WOOD PRESERVATION & WOOD PRODUCTS TREATMENT PEST CONTROL STUDY GUIDE

Volume X

(2004 - 2005 Version)

NEVADA STATE DEPARTMENT OF AGRICULTURE

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Nevada Department of Agriculture
Test Taking Rules

1) All Pest Control Examinations are Monitored; and video and Audio Taped.....

2) Anyone who cheats on an examination will be excluded from taking another pest control examination for a minimum of 6 months (NAC 555.340.7)......

3) No cell phones or pagers can be used at anytime during an examination.....

4) No unapproved study materials, notes or other aids are to be in your possession during an examination....

5) Tests must be paid for prior to examination....

6) PLEASE bring a sharp pencil, eraser and calculator...

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WOOD PRODUCTS TREATMENT
PEST CONTROL
STUDY GUIDE

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Preface and Acknowledgments

This manual was prepared as a general study guide for urban-structural pest control operators. The enclosed sections provide an understanding of current wood preservation practices in the pest control industry. This manual will apply primarily to wood-based materials used in construction and re-treatment of utility poles. The information contained herein is basic and practical and is not intended to serve as a complete guide to wood preservation. This information is not intended to replace or supplement standard industry practices or any pesticide label information or directions. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used.

The use of sample pesticide labels implies no endorsement by the State of Nevada Department of Agriculture.

This study guide was revised from a University of Georgia Cooperative Extension Service publication entitled *The Preservation of Wood, a Self Study Program for Wood Treaters*. Contributors of information contained in this manual include information from the Oregon State University Extension Service, Kansas State University, Utah Department of Agriculture and Utah State University Extension Service.

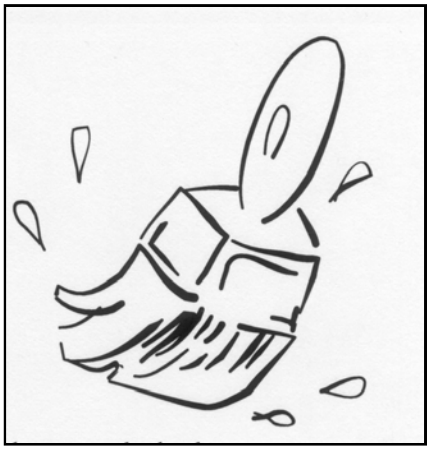
Nevada State Department of Agriculture.

Introduction

Wood pesticides (preservatives) extend the life of wood products by protecting them from damage by insects, fungi, marine borers, and weather. Preservatives are applied on the basis of how and where the products will be used, the expected conditions of exposure to wood-destroying agents, and the cost per year of service life.

Crossties, poles, posts, and other wood products that contact the ground or are exposed to the weather must be protected with preservatives to ensure a reasonable service life. Other wood products not in contact with the ground may be treated as a precautionary measure even though they are not exposed to moisture and weather.

Long-term tests and experience show the levels of protection needed for various products and uses. These guidelines become industry wide when they are accepted by the following groups:



- Groups that use the treated products
- Regulatory agencies
- Wood-preserving organizations

There are many standards and specifications to control the quality of treated wood and protect the purchaser. Federal and State specifications and requirements of the American Wood Preservers Association are the regulations most commonly used.

Properties of Wood

The origins of lumber

All woods are composed of approximately 60 percent cellulose and 28 percent lignin. These substances make up the woody and fibrous cell walls of plants and trees and the cementing material between them. The remaining 12 % consists of the elements that give each species individual qualities, like the rich color of mahogany used in cabinetwork, the unmistakable aroma of cedar, and the “rot-resistance” that makes redwood so ideal for lawn furniture and construction. The other characteristics that match lumber to specific uses are the result of the way it is sawed from the log, seasoned and/or treated.

Softwood and hardwood

Hardwoods come from broad-leafed, deciduous trees, such as oak, walnut, maple, birch and mahogany. The proper definition of a hardwood is based on its “enclosed seeds”. Hard woods do not have cones; instead seeds are enclosed in a fruit or nut which has to be opened to see the actual seed. In most cases, all North American hardwoods are broadleaf, deciduous trees that drop their leaves in the fall of each year (exceptions are holly, magnolia and live oaks).

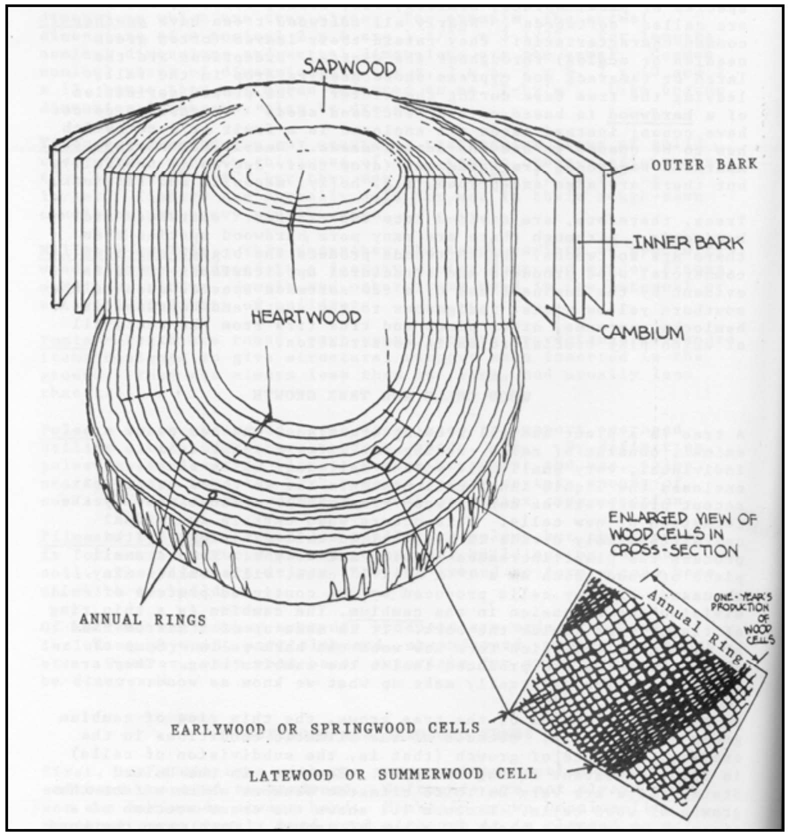
Softwoods come from coniferous (cone-bearing or evergreen) trees, such as pine, cedar, fir, hemlock, redwood, spruce, and cypress. The proper definition of softwood is wood that comes from a tree which produces “naked seeds”. This nearly always refers to all conifers, where the actual seeds usually are visible between the bracts of open cones. Nearly all softwood trees have another common characteristic, in that they retain their leaves (green needles or scales) throughout the winter (exceptions are larch, tamarack and cypress whose needles fall off in the winter).

Trees, therefore, are divided into two classes: softwoods and hardwoods. Although there are many more hardwood species than softwood species, more softwoods are used in commercial wood production and for structural applications in the United States. This is evident by the dominant use of a few softwoods, such as, Douglas fir, true firs, and pines, all which play crucial roles in the construction and utility pole industries.

Note: Softwoods are not always soft, nor are hardwoods always hard. Mountain grown Douglas fir produces an extremely hard wood although it is classified as a “softwood”, and Balsawood, so useful in model making, is classed as a “hardwood” although it is very soft.

Basics of a tree

Crosscut a mature Douglas fir or cedar tree trunk, and inside the bark you will find a zone of lighter wood (sapwood) surrounding a core of darker colored wood (heartwood). The heartwood is composed of dead cells which contribute to the overall strength of the tree trunk. In many ways, heartwood is similar to sapwood. The main differences are in their chemical and physical properties. Unlike animals, trees have no way to get rid of by-products (waste) or extractives produced by the chemical changes that take place in its living tissues. Some of these by-products could be harmful to the tree so provision is made to nullify such risk. What a tree does is to pass these substances towards its heartwood center, so heartwood, basically, is just sapwood where waste substances have been accumulated. This leads to two major differences in properties between heartwood and sapwood. Heartwood, because of its extractives and the presence of other substances, usually has:



- Greater resistance to insect attack and decay by fungi.
- Reduced permeability which can affect timber treatment because the natural cellular channels of heartwood can become clogged with extractive deposits.

Note: Fast growing trees usually have deeper sapwood than slow growing trees.

Ninety percent of wood is made up of minute, hollow fibers oriented lengthwise along the tree stem. These fibers, 1/5 inch long, are 100 times longer than wide. Through them, the tree transports water and nutrients vertically within the tree.

The remaining 10 percent of the wood is composed of short, hollow, brick shaped cells oriented from the bark towards the center of the tree as ribbons or rays of unequal height and length. These rays distribute food, manufactured in the leaves and transported down the inner bark, to the growing tissues between the bark and the wood.

Wood is composed of a complex mixture of substances, but the main constituent of all wood is a complex sugar called cellulose. This material serves as the primary source of energy and nutrition for many forms of life on this planet. People use the stored energy in cellulose, not as food but as heat, when they stoke up a wood stove or fireplace.

Deterioration of Wood by Pests

Decay may be thought of as a reversal of the wood growing process. During growth, the action of sunlight on the leaves of a tree, combined with water and carbon dioxide, form sugars (mainly glucose). This sugary solution is transmitted to all growing parts of the tree where it is converted chiefly into cellulose, which forms the cell walls. Some of the sugars combine to form starch used as a reserve form of "stabilized glucose" to restart the growth process when needed, usually in the spring.

During decay, cellulose and starch are first broken down into sugars and eventually into carbon dioxide and water. The sugars in the wood are food sources for decay fungi and some insects.

Only a relatively small number of insects and fungi are classified as "wood destroyers". Rot fungi produce enzymes which can digest wood cellulose and convert it to a usable form of sugar. The sugars provide energy for further growth and other life processes. By contrast, termites chew wood into very fine particles which are ingested and passed to protozoa which live in the gut of the termite. The protozoa produce enzymes which break down the cellulose in to digestible sugars (food). This symbiotic relationship is beneficial to both organisms.

Natural durability

Natural durability of wood is mainly due to the presence of substances called extractives in the heartwood. Extractives refer to a collection of chemicals which form when the tree is growing, but which are harmful to the sensitive cambium. The cambium is a thin ring of living tissue just inside the bark. To protect this growth zone, the harmful substances are passed along rays (cells orientated in a radial direction from the outside of the tree trunk towards its center) and deposited in the dead cells of the heartwood. Think of this as transporting liquid toxic waste through pipes. Needless to say, the extractives are often toxic to insects and fungi, as well as to the cambium. The extractives act like preservatives. The type and quantity of extractives are characteristic of each wood species, giving it a greater or lesser degree of natural durability, and sometimes a distinctive color or odor of it own.

The heartwood of several species of wood has naturally high resistance to decay fungi. **However, the sapwood of all known tree species is very susceptible to decay, regardless of any natural resistance of the heartwood**. Unless sapwood is entirely removed or impregnated with preservatives, decay is likely to occur even in durable species.

As with most products that were once plentiful, scarcity of very durable species of wood and virgin forests are rare or are being protected. Obviously, when virgin forests were available, naturally durable heartwood timber was used. As these large trees were harvested, they were replaced by younger faster growing trees which produce a greater proportion of sapwood with low natural durability. The need for greater durability gave rise to the wood preservation industry. The use of naturally durable wood has declined and will continue to diminish. The future need for durable wood products will be provided by forests replanted with fast growing trees of low natural durability, but wood from these trees will be treated with preservatives (wood preserving chemicals) for use under high-risk insect and/or decay situations.

Wood is literally used for millions of things other than a source of heat. Under proper conditions, wood can give centuries of good service; under unfavorable conditions, wood is readily damaged and destroyed by fungi, insects, and by marine borers in sea water environments. These pests can attack in many ways, so wood must be protected to ensure maximum service life when used under conditions favorable to these pests.

The science and/or art of wood preservation could be defined as the process of adding adequate quantities and concentrations of toxic or repellent substances to a given wood product to upgrade its resistance to biological attack and make it highly durable. All wood preservatives recommended for ground contact used in the U.S. are capable of protection against wood destroying organisms; provided that the wood cell structure allows for sufficient, deep and uniform penetration of the preservative into the wood.

Wood inhabiting fungi

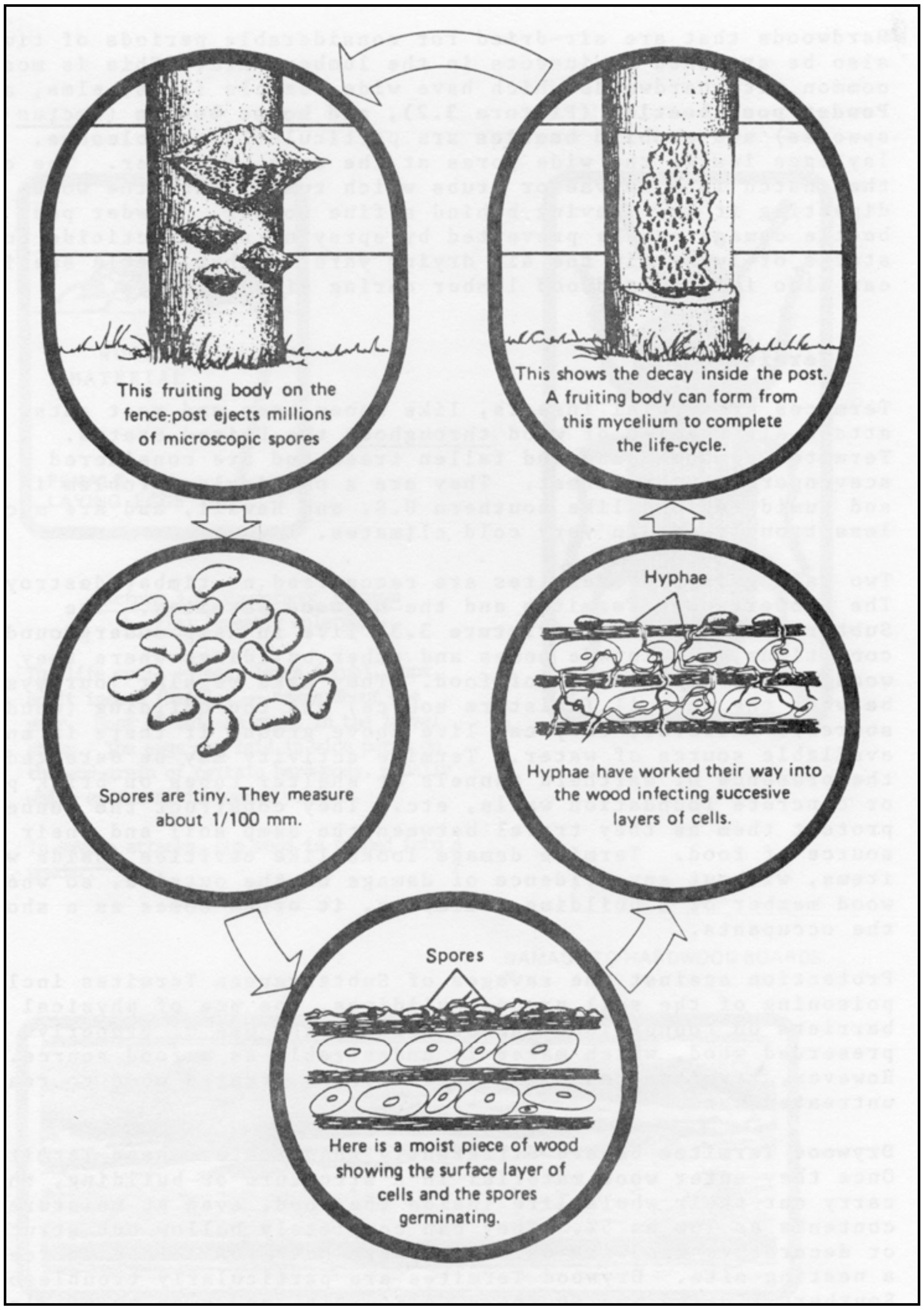
Wood decay, mold, and most sapwood stains are caused by fungi. These fungi, which feed on living or dead wood, produce spores (microscopic seeds), that are distributed by wind and water. The spores can infect moist wood during storage, processing, or use. All fungi that grow on wood have five basic requirements:

- Favorable temperature. This usually ranges between 50 and 90° F. Optimum temperature conditions generally are between 70 and 85° F. Wood usually is safe from decay at temperatures below 35 and above 100°F.
- Adequate moisture. Fungi will not attack dry wood (wood with a moisture content of 19 percent or less). Decay fungi require a wood moisture content of about 30 percent or the generally accepted **fiber saturation point** of wood, according to national design specifications. Thus, air-dried wood, usually with a moisture content (MC) not exceeding 19 percent, and kiln dried wood with a moisture content of 15 percent or less, usually can be considered safe from fungal damage, as long as the wood is kept dry.
- Adequate oxygen. Fungi can live in environments with fairly low levels of oxygen. If oxygen is excluded from the surface of wood by routinely spraying or soaking it with water, fungi can't live.
- Food source. The wood itself or wood components (cellulose, starch, hemicellulose and lignin are examples of wood components).
- Source of fungal infection. The spores ("seeds") of fungi are microscopic and abundant almost everywhere in nature. Because they are so easily moved by air and water we can expect decay to happen wherever the first four conditions are present.

The many fungi that develop on or in wood can be divided into two major groups based upon the damage they cause: wood-destroying fungi (decay fungi) and wood-staining fungi (sap-staining fungi, mold fungi).

Wood destroying fungi

Both the sapwood and heartwood of most tree species are susceptible to decay, and unprotected sapwood of all trees deteriorates rapidly in warm, moist soil. Douglas fir, western larch, western hemlock, and most other species also have nondurable heartwood. Heartwood of cedar, redwood, and a few other species is durable, lasting three to five times longer than nondurable woods.



Decay fungi may grow in the interior of the wood or appear on wood surfaces as fan shaped patches of fine, threadlike, cottony growths or as root-like shapes. The color of these growths may range from white through light brown, bright yellow, and dark brown.

The spore producing bodies may be mushrooms, shelf like brackets, or structures with a flattened, crust like appearance. Fine, threadlike fungal strands grow throughout the wood and digest parts of it as food.

In time, the strength of wood is destroyed. For example, untreated poles or posts first rot in the sapwood just below the ground line, where moisture and temperature are most favorable for fungal growth. Once established, the fungal strands may extend several inches or more into the heartwood.

Decay will stop when the temperature or moisture conditions in the wood are unfavorable for fungal growth; however, decay will resume whenever the conditions become favorable.

Wood decay fungi can be segregated into three major categories: brown rots, white rots, and soft rots.

Brown rot fungi break down the cellulose component of wood, leaving a brown residue of lignin. Brown rotted wood can be greatly weakened even before decay can be seen. The final stage of wood decay by the brown rots can be identified by the dark brown color of the wood, excessive wood shrinkage, cross grain cracking, and by the ease with which the dry wood substance can be crushed to powder.

Brown rot fungi are the most destructive fungi of softwood species used in above ground construction. (When dry, brown rot is sometimes called "dry rot". This is a poor term because wood will not decay when it is dry.)

> Note: There are a few fungi that can decay relatively dry wood. These fungi, (poria sp.) have water-conducting strands that are able to transport water from damp soil to wood in lumber piles or buildings. These fungi can decay wood that otherwise would be too dry for decay to occur. They sometimes are called "water-conducting fungi".

White rot fungi break down both lignin and cellulose in wood and have a bleaching effect, which may make the damaged wood appear whiter than normal.

Soft rot fungi usually attack green, water saturated wood, (high MC) causing a gradual softening of wood from the surface inward. The damage done by these fungi resembles that caused by brown rot fungi.

Several types of organisms may be involved in the decay of wood. Example: The succession of decay of a fence post may start with bacteria feeding on the wood just below the soil surface followed by soft rot fungi, then brown rot or white rot fungi, which result in the post falling over.

The succession of fungi, and their attack on wood, can be complicated. What should be known is that unprotected wood <u>will fail</u> within a few years, sometimes suddenly, especially when both fungi and termites attack wood.

Wood staining fungi, surface molds & mildew

The primary damage caused by these fungi is simply discoloration of the wood. They have little or no effect on its strength. They live on the starch in wood cells and may discolor the sapwood entirely or in patches without breaking-down the cellular structure of the wood.

Sap-staining fungi penetrate and discolor sapwood, particularly among the softwood species. Unlike staining by mold fungi, the typical stains from sap-staining fungi can not be removed by brushing or planing. Sap-staining fungi may become established in the sapwood of standing trees, sawn logs, lumber, and timbers soon after they are cut and before they can be adequately dried. The overall effect on the structural integrity of the wood is minimal. However, the impact strength of the wood may be effected (surface may dent more easily). A common sap-staining fungus is the blue-stain fungi. This fungus occurs inside wood tissue after it is introduced into the vascular system via a bark boring beetle. The spores are present on the outside of the beetles and when they contact the moist, nutrient rich environment of a tree's vascular system they grow and stain the wood. When the appearance of wood is important (siding, trim, furniture, and exterior millwork that is to be clear finished), sap stained wood may be unfit for use.

Mold fungi first become noticeable as green, yellow, brown, or black fuzzy or powdery surface growths on softwoods. Freshly cut or seasoned stock, piled during warm, humid weather, may be noticeably discolored within a few days. As with sap-staining fungi, molds don't reduce wood strength; however, they can increase the capacity of wood to absorb moisture, thereby increasing the likelihood of attack by decay fungi. Discoloration of wood surfaces by mold and mildew is superficial, and can be removed by brushing or planning. Fortunately, mold and mildew growth can be prevented by promptly drying green or moist wood and keeping it dry (below 19% MC). Pressure applied preservatives or other chemical treatments will also effectively prevent their growth.

Chemical stains

Although they may resemble fungal blue or brown stain damage, chemical stains are not caused by fungi; rather, they're caused by chemical changes in the wood during processing or seasoning. Chemical stains can downgrade lumber for some uses, but these stains usually can be prevented by rapidly drying the wood at relatively low temperatures during kiln drying.

Insects

Several kinds of insects attack living trees, logs, lumber, and finished wood products for food and shelter. The most important pests of wood and wood products include termites, carpenter ants, and various beetles.

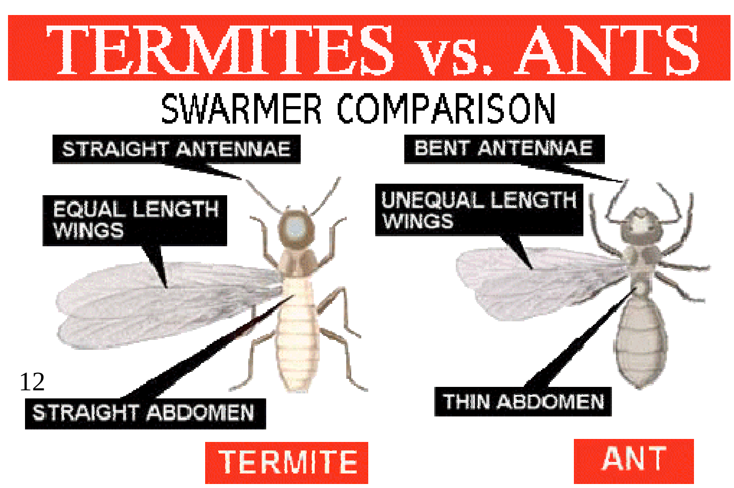
A detailed discussion of all termites and other wood destroying organisms in Nevada can be found, in detail, in the Nevada Department of Agriculture's Structural Pest Control, Control of Wood Destroying Pests Vol. IV. However, for this discussion, only the major groups of wood destroying organisms affecting the wood preservation industry will be discussed.

Termites

Termites use wood for both food and shelter, and nationally, termites are the most destructive of all wood pests. Termites are social insects, as are honey bees and most ant species. They attack all species of wood throughout the U.S. Termites naturally consume dead and fallen trees and are considered scavengers of the forests.

Three main groups of termites are recognized as timber destroyers, Subterranean Termites, Drywood Termites, and Dampwood termites.

Remember: Ants cannot use wood for food, but they are often confused with termites because they look somewhat alike. However, there are several distinct differences in their physical appearance. Ants have "elbowed" antennae; termites don't. Ants have narrow waists whereas termite bodies are broad. Ant hind wings are smaller than the front wings. Both pairs of termite wings are similar in size and shape.



Subterranean termites can attack any unprotected wood in buildings and other wood product throughout most of the continental U.S. as well as in Nevada. During certain seasons of the year, winged males and females are produced by the termite colony. They swarm, mate, lose their wings, and begin a new colony in the soil. They live in, and obtain their moisture from, the soil. Although subterranean termites prefer the soil environment, they often build "mud tubes" over exposed surfaces which extend from the soil to their food source. They do, however, require a constant source of moisture.

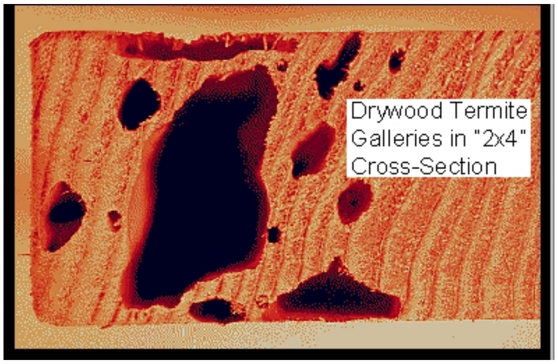
The presence of subterranean termites may be noted by:

- The sudden appearance of swarming, winged, "antlike" insects which discarded their wings after swarming. (The winged, reproductive termite form is known as an "alate".)
- Earthen shelter tubes or "mud tubes" built over masonry or other foundations to their food source which protect them as they travel to and from damp soil.
- The presence of white termite workers inside of shelter tubes.
- The hollowed-out interior of badly infested wood, without any evidence of damage on the outside. The wood may sound "hollow" when tapped with the handle of a screwdriver.
- An active termite colony will consist of eggs, nymphs, workers, solders, alates and a queen.

Alates: Winged forms of insect

Protection against the ravages of subterranean termites include, treatment of soil with termiticides, the use of physical barriers, and the use of properly preserved wood which makes it undesirable as a food source. However, depending upon the wood treatment used, termites may build tubes across treated wood to reach untreated wood.

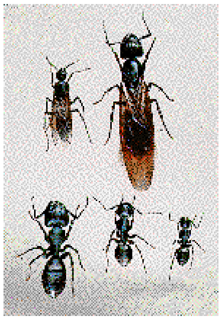
Drywood termites behave differently than subterranean termites. After swarming, drywood termites enter cracks and crevices in dry, sound wood in a structure, building, or untreated pole. In excavating their galleries, they occasionally discharge oval-shaped fecal pellets through temporary openings in the wood surface. They can completely hollow out structural or decorative woodwork which they use for both food and nesting. Drywood termites do not build shelter tubes, and, with the exception of the alates, carry out their lives inside wood with moisture contents as low as 5%.



Most literature reports that drywood termites are found naturally in Hawaii, a narrow strip of land extending from southern California and Texas to Florida and along the Atlantic coast to Virginia and Puerto Rico. However, drywood termites have been identified in limited sites within Nevada, southern Utah, and Western Colorado.

Dampwood termites live in the wood on which they feed and rely on the wood as a source of water; consequently, these termites attack only wood with a high moisture content, but once established, they can extend their activities into sound, dry wood.

Carpenter ants and carpenter bees



These insects can be fairly destructive to untreated wood and wood structures in the U.S. **Carpenter ants** may be black or red. They usually live in stumps, trees, or logs, but will infest virtually any wood including utility poles or other structural timbers set in the ground. These insects do not use wood for food, instead they excavate the wood for their nests. Carpenter ants are often confused with termites. However, there are several distinct physical differences between these two groups of insects. As previously mentioned, ants have "elbowed" antenna, termites do not, ants have very narrow waists, whereas, termite bodies are broad.

Carpenter ants usually prefer wood that is naturally soft or has been softened by decay. The galleries are large, smooth, and free of refuse and powdery wood. Mounds of sawdust indicate their presence.

Carpenter bees are a problem to unpainted or untreated wood. These insects also cannot digest wood, but they use their jaws to chew holes in the wood to form nests in which to lay their eggs. The small chewed out pieces of wood are discarded.

> Note: Preservatives will not completely protect wood against carpenter ant and carpenter bee damage. Suppliers of CCA treated lumber exclude carpenter bee and carpenter ant damage from warranties they may offer. The best defense against these insects is treating them with a registered insecticide.

Beetles

Powderpost or Lyctus beetles attack both freshly cut and seasoned hardwoods and softwoods. They attack the sapwood of ash, hickory, oak, and other hardwoods with the adults laying eggs in the wood pores. Emerging larvae burrow through the wood, making tunnels from one-twelfth of an inch in diameter, packed with a fine powder. After a larval period (from a few months to a year or more, depending on the species) and a much shorter pupal stage, newly emerged adults chew holes to the wood surface, where they lay eggs to produce another generation. These emerging adults are the most destructive to wood surfaces. Signs of damage by powderpost beetles are:

- Small, round, one-sixteenth of an inch holes in the surface of the wood made by emerging adults.
- Fine powder that fans out from the wood.

Anobiid beetles attack soft woods in damp or poorly ventilated spaces beneath buildings. Eliminating the source of moisture will cause the colony to slowly die out.

Roundheaded borers are longhorn beetles, commonly known as the “old-house borer”, and will infest live trees, as well as recently felled or dead, standing softwood trees. They can cause considerable damage in rustic structures and some manufactured products. Over many years in seasoned pine timbers, their tunneling can weaken structural timbers, framing members, and other wooden parts of buildings. Contrary to its name, the old-house borer most often infests new buildings. It is found most often in the Eastern and Gulf Coast States. Some species live in wood from 2 to 40 years.

Flatheaded borers infest live trees as well as recently felled and dead, standing softwood trees. They can cause considerable damage in rustic structures and some manufactured products by mining into sapwood and heartwood.

Typical damage consists of rather shallow, long, winding galleries that are packed with fine powder. Adults are often called metallic wood boring beetles because of their color. They are about ¾ inch long, with wing covers usually rough, like bark.

A detailed discussion of the above beetles can be found in the Nevada State Department of Agriculture's *Structural Pest Control – Control of Wood Destroying Pests* (Volume IV).

Bark Beetles

Bark Beetles are the most destructive insects in the coniferous forests of Nevada and the Western U.S. There are many bark beetle genera, most can be damaging to forest products. Adult bark beetles bore through the outer bark to the inner cambium (sapwood), where they channel out galleries to lay their eggs.

Photo from Ron Long, Simon Fraser University, www.forestryimages.org showing larvae & adult bark beetles.

Larvae hatch in these galleries and may excavate additional channels as they feed. As bark beetles carve out galleries, they may introduce blue-stain fungi which grows in the wood and interferes with the tree's water transport system. This results in tree mortality by either the gallery excavation (girdling) or the spread of the blue-staining fungi.

In either case, an infested tree should be harvested and converted to lumber in a technique known as "Salvage". By salvaging a tree, beetle populations are reduced thereby reducing beetle expansion. Salvage only works if the infested trees are removed from the harvest site before beetles emerge and re-infest healthy trees.

Marine borers

Excessive damage is done to submerged portions of marine pilings, wharf timbers, and wooden boats by a group of animal organisms known collectively as "marine borers." In the U.S., they are especially active in the warm waters of the Pacific, Gulf, and Southern Atlantic coasts. Untreated timbers can be infested and destroyed by these organisms in less than a year. The major marine borers include species in the Phylum **Mollusca** (related to clams and called "**shipworms**" and "**pholad**s") and the Phylum **Crustacea** (related to crabs or sow bugs and called "**gribbles**").

Shipworms drill tunnels in wood and line them with a thin shell like substance. The giant shipworm *Bankica setacea* and species of Teredo are the most common forms.

Gribbles mine the outer part of piling and other marine structures. Attack takes place from the mud line to the upper tidal level. Common "gribble" species include *Limnoria lignorum*.

Controlling Pests that Damage Wood

Wood should be protected whenever it is used where it will be subject to pest attack. This protection can be achieved by controlling the wood moisture content, using wood that is naturally resistant to the pests, using mechanical barriers (discussed in the Nevada Department of Agricultures Structural Pest Control, Control of Wood Destroying Pests Vol. IV), or by treating the wood with a chemical preservative.

Moisture control

The moisture content of living trees and the wood products obtained from them may range from about 30 percent to 60 percent for hardwoods, and up to 200 percent for softwoods. Moisture content is defined as the weight of water in the wood divided by the dry weight of that wood. Timber or logs stored for extended periods before processing can be protected from fungi and insects by keeping the logs submerged in pond water or by subjecting them to a continuous water spray. The water reduces the oxygen content and temperature of the logs to levels below those needed for pest development.

Much of this moisture must be removed before use. Green lumber usually is seasoned or dried for the following reasons:

- Prevent development of stain and decay organisms.
- Reduce insect damage.
- Control wood shrinkage.
- Reduce weight and increase strength.
- Prepare wood for chemical preservative treatments.

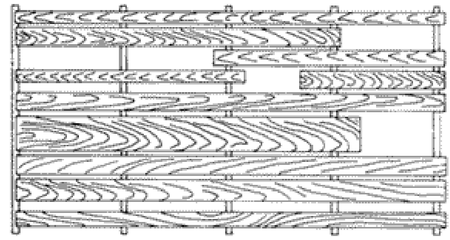
The moisture content of wood usually is reduced either by air drying in a yard, shed, or pre-drier; or by drying in a kiln, retort, or radio frequency drier. The most efficient and widely used system is kiln drying (or oven-dried) because it offers better control of air movement, temperature, and drying rate than does air drying. The amount of water in wood (its moisture content) is usually expressed as a percentage of its kiln dried weight. The moisture is measured by:

- **The kiln (oven) dried method –** A small sample of the wood to be dried is weighed, and then dried in a kiln using a constant temperature between 212 and 220 degrees F. When the weight of the wood sample becomes constant (no more moisture will come out), a percentage of the weight between the dried and un-dried sample is computed, and that percentage is used to express the moisture content.
- **The electrical method –** Use of a moisture meter that measures moisture by electrical resistance.

Seasoning or drying

The moisture content of wood is reduced by:

- Air-drying in a yard, shed or pre-drier.
- Drying in a kiln, retort, or by radio frequency.



Air-drying of wood

Although kiln drying is more expensive than air drying, it's much faster, and it provides better quality and more uniform drying. Furthermore, unless lumber is properly stacked and protected, air drying may result in surface cracking (checking), end cracking, warping, staining, and discoloration due to weathering.

Air drying offers the advantage of low capital investment and no energy costs. Drying time, however, is dependent on seasonal weather conditions, so inventory costs and space requirements may be high.

Even after being well seasoned, wood may again reach a moisture level favorable to pests; especially if exposed to rain or prolonged high humidity and favorable temperatures.

Before wood is used for most construction purposes, and especially before it can be pressure treated, the moisture content of the wood has to be reduced from its freshly felled ("green") condition to a much lower level, commonly 15% to 25%.

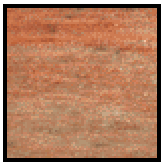
Using Naturally Resistant Wood

The sapwood of all native tree species and the heartwood of most species have a low natural resistance to decay; however, the heartwood of some trees, such as cedar and redwood, is quite resistant to decay. These species are resistant but definitely not immune to attack by decay fungi and insects.

Unfortunately, these naturally resistant woods usually are quite expensive or unavailable in commercial quantities. Because of high costs for labor and materials, the variable and undependable resistance of these species precludes their use for most high-hazard construction applications.

Emphasis must be placed on the fact that studies of naturally resistant wood are based on old growth trees.

There are some observations, which have not been well documented, that wood cut from second growth trees exhibits less resistance to decay and insects, even for those woods considered being highly resistant.



Redwood (*Sequoia sempervirens*)
This wood species has been known to possess some natural resistance to decay and termite feeding. Research with redwood indicates a fairly high durability in short-term exposures to high termite activity. Findings also suggest that extractives from this wood are quite toxic to Formosan subterranean termites.

Chemical Controls

The proper application of chemical preservatives can protect wood from decay and stain fungi, insects, and marine borers, thus prolonging the service life of wood for many years.

The effectiveness of preservative treatment depends on the chemical formulation selected, the method of application, the proportion of sapwood to heartwood, the moisture content of the wood, the amount of preservative retained, the depth of chemical penetration, and the distribution of the chemical in the wood. Sapwood of most commercial lumber tree species accepts preservatives much better than heartwood, and softwood species generally can be more uniformly treated than hardwood species. Preservative treatment by pressure is usually required for wood exposed to high risk of attack by fungi, insects, or marine borers.

Carrier liquids or solvents

Preservatives are used in liquid form. They rely on **solvents** to carry chemicals into the wood during impregnation. Each wood preserving chemical has unique properties of its own, like solubility, boiling point range, etc. In practice, therefore, each is commercially linked to one or more types of solvent, which suit the physical properties of the preservative chemical.

Creosote is unique in that it can act as both a preservative and a carrier. This is because creosote is a very complex liquid mixture. Creosote is a mixture of chemicals recovered from heating coal and wood in the absence of air; only a few of these chemicals are good wood protectors, the others act as carriers or fillers.

Major chemical preservatives

In this section, each of the major active ingredients used in wood preserving will be discussed. Detailed descriptions of their chemical and physical properties are published annually in the American Wood Preserver's Association (AWPA) Standards. As with any pesticide, it is up to the applicator to read and follow all label directions. Pesticide use directions change each year, with some uses being deleted or added to pesticide labels. Read, follow and understand all label directions prior to using a wood preservative or any other pesticide, it is the law. If the product is a Restricted-Use Pesticide, be sure to read the Restricted-Use statement carefully, it may require the actual pesticide applicator to be a Nevada Certified Applicator (not just under the supervision of a Nevada Certified Applicator; or that the actual Primary Principal Operator of the pest control company be present at the time of application). Currently there are several groups of chemical wood preservatives that have been designated as "Restricted-Use". This designation includes the requirement that only those who are Certified Applicators may purchase and/or use, or supervise the use of creosote, pentachlorophenol (penta), and inorganic arsenicals.

Wood preservatives fall into three broad categories:

- Creosote and creosote solutions
- Oil-borne preservatives
- Water-borne preservatives

Creosote and creosote solutions

Creosote is an oily liquid produced when coal is heated in the absence of air; it's the by-product of making coke from bituminous coal for the steel industry, called “Coal Tar Creosote”. This material usually is used as a preservative for railroad ties, large timbers, fence posts, telephone poles, and pilings. Coal Tar Creosote is always heated and forced into wood under pressure; this process is called the Full Cell Process. Creosotes are probably the oldest commercial wood preservatives. Creosote is a Restricted-Use pesticide.

Advantages:

- Toxicity to wood-destroying fungi, insects, and some marine borers.
- Low volatility.
- Insolubility in water.
- Ease of handling and application.
- Restricts moisture pick-up and reduces weathering.

Disadvantages:

- Dark color.
- Strong odor.
- Oily, unpaintable surface.
- Tendency to bleed or exude from the wood surface.
- Toxic fumes that make creosote-treated wood unsafe for use in homes or other living areas.
- Causes stains on cloths, and burns skin.
- Will ignite.
- Increases the weight of the wood by 25% – 50%.

Typical use of creosote

Poles – utility, farm buildings
Piles – land, fresh or sea-water
Docks – piers, timber and decking in harbors
Fencing – posts and rails, farms and estates
Cross-ties – railroads
Bridges – support and decking timbers

Creosote is unsuitable for:

Use inside most buildings where people live or work.
Most situations where there’s contact with people or animals.
Contact with or near food.
Wood surfaces requiring paint or glue

Pentachlorophenol

Pentachlorophenol (abbreviated PCP or penta) is the most common oil-borne preservative. PCP is a product of a complex chemical process. It is insoluble in water, so it is generally dissolved in petroleum or other organic solvents that will aid its penetration into wood. However, this versatile chemical also is formulated as a water emulsifiable compound or as a water soluble salt (ammonium pentachlorophenate) to protect freshly sawn lumber from sap stain fungi.

PCP is used to commercially treat poles, crossarms, lumber, timber, and fence posts. It is not recommended for use in marine installations or close to plants. It may not be used inside buildings except in very restrictive situations as indicated on the label. PCP is no longer available for the do it yourselfer and is therefore classified as a “Restricted-Use” pesticide.

Advantages:

- Toxicity to wood-destroying fungi, insects, and mold.
- Low solubility (reduced leaching from wood).
- Ability to be dissolved in oils having a wide range in viscosity and vapor pressure and to which color may be added, as PCP is colorless.
- Ease of handling and application.
- Ability to be glued, depending on the solvent or carrier.
- Can add a water repellent to improve weatherability.

Disadvantages:

- Can leave an oily, unpaintable surface, depending on the carrier.
- For some applications, provides somewhat less physical protection to wood than creosote does.
- Should not be used in homes or other living areas because of toxic fumes and retains an irritating smell when used with petroleum or creosote based carriers.
- May be toxic and irritating to plants, animals and humans.
- Not recommended for protection from marine borers.
- Contact with treated wood can cause skin burns.
- As with all oils it will ignite and burn.
- Increases the weight of the wood by 25% – 50% when heavy petroleum oil is used as a carrier.

Typical use of PCP

Poles – utility, farm buildings
Cross-arms – utility poles
Piles – in soil
Fencing – posts and rails
Bridges – support and decking timbers

PCP is unsuitable for:

Most uses inside homes or offices.
Marine protection of wood.
Use near livestock on farms.
Contact with or near food.

Inorganic arsenicals

Inorganic arsenicals are preservatives consisting of combinations of various metallic salts and other compounds. The principal compounds used include copper, chromium, fluoride and arsenic. The most commonly used compounds are **chromated copper arsenate** (CCA) and **ammonical copper arsenate** (ACA). These preservatives are water soluble or are considered to be water-borne preservatives; but when they're applied to wood, they become fixed in the wood in an insoluble form. The copper provides protection against attack by fungi, and the arsenic prevents insect attack. All arsenical compounds are Restricted-Use pesticides and when using powder formulations a “closed emptying and mixing system” must be utilized to prevent the release of subject chemicals into the environment.

In 2001, the **Chromated Copper Arsenates (CCA's)** used to treated wood became the subject of an EPA evaluation under provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, which directs the EPA to periodically reevaluate older pesticides to ensure that they meet current safety standards. The EPA conducted a risk assessment and an evaluation of public comments and input from an external scientific review panel on methodologies to perform a risk assessment for residential settings and potential exposure to children from CCA. CCA is a chemical preservative that protects wood from rotting due to insects and microbial agents. CCA contains arsenic, copper, chromium and arsenic. CCA has been used to pressure treat lumber used for decks, playground equipment (playsets) and for other outdoor uses since the 1940s. Since the 1970s, the majority of treated wood used in residential settings has been CCA treated wood.

On February 12, 2002, the EPA announced that the lumbar industry had made the voluntary decision to move consumer use of treated lumber products away from CCA treated wood by December 31, 2003, in favor of new alternative wood preservatives. This transition affects virtually all residential uses of wood treated with CCA, including wood used in play-structures, decks, picnic tables, landscaping timbers, residential fencing, patios and walkways/boardwalks. In addition, the EPA requires new labeling on all CCA products, specifying that no use of CCA will be allowed by the wood-treating industry for residential uses after December 31, 2003. Furthermore, in January of 2004, the EPA banned all CCA products for residential use.

The transition period provided consumers with increasingly more non-CCA treated wood alternatives while the wood treatment industry underwent conversion and retooling of their industrial equipment and practices, while also allowing adequate time to convert treatment plants with minimal economic disruption of the lumber industry. For the most part, wood treatment plants have converted to new alternative wood preservatives that do not contain arsenic.

Despite this shift away from CCA, the EPA asserts that no reason exists to remove or replace CCA-treated wood, including decks or playground equipment. The EPA also notes that some studies suggest that applying certain penetrating coatings (e.g., oil-based semi-transparent stains) on a regular basis (one re-application per year or every other year depending upon wear and weathering) may reduce individuals' exposure to wood preservative chemicals from CCA-treated wood.

There are a number of non-arsenic containing preservatives that have been approved by the EPA to pressure-treat wood for consumer applications (e.g., ammoniacal copper quat - ACQ, and copper boron azole - CBA). Wood treated with these preservatives is available at retail outlets. In addition, playground equipment made of other non-arsenic containing components is also available (e.g., woods such as cedar and redwood and non-wood alternatives such as metals and plastics.

CCA is injected into wood by a process that uses high pressure to saturate wood products with the chemical. CCA is a Restricted-Use product and only people who have received the proper certification and safety training are allowed to purchase and use CCA to treat wood products. CCA is intended to protect wood from dry rot, fungi, molds, termites, and other pests that can threaten the integrity of wood products. Remaining uses of CCA treated wood include highway noise barriers, sign posts, utility posts, and retaining walls. The phase-out of these uses will reduce the potential exposure risk of arsenic, a known

human carcinogen, thereby protecting human health, especially that of children, and the environment.

Also effective December 31, 2003, **ammonical copper arsenate** (ACA) products may only be used for preservative treatment of lumber and timber for salt water uses, piles, poles, plywood, wood for highway construction, poles, piles and posts used as structural members on farms, and plywood used on farms, wood for marine construction, round poles and posts used in building construction, sawn timber used to support residential and commercial structures, sawn crossarms, structural glued laminated members, structural composite lumber, and shakes and shingles. Forest products treated with ACA may only be sold or distributed for uses within the AWPA Commodity Standards under which the treatment occurred.

Other preservatives

Several other "new generation" wood preservatives have been developed, based upon copper solubilized in either ammonium hydroxide or monoethanolamine. Examples include, ammoniacal copper citrate, ammoniacal copper borate, ammoniacal copper quat, copper-8-quinolinolate and copper azole. Studies have shown that wood treated with these preservatives is highly resistant to leaching of the preservative (similar to the currently used CCA) - a highly desirable quality.

Copper-8-quinolinolate (copper-8), is the active ingredient in wood preservatives used for decades in diverse and demanding wood protection applications. Copper-8 containing preservatives have demonstrated outstanding control of mold, mildew and wood decay in a host of industrial, governmental, recreational, and residential environments.

In recent years, copper-8-quinolinolate chemistry has taken on a new role in the wood protection market. Reflecting today's strong focus on personal safety and concern for the environment, copper-8-containing preservatives are finding increasing acceptance as environmentally acceptable alternatives to such commonly used preservatives as chromated copper arsenate (CCA) and pentachlorophenol.

Copper-8 chemistry is unique in that it has earned the approval of the Food and Drug Administration (U.S. FDA) for use in indirect food contact applications. EPA-approved copper-8 chemistry also meets all state and federal air quality regulations and will not leach into the ground. Copper-8 chemistry is used extensively in seed preservatives for a variety of crops in the agricultural products field.

Ammoniacal copper quat (ACQ) and **copper azole** (CA) are the two existing wood preservatives most likely to replace CCA for non-industrial applications starting in 2004

- **Ammoniacal Copper Quat (ACQ-A, B, C)** - The preservative effects of copper are combined with a low toxicity co-biocide to achieve durability levels equivalent to copper/arsenic preservatives, with no impact on the mechanical properties of wood. A preservative containing ACQ-A is marketed under the brand name **ACQ Preserve**, by Chemical Specialties, Inc. (CSI).
- **Copper Azole-Type A (CBA-A)** - This new generation preservative contains copper and boron, and is marketed as **Wolmanized Natural Select** by Arch Wood Protection (formerly Hickson).

Wood products treated with borates are also available. However, borate-treated wood may not be used outdoor because they do not bond well to wood and are therefore readily leached from wood when exposed to moisture, thus leaving the wood unprotected. Borate-treated wood is well-suited for applications that are protected from exposure, like sill plates.

- **Borate Oxide (SBX)** - Boron compounds are well known, non-toxic preservatives. Wood products treated with SBX are not recommended for direct ground contact, but can effectively preserve wood for other applications like deck surfaces or furniture. Brand name products include **AdvanceGuard** lumber by Osmose, Inc. and **Smart Guard** products from Louisiana Pacific.

Amine Copper Quat (ACQ-D) - This product contains active ingredients similar to ACQ-A, B, C, but uses ethanolamine instead of ammonia as the solution carrier. Lumber treated with this preservative is marketed as **Nature Wood** by Osmose, Inc.

Copper Napthenate is made by reacting copper salts with naphthenic acid (a petroleum by-product). It is a viscous, dark blue/green liquid, soluble in petroleum solvents and should contain 6% to 8% copper by weight. It can also be produced in water-emulsifying form but is normally in heavy or light petroleum oils.

The product is a good wood preservative for preventing decay and has the advantage of being safe for use near growing plants (after drying). Treated wood has a distinctive green color which fades in sunlight. It is applied to lumber used for greenhouses, yard and landscape timbers, seed and mushroom boxes.

Similar to copper napthenate, **zinc napthenate** is available to the wood preservation industry but has fewer fungicidal qualities. The zinc salt does have an advantage of being almost colorless.

The following are some advantages and disadvantages to using the “new generation” wood preservatives discussed above:

Advantages:

- Most of the water-borne preservatives have no hazard from fire or explosion.
- For the most part, the wood surfaces where the water-borne preservatives are uses are left clean, paintable, and free of objectionable odors.
- Most of the products are safe for use in interior locations within homes and buildings and can be used on playground equipment.
- Most of these preservatives are fairly leach resistant.

Disadvantages:

- Unless re-dried after treatment, water-borne preservatives can leave the wood subject to warping and checking.
- Most of the new generation preservatives are not as good as CCA treated lumber and therefore, don't protect the wood from excessive weathering.

Prevention of destruction by fire and weathering

Each of the wood preservatives described above is capable of preventing certain types of biological degradation. However, there is also concern about the physical degradation of wood by fire and weathering which ultimately has the same effect as biological decay. The only difference between biological and physical deterioration is the source of the energy which causes it. Biological decay is trigger by the release of enzymes which breakdown the wood, whereas physical decay from fire relies on heat; energy for weathering is derived from light, wind, rain, frost and/or heat.

The **chemical treatment used to protect wood from fire** is accomplished with a **fire retardant treatment (FRT)**. Fire retardant formulations are used to change the behavior of the wood in a fire. Certain chemicals, especially **ammonium salts, borates, phosphates, bromides and antimony oxides** can help to prevent or reduce ignition and flaming of wood.

Chemical treatment used to protect wood form weathering is desirable for exposed wood that is adversely affected by the sun's heat and UV rays, or rain, ice, wind and dust. Birds often peck holes in outdoor wood, and some insects may remove the surface wood fibers to build their nests "(paper wasps"). To prevent this, weathered surfaces may be protected by using one to two coats of a water repellent liquid which contains **waxes and resins**. Wood finishes are also available to help prevent weathering of desirable wood.

Application of Wood Preservation

Preparation of wood for treatment

Most wood preservatives require some preparation of the wood prior to application. This preparation may include peeling, drying, conditioning, incising and cutting.

- **Peeling –** The bark and cambium must be completely removed before treatment. This assures that the preservative will penetrate into the wood. Bark obstructs penetration, which results in non-uniform treatment and/or possible untreated areas.
- **Drying –** In most treating methods, high moisture content prevents or slows entrance of the preservative into the wood cells. Drying the wood allows better penetration of the preservative and reduces product weight and shrinkage which aids in reducing the potential of warping and checking after treatment. Kiln-drying is one method which uses controlled drying conditions to speed drying.
- **Conditioning –** Is a steaming-and-vacuum process, whereby, green wood is steamed in a cylinder or retort chamber for several hours, and then subjected to a vacuum. The vacuum reduces the boiling point of water in the wood and speeds its removal. Then the evaporated water is replaced by a preservative which is applied under pressure.

  Another method of conditioning green wood is boiling under vacuum (Boulton method). The wood is placed in a treating cylinder and submerged in hot oil. Then a vacuum is applied, which removes water from the wood. With this method, wood can be conditioned at a lower temperature. Therefore, the Boulton method can be used to avoid damage to sensitive wood species (i.e. Douglas fir) that may be affected by the higher temperatures of the steaming-and–vacuum process.

  A third method of conditioning is known as vapor-drying. In this process, green wood is exposed to hot vapors of an organic compound, such as xylene, which gradually vaporizes the water and removes it.
- **Incising –** Incising consists of making a series of narrow holes or slits in the wood about one-half to three-fourths inch deep. This allows preservatives to better penetrate impregnation-resistant wood species (i.e. Douglas fir). Incising makes possible a more uniform penetration to at least the depth of the incisions.
- **Cutting –** Cutting, shaping or drilling wood after treatment can expose untreated wood. This exposure can be avoided by cutting, shaping or boring the wood for its intended use before the preservative treatment. The treated wood can then be used without further machining.

Flow of Liquids into Wood

Thus far we have learned about the structure of wood and how liquids flow through cells of live trees. With regard to treating, we must now consider how these same cells function when liquid preservative is forced into them. When considering wood preservation, two facts must be realized:

1. No matter what shape or size the wood is, **preservatives can only enter from the outside**. So the behavior of the outer cells is crucial in wood preservation. If they do not accept the preservative, the preservative cannot penetrate into interior wood cells.
2. If the wood is so wet (i.e. with a high MC) that **nearly all the cells are full of "free water", preservatives cannot be forced into wood** so penetration and absorption will be negligible. The "free water" evaporates when wood is dried to about 30% MC.

Softwoods

In softwoods, liquid preservative will mainly enter sawn wood at two locations; the "cross-sectional face" (transverse face) and the tangential face.

Cross-sectional faces expose end-grain or open tracheid cells to the liquid. These tracheids, acting as hollow tubes, readily accept liquid. Their small diameter actually encourages "suck-in" of the liquid by capillary action. The liquid will pass through holes or pits in the cell walls into adjoining tracheids.

Tangential faces expose open ends of ray tracheid cells to the liquid. The rays are also capable of capillary absorption of liquids, so they accept and transport the liquid in a radial direction to the interior portion of the wood.

In both cases, as the liquid is moved by capillary suction in the cells, air in the cells escapes through wider cells or is compressed within the cell, which allows space for more liquid to move into the cells. As this occurs more liquid is absorbed, allowing the wood to receive a good volume of liquid, eventually, most of the cells receive some liquid.

Hardwoods

As with the softwoods above, the same actions take place in the cross-sectional and tangential faces of hardwood. However, unlike softwood, hardwood is made up of **fibers**. Fibers respond differently because they are narrow, sealed cells, which play no part in sap movement of living hardwood trees. The exposed transverse sections of cut wood can readily accept liquid by capillary suction, but cannot pass it on to other fibers. Consequently these fibers will not normally receive liquid from the transverse section.

So what does this mean for hardwood preservation? Hardwoods will absorb a significant amount of liquid, mainly in the vessel segments (large cavities which are joined end-to-end with other vessel segments, which form long tubes) and ray cells. However, a significant portion of the internal sections of hardwood may not receive any liquid because of the fiber areas.

From a preservation standpoint, this leaves a lot of unprotected cells, predisposing them to decay. Hardwoods obtain their principal strength from these fiber areas.

Methods of applying wood preservatives

There have been almost as many methods for applying wood preservatives as there are different preservatives. Only the ones in current use will be discussed in this chapter. The treatment method chosen depends on the ultimate use of the product. The two major types of wood preservative treatment are pressure and non-pressure treatments. Many variations of these methods are described in the standards and specifications of the AWPA, the federal government, and other organizations.

Pressure Processes – We might expect wood to be easily treated due to its porous structure, but as stated above, wood can be surprisingly resistant to deep penetration by preservatives. Basically, the pressure process involves the placement of wood in an airtight steel cylinder or retort chamber, immersing the wood in a preservative, and pressurizing the chamber to force the preservative into the wood.

Impregnation of preservatives by pressure is the most common method used in commercially treated wood. It has several advantages:

- It gives a deeper and more uniform penetration.
- It allows better control of preservative retention.
- Wood can be preconditioned in the chamber.
- It’s quicker and more reliable than non-pressure methods.
- It can comply with code regulations and engineering specifications.

There are two basic variations of the pressure treatment method: the **full cell** process and the **empty cell** process.

FULL CELL: In the full cell process, the wood that is to be treated is placed in the treatment chamber. The air is then removed from the chamber to create a vacuum. This vacuum condition in the chamber causes the cells that make up the wood, to release the gases they contain. How much gas and from what depth within the wood these gasses are removed is determined by the type of wood, the strength of the vacuum, the length of time the vacuum is maintained, and other factors. The wood preservative is then pumped into the chamber under hydraulic pressure and forced into the wood cells. This process is usually used when the finished wood product will be exposed to extreme conditions. This process is used for most of the pressure treatments using CCA and PCP preservatives and a good proportion of the treatments with Creosotes.

EMPTY CELL: In the empty cell process, the wood that is to be treated is placed in the treatment chamber. The chamber may be operated at normal atmospheric pressure or slightly pressurized. The wood preservative is then pumped into the chamber under hydraulic pressure and forced into the wood. The empty cell process treats only the cell walls of the wood. This process requires less preservative than the full cell process. This process is usually used when the finished wood product won't be exposed to extreme conditions.

With either method, it's important to closely follow established standards on:

- Preparation of the wood product to be treated.
- Amount and duration of vacuum and of pressure.
- Solution temperature (when critical).
- Treatment time.
- Type of preservative.
- Concentration of the preservative.

However, note - there are several other vacuum pressure methods being used by America's pressure treating industry and they are the Modified Full Cell Process, Lowry Process and the Rueping Process.

Non-Pressure Processes – Non-pressure methods may be satisfactory where deep penetration, high levels of retention and precise treatment are not required. The effectiveness of non-pressure methods depends on the kind of wood, its moisture content, method and duration of treatment, and the preservative used. Brushing, spraying, pouring, dipping, or cold-soaking seldom provide adequate penetration and retention of the preservative to protect wood that is in direct contact with the ground.

There are many methods of applying preservatives to wood without the use of pressure. These methods were commonly used on farms and in other do-it-yourself projects prior to common preservative chemicals being classified as Restricted-Use.

Brushing, Spraying and Pouring Treatments are used when creosotes, oil-borne preservatives or water-borne preservatives are applied to the surface of wood. The wood should be thoroughly dried before treatment, and if oil-borne preservatives are used, the wood should be warm enough to avoid congealing the oil. Penetration by dipping or spraying is superficial, resulting mostly from capillary action, so only limited protection is afforded. The preservative should be flooded over the wood surfaces and be allowed to soak in. Two applications are desirable, but the second should not be applied until the first has soaked into the wood and dried. Brushing, spraying or pouring treatments probably are most widely used for protecting areas of previously treated wood that have been cut or machined, thereby exposing untreated surfaces or joints.

Note-all of the heartwood and much of the sapwood is left unpreserved by brushing or spraying methods. The ground line where a fence post enters the soil is the location where the combination of air, moisture, bacteria and fungi meet the wood. It is in this location where the greatest risk of decay exists. Even a shallow split in the post will expose untreated wood, and allow decay to start. These treatment methods are poor for preserving wood used in locations prone to decay.

Dipping consists of immersing wood in a preservative solution for several seconds to several minutes. As with brush type applications, the wood should be well dried before treatment. Although dipping is better than brushing for penetration of preservatives into the checks and cracks of wood surfaces and may add two to four years protection over untreated wood, dipping is unsatisfactory for uses subject to abrasion. Probably the main use of dipping is for window frames, which are dipped for three minutes.

Cold soaking is commonly used for treating round or cut fence posts and timbers. It uses pentachlorophenol or other viscous oil borne preservatives. The process involves soaking dried wood for two to seven days in a vat containing the unheated liquid preservative.

The **steeping** process employs a water-borne salt preservative solution applied to either dry or green wood. It consists of submerging the wood in a tank of the solution at atmospheric pressure for several days or weeks (heating the solution accelerates penetration). Absorption is rapid the first three days, and then continues at a decreasing rate almost indefinitely. When flat sawn wood products are to be treated, space should be provided around each piece of wood to permit complete exposure to the preservative solution.

The **hot-and-cold bath (thermal process)**, also called the boiling-and-cooling or open-tank treating method, is suitable for oil based and water borne preservatives. When used properly, the method provides a reasonably effective substitute for pressure impregnation. The process is quite simple, involving the use of one or two tanks. With two tanks, the wood product is first immersed into a hot solution, usually of the preservative or even boiling water, followed by its immersion into a tank of cold preservative. This thermal process is used mainly for treating poles with creosote mixtures.

Treatment by **double diffusion** is a two-stage dispersion of a preservative liquid into wood. An example of the process would be to first soak a green wood product, such as a post, in a solution of copper sulfate. When a sufficient amount of the chemical has diffused into the wood, it is then immersed in a second solution consisting of sodium arsenate and sodium chromate. When copper sulfate is exposed to the sodium arsenate and the sodium chromate, a chemical change occurs that converts these soluble, leachable salts to more stable preservative compounds within the wood. The purpose of double diffusion is to convert very leachable, chemical salt solution into fixed and stable preservatives within the wood that will not leach out of the wood.

In the **vacuum process**, wood products are enclosed in an airtight container from which air is removed with a vacuum pump. The container is then filled with the preservative without additional pressure and without the air re-entering. The partial removal of air from the wood by vacuum, followed by the addition of the preservative, creates a slight pressure that drives the preservative into the wood. Vacuum treatments work well with pentachlorophenol, easily treatable woods, and products like pine window stock. Incising, steaming and Boultonizing are three pre-treatment processes used with vacuum pressure treatments. However, steaming is not used as extensively as it once was in the vacuum pressure treating industry.

Treatment on site; there are several ways to use this concept:

- ✓ The preservative can be applied to the surfaces of wood, injected into wood, or placed into holes drilled in wood. The preservative used can be water borne, oil borne, in mineral solvent, or have a consistency of grease or mayonnaise.

  This method is most often used to extend the life of standing poles that had been previously treated. A detailed discussion of utility pole re-treatments can be found in the section on “Re-treatment of Utility Poles”.

Factors Influencing the Effectiveness of Wood Preservatives

There are many regulations and various agencies that govern the preservative treatment of wood and influence where, when and how it can be used in construction. These regulations, for the most part, are incorporated in building codes and standards.

- **Building codes**, in addition to other construction regulations, dictate the conditions under which treated wood must be used. Building codes are ordinances written to protect the life and safety of a building's occupants, and the public. They govern the materials and building practices to be used in construction throughout the country. Examples of U.S. building codes include the Uniform Building Code (ICBO), Basic Building Code (BOCA) and the Standard Building Code (SBCCI).
- **Standards** detail how wood should be preserved. Federal Specification TT-W-571 and the standards of the American Wood Preservers Association (AWPA) are commonly used by the wood preserving industry and consumers of treated wood. The AWPA and other specifications establish the standards for the wood preserving process and ensure the suitability of specific applications. The AWPA are the most comprehensive, up-to-date, and detailed wood pressure preserving standards available anywhere in the world. They specify all factors relating to pressure preservative treatment for most end-uses of treated wood. The standards also list the wood species and preservative retention recommendations. All wood preservers are advised to obtain a copy of the current AWPA standards. Examples of some other standards for treated wood are the Permanent Wood Foundation (PDN) and American Wood Preserver's Bureau (AWPB).

Penetration

The effectiveness of a wood preservative depends on several treatment factors, one of which is the penetration depth of the preservative. Inadequate chemical penetration may allow fungi and insects the opportunity to enter through checks and cracks, thereby bypassing the thin treatment layer, allowing them to reach the inner unprotected wood.

The depth of penetration attainable by a wood preservative depends on the wood species, the proportion of sapwood to heartwood, the condition of the wood (wet or dry) and the treatment process used. The sapwood of most species is easily penetrated when it has been well dried and pressure treatment is used. The treatment of heartwood is much more variable than that of sapwood. For instance, the heartwood of southern yellow pine and maple can be impregnated to depths of about one-fourth to one-half inch. Red oak heartwood can be completely penetrated, whereas it's almost impossible to penetrate the heartwood of white oak or western red cedar.

Retention of preservatives

Even with proper penetration, good protection can't be achieved unless enough preservative remains in the wood. Retention is measured in **pounds per cubic foot** (lbs./cu. ft.) of wood. For example, the minimum retention of creosote for lumber used in coastal salt waters is 25 lbs./cu. ft. (AWPA C-2), while for similar wood products in fresh water, only 10 lbs of creosote/cu. ft. is required.

Wood conditioning selection

Federal Specification TT-W-571 and the AWPA identify wood species that are acceptable for treatment for various uses. Selection of species or grade of wood for a particular use should be based on the application grading rule. These rules take into consideration wood characteristics such as knot sizes, warp, splits and grain that may limit some uses.

As discussed earlier in this manual, the proper drying and conditioning of wood before treatment significantly improves the effectiveness of the treatment.

Handling after treatment

Treated wood should be handled with sufficient care to avoid cutting or breaking through the treated area and exposing the underlying untreated wood.

Throwing, dropping or gouging treated wood may cause damage that exposes untreated wood. When damaged in this way, the exposed wood should be re-treated. This is usually done by brushing. When treated wood is machined, thereby exposing untreated wood (such as by boring or cutting the ends of piles after driving), a prescribed preservative should be applied to the exposed wood (AWPA M-4 standards).

End use

Treated wood that is used for a purpose for which it was not intended may result in unsatisfactory service life.

This is mainly a result of differences in specified penetration and retention levels. For example, pilings treated to meet specifications for fresh water should not be used in marine waters. Some end uses will place a greater physical stress on treated wood than others resulting in a shorter service life of the wood. The cost of replacement for some end uses may justify periodic re-treatment of the wood on site to prolong its service life (utility poles, for example – see the Re-treatment of Utility Poles section).

Protecting Human Health

Most chemicals used to protect wood from insects and decay must be toxic to be effective. The goal is to select chemicals and methods that will control the pests without harming the applicator, the user, the public, pets, plants, or the environment.

It is the responsibility of the Principal or manager of any wood preserving operation to ensure that the proper handling procedures, protective clothing, and necessary safety equipment are provided to workers, to protect their health and to conform with label instructions and Nevada's pesticide application laws (i.e. NAC 555.440). This section re-caps what is presented in the Nevada Department of Agriculture's general study manual Vol. I, about protecting human health, but will focus in more detail on wood preservation.

The EPA approved label on product containers, including wood preservatives, is the primary source of information about application methods, precautionary measures, emergency first aid, and disposal instructions.

The preservative's label is a legal document, and its provisions are enforced by the Nevada Department of Agriculture and the U.S. EPA. Therefore, make sure that labels for each formulated product used in your wood treatment operation are readily available; all responsible personnel should be thoroughly familiar with their contents.

Hazards to applicators

All handlers of wood preservatives must know about the potential hazards and the precautions necessary when working with these chemicals. Those who apply the chemicals are most subject to excessive exposure through application and volatilization; those who use the wood are at far less risk from preservative exposure. Therefore, it's especially important for those who apply preservatives and handle recently treated wood to minimize their exposure to these chemicals.

> The decision by the EPA to classify three of the major wood preservatives – creosote, inorganic arsenicals and pentachlorophenol – for Restricted-Use was based on the potential human risk from chronic toxicity.

Exposure to wood preservatives can occur in a variety of ways: during mixing and handling, carelessly entering pressure treatment cylinders, working around preservative spraying or dipping operations, handling freshly treated wood, cleaning or repairing equipment, or disposing of wastes. Closed systems for handling the chemicals and mechanically handling treated wood reduce potential exposure but do not eliminate accidental exposure for workers.

Like other pesticides, wood preservatives can enter the body through the mouth (oral), through the skin or eyes (dermal), or through inhalation (respiratory). Since most preservatives have a strong odor and taste, accidental ingestion of a dangerous amount of these chemicals is unlikely. The more likely routes of exposure are through skin contact, or by inhaling preservative vapors, dust, or other contaminated particles.

Skin varies in thickness and other characteristics from one place to another on the body. Skin also varies in its ability to absorb chemicals. The eye, eyelids, and the groin area will absorb almost 100 percent of some chemicals while the hand, especially the palm, will absorb less than 10 percent of the same chemicals. The addition of organic solvents to any preservative will enhance its ability to penetrate human skin.

Human lungs consist of a very large, membranous surface area well supplied with blood vessels. Chemical vapors or minute liquid droplets breathed into the lungs will be rapidly absorbed into the bloodstream.

Toxic effects of preservatives

The toxic effects of chemicals can be either "acute", based on high level, short term exposure; or they can be "chronic", based on low level, long term exposure. Human exposure to preservatives can produce both acute and chronic toxicity (see the General Study manual for more information on toxicity of pesticides).

Use pesticides safely!

- Read the pesticide label— even if you have used the pesticide before. Follow the instructions on the label closely as well as any other directions you have.
- Wear protective clothing and safety devices as recommended on the label. Bathe or shower after each use.
- Be cautious when you apply pesticides. Know your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide misuse.

The decision by the EPA to classify the three principal wood treatment preservatives as Restricted-Use is based on evidence that:

- Creosote causes cancer in laboratory animals and has been associated with skin cancer in some workers occupationally exposed to creosote.
- Creosote and inorganic arsenicals also cause mutagenic effects in bacteria and laboratory animals.
- Arsenic has been shown in epidemiology studies to be associated with cancer in humans who either drank water contaminated with arsenic or breathed air containing arsenic.
- Pentachlorophenol has produced defects in the offspring of laboratory animals.
- A dioxin contaminate (HxCDD) in pentachlorophenol has been shown to cause cancer in laboratory animals.

Because of the potential hazards of these preservatives, there are new label requirements for their handling and end use. In addition to the potential hazards of chronic toxicity, a single or short term exposure can cause the following acute effects:

- ✓ **Creosote** can cause skin irritation; vapors and fumes are irritating to the eyes and respiratory tract. (Repeated, chronic exposure, may lead to dermatitis.)

- ✓ **Pentachlorophenol** is irritating to eyes, skin, and respiratory tract; ingestion, inhalation or excessive skin contact may lead to fever, headache, weakness, dizziness, nausea, and profuse sweating. In extreme cases, coordination loss and convulsion may occur. High levels of exposure can be fatal.
- ✓ Exposure to high concentrations of **inorganic arsenicals** can cause nausea, headache, diarrhea, and abdominal pain (if swallowed). Extreme symptoms can progress to dizziness, muscle spasms, delirium and convulsion. Long term (chronic) effects can include liver damage, loss of hair and fingernails, anemia and skin disorders.

Protecting the applicator

Anyone working with wood preservatives will be exposed to these chemicals to some extent, but the exposure can be minimized by following the directions on the preservative label and developing good work habits.

Personal hygiene - Basic, commonsense hygiene rules can significantly reduce the risks of chronic exposure to wood preservatives. For example:

- Wash hands often, especially before using the restroom, smoking, or eating.
- Do not eat, drink, or smoke in the work area — these activities will increase the amount of preservative absorbed into the body.
- Remove gloves to handle paperwork, phones, or equipment that others may handle with unprotected hands.
- Launder protective clothing at the work site. If work clothes must be laundered at home, wash them separately from other laundry.

Protective equipment and clothing - The pesticide label will specify the type of protective equipment and clothing that should be worn when working with wood preservatives. If skin contact is expected (for example, handling freshly treated wood or manually opening pressure treatment cylinders), the label will specify the use of impermeable gloves.

Leather may protect hands from slivers, but leather gloves do not protect the wearer from wood preservatives! In fact, preservative contaminated leather gloves definitely will contribute to the amount of preservative absorbed into the body.

Individuals who enter pressure treatment cylinders or other related equipment contaminated with wood treatment solutions must wear protective equipment that does not allow the wood treatment solution to penetrate. This includes overalls, jacket, gloves, boots, and respirator.

Respirators must be approved by the Mine Safety and Health Administration and the National Institute for Occupational Safety and Health (MSHA/NIOSH), and they must be properly fitted and maintained.

Special precautions – The following are special precautions for pentachlorophenol and inorganic arsenicals.

Pentachlorophenol

- For prilled, powdered or flaked formulations of pentachlorophenol, a closed system must be used when emptying and mixing such formulations.
- For the spray method of application, spray apparatus must be operated to minimize overspray (no visible mist) and be free of leaks in the system. Should there be visible mist in the spray zone, applicators must wear respirators and protective clothing indicated by the label.

Inorganic arsenicals

- All exposed arsenic treatment plant workers will be required to wear a respirator if the level of ambient arsenic is unknown or exceeds a permissible exposure limit (PEL) of 10 micrograms per cubic meter of air (ug/m^3) average over an eight hour work day. This PEL is the same as the standard required by OSHA.
- Processes used to apply inorganic arsenical formulations will leave no visible surface deposits on the wood. Small, isolated or infrequent spots of chemical on otherwise clean wood will be allowed.

First Aid

Since accidents do happen, first aid information on the chemical(s) in use must be readily available. The product label provides basic first aid directions, as do Material Safety Data Sheets supplied by the chemical manufacturers. Take the following steps if accidental exposure to wood preservatives occurs:

- In cases of skin contact, first remove contaminated clothing in contact with the skin and immediately wash the affected skin areas with mild soap and water. Do not irritate the skin with vigorous scrubbing. If you notice skin inflammation later, consult a physician.
- In cases of eye exposure, immediately flush the eyes with running water. Lift the upper and lower eyelids for complete irrigation and continue for 15 minutes; then see a physician.
- If accidental inhalation occurs, move the victim to fresh air and apply artificial respiration as needed. *Get medical help immediately!*
- Accidental ingestion of any wood preservative requires immediate medical attention. If creosote or penta is swallowed — and if the person is conscious — give one or two glasses of water, induce vomiting, and then administer two tablespoons of “USP Drug Grade” activated charcoal in water. *Never attempt to administer anything orally or induce vomiting to an unaware or unconscious person.*
- If an arsenical chemical has been swallowed, the victim should drink large quantities of water or milk. *Get professional medical help immediately!*
- Acute toxicity symptoms for all three preservatives usually are noticed soon after exposure and usually are treatable if first aid is administered quickly.

Limitations on use

EPA regulations on wood preservatives include some limitations on treating wood intended for certain uses, and on certain uses of treated wood. Not all the limitations are the responsibility of commercial treaters, but all wood treaters should understand these limitations. The following points outline some use limitations on wood preservatives.

- Inorganic arsenicals, primarily CCA treated wood, were presented previously in the section "Chemical Controls".
- Pentachlorophenol and creosote must not be applied indoors.
- Pentachlorophenol and creosote treated wood must not be used where there may be contamination of feed, food, or drinking or irrigation water.
- Pentachlorophenol must not be applied to wood intended for use in interiors, except for millwork (with outdoor surfaces) and support structures that are in contact with soil in barns, stables, and similar sites and that are subject to decay or insect infestation. A sealer must be applied in those instances.
- Creosote must not be applied to wood intended to be used in interiors, except those support structures that are in contact with soil in barns, stables, and similar sites and that are subject to decay or insect infestation. Two coats of an acceptable sealer must be applied.
- Application of pentachlorophenol to logs for construction of log homes is prohibited.
- Pentachlorophenol and creosote applied to wood intended to be used where it could be exposed to body contact requires a sealant to be applied (as indicated above, these products are not approved for interior use)

Material Safety Data Sheets (MSDS)

Material Safety Data Sheets are available from the manufacturers and distributors of the wood preservatives they sell. Each MSDS provides information about the toxicity, first aid, protective equipment, storage and handling precautions, disposal procedures, transportation, spill and leak procedures, etc. for a specific product.

All licensed wood preserving companies operating in Nevada must, according to Nevada OSHA, have an MSDS on file for each type of formulation they use. Pest control laws and regulations do not require an applicator to have MSDS's in their possession. However, the Nevada Department of Agriculture requires a complete label of each product in the possession of the applicator (NAC 555.445.3).

Voluntary Consumer Awareness Program

The treated wood industry has developed a voluntary Consumer Awareness Program (CAP) designed to inform the consumer about the proper uses of treated wood and the proper precautionary measures to take when using treated wood. The wood treatment industry is committed to the implementation of the CAP and consumer education. The wood treatment industry has developed a model Consumer Information Sheet (CIS) containing use site precautions and safe working practices for each of the three types of preservatives. The CIS serves as the main vehicle for conveying information about treated wood to consumers.

The focus of the CAP is to ensure the dissemination of the CIS at the time of sale or delivery to end users. Wood treaters assume primary responsibility for dissemination of the CIS to consumers.

The following wording appears on the Consumer Information Sheets for the three "Restricted Use" chemicals:

Wood pressure-treated with an inorganic arsenical

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. Human exposure to inorganic arsenic may present certain hazards; therefore, the following precautions should be taken when handling the treated wood, in determining where to use the wood, and in disposing 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 preservatives may become a component of food or animal feed in such sites as structures or containers used to store 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 in patios, decks, and walkways.

Do not use treated wood for construction of those portions of beehives that 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 collections or burial. Treated wood should not be burned in open fires, wood 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 (for example, 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 or machining, wear goggles to protect eyes. After working with the wood, and before eating, drinking, or using tobacco products, wash exposed body areas thoroughly. If preservatives or sawdust accumulate on clothes, launder before reuse.

Wood pressure-treated with creosote

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 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.

As previously indicated, creosote treated wood is not intended for use in residential interiors. Creosote treated wood in interiors of industrial buildings should be used only for components that are in ground contact and are subject to decay or insect infestation. 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 the wood may be in direct contact with domestic animals or livestock that may crib (bite) or lick the wood. In interiors of farm buildings, where domestic animals or livestock are unlikely to crib or lick the wood, creosote treated wood may be used for building components that are in ground contact and are subject to decay or insect infestation; however, two coats of an effective sealer must be applied. Sealers may be applied at the installation site. Urethane, epoxy, and shellac are acceptable sealers for all creosote treated wood.

Do not use treated wood for fowling or brooding facilities. Do not use treated wood under circumstances where the preservative may become a component of food or animal feed in structures or containers used 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, or walkways. Do not use treated wood for construction of those portions of beehives that may come in contact with the honey.

Creosote treated wood should not be used where it may come into direct or indirect contact with public drinking water or 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, wood 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 (for example, 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 or machining, wear goggles to protect eyes.

Avoid frequent or prolonged skin contact with creosote treated wood. When you handle the treated wood, wear long sleeved shirts and long pants. Use gloves that are impervious to the preservative (for example, gloves that are vinyl coated). When power sawing or machining, wear goggles to protect your eyes. After working with the wood, and before eating, drinking, or using tobacco products, wash exposed body areas thoroughly. If preservatives or sawdust accumulate on clothes, launder before reuse.

Wood pressure-treated with pentachlorophenol

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 used both when handling treated wood and in determining where to use the treated wood.

Use site precautions - Logs treated with pentachlorophenol are not to 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 effective sealer has been applied.

Pentachlorophenol treated wood is not to be used in residential, industrial, or commercial interiors except for laminated beams or building components that are in ground contact and are subject to decay or insect infestations and where two coats of an appropriate sealer are applied. Sealers may be applied at the installation site.

Wood treated with pentachlorophenol is not to be used in the interiors of farm buildings where the wood may be in direct contact with domestic animals or livestock that may crib (bite) or lick the wood. In interiors of farm buildings, where domestic animals or livestock are unlikely to crib or lick the wood, pentachlorophenol treated wood may be used for building components that are in ground contact and are subject to decay or insect infestation; however, two coats of an effective sealer must be applied. Sealers may be applied at the installation site. Urethane, shellac, latex epoxy enamel, and varnish are acceptable sealers for pentachlorophenol treated wood.

Do not use pentachlorophenol treated wood for fowling or brooding facilities. Do not use treated wood under circumstances where the preservative may become a component of food or animal feed in structures or containers used 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, or walkways. Don't use treated wood for construction of those portions of beehives that may come into contact with the honey.

Pentachlorophenol treated wood must not be used where it may come into direct or indirect contact with public drinking water or 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, wood 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 (for example, 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. When power sawing or machining, wear goggles to protect your eyes.

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

After working with the wood, and before eating, drinking, or using tobacco products, wash exposed body areas thoroughly. If oily preservatives or sawdust accumulate on clothes, launder before reuse.

Treatment of Waste

Waste disposal

Wastes from preservative treating operations can kill plant life and harm aquatic life if it enters waterways. Oils and organic solids damage aquatic life by reducing aquatic plants which produce oxygen.

Some treating plants discharge their wastes into approved municipal sewer systems for processing along with municipal wastes. Many sewer plants use closed chemical and wastewater recovery systems to contain potentially harmful wastes. Solutions which are recovered may be used again. If they are contaminated, they can be filtered to remove solid wastes. Liquid waste materials may be diverted to settling ponds.

Door sumps should be used under pressure chamber doors and under hard surfaced drainage areas. Any excess chemicals that drip or are rinsed from freshly treated material are thus channeled into the waste or recovery system. It also is important to contain the runoff from areas where toxic chemicals are used.

Remember to read the preservative label carefully for disposal information. The U.S. EPA requires treatment facilities to meet certain disposal standards. The EPA also requires that treatment plants obtain permits for discharging excess chemicals. Compliance with the label and EPA regulations should assure proper environmental protection.

Storage and disposal of containers

Packaged chemicals should be stored in a dry, well ventilated, securely locked area. Keep them in well sealed containers whenever possible. Protect liquid storage against tank rupture. Wherever spills, leaks, or flooding could occur, be sure that runoff will drain into a recovery or disposal system.

Protect concrete vats against freezing, cracking, or spillage. Thoroughly rinse containers and empty them into storage or treating tanks before disposal. Dispose of the containers at an approved landfill or by other approved means. Be particularly careful not to contaminate streams or groundwater.

Be sure to read and follow the label requirements and the Material Safety Data Sheet (MSDS) for each preservative. If you are in doubt about how to safely store a product or dispose of an empty container, contact the chemical supplier or the Nevada Department of Environmental Protection (NDEP) and the local fire department’s hazardous waste division for storage and container disposal.

Spills

Correct cleanup procedures depend on the chemical involved. Treatment plant personnel should know what chemicals are being stored and used, and they should have an advance plan for handling spills. All workers who might be involved should know what help is available and who to notify in case of a major spill.

Environmental exposure

It is not only people who can suffer from the careless use or disposal of wood preservatives - your community's environment may also suffer. Creosote, pentachlorophenol, and inorganic arsenicals are toxic. They must be toxic to kill or repel the fungi, insects, and marine borers that destroy wood. Unfortunately, these chemicals are not selective; they can harm non-target organisms.

Contaminated runoff can pollute lakes, streams, and wetlands, thereby damaging habitat for fish and wildlife. Specifics vary, but pentachlorophenol, creosote, and inorganic arsenicals are all toxic to fish and other wildlife.

- ***Pentachlorophenol***

This chemical is extremely toxic to fish. Exposure to penta concentrations in the parts per billion range can cause death within minutes for many species of salmon and trout.

Circumstantial evidence, including the identification of penta in rainwater, indicates that penta may occasionally be present in ambient air. Low levels of this compound have been detected in both wastewater and surface water.

While the source of these residues often is unclear, it has been suggested that, Penta may naturally occur in aquatic environments by degradation of organic compounds.

Penta is moderately persistent in aquatic environments. Six months after an accidental spill, it was reportedly detected in lake water and fish.

Penta is also moderately persistent in the soil. Persistence reportedly ranges from 21 days to 5 years. Under most conditions, penta will seldom persist in soil for periods exceeding 9 months because many soil microorganisms have been identified that are capable of degrading penta.

Since the major uses of penta do not involve soil application, the likeliest source of soil contamination is through leaching or bleeding of the preservative from treated wood. This may result in low levels of penta contamination in the immediate vicinity of the treated wood.

Significant accumulation of penta in plants and mammals is not likely to occur because penta is not translocated in plants, and it is rapidly metabolized and eliminated by mammals following exposure.

- ***Arsenicals***

In aerobic soils, Arsenate, bonds tightly to the soil particles thereby making it unavailable for plant uptake or leaching. It is for these reasons that it is not know as an environmental contaminant.

- ***Creosote***
  During the production of this manual, no reports were found which would indicate Creosote as a hazard to wild or domestic animals. The amount of creosote that enters the environment as a liquid is relatively small. The fate of creosote in the environment is not fully understood, but it is believed that most of its components are quickly biodegraded.

Groundwater pollution

Decades of wood preservative use in many parts of this county have been cited as the source of pollution in surface and groundwater. Some of the contamination has come from obvious sources such as spills or illegal discharge of chemicals into ditches, storm drains, or sewers. Another less obvious source is the uncontained drippings from freshly treated wood.

Although preservative pollution of surface water is more obvious and can be a serious problem, groundwater pollution potentially is a very serious problem. In many communities, groundwater is the only source of drinking water. When groundwater becomes contaminated with any chemical, cleanup - where possible - is very difficult and costly. Testing has documented contamination in some public and private wells at levels exceeding health advisories.

Groundwater typically is affected by contamination of the overlying soil and the eventual leaching of the preservative into the groundwater. Such contamination is usually the result of applying preservatives directly to soil, spills, overflow from tanks or holding ponds, and improper disposal.

To reduce the chance of environmental contamination, proper protective measures must be an integral part of all wood preservation operations.

Re-Treatment of Utility Poles

Introduction

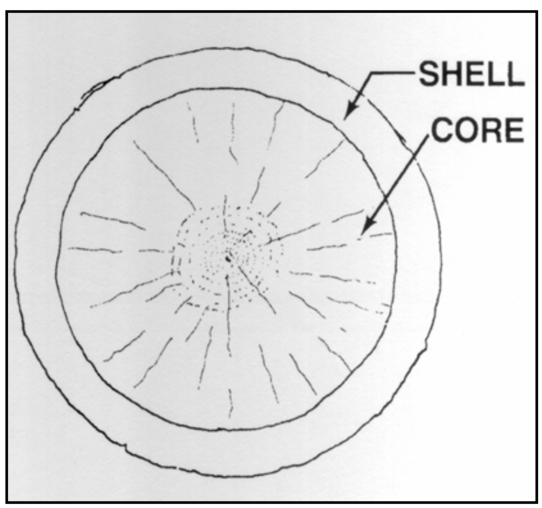
Traditionally, from a commercial standpoint, wood treatment means treating seasoned wood by putting it in a cylinder filled with a toxic liquid solution under elevated pressure. In some cases, the solution is heated to reduce the viscosity, resulting in better penetration of the wood.

Another kind of wood treatment that is becoming more important each year is the re-treatment of standing utility poles. Due to the exorbitant cost of replacing affected poles, the re-treatment of them is a multimillion dollar industry in the United States. The millions of utility poles in place usually require some maintenance every eight to 12 years. The attention they need often requires replacement of a cross arms, support brackets, re-treatment, or possibly removal and replacement of the entire pole every 20 to 25 years.

In almost every aspect, re-treatment of utility poles is different from factory pressure treatment of wood. The re-treatment is done with the pole in place, not in a factory setting. All equipment, material and manpower goes to the pole, so it must be easily portable. Crews that inspect and treat the poles work out of trucks, so their transport, storage and disposal problems are different from those at a pressure treatment factory. For example, handling contaminated clothing is somewhat different. Mobile crews do not have the luxury of leaving their soiled clothing in a factory setting, nor do they have factory facilities for washing up. (On the other hand, a cautious field crew will generate little waste, resulting in minimal contamination to themselves and the environment.)

The treatment methods and procedures are different. This section of the manual will cover these materials, methods and procedures. Some preservatives are the same but a few are different from those commonly used in pressure processes.

Descriptive concepts



For this discussion, a few descriptive concepts will be used. They are “destructive agents”, “thin” and “thick” sapwood species, “shell” and “core”, and “ground line area”.

Destructive agents refer to, fungi, insects, bacteria and other microscopic organisms that destroy wood or cause it to decompose. The main destructive agents of wood are fungi (decay) and termites.

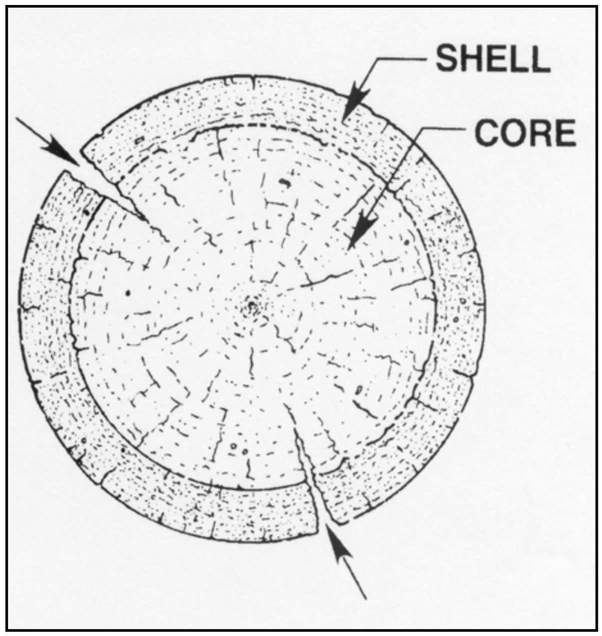
Most pole re-treaters recognize two basic types of poles. **"Thin" sapwood** species, which are generally Douglas fir, and **"thick" sapwood** species which are southern yellow pine. Sapwood thickness is significant because sapwood of most species is readily penetrated with preservatives in the pressure process. It is also important because thin sapwood species and thick sapwood species develop characteristic patterns of deterioration over time. Eighty-five percent of all poles being pressure treated are southern yellow pine. This is the species of choice in most instances because:

- It is a thick sapwood tree, so penetration and retention of preservative is better than in trees with less sapwood.
- It has permeable heartwood that preservative solutions can penetrate.
- It has good strength characteristics.
- It grows fast and straight, which reduces cost of production.
- It is generally readily available and economically competitive in the eastern two-thirds of the United States.

In some cases, other species are preferred. Thin sapwood species are:

- Often more readily available in the larger size poles— 60 feet or greater.
- Usually more accessible and locally available in western regions of the United States (west of the Rocky Mountains).

Shell and core



In the cross section of a pole, the outer ring of wood is the “shell” and the inner round cylinder is the “core”. With thick sapwood species, the shell is synonymous with the sapwood. As a rule of thumb, the total shell constitutes one-third of the diameter and the core constitutes two-thirds of the diameter at the ground line of a pole (a point 6 feet from the butt of the pole). For example, a 50 foot, class 2 pole must have a minimum circumference of 42 inches at the ground line. The diameter of this pole is 13.4 inches, which equates to a shell thickness of 2.2 inches and a core diameter of 9 inches.

In addition, in all cases the shell of a pole must have a minimum of 2 inches of sound wood. This dimension is, in many instances, the basis for rejection of a pole in place. Ninety percent or more of the strength of a pole comes from the shell ring of wood. This is the area that is partially or totally impregnated when the pole is initially pressure treated. The core does not receive treatment because the preservative does not penetrate the wood deeply enough. The primary function of treating wood poles is to prolong the life expectancy of the shell when the pole is exposed to the destructive agents of nature over time. This is not to say the core area is not important: it is clear that destructive agents can invade the shell from either the outside or the inside. The invasion must be resisted on both fronts. Reserve forces or re-treatments are applied in both places to substantially increase the safe life of a large capital investment - a wood pole in place.

Ground line area

The ground line of a pole not in place is a cross-section of the pole 6 feet from the butt. This is not the actual ground line, because most poles in place are imbedded 4 feet to10 feet in the ground, depending on their size.

The ***true*** **ground line** of a pole is the cross-section of the pole at the **ground line *in place***. The ground line area is an inexact section of the pole above and below the ground line. For this discussion, we might define the ground line area as the section of the pole from 3 inches above the ground line to12 to 18 inches below it. This is the most critical area of the pole in terms of rapid deterioration. The majority of the time spent on inspection and re-treatment will be spent in or near this area. This is not to say that the rest of the pole can be ignored. Nonetheless, most correctional work (90 to 95 percent) will be needed in this ground line area.

The ground line area is more vulnerable to attack by destructive agents than the rest of the pole because living conditions for decay and insects are optimal here. Because the pole contacts the soil, the wood at the ground line absorbs moisture, which is a necessary element for decay. The wood draws some moisture above the ground line to a limited height. Decay (rot) is usually restricted below the ground line because fungi require adequate levels of oxygen which may be limited at greater depths. (Moisture and temperature variations also play a role in fungal distribution.) Furthermore, preservatives are leached more rapidly from the pole at the ground line area. It is also an area where large splits form which allow rapid infestation of the untreated core.

Re-treatment

Factories that pressure treat utility poles would like to guarantee their treatments for-say, 50 to 60 years. This, of course, is not the case because poles actually begin to deteriorate as soon as they are placed in the soil. (Some believe that the deterioration process begins even before the pole is in place.) Poles deteriorate because the pressure process is imperfect, and so re-treatment becomes economically viable.

As poles age, the concentration of the toxic materials in them declines through leaching, chemical breakdown, and volatilization of the preservatives. At some point, the toxic chemicals are reduced to the “threshold level”. This is the theoretical level at which destructive agents can reinvade the wood. By re-treating the wood, the concentration of the toxic material is raised above the threshold level, and the wood acquires a renewed level of protection. Pressure treated wood poles are not originally treated internally. Therefore, the core sometimes decays prematurely because of external mechanical damage to the pole, heavy splitting or early decay present before the pole was treated. With proper testing and evaluation, incipient or early decay can be found and a preservative injected into the pole.

Projected pole strength is the ultimate criterion upon which the inspection crew must make its decision. Even though it is important to stop or reduce internal decay, the loss of wood strength in the core of the pole is not as critical as loss in the exterior or shell. Tests show that re-treatment can add as much as 10 to 15 years to the safe life of a pole when properly applied.

Inspection and re-treatment

Photo 1. Soil around ground line is excavated to a depth of 18 inches and all loose dirt is removed from the pole with a wire brush.

Photo 2. An external preservative is applied to the ground line area of the pole with a long-handled brush. The preservative is liberally spread into the checks and cracks to a thickness of 1/16 inch

Photo 3. A wrapping or bandage is place over the treated area and stapled to the pole. The bandage usually consists of a plastic film and a backing of stiffening paper. The film acts as a moisture barrier between the soil and treated pole. The excavated area is backfilled and a date tag is affixed to the pole

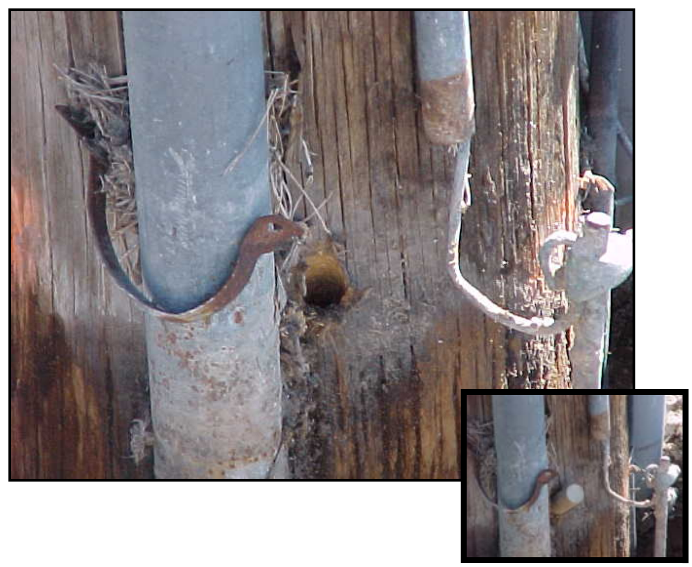


Photo 4. Should a fumigant need to be applied, a hole is drilled, the fumigant is injected and the hole is plugged.

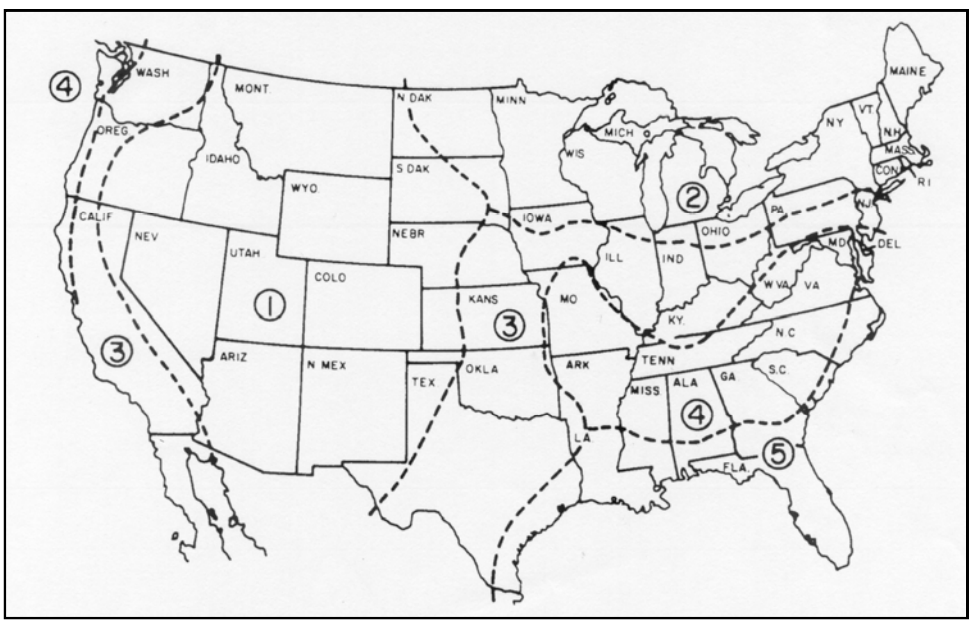
Deterioration of poles in place

Poles deteriorate in place for many reasons. The three major reasons of eventual breakdown of treated wood poles are as follows:

1. **Reduced toxicity of preservatives over time**.
2. **Persistent action of destructive agents**. The forces of nature are relentless. Agents such as fungi and insects (most noticeably termites) invade the wood as soon as conditions are favorable. As the preservative weakens and passes below the threshold level, decay and insect invasion can follow. Sun, wind and rain deteriorate exposed parts of the pole in a more subtle way over time.
3. **Changes due to moisture exchanges or mechanical damage**. Despite drying, the moisture content of the pole core may remain above a critical level called the "fiber saturation point". If decay was present in the core when the tree was cut in the forest, the decay may persist and grow even after drying and treatment. Whether the decay continues after drying and treatment depends to a high degree on how long the high moisture content remains in the core. Above the ground line, the moisture content will generally diminish to below the critical level within the first few years after the pole is put in place. At ground line drying may cease, or the pole may absorb moisture from the soil, increasing the moisture content, and encouraging fungal development in the untreated core.

Fungi and insects also gain entry into the untreated core as the surface of the pole dries after treatment which may cause large radial checks (splits), allowing decay and insects to bypass the exterior treated shell.

If the treated surfaces of poles are mechanically damaged in handling whereby the untreated core is exposed, decay or insect infestation may follow, especially if the damage occurs in the vulnerable ground line area.



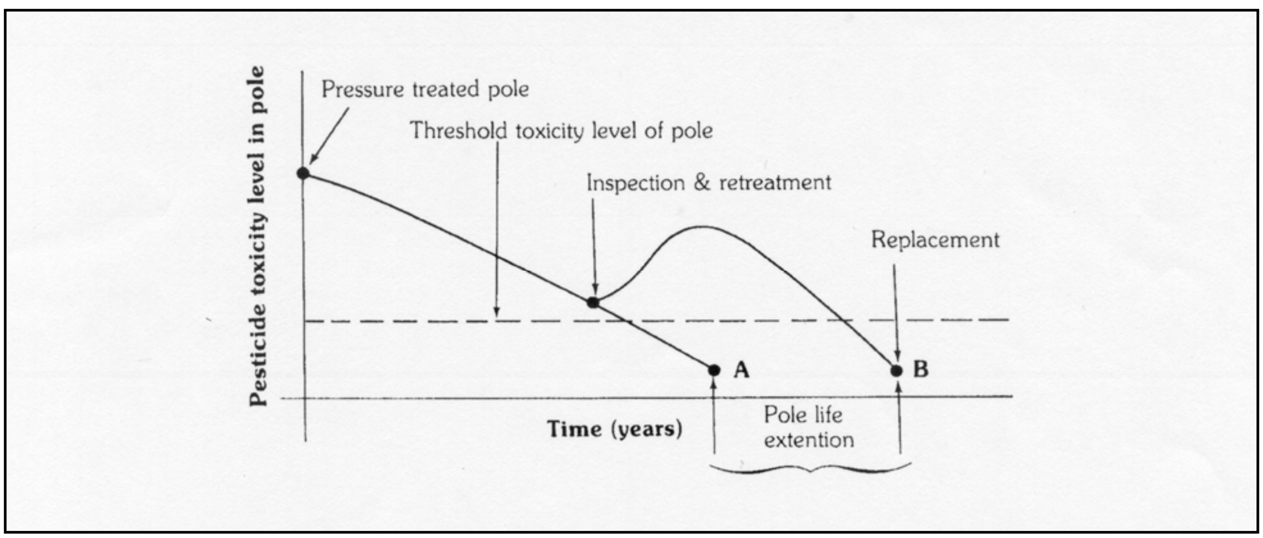
The picture to the right shows the decay severity zones in the United States. The severity of attack is related to the amount of moisture (annual rainfall) and the mean annual temperature. As the rainfall and temperature increase, the severity of attack and decay increases. Note that all of Nevada is in Zone 1. However, microclimates do exist within the state, and care should be taken when inspecting utility poles in these microclimates (i.e. mountainous areas**). Decay severity zones for wood utility poles as defined by the USDA Rural Electrification Association, where decay is least severe in zone 1, and most severe in zone 5**.

Reasons for re-treatment

The main reasons for re-treatment are almost the same as those for pressure treatment:

1. **Reduces costs by extending the use life of wood poles**. On an average, poles that are originally pressure treated but not retreated during their service life last for 25 to 40 years. A common life expectancy is 30 years. If, however, the pole is inspected on a routine basis and appropriately retreated, the life expectancy might be doubled.

   Re-treatment reduces costs by increasing the life of the pole and reduces labor and equipment costs by decreasing the frequency of replacement. The cycling and timing of the re-treatment process is illustrated in the figure below.
2. **Reduces the drain of the forest resources**. If the life expectancy of a pole is increased 50 percent or more by re-treatment, it is believed that the demand for new poles can be reduced about 33 percent. This benefit will probably become more important as time passes because of the ever increasing demand on forest resources.
3. **Reduce service interruptions and safer poles**. If a good inspection and re-treatment plan is followed, sound poles can be maintained. Breakage caused by ice build up during a winter storm or damage caused by other factors can be minimized. Occasionally, weakened poles break when the wire load is changed or when a lineman is on the pole, often with disastrous results. Re-treatment and a sound maintenance program can decrease the likelihood of these events.



Inspection options

The investment in each new wood utility pole in place can range from $500 to $2,000 depending on the type and size of the pole, its location, and other factors. Thus, most utility companies maintain fairly precise records for each of their poles. These records are important from an economic and a reliability standpoint, as well as from a safety standpoint, as linemen might be required to climb the poles at any time.

Most large utility companies inspect poles at 8 or 15 year intervals after installation. During inspection, a company may simply determine whether the pole is sound and will remain sound until the next inspection, or whether it is unsound and should be replaced. Other companies use a more sophisticated method of re-treatment in conjunction with inspection. After inspecting a pole both externally and internally, the inspection team methodically acts on the option most beneficial to the utility company. The options available to an inspection team are as follows:

1. The pole is projected unsound through the next inspection period. If during inspection the pole is noted to be seriously weakened, it is flagged for emergency (that is, immediate) replacement.
2. The pole is projected sound through the next inspection period, but decay is present in the pole.
   - ***External decay only*** - Remove decay and retreat with a bandage.
   - ***Internal decay only*** - Pocket present: Treat with appropriate preservative; Incipient decay (pocket not present): Treat with appropriate fumigant.
   - ***Combinations of external and internal decay*** - Use combined treatments outlined above.
3. The pole is projected sound through the next inspection period. No decay is found. (It is the policy of some re-treaters that the soil around the poles be excavated to a depth of 18 inches and the pole retreated with an external groundline bandage regardless of whether decay is present.)

This system gives utility companies a sound maintenance program that features maximum safety and reliability as well as substantial financial advantages in the long run.

Preservatives

Previously in this manual, the conventional preservatives used in pressure treating were discussed. Of these, creosote and pentachlorophenol are used extensively in re-treatment. In many instances, they are not used in their pure form but are mixed in various formulations.

External: Brush-on preservatives have various constituents. The most commonly used elements are creosote and sodium fluoride. Ground line areas treated and wrapped with a moisture barrier bandage receive good penetration of the preservative. Tests show that the chemicals move 2 inches to 3 inches into the shell-wood as a result of diffusion and osmotic action.

Internal: When voids are present in the core, oil solutions of pentachlorophenol or other proprietary preparations are injected into the confined void area and then capped with treated wood plugs. This has a flooding effect near the area of maximum deterioration and is similar to conventional soaking.

Fumigants, usually vapam or chloropicrin, are injected into solid cores to prevent and stop decay. They are injected into poles using a procedure like the one described above. They are not, however, used where internal voids are present. They are effective when incipient or early decay is present in the core but where the core is still intact. Fumigants volatilize inside the wood and diffuse 2 feet to 4 feet from the point of injection, thus giving wide protection in the core area. Fumigants are used more for particular species and special situations and applications.

Safety

Re-treatment of wood poles in place is safer than conventional pressure treatment from the standpoint of contaminating the environment or personnel. Nevertheless, all handlers of wood preservatives need to be aware of the potential hazards of these chemicals and the precautions to be followed in using them. Excessive exposure to wood preservative chemicals can be avoided through good work habits and common sense rules reflected on all wood preservatives labels.

Approved labeling - The EPA approved labels of all pesticide products, including wood preservatives, is the primary source of information about application methods, precautionary measure for workers, environmental hazards, emergency first aid for high level exposures and disposal instructions for pesticide materials and containers. The label has the force of law, and the provisions of the label are enforced by the Nevada Department of Agriculture and U.S. EPA. The labels for every formulated product used at a wood treatment operation should be readily available, and all responsible personnel should be familiar with their contents.

REMEMBER: READ, UNDERSTAND AND FOLLOW ALL PESTICIDE (WOOD PERSERVATIVE) LABEL DIRECTIONS. IT'S THE LAW.

Definitions

Cellulose. The carbohydrate that is the principal constituent of wood and forms the framework of wood cells.

Check. A lengthwise separation of the wood that usually extends across the rings of annual growth and commonly results from stresses set up in wood during seasoning.

Decay. The decomposition of wood substance by fungi.

Incipient decay. The early stage of decay that has not proceeded far enough to soften or otherwise perceptibly impair hardness of the wood. It usually is accompanied by a slight discoloration or bleaching of the wood.

Advanced (or typical) ***decay***. The older stage of decay in which the destruction is readily recognized because the wood has become punky, soft and spongy, stringy, ringshaked, pitted, or crumbly. Decided discoloration or bleaching of the rotted wood often is apparent.

Dry rot. A term loosely applied to any dry, crumbly rot, but especially to that which, when in an advanced stage, permits the wood to be crushed easily to a dry powder. The term actually is a misnomer for any decay, since all fungi require considerable moisture for growth.

Green. Freshly sawn or undried wood that still contains tree sap. Wood that has become completely wet after immersion in water would not be considered green, but may be said to be in the "green condition."

Hardwoods. Generally one of the botanical groups of trees that have broad leaves in contrast to the conifers or softwoods. The term has no reference to the actual hardness of the wood.

Heartwood. The wood extending from the pith to the sapwood, the cells of which no longer participate in the life processes of the tree. Heartwood may contain phenolic compounds, gums, resins, and other waste materials that usually make it darker and more decay resistant than sapwood.

Kiln. A chamber having controlled airflow, temperature, and relative humidity for drying lumber, veneer, and other wood products.

Lignin. The second most abundant constituent of wood, which is the thin cementing layer between wood cells, located principally in the secondary wall and the middle lamella. (Chemically, it is an irregular polymer of substituted propylphenol groups, so no simple chemical formula can be written for it.)

Millwork. Planed and patterned lumber for finish work in buildings, including items such as sashes, doors, cornices, panelwork, and other items of interior or exterior trim. Doesn't include flooring, ceiling, or siding.

Moisture content (MC). The amount of water contained in wood, usually expressed as a percentage of the weight of the ovendry wood.

Ovendry wood. Wood dried to a relatively constant weight in a ventilated oven at 101 to105° C.

Preservative. Any substance that, for a reasonable length of time, is effective in preventing the development and action of wood rotting fungi, borers of various kinds, and harmful insects that deteriorate wood.

Sapwood. The wood of pale color near the outside of the log and just under the bark of a tree. Under most conditions, the sapwood is more susceptible to decay than heartwood, and is usually more receptive to impregnation with preservatives and fire retardants.

Seasoning. Removing moisture from green wood to improve its serviceability.
Air-dried. Dried by exposure to air in a yard or shed, without artificial heat.
Kiln-dried. Dried in a kiln with the use of artificial heat.

Soft rot. A special type of decay which develops under very wet conditions (as in cooling towers and boat timbers) in the outer wood layers, caused by cellulose destroying microfungi that attack the secondary cell walls and not the intercellular layer.

Softwoods. Generally, one of the botanical groups of trees that, in most cases, have needlelike or scale-like leaves: the conifers. The term has no reference to the actual hardness of the wood produced by these trees.

Weathering. The mechanical or chemical disintegration and discoloration of the surface of wood caused by exposure to sunlight, the action of dust and sand carried by winds, and ever changing weather conditions (humidity, precipitation and freezing/thawing cycles) which cause alternate shrinking and swelling of the surface fibers. Weathering doesn't include decay.

White rot. In wood, any decay or rot that attacks both the cellulose and lignin and produces a generally whitish residue that may be spongy, stringy, or occur as pocket rot.

DIRECTIONS

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

IMPORTANT! DO NOT DILUTE FOR EXTERIOR USE ONLY.

This product is a ready-to-use penetrating preservative coating, designed for the groundline treatment of standing poles and for the treatment of the groundline area of poles in the yard that will be relocated or that have been in storage for prolonged periods. This product is also used for the treatment of piling cut-offs.

Standing Poles: Use this product only on poles-in-line found by a qualified inspector to be satisfactory for continued service. Dig a trench around the pole to the depth determined by the inspector to be necessary for the application of the preservative treatment. This may vary from 12 inches in wet areas to 18 inches or more in arid regions. Scrape away dirt and decayed wood from the pole surface. With a brush, paddle, scoop or mechanical applicator apply a coating a minimum of 1/16 inch thick from the bottom of the trench to a predetermined height - 2 inches to 12 inches above the ground line to suit local conditions. Cover the treated areas with a suitable plastic coated paper to increase the effectiveness of the treatment. Alternately, apply this product to a suitable wrapping material, and staple this wrapper to the pole before back-filling the trenched area.

Piling Cut-Offs: Treat the cut-end with a coating 1/16 inch thick.

Yard Poles: Poles that have been held in storage for a prolonged period or used poles to be relocated, may be treated in decay vulnerable zones in a manner similar to that described for standing poles, taking care to remove dirt and decayed wood before applying treatment.

This product may also be applied to bridge timbers, foundation piling, etc. in a manner similar to that described for standing poles.

STORAGE AND DISPOSAL

STORAGE: Store in a closed, properly labeled container in a cool place. If static generating conditions exist, provide necessary grounding and bonding. Keep containers closed when not in use.

PESITICIDE DISPOSAL: Do not contaminate water, food or feed by storage or disposal. Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the hazardous Waste representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

KOPPERS®

RESTRICTED USE PESTICIDE

For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicator's certification.

TRITOX™

PRESERVATIVE PASTE

For aiding in the control of termites and rot in standing poles, relocated poles, foundation piles, piling cut-offs, bridge timbers and similar applications.

ACTIVE INGREDIENTS:	
Pentachlorophenol*	8.96%
Other Chlorphenols and Related Compounds*	1.04%
Coal Tar Creosote Oil	35.00%
Sodium Flouride	40.00%
INERT INGREDIENTS	15.00%
Total	100.00%

EPA Reg. No. 453-182
EPA Est. 453-MO-1

*10.42% Technical Pentachlorophenol as defined in Federal Specification TT-W-570. This product contains petroleum distillates.

READ "LIMIT OF WARRANTY AND LIABILITY" BEFORE BUYING OR USING. IF SUCH TERMS ARE NOT ACCEPTABLE, RETURN AT ONCE UNOPENED.

KEEP OUT OF REACH OF CHILDREN

DANGER

STATEMENT OF PRACTICAL TREATMENT

If swallowed: Call a physician or Poison Control Center. Drink 1 or 2 glasses of water and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person.
In case of contact wash skin with soap and water, for eyes, flush with water for at least 15 minutes and get medical attention.
If inhaled, remove to fresh air.
NOTE TO PHYSICIAN: Pentachlorophenol in this product is a metabolic stimulant, causes hyperthermia. Treat symptomatically.
SEE SIDE PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS.
Medical Emergencies: 1-800-553-5631 In Pennsylvania: 1-800-327-6571

Koppers Company, Inc.
Protection Products Dept.
5137 Southwest Avenue, St. Louis, Missouri 63110-3497
314/772-2200

NET CONTENTS **POUNDS**

PRECAUTIONARY STATEMENTS HAZARDS TO HUMANS (AND DOMESTIC ANIMALS)

DANGER

CORROSIVE. CAUSES IRREVERSIBLE EYE DAMAGE. MAY BE FATAL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN. CAUSES SKIN AND EYE IRRITATION. MAY CAUSE SERVERE BURNS.

Do not get in eyes, on skin or on clothing. Do not breathe vapors or spray mist. Use with adequate ventilation. Do not take internally. Wash thoroughly after skin contact, before eating, drinking, use of tobacco products or using restrooms. Wear goggles or face shield when handling or applying. Use only in well ventilated areas.

APPLICATOR SAFETY:
The U.S. EPA has determined that pentachlorophenol can produce defects in the offspring of laboratory animals. Exposure to pentachlorophenol during pregnancy should be avoided.

Applicators must wear gloves impervious to the wood treatment formulations (e.g., polyvinyl acetate (PVA), polyvinyl chloride (PVC) or neoprene). In all situations where dermal contact is expected (e.g., during the actual application process and when handling freshly freshly treated wood).

Applicators must wear long sleeved shirts, long pants and an impermeable apron during the application and mixing process and all situations where dermal contact is expected.

Work clothing must be changed when it shows signs of contamination. Launder work clothing separately from other household clothing. Dispose of worn-out work clothing and workshoes or boots in any general landfill, in the trash or any other manner approved for pesticide disposal.

Applicators must not eat, drink or use tobacco products during those parts of the application process that may expose them to the wood treatment formulation.

Wash thoroughly after skin contact, and before eating, drinking, use of tobacco products, or using restrooms.

ENVIRONMENTAL HAZARDS:
This product is toxic to fish and wildlife. Do not apply directly to water. Do not contaminate water by cleaning of equipment or disposal of wastes.

This product is toxic to domestic animals. Treated sawdust and other wood wastes should not come in contact with domestic animals or be used as mulch where it will come in contact with useful living plants. Care should be taken to prevent contact with ornamental shrubs, trees, grass and other desirable vegetation.

Vapors may cause injury if adequate ventilation is not insured. Do not use this product indoors, or any other confined areas, where the vapors may concentrate or migrate indoors and cause injury to plant or animal life.

PHYSICAL AND CHEMICAL HAZARDS:
Do not use or store near heat or open flame. Close container after each use.

LIMIT OF WARRANTY AND LIABILITY
This company warrants that this material conforms to the chemical description on the label and is reasonably fit for the purposes referred to in the directions for use. This product is sold subject to the understanding that the buyer assumes all risks of use or handling of this material not in strict accordance with the directions given herewith which are beyond the control of the seller, such as for example incompatibility with other products and the manner of its use and application. NO OTHER EXPRESSED OR IMPLIED WARRANTY OF FITNESS OR MERCHANTABILITY IS MADE. The exclusive remedy of the buyer, and the limit of liability of this company or any other seller for any and all losses, injuries or damages resulting from the use or handling of this product shall be the purchase price paid by the user or buyer for the quantity of this product involved. The buyer and all users are deemed to have accepted the terms of this notice which may not be varied by any verbal or written agreement.

FPL 1252 R08 8610

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

IMPORTANT! DO NOT DILUTE

FOR EXTERIOR USE ONLY.

This product is a ready-to use penetrating preservative coating, designed for the groundline treatment of standing poles and for the treatment of the groundline area of poles in the yard that will be relocated or that have been in storage for prolonged periods. This product is also useful for the treatment of piling cut-offs.

Standing Poles: Use this product only on poles-in-line found by qualified inspector to be satisfactory for continued service. Dig a trench around the pole to the depth determined by the inspector to be necessary for the application of the preservative treatment. This may vary from 12 inches in wet areas to 18 inches or more in arid regions. Scrape away dirt and remove decayed wood from the pole surface. With a brush, paddle, scoop or mechanical applicator apply a coating a minimum of 1/16 inch thick from the bottom of the trench to a predetermined height — 2 inches to 12 inches above the ground line to suit local conditions. Cover the treated area with a suitable plastic coated paper to increase the effectiveness of the treatment. Alternately, apply this product to a suitable wrapping material, and staple this wrapper to the pole before back-filling the trenched area.

Piling Cut-Offs: Treat the cut-end with a coating 1/16 inch thick.

Yard Poles: Poles that have been held in storage for a prolonged period or used poles to be relocated, may be treated in decay vulnerable zones in a manner similar to that described for standing poles, taking care to remove dirt and decayed wood before applying treatment.

STORAGE AND DISPOSAL

STORAGE: Store in a closed, properly labelled container in a cool place. If static generating conditions exist, provide necessary grounding and bonding. Keep containers closed when not in use.

PESTICIDE DISPOSAL: Do not contaminate water, food, or feed by storage or disposal. Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

ASPLUNDH

RESTRICTED USE PESTICIDE

For sale to and use only by certified applicators or by persons under their direct supervision and only for those uses covered by the certified applicator's certificate.

POLE-TOX™

PRESERVATIVE PASTE

For aiding in the control of termites and rot in standing poles, relocated poles and piling cut-offs.

ACTIVE INGREDIENTS:	
Pentachlorophenol*	8.96%
Other Chlorophenols and Related Compounds*	1.04%
Coal Tar Creosote Oil	35.00%
Sodium Fluoride	40.00%
Potassium Bichromate	3.00%
INERT INGREDIENTS	12.00%
Total	100.00%

EPA Reg. No. 6314-1
EPA Est. 453-Mo-1

*10.42% Technical Pentachlorophenol as defined in Federal Specification TT-W-570. This product contains petroleum distillates.

READ "LIMIT OF WARRANTY AND LIABILITY" BEFORE BUYING OR USING. IF SUCH TERMS ARE NOT ACCEPTABLE, RETURN AT ONCE UNOPENED.

KEEP OUT OF REACH OF CHILDREN

DANGER

STATEMENT OF PRACTICAL TREATMENT

If swallowed: Call a physician or Poison Control Center. Drink 1 or 2 glasses of water and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconsious person.
In case of contact wash skin with soap and water, for eyes, flush with water for at least 15 minutes and get medical attention.
If inhaled, remove to fresh air.
NOTE TO PHYSICIAN: Pentachlorophenol in this product is a metabolic stimulant, causes hyperthermia. Treat symptomatically.
SEE SIDE PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS.

Manufactured Expressly For

ASPLUNDH TREE EXPERT COMPANY
POLE TREATING DIVISION
BLAIR MILL ROAD
WILLOW GROVE, PA 19090

NET CONTENTS POUNDS

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS (AND DOMESTIC ANIMALS)

DANGER

CORROSIVE. CAUSES IRREVERSIBLE EYE DAMAGE. MAY BE FATAL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN. CAUSES SKIN AND EYE IRRITATION. MAY CAUSE SEVERE BURNS.

Do not get in eyes, on skin or on clothing. Do not breathe vapors or spray mist. Use with adequate ventilation. Do not take internally. Wash thoroughly after skin contact, before eating, drinking, use of tobacco products or using restrooms. Wear goggles or face shield when handling or applying. Use only in well ventilated areas.

APPLICATOR SAFETY:

The U.S. EPA has determined that pentachlorophenol can produce defects in the offspring of laboratory animals. Exposure to pentachlorophenol during pregnancy should be avoided.

Applicators must wear gloves impervious to the wood treatment formulations (e.g., polyvinyl acetate (PVA), polyvinyl chloride (PVC) or neoprene). In all situations where dermal contact is expected (e.g., during the actual application process and when handling freshly treated wood).

Applicators must wear long sleeved shirts, long pants and an impermeable apron during the application and mixing processes and all situations where dermal contact is expected.

Work clothing must be changed when it shows signs of contamination. Launder work clothing separately from other household clothing. Dispose of worn-out work clothing and workshoes or boots in any general landfill, in the trash or any other manner approved for pesticide disposal.

Applicators must not eat, drink or use tobacco products during those parts of the application process that may expose them to the wood treatment formulation.

Wash thoroughly after skin contact, and before eating, drinking, use of tobacco products, or using restrooms.

ENVIRONMENTAL HAZARDS

This product is toxic to fish and wildlife. Do not apply directly to water. Do not contaminate water by cleaning of equipment or disposal of wastes.

This product is toxic to domestic animals. Treated sawdust and other wood wastes should not come in contact with domestic animals or be used as mulch where it will come in contact with useful living plants. Care should be taken to prevent contact with ornamental shrubs, trees, grass and other desirable vegetation.

Vapors may cause injury if adequate ventilation is not insured. Do not use this product indoors, or any other confined areas, where the vapors may concentrate or migrate indoors and cause injury to plant or animal life.

PHYSICAL AND CHEMICAL HAZARDS:

Do not use or store near heat or open flame. Close container after each use.

LIMIT OF WARRANTY AND LIABILITY

This company warrants that this material conforms to the chemical description on the label and is reasonably fit for the purposes referred to in the directions for use. This product is sold subject to the understanding that the buyer assumes all risks of the use or handling of this material not in strict accordance with the directions given herewith which are beyond the control of the seller, such as for example incompatibility with other products and the manner of its use or application. NO OTHER EXPRESSED OR IMPLIED WARRANTY OF FITNESS OR MERCHANTIBILITY IS MADE. The exclusive remedy of the buyer, and the limit of liability of this company or any other seller for any and all losses, injuries or damages resulting from the use or handling of this product shall be the purchase price paid by the user or buyer for the quantity of this product involved. The buyer and all users are deemed to have accepted the terms of this notice which may not be varied by any verbal or written agreement.

FPL 1232 RO1 8611

DESCRIPTION

OSMOPLASTIC® contains recognized salt preservatives used successfully in the art of wood preservation for more than forty (40) years. These colorless salts penetrate deeply into the wood and give long-lasting protection against decay.

OSMOPLASTIC® is designed for use in groundline treatment of standing poles, piling and other timber members.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Stir to an even consistency. Remove existing decay as thoroughly as possible. Apply with ordinary stiff bristle brush (preferably long handle) in a zone 18" below to 3" above ground, making liberal applications to checks in areas where decay has been removed. Where treated area comes in contact with the ground, wrap with our waterproof bandage, OsmoShield.

STORAGE AND DISPOSAL

STORAGE:
Do not contaminate water, food or feed by storage or disposal.

DISPOSAL:
Triple rinse (or equivalent). Puncture and dispose of in a sanitary landfill, or incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

If product is in metal container, do not attempt to burn or incinerate. Triple rinse (or equivalent). Puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

PESTICIDE DISPOSAL:
Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification.

GROUNDLINE TREATMENT FOR ALL STANDING POLES

OsmoPlastic®
WOOD PRESERVING COMPOUND

ACTIVE INGREDIENTS:	
Sodium Fluoride	44.42%
Creosote	45.62%
Potassium Bichromate	3.10%
2,4-Dinitrophenol	2.00%
	95.14%
INERT INGREDIENTS	4.86%
	100.00%

KEEP OUT OF REACH OF CHILDREN

DANGER

STATEMENT OF PRACTICAL TREATMENT

IF SWALLOWED: Induce vomiting by touching the back of the throat with finger. Avoid aspiration of vomit. Do not induce vomiting of an unconscious person. Call a physician immediately.

IF INHALED: Remove victim to fresh air. Apply respiration if indicated. Call a physician immediately.

IF ON SKIN: Remove contaminated clothing and wash affected area with soap and water.

IF IN EYES: Flush eyes with plenty of water. Call a physician immediately.

SEE SIDE PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS

E.P.A. Registration No. 3008-4 **E.P.A. Est. 3008-NY-1**

OSMOSE

Osmose Wood Preserving, Inc
980 Ellicott Street
Buffalo, New York 14209

NET CONTENTS 5 GALLONS (18.93 L.)

PRECAUTIONARY STATEMENTS HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER: May be fatal if swallowed or absorbed through the skin. Causes eye and skin irritation. Do not breathe vapor. Do not get in eyes, on skin, or on clothing. Wash thoroughly after handling and before eating or smoking.

Applicators must wear gloves impervious to the wood treatment formulations (e.g., polyvinyl acetate [PVA], polyvinyl chloride [PVC], or neoprene) in all situations where dermal contact is expected (e.g., during the actual application process and when handling freshly treated wood).

Applicators must wear long sleeved shirts, long pants, and an impermeable apron during the application and mixing processes and all situations where dermal contact is expected.

Work clothing must be changed when it shows signs of contamination. Launder work clothing separately from other household laundry. Dispose of worn-out work clothing and workshoes or boots in any general landfill, in the trash, or in any other manner approved for pesticide disposal.

Applicators must not eat, drink, or use tobacco products during those parts of the application process that may expose them to the wood treatment formulation.

Wash throughly after skin contact, and before eating, drinking, use of tobacco products, or using restrooms.

ENVIRONMENTAL HAZARDS

This product is toxic to fish and wildlife. Do not apply directly to water. Do not apply where runoff is likely to occur. Do not contaminate water by cleaning of equipment or disposal of wastes.

PHYSICAL OR CHEMICAL HAZARDS

Do not use, pour, spill or store near heat or open flame.

KOPPERS
Chemicals and Coatings

DATE OF PREP.
2/81, R1 April, 1984

MATERIAL SAFETY DATA SHEET

(Approved by U.S. Department of Labor "Essentially Similar" to Form LSB-005-4)

WHILE THE INFORMATION AND RECOMMENDATIONS SET FORTH HEREIN ARE BELIEVED TO BE ACCURATE AS OF THE DATE HEREOF, KOPPERS COMPANY MAKES NO WARRANTY WITH RESPECT THERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

Specialty Wood Chemicals

Section I — PRODUCT IDENTIFICATION

MANUFACTURER'S NAME: Koppers Company, Inc., Wood Treating Chemicals Dept.

EMERGENCY TELEPHONE NO.: 314-772-2200

STREET ADDRESS: 5137 Southwest Avenue

CITY, STATE, AND ZIP CODE: St. Louis, MO 63110

MANUFACTURER'S CODE IDENTIFICATION: EPA Reg. No. 453-182, FPL 1253

PRODUCT CLASS: Preservative Paste

TRADE NAME: TRITOX (R)

Section II — HAZARDOUS INGREDIENTS

INGREDIENT	CAS Registry Number	PERCENT	OSHA PEL PPM	OSHA PEL mg/M³	REMARKS
Pentachlorophenol	87-86-5	10		0.5	"Skin" Notation
Coal Tar Creosote	8001-58-9	35		0.2	Coal Tar Pitch Volatiles*
Naphthalene	91-20-3	5	10	50	
Sodium Fluoride	7681-49-4	40		2.5	as F
Potassium Dichromate	7778-50-9	5		0.5	as Cr**

*Benzen Soluble Fraction

**The American Conference of Governmental Industrial Hygienists (ACGIH) 1983-84 TLV = .05mg/M³

Section III — PHYSICAL DATA

BOILING RANGE 760 MM Hg	356-620°F	FREEZING POINT	Not Applicable/Paste
PERCENT VOLATILE BY VOLUME	4%	VAPOR PRESSURE AT 20° C	Pentachlorophenol 1mm
SPECIFIC GRAVITY (H_2O = 1)	1.41	EVAPORATION RATE (BUTYL ACETATE = 1)	Slower than ether
VAPOR DENSITY	Heavier than air	SOLUBLE IN WATER - % WT.	Negligible
APPEARANCE AND ODOR	Dark paste; creosote odor		

Section IV — FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED): Not Applicable

FLAMMABLE LIMITS: Lel: — Uel: —

EXTINGUISHING MEDIA:
Use Class B type Fire Extinguisher or Extinguishing AGent(s), e.g., water fog, foam, CO_2, and dry chemical.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
Water may be used to cool containers. Keep containers tightly closed. Isolate from heat, electrical equipment, sparks and open flame. Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. During emergency conditions, over exposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.

SPECIAL FIRE FIGHTING PROCEDURES:
Full protective equipment including NIOSH/MSHA approved self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible auto-ignition or explosion when exposed to extreme heat.

MATERIAL SAFETY DATA SHEET

Section V — HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE
See Section II.

EFFECTS OF OVEREXPOSURE
May be irritating to the eyes, skin and/or respiratory tract. Ingestion or inhalation of concentrated vapors or prolonged or repeated skin contact may lead to headache, weakness, dizziness, nausea, coordination loss, profuse sweating, convulsions and could be fatal. The pentachlorophenol in this product is a metabolic stimulant, causes hyperthermia.

EMERGENCY AND FIRST AID PROCEDURES In case of eye or skin contact, immediately flush with plenty of water for at least 15 minutes while removing contaminated clothing & shoes. Call a physician. Wash contaminated clothing before reuse. Discard contaminated shoes as a waste product (See Section VII). Inhalation: Remove to fresh air & call a physician; apply artificial respiration if necessary. Ingestion: Drink 1 or 2 glasses of water & induce vomiting by touching back of throat with finger. Never give anything by mouth to an unconscious person. Call a physician.

Section VI — REACTIVITY DATA

STABILITY (Check One)		CONDITIONS TO AVOID
UNSTABLE	[ ]	
STABLE	[X]	

INCOMPATABILITY (materials to avoid)
Oxidizing agents.

HAZARDOUS DECOMPOSITION PRODUCTS
May produce carbon monoxide, carbon dioxide, and/or hydrochloric acid by thermal decomposition.

HAZARDOUS POLYMERIZATION (Check One)		CONDITIONS TO AVOID
MAY OCCUR	[ ]	
WILL NOT OCCUR	[X]	

Section VII — SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Remove sources of ignition (flame, hot surfaces and electrical, static or frictional sparks). Confine area of spill. Cover with absorbent material such as Speedi-Dry* , processed clay or sand. Place in approved containers for disposal. Avoid breathing vapors. Ventilate area. Contain and remove with inert absorbent, such as Speedi-Dry* , and non-sparking tools. Do not contaminate water by cleaning of equipment or disposal of wastes.
*Sold by Minerals & Chemical Co., Edison, New Jersey

WASTE DISPOSAL METHOD Disposal must be carried out in accordance with Local, State & Federal Regulations. Dispose absorbent material in an approved chemical landfill or incinerate at an approved facility. Do not incinerate closed containers. Triple rinse (or equivalent) and offer for recycling or reconditioning or dispose of in accordance with Local, State and Federal Regulations.

Section VIII — SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (specify type) Use appropriate NIOSH/MSHA approved respirator to comply with OSHA 1910.134 if ventilation is inadequate for meeting PELS or TLV's in Section II.

VENTILATION		
	LOCAL EXHAUST Sufficient ventilation in volume and pattern to be provided to control vapor concentrations below the LEL and the PEL or TLV in Section II.	
	MECHANICAL (general) Necessary to supplement local exhaust	OTHER Remove heavy solvent vapors from lower levels of work areas.

PROTECTIVE GLOVES Impervious gloves

EYE PROTECTION Goggles or face shield

OTHER PROTECTIVE EQUIPMENT Provide accessible eye wash & safety shower. If clothing contamination and/or skin contact is possible, wear adequate resistant protective clothing.

Section IX — SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Store in closed, properly labeled containers in cool place. Keep container and freshly treated articles away from high-temperature areas, sparks, fire or open flame. Do not contaminate water, food or feed by storage.

OTHER PRECAUTIONS DO NOT TAKE INTERANALLY OR GET IN EYES. Avoid prolonged and/or repeated breathing of mist, vapors or substantially saturated atmosphere. Avoid contact with skin, eyes & clothing. If static generating conditions exist, provide necessary grounding & bonding. Not for use or storage in or around the house. Use only with adequate ventilation or proper respiratory equipment (See Section VIII). KEEP OUT OF REACH OF CHILDREN. Do not handle until manufacturers' safety precautions have been read and understood.