NL</td>
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<td>POLES</td>
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<td>Agricultural-Round\textsuperscript{*}</td>
<td>C16</td>
<td>.60</td>
<td>.60</td>
<td>7.5-16</td>
<td>.38-60</td>
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</tr>
<tr>
<td>Agriculture-Sawn\textsuperscript{*}</td>
<td>C16</td>
<td>.60</td>
<td>.60</td>
<td>12</td>
<td>.60</td>
<td>.075</td>
</tr>
<tr>
<td>Construction-Round\textsuperscript{*}</td>
<td>C23</td>
<td>.60</td>
<td>.60</td>
<td>12</td>
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<td>NL</td>
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<tr>
<td>Construction-Sawn\textsuperscript{*}</td>
<td>C24</td>
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<td>.80</td>
<td>12</td>
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<td>NL</td>
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<tr>
<td>Utility-electric/telephone/lighting</td>
<td>C4</td>
<td>.60</td>
<td>.60</td>
<td>9-16</td>
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<td>.075-.150</td>
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<td>PILING</td>
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<tr>
<td>Foundation use - Round</td>
<td>C3</td>
<td>.80-1.00</td>
<td>.80-1.00</td>
<td>12-17</td>
<td>.60-.85</td>
<td>NL</td>
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<tr>
<td>Foundation use - Sawn</td>
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<td>NR</td>
<td>12</td>
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<td>.80-1.00</td>
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<td>Salt water use</td>
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<td></td>
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<tr>
<td>Moderate borer hazard\textsuperscript{d}</td>
<td>C18</td>
<td>NR</td>
<td>NR</td>
<td>20\textsuperscript{a}</td>
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<tr>
<td>Severe borer hazard\textsuperscript{d}</td>
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<tr>
<td>Dual treatment\textsuperscript{1A}</td>
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<td>1.0</td>
<td>1.0</td>
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<td>POSTS</td>
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<tr>
<td>Construction-Round</td>
<td>C5</td>
<td>.40</td>
<td>.40</td>
<td>6</td>
<td>.30</td>
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<td>Construction-Sawn</td>
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<td>.40</td>
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<td>C16</td>
<td>.60</td>
<td>.60</td>
<td>7.5-16</td>
<td>.38-.60</td>
<td>.055</td>
</tr>
<tr>
<td>Agricultural-Sawn</td>
<td>C16</td>
<td>.60</td>
<td>.60</td>
<td>10-12</td>
<td>.50-.60</td>
<td>.060</td>
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<tr>
<td>Guard Rail (including blocks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Round</td>
<td>C14</td>
<td>.50</td>
<td>.50</td>
<td>10</td>
<td>.50</td>
<td>.069</td>
</tr>
<tr>
<td>Sawn four sides</td>
<td>C14</td>
<td>.60</td>
<td>.60</td>
<td>12</td>
<td>.60</td>
<td>.072</td>
</tr>
</tbody>
</table>

\textsuperscript{a} See AWPA Standard(s) column for retentions for different products and preservatives based on AWPA standards.
\textsuperscript{b} Retention Assay of Treated Wood -- lbs/cu.ft.
American Wood Preservers Association specifications are the principal wood treating standards used throughout the United States. By assay procedure—pounds per cubic foot. Retention varies with species. See referenced AWPA Standard.

It is generally recognized that Douglas fir is extremely difficult to treat with CCA to penetration and retention requirements, even when incised. Coastal Douglas fir, from a few geographical areas, has been found suitable for treatment with CCA. Douglas fir treated with CCA is not recommended for Permanent Wood Foundations.

Not listed in AWPA standards.

Building Poles—special uses—to be used where replacement of poles would be difficult and where exceptional durability is required. Involves requirement for very deep penetration, i.e. 1/2 the radius to 2 1/2 inches.

On the Pacific Coast north of San Francisco where Teredo attack is expected and where Limnoria tripunctata is not expected, creosote or creosote-coal tar solutions will provide adequate protection. On the Pacific Coast, San Francisco and south where Teredo and Limnoria tripunctata are expected and where pholad attack is not expected, either dual treatment, or high retentions of ACZA or CCA, will provide adequate protection. In tropical waters where Limnoria tripunctata and wood-boring pholad attack are expected, such as Hawaii, the Caribbean, or off the Mexican coastline, dual treatment, provides the maximum protection know at present. On the Eastern seaboard the line between Moderate and Severe Borer Hazard is usually drawn at Norfolk, Virginia.

Coastal salt water environments. Creosote for such use shall conform to AWPA Standard P-13.

Dual Treatment for marine use involves two separate preservatives: a waterborne preservative followed by a creosote treatment.

State specifications may differ, allowing 0.40 retention.

Note: Needs updating based on 1993 AWPA Standards when available.
Table 7-3. Brands used on wood products treated in accordance with AWPA standards.

### TYPICAL BRAND AND KEY

<table>
<thead>
<tr>
<th>Brand</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>ABCO</td>
<td>Supplier's Brand</td>
</tr>
<tr>
<td>D</td>
<td>Plant Designation</td>
</tr>
<tr>
<td>60</td>
<td>Year of Treatment</td>
</tr>
<tr>
<td>SPC</td>
<td>Species of Timber and Preservative Treatment</td>
</tr>
<tr>
<td>7-30</td>
<td>Class and Length</td>
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### SPECIES

<table>
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<th>Species</th>
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<tr>
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<tr>
<td>BE</td>
<td>Beech</td>
</tr>
<tr>
<td>BI</td>
<td>Birches</td>
</tr>
<tr>
<td>BW</td>
<td>Black Walnut</td>
</tr>
<tr>
<td>DF</td>
<td>Douglas Fir</td>
</tr>
<tr>
<td>ED</td>
<td>Northern White (Eastern) Cedar</td>
</tr>
<tr>
<td>ES</td>
<td>Engelmann Spruce</td>
</tr>
<tr>
<td>GU</td>
<td>Gum</td>
</tr>
<tr>
<td>HI</td>
<td>Hickories</td>
</tr>
<tr>
<td>JP</td>
<td>Jack Pine</td>
</tr>
<tr>
<td>LO</td>
<td>Locust</td>
</tr>
<tr>
<td>LP</td>
<td>Lodgepole Pine</td>
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<td>MA</td>
<td>Maples</td>
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<td>NP</td>
<td>Red Pine</td>
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<td>OA</td>
<td>Oaks</td>
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<td>RW</td>
<td>Redwood</td>
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<td>SP</td>
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</tr>
<tr>
<td>SS</td>
<td>Sitka Spruce</td>
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<td>WC</td>
<td>Western Red Cedar</td>
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<tr>
<td>WF</td>
<td>Western Firs</td>
</tr>
<tr>
<td>WH</td>
<td>Western Hemlock</td>
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<td>Ponderosa Pine</td>
</tr>
<tr>
<td>WS</td>
<td>White Spruce</td>
</tr>
<tr>
<td>YC</td>
<td>Alaska Yellow Cedar</td>
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</table>

### PRESERVATIVES

#### Organic Preservatives

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<tr>
<th>Letter</th>
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<tr>
<td>B</td>
<td>Copper napthenate in creosote</td>
</tr>
<tr>
<td>C</td>
<td>Creosote</td>
</tr>
<tr>
<td>CM</td>
<td>Creosote for marine use</td>
</tr>
<tr>
<td>PB</td>
<td>Pentachlorophenol in Volatile Petroleum Solvent (LPG)</td>
</tr>
<tr>
<td>PC</td>
<td>Pentachlorophenol in Light Hydrocarbon Solvent</td>
</tr>
<tr>
<td>PD</td>
<td>Pentachlorophenol in Chlorinated Hydrocarbon Solvent</td>
</tr>
<tr>
<td>N</td>
<td>Copper napthenate in petroleum</td>
</tr>
<tr>
<td>PA</td>
<td>Pentachlorophenol in petroleum</td>
</tr>
<tr>
<td>TA</td>
<td>80/20 Creosote-Coal Tar Solution</td>
</tr>
<tr>
<td>TB</td>
<td>70/30 Creosote-Coal Tar Solution</td>
</tr>
<tr>
<td>TC</td>
<td>60/40 Creosote-Coal Tar Solution</td>
</tr>
<tr>
<td>TD</td>
<td>50/50 Creosote-Coal Tar Solution</td>
</tr>
<tr>
<td>TM</td>
<td>Creosote-Coal Tar Solution for Marine Use</td>
</tr>
<tr>
<td>SA</td>
<td>55/25 Creosote Petroleum Solution</td>
</tr>
<tr>
<td>SB</td>
<td>70/30 Creosote-Petroleum Solution</td>
</tr>
<tr>
<td>SC</td>
<td>60/40 Creosote-Petroleum Solution</td>
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<tr>
<td>SD</td>
<td>50/50 Creosote-Petroleum Solution</td>
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#### Inorganic Preservatives

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<tr>
<td>SA</td>
<td>Acid Copper Chromate (ACC)</td>
</tr>
<tr>
<td>SB</td>
<td>Ammoniacal Copper Arsenate (ACA)</td>
</tr>
<tr>
<td>SC</td>
<td>Chromated Copper Arsenate (CCA-Type A)</td>
</tr>
<tr>
<td>SE</td>
<td>Chromated Zinc Chloride (CZC)</td>
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<tr>
<td>SF</td>
<td>Copperized Chromated Zinc (CuCZA)</td>
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<td>SH</td>
<td>Fluor Chrome Arsenate Phenol, Type A (FCAP-Type A)</td>
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<td>SI</td>
<td>Fluor Chrome Arsenate Phenol, Type B (FCAP-Type B)</td>
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<td>SJ</td>
<td>Chromated Copper Arsenate (CCA-Type B)</td>
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<td>SK</td>
<td>Chromated Copper Arsenate (CCA-Type C)</td>
</tr>
<tr>
<td>SZ</td>
<td>Ammoniacal Copper Zinc Arsenate (ACZA)</td>
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</table>

Note: Double treatment, salt and creosote, letter "C" to be placed ahead of salt symbol. Where organic preservative is other than creosote, use the symbol for that preservative instead of the symbol for creosote.

Note: Needs updating based on 1993 AWPA Standards when available.
Chapter 8. Post Construction Inspections and Remedial Treatments

Because biological deterioration can occur in treated wood, it is important, particularly in large commercial applications to develop a preventative maintenance program. The program should provide for the inspection of the wood product for biological damage and provide for remedial treatment where appropriate. A determination of the structural reliability of the product in the damaged condition should also be made. In this section, typical deterioration problems will be discussed, inspection procedures and equipment outlined, and possible remedial treatments presented.

To understand where serious biological deterioration of treated wood products can occur, the manner in which treated wood products are protected should be reviewed. The preservative is forced from the outside in. The penetration which is achieved is dependent on a number of factors some of which cannot be controlled. Very seldom are wood products completely penetrated, with the exception of sapwood lumber under about two inches in thickness and from easily treated species. Thus, there is a shell of treated or protected wood and a core of untreated wood. If the shell becomes broken by seasoning (drying) checks, machining such as sawing or boring, or by mechanical damage, the core is subject to biological deterioration.

If the retention of the preservative is not adequate, the treated wood may also begin to deteriorate. A poorly formulated preservative or selection of the wrong preservative for a particular application may also result in deterioration. In these cases, deterioration begins on the outside of the product.

Typical Problems

Lumber and Plywood

Lumber and plywood which has been properly treated for the intended end use generally does not present a
serious deterioration problem. As mentioned, the thickness dimension of standard lumber allows good penetration and as such good performance. Most treated lumber and plywood is also used in above ground applications such as decks and sill plates, where the hazard level is not as high as when the wood product is exposed to soil or marine borers.

Care should be taken to avoid exposure of southern pine lumber and timber heartwood faces to marine borers, because of the generally poor preservative penetration.

**Posts**

Posts, whether round or square, are larger in dimension than standard lumber. They are also often in soil contact which provides optimum conditions for wood decay and termites. Round posts with a high percentage of sapwood should treat easily and give good service. Square or sawn posts with a large percentage of heartwood will be difficult to treat and are likely not to perform as well.

Peeler cores are what remains after the outer portion of a larger log is removed for veneer. They are no longer included in the AWPA standards for posts. However, they may still be available, particularly in the form of landscape timbers. Whether round or with two or more flat faces, these cores are mostly heartwood and, therefore, are usually poorly treated.

**Poles**

Poles are like large posts and they are usually round, but sometimes sawn to rectangular dimensions. They are typically damaged either by internal decay and insect attack or by external surface decay, usually at or below the groundline. Internal decay can occur as a result of fungus infestations that start in large poles which are air dried in yards before treatment. Large Douglas-fir poles are often air dried for up to two years prior to treatment. Decay fungi may become established in the poles and if the poles are not heat sterilized during preservative treatment, the fungi will continue to grow and rot the center of the pole after it has been put in service.
If the outer protective shell of a pole is broken after treatment, wood-decay fungi and insects such as termites and carpenter ants can gain entry and deteriorate the untreated portion of the pole. The shell may be broken by mechanical damage during handling, deep season checks (Fig. 8-1) developing after treatment, woodpecker damage or other actions.

Due to the constant presence of moisture, internal decay is most common at the groundline. Internal decay will also develop in pole tops cut or bored in the field when supplementary treatment is neglected. Butt ends on poles should NOT BE cut when they are set in or on the ground. This exposes a central core of untreated wood at the bottom of the pole and provides easy access for termites and decay fungi.

External decay in poles is most common at or below the groundline (Fig. 8-2). Each occurrence of external decay reflects improper application of the preservative or use of treating solutions with poor preservative properties. As poles age, external decay may develop as the effectiveness of the treatment begins to decline.

Termites and carpenter ants can infest the internal untreated portion of poles. Therefore, little external visual evidence of their presence is apparent. Some termite galleries may be present if the insects are trying to bridge over treated wood. In addition, if a carpenter ant infestation has occurred, scattered bits of very fibrous and sawdust-like frass may be present in the area. Since a break in the protective shell must occur before these insects can reach and infest the untreated wood, decay is also likely to be present.

Damage from vertebrate organisms, such as woodpeckers, is usually apparent. Binoculars should be used when inspecting large poles. If the damage is fresh, broken pieces of wood from the excavated hole should be present on the ground. Decay will often be associated with older damage (Fig. 8-3).

**Piles**
In many respects, piles are much like poles and those portions of piles exposed above groundline to the atmosphere or fresh water are subject to the same problems as poles. However, piling are subject to additional problems.

Because it is difficult to drive piles to a uniform depth, it is common practice to cut the top end off. This practice exposes untreated wood and a hollow core due to decay often results (Fig. 8-4).

Marine borers are one of the worst enemies of piling driven in salt or brackish water. *Limnoria* and *Sphaeroma* often attack piling at the intertidal zone and their presence is obvious (Fig. 3-22, 3-23, 3-24).

Shipworms attack it below the tidal zone and they are not conspicuous.

**Timbers**

Timbers are sawn members five or more nominal inches in their least dimension. They are also called beams, stringers, posts, or girders. Because timbers are sawed products, the larger dimensioned ones, at least, usually do not contain a continuous sapwood band which is easily treated. Southern pine may be an exception in that it contains a higher percentage of sapwood than any other common commercial species, but large trees which are required to produce large timbers will have a substantial amount of heartwood. Small timbers cut from the core of medium sized trees will also have a substantial component of heartwood. Therefore, incising of most large timbers should help improve the preservative treatment.

Many timbers will contain a pith center which results in a deep radial seasoning check from the surface to the center (Fig. 8-5). This check often penetrates past the treated zone and can permit entry of decay and insects if it occurs after treatment. For this reason, it is highly preferable that timbers be dried prior to treatment to a lower moisture content than they are likely to reach when in service.

Heavy timber construction often requires substantial shaping, boring
and other machining at the erection site. This machining can break the protective shell. The shell can also be broken by nailing which often occurs in timber construction. As a result, interior decay can become a problem. Figure 8-6 shows the likely locations where decay might occur.

**Inspections**

Post construction inspections are carried out to determine if any biological damage has occurred and if remedial treatment or replacement should be considered. Obviously, if some damage has occurred, the structural integrity must be carefully considered. Advanced biological damage is sometimes obvious. Unfortunately, the damage often occurs in the interior of large timber products at or below groundline or under water and is difficult to detect. Furthermore, even in the early stages when decay can easily go undetected, serious loss of strength can occur. Therefore, it is probably best to have someone with technical training, experience and the proper equipment carry out any inspection programs of significant structures and of all structures where human life could be endangered.

This section will overview inspection procedures for poles, piles and timbers. Because treated structures are intended to endure for many decades, careful records of each inspection and recommended actions should be made. Photographs can be particularly useful. These materials are useful in documenting the rate of deterioration over time and providing a valuable training aid for those who follow.

**Visual**

A visual inspection represents the very basic level and in many cases it can yield valuable information. In a visual inspection, machined, damaged areas, and checks should be carefully examined. The size and location of seasoning checks should be noted. In general, the wider the check, the deeper it penetrates and the more likely untreated wood is exposed.

External evidence of advanced decay
(Fig. 8-7) includes features such as fruiting bodies, abnormal surface shrinkage such as localized depressions or sunken faces on wood surfaces, loose joints, abnormal deflections, crushing, cracking, and insect activity. Carpenter ants and termites prefer damp wood.

Other visual evidence such as water marks from periodic wetting; rust stains, especially if from wood-penetrating fasteners or hardware; and plant growth such as moss or other vegetation, especially in cracks or crevices indicates that existing conditions are, or have been, conducive to decay.

Remember, only decay in the advanced stages is readily apparent. Incipient decay can extend four feet or more above internal rotten areas in Douglas-fir poles. The presence of fungi in wood where decay has not progressed appreciably can be detected only by culturing or microscopic examination of the wood.

Surface decay is detected by the "pick test" or probing. The pick test (Fig. 4-1) will detect infected wood where strength loss of at least 10% has occurred. Scraping using a shovel or triangular blade is often used to detect below ground decay on the pole surface. The decayed wood is simply scraped or cut away until sound wood is evident. In poles, surface decay usually occurs at or below the groundline so digging is generally necessary to detect it.

**Sounding**

Sounding is probably the most common method which can be used by experienced individuals when inspecting large wood members for internal voids. The wood member is firmly hit with about a one-pound hammer. A crisp sound usually indicates soundness. A dull thud indicates wet and possible rotten wood and a "drum" sound indicates a hollow or void area. The sound produced varies considerably, but experience will eventually lead to distinguishing between sound wood and the various defects. Naturally, to develop experience, it helps to sound
a member and then bore or cut it apart to determine which defects are actually present.

**Increment Boring**

Boring is generally done where decay or insect attack is suspected and it needs to be confirmed. Increment borers are most commonly used (Fig. 8-8). The core can be closely examined at the site and also saved for later culturing or microscopic examination.

Wood members that sound suspicious should be bored near any deep checks which occur. Poles should generally be bored at one foot below the groundline. If rot is detected, borings should be made at three or four more points around the circumference to determine its extent. The shell thickness, depth of preservative treatment, and pole circumference are determined. Minimum circumference tables can be used to determine if the pole should be replaced, reinforced, field treated or scheduled for reinspection.

When boring holes above ground, the tool should be oriented slightly upward. This prevents water from accumulating in the hole afterwards. At groundline, a 45 degree angle downward is generally used. All openings made during inspection should be treated with the appropriate preservative as registered by EPA. The holes should be plugged with preservative treated dowels. These dowels can loosen and work out of the holes so treatment of the hole itself is important. Protective goggles and other safety equipment as appropriate should be worn as preservative can squirt out of the hole as the dowel is being driven or as the hammer strikes the treated wood.

**Moisture Meters**

Resistance type moisture meters (Fig.8-9) can detect the moisture content of wood to a depth of about 2 1/2 inches. Because the high moisture content of decaying wood--above 25 percent--causes a steeper than normal moisture gradient, the meter can be useful for determining the extent of decay in poles and other timbers. Meter
readings above 20 percent and steep moisture gradients indicate decayed wood in Douglas-fir poles. Moisture readings below 20 percent indicate the absence of active decay to the depth of the electrode.

The batteries and calibration of the meter should be checked frequently. For the meter to read from the tips of the electrodes, the coating on the electrode shanks must be intact. When necessary, meter adjustments for ambient temperatures and wood species must be made. Oilborne preservatives normally do not affect meter readings, but waterborne preservatives may cause erroneously high readings, particularly at moisture contents above 25 percent. Salt absorbed from sea water will result in abnormally high readings. Comparative tests for treated and untreated wood should be conducted to determine the effect of preservatives on the meter reading.

Sonic Testing

Some sonic testing equipment is currently available and other nondestructive equipment to estimate residual strength in standing poles is being developed. This technical equipment is generally employed only by technical experts specializing in its use.

Culturing and Identification

It is important that the presence of decay fungi be detected and treated before visual damage is present if the strength properties of the wood are to be maintained. Culturing is the most reliable means for detecting early stages of decay. It is done by collecting cores in the field. Each core is placed in a plastic straw, labeled and the ends of the straw stapled shut. The cores are brought to the laboratory and culturing begins within 24 hours. The cores are observed frequently for fungal growth. Microscopic examinations are made at the end of three to four weeks to determine if the fungi are capable of causing decay.

It is usually beneficial to identify insects if an infestation has occurred. If field identification is not possible,
either the insects, their frass or a portion of the wood with typical damage should be collected.

Marine borers are unique to piling and deserve special consideration. Their characteristics are discussed in Chapter 3. The presence of water serves as a physical barrier to inspection. In some cases, borers are present in a salt water wedge located under incoming fresh water.

Limnoria can be detected during periods of low tide and inspectors normally wade out to check piling in shallow water and use small boats or floats in deeper water. Damage signs include the hourglass shape of piles in the tidal zone, numerous bore holes in the wood and a general softening in the attacked areas. Holes made by hooks and tongs become oval-shaped as attack progresses, ends of bracing are hollowed out, and bolts and bracing are loosened. Limnoria also attack wood inside of holes, cracks, or gouges. Therefore, a flashlight or head lamp is useful. A scraper or probe is used to remove fouling organisms and to check inside holes and between adjoining members, etc.

Shipworms are much more difficult to detect since they bore tiny holes into the surface of the wood and concentrate their attack beneath the surface (Fig. 3-22). Observant divers in clear water may be able to see the nearly transparent siphons or the tiny pallets protruding from the pile surface, if the shipworms are alive. The extent of internal damage cannot be assessed visually.

Sounding of piling by divers can provide some information about the degree and location of borer damage. However, the procedure is highly subjective. Increment boring can also be used. However with poor underwater visibility, fouling, etc., it is difficult to determine where to bore and the odds of hitting a destroyed area are reduced due to the size of the bore. The bore holes must be plugged.

The potential damage from marine borers can be assessed by immersing "sacrificial" untreated wood samples
at the site in question. The simplest way to do this is to band or nail (use galvanized nails) lengths of untreated 2x4's, posts or similarly sized wood pieces to vertical posts or piling already installed in the area of interest (Fig. 8-10). These samples are removed at one month intervals and examined for damage. For shipworms, the blocks must be split open to accurately detect attack. Where freshwater flow is present, some blocks should be submerged and held in the salt water wedge located under the freshwater.

A sonic testing method which will locate and quantitatively assess marine borer and other internal damage for in-place timber piles has been developed. Liquid preservatives with an oil base such as pentachlorophenol or copper naphthenate are sometimes used in remedial treatment. At the time of treatment the wood should be as dry as possible. The surface is completely flooded and allowed to absorb as much preservative as possible. This is a superficial treatment and its effectiveness will be limited accordingly. The newer water soluble borate compounds diffuse into wet wood. They are being used where the treated wood is not subject to liquid water.

Liquid preservatives are also used for the treatment of internal voids. They are most successful on cedar and other woods that develop well defined rot pockets and the transition from

Remedial Treatments

The remedial preservative treatment of wood in existing structures is a common practice. In many cases only a small percentage of the wood members need treatment. The replacement value of many treated wood structures or even individual members is substantial and replacement will often result in interrupted service. Contractors who specialize in inspection work and remedial treatment are available.

Liquid Preservatives

Vertical posts or similarly sized wood pieces to vertical posts or piling already installed in the area of interest.
rotten to sound wood is abrupt; they are least effective in Douglas-fir with poorly defined rot pockets. To arrest internal decay, water-soluble chemicals or arsenicals and fluorides are forced into the voids and diffuse through the wet wood. Application of liquid preservatives without pressure can also be effective but penetration is primarily along the grain of the wood. Ants in pole voids can be controlled by injection with volatile liquids combined with creosote or pentachlorophenol.

Bandage or Groundline Treatments

Bandage or groundline treatments have long been used to control surface decay particularly in the outer shell of poles. Preservatives used include water soluble arsenicals and fluorides, alone or mixed with creosote, pentachlorophenol or dinitrophenol and potassium dichromate. These preservatives are brushed on or injected 2 1/2 inches into the wood with a hollow needle. The outer wrap, often black polyethylene film with a paper back, should be durable and extend from slightly above to 18 inches or more below the groundline. The layers are overlapped and the wrap is fastened tightly to the pole in order to shed water. These treatments contain restricted-use preservatives and, thus, are available only to certified applicators.

Fumigants

Fumigants can control internal decay for at least nine years in pressure treated Douglas-fir transmission poles and bulkhead piles. For piling they are applied near the top which is then covered with a cap of coal-tar cement and fiberglass mesh. Fumigants have also been effectively used in horizontal members, particularly Douglas-fir. As a result, the use of fumigants to treat Douglas-fir poles, piles and solid or laminated timbers with internal decay is common technology. However, fumigation treatments are not as long-lasting in southern pine poles and timbers as they are in Douglas-fir. The fumigants sodium N-methyl dithiocarbamate (Vapam), methylisothiocyanate (Vorlex), and trichloronitromethane
(chloropicrin) are currently registered with the U.S. Environmental Protection Agency for application to wood. They are normally applied by specialized personnel and only in exterior wood members. Re-treating of wood structures in nine to ten years is necessary because fumigants dissipate.

The control of insects by wood fumigants is uncertain. Vapam may control subterranean termites, but it has been noted that carpenter ants can reinfest wood shortly after fumigant application, perhaps because of the low concentration of the fumigant.

Piling

Piling again presents a special situation. Because piling are usually "cut-off" after driving, top decay results. This cut-off area should be treated (flooded) with hot creosote (150°F to 200°F), pentachlorophenol in diesel oil, or copper naphthenate. None of these preservatives penetrate the wood deeply. A water-shedding cap is then applied.

Materials used for capping piles include coal tar-roofing cement, galvanized metal, heavy roofing felt, heavy plastic, Noah's pitch, hot asphalt, and preservative-treated plywood. One effective capping device is coal tar-roofing cement held in place by a fiberglass mesh cloth. To cap a pile by this method, trowel a thick layer (1/2 inch) of cement on top, place two layers of fiberglass mesh on the cement, nail the mesh to the pile, and finish with an additional coat of cement. This patch remains flexible and resists water penetration into the untreated wood below.

Galvanized metal, roofing felts and plastic sheets make effective caps when applied in conjunction with chemical treatments. Without a preservative, condensation or leaks can create ideal conditions for decay beneath the cap. The material should be cut with at least a 2-inch overlap to permit the edges to be folded down and fastened to the pile sides with galvanized roofing nails or bands.

Preservative-treated plywood makes a simple and effective capping device.
Two narrow strips of treated wood are nailed to the pile top, and the plywood cap, cut to a slightly larger diameter than the pile, is attached to the strips. The strips permit air to circulate beneath the cap and, thus, keep the wood dry.

Because pile caps on working piers are often damaged or pulled off by hawsers, it is helpful to treat the pile top with a water-soluble preservative before cap installation. These treatments remain inactive as long as the cap remains effective, but they are activated whenever water penetrates.

Figure 8-1. If deep seasoning checks occur in poles after preservative treatment, the interior is subject to decay. This roofing hatchet is buried about 5 inches in the pole and it is still not at the bottom of the check.

Figure 8-2. External or surface decay as seen in this pole after removal from service is most common at the groundline. Figure 8-3. Serious internal decay has occurred in this pole because fungi gained access from the woodpecker damage and a small bore hole (upper left).

Figure 8-4. Because the end of this pile was cut off after driving, untreated wood was exposed and decay resulted.

Figure 8-5. This timber contains a pith center which has resulted in a deep radial seasoning check.

Figure 8-6. Schematic drawing of typical wood bridge construction showing likely locations where decay could develop.

Figure 8-7. Evidence of advanced decay.

Figure 8-8. Increment borer consisting of three parts, extractor, hollow bit, and case that also serves as a handle for turning coring bit into and out of wood members.

Figure 8-9. Moisture meter suitable for inspection work.
Figure 8-10. Untreated and lightly treated 2x4's fastened to an existing marine piling provide a simple means for determining which marine organisms are present.

Chapter 9. Specific Applications for Treated Wood

There are numerous specific applications for treated wood products, some of which are discussed here. Since many of the basic principles and concepts of deterioration and preservatives are discussed in earlier sections, the reader is encouraged to consult those sections as well.

Decks

Decks have been discussed in a number of different locations throughout this publication. There are several aspects which should be considered. First, select material of the grade which will provide the aesthetic characteristics needed.

Lower grades of lumber will have numerous knots and irregular edges where the bark has been removed.

Decks present a particularly severe exposure for wood and finishes and therefore require special consideration. Most of the wood members to be finished are in a horizontal or flat position. These horizontal surfaces are often exposed to the direct rays of the sun and tend to collect moisture, so the weathering process is greatly accelerated. As wetting and drying occurs, swelling and shrinking leads to checks which tend to enlarge rapidly into cracks and, along with the end-grain surfaces, tend to retain moisture. The conditions for decay and insect attack due to the presence of moisture are thereby greatly improved. Any film-forming finish (paint, solid color stain) is subjected to excessive stress because of the continuous shrinking and swelling of the wood that results from changes in the moisture content. Furthermore, the finish is subjected to abrasive wear, particularly in high-traffic areas. For these reasons, film-forming finishes should never be used on
FIG. 8-6

INCIPIENT DECEAY
INTERMEDIATE DECEAY
ADVANCED DECEAY
TREATED WOOD

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DECK NAIL

SAP WOOD EDGE

CHECK

BOXED-HEART STRINGER

STRINGER

DRIFT PIN

CAP

PILE

PILE CROSS X
Figure 8-7. Evidence of advanced decay.
Figure 8-8. Increment borer consisting of three parts, extractor, hollow bit, and case that also serves as a handle for turning coring bit into and out of wood members.
decks.

As a result of these severe conditions, lumber that has been pressure-treated with the waterborne preservatives, or naturally durable wood such as redwood, are generally used, at least on decks. All posts or other members in soil contact should be pressure treated with the appropriate preservative and recommended for soil contact. In purchasing preservative treated wood products, be sure to look for the quality mark or tag as discussed in Chapter 7. These materials are left to weather naturally or finished in a number of ways. Some waterborne-preservative-treated wood already contains a water-repellent preservative and a coloring material, usually brown. Water-repellent preservatives help reduce checking and cracking of the wood.

Because most lumber treated with a waterborne preservative is shipped green, about three to five percent shrinkage as it dries in above ground applications can be expected. Spacings between deck boards or other joints must be made accordingly. For example a 1/4 inch space between two six inch deck boards will widen to about one-half inch as the lumber dries. On the other hand, if the lumber is thoroughly dried before installation, it will swell up in wet weather. Buckling may result. As lumber dries, it also tends to cup, bow and twist if left unrestrained.

Therefore, the material should be securely fastened in place with spiral or ring-shanked nails. Decking screws may also be used. Where moisture is present and ferrous fasteners are used in conjunction with waterborne-preservative-treated wood, corrosion will occur. For decks, fasteners well treated by the hot-dip galvanizing process are suggested. Electroplated nails will likely corrode and should not be used. For additional protection and to prevent any rust stains from developing, stainless steel nails are available and preferred.

Because of the severe conditions for fully exposed decks a water-repellent preservative or a semi-transparent penetrating oil-based stain may provide the best finishing solution even on wood that has been pressure-
treated with preservatives. Special formulations specifically made for decks are available. These penetrating finishes should be applied as soon as the wood surface is dry. The deck finishes, at least the water-repellent preservatives, may be somewhat shorter lived than paint, but they are more easily renewed. These penetrating finishes should be renewed annually; spring is usually the best time. Light-colored penetrating stains will last longer than dark ones on flat surfaces subject to traffic since they show the least contrast in grain color as wear occurs. They will need refinishing every 1 to 2 years. To refinish, a simple cleaning with a bristle brush is usually adequate before application of the water-repellent or penetrating finish. Paint and solid-color stains, particularly in these applications, are likely to peel and should not be used. Laborious scraping and sanding before refinishing will usually be required. Thus, paint and solid-color stains are not good finishes for fully exposed decks. If they are used, the wood must be dry all the way through before application. A more thorough discussion on deck design, construction, and maintenance is available.21

Picnic Tables and Outdoor Furniture

Picnic tables and outdoor furniture are commonly constructed from wood treated with waterborne preservatives or from naturally durable wood. Recommendations for selecting material and fastening are the same as given for decks. Be sure to read the appropriate Consumer Information Sheets given in Chapter 11 where some concern is expressed if food will be in contact with a treated wood surface. It is recommended that wood treated with the waterborne preservatives CCA or ACZA not be used for cutting boards or countertops. In these applications, food is in intimate contact with the surface. Picnic tables are primarily used for serving prepared food. To avoid contact with treated wood, naturally durable material could be used for the tops and seats and treated wood for the legs and cleats. If treated wood has been used for the
tops and seats, a sealant of 20 percent varnish in mineral spirits will reduce exposure to the preservative. Additional information concerning the suitability of CCA is presented in Chapter 11.

**Landscape Timbers**

"Landscape timbers" can take various forms. One of the most common forms is a piece about 3 1/2 inches wide with two flat faces and two round faces. This product is generally intended for light residential uses such as raised flower beds or making borders, low retaining walls, etc. These pieces are generally produced from small diameter trees or from the core left when a larger log is peeled for plywood. If the pieces contain a large percentage of heartwood, they are probably not well treated. There are no AWPA standards for treatment of landscape timbers and many treaters expressly disclaim adequacy of treatment. Thus, if long-term performance is important or in critical structural applications, it would be better to select material specifically treated to AWPA Standard C2 (Lumber and Timbers).

Heavy timbers and some specialty treated products may also be used for landscape purposes. When using these larger members for more critical applications such as major retaining walls, a procurement and inspection system as discussed in Chapter 7 should be followed.

**Gardening Applications**

Lumber treated with waterborne preservatives has been used for any number of gardening and agricultural applications. Some of these uses include grape or tomato stakes, vineyard supports, orchard props, mushroom trays, trellises, raised vegetable beds, retaining walls, and compost beds. Unlike the oil-based pentachlorophenol and creosote, the material is virtually nontoxic to plants which come in contact with it. No particular problems have been reported and one recent study has shown that arsenic levels in soil samples taken near CCA treated wood are within the normal range for all soils. Chapter 11 presents
additional information.

**Playgrounds**

Wood is commonly used in the construction of playground equipment. When this equipment is exposed to the weather, it needs to be protected from decay and insect attack.

Naturally durable woods, as well as materials treated with waterborne preservatives, are commonly used.

AWPA Standard C17-92 says playground equipment treated with CCA must be "free of visible surface deposits". In addition, AWPA Standard C1-92 says all material treated "with waterborne preservative shall be supplied free of visible surface deposits." The State of California has ordered that state funds cannot be used to purchase new wooden playground equipment treated with arsenic, penta or creosote unless the equipment is free of visible surface residues. The law also prevents state funds from being spent on maintenance of wooden equipment treated with these preservatives unless a sealant (see section on picnic tables) is applied to prevent children from contacting the chemical. At least one material has been developed and accepted by that state to encapsulate the preservative treated wood.23

**Marine Framing and Seawalls**

Treated lumber and timbers are often used for marine framing and seawalls. Both creosoted and CCA-treated material or a combination of the two can be used. In fresh water applications, material treated with 0.4 pounds per cubic foot of CCA or that which is intended for soil contact can be used. In salt water applications, a retention of 2.50 pounds per cubic foot of CCA is required.

Lumber and timber of those pine species which have no heartwood penetration requirement, such as southern pine, and which are treated with waterborne preservative, should be free of exposed heartwood on the sawn faces. Such material is available commercially under the ALSC-approved designation "Marine Framing Grade". Cutting of material at the job
site should be minimized because of possible exposure of poorly treated wood to marine borers. Where cutting or other machining is necessary, exposed surfaces should be flooded with preservative, such as copper naphthenate.

**Permanent Wood Foundations**

Southern pine lumber and plywood specially treated with CCA and Douglas-fir treated with ACZA can be used to build full basements, crawl space foundations, or an under floor plenum system. Permanent Wood Foundation (PWF) is the correct industry terminology. These foundations can be installed during freezing weather, thus making winter construction feasible. PWF is accepted by the major model building codes, federal agencies, and by lending, home warranty and fire insurance institutions.

Because permanent wood foundations are a critical application for wood, a special AWPA Standard C22, has been developed. The wood is treated with 0.6 pounds per cubic foot of preservative as compared to 0.4 pounds for standard lumber used in soil contact. The FDN in the quality mark, which is an abbreviation for foundation, indicates that the material is suitable for that application.

For any PWF material which is applied below grade, stainless steel fasteners should be used. Hot dipped galvanized fasteners may be used above grade providing excessive moisture is not present. Standard ferrous fasteners will corrode.

**Treated Wood Shakes or Shingles**

Wooden shingles or shakes have typically been made of naturally durable species such as Western redcedar. Sawn shakes produced from southern pine pressure treated with CCA are now available. The industry is producing two different grades and an inspection program is in place to certify that the shingles are properly treated. A proposed standard labeled C33 and specifically written for this product is under consideration by AWPA.
Log Structures

Log structures present a unique challenge in wood preservation. They are particularly susceptible to decay because of the deep seasoning checks that occur on the surface of large wood members. These checks allow moisture to penetrate into the wood member, and decay results. Excessive end grain is also exposed, particularly on the corners of log structures. This end grain, as well as the notching of the logs, allows for easy penetration of moisture and subsequent high decay potential.

Old structures that are still sound were usually constructed with attention to moisture-proofing details. Also naturally durable woods such as white oak, walnut, heartwood of white pine, and cedar were usually used, particularly for the lower courses of logs where decay is most prevalent. However, even these woods will succumb to decay with prolonged exposure to moisture.

Many of the log structures available today are made with small diameter logs which contain large percentages of sapwood. Sapwood is susceptible to decay and to insect attack. As a result, proper construction is essential in preventing deterioration. Good practices include (1) adequate roof overhang with properly hung and maintained gutters and downspouts; (2) wrap around porches which protect the lower portion of exterior walls; (3) avoidance of tall exposed walls of logs; (4) roof or other appropriate vents, if attic space is present; (5) good drainage and ventilation around the foundation; (6) proper venting of showers, baths, and dryers; (7) adequate clearance between the soil and lower logs; and (8) most important of all, proper log design so that any moisture contacting the log surface will run down and off the logs rather than becoming trapped. Trapped moisture is certain to result in wood decay.

These practices, if properly done, will usually limit the amount of deterioration which can occur. Remember, that the log usually forms both the inside and outside of any walls. Therefore, any preservatives
applied by pressure or dipping prior to construction will be on both the inside and outside of the structure.

For existing structures, even those that are well weathered, the application of a water-repellent preservative to the exterior can help prevent further deterioration. Any decayed wood should be removed and the newly exposed wood liberally treated after the moisture source has been eliminated and the wood dried. To facilitate treatment of hard-to-reach areas that may have some decay, 1/4-inch holes can be drilled in the wood and filled, preferably several times, with preservative solution that will diffuse into the adjacent wood. The holes should then be plugged with preservative-treated wood dowels.

*Note: Most preservatives should not be used indoors. Always check manufacturer's recommendations and Material Safety Data Sheets for proper use of all preservatives.*

The use of borates to control wood decay is a relatively new development in the United States and may be particularly useful on log structures with moisture problems. The material is manufactured for brush or spray application or as a "rod" that can be inserted into holes bored in the wood. The material diffuses through wet wood and provides protection against decay and wood destroying insects. This material is available through distributors and can be applied by professionals such as pest control operators, log cabin manufacturers, and pole treaters.

**Railroad Ties**

Used railroad ties are commonly available for landscape and other construction purposes. These ties were initially treated with creosote to railroad specifications and have been removed from service because of a railroad line being closed, excessive mechanical wear at the tie plate and spike loosening, excess splintering or checking, and decay. Obviously, the quality can vary substantially. The sound treated wood which remains is likely to be very durable. Care should be exercised in making certain that the used ties are acceptable for the
intended end use. Remember, creosote has a pronounced odor, cannot be painted, and should not be used where skin contact is likely.

If new railroad ties or equivalent size timbers are being purchased, be certain to ask how the material was treated and if a warranty is available. Penetration of the preservative into large timbers or ties is sometimes difficult. It can be checked by boring or cutting in the middle of the piece. If the material is being offered "as is" and carries no quality mark or tag identifying the treater, it is probably best to avoid it.

Since disposal of wood materials in many landfills is restricted, the accumulation of excess quantities of treated wood should be avoided. The Consumer Information Sheets (Chapter 11) strictly prohibit the burning of treated wood except in approved incinerators.

Chapter 10. Finishing Preservative Treated

Wood Products

Wood products which are appropriately treated with preservatives for a specified end use and properly installed will withstand decay, insect, and marine borer attack for extended time periods. In addition to these biological organisms, wood in exposed conditions is subject to weathering. Weathering occurs as wood is exposed to the direct rays of the sun and alternating wetting and drying cycles caused by precipitation. With these forces, small checks tend to enlarge into cracks on both flat surfaces and end grain. Moisture accumulates more rapidly in these openings and on end grain and the process continues to accelerate. If the cracks become deep enough to penetrate the preservative shell, decay and insect attack can occur on the interior, untreated portion of the wood products. The wood also turns a gray color or it can mildew and turn dark.

This weathering phenomena is particularly troublesome on wood products treated with the waterborne preservatives such as CCA and ACZA
or untreated naturally durable wood (Fig. 10-1). Virtually all treated lumber, plywood, posts, small poles and timbers available at retail lumber yards are treated with the waterborne preservatives and subject to weathering if exposed. Some mildew or mold organisms can develop on the surface of waterborne-preservative-treated lumber. Therefore, if aesthetics are important and weathered wood is to be avoided, the application of wood finishes should be considered.

Characteristics of Treated Wood Affecting Finishes

Grain characteristics of the particular species being used is another factor which must be considered in selecting a finish. Much of the preservative treated lumber available in the eastern one-half of the United States is southern pine. Lumber from this species as well as Douglas-fir, which is more common in the west, is dominated by a flat-grain pattern and wide latewood bands. These two characteristics tend to cause paint to peel. As a result, these two species have the least desirable paint holding characteristics. Hemlock and a species group called hem-fir and ponderosa pine in the west and red and jack pine in the north have somewhat better paint holding characteristics.

On the more positive side, Forest Products Laboratory research has shown that clear water repellents, semi-transparent stains, and paints all perform much better on CCA-treated wood than they do on untreated lumber of the same species. The chromium in the CCA reduces the degrading effect of weather.

Waterborne-Preservative-Treated Wood

Because of the conditions to which most waterborne-preservative-treated wood is exposed, and the grain characteristics of the more common species, special precautions in the selection, application and maintenance of a wood finish must be considered. For fully exposed preservative treated wood or naturally durable material, a water-repellent preservative or a semi-
transparent oil-based penetrating stain may provide the best finishing solution. Some preservative treated wood is being produced with a water repellent and even a coloring material, usually brown, added at the time of treatment. Be sure to check with the supplier concerning the details. Film-forming finishes such as paint may be used in protected areas.

**Water-Repellent Preservatives**

A water-repellent preservative acts as a natural finish. The treatment reduces warping and checking, prevents water staining, and helps control mildew growth. Water-repellent preservatives contain a fungicide, a small amount of wax as a water repellent, a resin or drying oil, and a solvent such as turpentine, mineral spirits, or paraffinic oil. Those used for decks often contain an ultraviolet light stabilizer or absorber. This stabilizer prevents the sun from slowly degrading the surface of wood, releasing fibers and groups of fibers. The wax reduces the absorption of liquid water by the wood (Fig. 10-2), and the preservative prevents wood from darkening (graying) by inhibiting the growth of mold and mildew. The finish will vary in color, depending upon the wood color itself, but will usually weather to a clean, golden tan. For severe exposures, the finish should be renewed annually; spring is usually the best time. Some waterborne formulations are available.

**Semi-transparent Penetrating Stains**

Semi-transparent penetrating oil-based stains are pigmented water repellents or water-repellent preservatives. They penetrate the wood surface to a degree, are porous, and do not form a surface film like paint. Thus, they do not totally hide the wood grain. As a result, the stains will not blister or peel even if moisture penetrates the wood.

Penetrating stains are oil-based (or alkyd-based), and those used on decks should contain a fungicide (preservative or mildewcide), a water repellent, and often an ultraviolet light stabilizer. Make certain that the manufacturer's label indicates that the
finish will resist mildew or that the product contains a specific mildewcide. All fungicides are not effective against mildew. Light-colored penetrating stains will also last longer than dark ones on flat surfaces subject to traffic because light stains show the least contrast in grain color as wear occurs. On the other hand, dark colors can reduce or eliminate the green color of some waterborne-preservative-treated wood from showing through and even-out the substrate appearance. Semi-transparent stains may last up to four years for deck applications.

Latex-based (waterborne) stains are also available, but they do not penetrate the wood surface as well as do their oil-based counterparts. Newer latex formulations that may provide better penetrating characteristics are being developed.

To refinish a water-repellent preservative or semi-transparent stain, the surface should be clean, dry and free of mildew. The coatings may be applied by brush, spray, roller or pad. However, brushing the finish generally gives the best penetration and performance because it tends to work the finish into any surface checks or other small openings which have developed. If spraying is used to apply a pigmented finish, back brushing the wet coating with a brush or push broom will even out the finish and eliminate drip and lap marks. Be certain to apply the finish at the recommended coverage rate. Finishes specially formulated for decks are designed to penetrate the wood surface. Excess buildup of the material will form a film which can ultimately peel or crack. Over-applied stains can result in sticky surfaces due to improper finish drying and water repellents can become overly waxy, sticky, or slick.

Coatings should also be applied under favorable weather conditions following manufacturer's recommendations. Solvent-borne coatings should be applied when the temperature is at
least 40°F or higher. For water-based products, the temperature should be at 50°F or higher for at least 24 hours after application. Ideally, the coatings should have 12 to 24 hours to cure before any precipitation occurs.

**Paints**

Paints, varnishes and solid-color stains, applied in exposed applications, such as decks, are likely to peel. These finishes should not be used on exposed decks. Laborious scraping and sanding before refinishing will usually be required to restore such finishes. However, paints may be successfully used on roof-protected porch floors and vertical surfaces such as siding, trim, plywood foundations and lattice work. The best procedure is to treat the wood with a paintable water-repellent preservative first. After the treatment dries, a primer and two topcoats should be applied. Porch enamel is especially formulated to resist abrasion and wear.

Because of their low resin content, solid-color stains should never be used on flat surfaces such as decks and porches. Varnish will likewise fail, or peel, in a very short time period and should not be used. Since decks represent a combination of the most adverse conditions, refer to Chapter 9 for finishing and other details.

**Note:** Wood that is pressure treated with waterborne preservatives often contains large quantities of water when shipped to retail lumber yards. Therefore, care should be exercised to make certain that the lumber is dry before finishing. For penetrating stains, at least the surface should be thoroughly dry. If paint is to be applied, the piece should be dry throughout. Drying may take days or weeks depending on how wet the wood is initially and on drying conditions. Air drying in place is acceptable, although some shrinking, warping, and checking may result (Fig. 6-1). Finishes applied to wet wood will fail prematurely.

**Refinishing**

On well-weathered decks the original bright color of the wood can be
restored by application of commercial products called deck cleaners, brighteners, or restorers (Fig. 10-3). These products may remove the weathered wood surface and some care should be exercised not to remove excess wood. Color can also be restored using a liquid household bleach containing 5 percent sodium hypochlorite. The bleach is usually diluted with water (1 part bleach, 3 parts water) before it is applied to the deck. The bleach solution should be rinsed from the deck with water. If the deck is to be finished after cleaning, allow 1 or 2 days drying time.

In some sections of the country, contractors or rental agencies with power washing equipment may be available to help restore weathered wood ranging from decks and fences to wood-shingled roofs. Power washing can be damaging to the wood and must be done with care.

**Oil-Based Preservative Treated Wood**

When creosote or pentachlorophenol in a heavy oil solvent with low volatility is used to pressure treat wood, successful finishing is impossible. The surface is generally oily and dark, and the dark color will usually bleed through any paint. Poor adhesion is also likely for all film-forming finishes. Because of the oil base, wood treated with these preservatives does not tend to weather as rapidly as that treated with the waterborne preservatives. However, if the wood has weathered for several years, it can sometimes be stained, but rarely painted. It is best to finish a small area first and expose it to direct sunlight on warm to hot days to determine if the finish would perform well.

Wood which has been pressure treated with a water-repellent preservative is loaded with relatively large quantities of the preservative and solvent, and the solvent must be completely removed before painting is attempted. Solvents vary in their volatility, and the evaporation period may take from 1 to 2 years. Even with special drying schedules, the complete paintability of the wood may
not be restored. This process, however, should not be confused with the brush, spray, or dip treatment of a water-repellent preservative, which serves to enhance paint durability and wood performance.

For a more detailed discussion on wood finishing, the reader is encouraged to consult Exterior Wood Finishes in the South: Selection, Applications, and Finishes or Finishing Wood Exteriors: Selection, Application and Maintenance.

Figure 10-1. CCA-treated deck after about 12 years of weathering. The wood is not decayed but the deck has weathered to a dull gray. Some checking and warping has occurred.

Figure 10-2. Wood surface brush-treated with water repellent (left). The treated surface resisted penetration by liquid water, whereas the untreated wood surface (right) absorbed water quickly.

Figure 10-3. The weathered wooden deck shown in Figure 10-1 after cleaning the seats and railing.

Chapter 11. Safety and Environmental Issues

Wood preservatives are considered pesticides and, as such, their use is closely regulated by the U.S. Environmental Protection Agency. Some of these preservatives are available to anyone as "over the counter" purchases, while others are considered restricted-use pesticides and are available only to certified applicators. Certified applicators are individuals who have received specialized training on the proper use of pesticides. Some preservatives or preservative-treated wood products may require special handling or disposal under the Resource Conservation and Recovery Act (RCRA). Regulations may vary by region.

It is important to recognize that the wood preservatives (pentachlorophenol, creosote, CCA, and ACZA) most commonly applied by
pressure treatment are all restricted-use pesticides. Although these restricted-use pesticides are impregnated into the wood, the wood itself is not restricted. To provide for the maximum personal safety and to minimize any potential environmental damage, wood preservatives should be applied as specified on the label and wood treated with CCA, ACZA, pentachlorophenol, or creosote should be used as directed in the Consumer Information Sheets as developed by EPA. These sheets should be available from the supplier of the materials.

As indicated, CCA is a restricted-use pesticide and must be handled accordingly. After it is impregnated into the wood, its chemical composition changes and it becomes permanently fixed to the wood. This chemical change and fixation process occurs as the wood dries and it is accelerated by heat. Wood freshly treated with CCA which has not had time to dry or which has not been exposed to warm temperatures will contain "uncured" CCA. Particular caution should be paid when handling wet CCA-treated material purchased during the winter months in temperate climates. Precautions include wearing rubber gloves when handling the material, avoiding machining, and washing afterwards.

Another prudent practice is to use preservatives or preservative-treated wood products only where the end use requires it. Their use in other applications simply adds additional pesticide to the environment and increases costs.

Finally, alternate preservatives such as borates, copper naphthenate, and ACQ are available for some applications. These preservatives are not now restricted-use pesticides and reported effective if used as directed.

**Health Related Issues**

Wood treated with CCA has been used successfully for many years because the surface is not oily and the wood is durable. Because of these characteristics, it is often used where people, children or animals can come in contact with it. However, the basic
chemical components of chromium and arsenic have caused many health related and environmental questions to be raised, especially when the material is used in applications such as picnic tables and lawn furniture, gardening and agricultural uses, and playground equipment. The issue is if the material can leach from the wood and contaminate food, feed, and soil and whether dermal or oral contact, especially by children, will result in the chemicals being absorbed. As a result, several studies have been published and some are reviewed here.

Concerning the leachability of the material, Arsenault indicated that:

"Treated wood poles in service in various soil types from 26 to 32 years did not show significant loss of any pesticide component due to leaching or other factors. Furthermore, soil samples collected at various distances from poles treated with CCA of a type most comparable to current CCA showed an average (four poles) arsenic concentration of 53.0 ppm at the pole and decreasing to 16.3 ppm approximately one foot from the pole. The background soil arsenic level for the area was 14.2 ppm. Arsenic is present in soils naturally with a range of levels from about 1.0 ppm to about 8000 ppm and an average of 5-6 ppm. CCA in current use has been improved to provide even greater performance than that reported herein."

Although permitted under EPA guidelines, there is some controversy over the use of CCA-treated wood in raised-bed gardening applications, both over leaching of small amounts of chromium and arsenic into soil and over possible uptake by plants. One study of the use of CCA-treated grapestakes showed no uptake.

A more recent but limited study of soil samples from raised bed gardens constructed with CCA-treated landscape timbers also suggests that this is a defendable practice. Analysis of soil samples at several distances from the treated wood led Finch and Dainello to conclude that leaching of CCA was not a problem in this application. Other more rigorous
scientific studies have been proposed that should give more definitive answers to this issue.

In another study concerning the use of CCA-treated wood for playground equipment, it is reported that:

"No adverse effect on health of users has been reported. On theoretical grounds the health hazard, if any, should be only small because commercial CCA products in treated pine undergo fixation within a few days and the components become only sparingly soluble from wood in contact with water. However, the fact that the pine is treated with copper, chromium and arsenic compounds has raised some doubts as to its safety for use in children's playgrounds. The surface of the unweathered material may carry traces of soluble preservative or deposits of reacted components.

In this investigation, commercially treated rounds have been examined and the amount of preservative on the surfaces assessed.

The health hazard appears to be very small, but because a considerable variation is possible in the extent of fixation of the copper, chromium and arsenic components and because there is uncertainty as to the toxicity of the fixed arsenic to humans, a cautious approach is warranted. Thorough washing with scrubbing of the treated surface, particularly the intact ends, is recommended when the treated material is accessible to children." 28

Research has shown that wood treated with CCA presents a minimal health risk. However, for individuals concerned about the presence of chromium and arsenic, some additional actions or alternatives exist. First, thoroughly scrubbing and washing the surface, and especially the ends of treated lumber, will help remove any surface residues should they exist. It has also been suggested that the surface can be sealed with a 20 to 30 percent varnish mixture in mineral spirits. If exposed to the weather, this treatment will probably require renewal on a yearly basis. Naturally durable woods can also be
used. Or, alternative preservatives which do not contain chromium or arsenic such as copper naphthenate and ACQ can be considered for some applications.

**Disposal of Treated Wood**

The disposal of preservative treated wood is an issue that is becoming of increasing concern. The Consumer Information Sheets issued by EPA indicate that treated wood should be disposed of by ordinary trash collection or by burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. With rapidly-filling landfills and existing or pending restrictions against all wood-based materials, and increasing public concern about potential toxicity of treated wood products, disposal of even small quantities may become more difficult.

The use of the material as biomass fuel is one option which is being developed. The EPA Consumer Information Sheets indicate that, "Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers in accordance with state and federal regulations." Material treated with creosote such as railroad ties or pentachlorophenol-treated wood is being successfully disposed in this manner. Research on the incineration, bioremediation, physical and chemical treatment of used preservative treated wood products is on-going and is yielding important results. At this time, it is probably prudent to consider and possibly develop a life cycle plan which includes the proper management of treated wood during its primary use followed by one or more secondary uses and disposal options. For example, material treated and used for several years as small poles or railroad ties may find a secondary use as posts or for landscaping purposes.

**Preservative Poisoning and First Aid**

Certain non-restricted preservatives
are available to general consumers. The user of these preservatives is bound by law to follow all label directions. Following all label directions is essential to safe, effective, and environmentally sound pesticide application. First aid procedures are generally given on the label. Be sure to read the label before applying the preservative.

In the event of an acute preservative or other pesticide poisoning, there are certain emergency procedures which are generally recommended. Step one is to prevent further exposure and make sure the victim is breathing. Then call emergency medical personnel. While help is on the way, maintenance of vital signs is imperative, and cardiopulmonary resuscitation techniques may be required. Be ready to provide medical personnel with a copy of the pesticide label.

For your own personal safety, be sure you know and have a phone number for the closest poison information center. Also, be sure to contact your state pesticide program for local information and detailed information on safety. State pesticide programs are usually administered by the Cooperative Extension Service which is part of the Agricultural Complex in each land grant institution.

Consumer Information Sheets

EPA-approved information sheets for each of the three major groups of wood preservatives are being provided by producers to consumers of treated wood products. These sheets, reproduced below, provide users with information about the preservative and about the use and disposal of treated wood products. As a minimum, anyone involved with preservative treated wood products should become familiar with these information sheets and follow the advice therein.

Inorganic Arsenical Pressure-Treated Wood (including CCA and ACZA)

CONSUMER INFORMATION

This wood has been preserved by
pressure-treatment with an EPA-registered pesticide containing inorganic arsenic to protect it from insect attack and decay. Wood treated with inorganic arsenic should be used only where such protection is important.

Inorganic arsenic penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to inorganic arsenic may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use or dispose of the treated wood.

**USE SITE PRECAUTIONS**

Wood pressure-treated with waterborne arsenical preservatives may be used inside residences as long as all sawdust and construction debris are cleaned up and disposed of after construction.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such sites would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops.

Only treated wood that is visibly clean and free of surface residue should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come into contact with the honey.

Treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

**HANDLING PRECAUTIONS**

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. Treated wood...
from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

If preservatives or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing.

**Pentachlorophenol Pressure-Treated Wood**

**CONSUMER INFORMATION**

This wood has been preserved by pressure-treatment with an EPA-registered pesticide containing pentachlorophenol to protect it from insect attack and decay. Wood treated with pentachlorophenol should be used only where such protection is important.

Pentachlorophenol penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to pentachlorophenol may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use and dispose of the treated wood.

**USE SITE PRECAUTIONS**

Logs treated with pentachlorophenol should not be used for log homes.

Wood treated with pentachlorophenol should not be used where it will be in frequent or prolonged contact with bare skin (for example, chairs and other outdoor furniture), unless an
An effective sealer has been applied. Pentachlorophenol-treated wood should not be used in residential, industrial or commercial interiors except for laminated beams or building components which are in ground contact and are subject to decay or insect infestation and where two coats of an appropriate sealer are applied. Sealers may be applied at the installation site. Urethane, shellac, latex epoxy enamel and varnish are acceptable sealers for pentachlorophenol-treated wood.

Wood treated with pentachlorophenol should not be used in the interiors of farm buildings where there may be direct contact with domestic animals or livestock which may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib (bite) or lick the wood, pentachlorophenol-treated wood may be used for building components which are in ground contact and are subject to decay or insect infestation and where two coats of an appropriate sealer are applied. Sealers may be applied at the installation site.

Do not use pentachlorophenol-treated wood for farrowing or brooding facilities.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such sites would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops.

Only treated wood that is visibly clean and free of surface residue should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come into contact with the honey.

Pentachlorophenol-treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such
as docks and bridges.

Do not use pentachlorophenol-treated wood where it may come into direct or indirect contact with drinking water for domestic animals or livestock, except for uses involving incidental contact such as docks and bridges.

**HANDLING PRECAUTIONS**

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers rated at 20 million BTU/hour or greater heat input or its equivalent in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

Avoid frequent or prolonged skin contact with pentachlorophenol-treated wood. When handling the treated wood, wear long-sleeved shirts and long pants and use gloves impervious to the chemicals (for example, gloves that are vinyl-coated).

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

If oily preservatives or sawdust accumulate on clothes, launder before reuse.

Wash work clothes separately from other household clothing.

**Creosote Pressure-Treated Wood**
CONSUMER INFORMATION

This wood has been preserved by pressure treatment with an EPA-registered pesticide containing creosote to protect it from insect attack and decay. Wood treated with creosote should be used only where such protection is important.

Creosote penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to creosote may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use the treated wood.

USE SITE PRECAUTIONS

Wood treated with creosote should not be used where it will be in frequent or prolonged contact with bare skin (for example, chairs and other outdoor furniture) unless an effective sealer has been applied.

Creosote-treated wood should not be used in residential interiors. Creosote-treated wood in interiors of industrial buildings should be used only for industrial building components which are in ground contact and are subject to decay or insect infestation and wood block flooring. For such uses, two coats of an appropriate sealer must be applied. Sealers may be applied at the installation site.

Wood treated with creosote should not be used in the interiors of farm buildings where there may be direct contact with domestic animals or livestock which may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib (bite) or lick the wood, creosote-treated wood may be used for building components which are in ground contact and are subject to decay or insect infestation if two coats of an effective sealer are applied. Sealers may be applied at the installation site. Coal tar pitch and coal tar pitch emulsion are effective sealers for creosote-treated wood-block flooring. Urethane, epoxy and shellac are acceptable sealers for all creosote-treated wood.
Do not use creosote-treated wood for farrowing or brooding facilities.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such use would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops.

Only treated wood that is visibly clean and free of surface residues should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come into contact with the honey.

Creosote-treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

Do not use creosote-treated wood where it may come into direct or indirect contact with drinking water for domestic animals or livestock, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces or residential boilers, because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalations of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

Avoid frequent or prolonged skin contact with creosote-treated wood;
when handling the treated wood, wear long-sleeved shirts and long pants and use gloves impervious to the chemicals (for example, gloves that are vinyl-coated).

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking and use of tobacco products, wash exposed areas thoroughly.

If oily preservative or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing.

Chapter 12. Sources of Information

There are many additional sources of information for individuals trying to learn more about all types of construction wood products. These sources can be broken into two general categories. The first is public supported institutions and the second being any of the numerous industrial trade associations which promote the proper use of wood as a construction material.

Public Institutions

Of all the public supported institutions, the U.S. Forest Products Laboratory has the most breadth in terms of technical expertise in all areas of wood processing and publications which are available. Individuals seeking information should begin by talking with the publications section.

The land grant institutions, or equivalent, in each state may be another source of information. The department or college of forestry, or equivalent, is a logical starting place. More specifically, ask to speak to someone with a wood technology responsibility. Individuals with responsibilities for buildings and construction within agricultural engineering may be equally valuable. A few institutions have a wood research laboratory. The type and
 breadth of these programs vary substantially by state.

State forestry commissions or departments of natural resources may also be of some help. Ask to speak to someone familiar with the wood manufacturing industry.

**Trade Associations**

Trade associations can be an especially valuable source of information to buyers, users, and specifiers of the products they represent. Several important key associations are given below.

The American Wood Preservers' Association (AWPA) maintains the standards for the industrial pressure treating industry. Any specific questions on preservative treatment processes and how specific products should be treated are best referred to this organization.

The American Wood Preservers Institute (AWPI) is primarily concerned with environmental issues and regulations. Printed materials are available.

The American Lumber Standard Committee (ALSC) is responsible for maintaining the softwood lumber standards and for overseeing companies which inspect treated wood products to determine if they conform to AWPA standards.

The Southern Forest Products Association (SFPA) is a major trade association which represents several aspects of the southern pine manufacturing industry. Of specific interest is lumber, treated products, shakes, and certain other items. Numerous publications are available from the Southern Pine Marketing Council located at the same address.

The Western Wood Products Association (WWPA) is the west coast and western species equivalent to the SFPA.

The Western Wood Preservers Institute (WWPI) represents companies specifically involved in treating western species. Several publications on western species are
available.

The trade associations listed above and others can be reached at the following addresses and phone numbers.

American Forest and Paper Association
250 Connecticut Avenue, NW
Suite 200
Washington, DC 20036
Telephone: 202/463-2700
Fax: 202/463-2785

American Lumber Standard Committee
P.O. Box 210
Germantown, MD 20875-0210
Telephone: 301/972-1700
Fax: 301/540-8004

American Plywood Association
P.O. Box 11700
Tacoma, WA 98411
Telephone: 206/565-6600
Fax: 206/565-7265

American Wood Preservers’ Association
4128-1/2 California Avenue S.W.
No. 171
Seattle, WA 98116
Telephone: 206/937-5338
Fax: 206/937-5338

American Wood Preservers Institute
1945 Old Gallows Rd.
Suite 550
Vienna, VA 22182
703/893-4005
FAX 703/893-8492

National Wood Window and Door Association
1400 East Touhy Avenue
Des Plaines, IL 60018
Telephone: 708/299-5200
Fax: 708/299-1286

Southern Forest Products Association
P.O. Box 52468
New Orleans, LA 70152
Telephone: 504/443-4464
Fax: 504/443-6612

U.S. Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53705-2398
Telephone: 608/231-9200
Fax: 608/231-9592

Western Wood Preservers Institute
P.O. Box 2913
Vancouver, WA 98668
Telephone: 206/693-9958
Fax: 206/693-9967

Western Wood Products Association
Yeon Bldg.
522 S.W. Fifth Avenue
Portland, OR 97204
Telephone: 503/224-3930
Fax: 503/224-3934
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