

Wood Preservation

Introduction

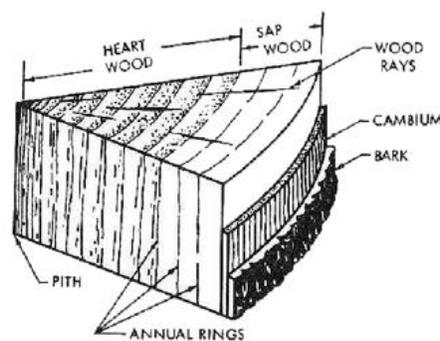
Wood, a renewable resource, is a desirable material for construction and is used in the manufacture of items such as railroad ties and utility poles. Chemically, wood is composed of

- **complex carbohydrates (cellulose and hemicellulose),**
- **lignin** – composed of phenolic compounds,
- **extractives,** and
- **mineral matter.**

The cell walls of wood fibers are made of bits of cellulose surrounded by hemicellulose. Both of these sugars are made of carbon, oxygen, and nitrogen. Lignin acts as a glue to keep the fibers together. Cellulose is one of the most abundant organic compounds on earth so wood is an attractive resource for various species of fungi, insects, and bacteria -- natural organisms of breakdown and decay. Wood preservatives are pesticides that can protect wood from attack and decay by these organisms. Proper application of preservatives can prolong the service life of wood for many years.

An estimated 10% of the timber cut each year in the United States is used to replace wood that has failed, often due to attack by fungi, bacteria, insects, or marine borers. Wise use of chemicals to preserve or temporarily protect wood can substantially increase service life. This significantly reduces wood losses and helps to conserve timber resources. Substitution of alternate structural materials for pressure-treated wood currently used would cost the US. economy \$4.5 to \$6.3 billion dollars each year and force us to use more of our nonrenewable resources. Similarly, failure to use anti-sap stain chemicals could cause unprotected, high quality lumber to lose as much as 50% of its value during processing and shipment.

A crosscut of most trees shows a zone of lighter sapwood surrounding a core of darker heartwood. Fast growing trees usually have deeper sapwood than slow-growing trees. About 90% of wood is minute, hollow fibers oriented lengthwise along the tree stem. Water and nutrients move vertically through these fibers, which also serve as a means of support. The remaining 10% of wood is composed of short, hollow, brick-shaped cells that are oriented from the bark toward the center of the tree. They are like ribbons or rays of unequal height and length. These rays carry the food manufactured in the leaves down the inner bark to the growing tissues between the bark and the wood.

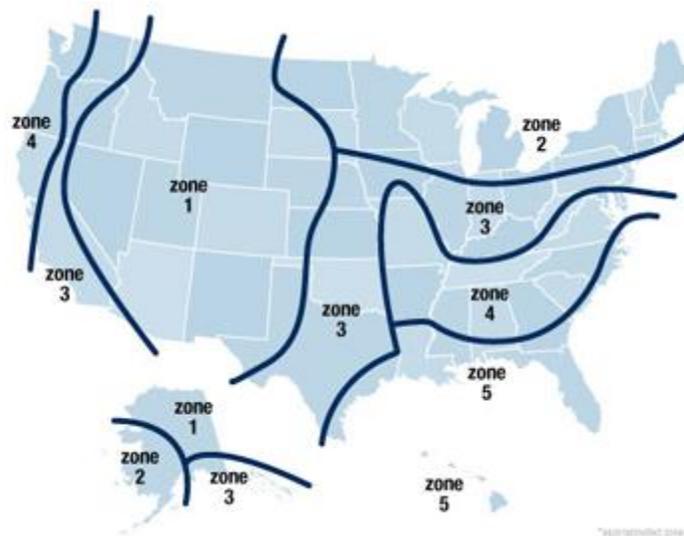


Basic parts of a tree trunk:

(image: HobbitHouseInc.com)

Minute passageways called **pits** interconnect the cavities of adjacent cells. While these pits often act as simple holes through adjacent cell walls, their structure is more complicated and they are sometimes obstructed. Water in the living tree moves from cell to cell by means of these pits. These pits often help the movement of water along in drying lumber or utility poles. These pits also may aid in the impregnation of wood with wood preservatives.

The **economic importance of wood destroying organisms (WDO) varies with location, environmental conditions, tree species, and differences between the sapwood and heartwood regions within a given tree.**



Wood pole decay hazard risk (1 = lowest decay risk, 5 = highest)
(image: osmose.com)

Sapwood, located next to the growing cambium layer just under the bark, represents the living part of the tree. It is less resistant to attack than the heartwood. The inner **heartwood** near the center of the tree is less resistant than the outer layers of heartwood that contain preservative chemicals such as phenols.

All wood species are susceptible to attack by wood-destroying organisms (WDO) but some are less susceptible (more resistant) than others depending on natural preservatives that they contain. The USDA Forest Service has grouped woods according to decay resistance. However, resistance is a relative term. Wood with high natural resistance is not immune to attack. Heartwoods of black locust, redwood and western red cedar have a reputation of being decay resistant. Heartwood of other tree species may exhibit lesser amounts of toxicity of decay fungi. Sapwood of all species does not have natural decay resistance.

Older, slow-growing trees from stands of virgin timber generally contain higher concentrations of natural preservatives than do younger faster-growing replacement trees. Consequently, older structures tend to be more durable than newer wood structures. The treatment of wood with chemical preservatives extends and supplements the natural preservatives in wood. Crossties, poles, posts, and other wood products in contact with the ground or that are exposed to the weather must be protected with preservatives to ensure a reasonable service life. 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.

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Preparing Wood for Treatment

Structurally, wood is made up of cells of various sizes and shapes. In soft woods (generally conifers) long, thin cells lie parallel to the vertical axis of the trunk, the other cells lie across the trunk. The organization of cells in deciduous (usually hardwood trees) is more complex.

Cells in growing trees store water, food reserves, and extractives (resins, tannins, pigments, essential oils, fats, waxes, gums, and starches). Free water is inside the cells, bound water is held in the cell walls. **Green wood from the forest contains a large amount of water. The high water content makes the wood attractive to wood destroying organisms and restricts the amount of preservative that it can absorb.** The wood may not take up enough preservative to provide sufficient protection. If wood is treated wet, further drying can cause surface and end cracking. In general, **green wood should be peeled and either seasoned or conditioned before the preservative is applied.**



(photo: NHStateParks.org)

The **moisture content (MC)** of wood is usually expressed as a percentage of the weight of the wood after it has been oven-dried at about 216°F. The wood must be weighed accurately before and after drying.

$$\%MC = (\text{wet weight (before drying)} - \text{weight after drying}) / \text{weight of dry wood} \times 100$$

If fresh wood contains a large amount of water and the dry weight is less than half of the wet weight, then the MC is greater than 100%. The MC of fresh wood from living trees can range from about 30% to more than 200% based on weight. **Timber or logs stored for long periods before processing can be protected from fungi and insects by submersion in pond water or by 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 the moisture in wood must be removed for most uses. Green lumber usually is seasoned or dried to:

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



(photo: 123RF.com)

Air-drying is a widely used, effective and inexpensive method of conditioning. Wood should be **dried as quickly as possible**; the time will vary, depending on climate, location and condition of the seasoning yard, methods of piling, season of the year, and size and species of the timbers. Drying offers some protection against wood-decaying organisms. Decay fungi do little damage to wood with a MC below 20%. They are most damaging at MC's from above 30% to saturation, which is too wet for favorable fungal growth. Bark obstructs penetration. In most cases, it should be peeled from wood products to enable quick drying. This also helps to avoid decay and insect damage and allows the preservative to penetrate the wood satisfactorily.



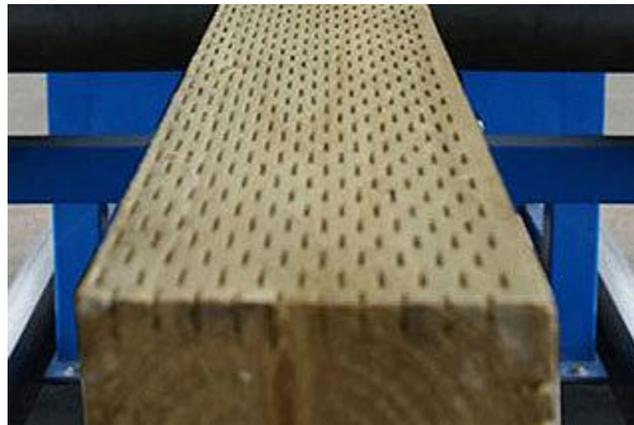
Air-drying rail ties (photo: Nisu Cellu-treat)

Air-drying yards and sheds should be located on well-drained sites with good air circulation. They should be kept free of weeds, debris, and rotted wood that retains moisture or provides a source of fungi or insects. The wood should be inspected often for such damage and handled carefully to prevent mechanical damage. **Air-drying may not be effective under warm, wet climatic conditions** because wood can absorb moisture from rain or from air that is excessively humid.

Kiln drying offers better control of air movement, temperature, and drying rate than does air-drying. It is **quicker but more expensive** so it is used for valuable materials.

Other methods for conditioning green wood materials include:

- 1). **Steam and vacuum process** - green wood is first steamed in a cylinder then subjected to a vacuum that removes the water in the wood by evaporation. The water is replaced by preservative applied under pressure.
- 2). **Boulton process** - creosote is introduced into a treatment cylinder at the same time that water is being removed under a vacuum. This process occurs at a lower temperature than the steam and vacuum process and is safer for some species of wood.
- 3). **Vapor drying** - green wood is exposed to an organic chemical such as xylene that gradually vaporizes and removes the water.
- 4). **Incising** creates a series of narrow 1/2 to 3/4 inch deep holes or slits in the wood to allow better penetration of preservatives.



Incised wood (photo: kopperspc.eu)

- 5). **Cutting, shaping, or boring the wood for its intended use before preservatives are applied** can prevent exposure of untreated surfaces that result if these processes are done after treatment.

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Methods of Applying Wood Preservatives

Pressure Treatment

Pressure treatment - the wood is placed into an airtight steel cylinder and immersed in a preservative. Increasing pressure drives the chemical into the wood. There are full cell and empty cell processes.



Lumber going into a pressurized treatment cylinder (image: jamaicaobserver.com)

The **full cell process** provides maximum retention of the preservative. A preliminary vacuum removes as much air from the wood as possible so that it will accept more liquid preservative. The heated preservative enters the cylinder without adding air. Then, pressure is applied until the required amount of preservative is retained by the wood.

The **empty-cell process** obtains deep penetration with a relatively low retention of preservative. First, the wood in the cylinder is subjected to air under pressure. Then the preservative is forced into the cylinder and air escapes into an equalizer tank at a rate that keeps pressure in the cylinder constant. When the cylinder is filled with preservative, the pressure is increased until the required amount of preservative has entered the wood.

Advantages of the pressure treatment over the non-pressure processes are:

- Deep, uniform penetration
- Better control over retention
- Wood can be pre-conditioned in the treatment chamber
- Faster and more reliable process
- More easily controlled and regulated

The **effectiveness of a wood preservative depends largely on penetration and retention**. The depth of penetration depends on the tree species, the proportion of sapwood to heartwood, and the treatment process

used. A preservative penetrates the well-dried sapwood of most species more easily when pressure-treated but results with heartwood are more variable. Even with the proper preservative penetration, good protection cannot be achieved unless enough preservative stays in the wood. **Preservative retention** is measured in pounds per cubic foot (lbs/cu ft) of wood.

Non-Pressure Treatments

Non-pressure treatments include superficial applications such as brushing, spraying, pouring and dipping, cold soaking, steeping, hot and cold bath (thermal process); diffusion, vacuum process, and preservative pads or bandages. They differ widely in preservative penetration and retention. Pressure treatment usually gives better protection than non-pressure treatment. However, non-pressure treatment may be satisfactory where pressure treatment is impractical or in situations where less protection is required.

Brushing, spraying, and pouring are generally done on cut or machined surfaces of previously treated wood. Penetration of preservative into wood is superficial, resulting mostly from capillary action. Creosote or other oil-borne materials and water-borne salts can be used. The temperature should be warm enough to permit as much penetration as the process allows. Liquid should cover the wood surface thoroughly to fill checks and depressions in the wood. Rough lumber may require 10 gallons of liquid per 1,000 square feet of surface; less for finished lumber. A second application, made after the first has dried is desirable. Wood treated in this manner and used in contact with soil may be protected for 1 to 5 years.

Dipping consists of immersing wood in a preservative solution for several seconds to several minutes. It allows better penetration into checks and cracks of wood but is unsatisfactory for uses subject to abrasion. There is little protection against termites and it is not recommended for wood used in contact with the ground.

Cold soaking well-seasoned wood for 2 to 7 days in a vat containing a low-viscosity oil-borne preservative is simple and relatively inexpensive. It is thought to give more protection than dipping.

Either green or seasoned wood can be **steeped** for several days in a tank full of water-borne preservative. Penetration and retention varies depending on the types of wood and treatment conditions.

Thermal process treatment consists of immersing wood alternately in separate tanks containing heated and cold preservative, either oil- or waterborne (or in one tank which is first heated than allowed to cool). During the hot bath, air in the wood expands and some is forced out. Heating improves penetration of preservatives. In the cold bath, air in the wood contracts, creating a partial vacuum, and atmospheric pressure forces more preservative into the wood. Temperature is critical; only use preservatives that can safely be heated.

In the **double diffusion process**, green or partially seasoned wood is soaked first in one water-borne preservative, then in another. The two chemicals diffuse into the wood and then react to form a combination that is highly resistant to leaching. The process converts leachable preservatives into stable ones.

Preservative pads or bandages are used on-site with previously-treated wood that is nearing the end of its protection time, e.g., utility poles. The soil around the pole is removed and the preservative (oil- or waterborne or paste) is applied to the surface, injected or placed into drilled holes in the wood. The treated area is then wrapped ("bandaged") with heavy duty water-resistant paper or plastic film to contain the preservative at the site of application.



Step 1 (image: osmose.com)



Step 2

Sap stain prevention is a temporary treatment applied quickly to newly felled green wood, preferably within 24 hours after sawing. This is usually done at the sawmill by carrying the logs through a tank of treated solution to prevent growth of sap stain fungi which can attack cut wood quickly.

Pole Treatments



Utility poles are most prone to decay in the groundline zone (from 6" above grade to 18" below grade) and the pole top.

Pole treatments can be used as an **internal treatment for wood utility poles** or to help protect open bolt holes, pole tops, and cross arms. **Rod delivery systems** are designed to be installed by utility personnel and are particularly well-suited for use in transmission spar arms and X-braces.

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Wood Preservative Pesticides

The **main types of wood preservative pesticides are: 1) oil-borne, 2) water-borne, and 3) fumigants.** The effectiveness of the different chemicals in each of these classes varies depending on exposure conditions.

The three exposure categories for preservatives are:

- 1) **Ground contact** (high decay hazard that needs a heavy-duty preservative),
- 2) **Aboveground contact** (low decay hazard that does not usually require pressure treatment), and
- 3) **Marine exposure** (high decay hazard that needs a heavy-duty preservative or possibly dual treatment).

Some active ingredients can be used in both oil-borne and water-borne preservatives.

The effectiveness of preservative treatment depends on the formulation selected, method of application, proportion of sapwood to heartwood, moisture content of the wood, amount of preservative retained, depth of chemical penetration, and distribution within the wood.

Sapwood of most commercial species accepts preservatives much better than heartwood. Softwood species are generally more receptive to impregnation than the hardwoods. Preservative treatment by pressure is usually required for most wood products used for structure and other applications exposed to high risk of attack by fungi, insects, or marine borers.

Oil-borne Preservatives

These chemicals are generally insoluble in water so they are **usually dissolved in petroleum or other organic solvents** in order to penetrate wood. Research developments have made available oil-borne preservatives formulated as water in oil emulsions or dispersions in water.

Advantages:

- Toxic to fungi, insects and mold
- Can be dissolved in oils having a wide range in viscosity, vapor pressure and color
- Low solubility in water
- Can be glued depending on the diluent or carrier
- Ease of handling and use.

Disadvantages:

- Can leave an oily, unpaintable surface, depending on the carrier,
 - Some applications provide less physical protection to wood than creosote,
 - Strong odor is toxic and irritating to plants, animals and humans.
 - Dark color,
 - Oily, unpaintable surface,
 - Tendency to bleed or exude from the wood surface.
-

Examples are creosotes, pentachlorophenol solutions, and copper and zinc naphthenate.

CCA (chromated copper arsenate) is used for fence posts, railroad ties etc. Creosote is a distillate of coal tar; a heavy oily liquid. Creosote improves the weathering characteristics of wood, provides protection from insects and fungi, and promotes insolubility in water. It is used in railroad ties, large timbers, fence posts, poles, and pilings.

Penta (pentachlorophenol) is a crystalline compound dissolved in light petroleum oil. Products treated with penta include construction lumber and timber, utility poles and crossarms, and fence posts.

Copper naphthenate solution COP-R-NAP (77% copper naphthenate) is diluted with a hydrocarbon solution (diesel fuel, mineral spirits, etc.) for application by brush, roller, immersion, etc. to the surface of poles, pole tops, beams, and lumber to prevent wood decay, termites, other wood attacking insects, and mildew.

Water-borne Preservatives

This class includes various metallic salts and other compounds. The **principal compounds used are combinations of copper, chromium, arsenic and fluoride**. Water-borne preservatives are **experiencing increasingly wider use** for lumber, plywood, fence posts, poles, pilings and timbers.

Advantages:

- No hazard from fire or explosion,
- Wood surface is left clean, paintable and free of objectionable odors,
- Safe for interior use and treatment of playground equipment,
- Leach resistant.

Disadvantages:

- Unless re-dried after treatment, the wood is subject to warping and checking,
 - Does not protect the wood from excessive weathering.
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Water-borne preservatives are **often used when cleanliness and painting of the treated wood are required**. Several formulations involving combinations of copper, chromium, and arsenic have shown high resistance to leaching and very good performance in service. Water-borne preservatives are included in specifications for items such as lumber, timber, posts, building foundations, poles, and pilings.

Examples include Acid copper chromate (ACC); Ammoniacal copper zinc arsenate (ACZA), 3 types of chromated copper arsenate (CCA), and others.

Fumigants

Fumigants are **used to control an existing internal decay or insect attack or to prevent future problems**. The fumigant, **methylisothiocyanate (mitc)**, is available in products that contain one of three active ingredients - methylisothiocyanate (mitc), dazomet, or metam-sodium. All rely on mitc as the preservative agent. Dazomet and metam-sodium must decompose in order to produce it.



Applying fumigant products (photos: Osmose Utilities Services, Inc.)

Mitc is applied at or near the groundline area in **liquid, solid melt, or powder/granular forms**. After application, the fumigant volatilizes and moves several feet from the point of application under vapor pressure. Fumigants control existing decay fungi and prevent the re-colonization of decay fungi by sterilizing the wood, including difficult-to-treat heartwood.

Methylisothiocyanate (mitc) (MITC-FUME) contains 97% mitc in solid melt pre-packaged individual dose tubes. This approach requires a high moisture content in the wood to be most effective. The dose rate is based on pole circumference.

Dazomet (DuraFume II) is a 98% solid pour granule that decomposes to produce smaller amounts of mitc than MITC-FUME. It is applied in from a metered 1-gallon container. The dosage is based on grams of product per hole and the hole is plugged.

Metam-sodium (WoodFume) is a 32.7% liquid that decomposes to produce the smallest quantities of mitc. It is applied in from a metered 1-gallon container. The dosage is based on pole circumference. For example, one pint of the product is applied for poles with circumferences between 22 and 39 inches.

Internal Treatments

Borate wood preservatives are composed of naturally occurring minerals that protect wood from fungus, termites, and other wood-decomposing organisms. They are **recommended for use in vulnerable, low-lying areas where water is prevalent or rises up from below, especially near masonry or sloping areas that might hold water**.



Boring pole to insert rod (photo: Osmose Utilities Services, Inc.)

BOR8 Rods are glass-like solid rods containing 96.65% water diffusible borate wood preservative. Borates are highly diffusible chemicals that help to control wood destroying fungi and insects. When the wood moisture content approaches a level that can support decay (about 25%), the rods dissolve. Borates diffuse along the path of moisture to provide a pattern of protection against future decay.

Copper and boron (Hollow Heart CB Concentrate) contains 5.84% copper and 5% boron designed to be applied by internal injection, brush, or spray.



Applying preservative paste (photo: Osmose Utilities Services, Inc.)

MP 500-EXT preservative paste contains borax and copper. Borax penetrates the wood to control wood decay fungi while copper protects the surface against soft rot fungi.

Wood Preservation

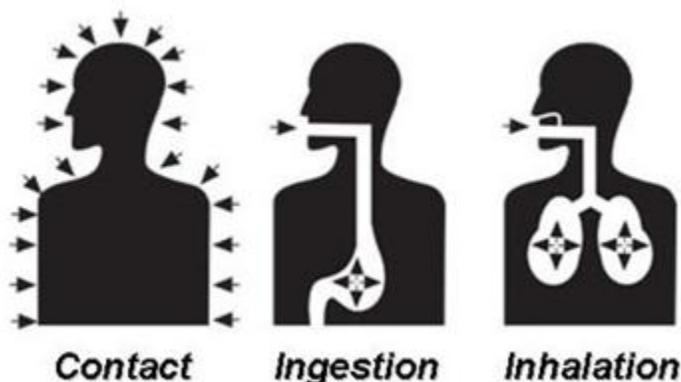
Protecting Human Health

Most chemicals used to protect wood from insects and decay are toxic. **Reduce risks of exposure by selecting products and application methods that will control the pests without harming the applicator, the user, the public, or the environment.** Ensure that the proper handling procedures, protective clothing, and any necessary equipment (such as respirators) are supplied to workers according to label instructions.

The EPA-approved label is the primary source of information on application methods, precautionary measures for workers, emergency first aid for high-level exposures, and disposal instructions for used pesticide materials and containers. **The label has the force of law.** Its provisions are enforced by the Kentucky Department of Agriculture. The label and Safety Product Data Sheet for each product used at a wood treatment operation should be readily available and all responsible personnel should be familiar with its contents.

Hazards to Applicators

Everyone who handles wood preservatives needs to know the risks in working with them and the necessary precautions to minimize these risks. **Most of the risk associated with wood preservatives comes from personal exposure during their application process.** Commonly used wood preservatives are toxic. Some can irritate and burn the skin, eyes, nose and throat and cause dizziness and muscle spasms. Excessive contact, particularly with some concentrates, can cause short-term, long-term, or permanently damaging effects.



Wood preservatives, like other pesticides, can enter the body in three ways:

- **Contact (skin)**
- **Ingestion (oral)**
- **Inhalation (respiratory)**

In many cases, wood preservatives are received, transferred, mixed, stored and applied in closed systems. However, *occasional leaks can present sources of human exposure*. Handling of freshly treated wood is highly mechanized; thus, potential dermal exposure of employees is usually minimal except for maintenance and cleanup jobs. Many wood preservatives have a strong odor and taste, so it is very unlikely that a person would swallow a dangerous amount. **Constant, careless and accidental dermal or respiratory exposure, however, can cause short or even long-term health effects.**

Exposure to wood preservatives can occur while handling and mixing the chemicals, entering pressure-treatment cylinders, working around spray or dip operations, handling freshly treated wood, cleaning/servicing equipment, or disposing of wastes. Closed systems for handling the chemicals and mechanical handling of treated wood helps to reduce potential exposure but does not eliminate the possibility of some routine or accidental exposure for workers.

Because of the potential hazard of these preservatives, there are EPA label requirements for their handling and use. **In addition to the potential hazards of chronic toxicity, a single or short-term exposure may cause acute health effects** such as:

- Eye irritation, irreversible eye damage
- Allergy or asthma symptoms or breathing difficulties if inhaled
- Mild skin irritation, allergic skin reaction, or skin burns
- Respiratory irritation.

First Aid

Since accidents do happen, first aid information on the chemical(s) in use must be readily available. The product label gives basic first aid directions, as do the Product Safety Data Sheets supplied by chemical manufacturers.

The following general steps apply to accidental exposure to wood preservatives:

- **Skin contact**

First remove contaminated clothing in contact with the skin. Immediately wash the affected areas with mild soap and water. Do not irritate the skin by scrubbing. Consult a doctor if you notice inflamed skin, redness or itching in the affected area.

- **Eye contact**

Immediately flush the eyes with running water. Lift the upper and lower eyelids for complete irrigation and continue for 15 minutes, then see a doctor.

- **Inhalation**

Move the victim to fresh air and apply artificial respiration as needed. Get medical help immediately.

- **Ingestion**

If chemical preservative has been swallowed, call medical help immediately. Only induce vomiting if the label first aid calls for it. Follow the instructions and get medical help immediately. Never attempt to give anything by mouth to an unconscious person. Never induce vomiting in an unconscious person.

Protecting the Applicator

Basic, common-sense hygiene rules can significantly reduce risks of chronic exposure to wood preservatives.

- **Don't eat, drink or smoke in the work area;** worker's hands can transmit residues to whatever they touch.
- **Wash hands often,** especially before using the restroom, smoking or eating.
- **Remove gloves to handle paperwork, phones or equipment** that others may handle with unprotected hands.
- At commercial treatment plants, protective clothing must be left at the plant. **If work clothes must be washed at home, keep them separate from other laundry.**
- **Protective clothing requirements are specified on the label.** These include the **use of impermeable gloves** for applying the preservatives and in all situations where skin contact is expected (e.g. handling freshly treated wood and manually opening pressure treatment cylinders). In certain situations such as spraying the chemicals and working around pressure treatment equipment, **additional clothing may be required.** Such

clothing may include overalls, jackets, boots, respirators (properly fitting and maintained, approved by MSHA/NIOSH) goggles and head covering.

- **Individuals who enter pressure treatment cylinders and other related equipment** that is contaminated with the wood treatment solution (such as cylinders that are in operation or are not free of the solution) must wear protective clothing, including **overalls, jacket, gloves, and boots impervious to the wood treatment solution, and a respirator.**

Work Practices and Protective Clothing

Protective clothing requirements will be specified on the product label attached to the container. It is imperative that the label requirements on these preservatives be strictly adhered to.

Posting Documentation and Technical Data

Certain documentation is available on site when wood treating chemicals are used, such as:

- **Material Safety Data Sheets (MSDS)**, available for each treating compound as shown in included examples.
- **Technical data sheets**, available from manufacturer and/or vendor.
- **Toxicity data**, available from the manufacturer.

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Protecting the Environment

It is not only people who can suffer from the careless use or disposal of wood preservatives—your community's environment also may suffer. Wood preservatives must be toxic in order to kill or repel the fungi, and insects 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 **the products are toxic to fish and other wildlife**. To reduce the chance of environmental contamination, proper protective measures must be an integral part of all your wood preservation operations.

Groundwater Pollution

Use of wood preservatives has been cited as a **source of pollution in surface and groundwater** in many parts of this country. Testing has documented contamination in public and private wells at levels exceeding health advisories. In some cases, sources of contamination are obvious—for example, **spills or illegal discharge of chemicals into ditches, storm drains, or sewers**. However, groundwater typically is affected by **contamination of the overlying soil**. Such contamination usually is **the result of applying preservatives to soil, spills, overflow from tanks or holding ponds, and improper disposal**. **Another less obvious source is the uncontained drippings from freshly treated wood**. 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.

Waste Disposal

Some treating plants discharge wastes into approved municipal sewer systems for processing with municipal wastes. **Many plants use closed chemical and wastewater recovery systems to contain wastes that could be harmful. Recovered solutions can be reused**. If they are contaminated, they can be filtered to remove solid wastes. Liquid waste materials can be diverted to settling tanks or lined ponds.

Use door sumps under pressure-chamber doors and hard-surfaced drainage areas. Any excess chemicals that drip or are rinsed from freshly treated material thus are channeled into the waste or recovery system. It also is important to contain runoff from areas where toxic chemicals are used in order to protect stored logs, poles, or lumber before processing or during seasoning.

Treating vessels and drip pads must be covered to reduce the risk of rainwater runoff, and plants must **routinely monitor storm water runoff** to ensure that contaminated water does not leave the site.

Storage and Disposal of Containers

Store chemicals in a dry, well-ventilated, locked area. Keep them in well-sealed containers whenever possible. Protect liquid storage against tank rupture. Protect concrete vats against freezing, cracking, or spillage. Wherever spills, leaks, or flooding could occur, be sure that runoff will drain into a recovery or disposal system.

Thoroughly rinse containers and empty them into storage or treating tanks before disposal.

Dispose of 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 Product Safety Data Sheet (PSDS) for each preservative. If you are not sure how to store a product safely or dispose of the empty containers, contact the chemical supplier or your state agency that regulates storage and container disposal.

Spills

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

Limitations on Use

Recent EPA regulations on wood preservatives include some limitations on treating wood intended for certain uses. **Be sure that the label allows you to use the preservatives for the specific use you intend.** Not all of these limitations are the responsibility of commercial applicators but these limitations should be known.

Product Safety Data Sheets (PSDS) are available from wood preservative manufacturers and distributors. These sheets contain information on such topics as toxicity and first aid, personal protection and controls, storage and handling precautions, spill-leak disposal practices, transportation, physical data and reactivity data. You should **have a PSDS on file for each different formulation that you use.**

Voluntary Consumer Awareness Program

In order to inform consumers of the proper uses of treated wood and the proper precautionary measures to take when using such wood, the treated wood industry has developed a voluntary Consumer Awareness Program (CAP). The treated wood industry is committed to the implementation of the CAP and the education of the consuming public.

Wood Preservation

Wood-Destroying Organisms (WDO)

Several species of fungi and insects normally infest wood, using it for food and/or shelter. Recognizing and understanding these organisms allows selection of select proper treatments to obtain satisfactory results.

Fungi

Some fungi cause wood decay, mold, and most sapwood stains. These colorless microscopic plants produce threads called **hyphae** and **fruiting bodies**. Large numbers of hyphae produce tangled webs called **mycelia**. Fruiting bodies, which usually are easy to see (deadwood conks, mushrooms), produce and release seed-like reproductive **spores**. Shed spores are carried away by wind or water. They can infect moist wood during storage, processing, or use. **Fruiting bodies often are the only indication that a fungus is present.**

Fungi require:

- **Food** in the form of cellulose, hemicellulose, or lignin. Chemically treated wood is not a food source.
- **Temperature** usually must be between 50°F and 90°F; the optimum is about 70°F to 85°F. Generally, wood below 35°F or above 100°F is safe from decay.
- Decay fungi require a **wood moisture content (M.C.) of about 30%** (the generally accepted fiber saturation point of wood). Air-dried wood, usually with a M.C. below 19% and kiln dried wood with a M.C. of 15% or less, are usually safe from fungal damage.
- **Adequate oxygen** - fungi cannot live in water-saturated wood.

Fungi can be divided into two major groups based on the damage that they cause.

- 1) **Wood-destroying fungi (decay fungi)** change the physical and chemical properties of wood, reducing its strength.
- 2) **Wood-staining fungi (sap stain fungi, mold fungi)** merely discolor wood

Wood Destroying Fungi

The sapwood and heartwood of the most tree species is susceptible to decay. **Decay fungi may grow inside the wood or appear on surfaces as fan-shaped patches** of fine, threadlike, cottony growth or root-like shapes. Color may range from white through light brown, bright yellow, to 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 as food, in time, destroying the strength and other properties of the wood.



White mycelia growing on wood (photo: bugginout.com)

Once started, the rate and extent of decay depends on how long favorable conditions for fungal growth last. **Decay will stop when the temperature of the wood is either too low or too high or when the moisture content is drier than the fungi's requirements.** However, **decay can resume when the temperature and moisture content become favorable again.** Early decay sometimes is accompanied by discoloration so it may be confused with stains caused by other fungi or by chemicals. Early decay is easier to see on freshly exposed surfaces of unseasoned wood than on wood that has been exposed to and discolored by the weather.

The **three major categories of wood destroying fungi are brown rot, white rot, and soft rot.**

Brown Rots

Brown rots are probably the **most important causes of decay of softwood species used in aboveground construction.** They are **sometimes called "dry rots"** but this is a poor term because dry wood will not decay. Brown rot fungi break down cellulose for food, leaving a brown residue of lignin. Brown rot greatly weakens wood even before decay can be seen. The final stage of decay by brown rots is distinguished by:

- dark brown color of the wood,
- excessive shrinkage,
- cross-grain cracking,
- dry wood that can be easily crushed to a brown powder.



Brown rot fungus (www.basementsystems.com)

A few fungi can decay relatively dry wood because they have water-conducting strands that can carry 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 the "dry rot fungi", or "water-conducting fungi".

White Rots

White rots break down both lignin and cellulose leaving a bleaching effect that may make the damaged wood appear whiter than normal. Affected wood exhibits normal shrinkage and usually does not collapse or crack across the grain as with brown rot damage. Rotting wood gradually loses its strength, becoming spongy to the touch. White rot fungi usually attack hardwoods but several species also decay softwoods.



White rot fungus (photo: sawmillcreek.org)

Soft Rot

Soft rot usually attacks green (water-saturated) wood, causing a gradual shallow softening from the surface inward that resembles brown rot. The surface of affected wood darkens and this superficial layer, up to 3-4 mm deep, becomes very soft, thus the name soft rot.

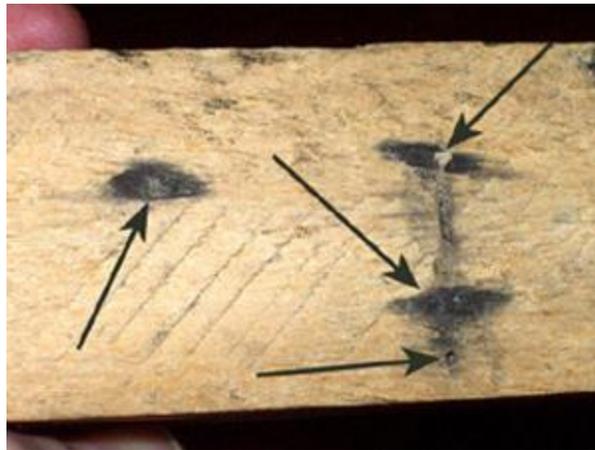


Soft rot (image: liveattack.slideshare.net)

Wood Staining Fungi

Sap-Staining Fungi

Sap-staining fungi penetrate and discolor sapwood. Unlike staining by mold fungi, **sap stain cannot be removed by brushing or planing**. These fungi may become established in the sapwood of standing trees, sawlogs, lumber, and timber soon after they are cut and before they have adequately dried. While strength is not appreciably affected, the wood **may not be fit for use where appearance is important (such as siding, trim, furniture and exterior millwork that is to be clear-finished)**.



Sap stain fungus (photo: entomology.ces.ncsu.edu)

Blue stain fungi are the most common of this group. They produce bluish mycelia deep within the wood, giving a stain that may completely cover the sapwood or appear as specks, streaks, or patches in varying shades of blue.



Blue stain fungus

Blue stains are not the only sap staining fungi that may infect wood. Stain color depends upon the kind of fungus and the species and moisture content of the wood. There may be yellow, orange, purple, or red stains.

Mold Fungi



Mold fungus (photo: themoldremediation.com)

Mold fungi first appear as powdery green, yellow, brown, or black growths on the wood surface. Their **colored spores usually are easy to remove**. However, **some surface molds may cause deep stains in open-pored hardwoods**. Freshly cut or seasoned wood that is piled during warm, humid weather may be noticeably discolored with mold in 5 or 6 days. These molds **do not reduce wood strength; however, they can increase the capacity of wood to absorb moisture**, thus increasing the possibility of attack by decay fungi.

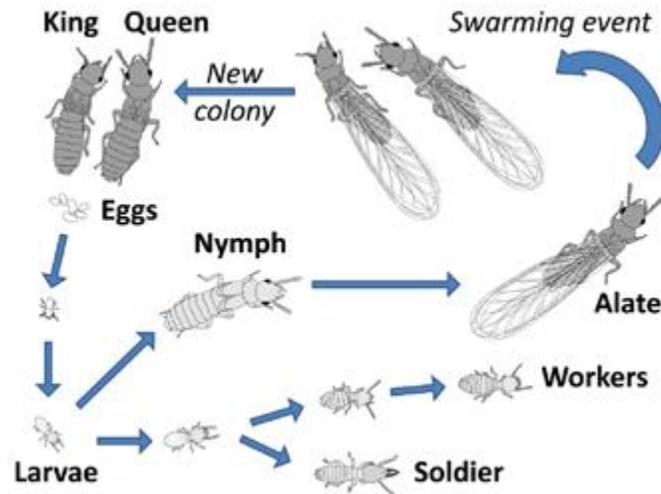
Chemical Stains

Chemical stains may resemble some caused by fungi. They **result from chemical changes in the wood**. Staining usually occurs in logs or in lumber during seasoning, and may be confused with a brown sap stain caused by fungi. The most important chemical stains are the **brown stains that can downgrade lumber** for some uses. They usually **can be prevented by rapid air drying or using relatively low temperatures during kiln drying**.

Wood-Destroying Insects

Several insect species use living trees, logs, lumber and finished wood products for food and/or shelter. These include various termites, ants, and beetles.

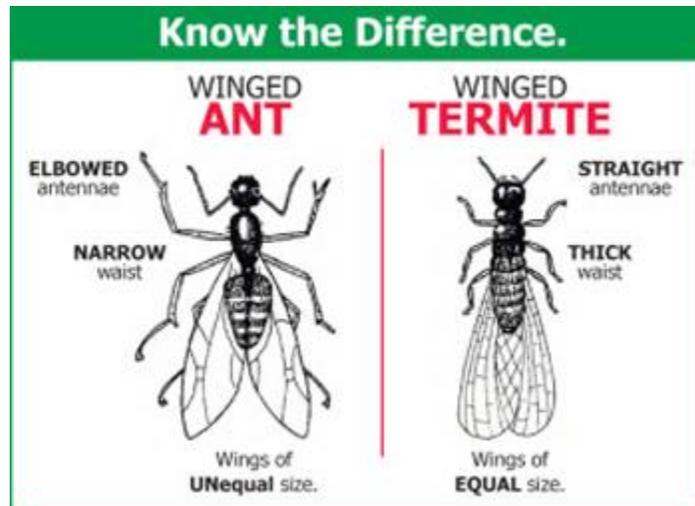
Termites



*Termite life stages are: the egg, the nymph, and the adult.
Castes include winged reproductive, soldiers, and workers. (image: <http://flrec.ifas.ufl.edu>)*

Eastern subterranean termites are social insects that live in underground colonies. A colony contains three castes: workers, soldiers, and winged reproductive forms (kings and queens). Each caste performs specific colony functions. The creamy-white workers cause damage as they feed on wood. They also keep the colony running. Soldiers, easily recognized by their long yellowish heads with large jaws, protect the colony from invading insects. The dark-brown or black kings and queens are the reproductive part of the colony. They leave the colony in swarms between March and June. After mating, wings break off the queens when they enter the soil to start new colonies.

Winged termites often are confused with winged ants. The easiest way to distinguish the two groups is to look at their antennae or feelers. Ants have L-shaped antennae; the antennae of termites are straight. Ants have narrow, wasp-like waists; termites have thick waists. Finally, the four equal-sized wings of a termite are almost two times longer than its body. The front wings of ants are larger than the hind wings and both are about the length of their bodies.



How to distinguish between ants and termites (image: primepest.net)

Jagged galleries in wood attacked by termites are coated with a mixture of soil and glue to keep the humidity high. Wood that has been infested for some time may be mostly hollow with passages and may appear rotten. Upon probing such wood with a screwdriver or similar tool, many of the hidden worker termites may spill out.



Termite galleries in wood have a jagged appearance and contain some mud (photo: www.narragansetpestcontrol.com)

Exposed mud tubes are another sign of termites. They are a protected runway from the earth to the wood the workers are eating. In addition, the tubes may serve as swarming exits for the winged termites. Wood embedded in earth or in concrete cellar floors is especially susceptible to termites.



Mud tube (www.greenninjapestcontrol.com)

Breaking the connection between wood and the soil is essential in termite control. This may be done with either a chemical or a mechanical barrier.

Carpenter Ants



Carpenter ant

Carpenter ants vary in size (up to 1/2 inch long) and can range in color from red to black. Workers are wingless; reproductive males and females have wings. These insects commonly **build nesting galleries in damp wood**. Since there **often will be no external signs of damage**, probing the wood with a screwdriver helps reveal the excavated galleries. Another technique for locating hidden nests is to tap along wood surfaces with the blunt end of a screwdriver, listening for the hollow sound of damaged wood. If a nest is nearby, carpenter ants often will respond by making a "rustling" sound similar to the crinkling of cellophane.



Clean carpenter ant galleries in wood (photo: mcinroybasementsystems.com)

Carpenter ant galleries have a smooth, sandpapered appearance and are clean; there is no mud-like material, as seen with termites. **Shredded fragments of wood, like coarse sawdust**, are dumped from the galleries through preexisting cracks or slits made by the ants. These accumulations are a good indication of carpenter ant activity.

Powderpost Beetles (PPB)

Powderpost beetle is a term used to describe **several species of small (1/8-3/4 inches long), wood-boring insects that reduce wood to a fine, flour-like powder**. The larvae chew narrow, meandering tunnels in wood as they feed. Infestations are discovered after noticing **small, round "shotholes" in the wood surface and accumulations of sawdust**. They are exit holes used by beetles that are leaving the wood after completing their development. Newly-emerged adults mate and lay eggs on or below the surface of bare (unfinished) wood. Tiny newly hatched larvae bore into the wood and feed from 1 to 3 years, depending on wood characteristics. You are more likely to see damage holes than the beetles because the adults are short-lived and are active mainly at night.



Powderpost beetle "shotholes" and sawdust (townandcountrysolutions.com)

The two **most common and destructive families of powderpost beetles in Kentucky** are the **Lyctidae** and **Anobiidae**.

Lyctid Powderpost Beetle

Lyctid powderpost beetles **attack only hardwoods**, e.g., oak, ash, walnut and hickory.



Lyctid powderpost beetle (image: publish.illinois.edu)

Lyctids rarely infest wood that is more than 5 years old so infestations **generally occur in new logs and lumber**. In many cases, the infestation was present when the tree was harvested or soon afterward. Typically, the infested article was constructed from untreated wood or wood that was improperly dried or stored.

Anobiid Powderpost Beetle



Anobiid powderpost beetle (image: itp.lucidcentral.org)

Anobiid powderpost beetles may **attack both hardwoods and softwoods** so infestations may be found in the same places as Lyctid beetles, as well as in **structural timbers (beams, sills, joists, studs, subflooring, etc)**. **Maple, beech, poplar and pine are especially susceptible to attack.**

Anobiids prefer to infest wood that is damp; therefore, **infestations usually begin in moist, poorly-ventilated areas** such as crawl spaces, basements, garages and utility sheds. Under favorable moisture and temperature conditions, infestations may spread upwards into walls and upper levels of the structure and occasionally, furniture. Infestations may result from using infested lumber or from beetles flying in from outdoors. Infestations develop slowly, but wood can be reinfested year after year. This **can result in extensive damage.**

References

2006. G. Thomasson, J. Capizzi, F. Dost, J. Morrell, and D. Miller Wood preservation and wood products treatment training manual (<http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20518/em8403.pdf>)

Wood preservation Category 4b Study guide for commercial applicators Ohio Department of Agriculture publication for pesticide regulation 08/03
(http://www.agri.ohio.gov/Public_Docs/Pest_Study_Material/4b%20Wood%20Preservation%20Study%20Guide.pdf)